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NOISE MEASUREMENT OF CONCORDE 02 APPROACH AND TAKEOFF AT DALLAS – FT. WORTH AND DULLES INTERNATIONAL AIRPORTS

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U.S. ENVIRONMENTAL PROTECTION AGENCY
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Mr. Ed Sellman
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LIST OF SYMBOLS

Symbol	Definition	Unit
A-Level	A-weighted sound level – as specified in ANSI S1.4	AdB
B-Level	B-weighted sound level – as specified in ANSI S1.4	BdB
C-Level	C-weighted sound level – as specified in ANSI S1.4	CdB
C(K)	Tone correction – as defined by FAR Part 36	dB
CPA	Closest point of approach of airplane to microphone	-
CPNL	Composite perceived noise level – the perceived noise level computed from the highest levels reached in each of the one-third octave bands, irrespective of time	PNdB
d	Duration time – as defined by FAR Part 36	seconds
D	Duration correction – as defined by FAR Part 36	dB
D-Level	D- (or N-) weighted sound level – as specified in SAE ARP 1080	DdB
EPNL	Effective perceived noise level – as defined by FAR Part 36	EPNdB
EQL (Leq)	Equivalent noise level for single event flyby	AdB
N2	High pressure rotor speed – a measure of engine performance	Percent
OASPL	Overall sound pressure level	dB
PNL	Perceived noise level – as defined by FAR Part 36	PNdB
PNLTM	Maximum tone corrected perceived noise level – as defined by FAR Part 36	PNdB
SENEL	Single event noise exposure level – as specified in California Noise Standards	AdB/sec
SR	Shortest distance from microphone to flight path (slant range at CPA)	feet

LIST OF SYMBOLS, Contd

Symbol	Definition	Unit
x	Rectangular coordinates for point on flight track or for microphone station	feet
$\bar{x}$	Shortest distance from microphone to flight track (Horizontal projection of microphone to flight track)	feet
X	Rectangular coordinate axis whose origin is the approach or takeoff runway threshold.	–
y	Rectangular coordinates for point on flight track or for microphone station	feet
$\bar{y}$	Distance along flight track (which may be curved) from axes origin to microphone projection	feet
Y	Rectangular coordinate axis whose origin is the approach or takeoff runway threshold – coincident with runway centerline and takeoff brake release is assumed to occur at the origin	–
z	Rectangular coordinate for point on flight path (vertical projection of point on flight path to ground)	feet
$\bar{z}$	Shortest distance from microphone projection on flight track to flight path	feet
Z	Rectangular coordinate axis whose origin is the approach or takeoff runway threshold	–
α	Aircraft takeoff (climb) angle	degrees
$\bar{\alpha}$	Angle of elevation from microphone to CPA for takeoff	degrees
σ	Aircraft approach (glide) angle	degrees
$\bar{\sigma}$	Angle of elevation from microphone to CPA for approach	degrees
ψ	Aircraft flight heading	degrees

UNITS

Aircraft physical characteristics and operational performance are controlled by the Federal Aviation Regulations (FAR's) which are expressed in English units. Therefore, for ease in correlation with the FAR's, much of the data in this report has been expressed in English units. The conversion factors between English and Metric Units are as follows:

Force (F)	(F-L-T-System)
0.4536	kilograms/pound
Length (L)	
2.540	centimeters/inch
0.3048	meters/foot
1.853	kilometers/nautical mile
1.609	kilometers/statute mile
Velocity (LT^{-1})	
1.853	(kilometers/hour)/knot
Temperature	

°Celsius = (5/9) (°Fahrenheit - 32)

BACKGROUND

During the month of September 1973, the British Aircraft Corporation and Aerospatiale conducted a world tour of the Concorde Supersonic aircraft. During this flight schedule the Concorde made two stops in the continental United States for purposes of ground and flight demonstrations. On 21-23 September 1973 the Concorde performed a number of approaches and take-offs at the new Dallas-Ft. Worth International Airport. On 23 September 1973, the Concorde landed at Dulles International Airport and departed from same on 26 September 1973 for a non-stop trip to Paris, France.

Based upon the requirements of the Noise Control Act of 1972 (Public Law 92-574) that EPA shall submit to the FAA proposed regulations to provide such control and abatement of aircraft noise and sonic boom as EPA determines is necessary to protect the public health and welfare, the EPA undertook the task of acquiring as much community noise data as was practical. This effort is associated with the EPA's effort to estimate the noise effects in airport communities resulting from the landing, approach, and takeoff of the Concorde and similar versions of a civil supersonic type aircraft.

To that end the EPA pursued the following actions:

1. Through an inter-agency agreement with the United States Army Corps of Engineers, recordings of noise levels at 25 sites in the communities surrounding the new Dalles-Ft. Worth International Airport were made during Concorde ground and flight operations in the period 21-23 September 1973.

2. Under contractual agreement to Hydrospace-Challenger, Inc. and the Environmental Defense Fund, recordings of noise levels at ten sites in the communities surrounding Dulles International Airport were made during the Concorde approach and takeoff operations on 23 and 26 September, respectively.

3. EPA acquired, by in-house staff, hand-held meter readings at nine sites in the vicinity of Dulles International Airport during Concorde approach and takeoff operations on 23 and 26 September, respectively.

This report contains a comprehensive review and analysis of all available data as well as setting forth the specific circumstances of the measurements and the factors affecting aircraft operations. It was prepared by Hydrospace-Challenger Inc. (HCI), San Diego, Ca., under Contract 68-01-1599.

CONCORDE 02 OPERATIONS

The aircraft used during the tour was Concorde 02, one of the two prototype vehicles. The basic details of the Concorde given in Table 1 were obtained from Reference 1.

Table 1. Concorde Description

WING SPAN	84 FT 0 IN. (25.60 M)
LENGTH OVERALL	203 FT 11-1/2 IN (62 17 M)
MAX TAKEOFF WEIGHT	385,000 LB (174,640 KG)
MAX LANDING WEIGHT	240,000 LB (108,860 KG)
ENGINES	OLYMPUS 593 AXIAL FLOW JET
NO. OF ENGINES	4
MAX POWER @ S.L.	38,050 LB THRUST
NOISE SUPPRESSORS	RETRACTABLE SPADE SILENCERS (2 IN EACH NOZZLE)

It should be noted that the nozzle area control schedule of Concorde 02 for the Dulles and Dallas flights was set to give a lower nozzle area than the production aircraft will have. The production nozzle area will result in noise levels about 1.5 PNdB quieter.

Operations of the Concorde 02 include a number of takeoffs, flybys, and approaches as detailed in Table 2.

Standard operating procedures and configurations were normally used during all flights. There were several exceptions. Firstly, the prototype aircraft did not have an automatic control system installed to aid in noise abatement power cutback operations. The normal noise abatement procedure involves climbing at full throttle to 750-ft altitude, at which point two engines are throttled back out of reheat. One second later, reheat power on the other two engines is cut. Two seconds after that, slow throttling is initiated to reach cutback power after 5 seconds. Thus, a total power

Table 2. Concorde 02 Dallas Flights

FLIGHT NO	DATE	AIRPORT	OPERATION
76	9-20-73	DALLAS-FT. WORTH	APPROACH AND FLYBYS
77	9-21-73	DALLAS-FT WORTH	TAKEOFF/APPROACH AND FLYBYS
78	9-21-73	DALLAS-FT WORTH	TAKEOFF/APPROACH
79	9-22-73	DALLAS-FT. WORTH	TAKEOFF/APPROACH AND FLYBYS
80	9-23-73	DALLAS-FT WORTH	TAKEOFF
80	9-23-73	DULLES	APPROACH
81	9-26-73	DULLES	TAKEOFF

reducing period of 8 seconds is scheduled. Secondly, the nozzle area control schedule for Flight 80 was set to give a lower nozzle area than the production aircraft. The production nozzle area will give noise levels about 1.5 PNdB quieter (Reference 2).

Due to the absence of automatic controls and the heavy pilot workload during Flight 81, the actual procedure consumed 22 seconds, thereby reducing the amount of noise abatement achieved.

COMMUNITY NOISE MEASUREMENTS

Measurements were made at 25 sites in the community surrounding the Dallas-Ft. Worth International Airport. The sites are depicted upon the map given in Figure 1. Measurements were made by the U.S. Army Construction Engineering Research Laboratory. A total of seven tests were recorded. A description of each test and site used is given in Table 3.

Table 3. Noise Measurement Operations

TEST NO.	FLT NO.	OPERATIONAL PROCEDURE	SITES USED
1	77	CONCORDE TAKEOFF	1, 2, 3, 4, 5, 6
2	77	CONCORDE APPROACH	7, 8, 9, 10, 11, 12
3	78	CONCORDE TAKEOFF	1, 2A, 3, 4A, 5, 6
4	78	CONCORDE APPROACH	7, 8, 9, 10, 11, 13
5	79	OTHER AIRCRAFT AND AMBIENT*	1, 3, 7, 14, 15, 16
6	79	CONCORDE TAKEOFF/APPROACH	1, 3, 7, 14, 15A, 16
7	80	CONCORDE TAKEOFF AND LEVEL PASSES	17, 18, 19, 20, 21, 22

*NOISE DATA NOT PROCESSED.

The measurement equipment consisted of Type 1 ANSI S1.4(1971) sound level meters and Nagra tape recorders. In some cases data were recorded on two-channel recorders using different gain settings to enhance the dynamic range of available data. Meteorological data were obtained at each site during the tests and a compilation of weather data for the Dallas-Ft. Worth measurements are given in Table 4. The equipment was calibrated using B&K pistonphone signals before and after each recording.

The performance of the aircraft during these operations was recorded using on-board instrumentation. (See Reference 2.) The relationships between the measurement locations and flight paths are given in Table 5.

The aircraft performance and flight profiles of the Dallas-Ft. Worth flight numbers 78, 79, and 80 are given in Figures 2, 3, and 4.

Table 4. Weather Data – Dallas-Ft. Worth

TEST NO.	FLIGHT NO.	DATE	SITE NO.	WIND SPEED (MPH)	WIND DIRECTION FROM TRUE NORTH	TEMP (°F)	RELATIVE HUMIDITY (%)
1	77	9-21-73	1	8	180	77	67
			2	6	180	-	-
			3	0-3	180	77	73
			4	2-5	180	77	70
			5	5	128	77	71
			6	9	165	77	71
2	77	9-21-73	7	7	180	87	72
			8	7-15	180	86	73
			9	10	180	-	-
			10	5-8	180	85	72
			11	8	220	84	71
			12	12	172	86	73
3	78	9-21-73	1	10	180	90	70
			2A	0-10	180	-	-
			3	5-7	180	91	71
			4A	3-10	180	89	69
			5	9	162	89	67
			6	7	166	91	70
4	78	9-21-73	7	8	180	95	64
			8	10-15	180	94	63
			9	10-15	180	-	-
			10	7-10	180	92	68
			11	9	175	92	68
			13	7	146	97	58
5	-	9-22-73	1	10	180	89	69
			3	-	-	-	-
			7	3-8	180	87	67
			14	8-10	220	-	-
			15	5-10	164	85	69
			16	7	168	89	71
6	79	9-22-73	1	10	180	95	73
			3	2-3	180	89	72
			7	3-8	180	90	67
			14	8-10	220	-	-
			15A	6	120	90	67
			16	3	110	89	66
7	80	9-23-73	17	3	148	85	71
			18	5	180	89	-
			19	-	-	-	-
			20	5-10	150	83	72
			21	6	180	82	66
			22	0-2	145	82	72

Performance data for Flight 77 are not available. Data include altitude above ground, percent N_2, ground speed, and aircraft heading plotted versus flight track distance and, in addition, aircraft flight track versus coordinate system.

Measurements were made at 15 sites in the community surrounding the Dulles International Airport on 23 September 1973 during approach and at 17

PAGE NOT

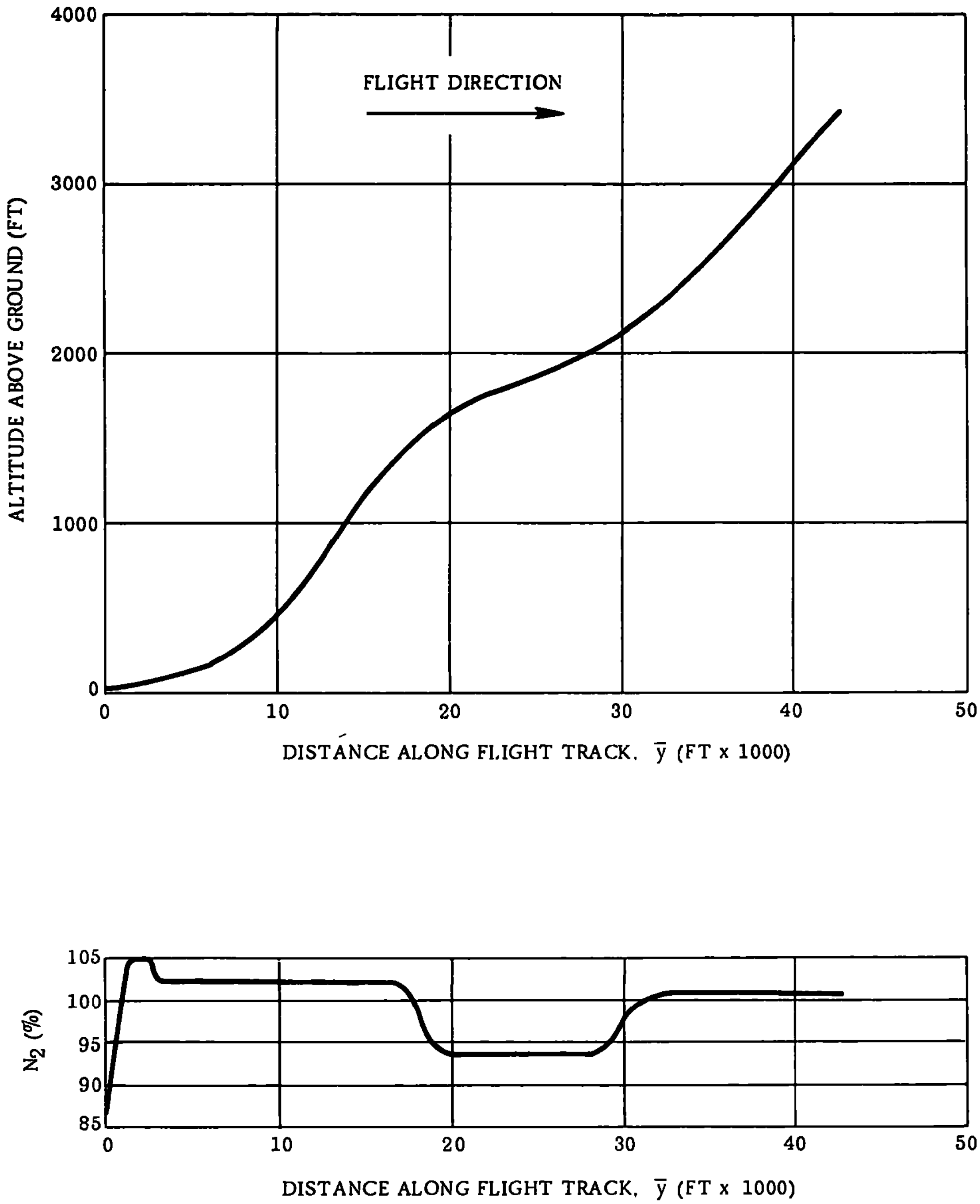
AVAILABLE

DIGITALLY

Table 5. Geometrical Relationships - Dallas-Ft. Worth

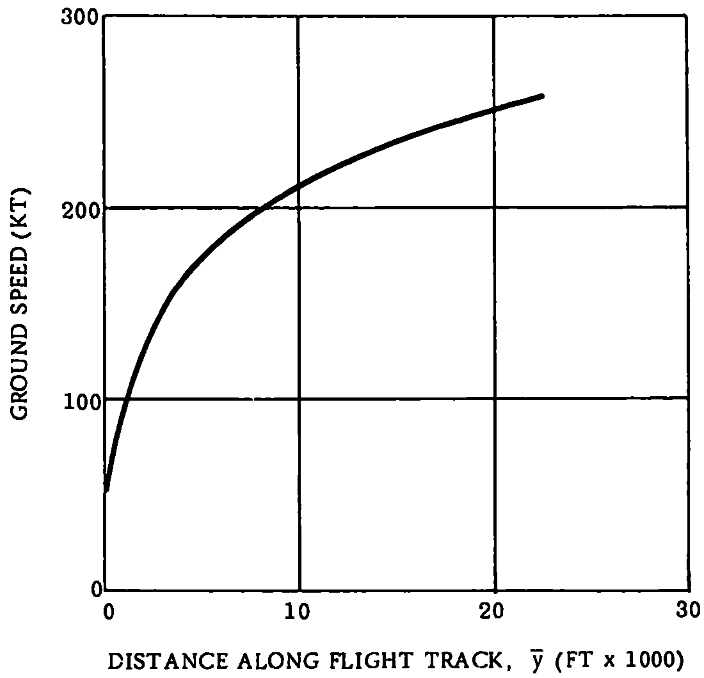
①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
MICROPHONE STATION										
		COORDINATES								
SOURCE	NO.	x (KFT)	y (KFT)	$\bar{x}$ (KFT)	$\bar{y}$ (KFT)	z (KFT)	σ OR α (DEG)	z ⑦ x COS ⑧ (KFT)	SR $[⑤^2 + ⑨^2]^{1/2}$ (KFT)	$\bar{\sigma}$ OR $\bar{\alpha}$ TAN^{-1} ⑨ / ⑤ (DEG)
CERL 78 T.O.	1	0	17.247	0	17.247	1.440	6.5	1.430	14.300	90.0
	*2A	13.320	19.027	13.320	19.027	1.600	5.3	1.593	13.414	6.8
	3	0.320	28.927	0.320	28.927	2.080	3.0	2.077	2.101	81.2
	4A	3.200	19.310	3.200	19.310	1.630	3.0	1.628	3.590	26.9
	*5	31.240	28.810	31.240	28.810	2.070	5.3	2.061	31.307	3.8
	6	1.340	53.090	1.340	53.090	No Data →				No Data
CERL 78 APP	7	0.380	5.660	0.380	5.660	0.210	2.1	0.210	0.434	28.9
	8	2.680	12.300	2.680	12.300	0.660	3.9	0.658	2.759	13.8
	*9	13.440	13.520	13.440	13.520	0.740	3.7	0.738	13.460	3 1
	10	-2.640	17.840	-2.640	17.840	0.980	3.2	0.978	2.815	20.3
	*11	26.340	18.920	26.340	18.920	1.050	3.7	1.048	26.360	2.3
	13	-1.900	36.600	-1.900	36.600	2.170	0	2.170	2.884	48.8
CERL 79 T.O.	1	6.500	17.247	No Data →						No Data
	3	6.820	28.927	No Data →						No Data
	*14	8.500	11.640	14.600	13.200	1.490	0	1.490	14.675	5 8
	*15A	14.480	11.000	20.380	12.500	1.400	0	1.400	20.428	3.9
CERL 79 APP	*7	6.880	5.660	6.880	5.660	0.210	2.4	0.209	6.883	1.7
	16	5.700	21.420	4.100	21.800	1.380	4.1	1.376	4.324	18.6
CERL 80 T.O.	17	-1.500	53.590	No Data →						No Data
	18	-1.380	28.970	-4.320	30.800	3.600	0	3.600	5.623	39.8
	19	0.140	16.990	0.860	16.990	1.260	9.2	1.243	1.511	55.3
	20	0.100	5.720	No Data →						No Data
	21	64.200	16.450	5.420	16.450	1.170	9.2	1.155	5.541	12.0
	*22	-6.800	16.850	7.800	16.850	1.220	9.2	1.204	7.892	8.8

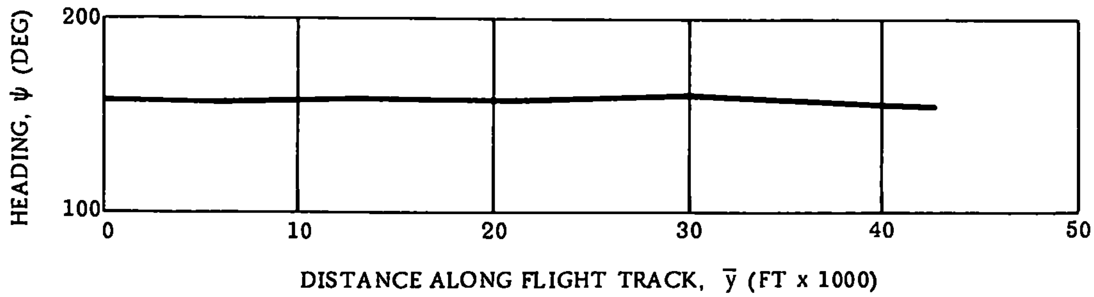
* $\bar{\sigma}$ OR $\bar{\alpha}$ < 10°



a. Takeoff

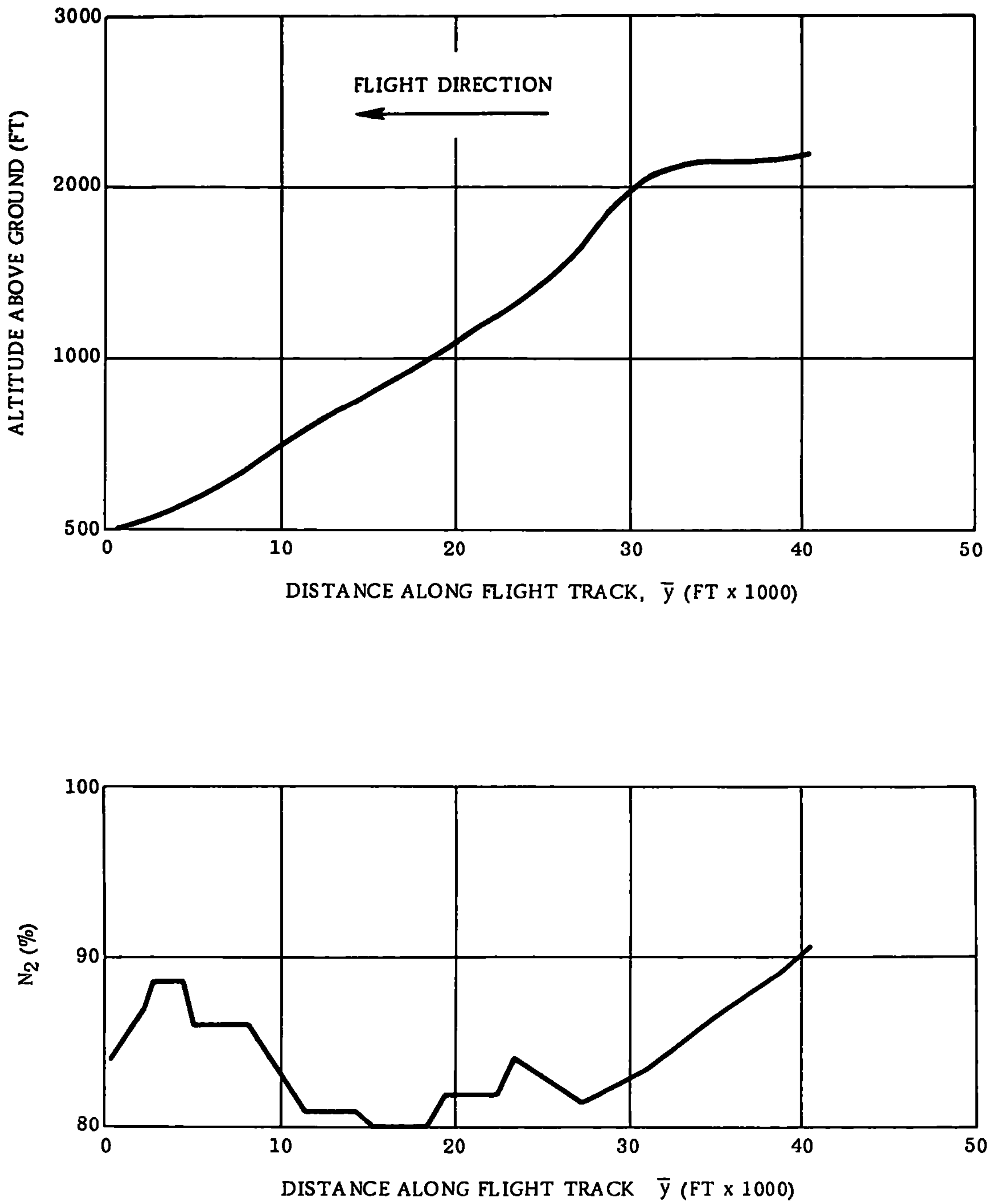
Figure 2. Aircraft Performance – Flight 78





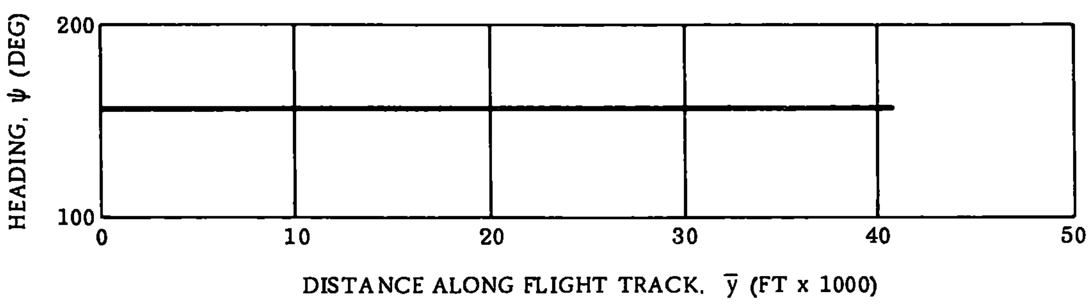
a. Takeoff, Contd

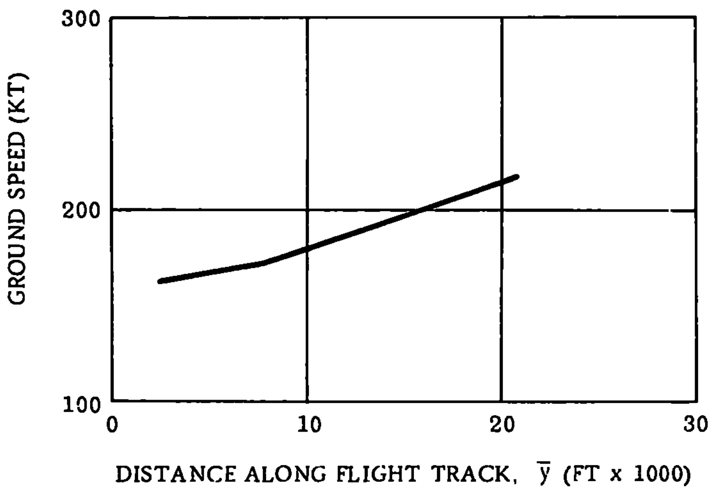
Figure 2. Aircraft Performance – Flight 78, Contd



b. Approach

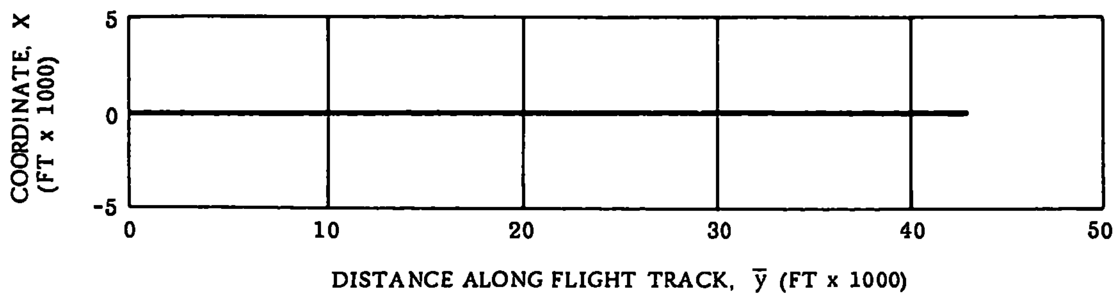
Figure 2. Aircraft Performance – Flight 78, Contd

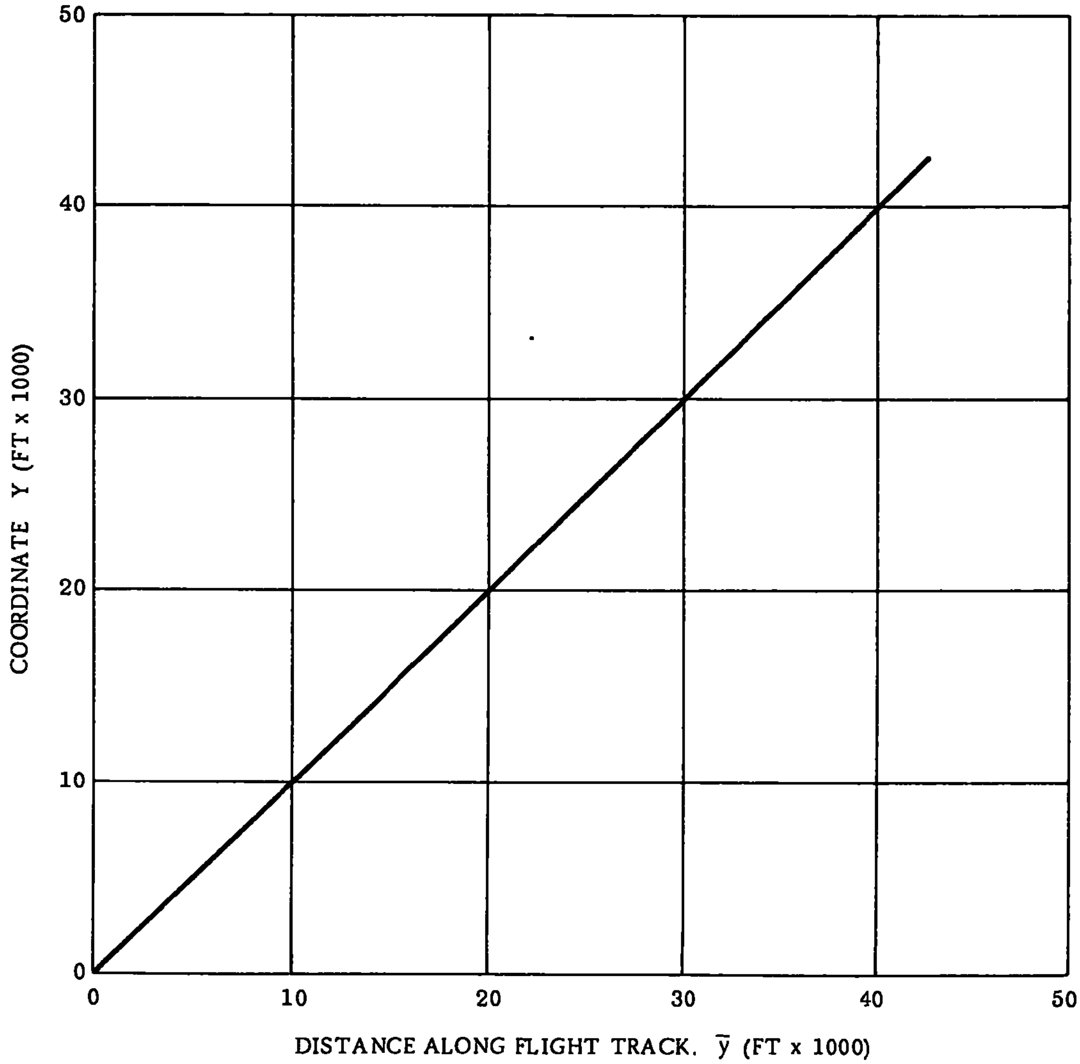




b. Approach, Contd

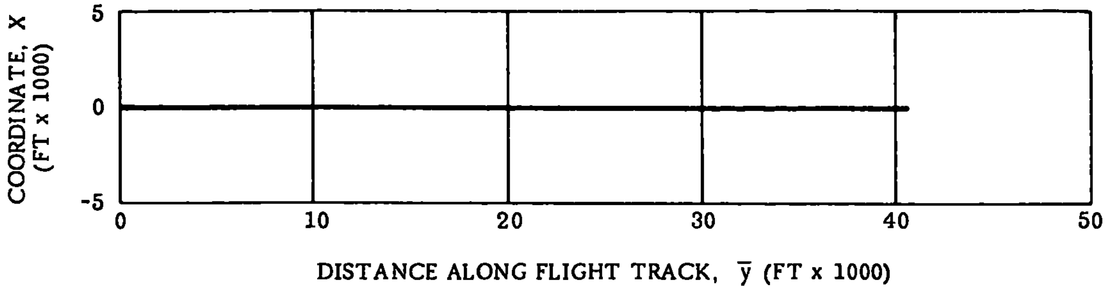
Figure 2. Aircraft Performance – Flight 78, Contd

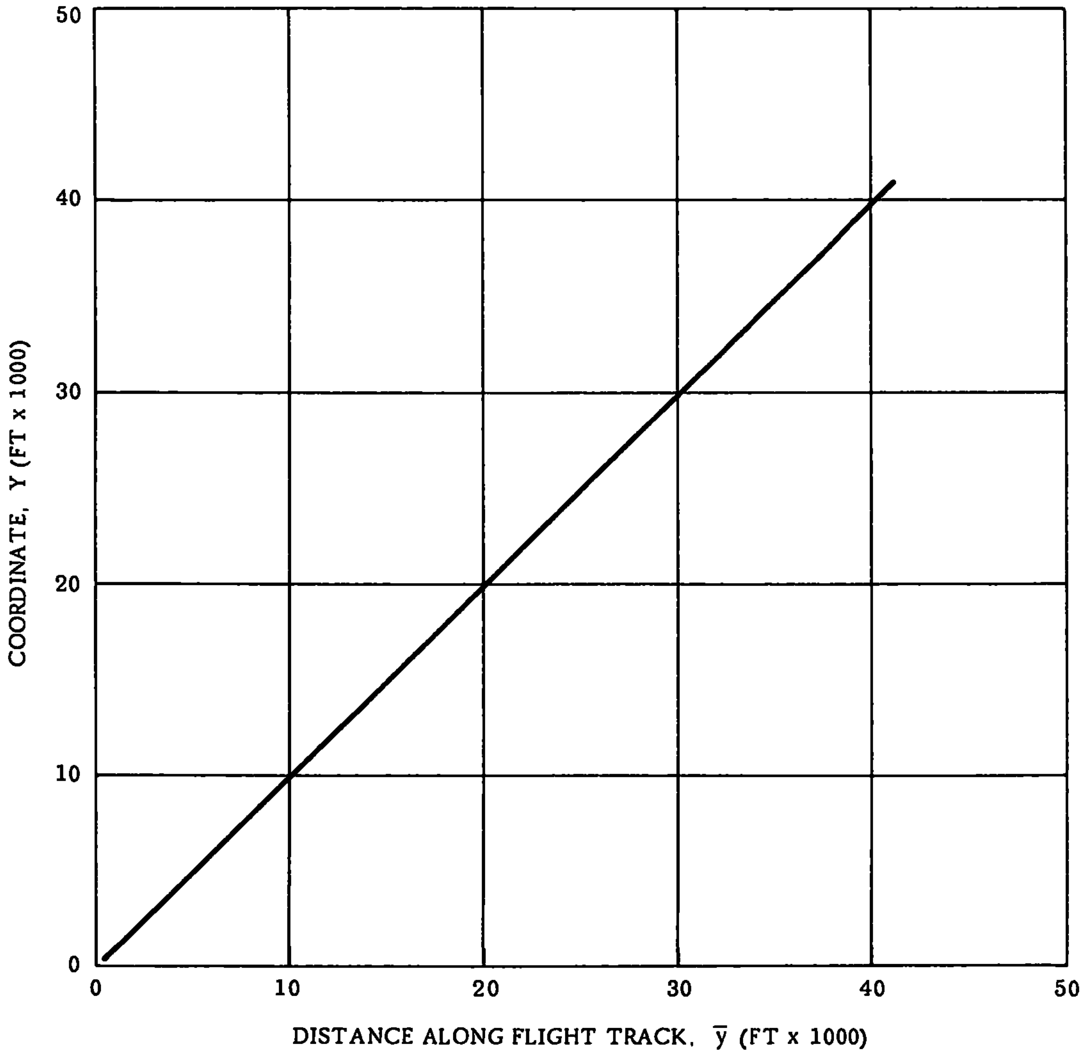




c. Takeoff Flight Track

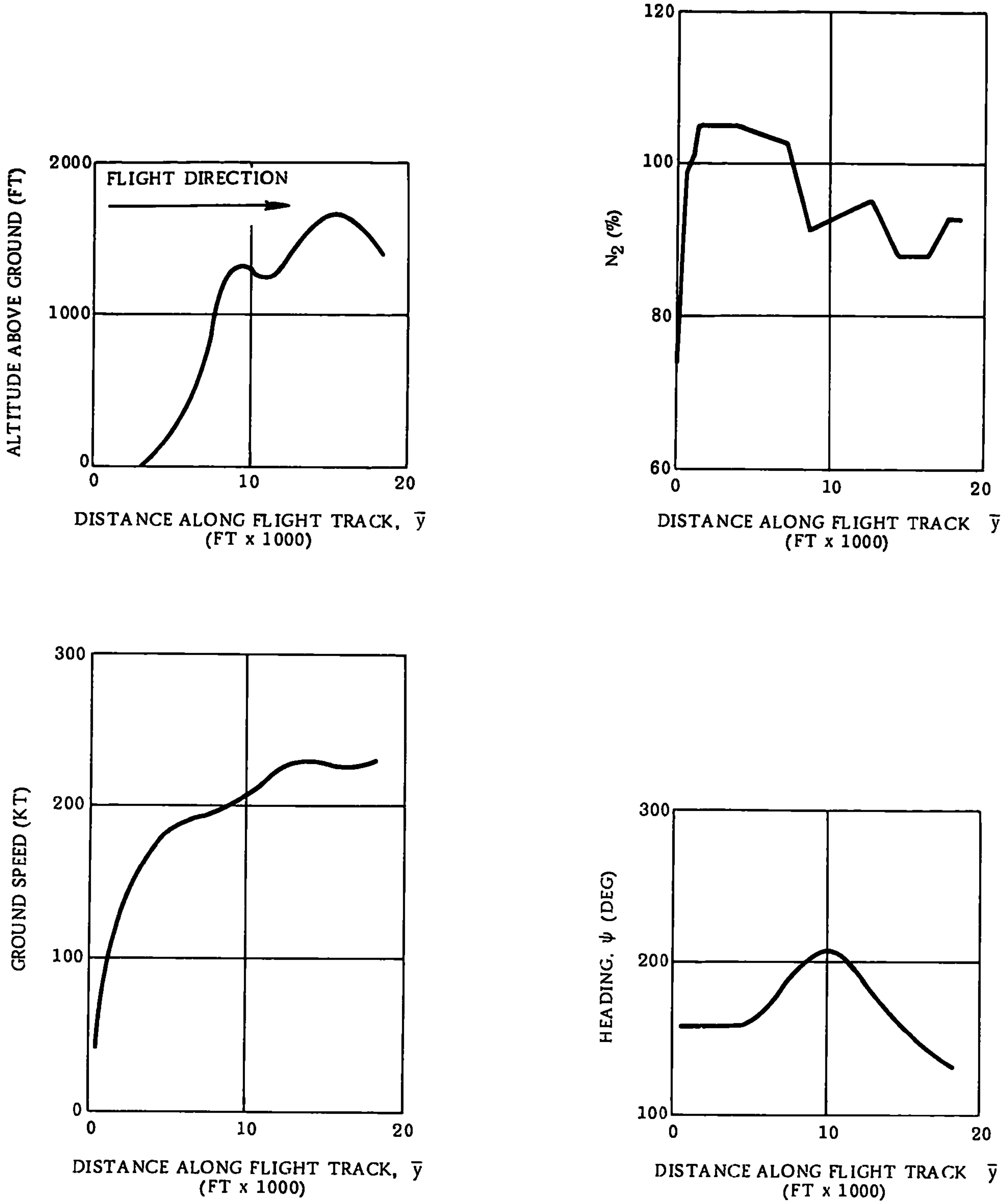
Figure 2. Aircraft Performance – Flight 78, Contd





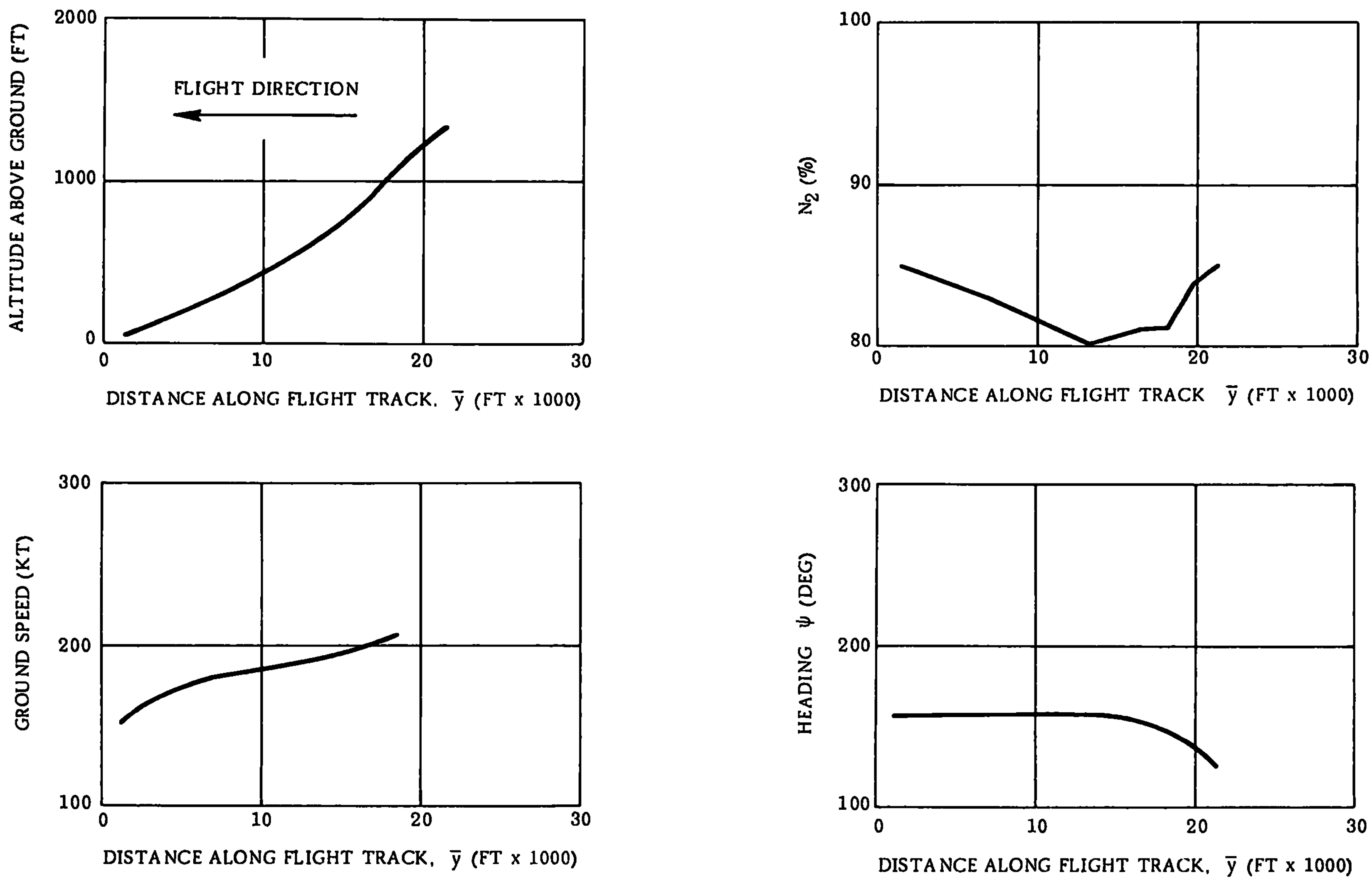
d. Approach Flight Track

Figure 2. Aircraft Performance – Flight 78, Contd



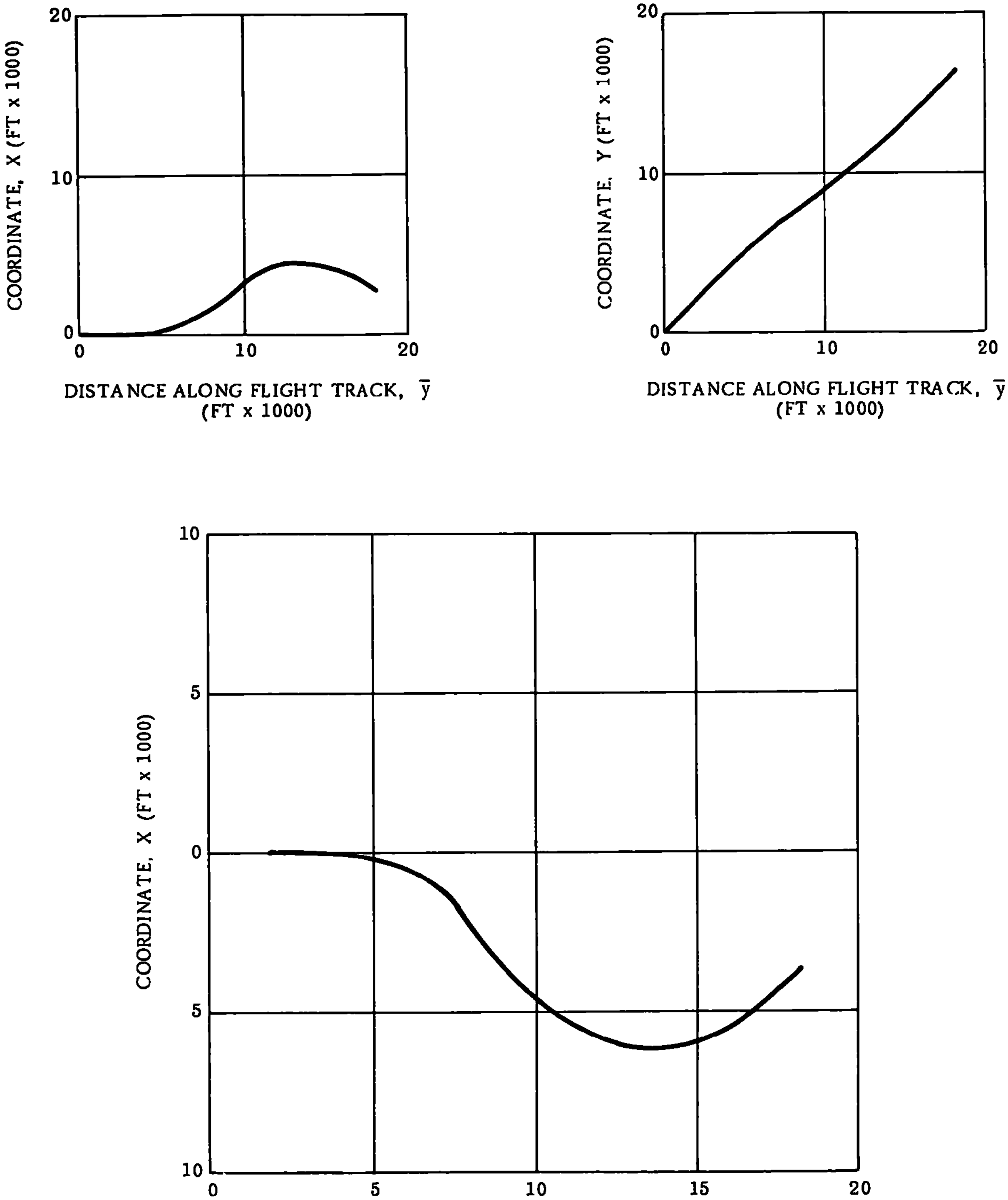
a. Takeoff

Figure 3. Aircraft Performance - Flight 79



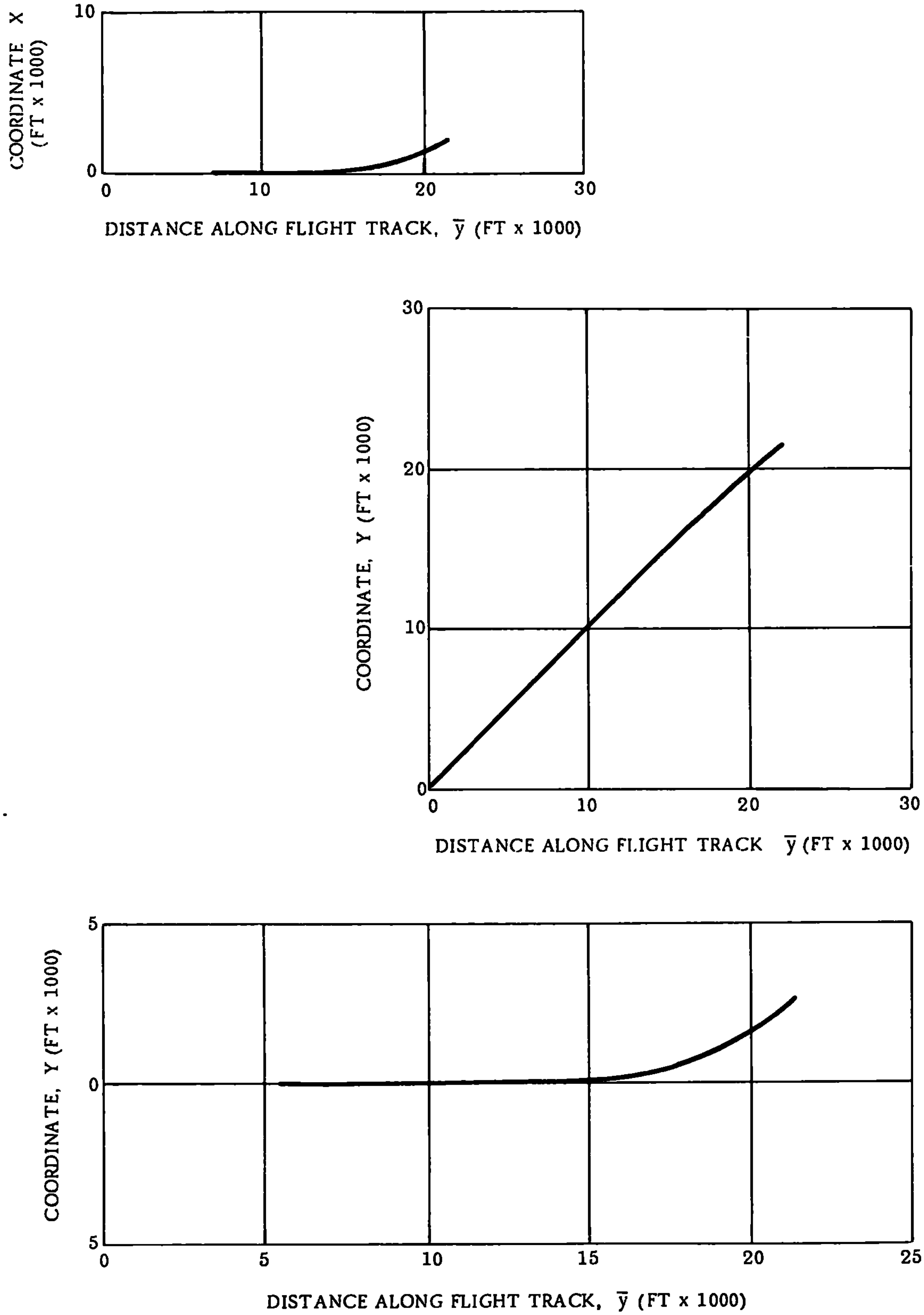
b. Approach

Figure 3. Aircraft Performance – Flight 79, Contd



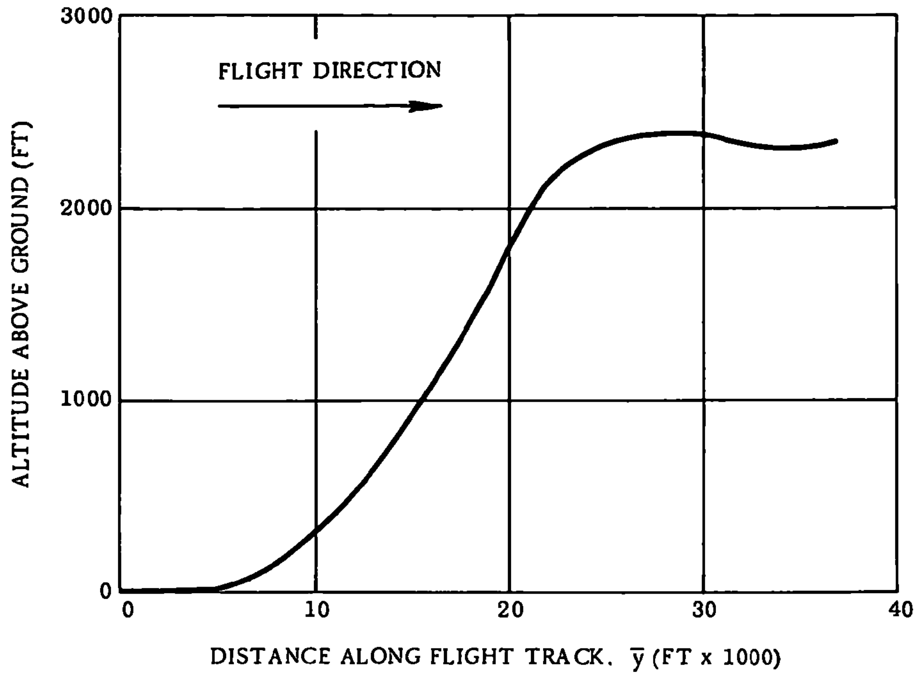
c. Takeoff Flight Track

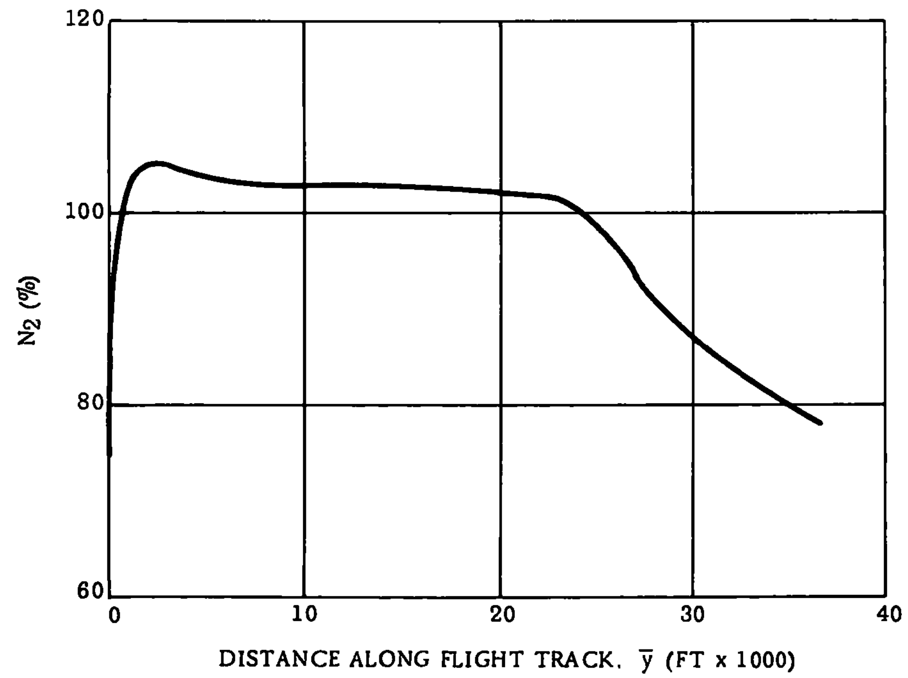
Figure 3. Aircraft Performance – Flight 79, Contd



d. Approach Flight Track

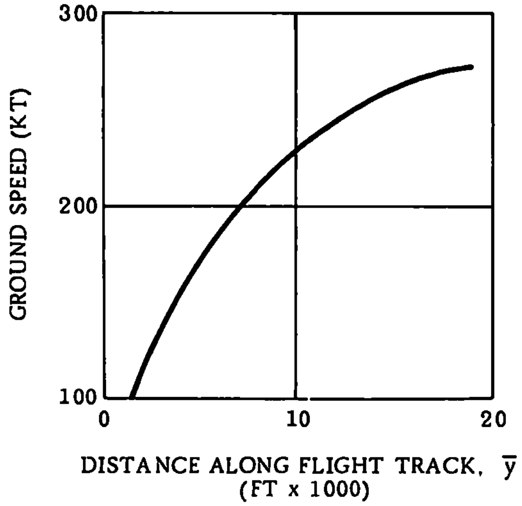
Figure 3. Aircraft Performance – Flight 79, Contd

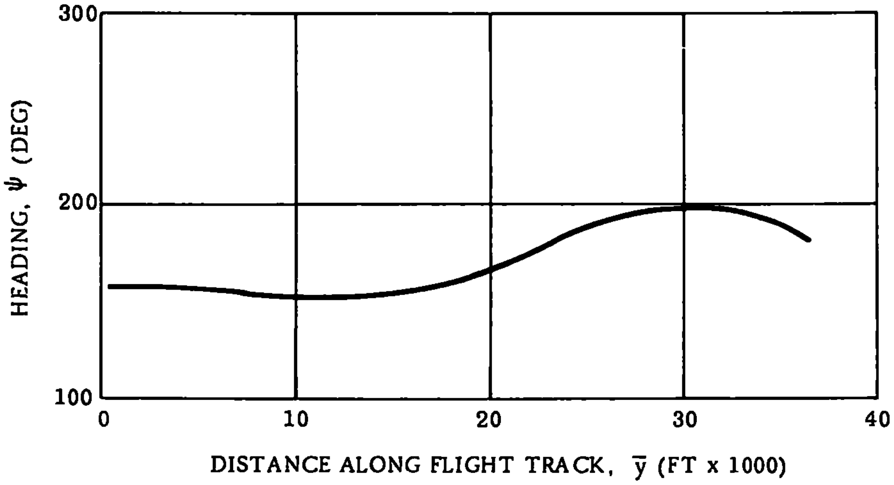




a. Takeoff

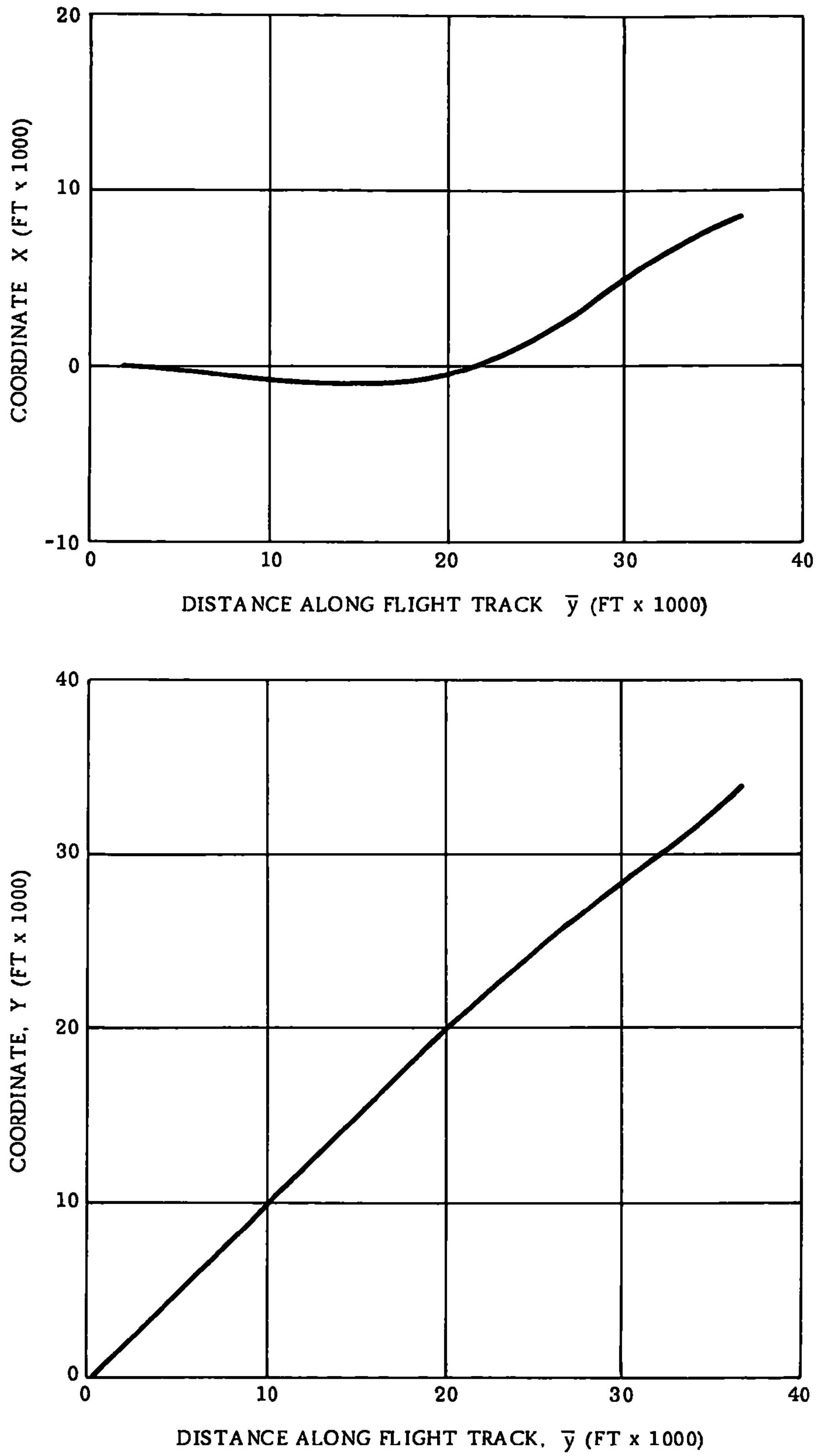
Figure 4. Aircraft Performance - Flight 80





a. Takeoff, Contd

Figure 4. Aircraft Performance - Flight 80, Contd



b. Takeoff Flight Track

Figure 4. Aircraft Performance – Flight 80, Contd

sites on 26 September 1973 during takeoff. The measurements points are depicted on the map in Figure 5.

The Dulles measurements were performed by four groups: 1) Hydrospace-Challenger, Inc. (HCI), 2) Environmental Defense Fund (EDF), 3) EPA Office of Noise Abatement and Control, and 4) the FAA Environmental Quality Office. There were a variety of instruments used.

Seven HCI systems consisted of B&K 1/2-inch and General Radio 1-inch microphones and preamplifiers, B&K 141 portable noise systems, and Uher 4200 tape recorders. The eighth HCI system was a B&K 2204 sound level meter with Nagra tape recorder.

The EDF equipment consisted of B&K 2209 sound level meters and Nagra tape recorders. EPA-ONAC equipment included both Type 1 and Type 2 General Radio sound level meters. The FAA equipment was a Type 1 sound level meter.

Calibrations of each set of equipment varied with the users standard operating procedures. For those groups performing magnetic tape recordings, the calibration procedures included an electrical frequency response check at the center frequency of each one-third octave band from 50 Hz to 10,000 Hz and a single-tone sound level calibration.

In addition to the noise data, some temperature and humidity readings were made. These data, in addition to tower weather data, are given in Table 6. Again, the performance of the aircraft was recorded using on-board instrumentation. The performance data was supplied by Reference 3.

The approach was essentially straight in on an approximate 3-degree glide slope. See Figure 6 for performance data. The relationship between the approach measurement locations and the flight path yield the data given in Table 7.

The takeoff from Dulles was straight out with a right turn initiated at about 3.9 n.mi. from brake release. See Figure 7 for details. The relationship between the measurement locations and the flight path yield the data

Table 6. Weather Data — Dulles

TEST	DATE	SITE	WIND SPEED (MPH)	WIND DIRECTION (DEG FROM TRUE NORTH)	TEMP (°F)	RELATIVE HUMIDITY
APPROACH FLIGHT 80	9-23-73	1			80	72
		2			83	62
		3			83	62
		4			80	72
		5			84	66
		6			76	89
		7			82	63
		TOWER	6.0	320	81	55
TAKEOFF FLIGHT 81	9-26-73	8			61	89
		9			61	94
		10			60	91
		11			63	86
		12			60	94
		13			60	94
		14			60	89
		16			61	91
		TOWER	5.0	120	61	84

Table 7. Concorde Approach Noise Measurement Geometry - Flight 80

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
MICROPHONE STATION										
		COORDINATES								
SOURCE	NO.	x (KFT)	y (KFT)	$\bar{x}$ (KFT)	$\bar{y}$ (KFT)	z (KFT)	σ (DEG)	$\bar{z}$ ⑦ x COS ⑧ (KFT)	SR [⑤ ^{2} + ⑨ ^{2}]$^{1/2}$ (KFT)	$\bar{\sigma}$ TAN^{-1} ⑨ / ⑤ (DEG)
EPA HCI	1	8.16	17.60	8.16	17 60	0.88	1.5	0.88	8.21	6.16
	2	-5.66	22.64	-5.66	22.64	1.15	3.6	1.15	5.78	11.49
	3	0.60	34.54	0.60	34.54	1.96	4.5	1.95	2.04	72.90
	4	-2.26	55.84	-2.26	55.84	2.90	0	2.90	3.84	52.07
	5	2.60	41.06	2.60	41.06	2.50	2.3	2.50	3.61	43.88
	6	0.30	22.12	0.30	22.12	1.10	3.5	1.10	1.14	74.74
	7	-0.34	15.52	-0.34	15.52	0.81	2.0	0.81	0.88	67.23
	15	0	10.30	0	10.30	0.53	2.8	0.53	0 53	90.00
EPA ONAC	7	-5.02	30.62	-5.02	30.62	1.67	4.3	1.66	5.29	18.30
	8	-4.75	13.20	-4.75	13.20	0.72	2.5	0.72	4 80	8.62
	9	5.54	15.05	5.54	15.05	0.80	2.2	0.80	5.60	8.22
EDF	1	0.50	7.20	0.50	7.20	0.38	2.8	0.38	0.63	37 23
	2*	1.80	-5.90	1.80	-5.90	0	0	0	1.80	0
FAA	1	0	12.16	0	12.16	0.67	2.7	0.67	0.67	90.00
	2	0	24.32	0	24.32	1.24	3.8	1.24	1.24	90.00

* THRUST REV.

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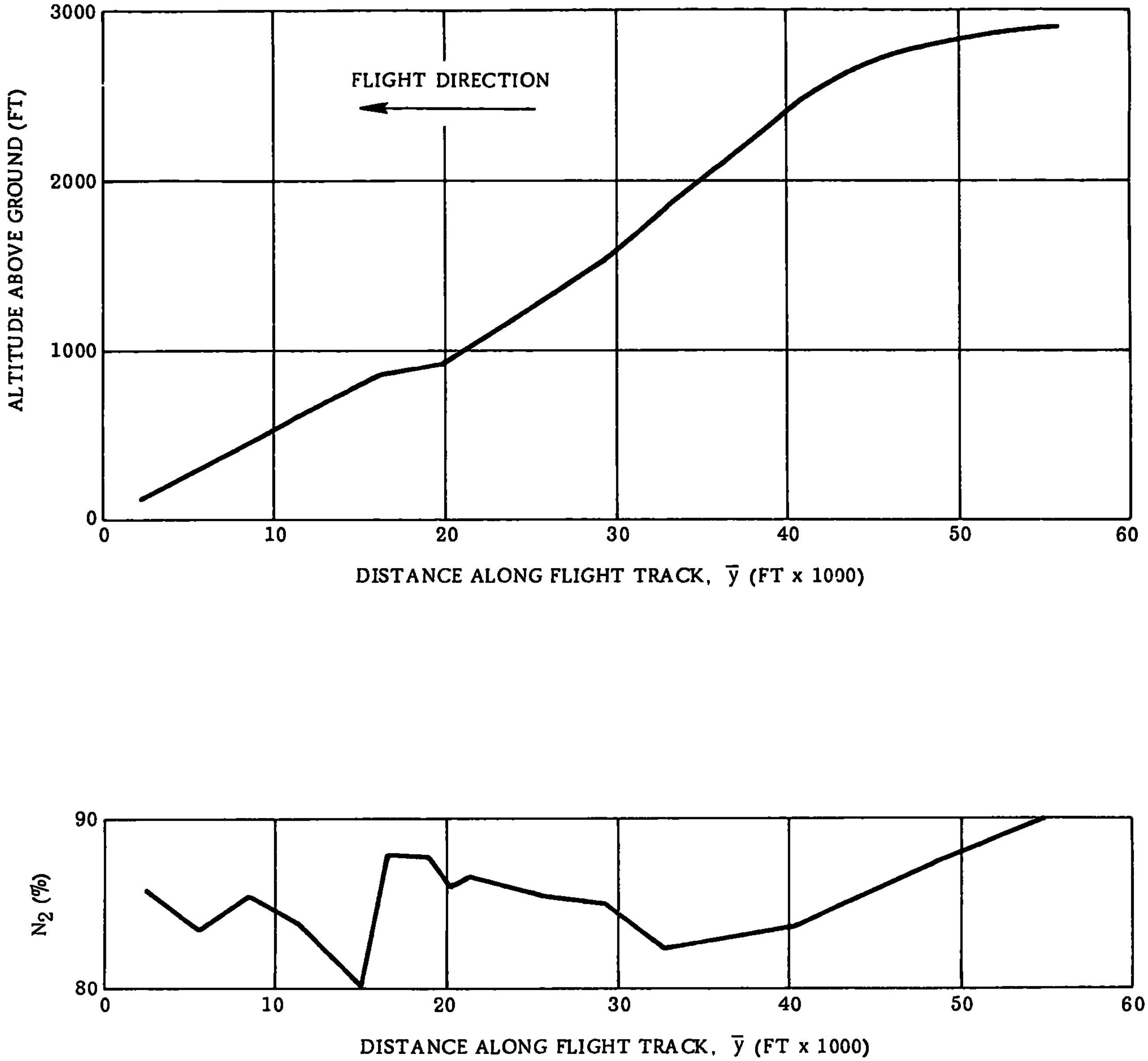
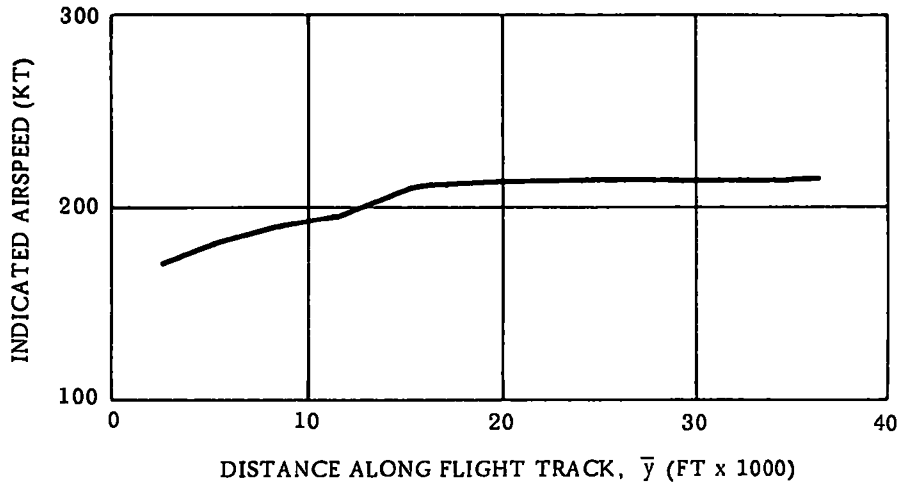
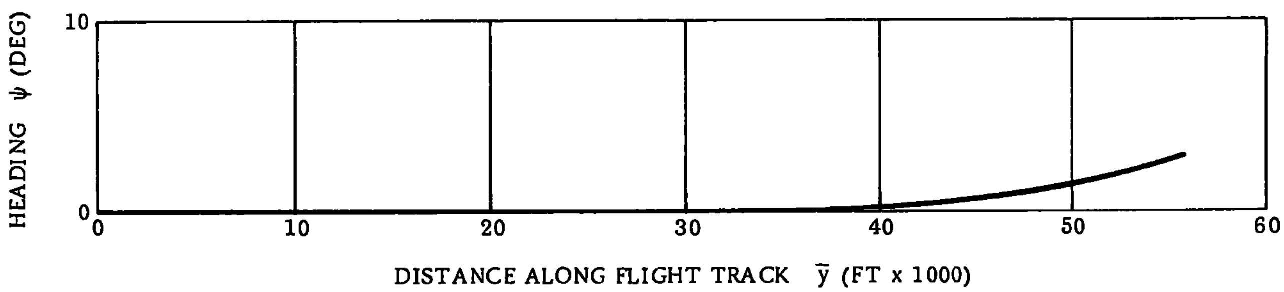


a. Approach

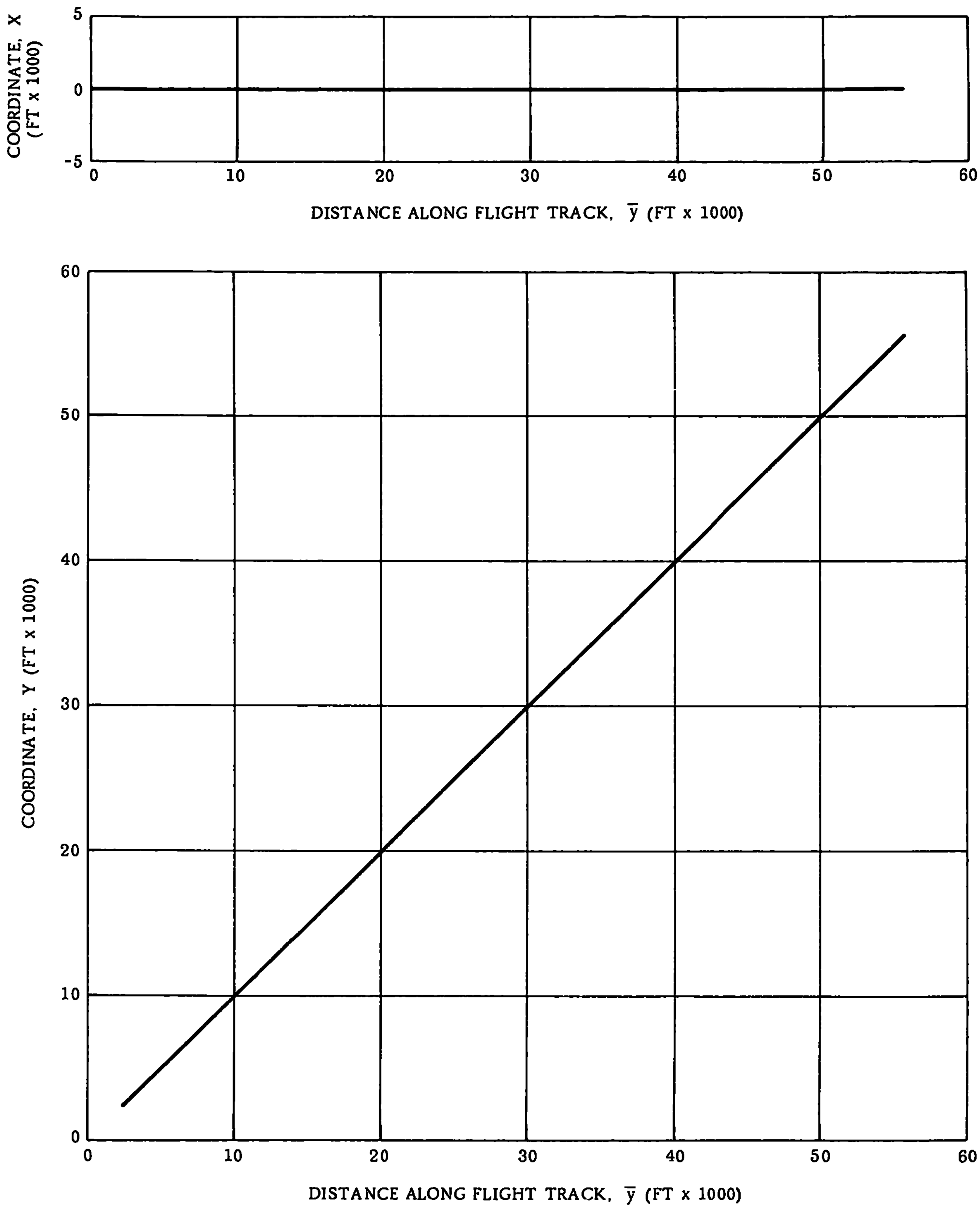
Figure 6. Aircraft Performance – Flight 80





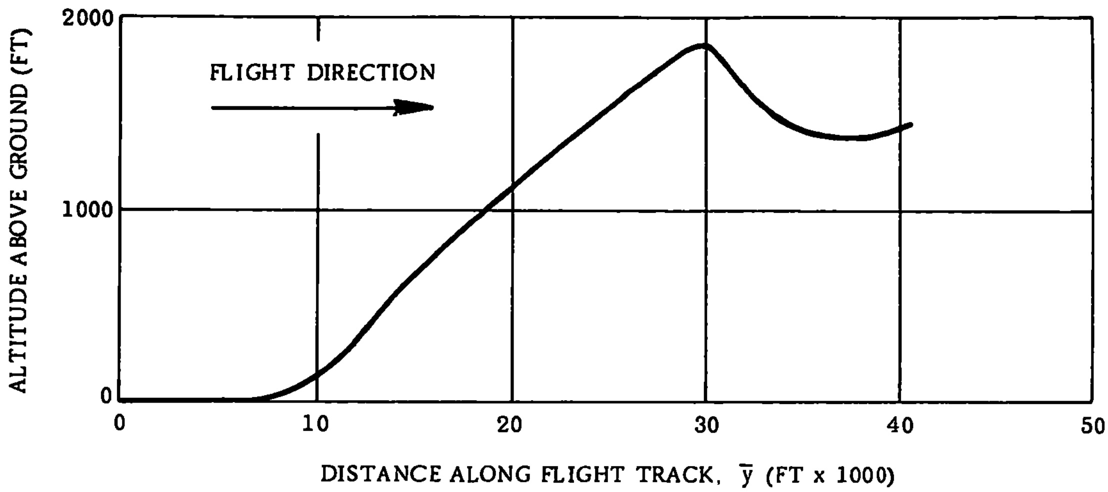
a. Approach, Contd

Figure 6. Aircraft Performance - Flight 80, Contd



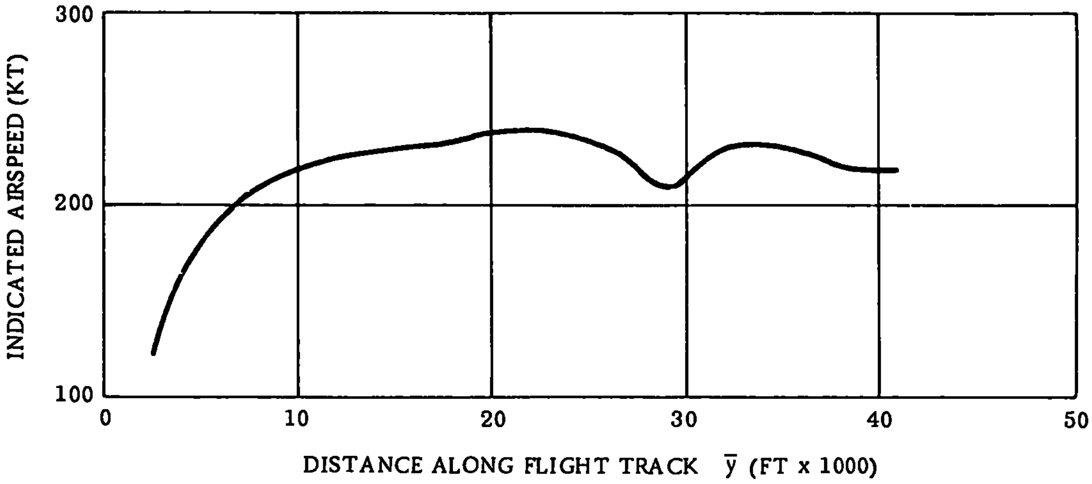
b. Approach Flight Track

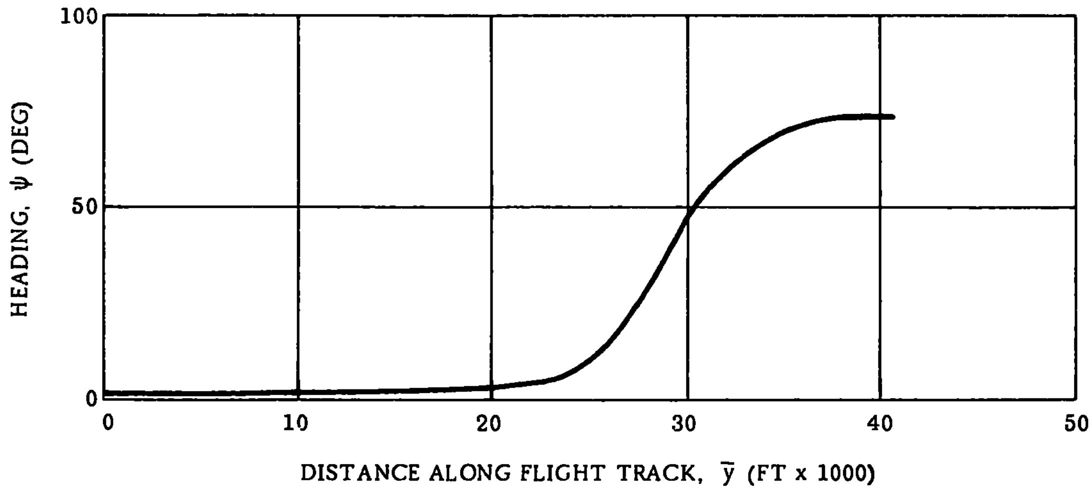
Figure 6. Aircraft Performance – Flight 80, Contd



a. Takeoff

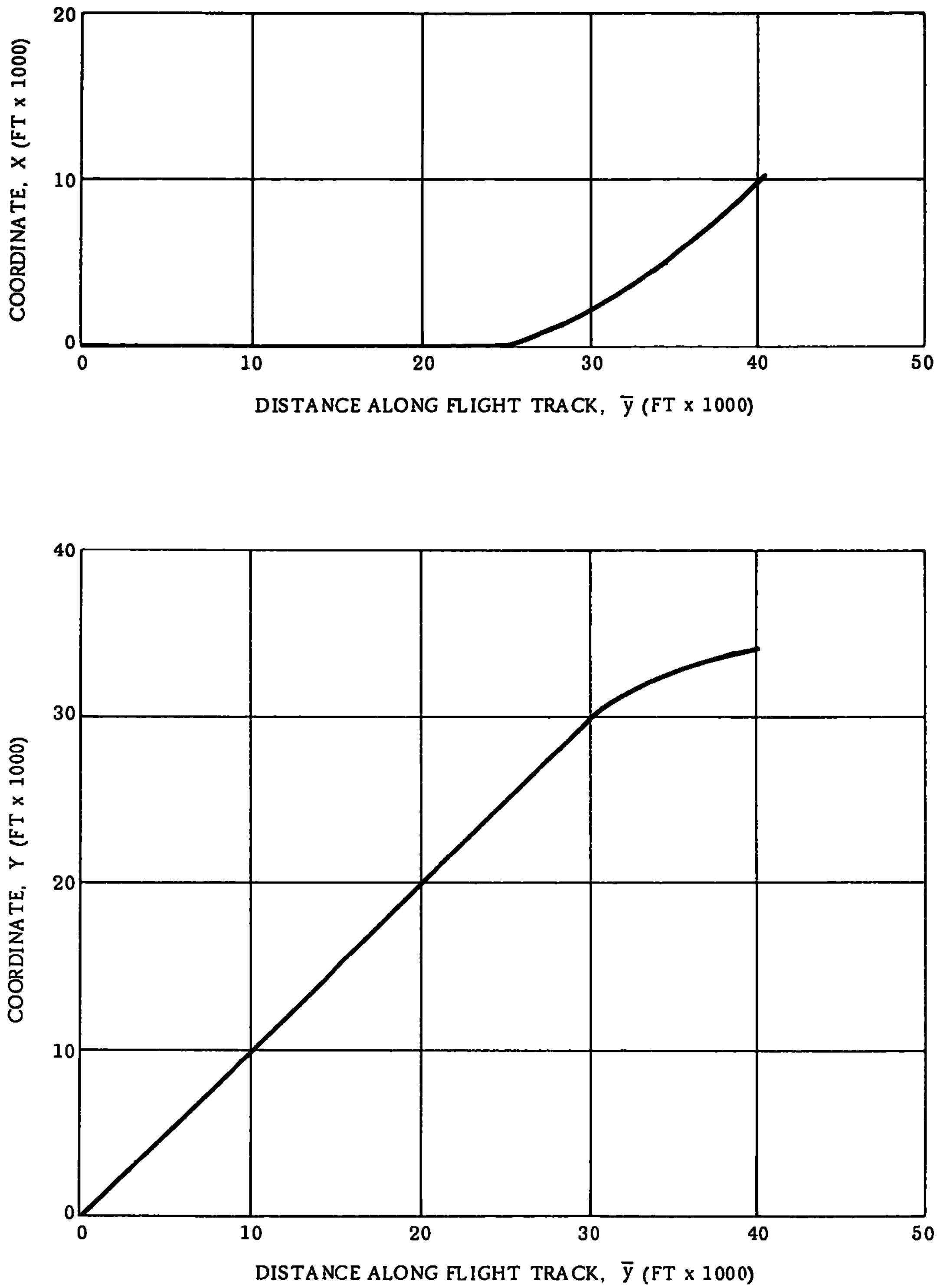
Figure 7. Aircraft Performance – Flight 81





a. Takeoff, Contd

Figure 7. Aircraft Performance – Flight 81, Contd



b. Takeoff Flight Track

Figure 7. Aircraft Performance - Flight 81, Contd

given in Table 8. During takeoff, a noise abatement procedure was used. This consisted of power throttling only since no spades (Table 1) were used. The throttling occurred as shown in Figure 7. Thus, during takeoff the power settings change, hence the noise over any one site can be significantly different. Likewise, the location of some sites resulted in elevation angles below 10 degrees. This introduces additional ground absorption effects.

Table 8. Concorde Takeoff Noise Measurement Geometry – Flight 81

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
MICROPHONE STATION								$\bar{z}$	SR	$\bar{\alpha}$
		COORDINATES						⑦ x COS ⑧	[⑤^2 + ⑨^2]$^{1/2}$	TAN^{-1} ⑨ / ⑤
SOURCE	NO.	x (KFT)	y (KFT)	$\bar{x}$ (KFT)	$\bar{y}$ (KFT)	z (KFT)	α (DEG)	(KFT)	(KFT)	(DEG)
EPA HCI	8	0.88	32.24	-2.5	30.7	1.78	-3.0	1.78	3.91	35 5
	9	-0.38	38.46	-8.0	32.7	1.56	-6.5	1.55	8.15	11 0
	10*	-6.88	38.96	-12.6	30.0	1.83	0	1.83	12.73	8 3
	11*	1.00	48.36	-16.3	37.5	1.38	-0.2	1.38	16.36	4 8
	12	9.14	39.00	-4.7	31.9	1.65	-5 9	1 64	4.98	19 2
	13*	11.56	24.88	9.4	38.4	1.39	0 4	1 39	9 50	8 4
	14**	9.88	14.66	9.9	14.7	0.55	5 5	0 55	9 92	3 2
	16	0	22.60	0	22 6	1.35	6 1	1.34	1 34	90 0
EPA ONAC	1	0	26.28	-0.3	26.1	1.61	3.3	1.61	1.64	79.4
	2	6.34	27.08	5.0	32 0	1.64	-6.0	1 63	5 26	18 1
	3	1.85	19.68	1.8	19.7	1.05	4.5	1 05	2 08	30.3
	4**	4.75	16.25	4 8	16.3	0.77	6 2	0 77	4 86	9 1
	5	-3.96	22.80	4.0	22.8	1 35	6.0	1 34	4 22	18 5
	6	-3.70	27.34	-4.2	26.1	1 61	3.3	1.61	4.50	21 0
EDF	3**	-2.10	10.00	-2.1	10 0	0 15	3.1	0.15	2 11	4.1
	4	0	21.50	0	21 5	1.22	5.5	1 21	1 21	90.0
FAA	3**	-2.10	10.00	-2.1	10.0	0.15	3.1	0.15	2 11	4 1

* $\bar{\alpha} < 10°$

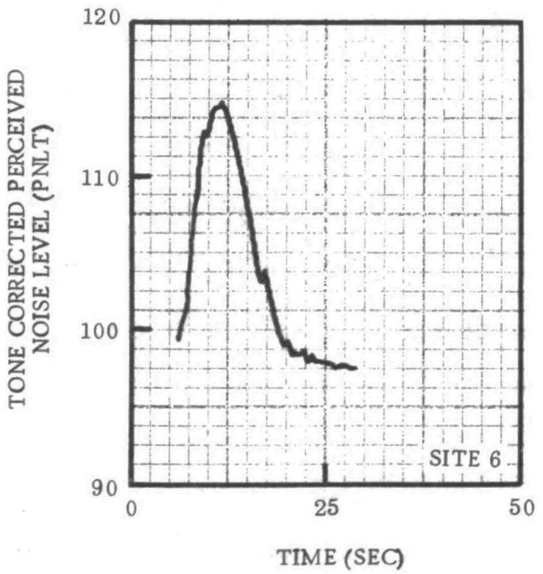
** A/B $\bar{\alpha} < 10°$

DATA ANALYSIS

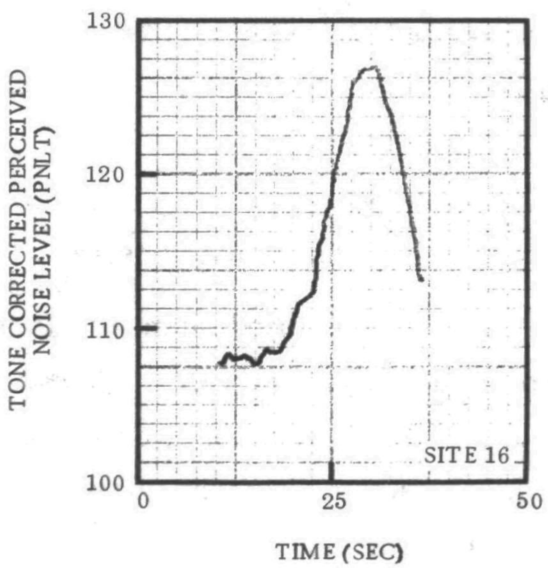
All magnetic tape data obtained at Dallas-Ft Worth and that recorded by HCI and EDF at Dulles were processed to yield a variety of noise measures. Processing was performed by HCI at its San Diego Division using equipment meeting FAR 36 requirements. The EPA-ONAC data taken at Dulles was not recorded on magnetic tape.

The procedure used was to read into the computer the half-second spectra acquired during data processing and compute the various measures. The A, B, C, and D weighted levels and the PNL are the maximum values obtained, not necessarily associated with the time of PNLTM. The results are given in Table 9. Those values marked with an asterisk are ambient noise limited in the high frequencies.

In addition, a typical plot of the PNLT time histories for an approach and takeoff are given in Figure 8 for the Dulles data. The spectra corresponding to the time of PNLTM are given in Figures 9 and 10.



a. Approach



b. Takeoff

Figure 8. PNLT Time History

In order to obtain an understanding of the potential community noise generated by supersonic aircraft, it is necessary to generate a curve of noise versus distance and then a curve illustrating aircraft flight profile. These types of data, especially that of noise versus distance are best obtained during engineering tests where aircraft performance, and other test parameters, are accurately measured and where it is possible to perform a repeated series of tests. The minimum number of tests provided for certification as per FAR Part 36 are six data points at any one measurement location and the engineering values must be within ±1.5 dB with a confidence of 90 percent. It was not possible to conduct the measurements of the Concorde 02 aircraft according to the requirements of FAR Part 36 or Annex 16. However, the data obtained at Dallas-Ft. Worth and Dulles can be used to obtain a qualitative idea of community impact.

The method used was to plot the data points both in terms of EPNL and A-level as a function of slant range at the closest point of approach (CPA). Next, the data points were tagged to denote any significant factors that would affect acoustical performance. These factors included engine power condition and viewing angle. The resultant curves are shown in Figures 11 and 12 for the takeoff and Figures 13 and 14 for the approach. A theoretical noise level versus slant range curve based on extrapolations of spectra measured at Dulles and reported in Reference 4 is superimposed on each figure. See Appendix A for details. The starting point for the curve is a point representing the levels of Concorde noise for the particular airplane shown relative to the FAR 36 measurement conditions. These values were determined as shown in Table 10.

Due to the limited quantity of data it is necessary to assign an error envelope to Figures 12 through 15. The value of ±5 dB was based on several factors. First, it is known from Reference 2 that a -1.5 dB difference is due to nozzle area difference between the prototype and production aircraft. Next, the fact that full utilization of noise abatement was not made can lead to further reductions in noise at greater slant ranges. The absence of the spades will account for another negative correction.

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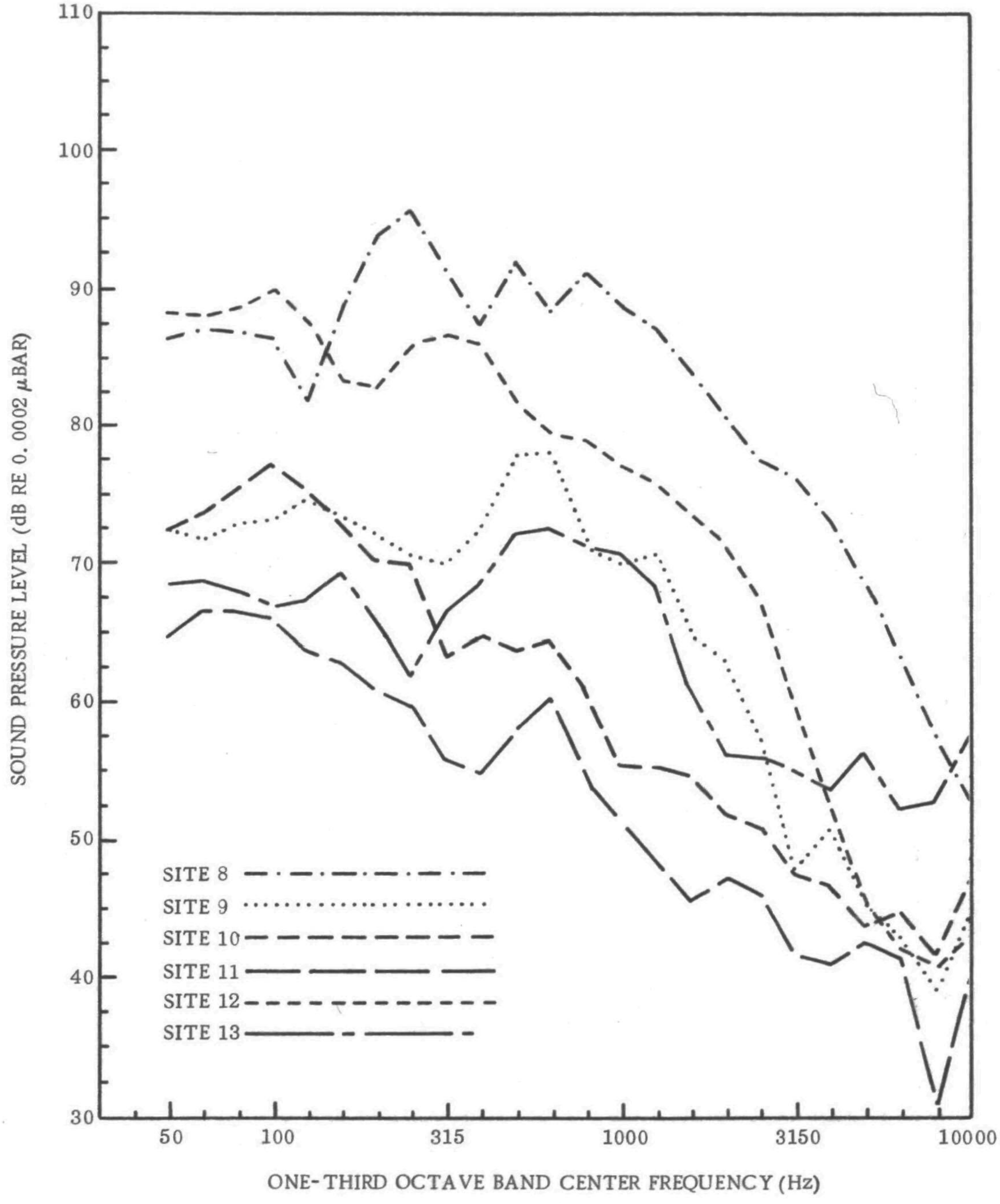

Figure 9. Takeoff Spectrum

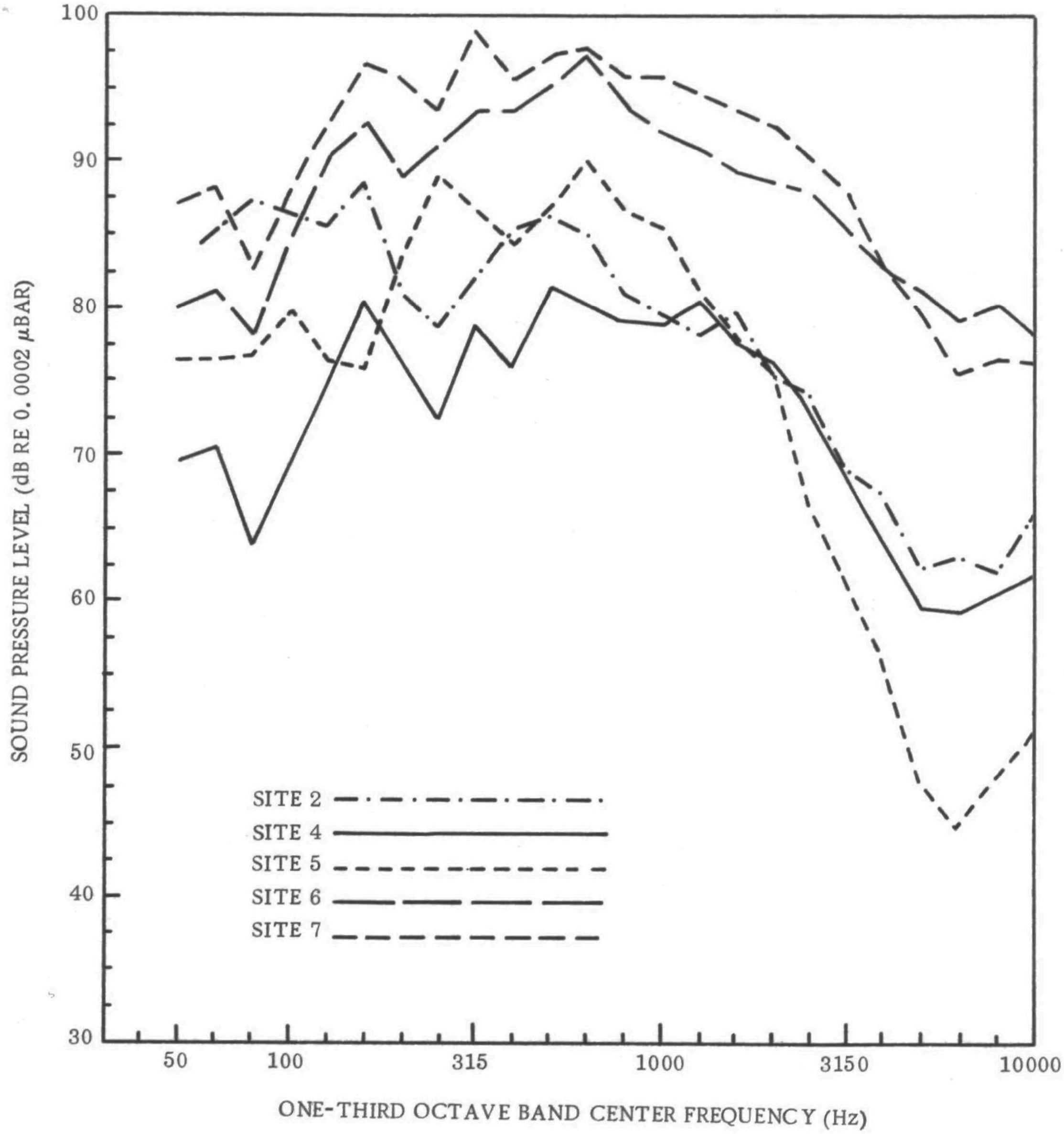

Figure 10. Approach Spectrum

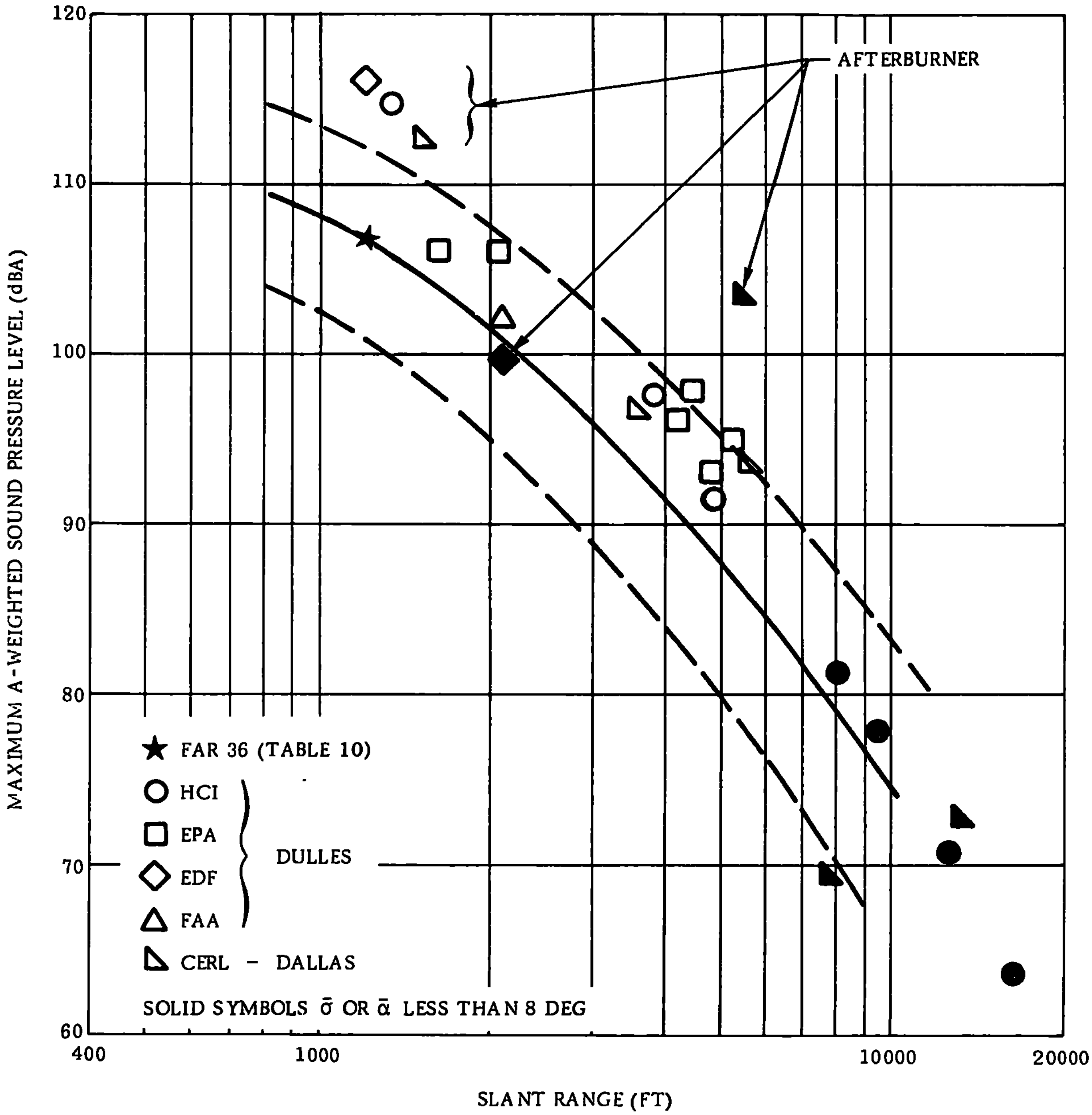

Figure 11. A-Level Versus Slant Range Takeoff

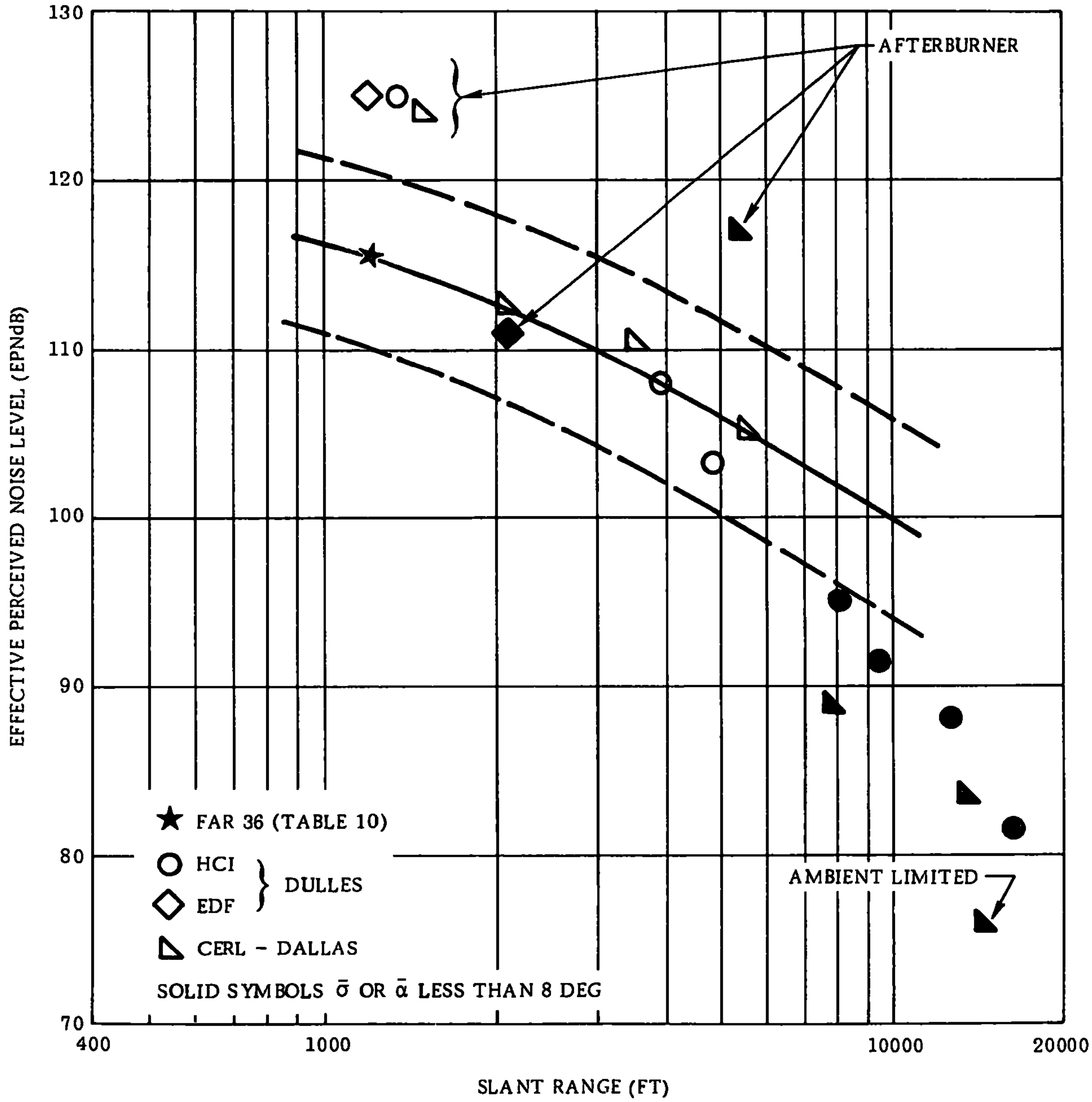

Figure 12. EPNL Versus Slant Range Takeoff

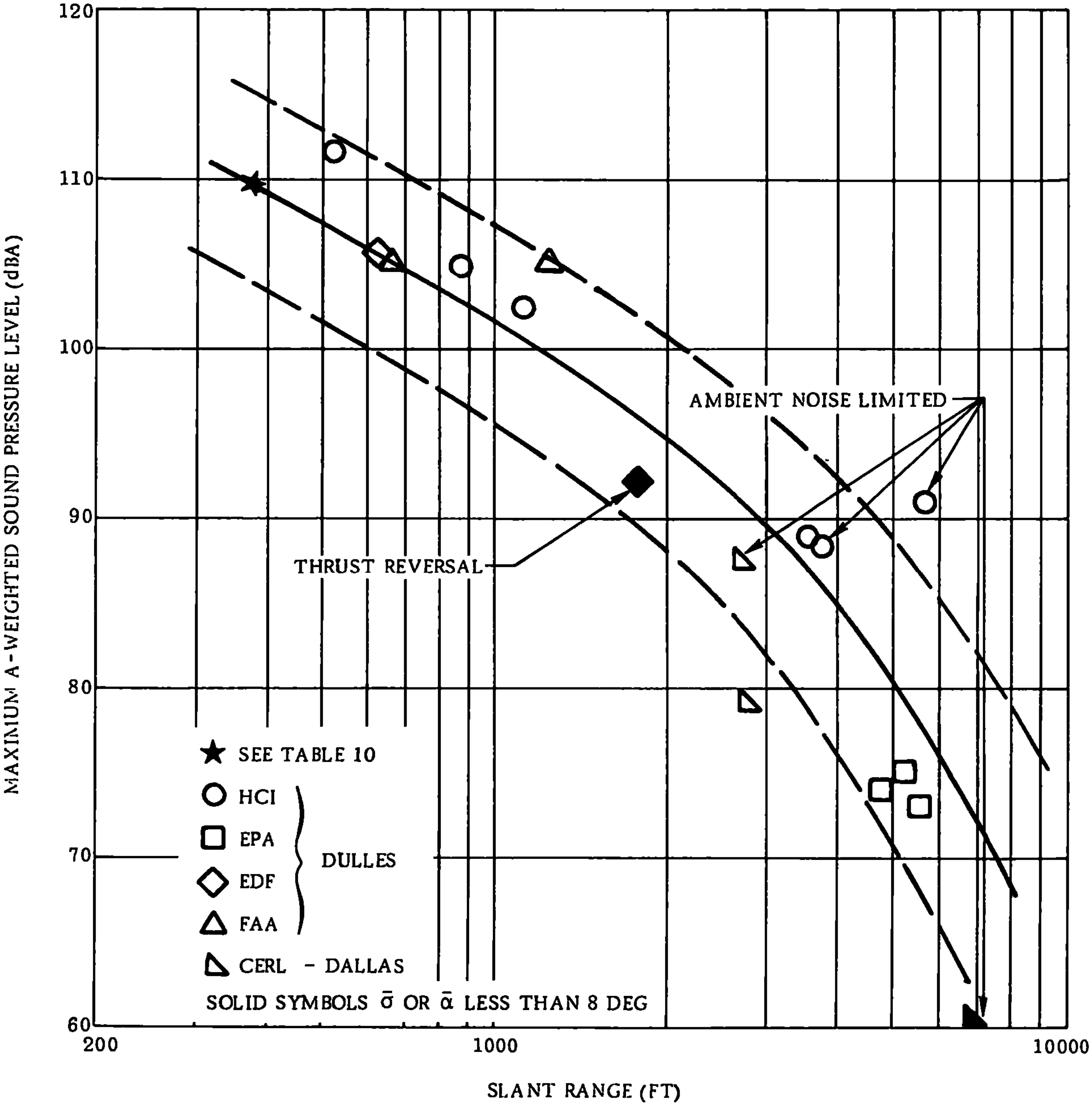

Figure 13. A-Level Versus Slant Range Approach

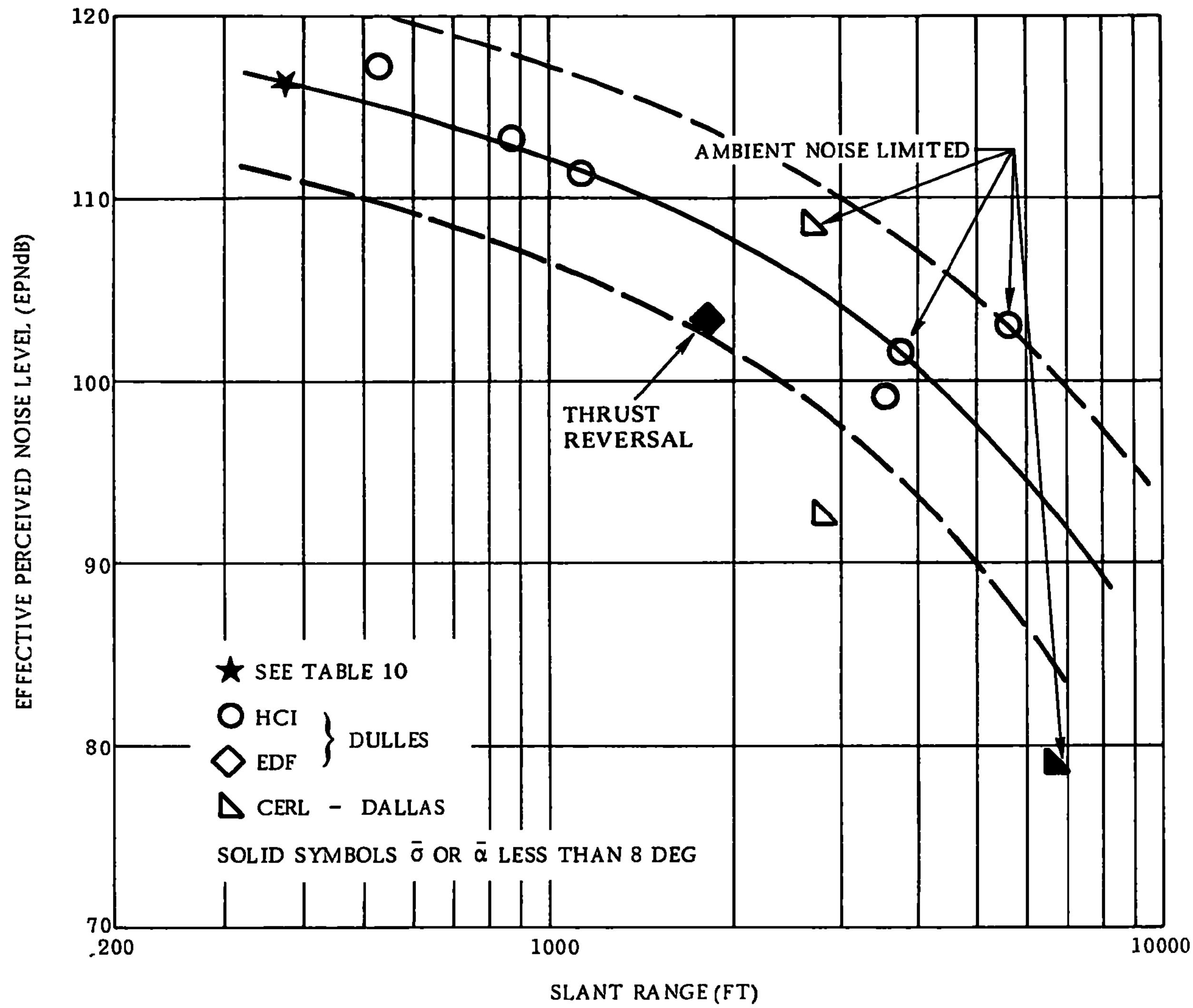

Figure 14. EPNL Versus Slant Range Approach

Table 10. Concorde 02 Noise Levels Measured Under FAR 36 Conditions

FAR 36 MEASUREMENTS†					ASSUMPTION	
	DISTANCE					
STATION	(N.M.)	(FT)	LEVEL (EPNdB)	HT (FT)	CORR (dB)	LEVEL (dBA)
SIDELINE	0.35	2,130	114.2	-	-11.0	103.2
TAKEOFF*	3.50	21,300	115.4	1200	-9 0	106.4
APPROACH	1.00	6,080	114.5**	370	-6.5	108.0**

* THRUST CUTBACK TO 4-DEG CLIMB ANGLE.

** ADD 1.5 DB TO DULLES OPERATIONS BECAUSE NOZZLE AREA WAS SMALLER THAN SCHEDULED FOR PRODUCTION.

†CONDUCTED BY CONCORDE DEVELOPERS.

Data supplied in Reference 4 shows at the most a data spread of ±2 dB for PNL and a data spread of ±1.5 dB for duration correction. This yields an immediate variability of ±3.5 dB. It is reasonable to expect that an additional ±1.5 dB exists within the data measured.

Such a variation of data makes the calculation of noise contours at this point extremely risky. However, some comparisons can be made with other aircraft at specific points on the ground. Using measured noise and flight profile data from Reference 5 and that of Figures 12 and 15 of this report, the EPNL at points 3, 5, and 7 miles from brake release for the Concorde, 707, 727, and DC-9 are compared in Table 11. The T5 profile of Reference 5 is for a maximum gross weight takeoff, as were the Concorde measured data.

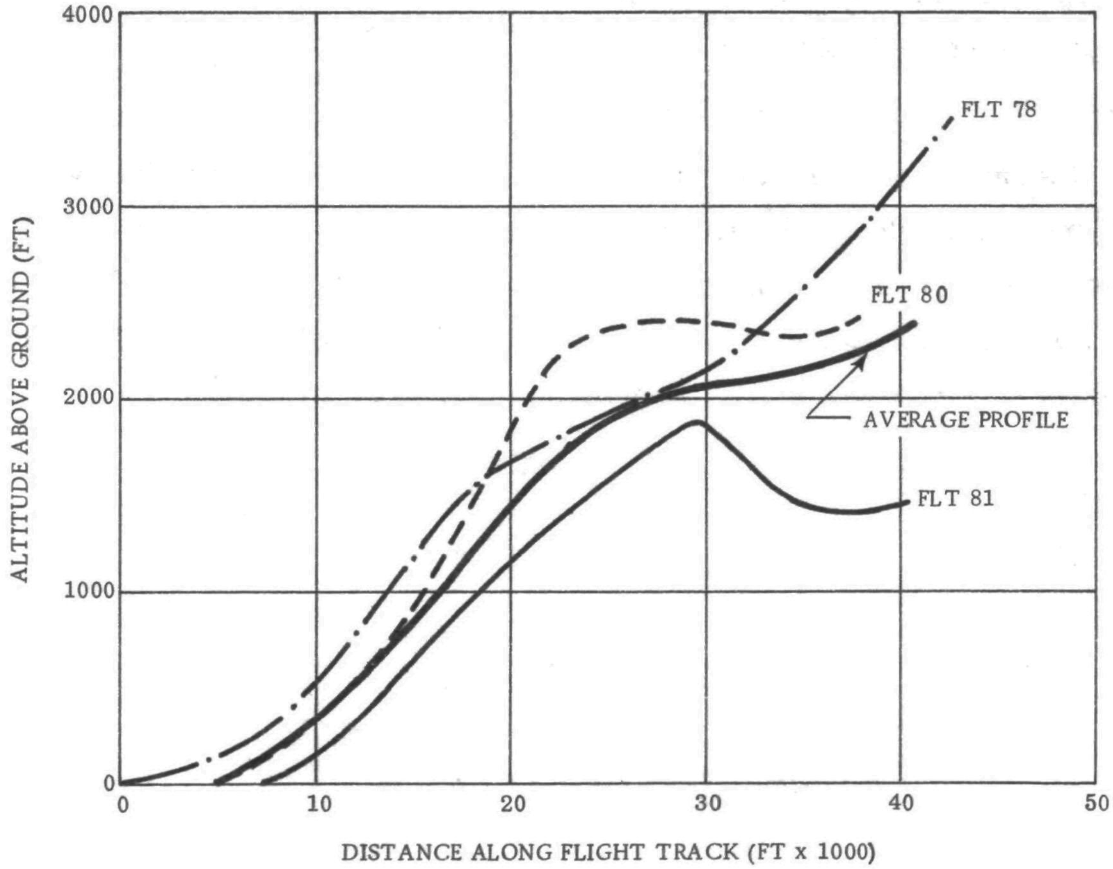

Figure 15. Average Takeoff Profile - Concorde 02

Table 11. Takeoff Noise Comparison (Estimated Values)

PROFILE	AIRCRAFT	3 N. MI. ALT	3 N. MI. EPNL	5 N. MI. ALT	5 N. MI. EPNL	7 N. MI. ALT	7 N. MI. EPNL
FIGURE 15	CONCORDE	1200	125*	2100	112	2500	111.5
T5	707-320B	800	113	1200	108	2200	98. 0
T5	727	950	108	1800	102	3200	96. 0
T5	DC-9	1400	105	2900	96	4300	92 0

*Afterburner (115.4 EPNdB without afterburner)

For the approach case there are actual data recorded immediately before and after the Concorde 02 approach at Dulles. The results are compared in Table 12 at locations 2.6 - 3.6 n.mi. from threshold.

Table 12. Approach Noise Comparison (Measured EPNL Values)

AIRCRAFT	SITE 7 2.6 N. MI.	SITE 6 3 6 N MI
707	111. 8	107 0
707	118. 5	110. 5
CONCORDE	113.2	111.4
707	113 1	106. 0
727	110. 2	101. 8

It should be noted that it is assumed that all aircraft are following the 3-degree glide slope. Based on the data given in Tables 11 and 12, it appears that the approach noise of the Concorde is somewhat higher than that for present day commercial aircraft. The takeoff noise is, for locations close to an airport, considerably higher than present aircraft.

SUMMARY

The numerous data points measured at Dallas-Ft. Worth and Dulles International Airports and plotted as a function of level versus distance show a scatter sometimes exceeding ±5 EPNdB. This scatter is the result of noise measurements made under non-controlled test and operating conditions. During these operations it was not always possible for the pilot to execute the scheduled noise abatement procedure.

Direct comparisons of Concorde and 707 approach noise were possible at Dulles. These few measurements indicate the Concorde noise levels relative to the 707 levels to be less, in general, at 2.6 n.mi. and greater at 3.6 n.mi. from threshold.

All of the measurements have been presented in terms of a variety of noise evaluation measures. When computing correction factors from these data the reader is cautioned to refer to the operating conditions of the aircraft to avoid misinterpretation.

In conclusion, it would appear that when measured data are compared with the theoretical curves there is no reason to believe that the noise levels (Table 11), measured under FAR 36 or Annex 16 conditions, claimed by the Concorde developers will not be achievable.

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1. Janes, "All the World's Aircraft," 1972.
2. Acoustic Memo 131, Acoustics Office, British Aircraft Corporation, Ltd., Weybridge Surry, England, 11 October 1973.
3. W. C. Sperry, Information Brief on Concorde Noise and Flight Data, Environmental Protection Agency, 15 January 1974.
4. Data presented at Concorde Noise Working Session, attended by representatives of France, United Kingdom, and United States, 23-24 October 1973.
5. Carole S. Tanner, "Measurement and Analysis of Noise from Four Aircraft During Approach and Departure Operations (727, KC-135, 707-320B, and DC-9), FAA-RD-71-84, September 1971.
6. "Standard Values of Absorption as a Function of Temperature and Humidity for Use in Evaluating Aircraft Flyover Noise," Society of Automotive Engineers, ARP 866, April 1970 (proposed).

APPENDIX A

The method used to derive the theoretical curves of EPNL and A-level versus slant range which are displayed in Figures 11 through 14 are herein described.

The basic starting point for arriving at the theoretical curves consisted of using the measured data obtained during the tests at Dulles. The spectrum at PNLT maximum was chosen for selected measurements sites and that data extrapolated to various ranges. The extrapolation consisted of the inverse square law correction and atmospheric absorption correction for a standard day temperature and relative humidity as per SAE 866 (Reference 6) The perceived noise level and A-level for each extrapolated spectrum was then computed.

Assuming that the tone corrections for every site would decrease and since the measured tone corrections were on the order of 1.0 dB no tone corrections were made on the extrapolated data.

A duration correction was calculated for the difference in distance using the equation:

$$\Delta D_{extrapolated} = -10 \log_{10} \frac{(SR_{actual})}{(SR_{extrapolated})}$$

The extrapolated EPNL was computed using the following equation:

$$EPNL_{extrap} = EPNL_{actual} + PNL_{extrap} - PNL_{actual} + \Delta D$$

Separate plots of A-level and EPNL versus slant range were made for the takeoff and approach operations. See Figures A-1 through A-4. These plots show a lack of data points at the closer slant ranges. This is especially true for the takeoff operations.

In order to provide additional data points to define the curve shape, spectra contained in Reference 4 were extracted and subjected to the same computations. These points are also depicted in Figures A-1 through A-4.

The next step was to fit a least squares curve through the data points. The resultant curve adjusted to pass through the FAR Part 36 noise level at each operational condition is that shown in Figures 11 through 14, respectively. These curves were developed on a semi-empirical basis; that is, measured data extrapolated by standard prediction techniques. Therefore, they should be more accurate than the theoretical curves shown in Reference 3 which did not have the benefit of test results in their development.

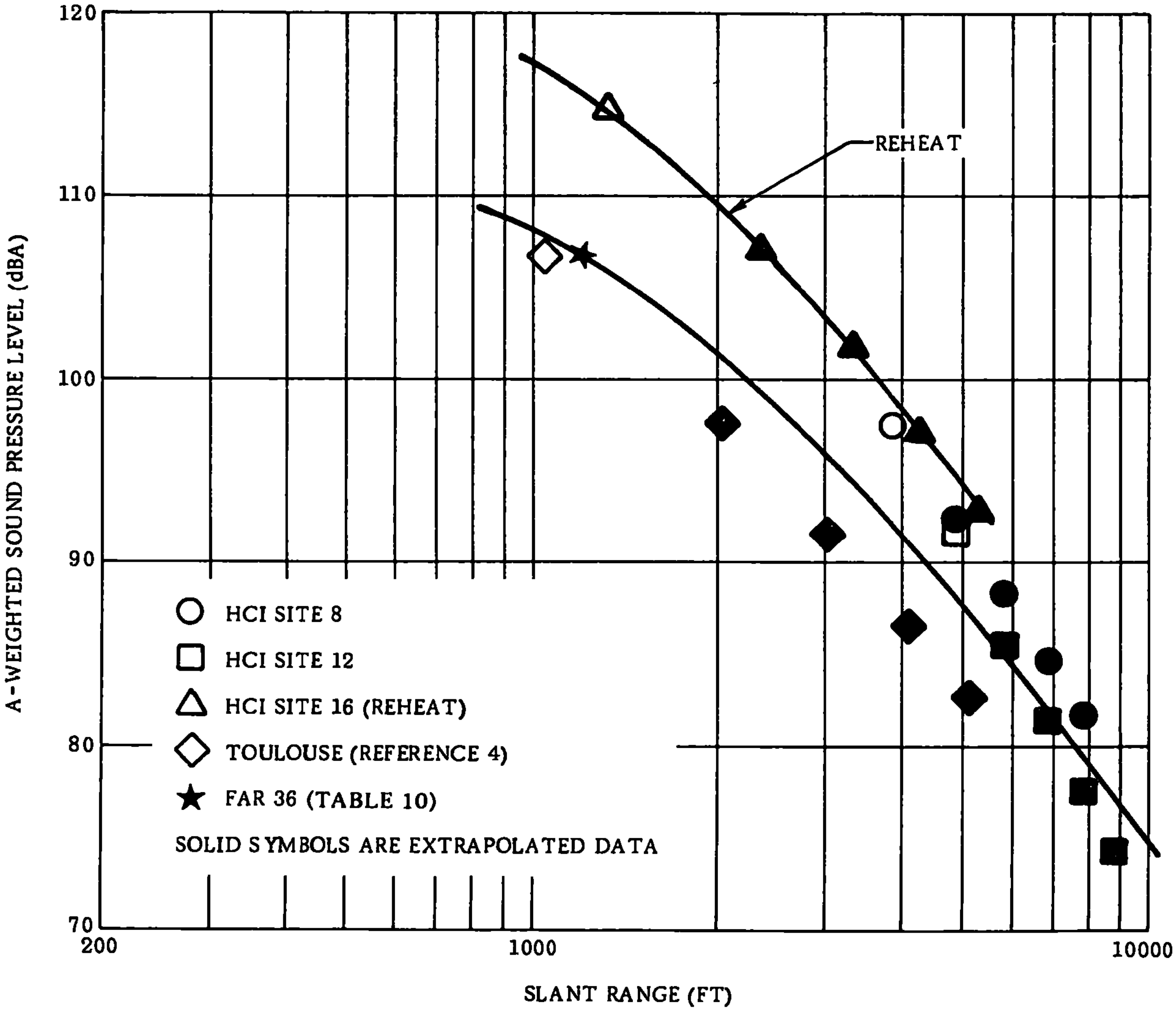

Figure A-1. A-Level Extrapolations for Takeoff

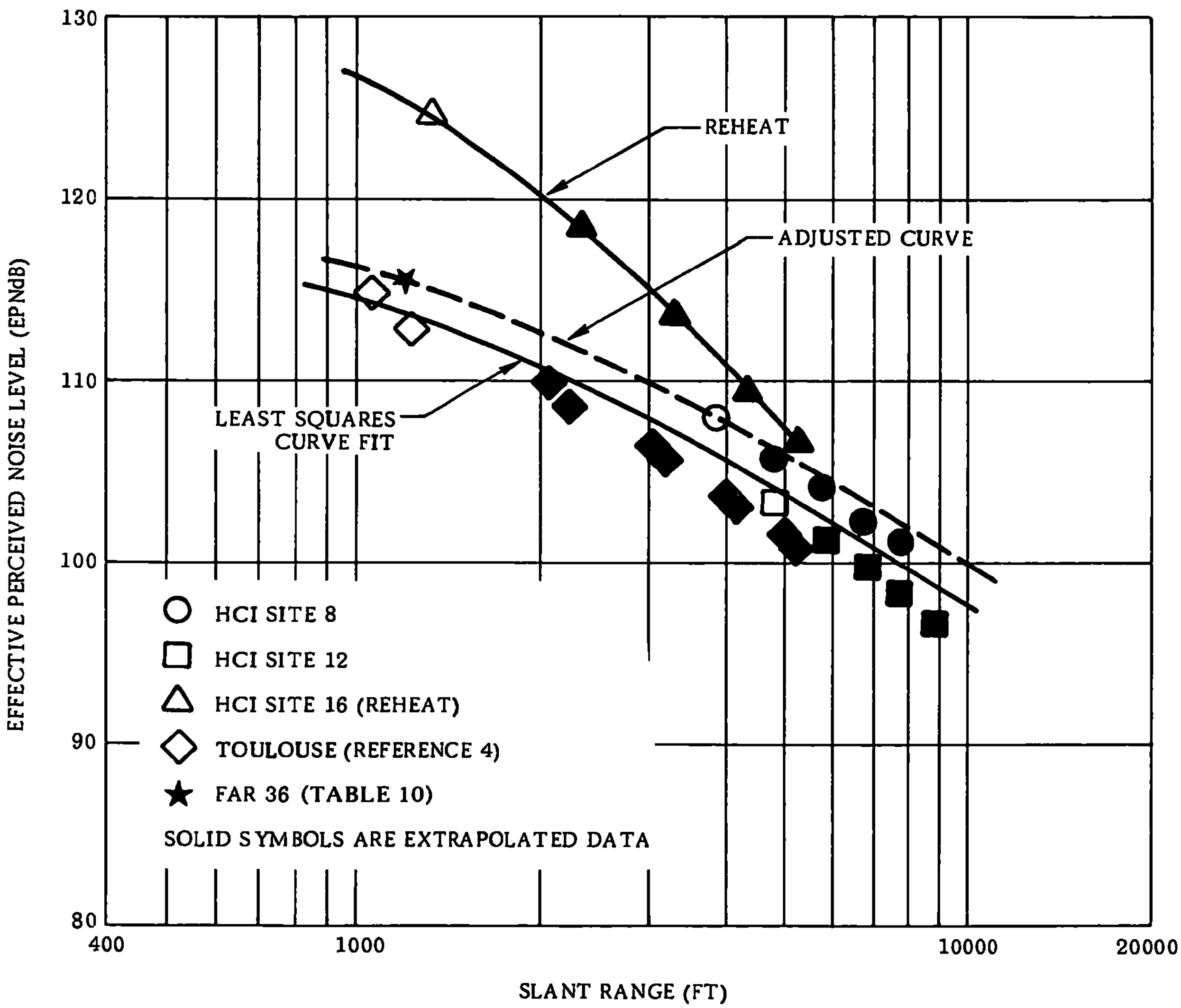

Figure A-2. EPNL Extrapolations for Takeoff

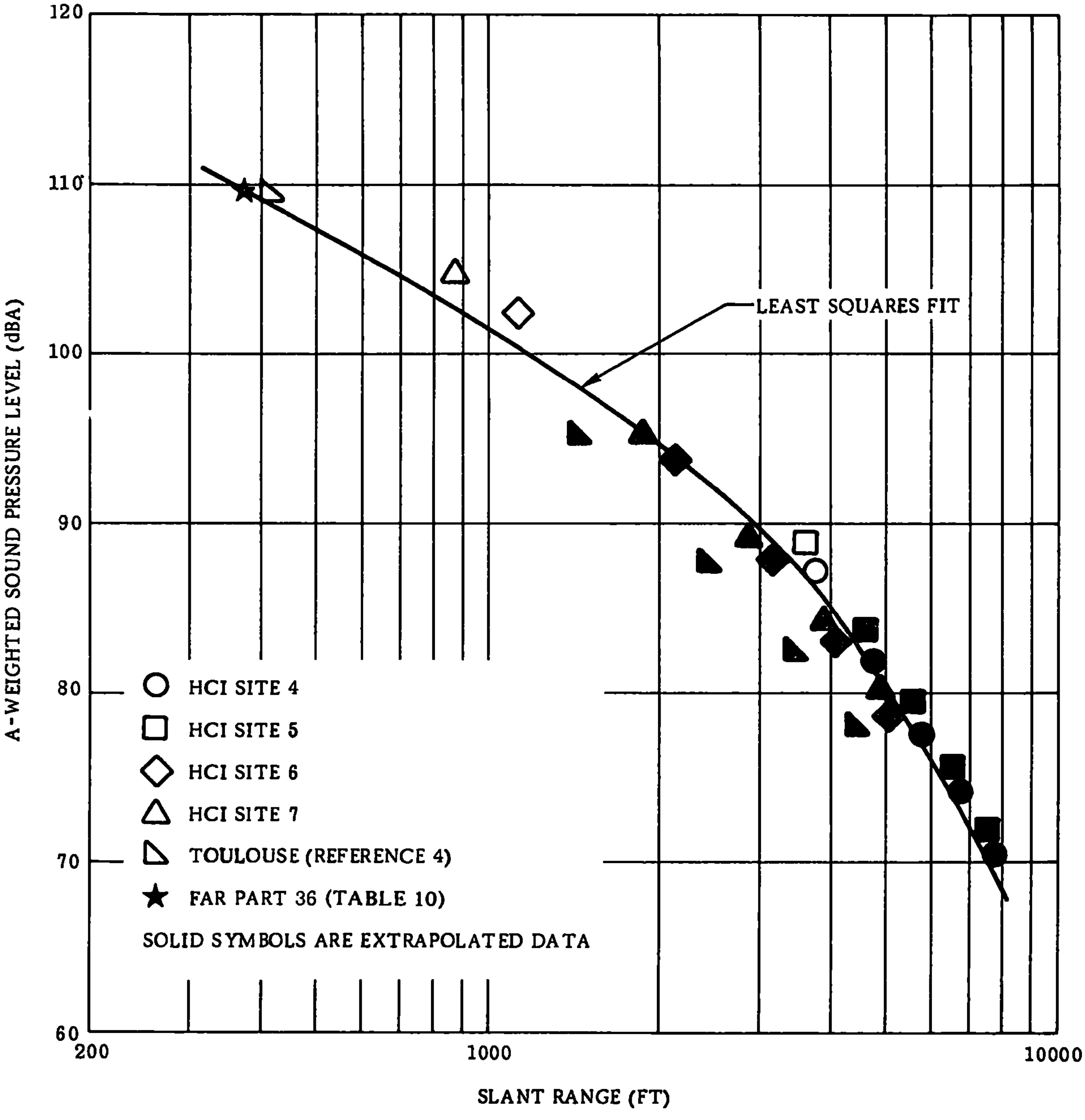

Figure A-3. A-Level Extrapolations for Approach

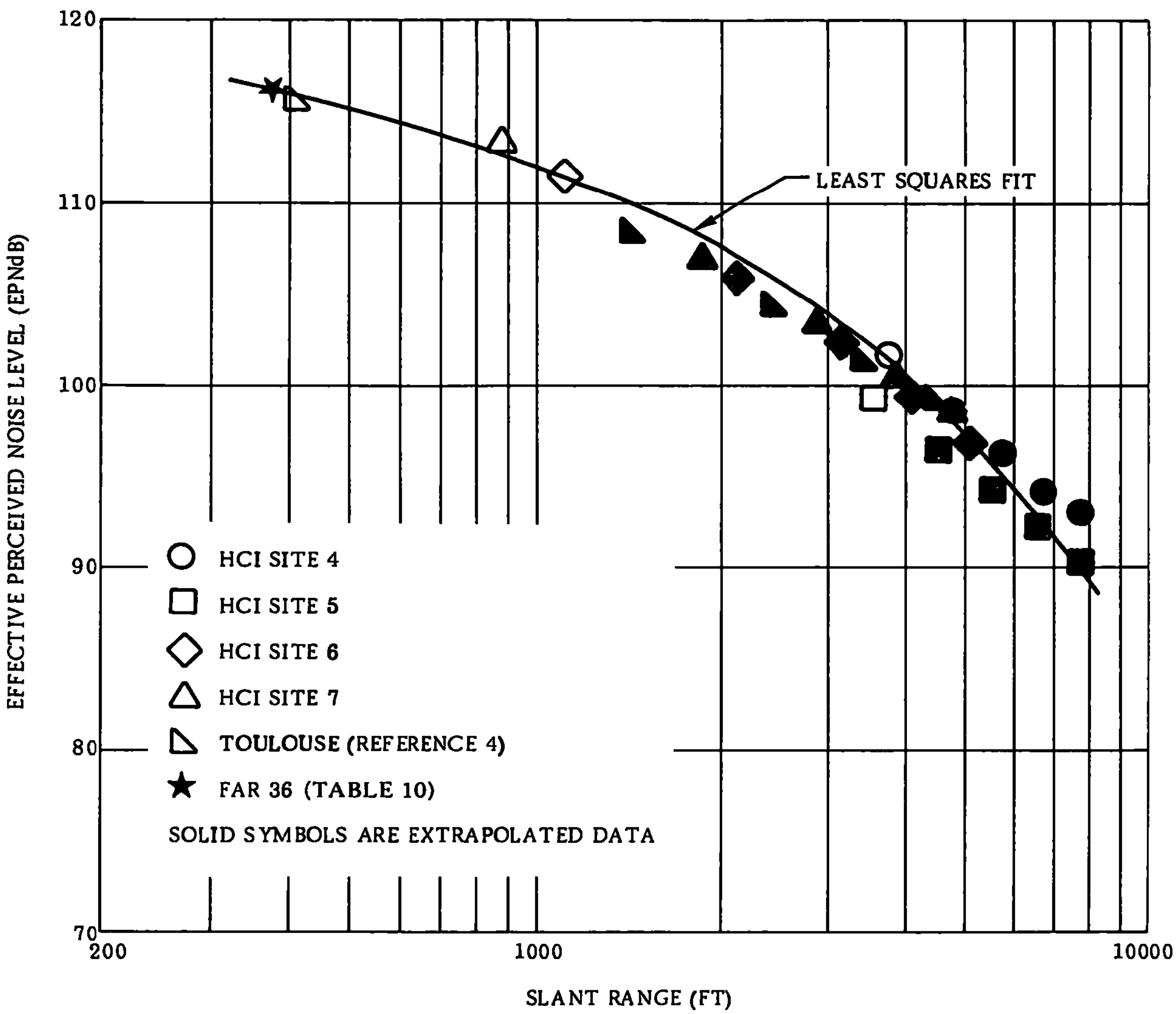

Figure A-4. EPNL Extrapolations for Approach

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7. Author(s) Carole S. Tanner			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Hydrospace-Challenger, Inc. 1360 Rosecrans Street San Diego, California 92106			10. Project/Task/Work Unit No. 11. Contract/Grant No. 68-01-1599
12. Sponsoring Organization Name and Address Environmental Protection Agency Office of Noise Abatement and Control (ONAC) Crystal Mall #2, 1921 Jefferson Davis Highway Arlington, Virginia 20460			13. Type of Report & Period Covered Final Report 14.

15. Supplementary Notes

16. Abstracts Noise measurements were made of the Concorde 02 aircraft during operations at Dallas-Ft. Worth and Dulles International Airports in September 1973. Data were acquired at 25 sites surrounding Dallas and 15 sites surrounding Dulles. The results are reported in terms of various noise evaluation measures (A-level, Effective Perceived Noise Level, etc.) and correlated with respect to distance and aircraft/engine operating parameters. Included are representative one-third octave band spectra for takeoff and approach operations at Dulles.

A prediction procedure is presented based upon data measured at various distances extrapolated to larger distances by standard methods. The results of the semi-empirical predictions indicate that there is no reason to believe that the noise levels measured and reported by the Concorde developers cannot be achieved with the use of noise abatement procedures. However, noise abatement takeoff procedures were not fully utilized at Dulles and, as a result, the measured noise levels exceed the values claimed by the developers.

17. Key Words and Document Analysis. 17a. Descriptors

Aircraft noise
Aircraft Performance
Approach Noise
Community Noise
Concorde
Dallas-Fort Worth Airport
Dulles International Airport
Noise Measurement
Noise Measures
Supersonic Transport
Takeoff Noise

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

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