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NOISE MEASUREMENTS TAKEN AT LAX DURING OPERATIONAL EVALUATION OF TWO-SEGMENT APPROACHES IN A 727-200 AIRCRAFT

By Carole S. Tanner and Ray E. Glass

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NOISE MEASUREMENTS TAKEN AT LAX DURING OPERATIONAL EVALUATION OF TWO-SEGMENT APPROACHES IN A 727-200 AIRCRAFT

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Hydrospace-Challenger, Inc.

SUMMARY

A series of seven noise measurements were made each day over a period of fifteen days. The first and last flights each day were made by a specially instrumented 727-200 aircraft being used to evaluate the operational effectiveness of two-segment noise abatement approaches in scheduled service. Noise measurements were made to determine the noise reduction benefits of the two-segment approaches.

INTRODUCTION

This report presents the results of acoustic measurements made on 727-200 aircraft in revenue service. There were a total of seven flights recorded each day. The first and last measurement flights each day utilized a United Airlines aircraft equipped with a special-purpose glide slope computer to provide the capability of making two-segment noise abatement approaches. For upper segment computations, the computer used barometric-corrected pressure altitude and the slant range to a DME transmitter which was co-located with the glide slope transmitter. The computer used the ILS glide slope deviation for lower segment computations.

Additional measurements were taken each day on three PSA revenue flights and two other United Airlines revenue flights. The PSA revenue flights performed visual two-segment approaches whenever possible. The two United Airline flights always utilized ILS approaches. These latter were intended as baseline data.

The purpose of the acoustical portion of the test was to measure and identify the noise levels associated with automated and visual two-segment approaches and to compare approaches. A total of six measurement sites were utilized. These were located on or near the extended runway centerline from 1 to 7 nautical miles from runway threshold.

The acoustic tests were conducted from 15 to 29 June 1973 on runway 25L at Los Angeles International Airport.

APPARATUS AND METHODS

Aircraft and Test Profiles

The United aircraft were Boeing 727-222 with three Pratt & Whitney JT8D-7 turbofan engines. The specially instrumented United Airlines aircraft flew a two-segment six-degree/690-foot intercept profile as shown in Figure 1. The PSA aircraft were Boeing 727-214 with three Pratt & Whitney JT8D-9 turbofan engines. The PSA aircraft flew a visual two-segment approach when weather permitted. Figure 2 shows a typical high two-segment approach and Figure 3 shows a typical low two-segment approach. The conventional United Airlines aircraft flew standard ILS approaches. Figure 4 shows a typical ILS approach profile.

The specially equipped United Airlines aircraft was instrumented to record on-board a number of flight parameters. These data were time synchronized to both the radar and acoustic data using IRIG B time code.

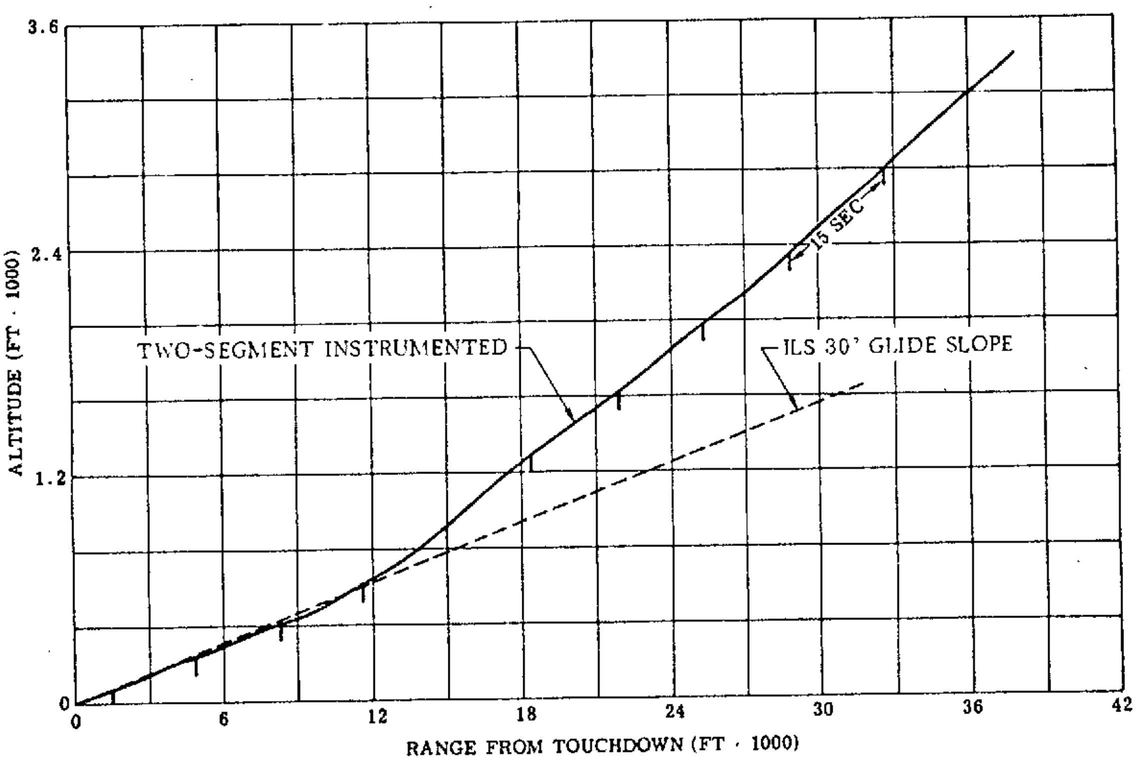


Figure 1. Two-Segment Instrumented Aircraft, 6 Deg/690 Ft

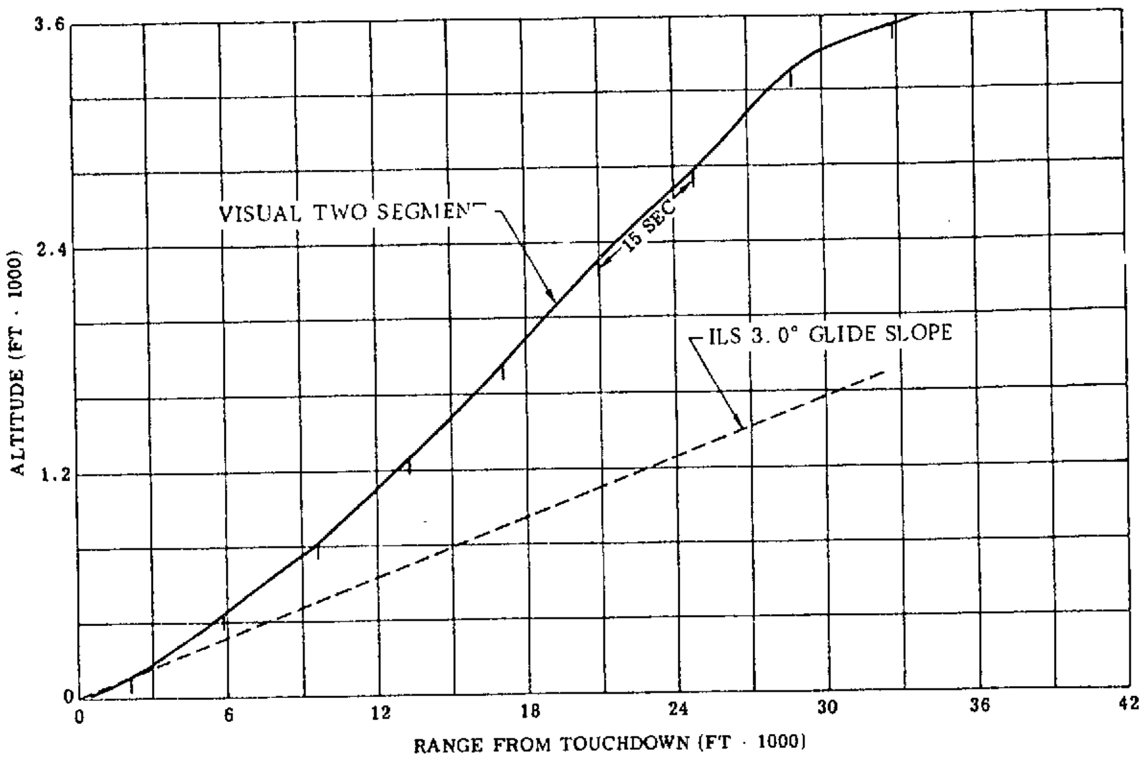


Figure 2. Visual Two-Segment High Profile

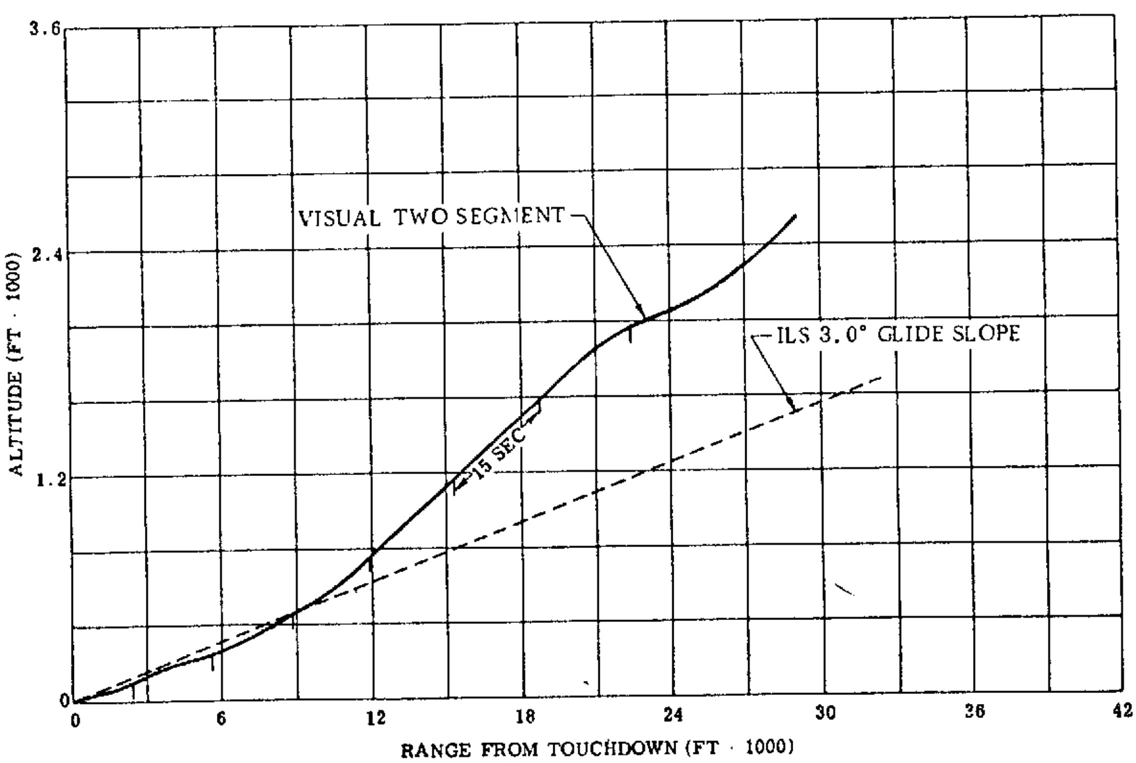


Figure 3. Visual Two-Segment Low Profile

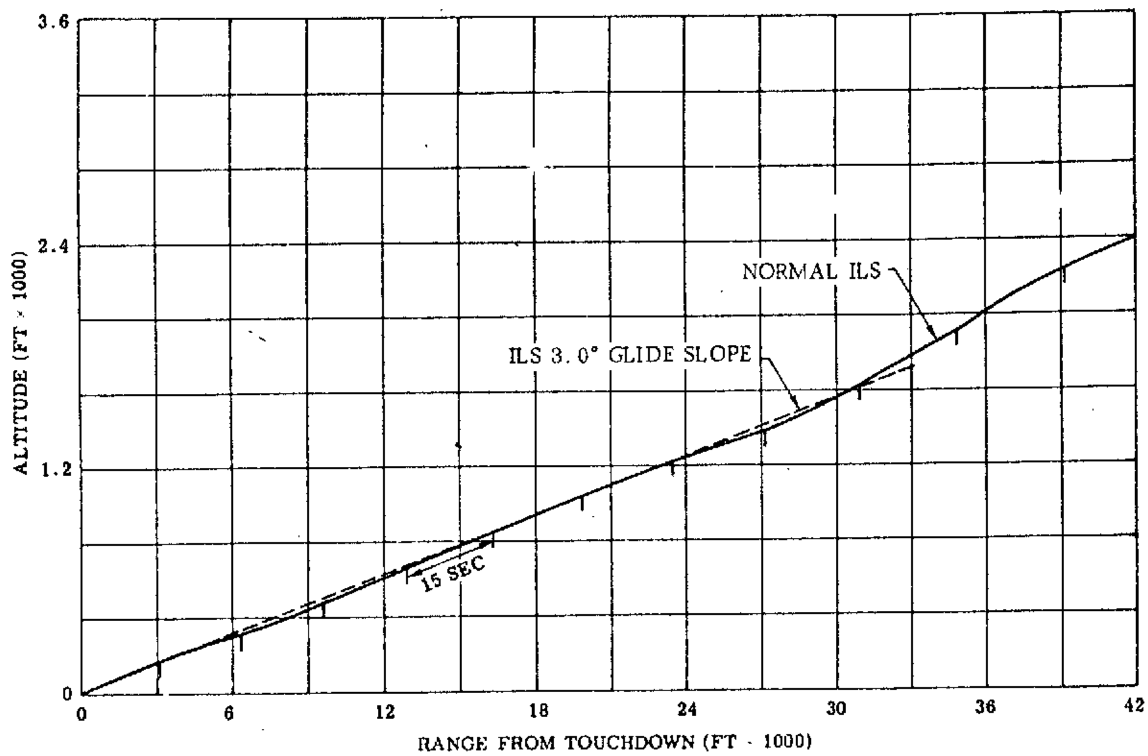


Figure 4. Normal ILS

Acoustic Measurements

Acoustic data were acquired using battery-operated remote-controlled, portable acquisition systems. Figure 5 presents a block diagram of the systems. The typical system utilizes a two-channel analog tape recorder. One channel records acoustic data and the other channel records an IRIG B time signal. The time is broadcast over a radio link at 162.275 MHz (megahertz). The time signal is a 1-kHz (kilohertz) modulated carrier. The received time signal serves two functions: 1) it provides a common recorded time base for all systems and 2) the 1-kHz carrier operates a tape motion controller built by Hydrospace-Challenger, Inc. (HCI).

Each system was calibrated over a frequency range of 40 to 12 000 Hz using an electrical signal. Figure 6 is a typical total system frequency response. The high frequency pre-emphasis is removed during processing but provides a better signal for analog recording since it compensates for high-frequency sound attenuation due to the atmosphere.

The recording systems were checked for tape quantity as well as acoustically calibrated every morning.

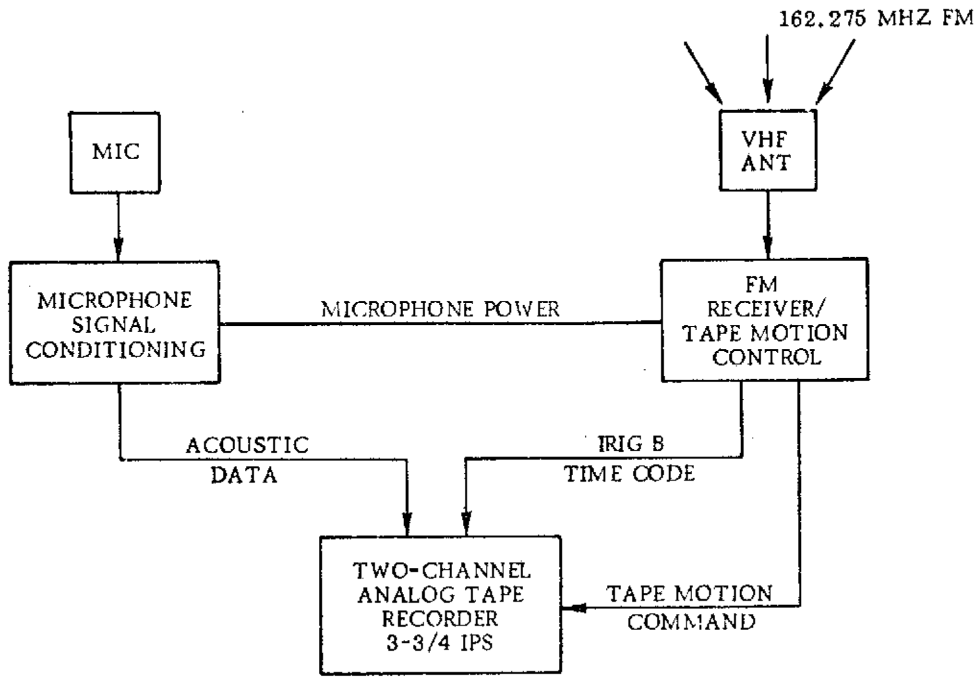


Figure 5. Acoustic Data Acquisition System

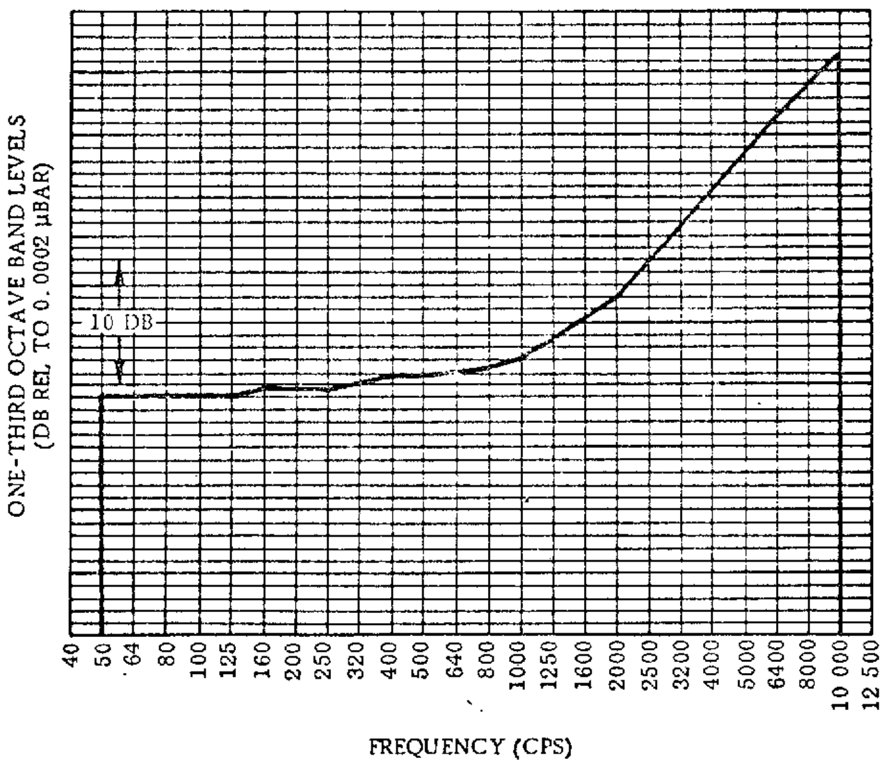


Figure 6. Typical System Response

The radio receiver was always operated using normal 115-volt 60-Hz power. The 1-kHz signal from the IRIG B time code controlled power to the microphone system and tape recorder. The warm-up time was less than 10 seconds. All systems were activated when the aircraft was 8 to 10 nautical miles from runway threshold and deactivated 0.5 mile after touchdown.

Acoustic measurements were made at six locations on or near the extended runway centerline. Table I presents the positioning of the sites used during the exercise. All distances along the extended centerline are referenced to the runway threshold. The sites were located using an orthographic map obtained from the U.S. Geological Survey. The site locations were measurable to an accuracy of ±150 feet. Figures 7 through 12 show the measurement microphone and antenna arrangements at each of the six sites; Sites 1, 2, 3, 4, 5, 7, respectively. Figure 13 shows the noise measurement site locations and major topographical features.

Table I. Noise Measurement Site Locations

Site	Distance From Runway Threshold (ft)
1	6 822
2	10 557
3	16 760
4	21 500
5	27 735
7	37 685

Meteorological Measurements

Meteorological measurements of temperature, relative humidity, and wind speed and direction were obtained from the National Weather Service at LAX. Their measurement equipment was located between runways 25L and 25 R. The measurements were less than 0.5 mile from the radar van, which also housed the noise acquisition command station. Table II lists the appropriate meteorological parameters.

Aircraft Tracking

Radar tracking was provided by a Bell Aerospace radar unit. The radar provided both an on-line two-dimensional plot and digital three-dimensional data. Acoustic data processing was performed using the three-dimensional data which was reduced to slant range from the measurement site to the aircraft for each measurement site as a function of time.

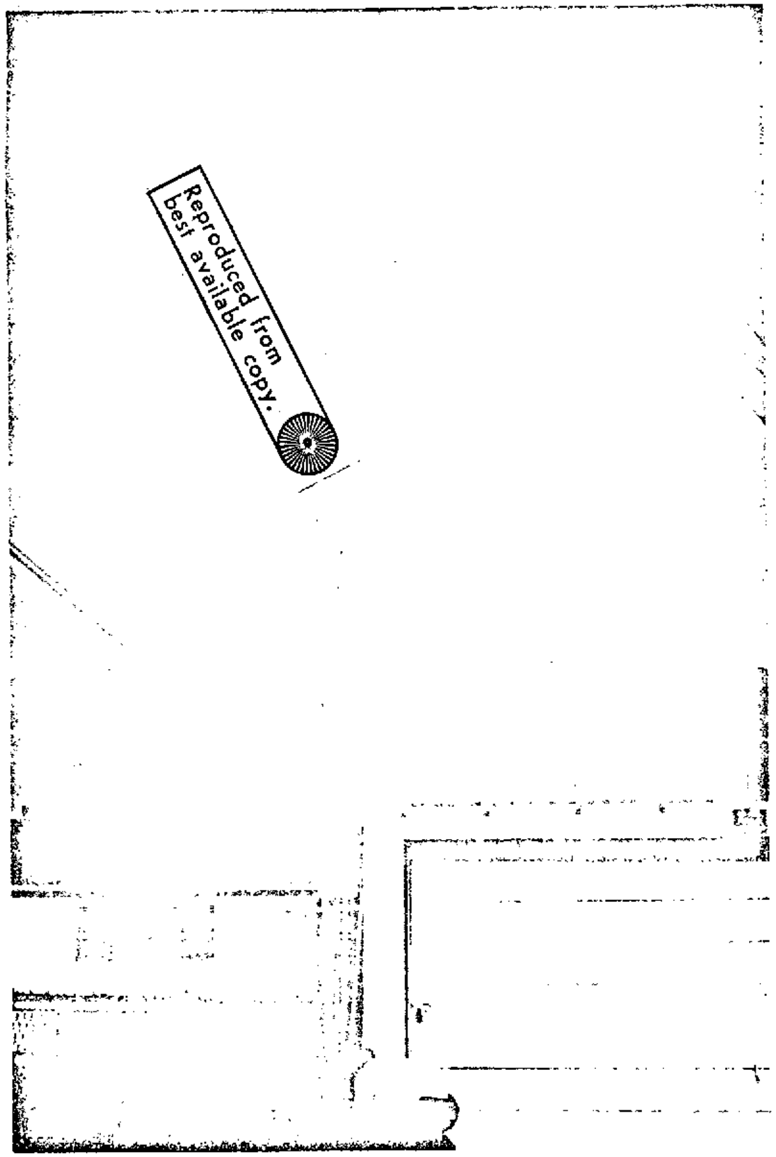


Figure 7. Measurement Site 1

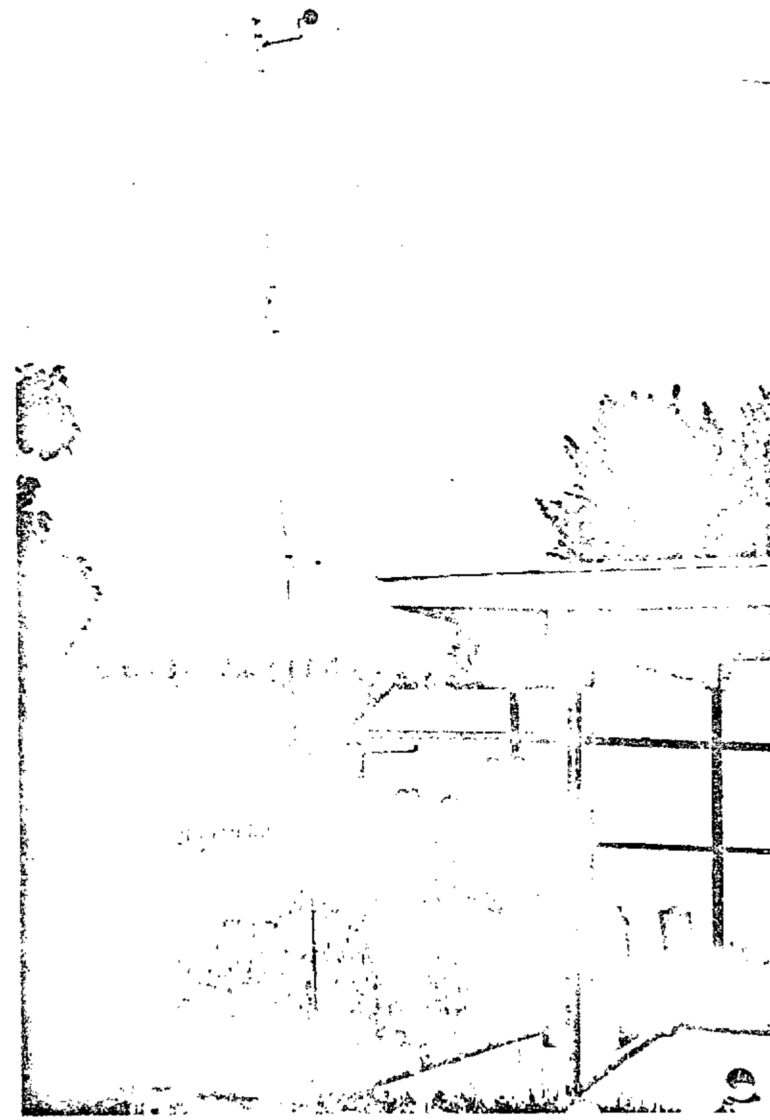


Figure 8. Measurement Site 2

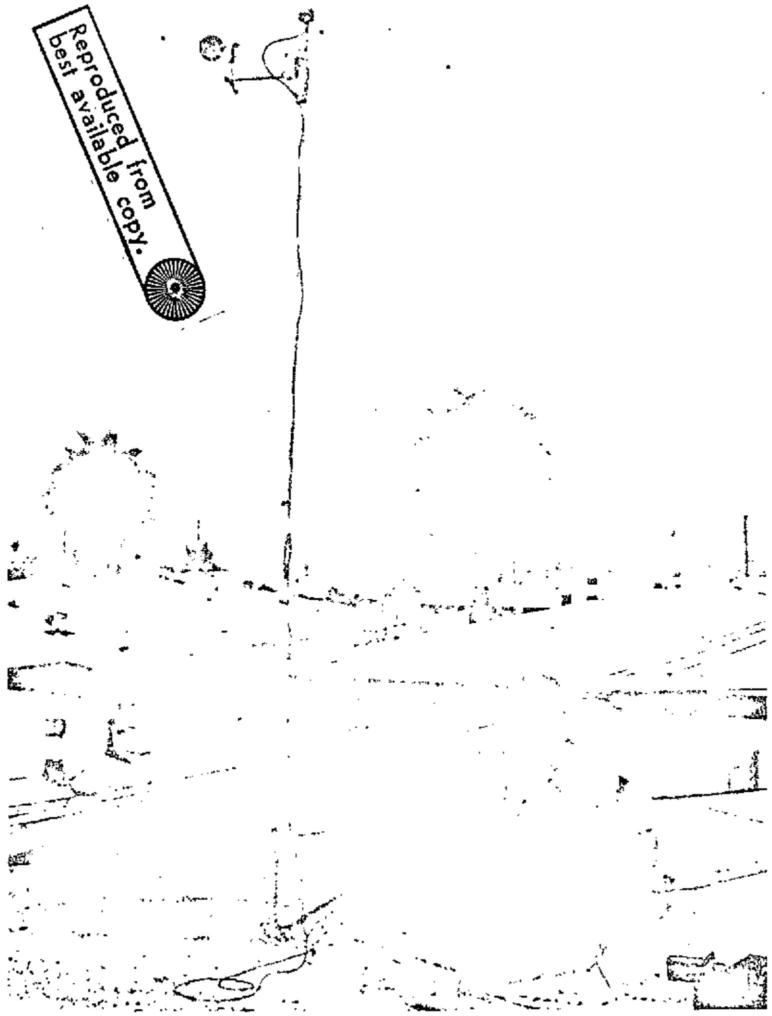


Figure 9. Measurement Site 3

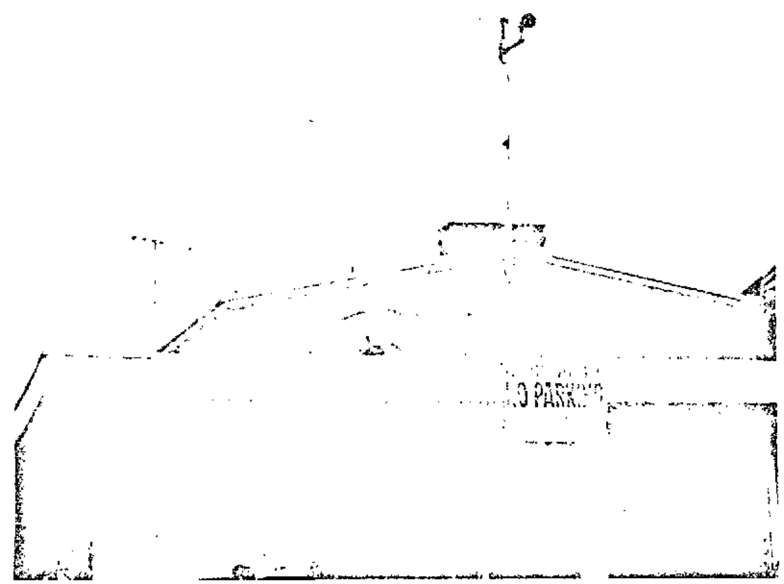
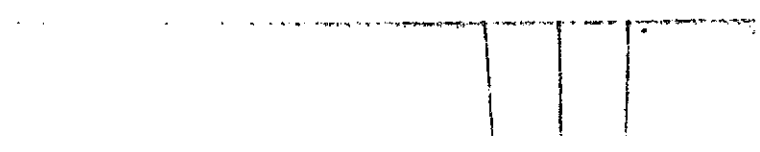


Figure 10. Measurement Site 4



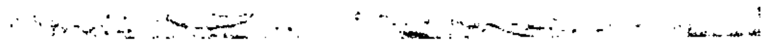


Figure 9. Measurement Site 3

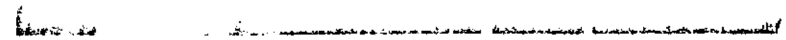


Figure 10. Measurement Site 4

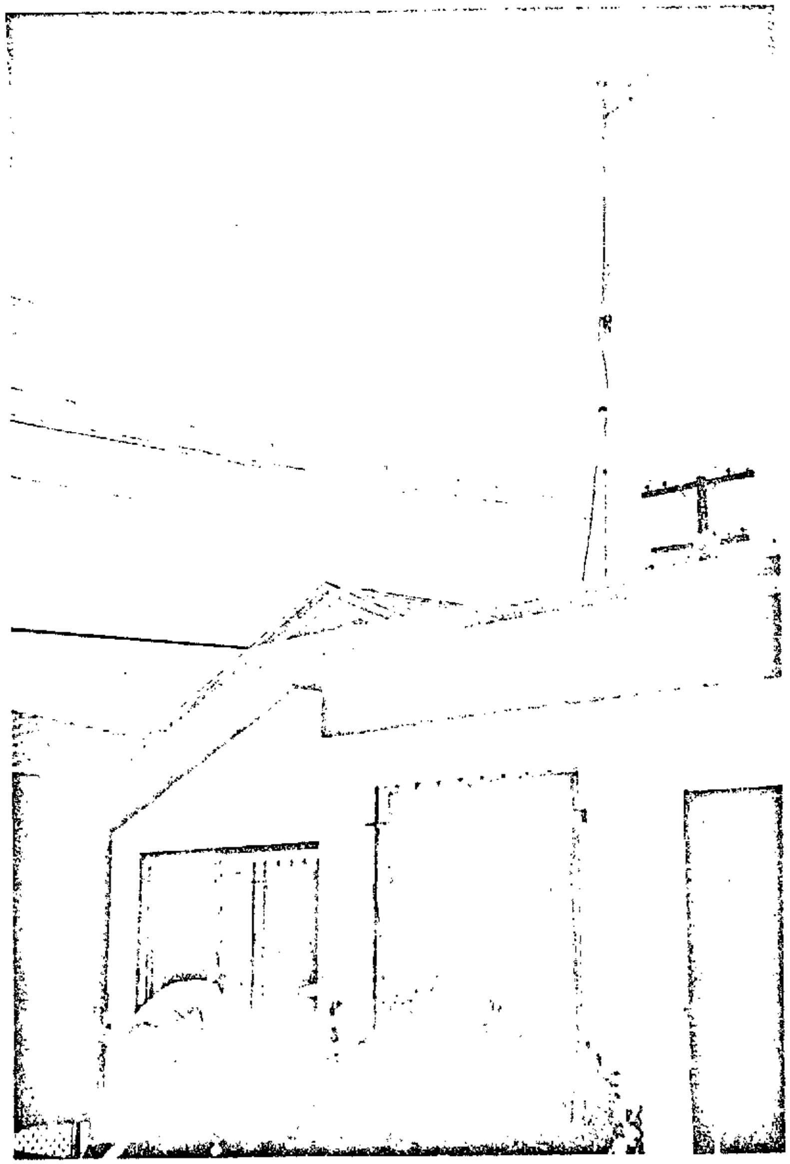


Figure 11. Measurement Site 5

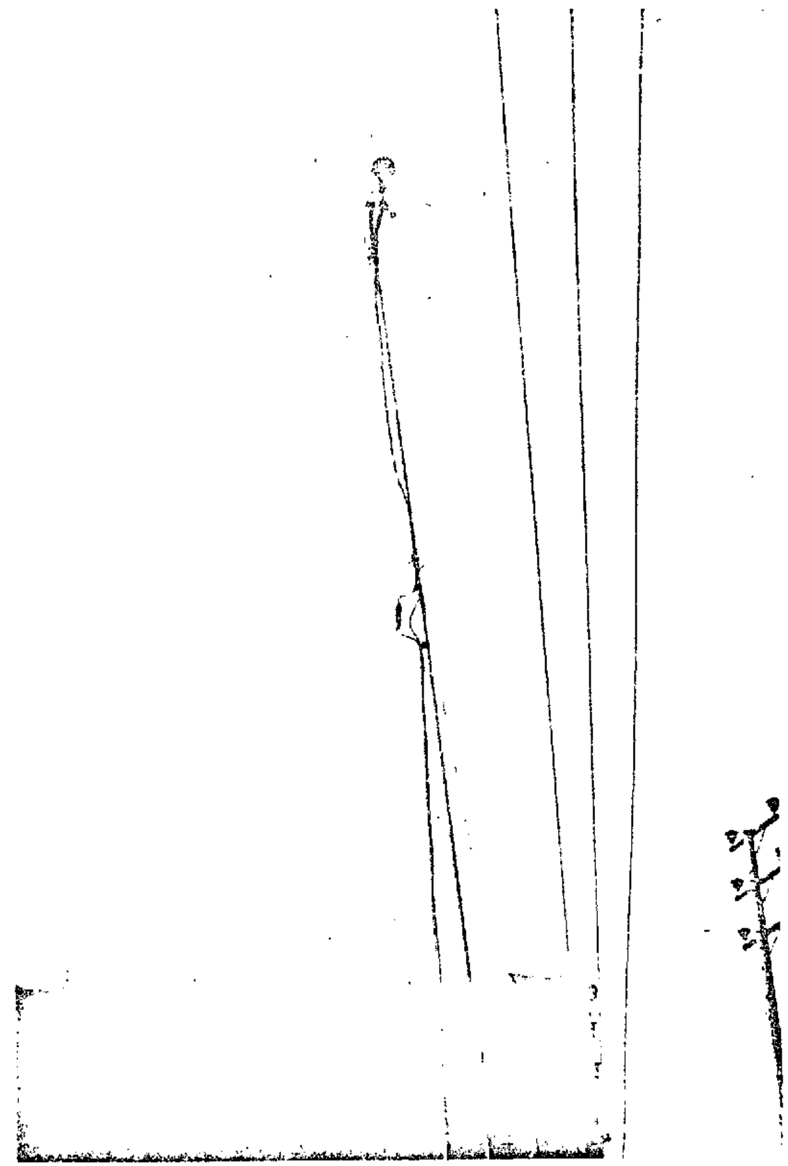


Figure 12. Measurement Site 7

Table II. Weather Summary

Run No.	Flight	Time of Reading	Temp (°F)	Data Point	Relative Humidity (%)	Wind Direction (deg)	Wind Speed (kt)
1502	PSA 181	7:55	66	52	36	230	4
1503	PSA 281	9:55	68	52	31	24[illegible]	[illegible]
1505	PSA 59	11:55	70	53	29	250	11
1601	UA 975	7:35	66	54	44	150	5
1602	PSA 181	7:55	68	55	42	200	5
1605	PSA 59	11:55	70	55	36	230	11
1607	UA 729	14:55	70	56	40	250	13
1701	UA 975	7:18	65	56	56	070	6
1704	UA 289	9:55	70	56	40	240	10
1706	UA 371	12:55	71	56	37	240	11
1707	UA 729	14:55	70	57	44	250	13
1801	UA 975	7:33	68	58	54	100	5
1803	PSA 281	9:55	71	59	48	250	6
1805	PSA 59	11:55	72	60	49	240	13
1806	UA 371	12:55	72	60	49	230	10
1807	UA 729	14:55	73	58	39	240	10
1904	UA 289	9:55	78	62	39	250	7
1905	PSA 59	11:55	83	61	25.5	260	9
1907	UA 729	14:54	78	62	39	270	16
2001	UA 975	7:35	85	56	10	330	4
2102	PSA 181	7:56	87	44	<1	110	5
2104	UA 289	9:55	86	62	23	260	8
2105	PSA 59	11:55	85	57	13	250	11
2106	UA 371	12:55	88	54	03	240	9
2203	PSA 281	9:55	68	58	54	240	8
2204	UA 289	9:55	68	58	54	240	8
2206	UA 371	12:54	72	59	45	250	12
2207	UA 729	14:54	73	58	39	240	13
2301	UA 975	7:56	73	61	50	140	3
2302	PSA 181	7:56	73	61	50	140	3
2303	PSA 281	9:56	73	61	50	240	8
2305	PSA 59	11:55	74	58	36	250	10
2306	UA 371	12:46	73	58	39	240	12
2307	UA 729	14:55	71	56	37	240	17
2401	UA 975	7:55	72	59	45	130	4
2404	UA 289	9:55	74	61	47	240	8
2406	UA 371	12:55	73	62	53	250	9
2407	UA 729	14:55	73	63	57	250	10
2505	PSA 59	11:55	72	62	57	250	6
2602	PSA 181	7:55	64	61	84	240	5
2603	PSA 281	9:55	69	62	67	140	6
2604	PSA 289	9:55	69	62	67	140	6
2606	UA 371	12:56	74	62	50	240	10
2702	PSA 181	7:55	67	61	71	210	5
2703	PSA 281	9:55	71	61	56	250	6
2706	UA 371	12:55	71	60	52	250	11
2801	UA 975	7:54	63	59	79	240	7
2802	PSA 181	8:54	63	59	79	240	7
2805	PSA 59	11:55	69	62	67	150	5
2806	UA 371	12:55	67	61	71	140	4
2901	UA 975	7:32	63	59	79	240	6
2902	PSA 181	7:55	63	58	79	250	5
2904	UA 289	9:55	67	61	71	240	6
2906	UA 371	12:55	74	61	47	240	8
2907	UA 729	14:55	71	56	37	240	6

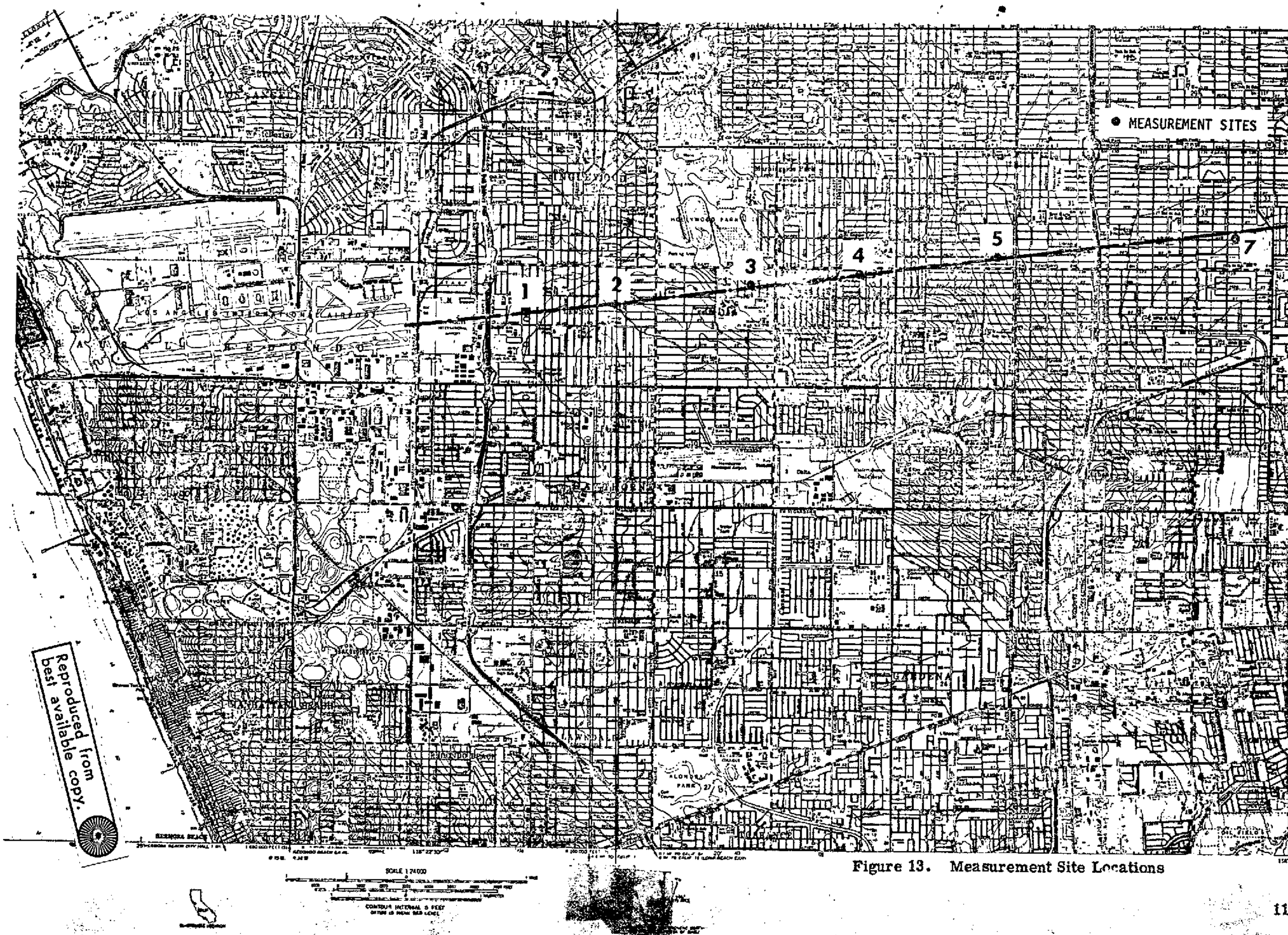


Figure 13. Measurement Site Locations

Acoustic Data Processing

The acoustic data were processed at HCI's San Diego Operations. The processing equipment and the computer program used conform to the requirements of FAR Part 36. The acoustic data were adjusted for system frequency response, effect of windscreen, grazing incidence, effects of temperature and humidity, and effects of background. Data were not corrected for gross weight differences.

Aircraft Performance Data

For the specially instrumented test aircraft, which made two approaches a day into LAX, flight, control, and engine parameters were recorded on a digital recording system aboard the aircraft along with time code. A flight data entry panel was provided on the flight deck and a time code generator enabled synchronization of the airborne recorder with data recorded at the ground radar and noise data. The remaining five flights each day simply reported gross weight, flaps, and EPR. The pilots attempted to maintain constant flaps and EPR. The changes are not known, however.

Time Synchronization

Timing between the radar and acoustic data was provided with a single time code generator synchronized daily to WWV. The time code generator was located in the radar van. The radar van also housed the noise measurement command station. The time code generator output signal (IRIG B) was connected in parallel to both the radar recorder and the noise measurement timing and command transmitter. There is no timing error between radar and acoustic data.

RESULTS

Tables III through VIII represent the noise measurements at each site. The measurements at each site are grouped according to the specific day and ordered as they occurred each day. Missing flights are the result of landing on an uninstrumented runway, inability to track aircraft, or ambient acoustic interference during the flyover, as well as occasional hardware malfunction of either the radar or acoustic instrumentation.

Corresponding aircraft range for each noise data point was obtained from Government-furnished data. Slant range at CPA is the closest the aircraft came to the measurement site. The time of PNLTM is the time during the flyover of a given site when the maximum tone-corrected perceived noise level occurred. It does not necessarily occur at the CPA time. This time is an output of the acoustic data processing program.

Hydrospace-Challenger, Inc.
1360 Rosecrans Street
San Diego, California, August 31, 1973

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Table III. LAX - June 1973, Site 1

DATE	FLIGHT	$EPNL_C$	SLANT RANGE (CPA) (ft)	TIME OF $PNLT_M$ (hr:min:sec)
15 June	PSA 181	110.6	343	08:04:27
	PSA 59	116.1	368	12:03:14
16 June	PSA 181	103.2	372	07:57:33
	PSA 59	104.8	321	11:59:05
	UA 729	100.9	186	14:52:30
17 June	UA 975	102.0	350	07:35:05
	UA 289	100.0	353	10:11:13
	UA 371	102.6	313	12:46:56
	UA 729	107.3	360	14:53:51
18 June	UA 975	102.6	339	07:32:07
	PSA 281	98.3	455	10:01:12
	PSA 59	96.2	352	12:04:19
	UA 371	100.2	366	12:50:30
	UA 729	102.2	327	14:47:17
19 June	UA 289	101.5	323	10:12:27
	UA 729	99.4	320	14:56:30
20 June	UA 975	99.8	334	07:34:40
21 June	PSA 181	110.3	527	07:59:44
	UA 289	111.6	320	10:12:49
	PSA 59	109.9	392	11:58:31
22 June	PSA 281	98.0	875	09:57:24
	UA 289	111.9	308	10:20:03
	UA 371	109.4	320	12:57:39
	UA 729	111.1	303	15:00:53
23 June	UA 975	111.3	340	07:30:52
	PSA 181	105.4	390	07:55:07
	PSA 281	110.0	418	09:54:47
	PSA 59	116.2	304	11:55:54
	UA 729	112.8	318	14:53:01
24 June	UA 975	105.6	330	07:29:54
	UA 289	114.0	340	10:10:52
26 June	UA 289	108.5	318	10:26:56
	UA 371	108.9	318	12:57:01
27 June	UA 371	109.6	318	12:59:14
28 June	UA 975	109.5	344	07:33:42
	PSA 181	114.2	248	08:04:19
	PSA 59	108.9	299	12:05:00
	UA 371	111.3	325	13:04:06
29 June	UA 975	111.5	357	07:35:24
	PSA 181	106.7	362	08:03:51
	UA 289	113.5	309	10:11:41
	UA 371	111.8	314	13:13:54
	UA 729	110.4	347	15:01:02

Table IV. LAX - June 1973, Site 2

DATE	FLIGHT	EPNLC	SLANT RANGE (CPA) (ft)	TIME OF PNLTM (hr:min:sec)
15 June	PSA 181	108.0	631	08:04:[illegible]
	PSA 59	109.5	552	12:02:59
16 June	PSA 181	96.1	711	07:57:17
	PSA 59	109.0	476	11:58:46
	UA 729	105.6	518	14:52:12
17 June	UA 975	102.6	571	07:34:51
	UA 289	102.4	534	10:10:58
	UA 371	103.6	492	12:46:40
	UA 729	96.4	597	14:53:34
18 June	UA 975	100.6	535	07:31:51
	PSA 281	94.3	861	10:00:58
	PSA 59	92.2	748	12:04:03
	UA 371	102.3	510	12:50:12
	UA 729	102.7	525	14:46:59
19 June	UA 289	99.0	540	10:12:11
	UA 729	100.2	529	14:56:12
20 June	UA 975	98.4	529	07:34:26
21 June	PSA 181	101.1	913	07:59:30
	UA 289	105.7	471	10:12:33
	PSA 59	99.2	749	11:58:16
22 June	PSA 281	95.0	875	09:57:02
	UA 289	96.0	466	10:19:40
	UA 371	106.6	506	12:57:21
	UA 729	105.6	526	15:00:33
23 June	UA 975	102.9	574	07:30:36
	PSA 181	97.3	790	07:54:53
	PSA 281	95.6	769	09:54:31
	PSA 59	106.2	594	11:55:36
	UA 729	108.6	498	14:52:39
24 June	UA 975	98.9	540	07:29:41
	UA 289	104.9	489	10:10:16
	UA 371	99.3	1020	12:52:02
25 June	PSA 59	102.5	776	12:01:22
26 June	UA 289	105.0	506	10:20:41
27 June	UA 371	105.2	509	12:58:55
28 June	UA 975	106.4	520	07:33:26
	PSA 181	103.4	495	08:04:02
	PSA 59	103.9	509	12:04:42
	UA 371	107.5	508	13:03:48
29 June	UA 975	109.2	519	07:35:09
	PSA 181	102.1	537	08:03:36
	UA 289	110.1	485	10:11:23
	UA 371	107.1	504	13:13:37
	UA 729	104.2	666	15:00:46

Table V. LAX - June 1973, Site 3

DATE	FLIGHT	$EPNL_C$	SLANT RANGE (CPA) (ft)	TIME OF $PNLT_M$ (hr:min:sec)
15 June	PSA 181	104.3	965	08:03:46
	PSA 59	102.4	835	12:02:31
16 June	PSA 181	94.1	1219	07:56:56
	PSA 59	96.7	1023	11:58:20
	UA 729	100.6	1000	14:51:40
17 June	UA 975	98.5	1096	07:34:28
	UA 289	105.4	835	10:10:34
	UA 371	102.0	851	12:46:11
	UA 729	99.7	1316	14:53:12
18 June	UA 975	97.3	1059	07:31:27
	PSA 281	91.7	1347	10:00:34
	PSA 59	92.4	1208	12:03:40
	UA 371	106.2	827	12:49:41
	UA 729	100.5	1049	14:46:30
19 June	UA 289	100.2	852	10:11:45
	UA 729	93.3	1026	14:55:45
20 June	UA 975	92.3	1019	07:34:03
21 June	PSA 181	89.0	1554	07:58:32
	UA 289	103.0	800	10:12:02
22 June	UA 289	102.0	823	10:19:21
	UA 371	102.5	807	12:56:55
	UA 729	101.6	977	15:00:07
23 June	UA 975	99.3	957	07:30:13
	PSA 181	88.4	1613	07:54:29
	PSA 281	88.0	1308	09:54:08
	PSA 59	90.6	1290	11:55:13
	UA 729	94.9	1039	14:52:09
24 June	UA 975	94.3	1030	07:29:19
	UA 289	102.8	820	10:08:58
	UA 371	101.5	884	12:51:39
25 June	PSA 59	90.6	1310	12:00:58
26 June	UA 289	106.0	803	10:20:14
	UA 371	103.0	762	12:56:16
27 June	UA 371	105.6	802	12:58:24
28 June	UA 975	91.9	1019	07:32:59
	PSA 181	102.9	796	08:03:38
	PSA 59	104.3	757	12:04:17
	UA 371	108.7	836	13:03:22
29 June	UA 975	102.8	887	07:34:45
	UA 371	106.3	817	13:13:08
	UA 729	99.3	1099	15:00:22

Table VI. LAX - June 1973, Site 4

DATE	FLIGHT	$EPNL_C$	SLANT RANGE (CPA) (ft)	TIME OF $PNLT_M$ (hr:min:sec)
15 June	PSA 181	100.8	1301	08:03:24
	PSA 59	96.2	1173	12:02:10
17 June	UA 371	95.6	1338	12:45:50
18 June	PSA 281	88.6	1844	10:00:18
	PSA 59	89.6	1541	12:03:22
	UA 371	101.8	969	12:49:21
	UA 729	94.1	1452	14:46:11
19 June	UA 289	95.9	962	10:11:23
	PSA 59	81.4	1987	11:56:43
21 June	UA 289	100.2	930	10:11:56
22 June	UA 729	92.9	1397	14:59:41
23 June	UA 975	92.8	1453	07:29:53
	PSA 181	98.4	1990	07:54:13
24 June	UA 975	90.5	1404	07:29:05
	UA 289	99.1	869	10:08:47
25 June	PSA 59	97.7	1783	12:00:45
26 June	UA 289	100.9	905	10:20:00
	UA 371	107.0	850	12:55:56
27 June	UA 371	101.4	914	12:58:10
28 June	UA 975	87.5	1416	07:32:53
	PSA 181	99.4	908	08:03:14
	PSA 59	97.3	1011	12:04:00
	UA 371	96.4	956	13:03:03
29 June	UA 371	101.0	900	13:34:37
	UA 729	98.4	1821	15:00:13

Table VII. LAX - June 1973, Site 5

DATE	FLIGHT	$EPNL_C$	SLANT RANGE (CPA) (ft)	TIME OF PNLTM (hr:min:sec)
15 June	PSA 181	94.3	1658	08:03:05
	PSA 59	92.6	1880	12:01:40
16 June	PSA 181	84.4	2156	07:56:16
	PSA 59	88.3	2210	11:57:30
	UA 729	92.2	2203	14:50:59
17 June	UA 975	87.4	2193	07:33:39
	UA 289	97.3	1156	10:09:48
	UA 371	95.4	1368	12:45:27
	UA 729	83.2	3305	14:52:43
18 June	UA 975	88.8	2097	07:30:41
	PSA 281	92.7	2654	09:59:46
	PSA 59	85.8	2108	12:02:55
	UA 371	96.6	1375	12:48:55
	UA 729	90.7	2239	14:45:59
19 June	UA 289	91.6	1313	10:11:00
	PSA 59	90.2	2516	11:56:25
20 June	UA 975	82.8	2331	07:33:19
21 June	PSA 181	87.3	3033	07:58:20
	UA 289	89.7	1354	10:11:02
22 June	UA 729	91.4	2038	14:59:10
23 June	UA 975	84.3	2164	07:29:27
	PSA 181	82.4	2588	07:53:48
	PSA 281	83.6	2240	09:53:31
	PSA 59	82.2	2268	11:54:27
	UA 729	80.6	2080	14:51:40
24 June	UA 975	83.8	2099	07:28:37
	UA 289	95.7	1379	10:08:12
	UA 371	95.6	1528	12:50:59
25 June	PSA 59	88.8	2436	12:00:27
26 June	UA 289	95.4	1285	10:19:29
	UA 371	92.6	1312	12:55:30
27 June	UA 371	94.2	1233	12:57:36
28 June	UA 975	85.2	2165	07:32:20
	PSA 181	96.8	1230	08:02:53
	PSA 59	91.4	1303	12:03:34
	UA 371	94.1	1188	13:02:32
29 June	UA 975	85.6	1964	07:33:58
	PSA 181	89.2	1110	08:02:33
	UA 289	97.0	1355	10:10:06
	UA 371	94.8	1249	13:12:21
	UA 729	89.0	2124	14:59:40

Table VIII. LAX - June 1973, Site 7

DATE	FLIGHT	$EPNL_C$	SLANT RANGE (CPA) (ft)	TIME OF $PNLT_M$ (hr:min:sec)
15 June	PSA 181	88.3	2577	08:02:25
	PSA 59	98.1	2748	12:01:02
16 June	PSA 181	92.0	2912	07:55:53
	PSA 59	96.9	2810	11:56:53
	UA 729	87.2	3199	14:50:19
17 June	UA 975	87.7	3190	07:33:06
	UA 289	95.0	1935	10:09:10
	UA 371	89.6	1996	12:44:55
18 June	UA 975	83.6	3285	07:30:00
	PSA 281	84.2	2921	09:59:12
	PSA 59	84.2	3157	12:02:23
	UA 371	89.3	2089	12:48:18
	UA 729	88.9	3260	14:45:14
19 June	UA 289	88.0	2095	10:10:21
	PSA 59	82.7	2920	11:56:01
	UA 729	92.7	3239	14:54:32
20 June	UA 975	83.5	3267	07:32:41
21 June	PSA 181	84.8	3669	07:57:46
	UA 289	94.2	1657	10:10:48
	PSA 59	83.0	3757	11:56:41
22 June	PSA 281	89.0	3439	09:55:05
	UA 289	92.7	2055	10:18:08
	UA 371	87.3	1872	12:55:34
	UA 729	81.5	3397	14:58:44
23 June	UA 975	88.5	3266	07:28:36
	PSA 181	88.7	3362	07:53:11
	PSA 281	81.5	3349	09:52:53
	UA 729	80.4	3267	14:50:41
24 June	UA 975	89.9	3313	07:28:10
	UA 289	86.9	2686	10:07:35
	UA 371	90.2	1749	12:50:23
25 June	PSA 59	83.0	5650	11:59:59
26 June	UA 289	95.9	6602	10:18:52
27 June	UA 371	94.8	1820	12:56:55
28 June	UA 975	82.7	3501	07:31:44
	PSA 59	94.8	1821	12:03:02
	UA 371	91.9	1893	13:01:55
29 June	UA 975	81.6	2934	07:33:22
	UA 289	90.9	1881	10:09:29
	UA 729	90.3	3219	14:59:05