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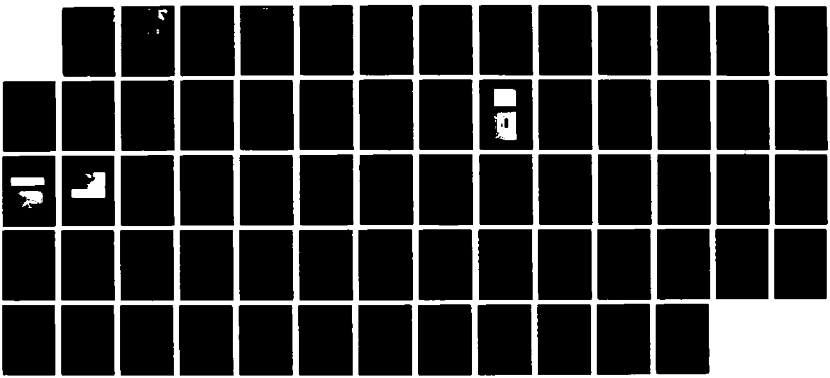

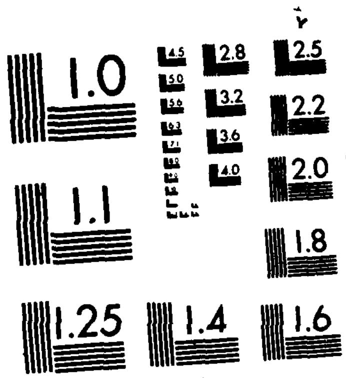

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ENVIRONMENTAL NOISE ASSESSMENT FOR MILITARY AIRCRAFT TRAINING ROUTES VOLUME 1: SAC LOW-LEVEL ROUTES

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APRIL 1987

Approved for public release; distribution unlimited.

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NOTICES

TECHNICAL REVIEW AND APPROVAL

AAMRL-TR-87-001

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

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

FOR THE COMMANDER

Henning E. von Gierke

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A series of noise measurements was conducted underneath a low-altitude military training route utilized by SAC aircraft. The primary measurement system consisted of 17 automatic noise monitors deployed on a two-mile array across the route. These recorded A-weighted noise metrics and provided identification of the lateral position of each aircraft. Data were obtained for 48 aircraft over a 15-day period. It was found that maximum A-weighted sound levels and sound exposure levels for B-1 and B-52 aircraft agreed well with predictions from the Air Force's existing NOISEFILE data base. It was also found that the distribution of lateral position re: centerline is well described by a Gaussian distribution with a standard deviation of 0.5 mile. Analog recordings were made of selected overflights of B-1, B-52, and FB-111 aircraft. These provided definition of the temporal and spectral characteristics of these flight operations.

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We would like to thank the personnel at Headquarters, Strategic Air Command, DOTO, Offutt Air Force Base, Nebraska, for their participation in this project. The schedule and flight parameter data they supplied were essential to the success of the field measurement effort.

ABSTRACT

A series of noise measurements was conducted underneath a low-altitude military training route utilized by SAC aircraft. The primary measurement system consisted of 17 automatic noise monitors deployed on a two-mile array across the route. These recorded A-weighted noise metrics and provided identification of the lateral position of each aircraft. Data were obtained for 48 aircraft over a 15-day period. It was found that maximum A-weighted sound levels and sound exposure levels for B-1 and B-52 aircraft agreed well with predictions from the Air Force's existing NOISEFILE data base. It was also found that the distribution of lateral position re: centerline is well described by a Gaussian distribution with a standard deviation of 0.5 mile. Analog recordings were made of selected overflights of B-1, B-52, and FB-111 aircraft. These provided definition of the temporal and spectral characteristics of these flight operations.

1.0 INTRODUCTION

Low-altitude, high-speed training operations are routinely conducted by all Air Force flight operation commands. These operations are conducted on specially designated Military Training Routes (MTRs). Routes are continually changed because of the need for variety, changing requirements of weapon systems and tactics, and encroachment on existing routes. Environmental assessments are required for new routes. Current environmental assessment methodologies do not provide a full evaluation of the noise impact of these routes. There are two shortcomings. First, prediction of the noise environment is incomplete. The major unknown is the spatial positioning of aircraft across a route; current environmental assessments often assume all aircraft are on the centerline, resulting in significant overestimates of noise at that position. Aircraft noise data at MTR operating conditions are also somewhat meager. NOISEFILE data can be utilized to provide credible estimates, but additional data under actual conditions are needed. The second shortcoming is that noise along an MTR is sporadic, and is very different in character from the airport noise environments upon which current L_{dn}-based noise guidelines were developed. There is therefore a need to determine if the current noise metric and land-use criteria are appropriate and, if not, to define suitable alternatives.

An overview of this problem and long-term research needs is contained in Reference 1. The recommendations in that study included field measurements of MTR noise, field observation of demographics in areas traversed by such routes, and a formal psychoacoustic study to establish human response to sporadic noise. Until this complete study can be performed, a short-term project has been embarked upon to provide interim noise assessment technology for MTRs. The short-term study is based on the initial stages of the long-term study, and includes the following elements:

1. Noise measurement programs on two MTRs: one operated by SAC and one by TAC. These are the types of routes of greatest current interest. The noise measurement programs also include preliminary demographic assessments and qualitative observations of noise impact.

2. Recommendations for the ultimate form of the route noise prediction model, with specific considerations for consistency with existing Air Force noise models and utility to Air Force planning personnel.

3. Recommendations for an interim noise metric for MTRs, based on the best currently available knowledge. A key consideration is whether L_{dn} (with or without some type of adjustment) is a technically defensible basis for this. It is also important that the recommended metric not overstep the bounds of current knowledge.

This report presents the results of the first measurement program, conducted on a SAC MTR. Section 2.0 is an overview of SAC routes and operations, adapted from material in Reference 1. Section 3.0 is a description of the field program and data acquisition procedures. Results of the field study are presented in Section 4.0. Section 5.0 contains the conclusions of this study.

2.0 SAC STRATEGIC TRAINING ROUTES (STR) AND OPERATIONS

2.1 Route Structure and Mission Profiles

SAC conducts low-level training missions under instrument flying rules (IFR) on strategic training routes (STRs) for B-1, B-52, and FB-111 aircraft. The objective of these missions is to provide terrain avoidance (TA) training during flights to bomb scoring ranges. Scoring of arrival time and position is accomplished by radar. Crews are also scored on their use of electronic devices and other tactics within the range. The conduct of these missions is defined in SACR 50-4, "Training Bombing/Navigation/AGM Operations (RCS: SAC-DOT (M&SA) 7105)". Table 1 is a list of STR sites and routes from the 17 September 1984 edition of SACR 50-4. There are two general types of missions. Where specific IFR routes are designated in Table 1, the mission simulates an attack on a single site, with several runs (typically two) over the target accomplished via a racetrack pattern. Figure 1 is a sketch of this type of route and site. The other type of mission involves routes designated "STRC" (Strategic Training Route Complex) in Table 1. This is a network of routes and sites in seven states centered around Wyoming and Montana, with each route passing over several sites. Various alternative routes run contiguously in many places. Missions on STRC routes simulate attacks on multiple targets. Route utilization is much more varied on STRC than over single-site routes.

Table 2 is a summary of semi-annual operations at a number of sites, provided by HQ SAC OLOC, 1 CEVG/AN. Note that these sites do not correspond exactly to the list in Table 1; sites and routes are continuously modified.

Flight profiles on STRs follow procedures defined in SACR 50-4 and Flight Information Publication AP/1B, "Area Planning Military Training Routes North and South America". Figure 1 is a simplified sketch of IR-276 leading to Holbrook, Arizona, taken from AP/1B. The route is defined by a series of points (letter identification shown here only for some) along the centerline and allowable IFR altitudes on each segment. Altitudes are shown as FL (flight level, hundreds of feet), either AGL or MSL. Altitudes in Figure 1 are MSL. The segments from L to N, where IFR altitude is FL 100, is over a mountain range with elevations of 7,000 to 9,000 feet MSL. S indicates flight to ground level is allowed by route definition. Ground elevation over much of the route is 5,000 to 7,000 feet MSL, so that TA segments have IFR altitudes up to about 3,000 feet AGL. Actual minimum altitudes allowed by SAC are defined in SACR 50-4 and depend on

Table 1

STR Site/Route Planning Information
(From SACR 50-4 Vol. 1, 17 September 1984)

Route	Scheduling Site/Units	Detachment	Altitude (Feet)	Ballistic KTAS Enroute
IR-075	HQ SAC	Richmond, KY (RMD)/Det 8	750	320
IR-177/501	HQ SAC	LaJunta, CO (LAJ)/Det 1	600	320
IR-275	HQ SAC	Hawthorne, NV (HAW)/Det 12	8000	340
IR-276	HQ SAC	Holbrook, AZ (HOL)/Det 2	850	340
IR-300	HQ SAC	Wilder, ID (WDR)/Det 5	1000	340
IR-502	HQ SAC	Hastings, NE (HAS)/DET 10	700	320
IR-644/645/646	HQ SAC	Bismarck, ND (BMK)/Det 14	750	320
IR-700	HQ SAC	Fort Drum, NY (CPD)/Det 11 (Watertown Entry)	750	320
IR-800/804	HQ SAC	Ashland, ME (ASH)/Det 7	400	320
IR-801	HQ SAC	Fort Drum, NY (CPD)/Det 11 (Burlington Entry)	750	320
IR-983	43	SW Andersen AFB GU Det 24	1000	320
IR-986	43 SW	Andersen AFB GU Det 24	2000/1000	320
IR-982	43 SW	Osan AB, Korea Det 9	1000	320
Bann STR	HQ USAFE/DOOB	Bann, Germany Det 4		
STRC	HQ SAC	Powell, WY (POW)/Det 16	400	340
STRC	HQ SAC	Gillette, WY (GIL)/MDL 33	400	340
STRC	HQ SAC	Wibaux, MT (FOR)/MDL 34	400	340
STRC	HQ SAC	Scobey, MT (HAV)/MDL 35	400	340

Table 2

Semi-Annual SAC Operations on Strategic Training Routes

IR Route No.	Site	B-52[4]						FB-111					
		TA	IFR	Low	High	Total	% Low	TA	IFR	Low	High	Total	% Low
501/177	La Junta	1,173	291	1,464	67	1,531	14.4	54	12	66	16	82	10.9
276	Holbrook	1,065	381	1,446	3	1,449	14.3	0	0	0	0	0	0.0
300	Wilder	758	391	1,149	84	1,233	11.3	0	0	0	0	0	0.0
502	Hastings	809	147	956	223	1,179	9.4	27	0	27	42	69	4.4
644/645	Bismarck	695	120	815	67	882	8.0	70	7	77	2	79	12.7
800/804	Ashland	543	259	802	25	827	7.9	63	26	89	0	89	14.7
75	Richmond	324	250	574	44	618	5.7	86	27	113	28	141	18.6
700/801	Fort Drum	324	204	528	4	532	5.2	62	23	85	0	85	14.0
472, 473, 480 481, 492, 495	Belle Fourche	276	28	304	1	305	3.0	22	1	23	0	23	3.8
275	Hawthorne	0	0	0	259	259	0.0	0	0	0	0	0	0.0
313, 478, 479	Havre	14	1	15	0	15	0.1	0	0	0	0	0	0.0
472, 473, 474, 483, 494, 497[3]	Powell[3]	496	316	812	76	888	8.0	47	7	54	8	62	8.9
483, 494, 497	Gillette[3]	504	239	743	67	810	7.3	33	8	41	0	41	6.8
492, 494[3]	Wibaux[3]	64	17	81	0	81	0.8	16	0	16	0	16	2.6
	Scobey[2,3]	68	13	81	0	81	0.8	16	0	16	0	16	2.6
	Guam[1]	114	171	285	264	549	2.8	0	0	0	0	0	0.0
	Osan[1]	54	24	78	31	109	0.8	0	0	0	0	0	0.0
	Bann[1]	4	1	5	24	29	0.0	0	0	0	0	0	0.0
	Total:	7,285	2,853	10,138	1,239	11,377	89.1	496	111	607	96	703	86.3

[1] Outside Continental United States

[2] No longer in use.

[3] STRCs.

[4] TA = Terrain Avoidance Flights, typically 400–600 Ft AGL
IFR = Instrument Flying Rule altitude, typically 2,000–3,000 Ft AGL
Low = Total of all TA and IFR operations
High = High-Altitude Flights, typically above 35,000 Ft
Total = Total operations per six months
% Low = Percent Low Operations of Total for SAC

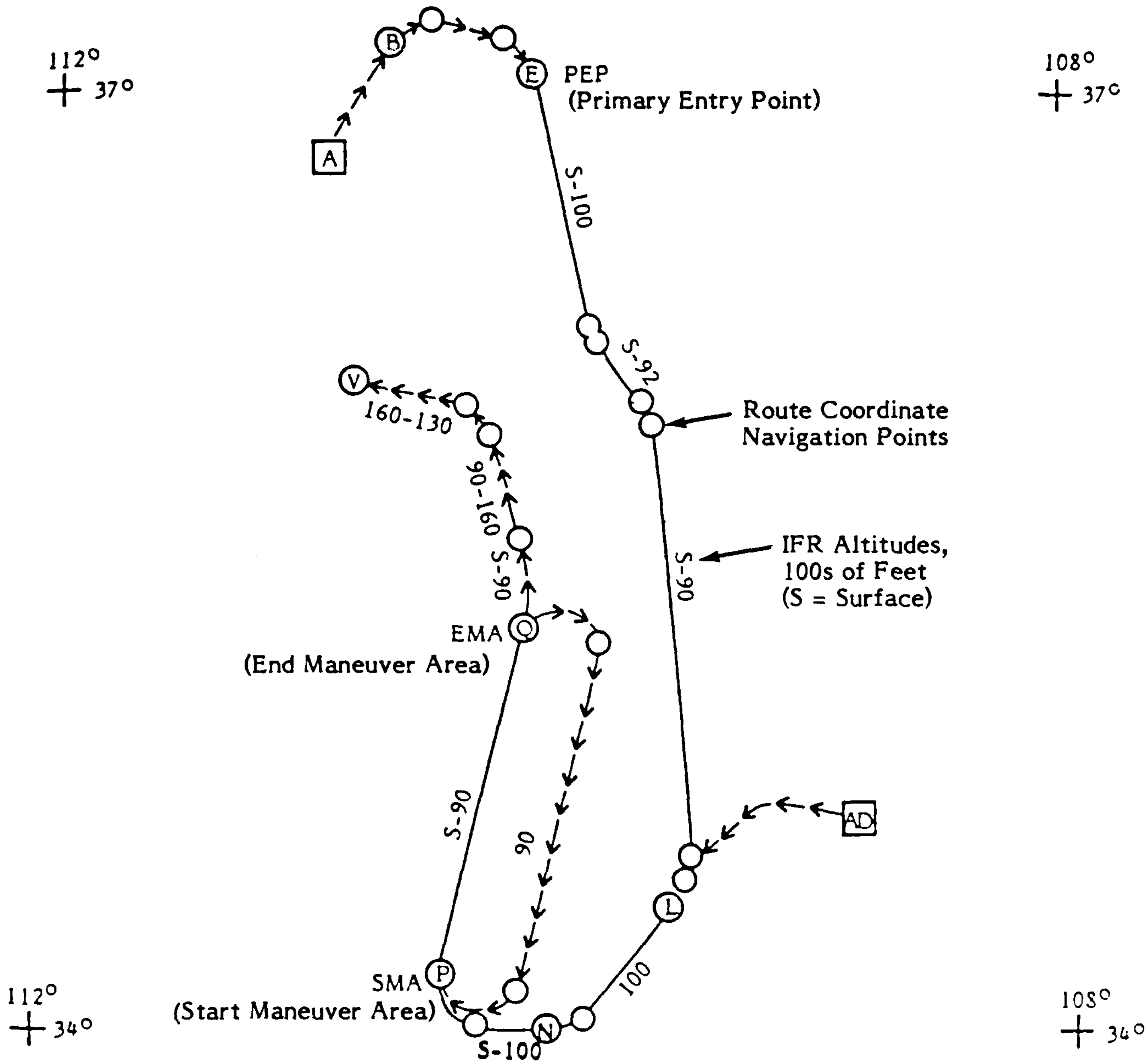

Figure 1. Typical STR Route and Site (IR-276, Holbrook, AZ).

equipment used and whether the route is mountainous or non-mountainous. Route descriptions in AP/1B define whether the route is mountainous or non-mountainous. Typical minimum altitudes are 400 to 600 feet. Minimum altitudes are also constrained by Federal Aviation Regulation 91.79, which prohibits aircraft operation closer than 500 feet to any person, vessel, vehicle, or structure. Weather conditions or equipment malfunctions can cause a mission to be conducted at the upper IFR altitude.

A typical mission on IR-276 consists of entering the route at point A, at a typical altitude of 20,000 feet or higher. The aircraft descends (following a profile defined in AP/1B) to point E, the primary entry point (PEP). Terrain following is authorized from E to L and from N to Q. On some routes, points are designated "Start TA/TFR" and "End TA/TFR". After passing PEP, the crew will fly slightly above the planned TA altitude briefly while the clearance plane is set and calibrated, then descend to the TA altitude. While this can be any altitude within the allowable IFR range, crews are scored on their ability to maintain as low an altitude as possible. Clearance planes are therefore set so as to satisfy minima given in SACR 50-4, allowing for a 50- to 75-foot safety margin. Navigation precision is scored, so that aircraft are virtually always within one mile of centerline, although route width definitions are typically several miles from centerline. Discussions with SAC personnel indicate that aircraft with the latest navigation equipment stay within one-half mile of centerline. B-52s fly at a nominal airspeed of 320 to 340 kts, FB-111s at 420 to 450 kts, and B-1s at 520 to 540 kts. Speeds will vary depending on the type of operation. Some speed management may be performed to ensure on-time arrival at the scoring site.

The scoring site in Figure 1 is between P and Q, with ends designated start maneuver area (SMA) and end maneuver area (EMA). Within the site, a number of target positions are defined and the lateral position of the aircraft relative to centerline depends on target position and the aircrew's technique. Targets are not physically marked; they are defined only by their coordinates. Altitude is treated the same as on other route legs, although there may be particular maneuvers such as pullups associated with the dynamics of weapon release. Current SAC practice is for low-altitude targets to be sequentially spaced close to the centerline, and for there to be no maneuvers other than navigation corrections. Navigation is more precise within the scoring site, typically within 1,000 feet of centerline when approaching an assigned target. According to SAC personnel, navigation precision is tightened up beginning at a point within 10 miles of the site entry point.

After passing the end maneuver point, the aircraft can either exit or go around the racetrack for another target run (TA is not authorized at the site shown in Figure 1, but is on some others). This route essentially ends after point Q, with the route climbing through point V and beyond; note the increasing altitudes on segments from Q to V. Some routes include TA sections after the site. STRC routes continue at low altitudes to the next site.

Routes typically have more than one entry point. Point AD in Figure 1 is an alternate entry. Point P, where the racetrack enters, is an alternate entry or reentry. Some routes have alternate entries which are aligned with exits. However, discussions with SAC personnel indicate that, except for reentry from the racetrack, routes are nearly always entered at the primary entry.

The STRC route structure is somewhat more complex. There is a multiplicity of STRC routes and sites, with a given mission hitting several sites and carrying out TA before, after, and between target runs. Powell and Gillette, Wyoming, which are a part of the STRC network, have about 1,000 annual operations each (15 percent of total operation, and the majority in the STRC area), and are associated with six IFR routes. These overlap to a large degree, and there are about six more in the network, with about half a dozen target sites. The six routes associated with Powell and Gillette include about 1,400 miles where TA is authorized, half of which is in mountainous terrain. They traverse a total of seven sites, not all of which are extensively used. The sites are similar to the STR sites, except for the absence of a racetrack segment. A nominal STRC TA mission would fly several hundred miles over one of about half a dozen routes, hitting lesser used sites. For example, a mission might follow IR-483 to Gillette, traverse IR-483, 494, 497 (contiguous) to Powell, then exit the route. However, the particular sequence of TA runs and target runs will vary for the other STRC routes. The general utilization of these sites and routes is thus similar to the others: about 200 miles of TA operation leading to each site. There is only one bomb run per site per mission, but several sites are normally involved with each mission. In the STRC area, there are thus about 400 miles of route with about 1,000 operations per year (comparable to the busier single-site routes) and another 1,000 miles of route with lower frequencies of operation. Except for the absence of racetrack reentry at the STRC sites, operation along this route complex is the same as on the other routes. For the purpose of acquiring on-route data, there is thus no need to distinguish between STRC and the other routes.

2.2 Operations and Schedule

Operations on the routes are sporadic. For the busiest sites listed in Table 2, there is an average of about five route traverses per day, assuming 200 flying days per year and two scored runs per sortie. Operations are not uniformly distributed; some days can have up to 15 operations and some have none. Intervals between flights are at least 12 minutes (B-1 and FB-111) to 15 minutes (B-52), so each one is an individual event. The noise impact implications of these sporadic events are discussed in Reference 1. For present purposes, it may be noted that there is no reason to expect mission profiles on busy routes to differ from those on lightly used routes. It is therefore reasonable to obtain data on a busy route, and adjust these data by numbers of operations.

Schedule activity for SAC routes is centralized at HQ SAC DOTO, who forward time allocations to the scoring sites. Time allocations are requested weekly, with a nominal schedule set by the end of the previous week. Additions or changes to the schedule are made as required. In the event of weather or maintenance problems, schedule changes may not be made until mission takeoff time. Cancelled time slots are not reported to DOTO or the sites except by default if they are reallocated to a different unit. When a mission is flown, it enters the site within two minutes of scheduled time. All flown missions are, of course, recorded by the scoring site. There is currently no central recording of the route used if more than one route leads to a given site.

3.0 FIELD PROGRAM

3.1 Site Selection

A site was selected based on the following criteria:

- The associated route should have high activity.
- Activity should include a variety of aircraft.
- Non-mountainous terrain, both for simplicity and because of worst-case lower altitude operations.
- Accessibility to measurement sites on the route, at least 10 miles from the scoring site entry, so as to obtain "on-route" data.

A location meeting these criteria is along IR-177 and IR-501 north of the La Junta site in southeastern Colorado. As seen in Table 2, La Junta is the busiest scoring site. It serves B-1, B-52, and FB-111 aircraft, plus some activity from TAC and ANG units. The two routes, each carrying about half the activity, merge about 15 miles from the SMA point, giving about a 5-mile window satisfying the above criteria. The route is 8 nautical miles* wide in this area. A reconnaissance trip was made to the area, and a suitable noise measurement site was found on a privately owned cattle ranch. Figure 2 shows the route structure and the site. Permisson was obtained from the ranch foreman to operate there, but we were requested to keep all vehicles on roads because of the danger of prairie fires set by catalytic converters. Instrumentation was therefore arrayed parallel to an all-weather dirt road crossing the route.** The site was about 6 miles from the nearest paved road, U.S. Route 40 passing through Wild Horse, Colorado. A base of operations was established at a motel in Kit Carson, about a 60- to 90-minute round trip from the site.

There were two negative aspects to the site. One was that the road was at about 45 degrees to the route; straight across would have been ideal. The second was that the cattle proved to be a problem, chewing on the windscreens and cables at night and in the early morning. This activity was sporadic, but when it occurred tended to cause many false records in the automatic monitors.

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* Except for specific citation of nautical miles, distances in this report are statute miles.

** Cheyenne County Road M. The north-south road 3 miles to the east, leading north to Wild Horse, is County Road 8.

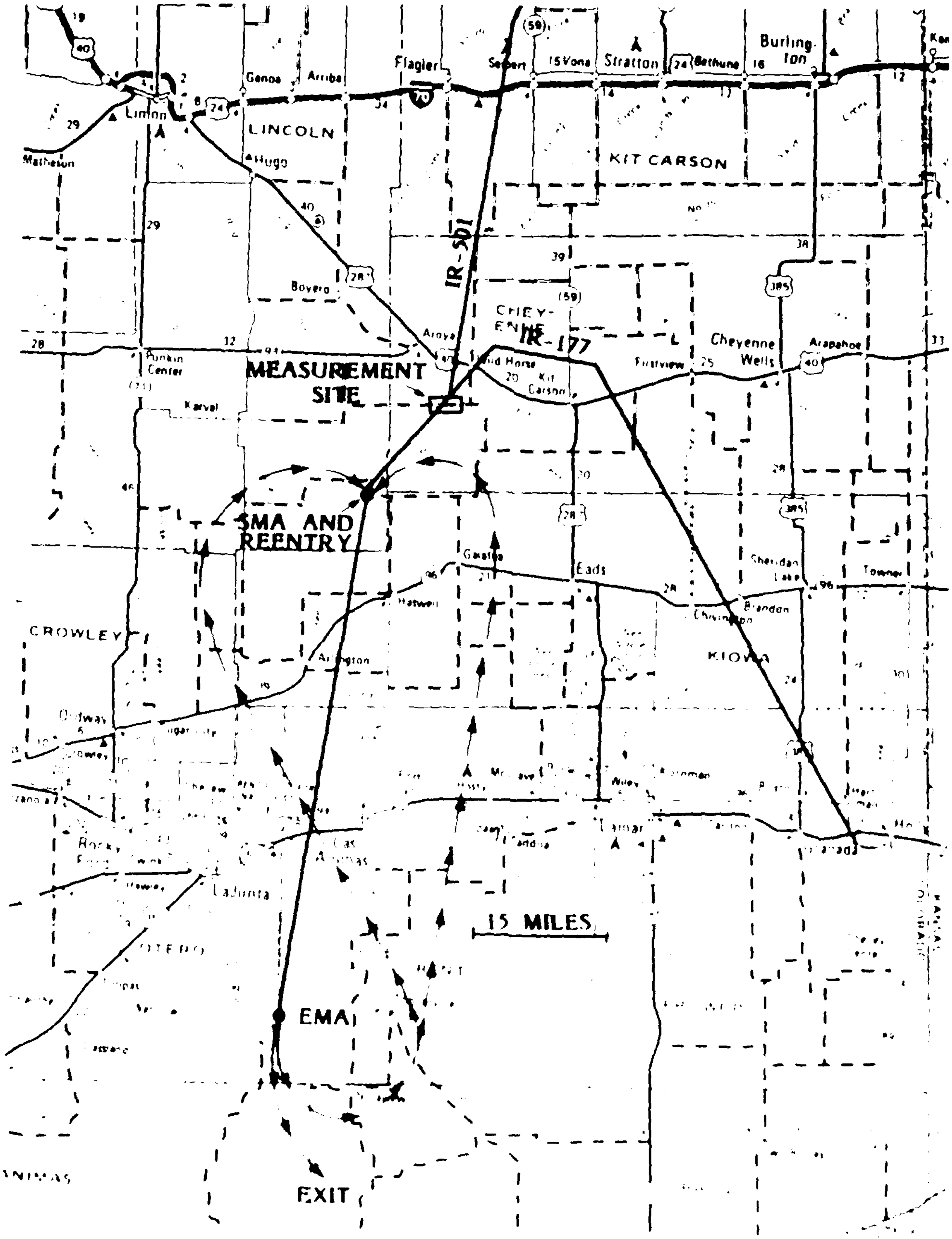

Figure 2. IR-177/501 Route Structure Near La Junta Scoring Site.

An unexpected bonus of this site was that many aircraft scheduled for several passes would rejoin IR-177, rather than reenter as shown by the racetracks, and pass over the site additional times. Initial passes over the site were virtually always at TA altitude. Second and third B-52 passes were virtually always at IR altitude, and sometimes had not rejoined the route far enough north to be clearly on the route. Second and third B-1 passes were always clearly on the route, and were often at TA altitude.

3.2 Instrumentation and Field Procedures

3.2.1 Automatic Monitors

Seventeen automatic noise monitors were deployed. These consisted of Larson Davis Model 700 dosimeters, fitted with GenRad 1571-9065 1-inch piezoelectric microphones and PCB Piezotronics 402A line amplifiers. Microphones were mounted 4 feet above the ground, using metal fenceposts obtained for this purpose. Each LD-700, together with a battery, was placed in an environmentally sealed container. Figure 3 shows a typical installation; foam windscreens were used on all microphones. Figure 4 shows the LD-700 and its battery inside the container.

The 17 units were placed in a two-mile-long array on the north side of the road. The intent was to place monitors at about 500-foot intervals across the route, based on expected 500-foot minimum altitudes and a desire not to miss absolute maximum levels by more than 1 dB ($10 \log_{10} (500^2 + 250^2) / 500^2$). There were utility poles on the south side of the road spaced 16 to the mile, which provided convenient reference markers. Monitors were aligned with every other pole, corresponding to a 660-foot (one-eighth mile) spacing along the road, or a 467-foot spacing across the route (45 degrees to the road). The total span ($\pm$1 mile along the road, $\pm$0.7 mile across the route) covered the area where most aircraft were expected. Aligning monitors with poles greatly facilitated locating them for service.

The LD-700 is a microprocessor-based digital integrating sound level meter. It can be programmed to record interval, exceedance, and history data. Interval data consists of L_{eq} and percentile exceedance levels. Exceedance data consists of records of levels that exceed a preset threshold. History data consists of time histories of noise. The unit can be programmed to record A- or C-weighted levels, slow or fast detector, and to integrate with 3, 4, or 5 dB/doubling of time tradeoffs, corresponding to L_{eq}, DoD noise dose, and

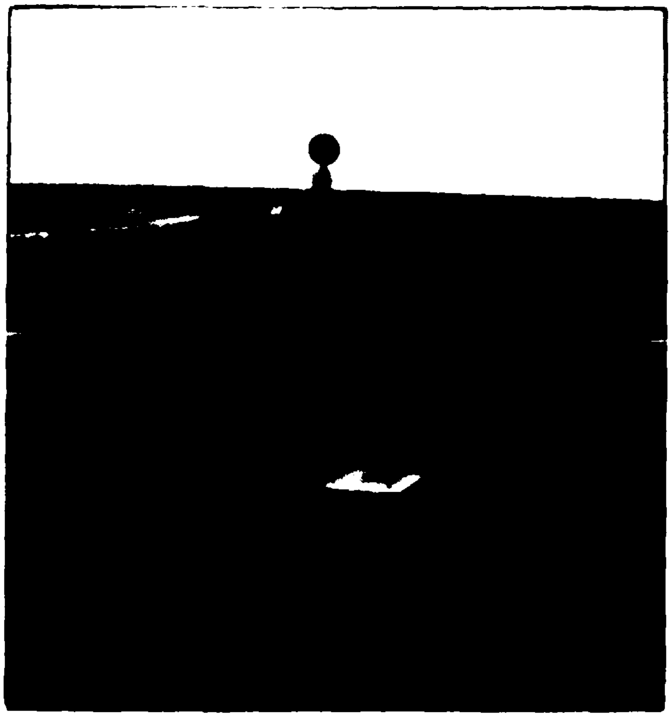

Figure 3. Typical Automatic Monitor Station.

Figure 4. LD-700 and Battery Inside Environmental Case.

OSHA noise dose. Table 3 is a list of settings used for this project and a summary of the data types acquired. The primary information collected for this project was the exceedance data.

The LD-700s have a bidirectional RS-232 computer interface. This port can be used to program the unit and to read data from it. A Zenith Z-171 portable microcomputer was used for this purpose. The Z-171 is 8088 based, battery powered, has dual floppy disks, and operates under the MS-DOS operating system. A BASIC program was used to initialize and program the LD-700s, and to read data and store them for subsequent analysis. The initialization routine included setting the LD-700's internal clock, so that all monitors were time synchronized. On initial setup, the monitors were calibrated with a B&K Type 4230 sound level calibrator.

Following initial installation, monitors were inspected at least once per day, generally as the first task each morning. Items checked during inspection were the physical condition of the windscreen and microphone cable, battery voltage, remaining memory, and obvious function of the unit. Missing windscreens* or damaged cables (always caused on a random basis, by cattle) were replaced. When a substantial fraction of memory was full, data would be transferred to the computer and the unit reset, recalibrated, and restarted. Servicing was done between scheduled flights. Data transfer from a full unit would take about 30 minutes. Units were selected for data transfer based on the number with adequate remaining memory and the time available before the next scheduled flight. Units to be serviced were generally removed and brought to the base of operations in Kit Carson, where they could be serviced efficiently while supporting work (e.g., log book updates, repair of spare cables, etc.) was accomplished. As few units as possible were removed at any given time, especially avoiding removal of adjacent units, so as to minimize data loss if an unexpected flight occurred.

Batteries were replaced approximately every third day, in conjunction with restarting a serviced unit. No unscheduled battery changes were required.

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* Surprisingly, no windscreens were lost. When knocked off, they were always found within a foot or two of the unit, stuck to vegetation. Wet windscreens (rain, dew, or animal activity) were dried before replacement.

Table 3

Automatic Monitor Setup and
Data Acquisition Characteristics

Sound Level Meter Parameters	
Frequency weighting	A
Meter Response	Slow
Integration Exchange Rate	3 dB (L_{eq})
Interval Data	
Interval Period	1 Hour
Basic Data Stored	L_{eq}, SEL, L_{max}, L_{min}
Statistical Levels	L_{01}, L_{10}, L_{50}, L_{90}
Exceedance Counts	RMS Exceedance, Peak Exceedance, Overload
Exceedance Data	
RMS Threshold	65 dBA
Peak Threshold	115 dBA
Unweighted Peak Threshold	Not used
Hysteresis *	4 dB
Data Stored	Time, date, duration (seconds), L_{eq}, SEL, L_{max}, L_{peak}, Peak exceedance, and overload counts

* Exceedances begin when the threshold is exceeded, and end when level falls below the threshold minus hysteresis.

About half the array was installed by the evening of Tuesday, 17 June, with the full array of 17 installed by the evening of 18 June. Two units were found to be malfunctioning, and were removed on 21 June, and replaced with spares on Monday, 23 June. One unit whose automatic start/stop function was erratic was moved to a non-critical position near the edge of the array. No other malfunctions occurred with the LD-700s. Three cases of lost data did occur:

- On occasion, a unit would fill with false data due to a missing windscreen during windy conditions, and time was not available to transfer the gcod data before the next event.
- Four data files (each representing one to four days' data from one unit) were irretrievably lost due to a disk system failure on the computer.
- On Monday, 30 June, about half the array was inoperative due to full memories while the computer was being repaired.

Enough monitors were always operational so that maximum level and position were determined for all aircraft passing within the span of the array. The array was kept operational through the afternoon of Thursday, 3 July, for a total of 15 days, or 11 days excluding weekends.

3.2.2 Analog Tape Recorders

Analog tape recordings were made with three Kudelski Nagra IV-SJ instrumentation tape recorders. Each recorder has three channels: two direct and one FM. At a tape speed of 7½ ips, the direct channels have a flat frequency response from 25 Hz to 15 kHz and the FM channel from DC to 3.5 kHz. Two microphones were used with each recorder. The basic microphone system consisted of a B&K Type 4166 one-half-inch condenser microphone and Kudelski QSPB preamplifier, input to the recorder via the microphone input.

In order to collect data below 25 Hz, two recorders were equipped with low-frequency microphone systems. These consisted of a B&K Type 4155 one-half-inch electret microphone specially calibrated to below 1 Hz (supplied by AAMRL) and a sound level meter (Larson Davis Model 800B on one recorder, B&K Type 2230 on the other) used as a linear amplifier. The AC output of the sound level meter was connected to both a direct channel line input and the FM channel input. This provided a supplemental recording from about 1 Hz to 3.5 kHz, in addition to the audio frequency direct recording. In practice, the useful lower frequency limit was bounded by wind noise.

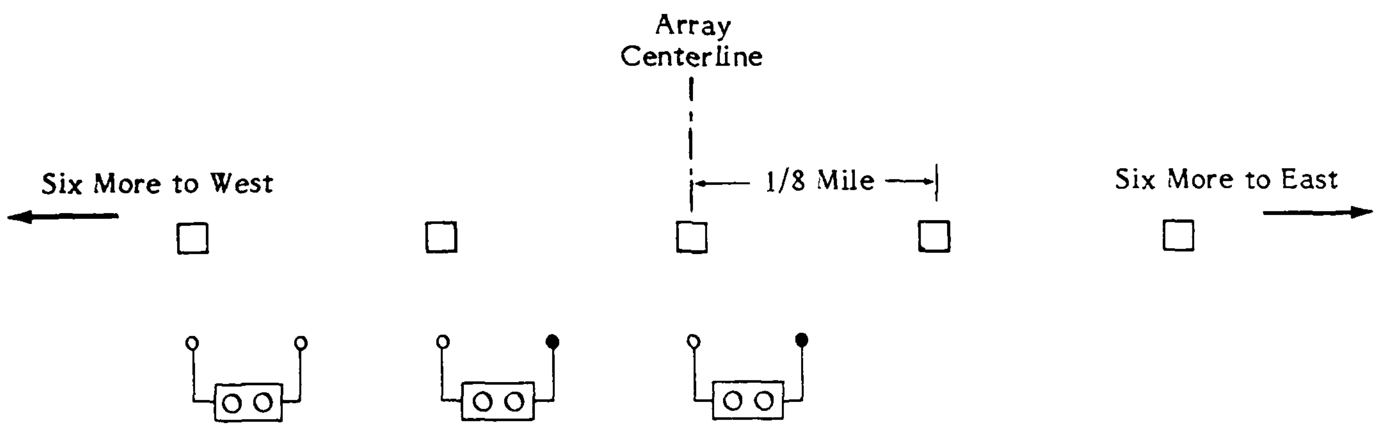
The frequency response of all preamplifiers, sound level meters, and tape recorders was calibrated with pink noise prior to the field program. The frequency ranges noted above for the tape recorders were confirmed by that laboratory calibration. Field calibration was accomplished with a B&K Type 4230 sound level calibrator.

Microphone positions for the analog channels were spaced approximately 330 feet apart (half the unmanned monitor spacing) near the center of the array. Figure 5 shows the positions used for most recordings. Slightly different positions were used early in the project, when emphasis was on installation and checkout of the automatic monitor array. It was planned to deploy the tape recorders for as many scheduled operations as possible. In practice, most time slots after 0800 and before 2200 were covered, with allowance for workload. B-1 slots were given priority over B-52 slots. Priority was given to maintaining the LD-700 array; this resulted in fewer than three analog recorders being deployed during portions of the program.

3.3 Meteorological and Photographic Data

A Weathertronics Recording Wind System 2361 was installed on a 15-foot-high mast near the center of the automatic monitor array. This provided a continuous record of wind speed and direction. Periodic temperature and humidity measurements were made with a sling psychrometer. Notes were made as to periods of precipitation or thunderstorm activity.

As workload permitted during analog recording, photographs were taken of the aircraft. A hand-held 35mm single-lens reflex camera was used, with a shutter speed of 1/1,000 second. Ideally, three photographs were taken: one while the aircraft was approaching, one at its nearest point, and one while departing. An attempt was made to include the horizon in at least one photograph, so that altitude could be estimated. Photographs were obtained for about half the analog events during daylight hours. Figure 6 is a sequence of three photographs from one B-52 event. No photographs of B-1s were obtained. The photographs were not quantitatively utilized, since SAC provided adequate altitude information.



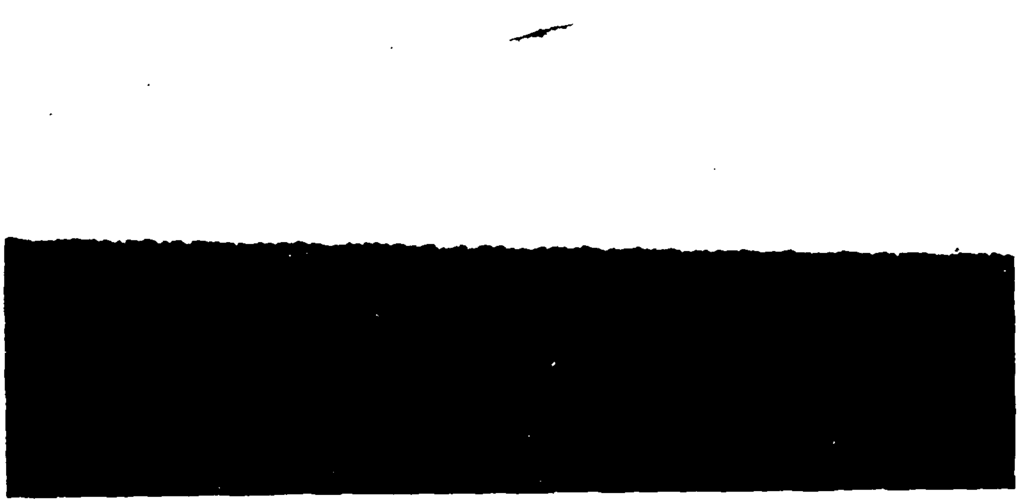
Automatic Monitor

Tape Recorder

o Microphone to Direct Channel

• Microphone to Direct and FM (Low-Frequency) Channel

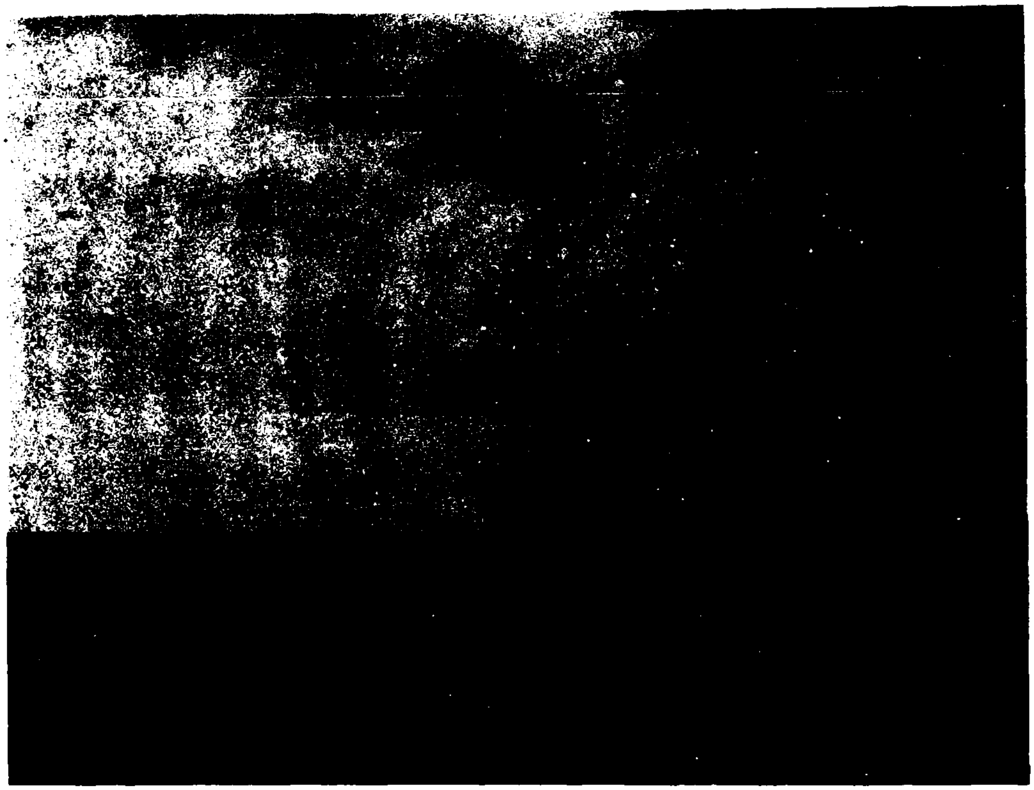
Figure 5. Analog Recorder Microphone Positions.



(a) Approaching.

(b) Overhead.

Figure 6. B-52H TA Flight Operation.



(c) Departing.

Figure 6 (Continued).

3.4 Schedule and Flight Parameter Information

Each morning, HQ SAC/DOTO was contacted by telephone to obtain the day's schedule, plus the first few events the following morning. This was used to plan the daily analog recording and automatic monitor service schedule. As described in Section 2.3, not all scheduled slots are used. A record was kept of whether or not each slot was used, based on observations while at the site. On occasion, an unexpected flight occurred. This was always a mission scheduled after our last contact with DOTO, and could be identified the next day. Several flights recorded by the LD-700s while personnel were not at the site were identified by DOTO after completion of the field program.

For the period 23 June through 4 July, the planned operational period of the monitor array, we requested that aircrews record (on a non-interfering basis) speed, altitude AGL, power setting, and approximate position as they passed the site. This request was forwarded to the units, and data were obtained for about half the flights.

3.5 Demographic and Attitude Observations

During the field program, informal observations were made as to the nature of the area and the attitude of local residents to flight operations. Most of this was accomplished by conversations with local residents along the route (near the Wild Horse site, and also near La Junta where measurements were attempted during the reconnaissance trip) and in nearby towns. The small size of Wild Horse and Kit Carson, plus local contacts necessary to obtain permission to operate on the ranch, resulted in general awareness of the project. All people whose opinions were solicited were told of the nature of the flight operations and this project. Additionally, one member of the field team drove throughout the area to assess the nature of the area and practical considerations for conducting formal social surveys. Some local officials were sought out and interviewed.

4.0 DATA ANALYSIS AND RESULTS

4.1 Automatic Monitor Data: Noise Levels and Positions

Following completion of the field program, data from the LD-700 monitors were collated and correlated with schedule and field log data to obtain an inventory of events. Reduction of monitor data consisted of the following steps:

- All field data files were printed out.
- A list of potential event times was compiled, consisting of all scheduled times plus observed aircraft times. Exceedances at these times were flagged.
- Exceedances clearly matching known events typically had maximum levels above 80 dBA, durations longer than 10 seconds, and appeared simultaneously on several monitors. The data files were reviewed again, and similar patterns flagged.
- Copies of data files were edited to include only flagged events. Edited files were merged, and reordered so as to group together simultaneous exceedances across a number of monitors.
- Data from the merged and reordered file were plotted, showing maximum A-weighted level and SEL* as a function of location on the array. From these plots, maximum recorded levels were identified and aircraft position was identified as the location of the maximum level. Numeric values of maximum levels, once identified, were taken from the original digital data files.

Figures 7, 8, and 9 are samples of the final data plots. They show a B-52 at TA altitude, a B-52 at IR, and a B-1 at TA, respectively. Note that the abscissa is marked in units of monitor station spacing intervals, which are one-eighth mile apart along the array, approximately 470 feet apart across the route. Note the distinct difference in character between the TA and IR data. Aircraft were either at TA altitude of 450 to 830 feet AGL, or at IR altitude of 2,200 to 3,000 feet AGL.** The characteristics of the data plots provided a means to identify altitude range for those flights not observed and for which aircrews were not able to report flight parameters.

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* All sound levels in this report are referenced to 20μPa. All sound exposure levels are referenced to $(20\mu Pa)^2 \cdot 1$ second.

** As reported by aircrews. This is consistent with expectations from the discussion in Section 2.1. Average airspeeds at TA conditions were 328 kt, 530 kt, and 420 kt for B-52, B-1, and FB-111, respectively. Average power settings were 85 percent, 98 percent, and 90 percent, respectively.

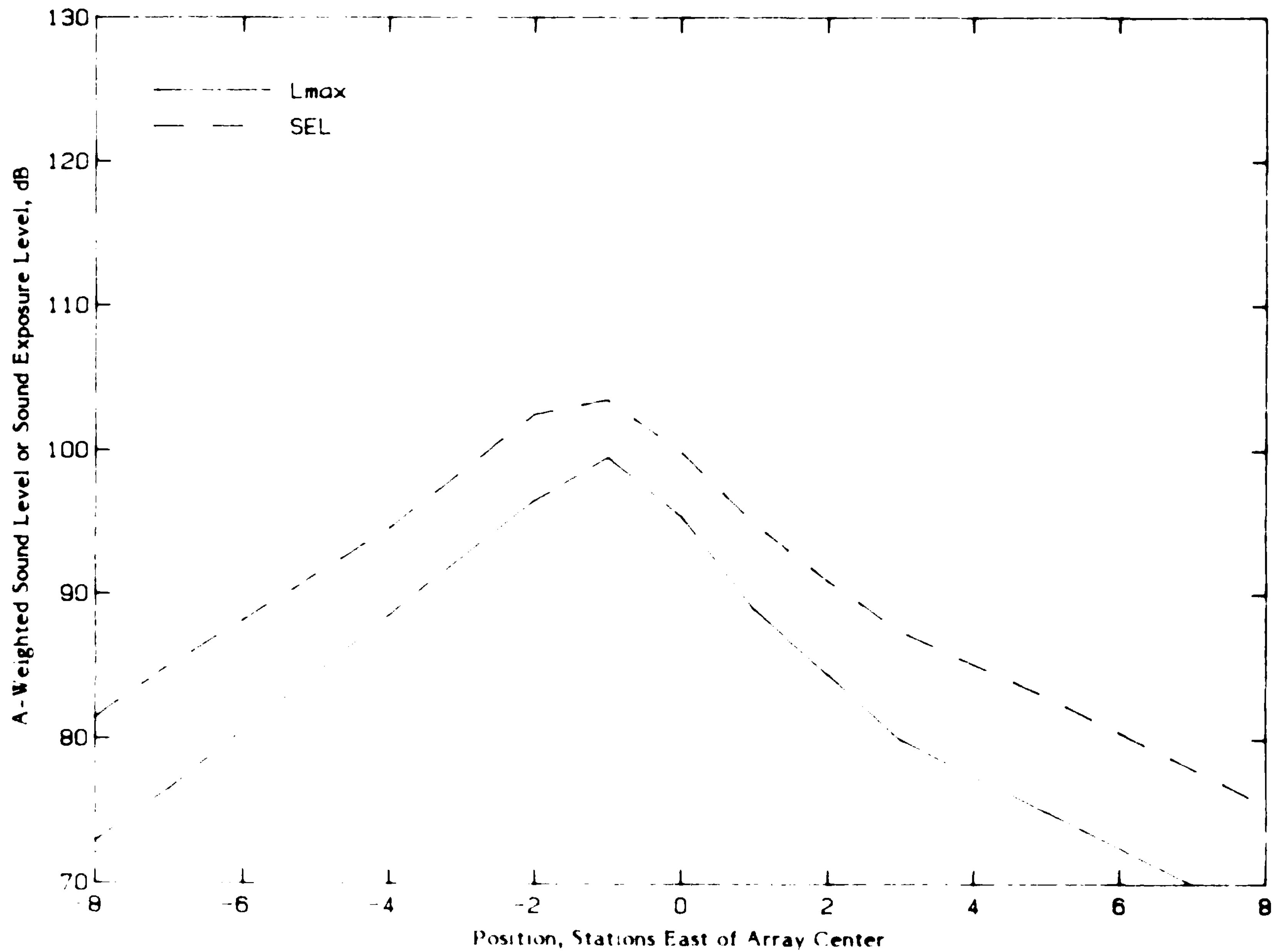

Figure 7. Noise Footprint of B-52H at TA Altitude (830 Feet AGL, 298 kt, 80 Percent Power).

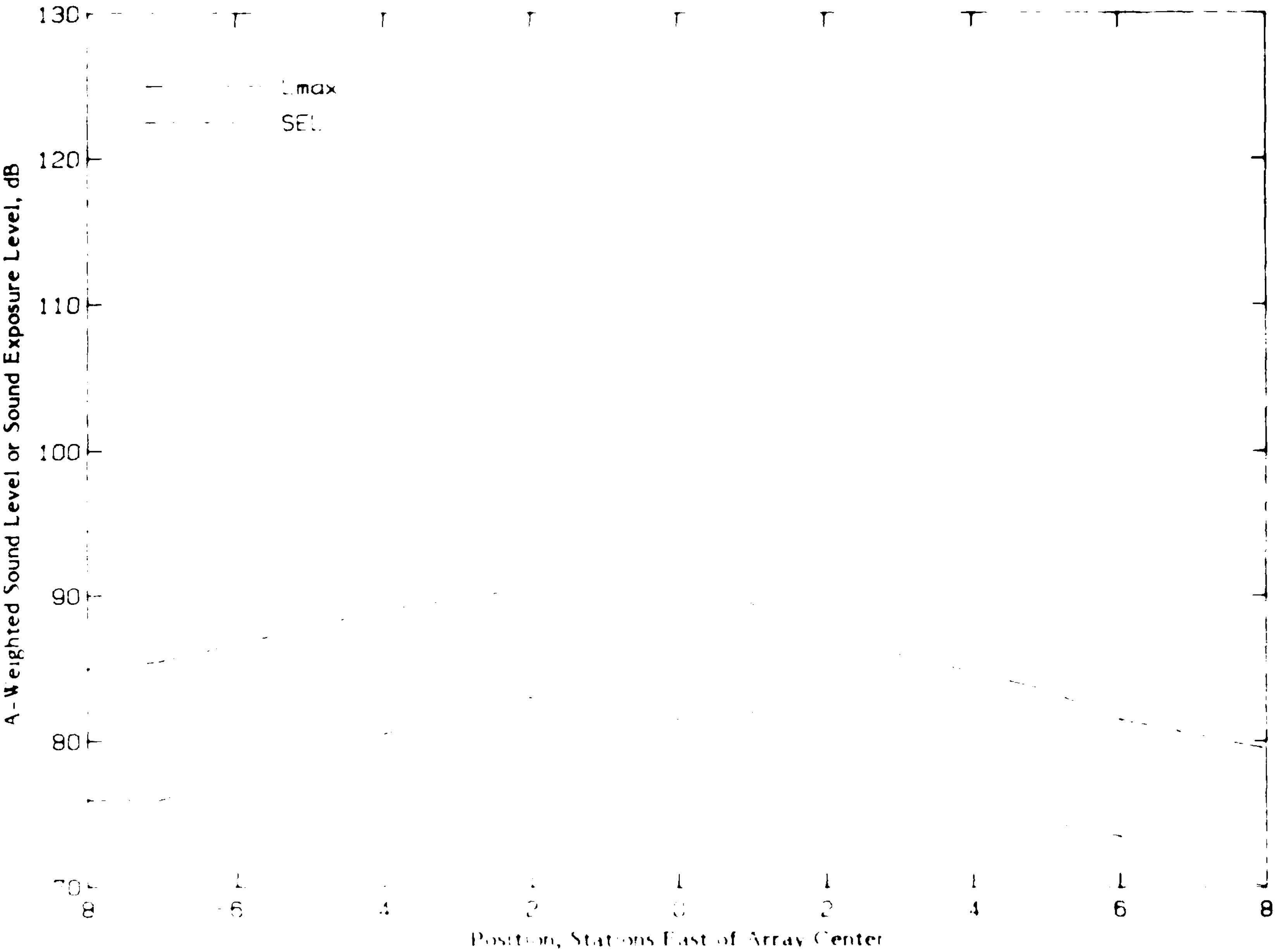

Figure 8. Noise Footprint of B-52H at IR Altitude (2,850 Feet AGL, 368 kt, 84 Percent Power).

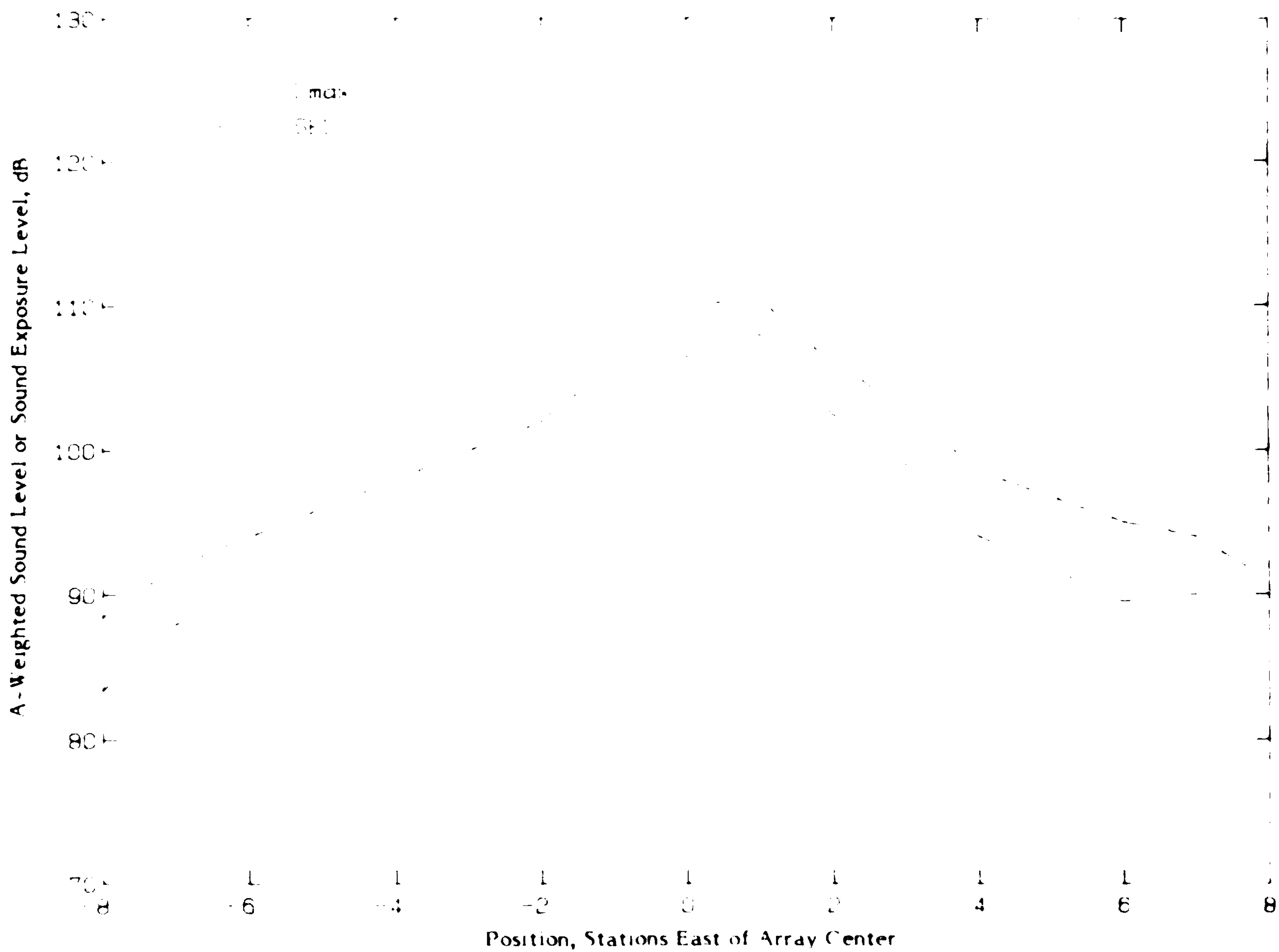

Figure 9. Noise Footprint of B-1B at TA Altitude (600 Feet AGL, 530 kt, 98 Percent Power).

A total of 53 events was logged, including two B-52 flights observed on 16 June for which analog recordings were attempted. This is the total of aircraft detected by the monitors, seen at the site, and known to have flown from schedule information. Of these, five yielded no data. Two "no-data" events were the 16 June flights, which did not pass close enough to the tape recorders. The other three "no-data" events were B-52 second or third passes, all at IR altitude, which had not entirely rejoined the route. The remaining 48 events registered on the monitors such that their position could be positively identified.

Table 4 is a summary of those 48 flights. Shown are date, time (both local time and Greenwich mean time), aircraft type, altitude (either TA or IR), position, and sound level. Sound level data are maximum values, and are shown for the 39 events within the bounds of the array. Table 5 is a summary of the distribution, by aircraft type and altitude, of these 39 events within the array bounds.

The average noise levels for all three types of aircraft at both altitudes are shown in Table 6. Both the arithmetic average and the energy average are shown. The energy average is appropriate if these data are used for L_{dn} projections. Also shown in Table 6 are the numbers of each type of event, replicated from Table 5. The standard deviation of each sample was 3 to 5 dB. The number of samples and standard deviations should be kept in mind when interpreting these data, particularly for FB-111s where only a few isolated events occurred.

Measured levels for B-52 and B-1 aircraft are in excellent agreement with predictions from the Air Force's existing NOISEFILE data base. Table 7 shows predictions generated by Omega 10.5 analysis software operating on NOISEFILE 5.1 data.[7] Also shown in Table 7 are averages from Table 6, plus the range spanned by each data set. Except for B-1 L_{max} measurements being slightly lower than predicted, energy-average levels and predicted levels agree extremely well, with differences within the 90-percent confidence intervals of the field data. The B-1 L_{max} data may be low because of the slow meter response, versus a nominal 0.5-second integration time in the NOISEFILE data base. One of the B-1 events estimated to be TA had L_{max} of 95 dB. This was 7 dB below the next quietest event, and lowered the B-1 averages. The lateral footprint pattern for this event generally matches other TA characteristics, however, and there are no independent flight parameter data which could justify deleting it from the data set. Allowing for this single anomaly, the field data and the NOISEMAP predictions are seen to be fully consistent.

Table 4

Summary of Position and Noise Level Data

Date Local	Time Local (MDT)	Time Zulu (GMT)	Aircraft	Alt	Pos	Lmax	SEL	
17 June	2316	0516	B-1	IR	3	84	90	
18 June	0020	0620	B-52G	IR	3	91	99	
	0050	0650	B-52G	IR	3	89	[illegible]	
	1129	1729	B-1	TA	[illegible]	[illegible]	114	**
	2106	0306	B-1	TA	3	[illegible]	[illegible]	
	2130	0320	B-1	IR	6	86	92	
	2154	0354	B-1	TA	4	[illegible]	[illegible]	
19 June	[illegible]	[illegible]	B-52G	TA	[illegible]			**
	0819	1419	B-52G	TA	6			**
	[illegible]	[illegible]	B-52H	TA	[illegible]	[illegible]	[illegible]	**
	[illegible]	[illegible]	B-52H	IR	[illegible]	85	[illegible]	**
	[illegible]4	[illegible]4	B-52H	IR	[illegible]	[illegible]	[illegible]	**
	[illegible]	[illegible]	F-111	IR	6	[illegible]	[illegible]	**
[illegible] June	[illegible]	[illegible]	FB-111	TA	8			**
23 June	[illegible]	1613	FB-111	TA	8	[illegible]	[illegible]	**
	[illegible]	1855	B-52G	TA	[illegible]	94	[illegible]4	**
24 June	[illegible]	[illegible]	B-1	TA	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	B-52H	TA	4	[illegible]	[illegible]4	**
	[illegible]	[illegible]	B-52G	TA	[illegible]	[illegible]	[illegible]	**
	2349	0549	B-52G	TA	[illegible]	99	[illegible]4	
25 June	[illegible]	[illegible]	B-52G	IR	4	88	[illegible]	
	1219	1819	B-52H	TA	8			**
	1250	1850	B-52H	TA	8			**
	[illegible]	[illegible]	B-52H	IR	8	85	[illegible]	**
	[illegible]	[illegible]	B-52H	IR	[illegible]	91	[illegible]	**
27 June	[illegible]	[illegible]	B-52H	TA	[illegible]	[illegible]	[illegible]4	**
	[illegible]4	[illegible]4	B-52H	IR	8	[illegible]	[illegible]	**
	[illegible]4	[illegible]4	B-52H	IR	[illegible]	[illegible]	[illegible]	**
[illegible] June	[illegible]	[illegible]	B-1	TA	4	[illegible]	[illegible]	**
[illegible] June	[illegible]	[illegible]	B-1	TA	8			
	[illegible]418	[illegible]	B-1	IR	8			**
	[illegible]	[illegible]	B-1	IR	8			**
	[illegible]	[illegible]	B-52G	TA	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	B-52G	TA	[illegible]	[illegible]	[illegible]	
[illegible] July	[illegible]	[illegible]	B-52G	IR	4	[illegible]	[illegible]	
	[illegible]	[illegible]	B-52G	IR	[illegible]	[illegible]	[illegible]	
	[illegible]244	[illegible]44	B-1	TA	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	B-1	IR		[illegible]	[illegible]	
	[illegible]	[illegible]	B-1	TA	4	[illegible]	[illegible]	
	[illegible]	[illegible]	F-111	IR	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	B-52G	TA	[illegible]	[illegible]	[illegible]	
2 July	[illegible]4	[illegible]4	B-52G	IR	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	B-1	TA	4	[illegible]	[illegible]4	
	[illegible]	[illegible]	B-52G	TA	4	[illegible]	[illegible]4	**
	[illegible]	[illegible]	B-52G	TA	[illegible]	[illegible]	[illegible]	**
	[illegible]	[illegible]	B-52G	TA		[illegible]	[illegible]	**
	[illegible]	[illegible]	B-1	TA	4	[illegible]	[illegible]	**
	[illegible]	[illegible]	B-1	TA	8			**

[illegible] estimate from level and lateral footprint
[illegible] off array; no noise data
** = analog recording made

Table 5

Summary of 39 Events Over Array

	B-52	B-1	FB-111
TA	12	9	1
IR	12	3	2

Table 6

Average Maximum Levels

Aircraft	Altitude	Average L_{max}		Average SEL		Number of Samples
		Arith.	Energy	Arith.	Energy	
B-52	TA	100.3	102.1	105.2	106.6	12
B-52	IR	86.8	87.8	94.4	95.5	12
B-1	TA	104.9	106.9	108.8	110.9	9
B-1	IR	85.3	85.4	91.3	91.4	3
FB-111	TA	100.0	100.0	105.0	105.0	1
FB-111	IR	93.5	93.8	97.5	97.5	2

Table 7

Comparison of Measured TA Levels
With NOISEFILE Predictions

	L_{max}				SEL			
	Measured			Predicted*	Measured			Predicted*
	Range	Arith. Average	Energy Average		Range	Arith. Average	Energy Average	
B-52	95-105	100.3	102.1	102.8	101-112	105.2	106.6	106.7
B-1	95-111	104.9	106.9	111.3	101-114	108.8	110.9	112.8

* Based on cruise at an altitude of 630 feet for both aircraft.
B-52 predictions are for H model at 330 kt and 1.16 EPR (equivalent to 85 percent power).
B-1 predictions are for B-1A at 530 kt and 98 percent power.

The most important information sought was the distribution of flights relative to the centerline. This is essential to predicting long-term average noise, and had never before been measured. A cumulative distribution of position was prepared, from the data in Table 4. In preparing the distribution, half the events assigned to a given monitor location were considered to be east and half to be west of it; this avoided a half-station offset error, and introduced a slight amount of smoothing. Use of the cumulative distribution allowed utilization of all 48 data points, including those beyond the ends of the array.

The position distribution is shown in Figure 10, on normal probability coordinates. A Gaussian distribution, represented by a straight line in these coordinates, fits the data extremely well. The mean position is very close to centerline, and the standard deviation is about 0.74 mile along the array. Since the array is at 45 degrees to the route, the standard deviation normal to the route centerline is one-half mile.* The result that operations are normally distributed about the centerline is quite reasonable, since each flight is an independent event and there are no constraints which would lead to expectation of a unique distribution. The measured value of the standard deviation is also consistent with estimates by SAC personnel that 90 percent of flights are within one mile of centerline.

4.2 Analog Recordings: Time Histories and Spectra

The analog recorders were deployed around the center of the array, as shown in Figure 3. When all three recorders were deployed, aircraft within about a 1,800-foot window (from just west of position -2 to about position +1) would pass nearly directly over at least one microphone. From Table 4, it is seen that one B-1 and five B-52s at TA altitudes were within this range. Two additional B-1s and three B-52s at TA altitudes passed within one-quarter to one-half mile (two to four stations) of a microphone. Several recordings of B-52s at IR altitude were obtained, with two nearly overhead. Only two recordings were obtained of B-1s at IR altitude, both beyond the ends of the array.

One recording was obtained of an FB-111 at TA altitude over the array, at its eastern end. One recording was obtained of an FB-111 at IR altitude, also near the eastern end of the array.

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* The relationship between the route and the measurement array may be seen in the site map, Figure 2. Due to logistical considerations, the array center was two stations west of the geometric route centerline. The mean location shown in Figure 10 is about midway between the array center and the route centerline, about 0.2 standard deviation west of the route centerline.

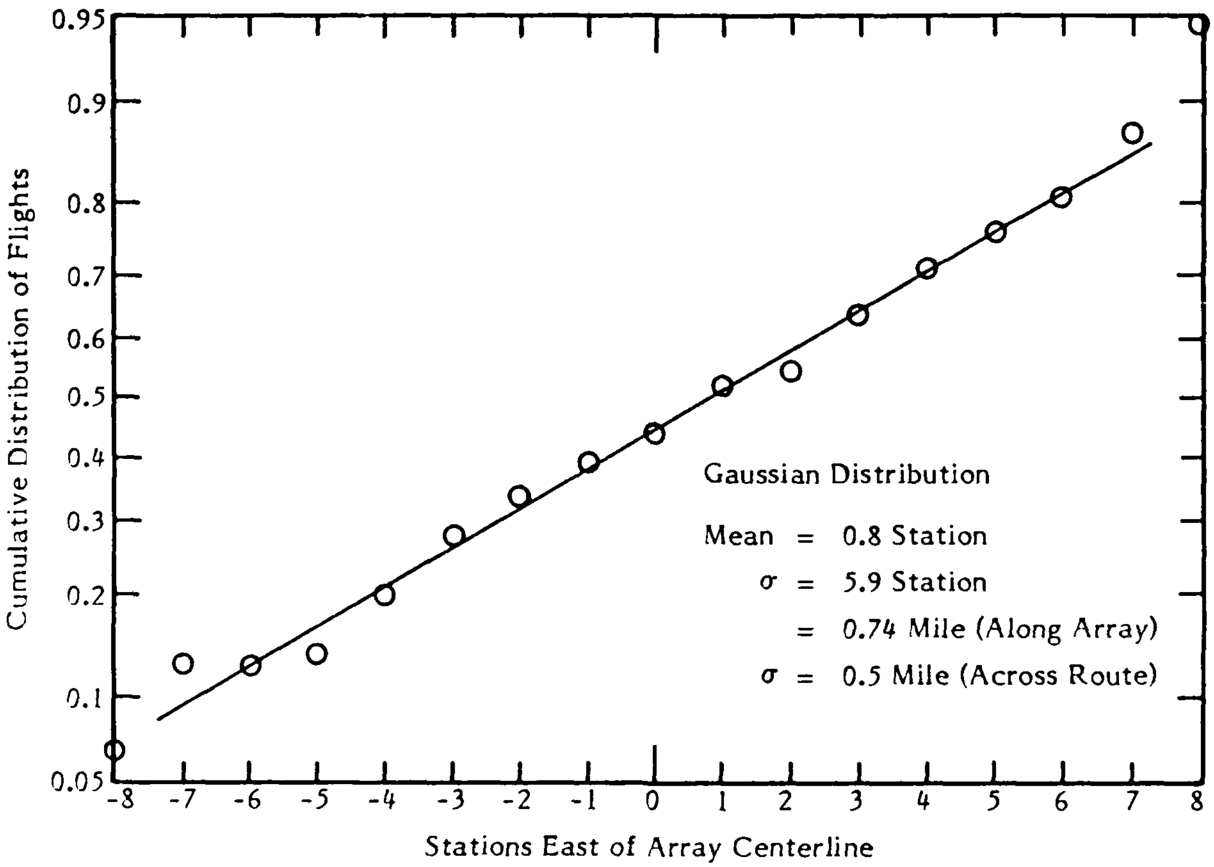


Figure 10. Statistical Distribution of Lateral Positions of All Aircraft on IR-177/501.

4.2.1 A-Weighted Time Histories

Figures 11 through 18 are selected A-weighted time histories obtained from the analog tape recordings. They were drawn by a B&K Type 2305 Level Recorder using a pen speed of 100 dB/sec, approximating about one-half the integrating time of "fast" response.

- Figures 11 and 12 are overhead TA passes of a B-52 and a B-1, respectively. They are the best individual records.
- Figures 13 and 14 are sequences of simultaneous measurements of all six microphones, for B-52 and B-1 TA passes. They are the best sets of records where all six analog recording channels were in operation and the aircraft passed over or near the end of the analog array.
- Figures 15 and 16 are IR passes of a B-52 and B-1, respectively. The B-52 was overhead, while the B-1 was beyond the end of the automatic monitor array, about a mile to the side. Note that the time scale on these figures is different from the others.
- Figures 17 and 18 are TA and IR passes, respectively, of an F/FB-111. Both were well to the side, just within the automatic monitor array.

Position data in the captions are in units of automatic monitor station spacing, which was one-eighth mile along the array or 470 feet normal to the route.

The one striking feature of these data is the difference between B-52 and B-1 time histories. The temporal pattern of a B-52 is fairly symmetric, indicating significant noise emission from both the inlet and exhaust of the engines. The onset rate seen in Figure 11 is about 10 dB/second, and the general shape is consistent with a field observation that B-52s could be heard approaching and did not sound significantly different from commercial jet aircraft. The onset rate of a B-1, as seen in Figure 12, is two to three times as rapid. This is consistent with field observations that B-1s could not be heard approaching, and suddenly became audible when overhead. This observation held true for the point of closest approach when a B-1 passed to one side, while B-52s to one side tended to have longer, more gradual noise signatures. In Figure 13, the overhead B-52 event has an onset of about 7 dB/second; this rate consistently diminishes with lateral distance to about 4 dB for the farthest position in Figure 13(f). The B-1 onset times in Figure 14 are consistently about 25 dB/second (with an anomalous 15 dB/second at 13(e)) at all distances.

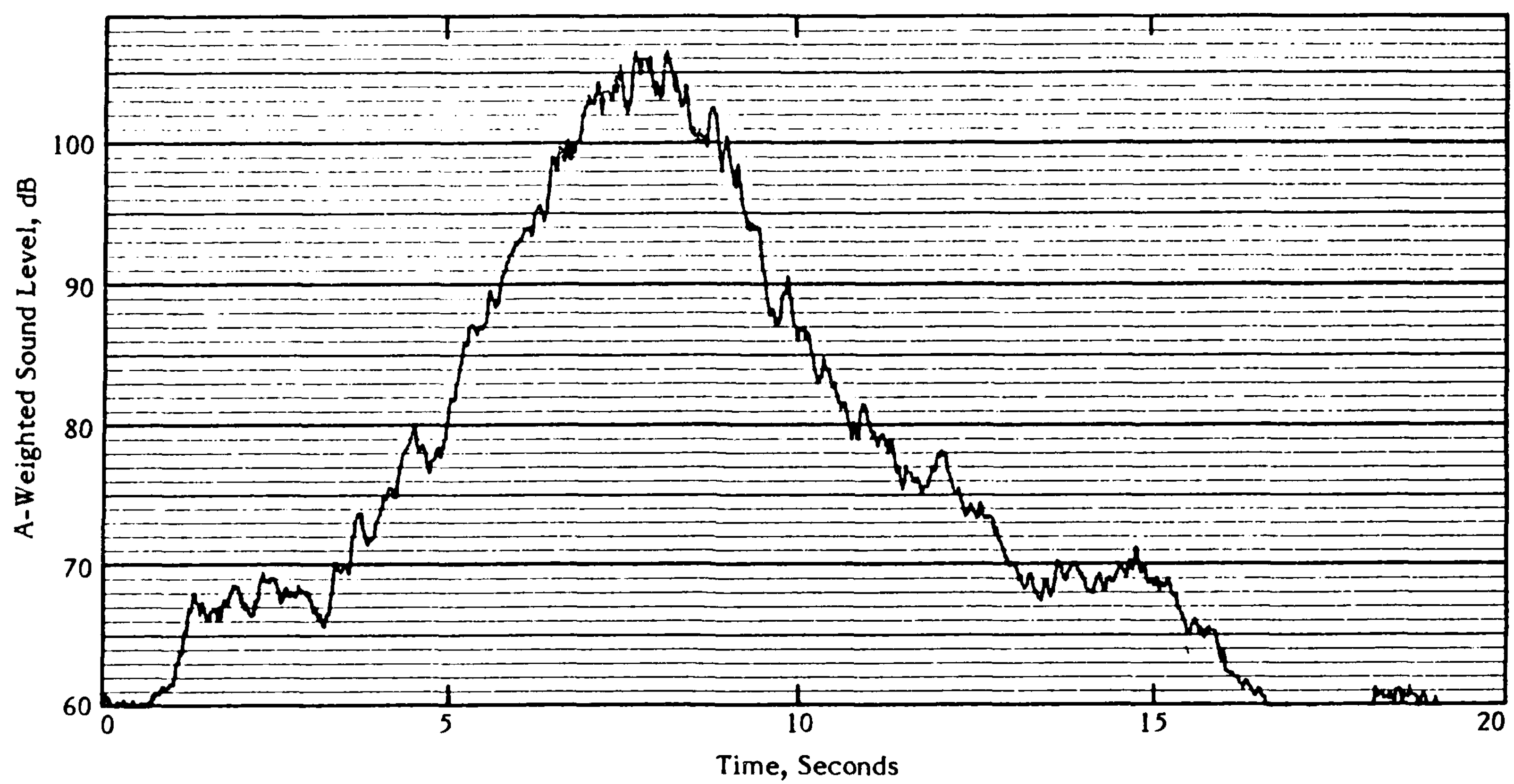


Figure 11. Time History of A-Weighted Sound Level, B-52H at TA Altitude, Directly Overhead.

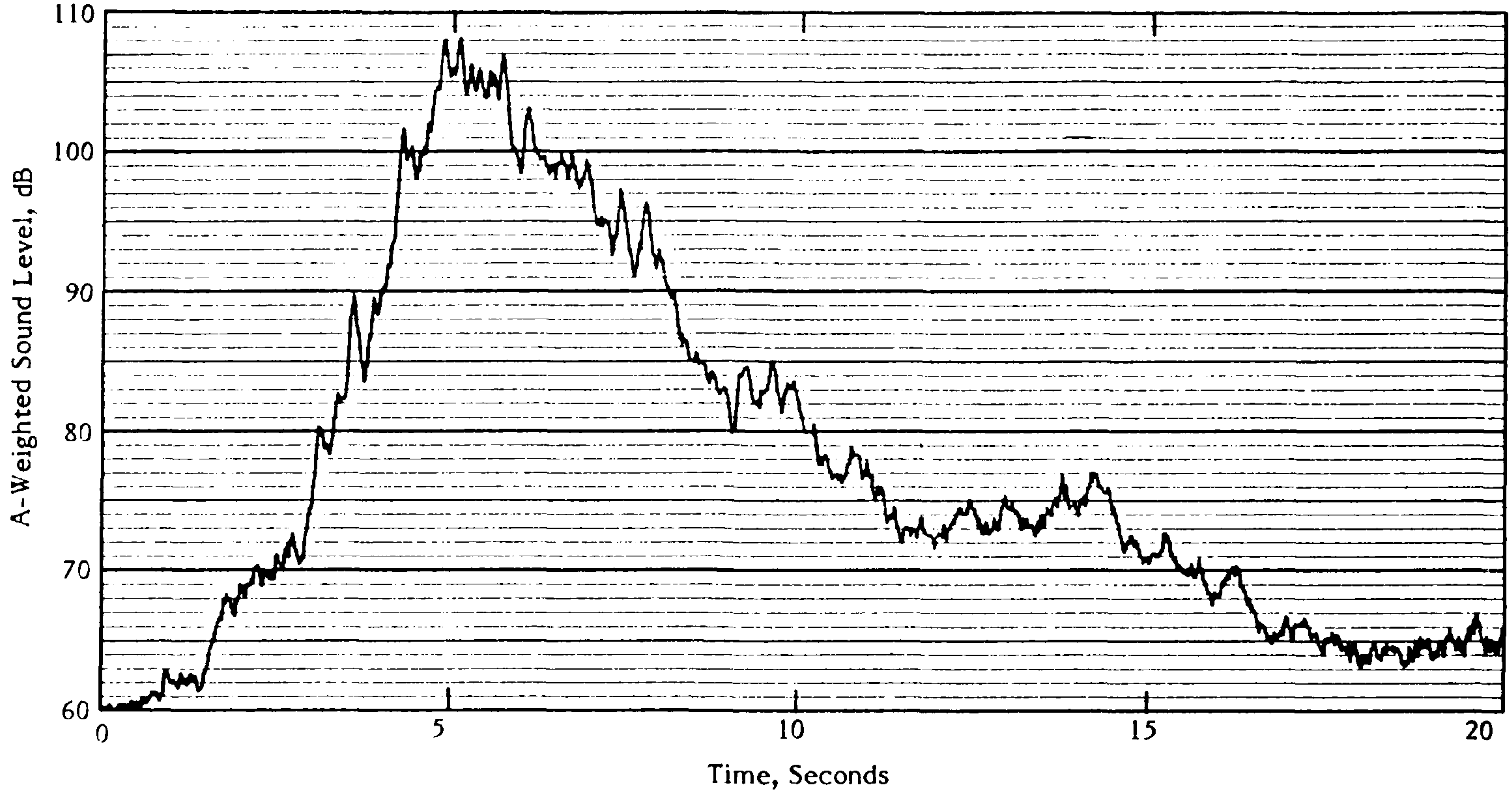
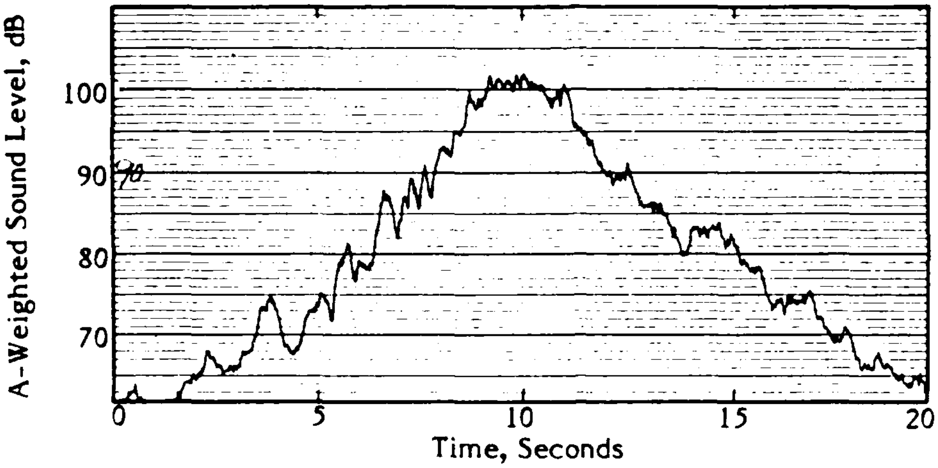
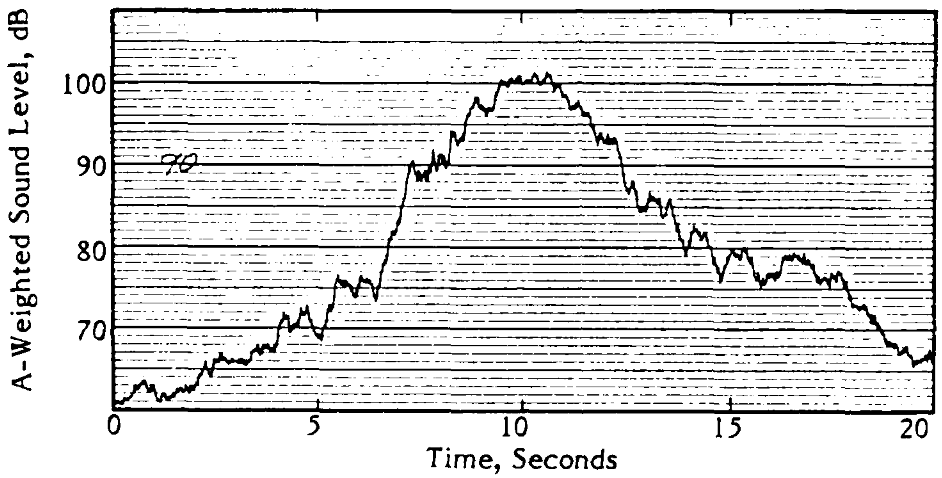


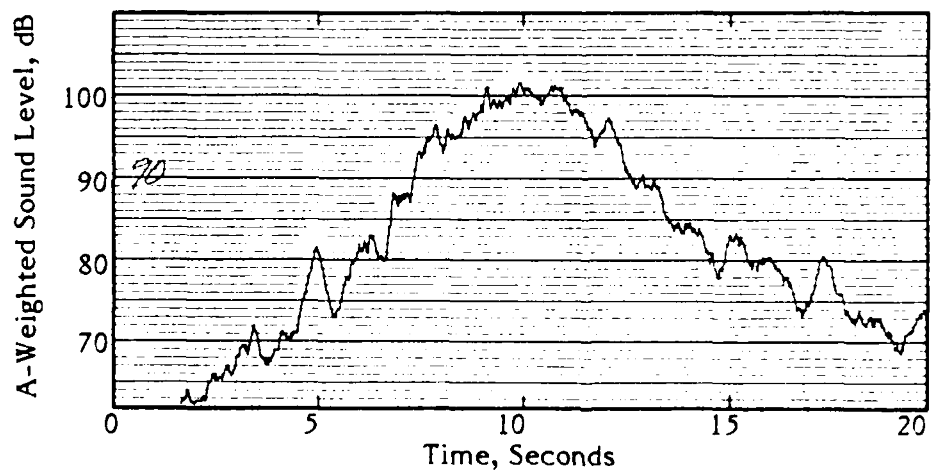
Figure 12. Time History of A-Weighted Sound Level, B-1B at TA Altitude, One Station Off-Track.



(a) On-Track.

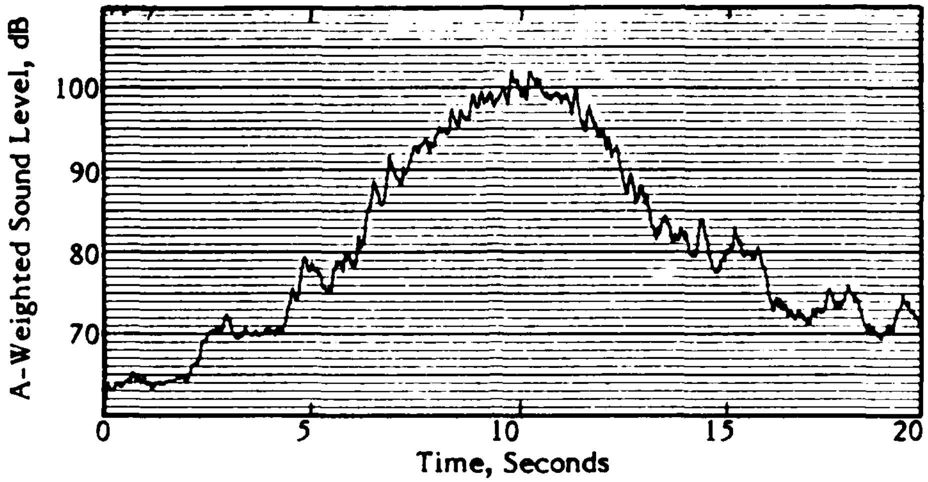


(b) 0.5 Station Off-Track.

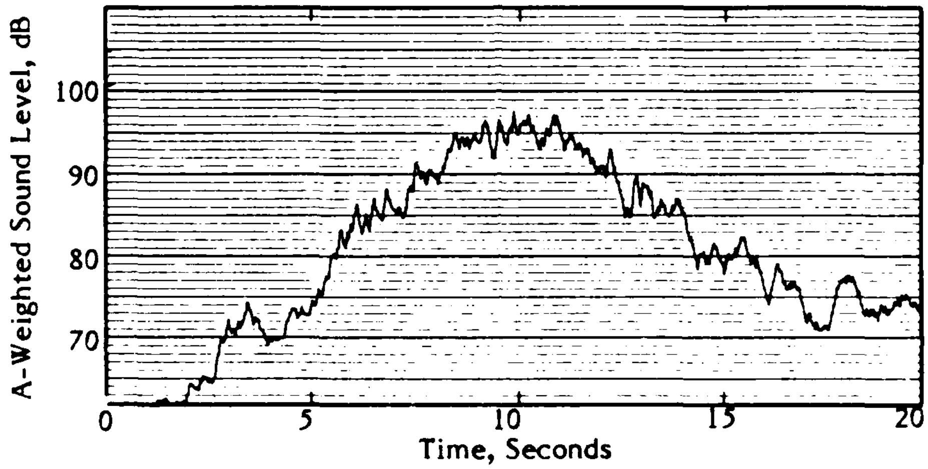


(c) 1.0 Station Off-Track.

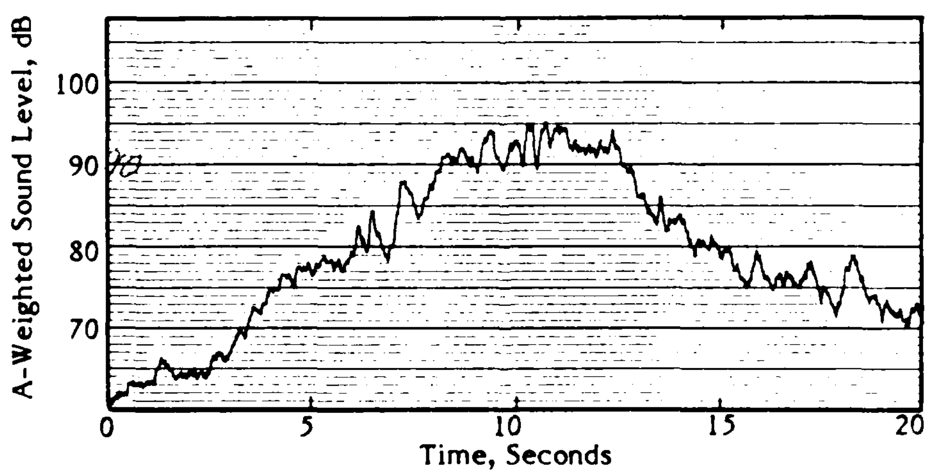
Figure 13. Time Histories of A-Weighted Sound Levels of B-52G, TA Altitude, Various Distances Off-Track.



(d) 1.5 Stations Off-Track.

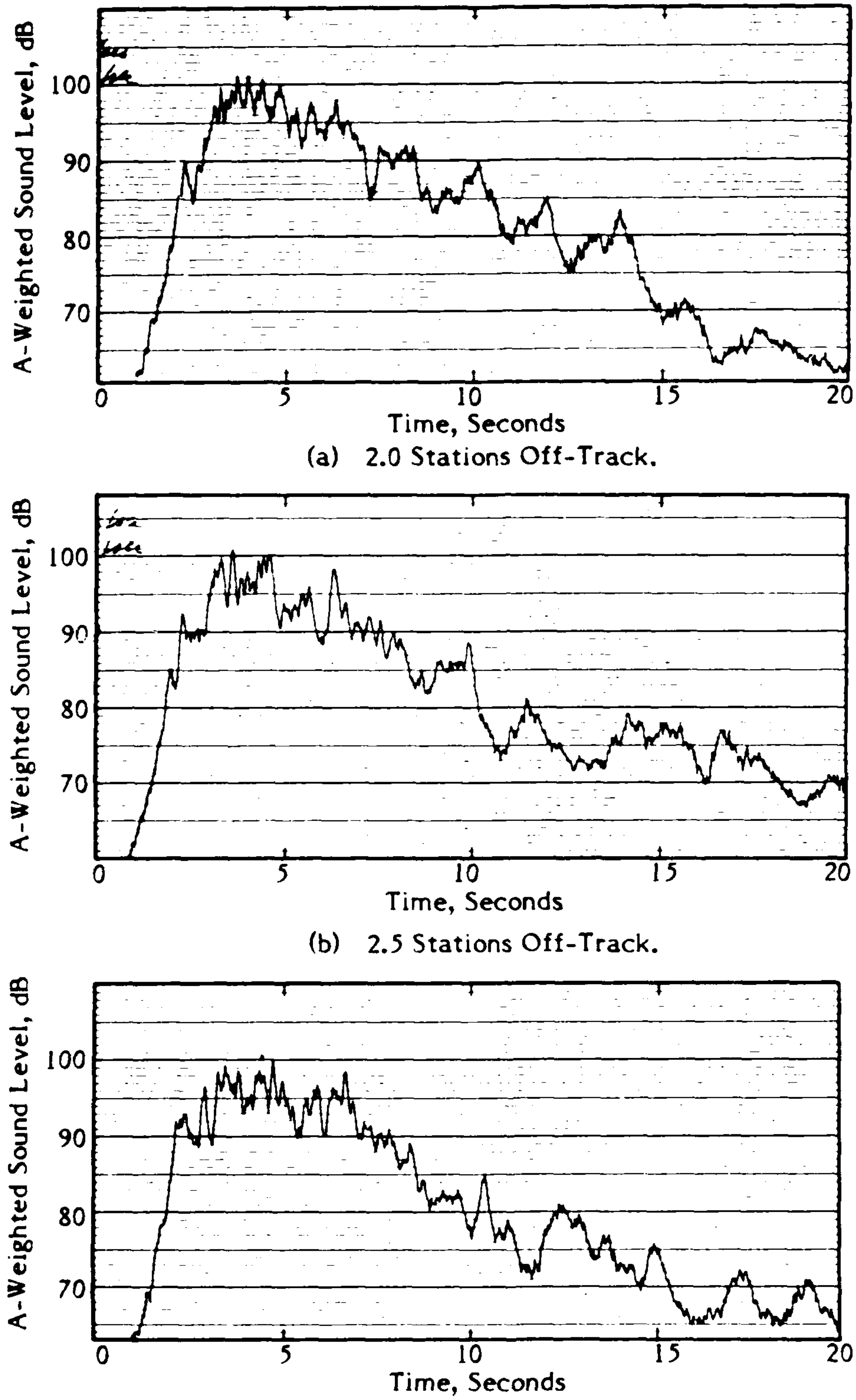


(e) 2.0 Stations Off-Track.



(f) 2.5 Stations Off-Track.

Figure 13 (Concluded).

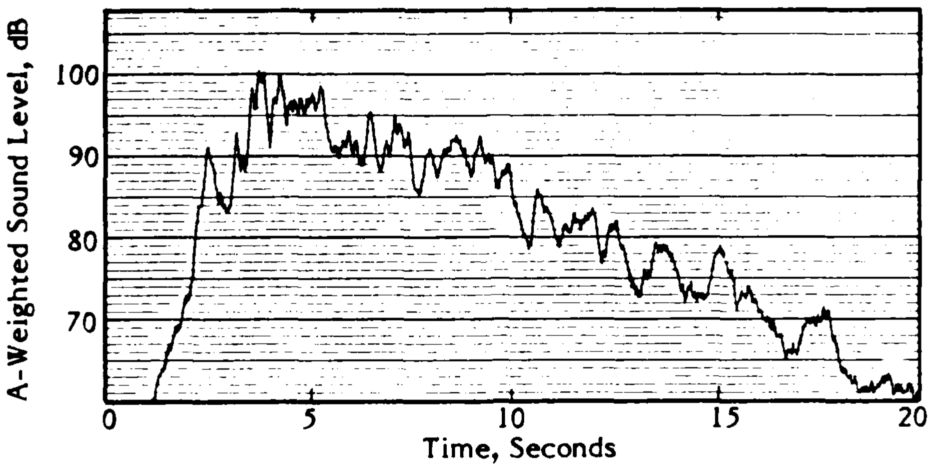


(a) 2.0 Stations Off-Track.

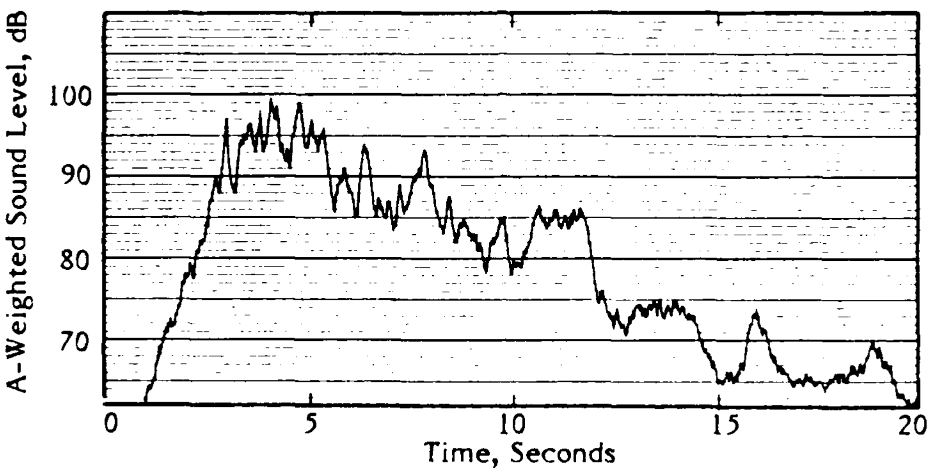
(b) 2.5 Stations Off-Track.

(c) 3.0 Stations Off-Track.

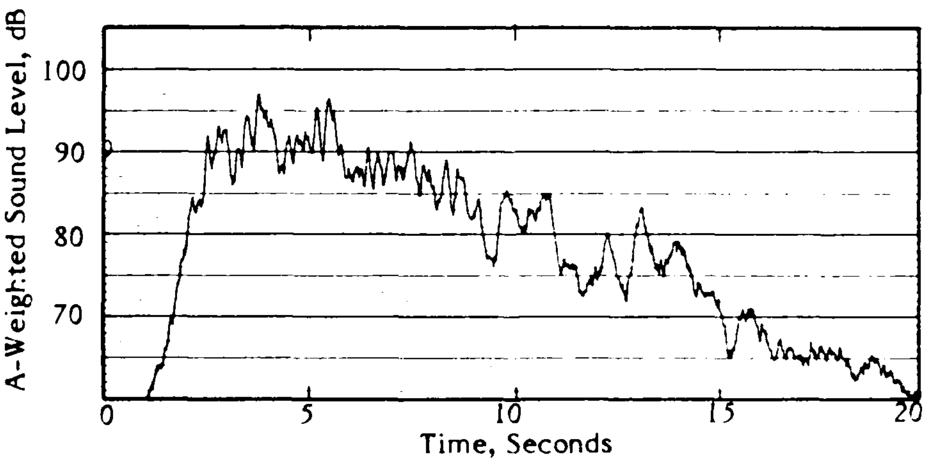
Figure 14. Time Histories of A-Weighted Sound Levels of B-1B, TA Altitude, Various Distances Off-Track.



(d) 3.5 Stations Off-Track.



(e) 4.0 Stations Off-Track.



(f) 4.5 Stations Off-Track.

Figure 14 (Concluded).

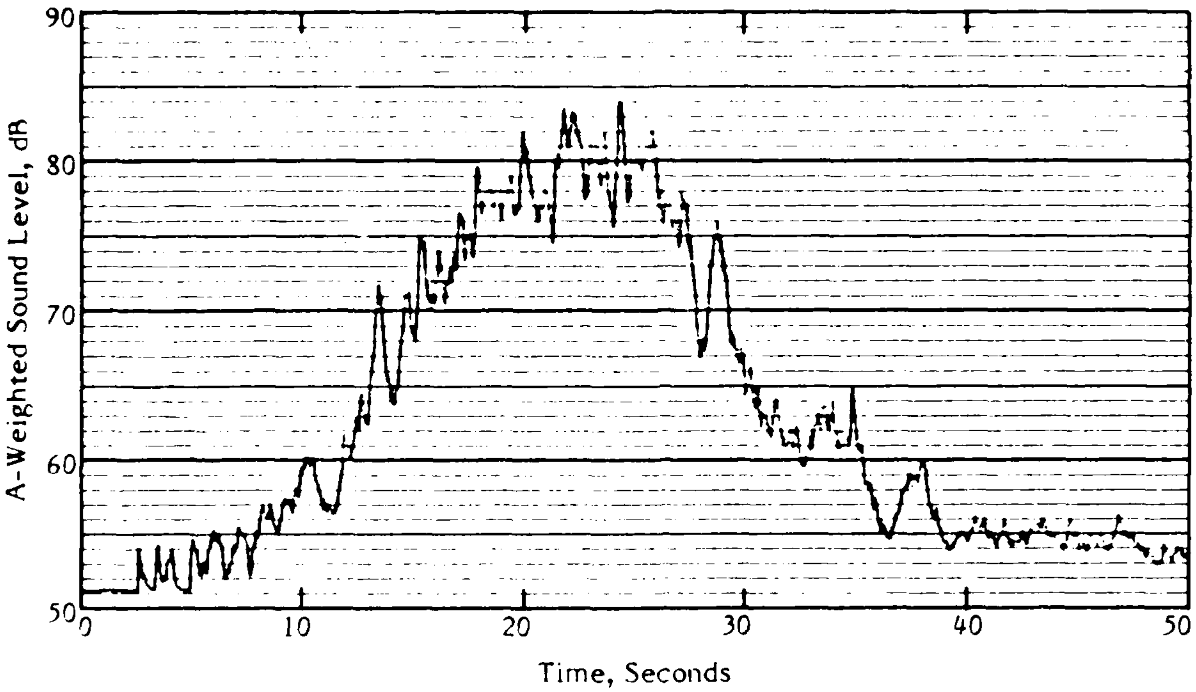


Figure 15. Time History of A-Weighted Sound Level of B-52H at IR Altitude, Overhead.

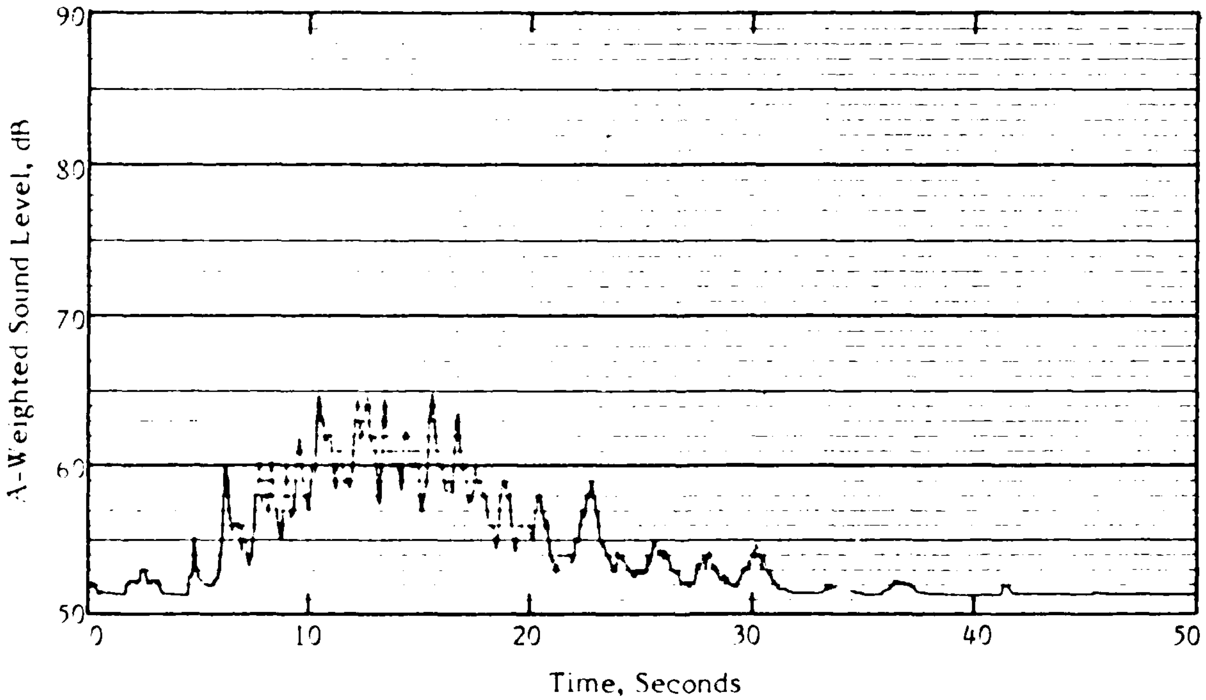


Figure 16. Time History of A-Weighted Sound Level of B-1B at IR Altitude, One Mile Off Track.

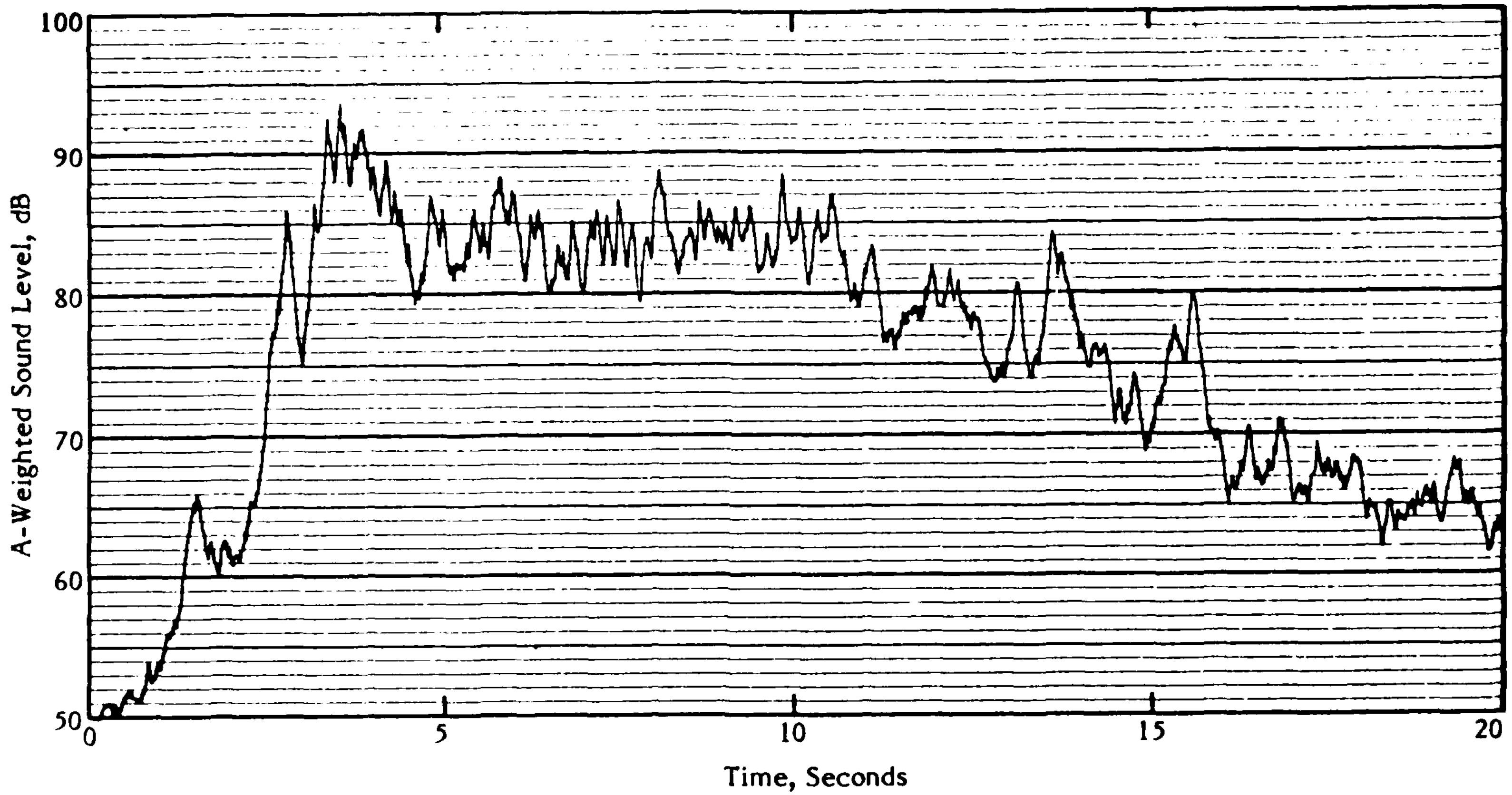


Figure 17. Time History of A-Weighted Sound Level of FB-111 at TA Altitude, Eight Stations Off-Track.

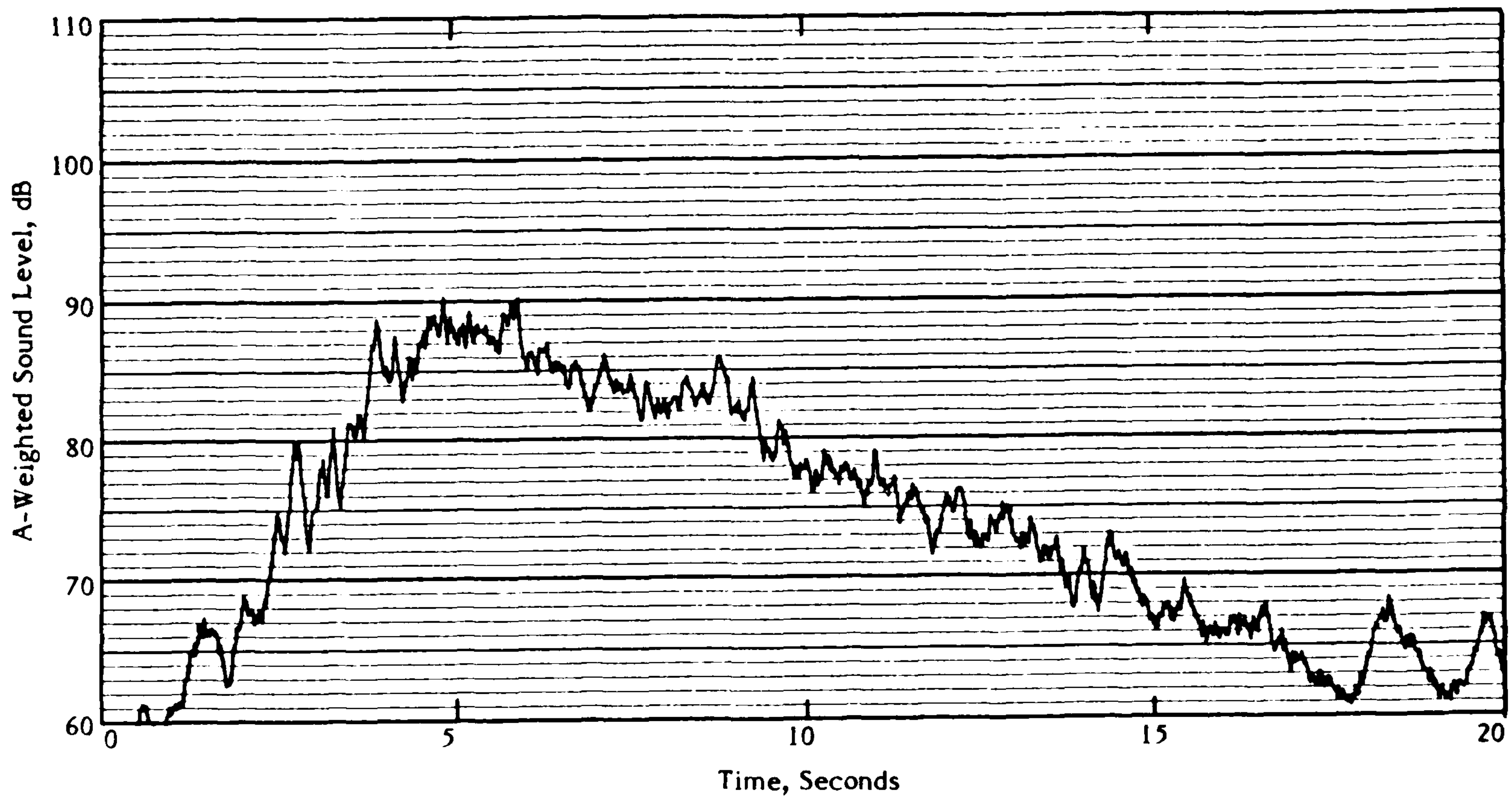


Figure 18. Time History of A-Weighted Sound Level of F-111 at IR Altitude, Six Stations Off-Track.

The character of B-1 time histories is clearly associated with directional characteristics of the engines, their installation, and the high speed. The airspeed of 530 kts is about Mach 0.8, for which a simple moving monopole would exhibit significant temporal distortion. The supersonic-design inlets have more ductwork ahead of the engine than the subsonic nacelles of a B-52. Maximum flow speed through the inlet throat would also be somewhat higher than Mach 0.8, further blocking forward noise emissions. The B-1's directivity pattern is consistent with the nature and speed of the aircraft, and can quite reasonably be expected for this type of high-performance aircraft. The significance of this characteristic is that a B-1 sounds different from a B-52 or a commercial jet aircraft, and human reaction may not necessarily be the same.

Time histories for IR altitudes (Figures 15 and 16) are consistent with expectations: lower levels and slower onset times. The limited F/FB-111 data shown in Figures 17 and 18 indicate this aircraft's noise characteristics are similar to those of the B-1. This is fully consistent with the nature of the aircraft.

4.2.2 Spectra

The B-52 and B-1 events shown in Figures 11 and 12, respectively, have been analyzed to obtain one-third octave band spectra. Spectra at 0.5-second intervals, witn one-second exponential averaging, were obtained using a Larson Davis Model 3100 real-time analyzer. Figures 19 and 20 show the spectra in the audio frequency range (31.5 Hz through 8 kHz bands), from the direct recordings. Shown in each figure are spectra at the time of maximum A-weighted level, at 10 dB down before and after times, and 10 seconds after the maximum. Also shown for the B-1 is the spectrum 15 seconds after the maximum. The maximum for both events is about 105 dBA, and the level at the last point shown for each is about 65 dBA. The 10 dB down points are within 1 to 4 seconds of the maximum. The 10-second after points correspond to distances of about 1.1 miles for the B-52 and 1.7 miles for the B-1.

The spectral characteristics are as expected. B-52 spectra are reasonably flat, with some tonal characteristics around 2 to 4 kHz, consistent with the turbofan engines of the B-52H. Figure 21 shows spectra for a turbojet-powered B-52G, which are similar except for the lesser tonal components. The relatively minor change in spectral shape within the

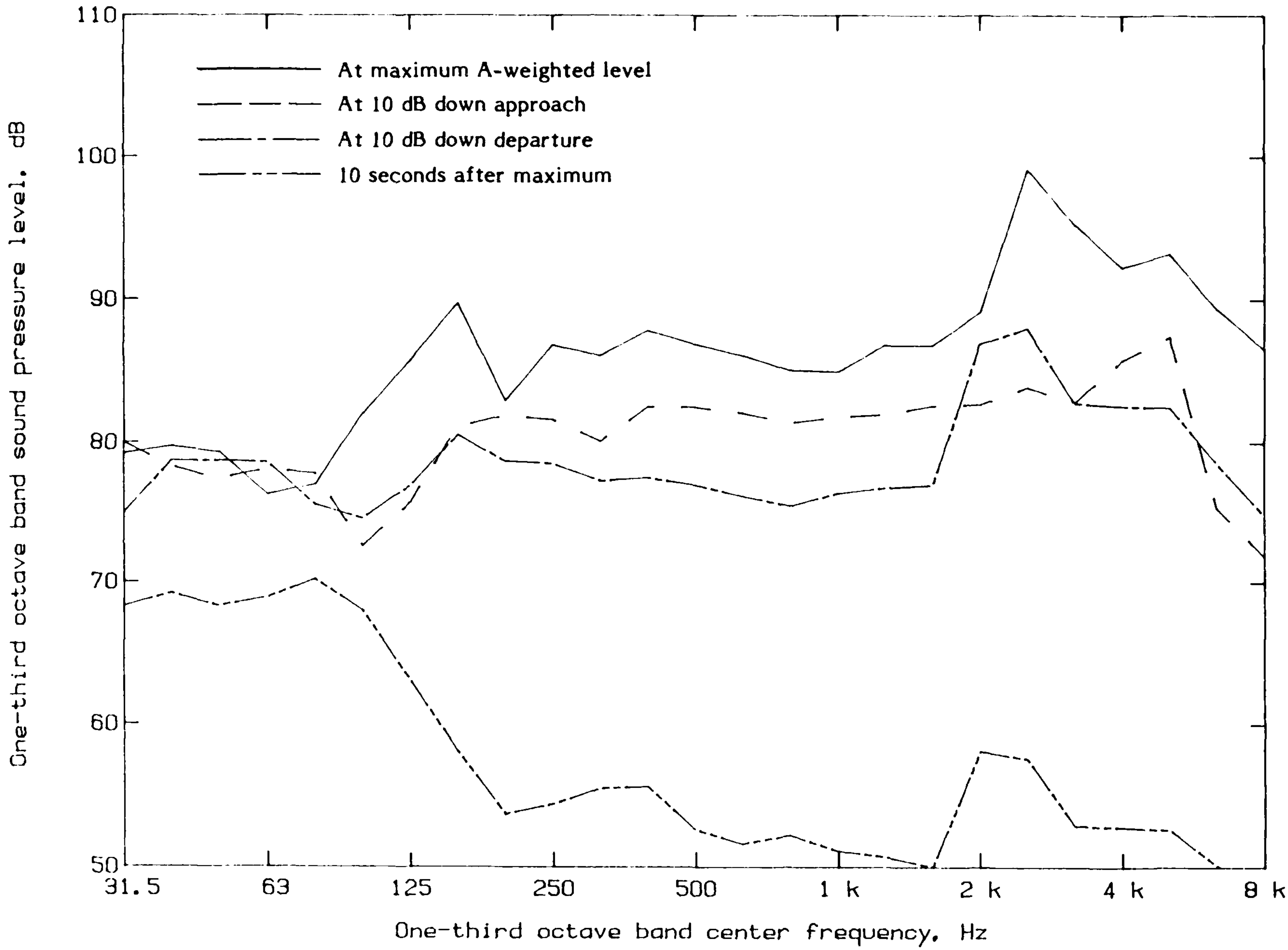


Figure 19. B-52H Spectra, TA Flight.

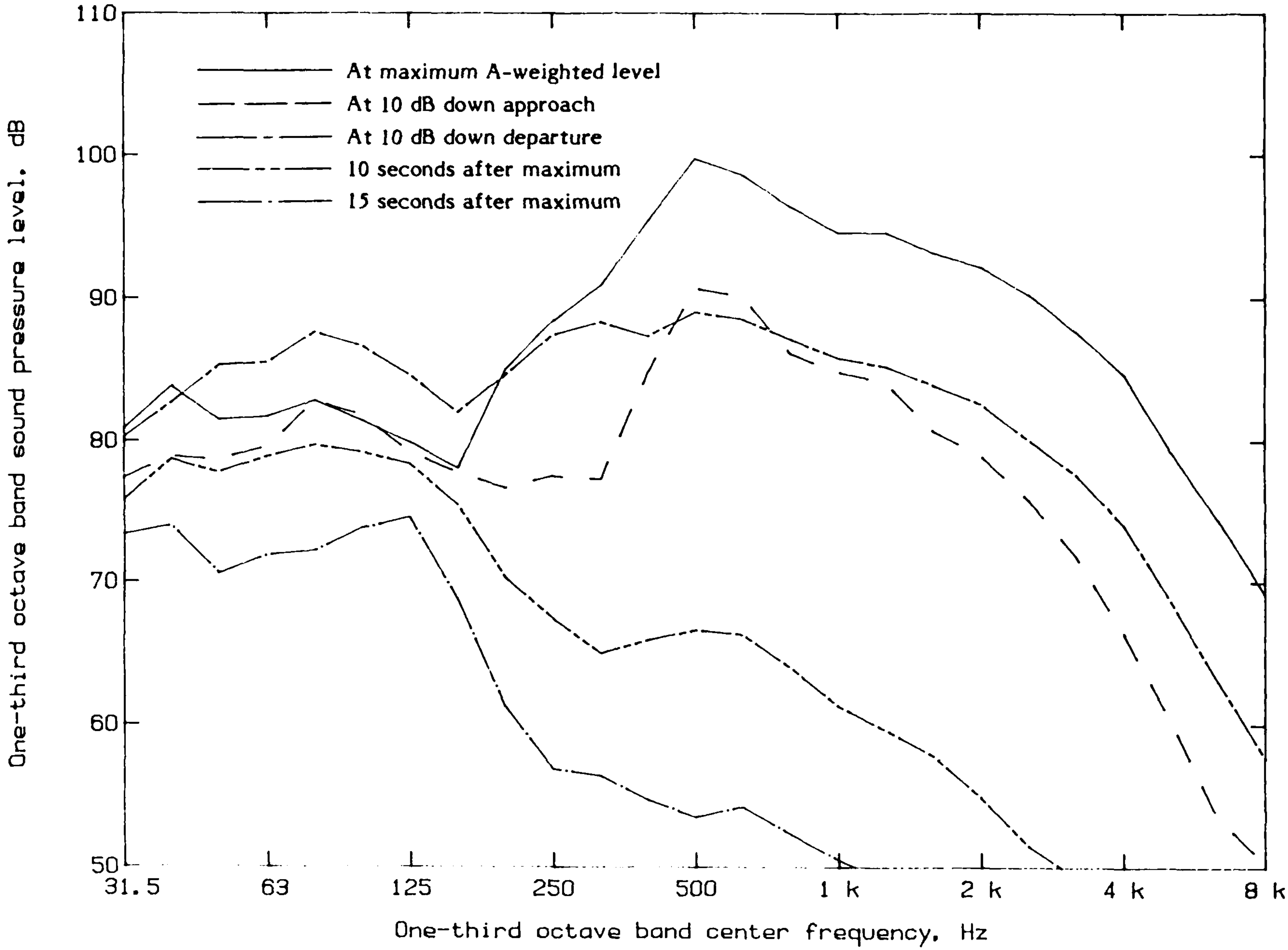


Figure 20. B-1B Spectra, TA Flight.

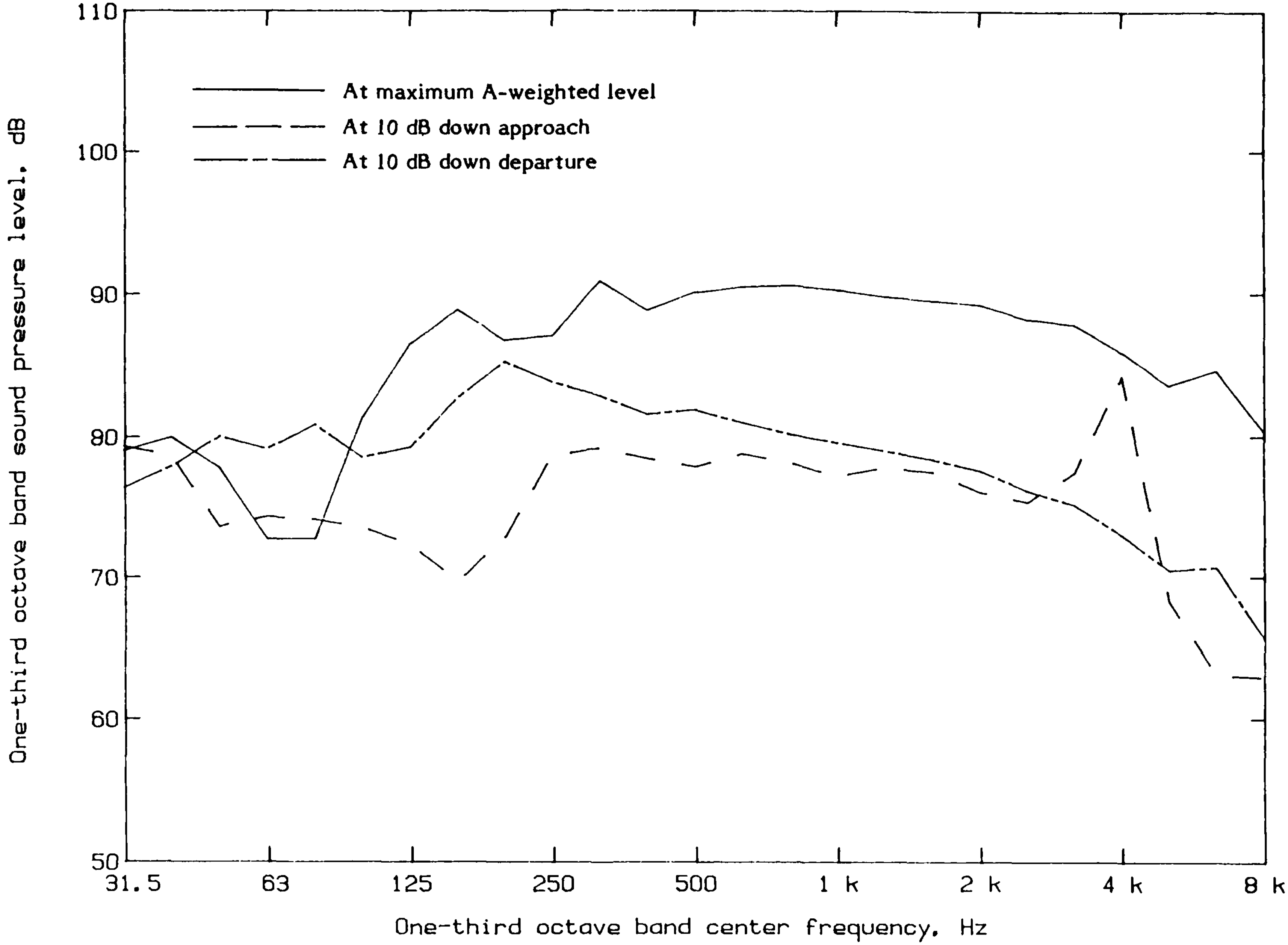


Figure 21. B-52G Spectra, TA Flight.

10 dB down range is consistent with the lack of perceived Doppler shift. The B-1 exhibited a larger shift toward low frequencies, as might be expected from its speed. Any perceived Doppler shift was, however, overwhelmed by the rapid onset time. Spectral shapes shifted to low frequency, at lower levels, as the aircraft disappeared into the distance. This is the usual behavior, due to the directional characteristics of jet engine exhaust noise, Doppler shift effects, and the sound absorption characteristics of the atmosphere.

Neither aircraft exhibited a substantial portion of its acoustic energy at very low or infrasonic frequencies. Maximum levels for both were dominated by medium to high frequencies, 250 Hz to 4 kHz, and C-weighted levels were generally within 2 dB of A-weighted at times within the 10 dB down period. Figures 22 and 23 show low-frequency spectra, from FM recordings, for a B-52 (same record and Figures 13(d) and 21) and a B-1 (same record as Figure 14(d)).

Most of the energy below 50 Hz is due to wind noise, as evidenced by the relatively small change through the event. The levels are also consistent with ambient measurements. The B-52G spectrum does exhibit an increase in the infrasound range (below about 20 Hz) shortly after L_{max}. The shape of the spectrum in this region, and the minimum around 25 to 50 Hz, suggests that this may have been a coincidental wind gust (wind was 5 to 9 mph, which was observed to generate levels above 90 dB on this channel) or a wake effect rather than low-frequency acoustic energy. This would bear further examination under more controlled test conditions.

The bulk of acoustic energy was clearly in the audio frequency range and field personnel did not observe objectionable low-frequency effects. However, the low-frequency levels seen in Figures 19 through 21 border on the range which can produce potentially annoying rattling of buildings.[3] This is a factor which must be considered if lower altitude flights are planned. Perspective must be maintained, however, that the high levels of low frequency are not a unique shape characteristic of these spectra, but simply an artifact of the fact that the overall sound levels are high. Potential building rattle would occur at a time when audible sound is well into the intrusive range.

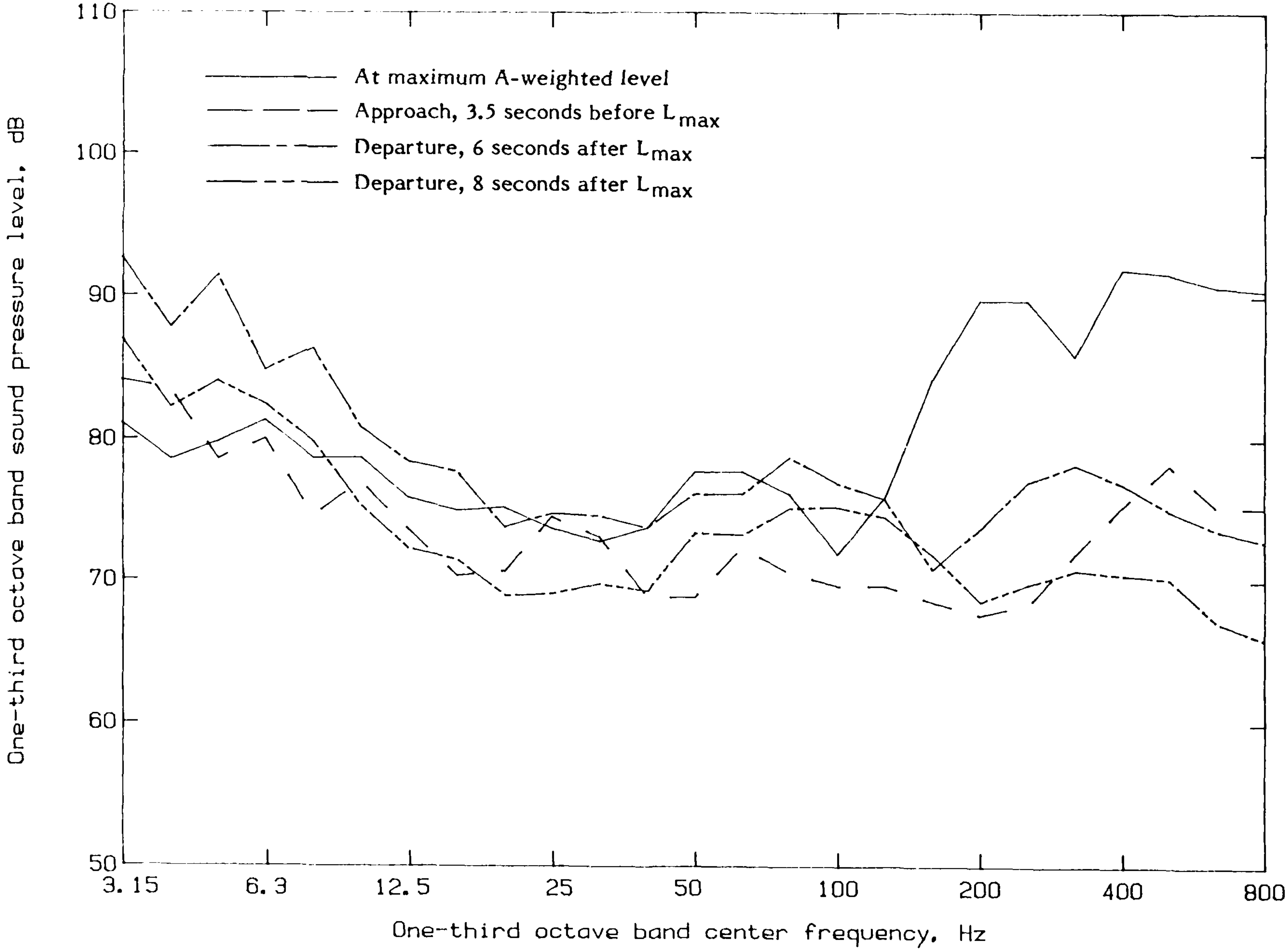


Figure 22. B-52G Low-Frequency Spectra, TA, 1.5 Stations Off-Track.

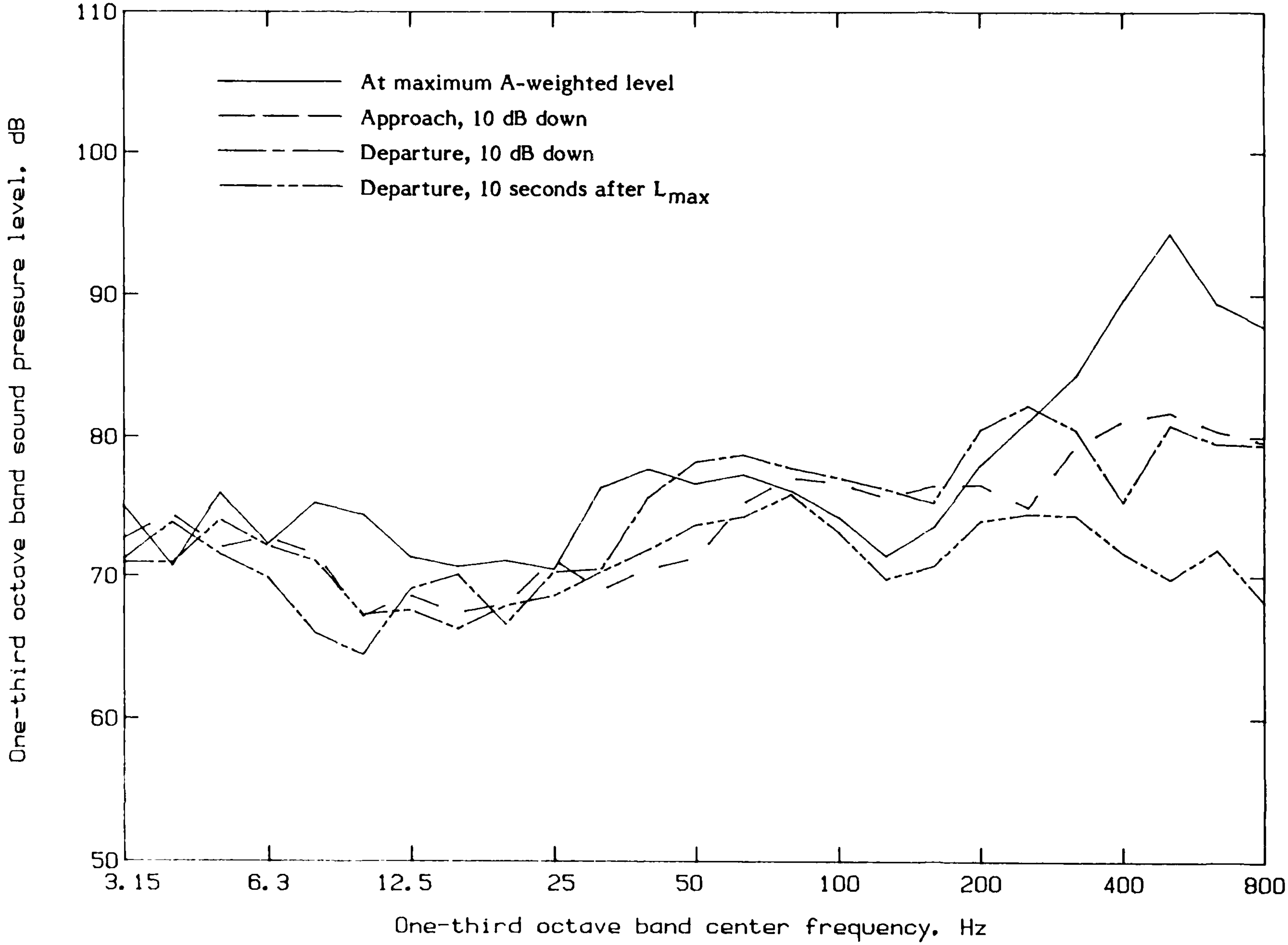


Figure 23. B-1B Low-Frequency Spectra, TA, 3.5 Stations Off-Track.

4.3 Demographic and Subjective Information

Demographic and subjective information was collected as described in Section 3.5. This information, which consists of anecdotes and subjective observations, is documented in two memoranda reproduced in Appendix A. The basic findings were as follows:

- Population is very sparse and distances are large. Formal social surveys will pose logistical challenges. A telephone survey is probably the most efficient method to conduct such a survey.
- The route and its impacted area are very narrow. Care must be taken to properly locate subjects relative to the route. Conversely, once on-route subjects are identified, off-route control subjects should be easy to find.
- The most common reaction to these operations was startle. This was consistent with the brief nature of the noise, particularly the onset time of B-1s and FB-111s.
- Nobody interviewed complained of intrusion on conversations, TV watching, etc., as commonly occurs around commercial airports. This is consistent with the brief event duration.
- Annoyance appears to be inversely related to understanding of the purpose of the operations. Public relations activity by the current commander of the La Junta scoring site has apparently had a substantial positive effect.

5.0 CONCLUSIONS

A field measurement program has been conducted of noise from a low-level SAC Military Training Route. Aircraft involved were B-1, B-52, and F/FB-111 engaged in TA operations. The following conclusions have been reached:

- A-weighted noise levels – both maximum and sound exposure level – were fully consistent with expectations from the existing NOISEFILE data base.
- The lateral dispersion of aircraft relative to the route centerline is well described by a Gaussian distribution, with a standard deviation of 0.5 statute mile.
- The spectral characteristics of these aircraft are such that A-weighted levels are fully expected to be an adequate descriptor for most effects. Very little of the acoustic energy is at very low "infrasound" frequencies.
- The temporal characteristics of B-1 and FB-111 aircraft exhibit very fast onset rates, so that startle may be a significant factor in intrusiveness.
- Operations are sporadic. Aircraft arrive unexpectedly at infrequent, irregular intervals. This is different from airport and airbase operations, where aircraft arrive at regular intervals and can be heard approaching for some time.
- The low population density in areas traversed by such routes will pose special problems when constructing sample populations for reaction surveys.

REFERENCES

1. Wyle Research Staff, "Noise Impact of Military Training Routes, Preliminary Considerations", Wyle Research Technical Note TN 85-12, December 1985.

2. Speakman, J.D. Private communication, 14 November 1986.

3. Sutherland, L.C., Sharp, B.H., and Mantey, R.A., "Preliminary Evaluation of Low-Frequency Noise and Vibration Reduction Retrofit Concepts for Wood Frame Structures", Wyle Research Report WR 83-26, June 1983.

APPENDIX A

Summary of Observations on Demographics and Responses to MTR Overflight Noise At La Junta and Wild Horse, Colorado

The following are observations by two members of the field team during the reconnaissance and measurement program. They are adapted from memoranda written shortly after the field effort, while subjective impressions were still fresh.

Section A.1 was prepared by J. Lukas. He was present during setup and initial measurements, from 16 through 20 June. His observations are based on chance meetings with residents plus deliberately sought-out local officials. He also evaluated the area from the viewpoint of estimating logistical requirements for formal socioacoustic surveys.

Section A.2 was prepared by K. Plotkin. He conducted the reconnaissance on 2 through 4 June, and was present for the full field program from 16 June through 3 July. His encounters with residents were entirely by chance. His subjective impressions of the overflights are based on about thirty observations.

It should be noted that several of the chance encounter interviews in A and B were the same residents around Wild Horse.

A.1 Observations by J. Lukas

A.1.1 Purpose

This effort had several purposes:

1. To gain some direct experience with the characteristics of the noise generated by various SAC aircraft during MTR missions.
2. To develop an appreciation of the distribution and characteristics of the population affected by MTR operations, and thereby better estimate techniques for conducting noise/annoyance surveys among the population.
3. To obtain some initial estimates of the characteristics of the operations contributing most to annoyance.

A.1.2 Method

The interviews discussed below were obtained through chance meetings and discussions with local residents in restaurants, cafes, stores, or, in one case, a rancher driving by. In addition, city and county officials in Las Animas were sought out and interviewed specifically to determine whether or not they had received or heard of complaints about noise. Similar interviews with officials of La Junta were not conducted because my arrival in La Junta was after normal working hours, and the police were not available. Five of a total of eight interviews were conducted on 20 June 1986 because most of the preceding days (16 June through 19 June) were used awaiting or recording overflights when they occurred or setting up the automatic noise monitor array.

A.1.3 Observations

1. Various agricultural land uses are common in the area. In the north, near the Wild Horse measurement site, cattle ranchers predominate; in the center, non-irrigated crops such as wheat, millet, and others are common; while in the south (but north of Las Animas and La Junta), where irrigation from the Arkansas River is possible, water-demanding crops such as corn and alfalfa predominate. However, herds of cattle appear at random throughout the area in hilly locations and in recently harvested fields. Small groups of horses were commingled with some cattle herds.

2. Because the farms and ranches are very large (many covering ten or more square miles as indicated by ownerships shown in the plat maps), residences are best described as being very widely scattered. In contrast, most of the populations of Las Animas and La Junta are more concentrated and resemble middle-income suburbs of cities. In the farming areas and towns, some abandoned residences and barns were apparent.

3. Cattle ranchers were less concerned with their own responses to the aircraft than with the responses of their cattle. It was reported that if the cattle are in open ranges the responses are slight; but if the cattle are penned or in the process of being herded together for purposes of branding, separating calves from the cows, or other reasons, scattering of the cattle is reportedly a common response. The ranchers were displeased with the extra time and effort required

to regroup the animals. Cattle were reported to have run into fences, without damage to the cattle but with possible damage to the fences. One rancher (from Eads near the northbound "racetrack" where aircraft reenter the IR route) reported that the horses used to herd the cattle were also "spooked" and could possibly throw an inexperienced rider. L. Sutherland (another field team member) obtained similar reports from another group of cattle ranchers.

During flyovers of the measurement site we were unable to observe the cattle because they were at too great a distance.

4. The owner of the cattle ranch where the noise measurement occurred remarked that the noise is most disturbing at night, particularly when it is very quiet with little wind. He also noted that he would complain but does not know to whom.

5. A lifelong resident of Kit Carson, who is a member of the National Guard and trains in La Junta and knows about the bomb sites, implied that the rise time of the noise caused fear ("scary"). While hunting he sees the shadow and then hears the roar. "It's not like a 707, or one of those, after they're past you hear all this rumble, rumble." Although he is not a rancher, ranchers have told him that the cows appear more frightened by the shadows than the noise.

6. Officials (city clerk, police chief, and the secretary to the County Agricultural Commission) in Las Animas reported that they had received no complaints. To confirm her opinion, the secretary called the chairman of the Agricultural Commission who also reported that he had not heard of any complaints.

   The secretary made the following two interesting observations: "Most of the people are farmers so they are awake long before the planes fly," and "The farmers enjoy the excitement," implying that the planes provide some relief from the monotony of farming.

7. The police chief noted that the citizens expressed safety concerns for a short while after the B-52 crashed south of Las Animas, but no complaints about noise have been expressed.

A.1.4 Preliminary Conclusions and Recommendations

1. Initial observations of narrow lateral spreading of the noise from low-altitude jet flyovers, confirmed by subsequent analysis of the noise measurement data, implies that noise impacts such as annoyance and startle are likely confined to areas below and very near to the flight tracks. Because MTR flights occur primarily in sparsely populated areas, it is important to identify the specific residences or land uses over which these flights occur. Moreover, it implies that surveys and observations to determine either human or animal effects should be confined to the relatively narrow areas impacted by the overflights. Insofar as the La Junta area and its distribution of population and land uses are representative of other MTR routes, it appears that an evening telephone survey is the most efficient technique to obtain human and animal impact data. An evening telephone survey is best because the farmers and ranchers are more likely to be home (rather than in the fields) in the evening and because the interviewers' time will not be spent driving the long distances between impacted areas. Telephone interviews can be supplemented by face-to-face interviews if necessary.

2. I did not interview any women who had been exposed to overflights. Whether women will respond in a manner similar to that of the men interviewed is unclear. It is recommended that a brief telephone survey (names and telephone numbers are available in the Plat maps) be conducted to determine women's concerns about the overflights.

3. The apparent difference in response between cattle ranchers and dirt farmers needs verification because of its possible implications for route planning. It is recommended that a telephone survey be used to obtain such verification.

A.2 Observations by K. Plotkin

During noise measurements on IR-177 and IR-501 near Wild Horse, Colorado, and during the earlier site-selection visit, I encountered local residents who volunteered their opinions on low-level flights. These encounters occurred while I was seeking permission to use the site, and as chance meetings when I was in the area.

Most of the reaction was essentially "They are not much of a problem except when they come right overhead at night or catch you by surprise." I will refer to this as the "standard reaction". Annoyance also appeared to be inversely related to the knowledge of operations. People who knew the purpose of the route and scoring site were much more accepting of the intrusion.

Specific encounters were as follows:

- Near Target #3 (between La Junta and Las Animas), two ranchers live near the route centerline. One was bothered by them flying right over his house at night. He has also been apprehensive about safety ever since a B-52 crashed 30 seconds after passing over his house a few years ago. The other rancher (who knew all about the route, and was the only person I encountered who could tell a B-1 from an FB-111) appeared to be entertained by the aircraft. He apparently was not exposed to flyovers directly overhead.

- The rancher at Brown Mill Ranch (southwest of Wild Horse, directly under the route centerline) visibly reacted when I mentioned the aircraft. He expressed the standard reaction, particularly with regard to nighttime operations. He also wanted to complain, but did not know to whom to complain.

  He also indicated that the noise generally did not bother the cattle. However, when cattle were rounded up by helicopter, low-flying aircraft would confuse them and at times caused considerable trouble.

- The foreman of the Rush Creek Ranch (location of our measurement array) reiterated the problem with noise confusing the cattle. He was not exposed to overflights at his house.

- Most annoyed by the noise were a couple who operate a gas station and flea market in Wild Horse. They were particularly upset by two direct flyovers (an FB-111 that really caught them by surprise, and a B-52), and filed a complaint with the sheriff after the FB-111. They were also irritated by noise from truck traffic on the highway – both their business and their home are on the main highway.

  In May, the Rocky Mountain News had a feature article about the La Junta scoring site. This couple showed me the article, and indicated that knowing what was going on made them feel better. The aircraft were still an intrusion, but at least they knew there was a purpose and they were not out of control.

- Three or four other people in Wild Horse (including some women) expressed the standard reaction. One elderly woman expressed concern about her "ear drums being blown out." One rancher said that he liked the noise because "it is the sound of freedom." However, he apparently did not live under the route, and may have been digging at the couple operating the gas station/flea market.

Reaction to B-1s and FB-111s appeared to be stronger than to B-52s, apparently due to startle. This agreed well with my own observations. All aircraft had rapid noise rise times, but B-52s could at least be heard while approaching. An approaching B-1 simply could not be heard until it was nearly directly overhead, at which time it very suddenly became very loud.

My own subjective reaction (obviously not an objective sample) is that B-52s were less spectacular than I had expected. Because of their size, they tended to look like they were moving slowly. The visual impact was much less than I had expected. This may have been because I knew when and from where they were coming. It seems reasonable to expect that this would be quite an event for somebody who had never seen one before and was not previously aware of these operations. B-52s were always clearly visible. B-1s and FB-111s were less visible, and were often difficult to spot. B-1 and FB-111 overflights tended to sound more spectacular because of their speed and sudden noise onset, particularly the B-1. None of the aircraft gave a clearly apparent "doppler shift" impression, this apparently being heavily outweighed by directional characteristics. There was also no obvious tactile low-frequency impression when observed from an open field.

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