NASA/CR-1998-206946

XV-15 Low-Noise Terminal Area Operations Testing

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Prepared for Langley Research Center
under Contract NAS1-20094

February 1998

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1. INTRODUCTION

This report describes noise testing of the XV-15 tiltrotor aircraft conducted by the National Aeronautics and Space Administration (NASA) and Bell Helicopter Textron, Incorporated (BHTI) during October and November 1995, at BHTI's test site near Waxahachie, Texas. NASA-Langley Research Center was responsible for overall test direction as well as acoustic and meteorological measurements. NASA-Ames provided aircraft position tracking. BHTI supported the tests by providing the XV-15 aircraft and test site coordination under contract NAS1-20094, Task 3. As an additional effort under this contract, BHTI also developed a computerized visualization tool to display instantaneous noise contours concurrently with XV-15 position and nacelle angle.

This report documents the test setup and procedures used during this program. Acoustic and flight profile data are not included, since these were recorded and analyzed by NASA. Questions concerning the complete database generated during this test should be addressed to Mike Marcolini of NASA-LaRC.

1.1 PURPOSE OF TEST

Noise impact is currently considered to be a major obstacle to developing the tiltrotor's full potential within the civil transportation system. If this potential is to be realized, noise reduction must be considered in each new tiltrotor design, and low-noise operating techniques must be defined for all tiltrotors. The purpose of this test was to support the noise reduction design and operation of future tiltrotors. The stated objectives were to:

- provide a comprehensive acoustic database for NASA and U.S. industry
- validate noise prediction methodologies, and
- develop and demonstrate low-noise flight profiles.

This is the latest in a series of XV-15 noise tests aimed at understanding the noise characteristics of the relatively new tiltrotor aircraft (References 1 through 4). The timeline shown in Figure 1 illustrates the history leading up to the current test. Primary emphasis was given to the approach flight condition where blade-vortex interaction (BVI) dominates the noise signature. Since this flight condition influences community noise impact more than any other, an understanding of the noise generating processes is required to guide the development of low noise flight operations. This, in turn, can substantially reduce the tiltrotor's impact on the community.

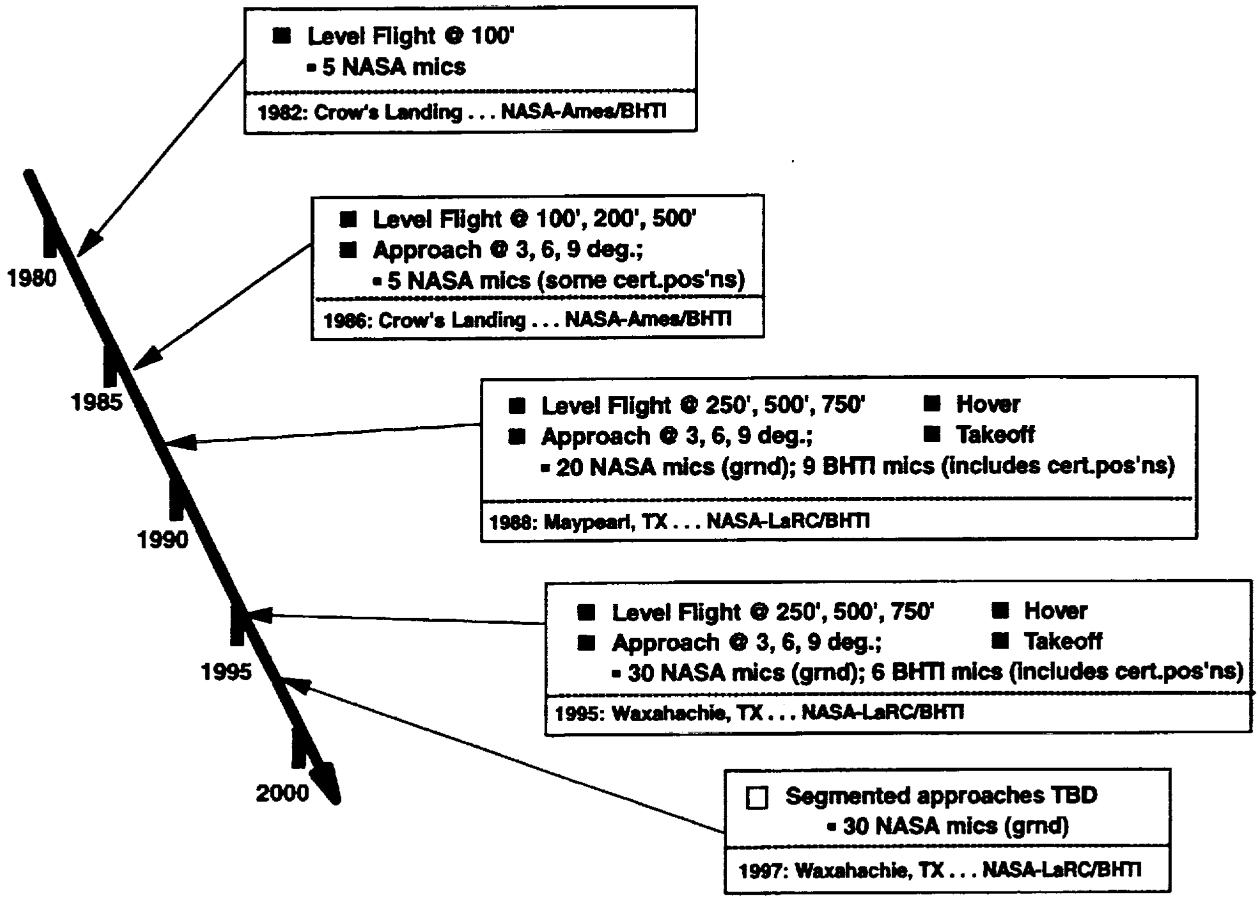


Figure 1. XV-15 Noise Test History Leading Up to the Present Test

2. TEST DESCRIPTION

The test consisted of two distinct phases: Phase 1 provided an acoustic database for validating analytical noise prediction techniques, and Phase 2 directly measured large area noise impact over a broad range of operating profiles.

2.1 TEST SITE

Testing was performed in a rural area near the town of Waxahachie, Texas, on an available tract of land that had been the site of the former Superconducting Super Collider (SSC). The site is sufficiently remote that the ambient noise levels were low, 35-40 dBA, yet near enough to the Dallas-Fort Worth area to allow flight operations out of BHTI's Arlington flight facility. The terrain is flat with few trees, and during the test the ground was covered with short, mowed grass.

Since the XV-15 is not equipped with a particle separator, a helipad was constructed for hovering flight. Figure 2 shows the XV-15 hovering above this pad. The terrain in the background is typical of the topography at this site.

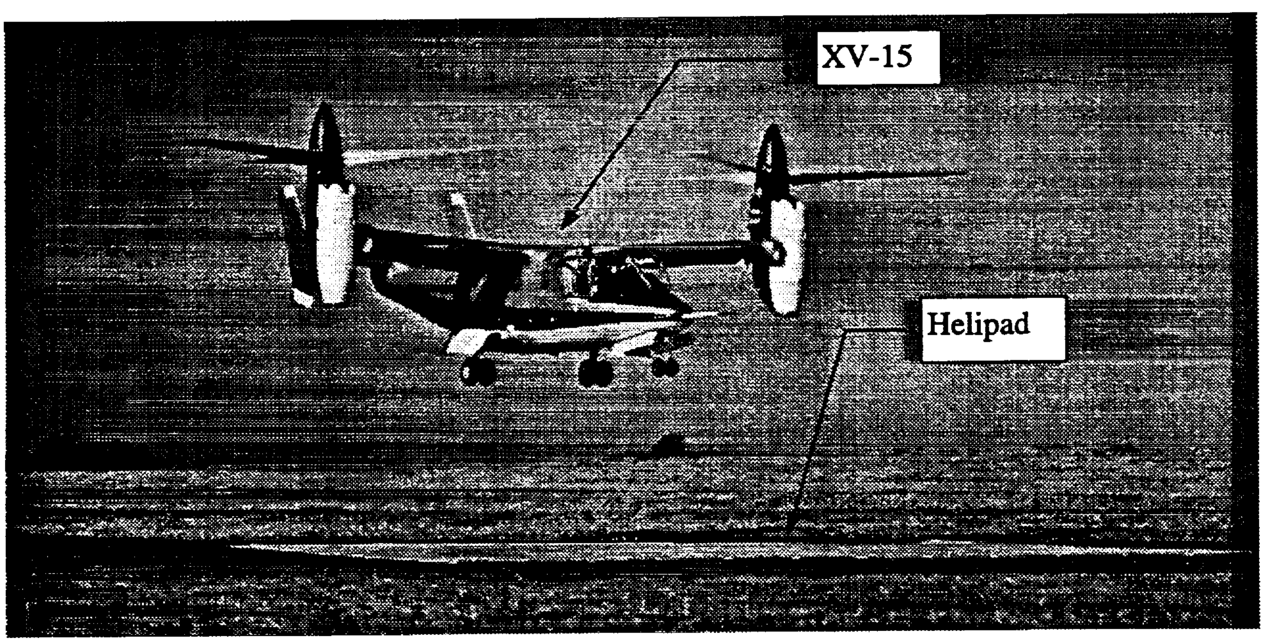


Figure 2. XV-15 Over Helipad Constructed for Tests

2.2 PERSONNEL/ CREW ASSIGNMENTS

As stated earlier, NASA-LaRC was responsible for the overall test direction and for selecting test points and flight procedures that would receive the highest priority. These selections were made with the assistance from BHTI and other industry members and from NASA-Ames/Army handling qualities/simulation personnel, notably Mr. Bill Decker. Handling qualities were considered an integral part of the program to ensure that any "low noise" flight operations were practical ones which could actually be used in a commercial tiltrotor.

NASA-LaRC provided equipment and personnel for acoustical (30 microphone stations) and meteorological measurements during the test, and for overnight analysis of each dataset. The NASA-LaRC team included personnel under contract from Wyle and Lockheed.

NASA-Ames supported the test by providing the XV-15 position tracking. A laser optical tracking system, discussed later (Section 2.3.3) provided precision readouts of x, y, and z position. This system required a substantial support team headed by NASA-Ames and assisted by personnel from Recom and Stering.

BHTI provided the XV-15 aircraft and flight support, as well as test site coordination. BHTI monitored and recorded acoustically influential aircraft parameters, including rotor RPM, nacelle angle, flap angle, airspeed, and radar altitude.

A list of personnel involved in the test is given in Appendix A. Each individual's responsibilities during the test are given, along with his company affiliation.

Aircraft Description

The XV-15 tiltrotor has a design gross weight of 13,200 pounds, and was built by BHTI as a proof-of-concept aircraft and technology demonstrator with first flight in May 1977. The aircraft has a fuselage, empennage, and fixed wings similar to those of a conventional airplane, with an engine/nacelle/rotor assembly mounted on each wingtip. Each nacelle houses a main transmission and a Lycoming T-53 turboshaft engine capable of generating 1800 shaft horsepower. A cross-shaft connects the two transmissions for transient power transfer and one-engine-out operation. Rotor orientation is changed by pivoting the nacelles with respect to the wings. The wings are swept forward 6.5 degrees to provide clearance for rotor flapping during forward flight in the airplane mode. Figure 3 shows the XV-15 in transitional flight, with nacelles tilted approximately 60 degrees. Only two flight aircraft were built, Tail Numbers N702NA and N703NA. Both have been extensively tested to define the capabilities and limitations of the tiltrotor concept, and have successfully demonstrated the practicality of this new aircraft type. Aircraft #2 (Tail Number N703NA) was used in the tests described in this report.

The XV-15 test aircraft, shown in Figure 3, has two 25-foot diameter rotors mounted on wingtip nacelles that are capable of tilting from approximately 95 degrees (helicopter mode) to 0 degrees (airplane mode). Each rotor has three highly twisted, square-tip metal blades. The XV-15 rotors typically operate at 589 RPM during the hover mode and transition, but are reduced to 517 RPM for high speed forward flight. The RPM's correspond to 98% and 86% of rotor design speed. Major XV-15 aircraft parameters are listed in Table 1. A more detailed description of the XV-15 is available in Reference 5.

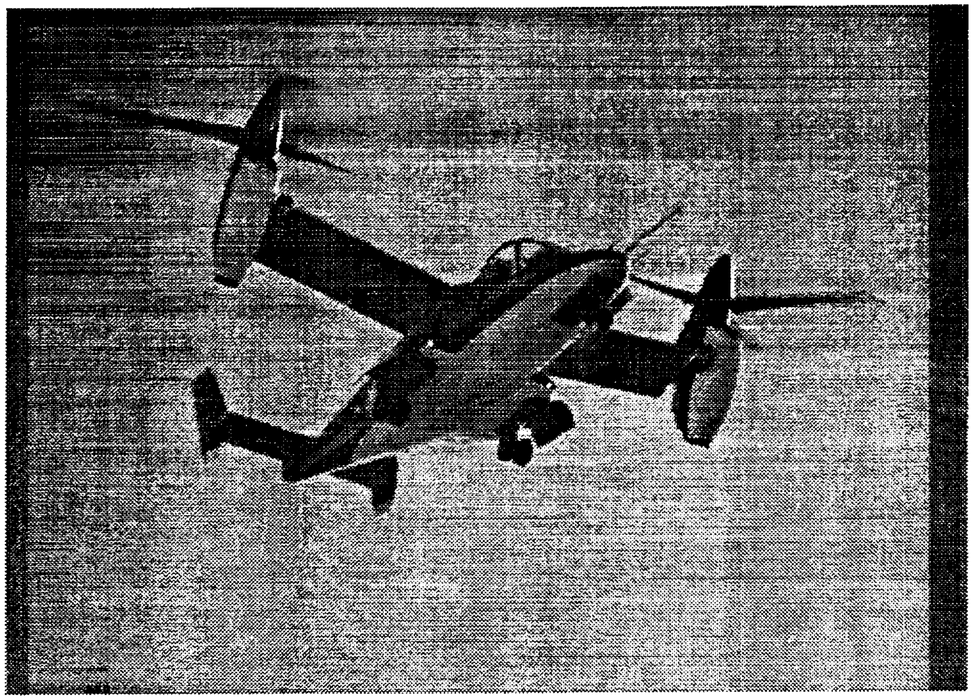


Figure 3. XV-15 Aircraft #2 (N703NA) Used in Noise Tests

TABLE 1. XV-15 TILTROTOR DESIGN AND OPERATING PARAMETERS

GROSS WEIGHT..	13,200 lb.
PROPS/ROTORS (2)	
NUMBER OF BLADES.......................	3
DIAMETER..	25 feet
ROTATIONAL SPEED	601 RPM @ 100% 589 RPM @ 98% (HELICOPTER MODE) 517 RPM @ 86% (AIRPLANE MODE)
ROTATIONAL TIPSPEED.................	771 FEET PER SECOND @ 98% 677 FEET PER SECOND @ 86%
ENGINES (2).......................................	LYCOMING T53

The XV-15 flight envelope, shown in Figure 4, illustrates the combinations of nacelle angle and airspeeds for stabilized flight. It should be noted that a fairly broad range of nacelle angles and airspeeds is possible within this operating envelope. The acoustic effects of avoiding certain portions of this envelope can guide flight operations of the XV-15 (and presumably other tiltrotors) in minimizing external noise. The present test was designed to extend the body of information available to define these effects.

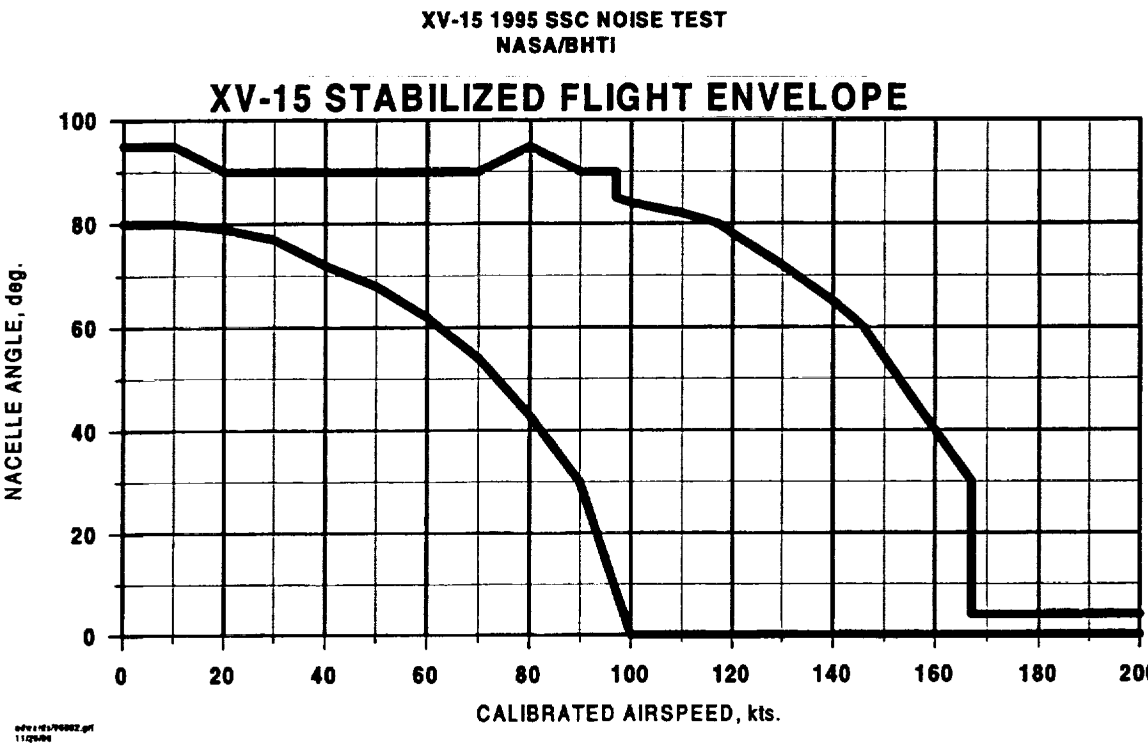


Figure 4. XV-15 Flight Envelope

2.3 TEST SETUP

The general layout of the test site is shown in Figure 5. The flight track was selected so the microphone array would be in the flattest portion of the terrain, away from trees and easily accessible by vehicle. NASA-LaRC acoustic recording equipment was housed in instrumentation vans, with 10 microphone sites being supported by each van. A trailer was set up south of the flight track to serve as control headquarters for the test. The optical tracker site, north of the flight track and offset by about 4700 feet, was on a rise which commanded a view of the entire flight track, allowing for early acquisition of the aircraft. A weather balloon was deployed near the tracker site to acquire layered atmosphere data, and ground-based meteorological data was recorded at the BHTI van and at one of the NASA vans. Aircraft parameters were recorded onboard the XV-15.

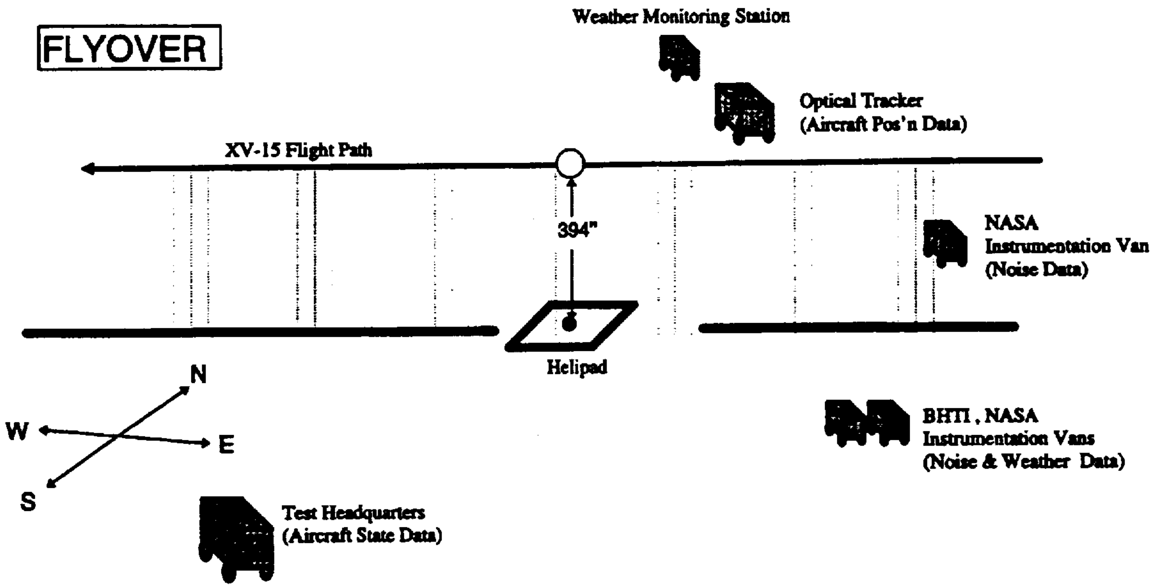


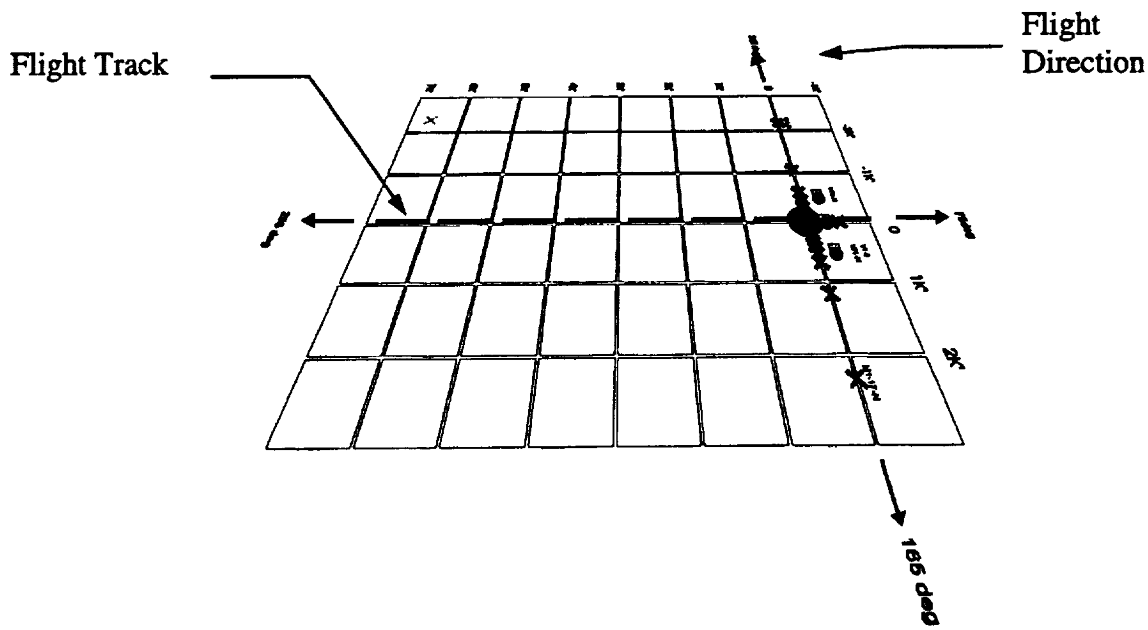
Figure 5. XV-15 Noise Test Setup (Phase 1 Test)

All datasets were recorded in parallel with a satellite-synchronized time code signal. Prior to each flight, the XV-15's onboard timecode generator was synchronized with a satellite time code unit at the BHTI Flight Test Center to provide time correlation between airborne and ground based recordings. During the test, safety of flight data was telemetered from the XV-15 to the ground station at the test site command post, where it was monitored continuously.

2.3.1 Acoustic Measurements

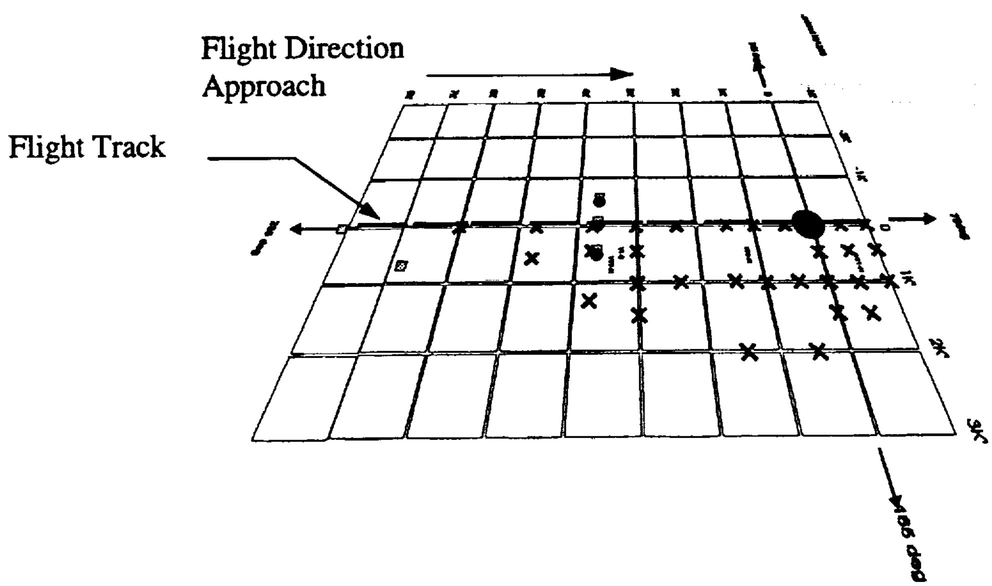
During "Phase 1" testing, noise was measured with microphones arranged as shown in Figure 6. This is a fairly linear array oriented perpendicular to the flight track, and extending about 2300 feet to each side. The exact positions are given in Appendix B. The purpose of this phase was to provide data to support noise prediction efforts and to document tiltrotor sound characteristics at specific points in the flight envelope. XV-15 flight conditions consisted of descents, level flights, takeoffs, and hover.

In "Phase 2" testing, the microphones were re-deployed over a large ground area near a simulated "vertiport", as shown in Figure 7. The purpose was to define maximum and minimum noise contours for civil vertiport land use planning. As in the initial Phase 1 testing, the flight conditions consisted of descents, level flights, takeoffs, and hover.



X NASA Microphones
☐ Bell Microphones

Figure 6. Phase 1 Testing: Linear Microphone Array



X NASA Microphones
☐ Bell Microphones

Figure 7. Phase 2 Testing: Distributed Microphone Array

The sequence of testing, along with field notes made by the author, is listed in Appendix C.

2.3.2 Meteorological Measurements

Acoustic testing was generally conducted when weather conditions met the following criteria:

- average surface (10 meter above ground level) winds less than 10 knots
- relative humidity less than 95%
- no precipitation present
- visibility greater than 3 miles
- ceiling greater than 1500 feet.

Because of the low wind requirements, early morning flights were scheduled. Based on weather information available at 3:00 PM prior to each potential test day, plans for the next day's testing were made.

During testing, meteorological data was recorded at the BHTI acoustics van, where monitor instrumentation was located on a 10-meter tower. These data are presented graphically in Appendix D. In addition, NASA monitored meteorological conditions at a ground tower and aloft on an airborne weather balloon positioned near the flight track. Figure 8 shows NASA's ground tower.

2.3.3 Position Tracking System

Aircraft position was monitored and recorded during the test by an optical tracking system provided by NASA Ames. A photo of the tracker support vans is shown in Figure 9. This system provided a continuous, real-time display of longitudinal (x), lateral (y), and vertical (z) aircraft position to a display in the XV-15 (Figure 10) and to a monitor in the control trailer (Figure 11). The tracker's ground station generates and directs a laser beam toward the aircraft, where an aircraft-mounted retro-reflector reflects the beam back to the ground station. The retro-reflector mounted on the XV-15 is shown in Figure 12. The ground station was stabilized at a known, pre-surveyed position with respect to the flight track, and the measured return time of the beam, along with precise knowledge of the its azimuth and elevation, provided a very accurate (± 1 meter) measure of x,y, and z position at a sample rate of 10 per second. The ground station was located approximately 4700 feet north of the flight track (see Figure 13).

To assist the pilot in setting up each pass, three 1000-watt lights were stationed along the track. By aligning these lights, the pilot could enter each pass very accurately, so that only small corrections were necessary when the tracker acquired the XV-15 and enabled the onboard position indicator. One of these lights is shown in Figure 14.

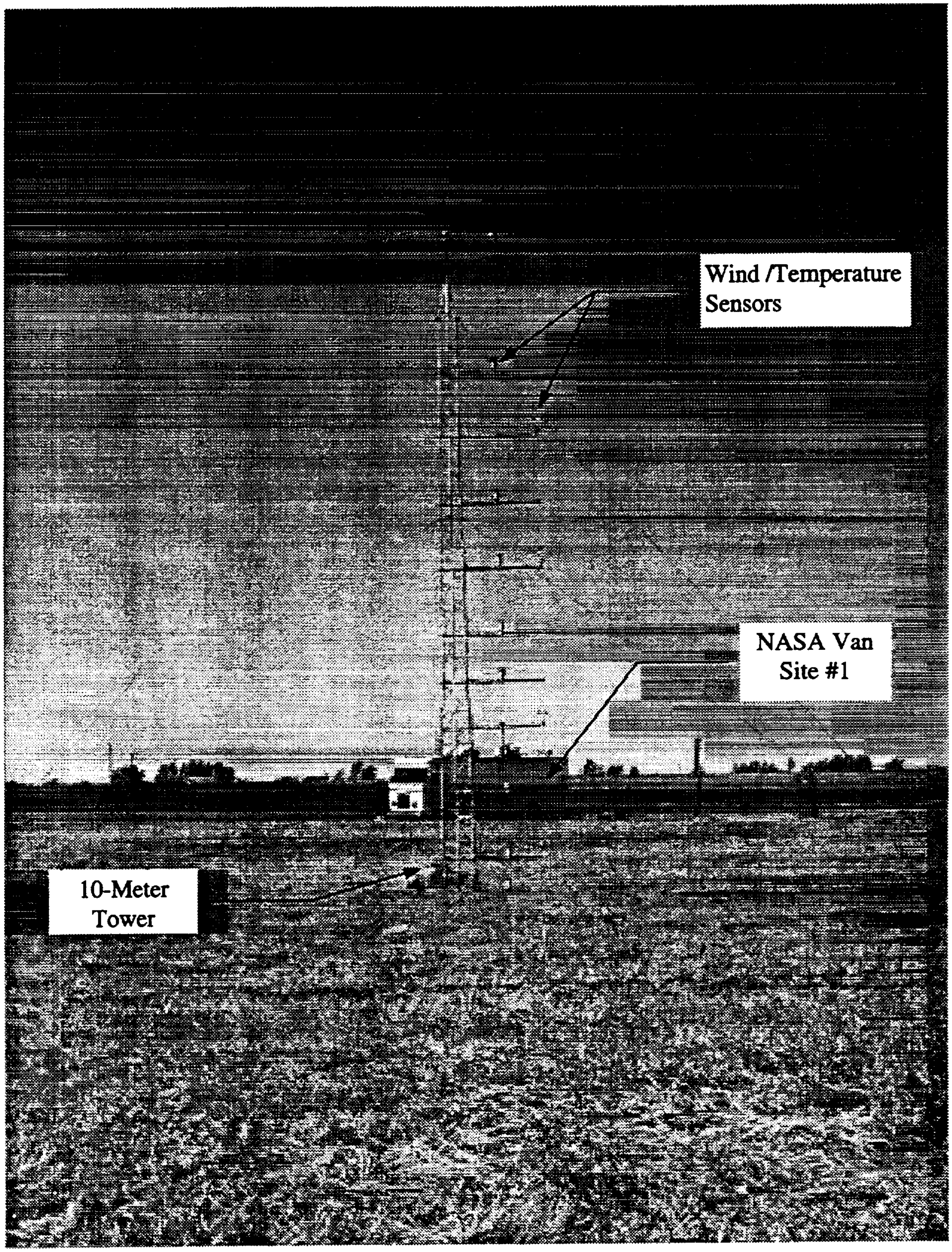


Figure 8. NASA's Weather Tower

Figure 9. NASA-Ames Mobile Optical Tracker

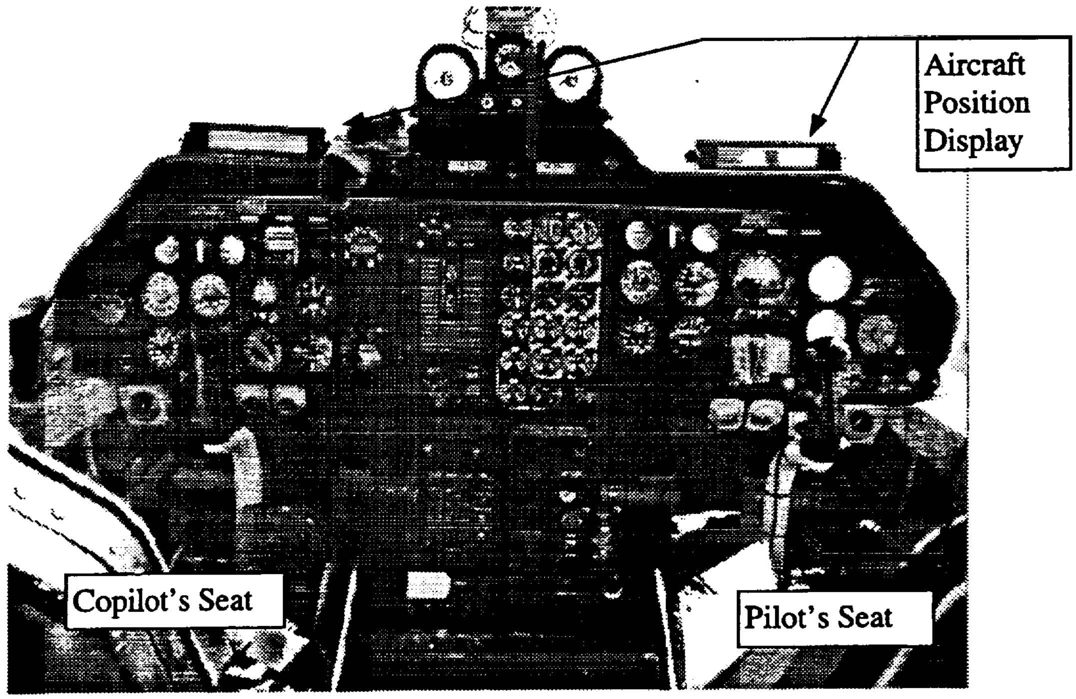


Figure 10. XV-15 Cockpit

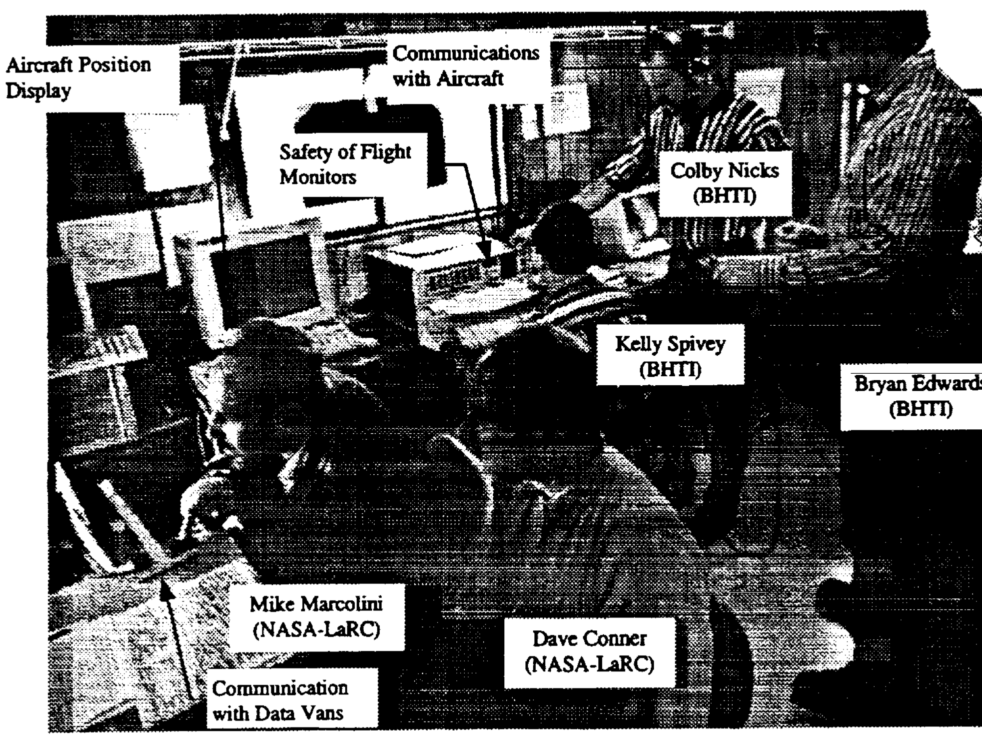


Figure 11. Headquarters Trailer with Test Personnel

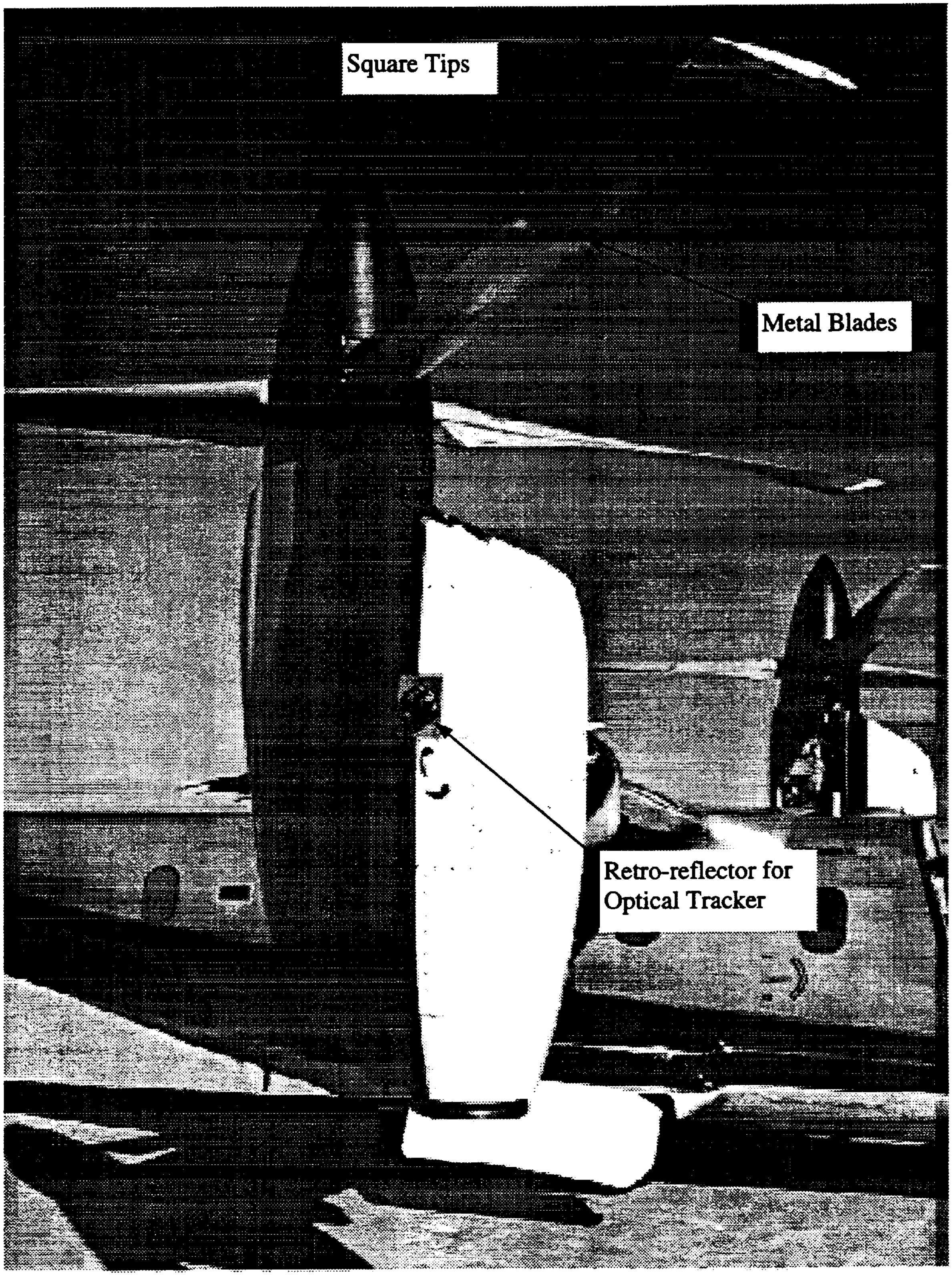


Figure 12. XV-15 Details

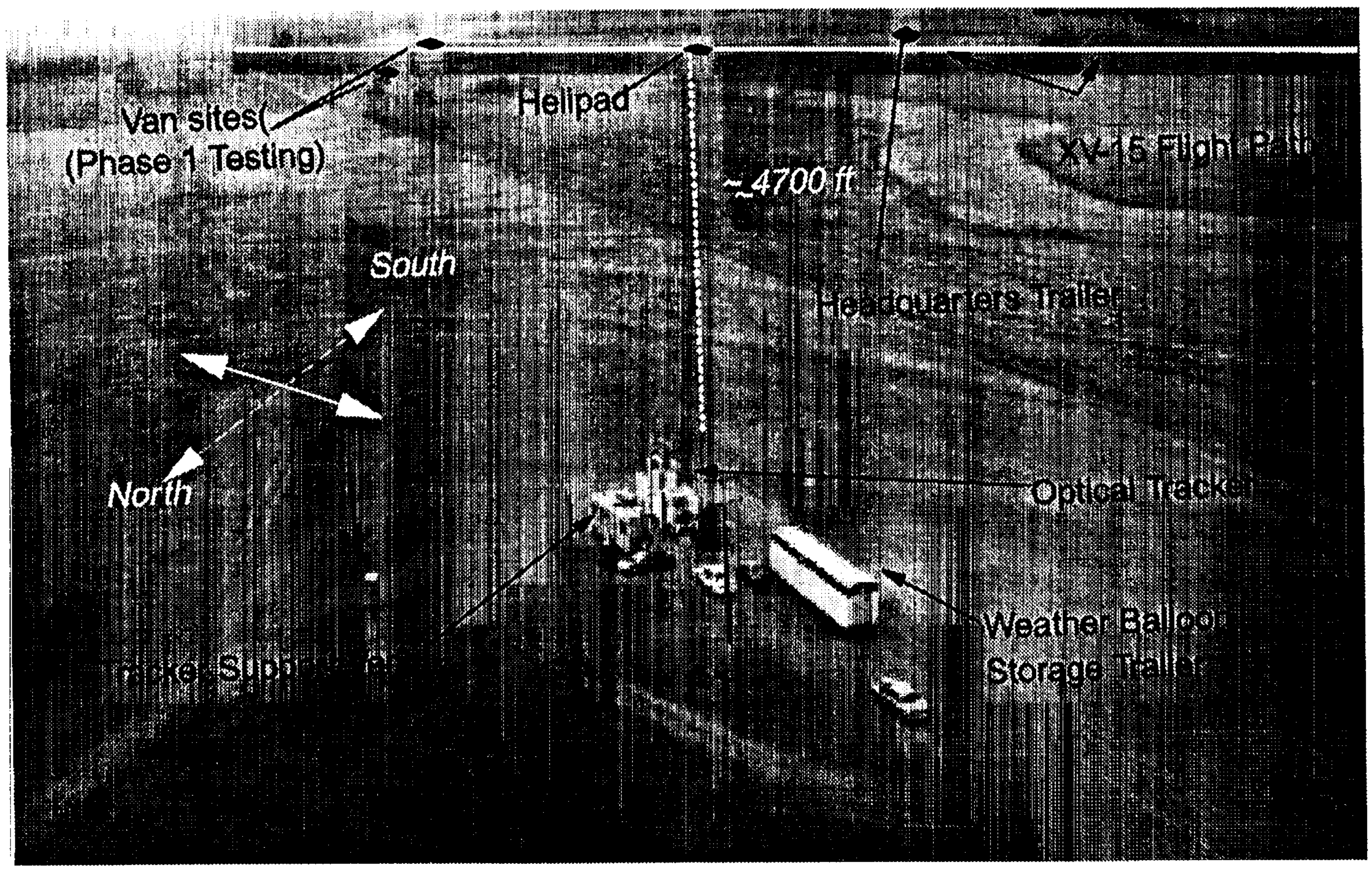


Figure 13. Optical Tracking Station

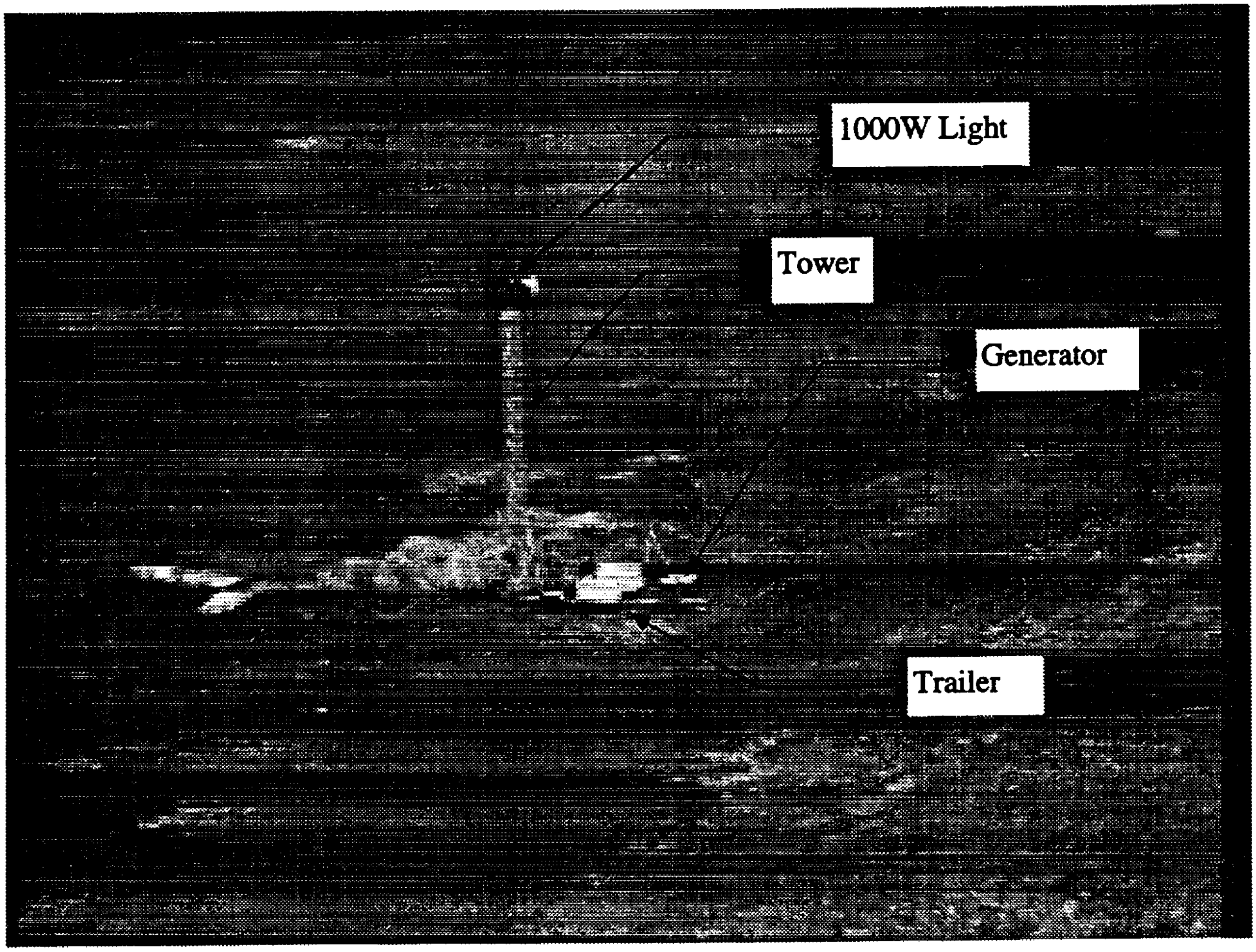


Figure 14. Flight Track Marker

2.3.4 Aircraft Parameters

An onboard recording system monitored basic aircraft flight and operating parameters. These were recorded in flight, then analyzed and permanently stored. Table 2 is a list of the flight data recorded during these tests.

TABLE 2. FLIGHT DATA RECORDED DURING TESTS

DATA CODE	ITEM CODE	DESCRIPTION	UNITS
00DV02	P342	BOOM ALTITUDE	FT
00DV04	D327	RADAR ALTIMETER	FT
00QP01	D010	PITCH ATTITUDE	DEG
00QP02	D008	ANGLE OF ATTACK	DEG
00QQ01	D011	YAW ATTITUDE	DEG
00QQ02	D007	ANGLE OF SIDE-SLIP	DEG
00QR01	D009	ROLL ATTITUDE	DEG
00VF03	P002	BOOM AIRSPEED	KNOTS
00VV02	V086	RATE OF CLIMB	FT/MIN
10DF04	DO21	F/A CYC STICK CONTROL POSN	%
10DF05	DO24	RUDDER PEDALS CONTROL POSN	%
10DF06	DO23	POWER LEVER CONTROL POSN	%
10DL02	DO22	LAT CYC STICK CONTROL POSN	%
12DM13	D617	FLAP POSITION	DEG
25DM12	D161	#2 PYLON CONVERSION POSN	DEG
25DM13	D186	#1 PYLON CONVERSION POSN	DEG
30RM03	R106	ROTOR RPM (@ reduced sample rate)	%

2.4 PHASE 1. "LINEAR" MICROPHONE ARRAY TESTING

Phase 1 testing was accomplished on 9 test days during 1995. October 10, 12, 16, 27, 28 and November 1,4,7, and 8.

The linear microphone array consisted of 17 microphones along a line perpendicular to the flight track, and an additional 3 microphones along the flight track. The exact positions are given in Appendix B. An aerial view of a portion of the linear array is shown in Figure 15.

2.4.1 Flight Conditions

The XV-15 passed over the microphone array at constant airspeed/nacelle angle combinations and constant flight angles. Test conditions consisted of level flights, descents, climbs, and hover as defined in Appendix E. Prior to the test, each condition was assigned a priority classification of 1, 2, or 3. The "priority 1" conditions were considered essential to the overall test objectives. All the Priority 1 conditions was completed first, then the Priority 2 and 3 test conditions were included as flight time permitted. The XV-15's landing gear was up during level flight and during descents at airspeeds greater than 90 knots. During descents less than 90 knots, the landing gear was down.

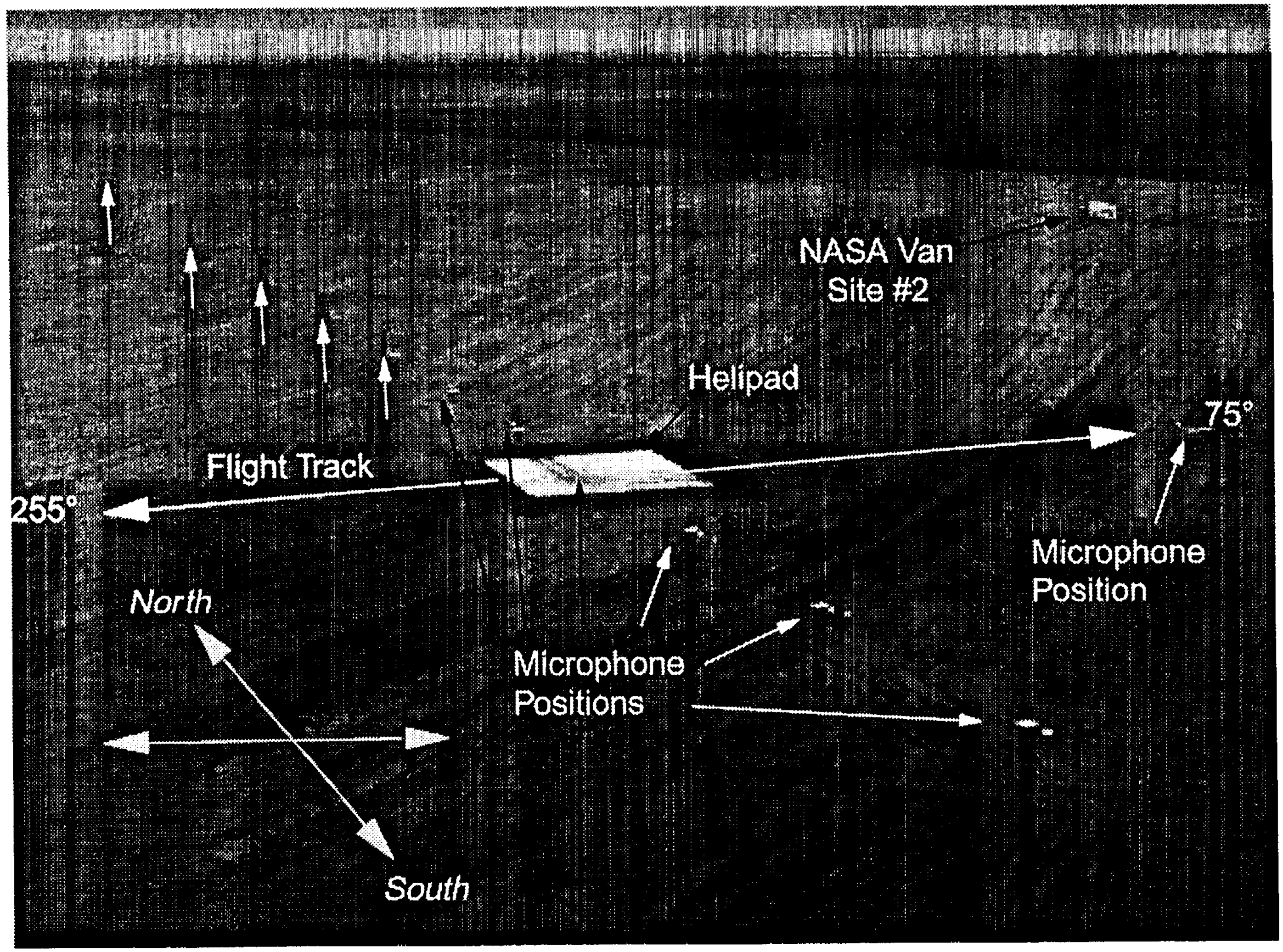


Figure 15. Linear Microphone Array During Phase 1 Testing

2.4.1.1 Level Flight (Phase 1 testing)

The flight profile for the Phase 1 level flights is sketched in Figure 16a. During each pass, the XV-15 passed over the microphones at a specific altitude and flight condition. The level flight airspeed/nacelle angle combinations tested are shown in Figure 16(b), and listed in Appendix E.

Each level flyover was initiated at a point approximately 2 nautical miles uprange of the line of microphones. From this point, the desired flight condition was maintained while passing over the line of microphones and continuing to a point approximately 1 nautical mile past the microphones. After breakoff, the XV-15 continued in a "racetrack" pattern and set up for the next pass.

2.4.1.2 Descents (Phase 1 testing)

The flight profiles for the Phase 1 descents are sketched in Figure 17a. Flight direction was from East to West. During each pass, the XV-15 passed through a point 394 feet (120 meters) above ground level, an altitude that corresponds to the descent condition currently used in helicopter noise certification. The nacelle angle/airspeed combinations flown during descent are shown in Figure 17b, and listed in Appendix E.

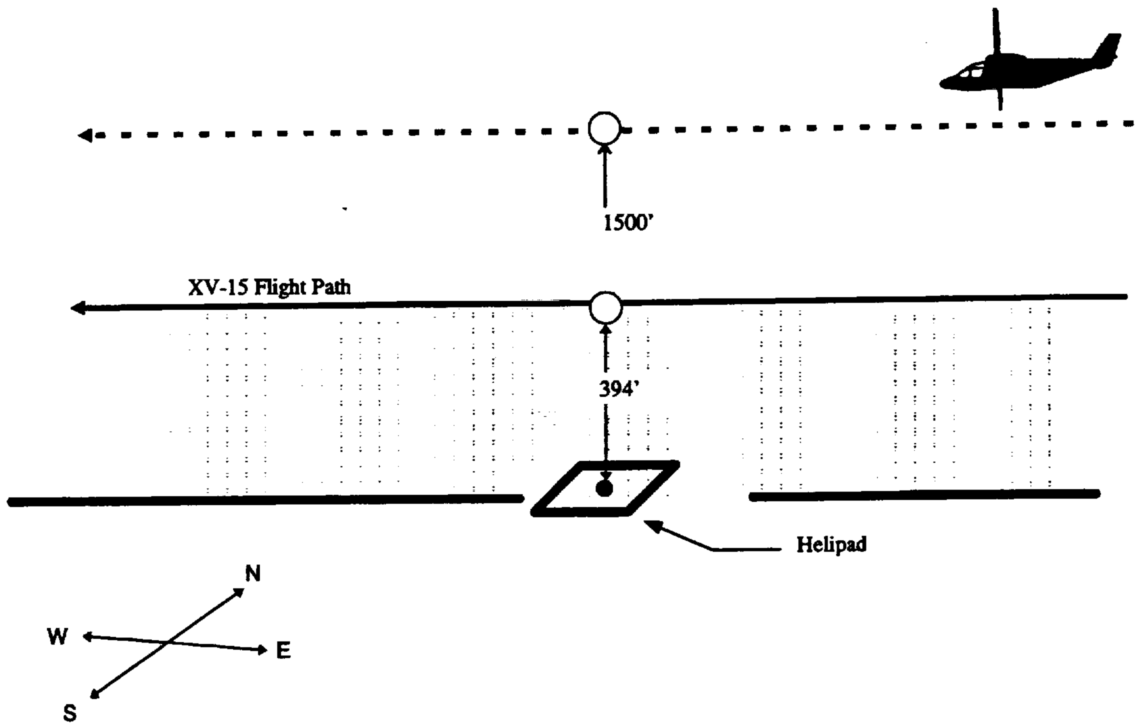
Each descent was initiated at a point about 2 nautical miles uprange of the line of microphones. From this point, the desired flight conditions was maintained while passing over the microphones and continuing as long as practical past them. Specific breakoff altitude was left to the pilot's judgment. After breakoff, the XV-15 went around and set up for the another pass.

Descents received the heaviest emphasis during this test because of the strong influence this condition has upon terminal area noise impact.

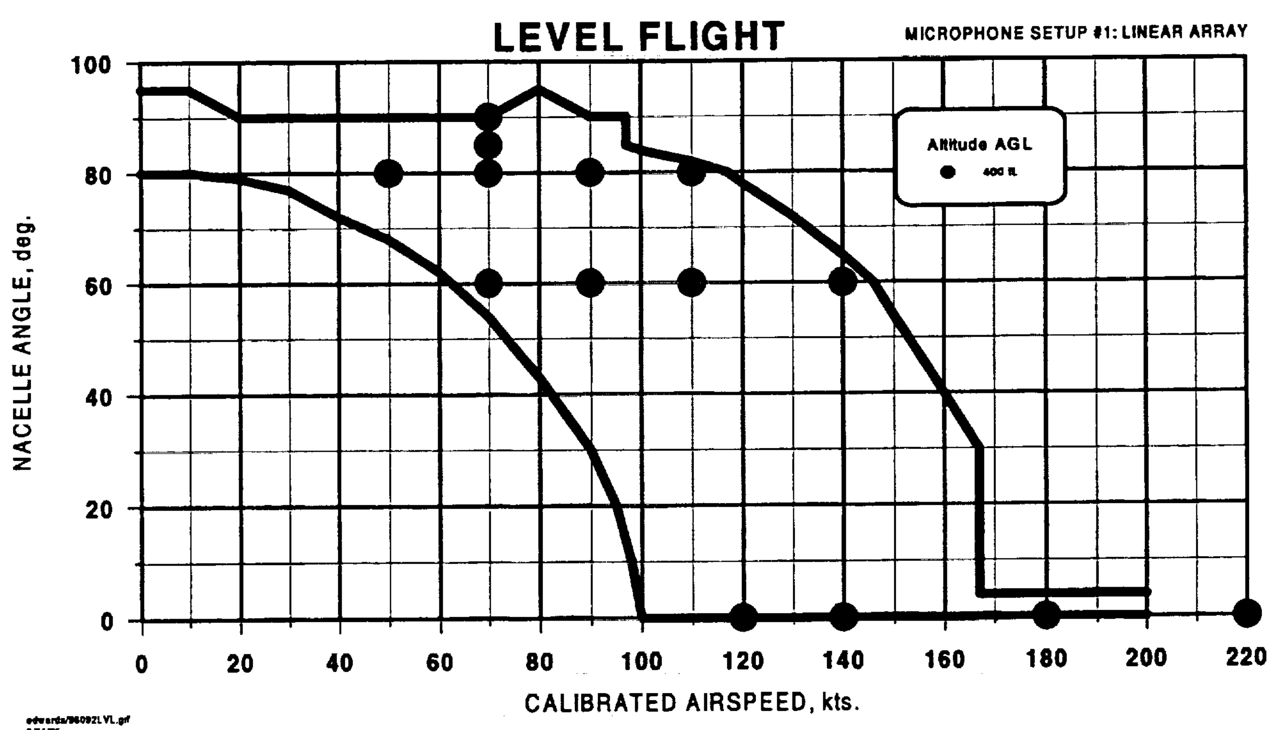
2.4.1.3 Takeoffs (Phase 1 testing)

The flight profiles for the Phase 1 takeoffs are sketched in Figure 18(a), patterned after the helicopter noise certification procedure. Flight direction was from East to West. During each pass, the climb was initiated at an uprange position intended to bring the XV-15 through a point 394 feet (120 meters) above ground level. This altitude matches that used in the descent conditions.

Each takeoff was entered by first flying level at 100 feet above ground level toward the line of microphones, then initiating a climb at pre-determined uprange point based on the predicted climb angle for that flight condition. From this climb initiation point, the desired flight condition was maintained while passing over the line of microphones and continuing to a point approximately 1 nautical mile downrange from the microphones. After breakoff, the XV-15 went around and set up for the next pass.

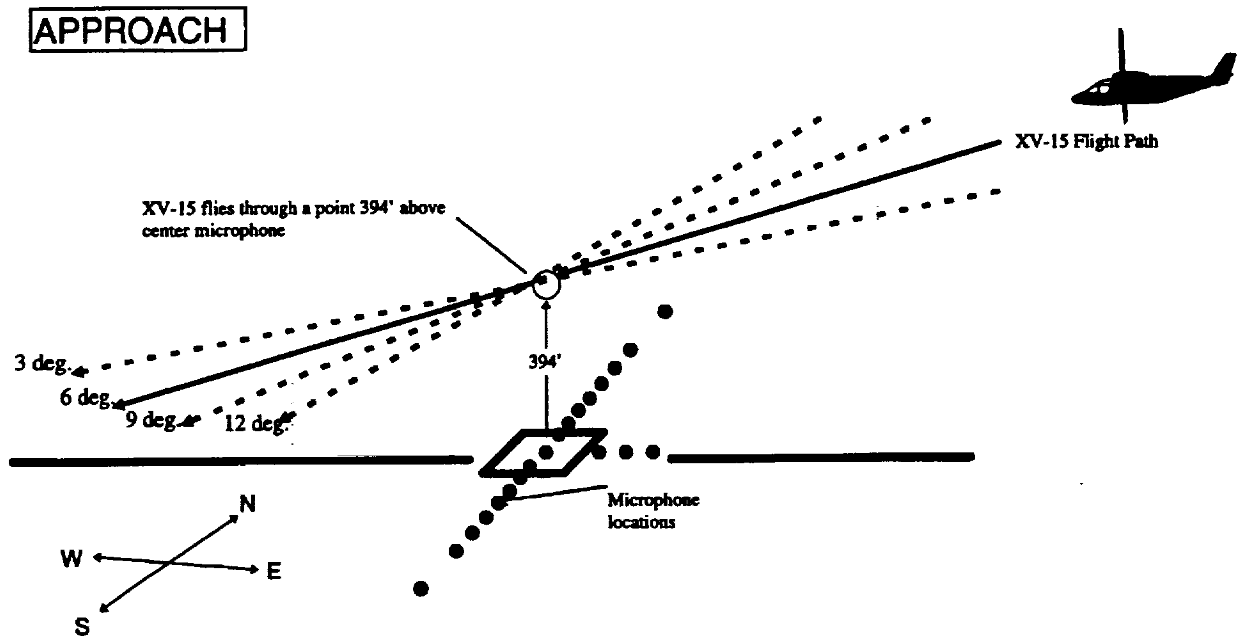


(a) Flight Path

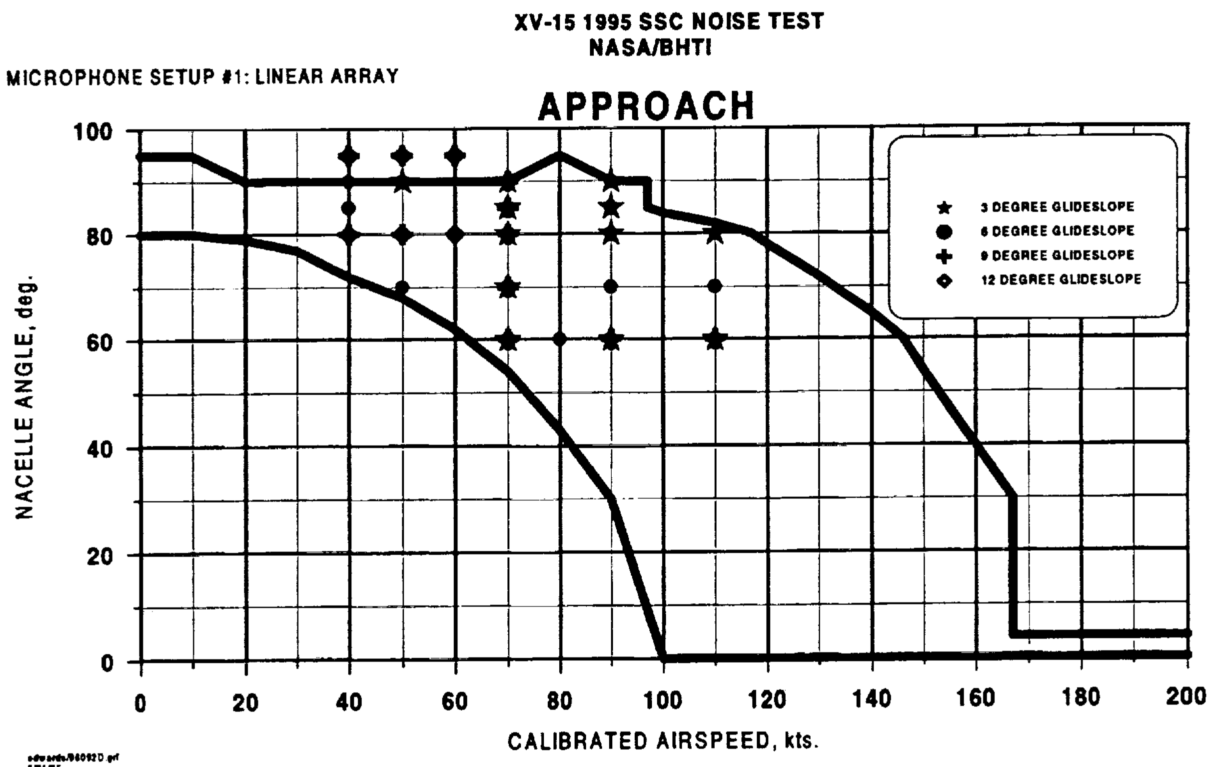


(b) Flight Conditions

Figure 16. Phase 1 Level Flight



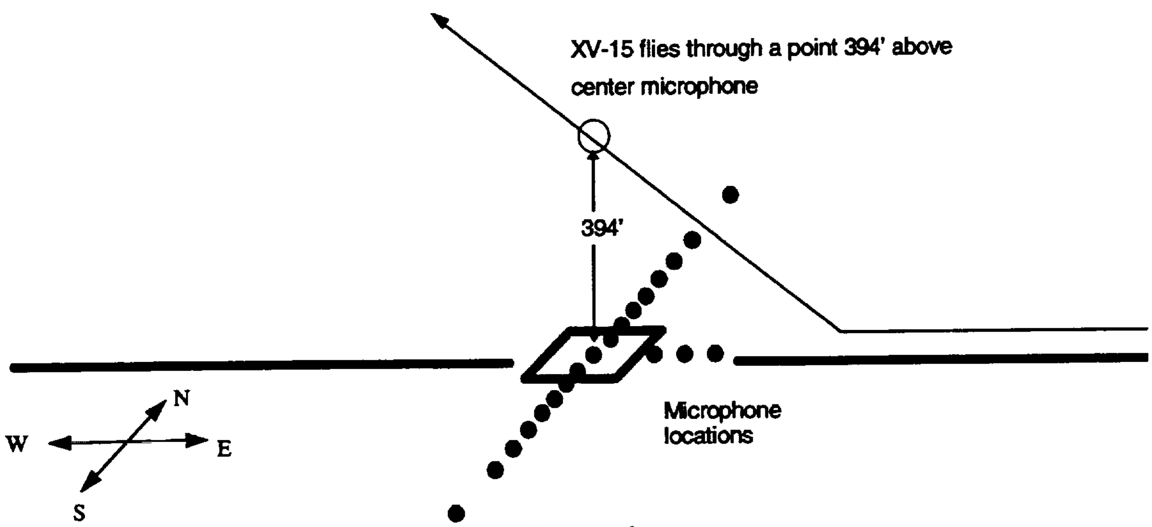
(a) Flight Paths



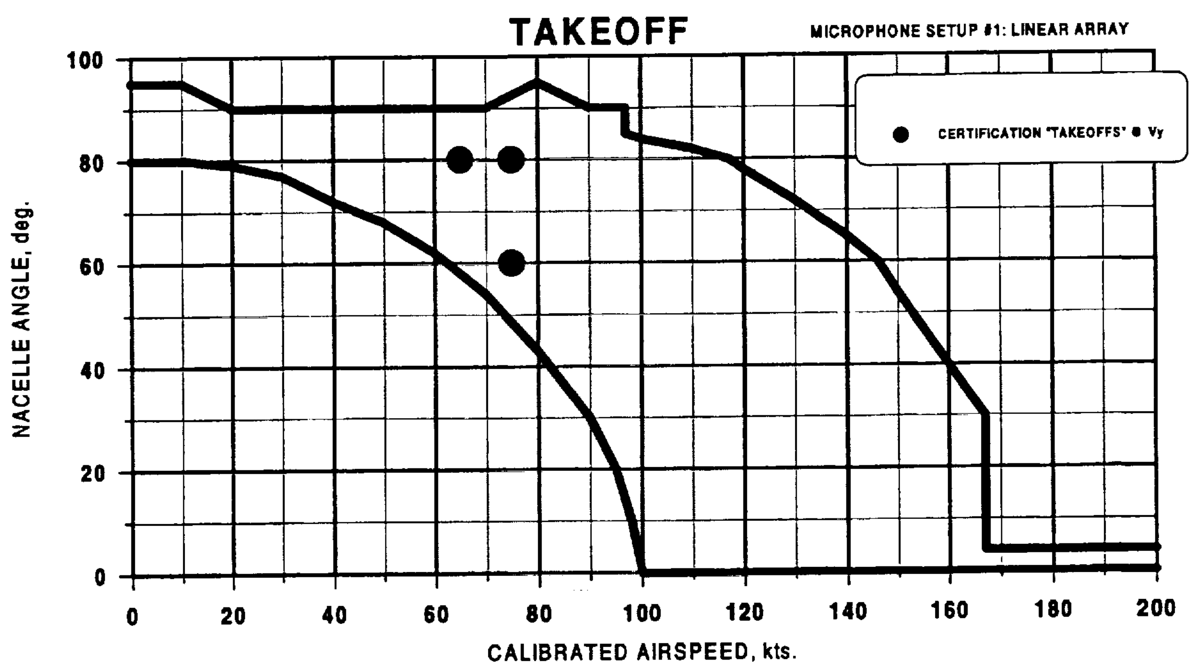
(b) Flight Conditions

Figure 17. Phase 1 Approaches

TAKEOFF



(a) Flight Path



(Flight Conditions)

Figure 18. Phase 1 Takeoffs

2.4.1.4 Hover (Phase 1 testing)

The XV-15 hovered over the center microphone at an altitude of 394 feet, slowly changing azimuth while maintaining a stationary position. The original intent was to hover at 15 degree incremental headings while taking acoustic data. At this altitude, however, the pilot had no visual landmarks, and station-keeping was a problem for long-duration hovers. For this reason, a brief, continuous-turn hover was performed.

2.4.2 Meteorological Conditions - Phase 1 Testing

The meteorological conditions during each Phase 1 test day, as measured at BHTI's 10-meter tower, are presented graphically in Appendix D, pages 1-9.

The meteorological conditions measured at altitude and at NASA's ground station are not included in this report. These are part of the database acquired and processed by NASA.

2.4.3 XV-15 Position/Aircraft Parameters

Position data and aircraft state data are not included in this report. These have been incorporated in the database processed by NASA in parallel with the noise data for each of the twenty Phase 1 microphone positions.

2.5 PHASE 2. "DISTRIBUTED" MICROPHONE ARRAY TESTING

After completion of the Phase 1 testing, the microphones were re-deployed into the distributed array previously shown in Figure 7. Phase 2 testing was accomplished on 3 test days. November 13, 15 and 16.

The distributed microphone array consisted of 30 microphones covering an area 2000 feet laterally from the flight track, and 7000 feet (-6000 to +1000) along the flight track, as previously shown in Figure 7. The exact measurement positions are given in Appendix B.

2.5.1 Flight Conditions

During Phase 2 testing the XV-15 test conditions included level flights, descents to IGE hover, takeoffs from IGE hover, and flight idle. Details of each flight condition flown are given in Appendix E.

2.5.1.1 Level Flights (Phase 2 Testing)

A limited number of level flights were performed during Phase 2. These consisted of the "housekeeping" pass conducted each test day to allow tracing of day-to-day test condition variations, and a right and a left level turn over the array. A total of 4 level flight conditions were flown.

2.5.1.2 Descents (Phase 2 Testing)

For descents, the XV-15 approached the helipad from the West along a heading of approximately 75 degrees, guided by the optical tracker signal displayed in the cockpit. The approaches were categorized according to their glideslopes. A total of 22 descent conditions were flown during Phase 2.

Fixed Glideslopes to 100 ft Waveoff. These descents were performed in a manner similar to those in Phase 1 testing. The intent was to provide "large-array" data that could be correlated with noise predictions based on the Phase 1 results. During each pass, the XV-15 maintained a fixed glideslope and flight condition while attempting to fly through a point 396 above the helipad. After passing over the pad, the condition was held until a point about 100 feet above the ground, where the XV-15 broke off and climbed out in preparation for the next pass.

Fixed Glideslopes to Flare/Hover
During each of these descents, the XV-15 initially maintained a fixed glideslope and flight condition, but it was necessary to bring the nacelles to the full helicopter mode and flare to an IGE hover over the helipad. The point at which the constant flight condition was discontinued was at the discretion of the pilot, and was of course dependent on the target descent angle and airspeed.

Segmented Glideslopes to Flare/Hover
This descent was similar to those discussed in the previous paragraph, but included two glideslope segments. The initial segment required a 3 degree glideslope, and the second segment required a 12 degree slope. As in the fixed glideslope tests, the XV-15 maintained a constant flight condition as long as practical, then flared to a hover over the helipad. Only one of these segmented approaches was included in this test.

Pilot Discretion to Flare/Hover
During this series of tests, the pilot was constrained only by the requirement to maintain the desired flight track and to approach to a hover over the helipad. The pilot, Roy Hopkins, selected a series of practical approaches which might produce a broad range of noise contours. These were labeled A through G in the test log. This series of approaches was run November 14, and was repeated November 16.

2.5.1.3 Takeoffs (Phase 2 Testing)

For takeoff, the XV-15 hovered over the helipad, then climbed out to the West along a heading of approximately 255 degrees, guided by the optical tracker signal displayed in the cockpit. Except for the requirement to maintain flight track, the takeoff flight parameters were not constrained, but were left to the discretion of the pilot. These were labeled Takeoff "A" through "Q" in the test log.

2.5.1.4 IGE Hover (Phase 2 Testing)

An IGE hover was performed at an approximate wheel height of 15 feet over the helipad as previously shown in the photograph of Figure 2. Measurements were taken at four aircraft headings. Two headings were aligned with the flight track (75 and 255 degrees) and two more were perpendicular to the track (165 and 345 degrees).

2.5.1.5 Flight Idle (Phase 2 Testing)

A brief set of acoustic data was acquired with the XV-15 at flight idle, i.e., the rotors were at flat pitch and turning at approximately 98% RPM. The XV-15 was positioned at the center of the helipad. Two headings (75 and 255 degrees) were included.

2.5.2 Meteorological Conditions

The meteorological conditions during each Phase 2 test day as measured at BHTI's 10-meter tower are presented graphically in Appendix D, pages 10-12.

2.5.3 XV-15 Position/Aircraft Parameters

Position data and aircraft state data are not included in this report. These have been incorporated in the database processed by NASA in parallel with the noise data for each of the thirty Phase 2 microphone positions. During the final test day, November 16, the optical tracker was not available, so tracking data was acquired using an experimental Differential Global Positioning System (DGPS) installed on the XV-15.

3. RESULTS/CONCLUDING REMARKS

The acoustic results are not included in this report, and no conclusions are drawn as to the optimal operating modes of the XV-15. NASA-Langley is processing and correlating the acoustic, position, aircraft state, and meteorological datasets for Phase 1 and Phase 2 testing. These will be made available to authorized users.

An experimental means of viewing the Phase 2 test results using computer graphics has been developed under the current contract. This display, called the Large Array Noise Data Display (LANDD), simultaneously displays aircraft position, noise data at 30 microphone locations, and limited aircraft state data (heading, roll, pitch, yaw, nacelle position) on a computer screen. Computer interpolation of the noise data allows instantaneous color contours of the time-varying noise to also be displayed. A sample of the on-screen display is shown in Figure 19. This simultaneous viewing of flight path, noise, and aircraft state, provides a tool for visually isolating those flight parameters which most influence total noise.

The LANDD employs the NASA-developed Flow Analysis Software Toolkit (FAST), and was developed on a Silicon Graphics Indigo 2 platform. Currently, 11 approaches and 1 takeoff condition are loaded and available for display. It is recommended that additional Phase 2 approaches and takeoffs be incorporated into LANDD so that comparative studies can be completed.

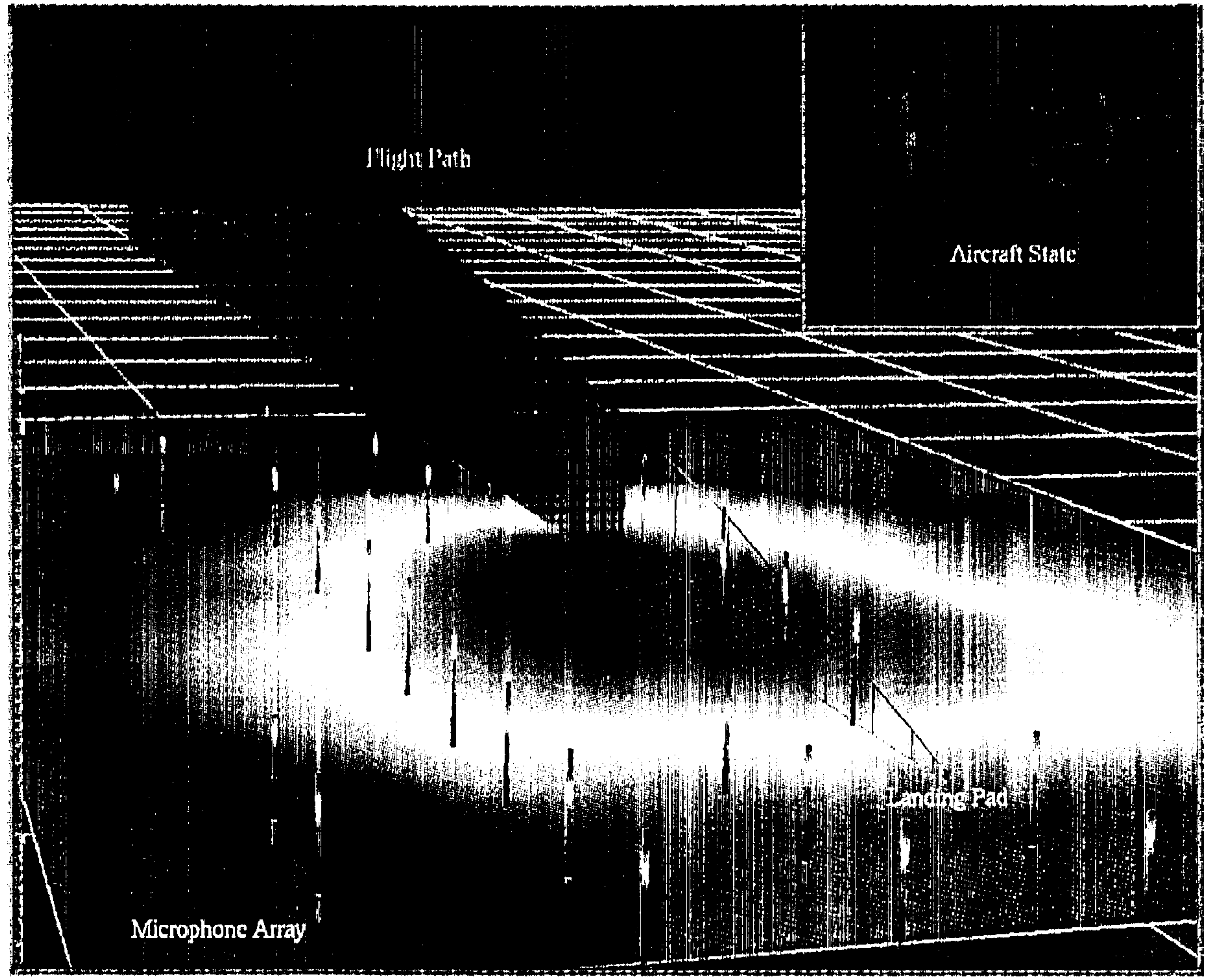


Figure 19. Bell Helicopter Textron Large Noise Data Display XV-15 Tests at Waxahachie (Oct-Nov 1995)

REFERENCES

1. Riley, R.,Brieger, J.,and Maisel, M, "Preliminary Investigation into XV-15 Tiltrotor Acoustic and Directivity Characteristics," BHTI Report 699-099-288, November 1988.

2. Brieger, J., Maisel, M., and Gerdes, R. "External Noise Evaluation of the XV-15 Tiltrotor Aircraft," presented at the American Helicopter Society National Specialists' Meeting on Aerodynamics and Aeroacoustics, Arlington, Texas, February 1987.

3. George, A. R., Smith, C. A., Maisel, M. D., and Brieger, J. T., "Tiltrotor Aircraft Aeroacoustics," presented at the 45th Annual National Forum of the American Helicopter Society, May 1989.

4. Edwards, Bryan D,"External Noise of the XV-15 Tiltrotor Aircraft," NASA Contractor Report 187463, May 1991.

5. Maisel, M. D., "XV-15 Tiltrotor Aircraft Research Aircraft Familiarization Document," NASA TMX-62,407, January 1975.

APPENDIX A

LIST OF TEST PERSONNEL

XV-15 NOISE TEST PERSONNEL

Oct.-Nov. 1995 @ SSC, Waxahachie, Texas

TEAM	ASSOCIATION	NAME	INDIVIDUAL RESPONSIBILITIES
NASA-LaRC ACOUSTICS	NASA-LaRC	DAVID CONNER	PROJECT ENGINEER
NASA-LaRC ACOUSTICS	NASA-LaRC	MICHAEL MARCOLINI	PROJECT ENGINEER
NASA-LaRC ACOUSTICS	NASA-LaRC	JOHN CLINE	TEST ENGINEER
NASA-LaRC ACOUSTICS	NASA-LaRC	KAREN LYLE	INTERNAL NOISE
NASA-LaRC ACOUSTICS	NASA-LaRC	ODILYN SANTA MARIA	TEST ENGINEER
NASA-LaRC ACOUSTICS	LOCKHEED	CHARLES (KEN) RUTLEDGE	NASA- LaRC DATA ANALYSIS
NASA-LaRC ACOUSTICS	NASA-LaRC	DAVID (D.C.) DAVIS	NASA INSTRUMENTATION
NASA-LaRC ACOUSTICS	LOCKHEED	MARK WILSON	NASA- LaRC DATA ANALYSIS
NASA-LaRC ACOUSTICS	WYLE LABS	TOM BAXTER	NASA INSTRUMENTATION
NASA-LaRC ACOUSTICS	WYLE LABS	NICHOLAS KARANGELEN	NASA INSTRUMENTATION
NASA-LaRC ACOUSTICS	WYLE LABS	VIRGILIO MARCELO	NASA INSTRUMENTATION
NASA-LaRC ACOUSTICS	WYLE LABS	KEITH SCUDDER	NASA INSTRUMENTATION
NASA-LaRC ACOUSTICS	WYLE LABS	JOHN SWAIN	NASA INSTRUMENTATION
NASA-LaRC ACOUSTICS	NASA-LaRC	JAYE MOEN	METEOROLOGICAL (BALLOON) INSTRUMENTATION
BELL ACOUSTICS	BELL	BRYAN EDWARDS	PROJECT ENGINEER -ACOUSTICS
BELL ACOUSTICS	BELL	JOHN BRIEGER	ACOUSTICS
BELL ACOUSTICS	BELL	RICK RILEY	ACOUSTICS
BELL ACOUSTICS	BELL	CHARLES COX	ACOUSTICS
BELL FLIGHT	BELL	COLBY NICKS	PROJECT ENGINEER - FLIGHT
BELL FLIGHT	BELL	ROY HOPKINS	PILOT
BELL FLIGHT	BELL	DON BORG	PILOT
BELL FLIGHT	BELL	BILL MARTIN	FLIGHT TEST
BELL FLIGHT	BELL	JERRY PICKARD	LOGISTICS
BELL FLIGHT	BELL	ALAN ADAMSON	INSTRUMENTATION
BELL FLIGHT	BELL	JERRY WALKER	INSTRUMENTATION
BELL FLIGHT	BELL	JIM WILSON	DYNAMICS
BELL FLIGHT	BELL	MIKE SHAW	DATA OPERATIONS
BELL FLIGHT	BELL	MARK STOUFFLET	DATA OPERATIONS
BELL FLIGHT	BELL	KELLY SPIVEY	DATA OPERATIONS
BELL FLIGHT	BELL	KEN COGDILL	FLIGHT
BELL FLIGHT	BELL	HARRY DURAND	FLIGHT
BELL FLIGHT	BELL	FRED MAJOR	FLIGHT
BELL FLIGHT	BELL	KEN MITCHELL	FLIGHT
BELL FLIGHT	BELL	WELDON RHEA	FLIGHT
NASA- AMES LASER TRACKER	NASA-AMES	FRED SHIGEMOTO	LASER TRACKER
NASA- AMES LASER TRACKER	RECOM	ED FARR	LASER TRACKER
NASA- AMES LASER TRACKER	RECOM	JIM LAWRENCE	LASER TRACKER
NASA- AMES LASER TRACKER	RECOM	RICK TAYLOR	LASER TRACKER
NASA- AMES LASER TRACKER	STERING	PAM PFOHL	LASER TRACKER

APPENDIX B

MICROPHONE POSITIONS - SURVEYED POINTS

SIDELINE ANGLE FROM VERTICAL (DEGREES) TARGET ALTITUDE 394 ft.	LOCATION CALLOUT*	x (+ is Westerly) DISTANCE (ft.)	y (+ is Southerly) DISTANCE (ft.)	z (+ is up) DISTANCE (ft.)	<<<<<<<< NAD-83 COORDINATES >>>>>>>>>								
					<<<<<<<<LATITUDE>>>>>>>>>				<<<<<<<<LONGITUDE>>>>>>				Elevation
	TRACKER SITE			65.7	N	32	20	6.29265	W	96	54	54.36509	723.07
80	M1- 1 -N	0	-5671	17.3	N	32	19	42.72147	W	96	54	48.34208	674.70
70	M1- 2 -N	0	-2747	10.8	N	32	19	31.43729	W	96	54	46.44261	668.20
60	M1- 3 -N	0	-1732	6.6	N	32	19	27.51817	W	96	54	45.78267	663.99
50	M1- 4 -N	0	-1192	3.9	N	32	19	25.43206	W	96	54	45.43265	661.28
40	M1- 5 -N	0	-839	3.8	N	32	19	24.07174	W	96	54	45.20282	661.17
30	M1- 6 -N	0	-577	1.6	N	32	19	23.06127	W	96	54	45.03278	659.04
20	M1- 7 -N	0	-364	0.7	N	32	19	22.23797	W	96	54	44.89429	658.09
10	M1- 8 -N	0	-176	-0.0	N	32	19	21.51365	W	96	54	44.77243	657.36
0	M1- 9 -N	0	0	-0.0	N	32	19	20.83135	W	96	54	44.65822	657.39
10	M1- 10 -N	0	176	-1.7	N	32	19	20.15273	W	96	54	44.54313	655.66
20	M1- 11 -N	0	364	-2.8	N	32	19	19.42834	W	96	54	44.42129	654.63
30	M1- 12 -N	0	577	-3.5	N	32	19	18.60421	W	96	54	44.28276	653.90
40	M1- 13 -N	0	839	-3.7	N	32	19	17.59412	W	96	54	44.11269	653.70
50	M1- 14 -N	0	1192	-5.3	N	32	19	16.23299	W	96	54	43.88329	652.14
60	M1- 15 -N	0	1732	-6.8	N	32	19	14.14793	W	96	54	43.53259	650.57
70	M1- 16 -N	0	2747	-7.7	N	32	19	10.22915	W	96	54	42.87306	649.71
80	M1- 17 -N	0	5671	-17.5	N	32	18	58.94370	W	96	54	40.97376	639.92
0	M1- 18 -N	-200	0	-3.6	N	32	19	21.10635	W	96	54	42.34937	653.85
0	M1- 19 -N	-400	0	-5.5	N	32	19	21.38039	W	96	54	40.04142	651.93
0	M1- 20 -N	-600	0	-6.2	N	32	19	21.65423	W	96	54	37.73286	651.21
VANS	V1- 1 -N	-600	700	-11.9	N	32	19	14.79740	W	96	54	36.57890	645.54
VANS	V1- 2 -N	-600	-700	-1.7	N	32	19	28.51144	W	96	54	38.88704	655.67
VANS	V1- 1 -B	-600	600	-11.1	N	32	19	15.77691	W	96	54	36.74315	646.32
BELL MICS	M1- 1 -B	-200	492	-3.4	N	32	19	16.28707	W	96	54	41.53812	650.01
BELL MICS	M1- 2 -B	-200	0	0.4	N	32	19	21.10635	W	96	54	42.34937	653.85
BELL MICS	M1- 3 -B	-200	-492	5.6	N	32	19	25.92615	W	96	54	43.16109	658.97
BELL MICS	M1- 4 -B	-200	492	-7.4	N	32	19	16.28707	W	96	54	41.53812	650.01
BELL MICS	M1- 5 -B	-200	0	-3.6	N	32	19	21.10635	W	96	54	42.34937	653.85
BELL MICS	M1- 6 -B	-200	-492	1.6	N	32	19	25.92615	W	96	54	43.16109	658.97

Table title: XV-15 SURVEYED LOCATIONS - PHASE 1 TESTING

M2=MICROPHONE LOCATION, PHASE 2 TESTS
N=NASA LOCATION
B=BELL LOCATION
V=VAN LOCATION

X - DISTANCES ARE ALONG THE FLIGHT TRACK
Y - DISTANCES ARE PERPENDICULAR TO THE FLIGHT PATH
Z - DISTANCES ARE VERTICAL HEIGHT ABOVE LANDING PAD
FLIGHT PATH RAN ROUGHLY EAST-WEST (75 DEG/255 DEG)

XV-15 SURVEYED LOCATIONS - PHASE 2 TESTING

Description	LOCATION CALLOUT*	x (+ is DISTANCE (ft.)	y (+ is DISTANCE (ft.)	z (+ is up) DISTANCE (ft.)	<<<<<<<< NAD-83 COORDINATES >>>>>>>>> <<<<<<<<LATITUDE>>>>>>>>				<<<<<<<<LONGITUDE>>>>>>				Elevation	Description
WEATHER BALLOON		TBD	TBD	65.7	N	32	20	6.29265	W	96	54	54.36509	723.07	WEATHER BALLOON
OPTICAL TRACKER		TBD	TBD	65.7	N	32	20	6.29265	W	96	54	54.36509	723.07	OPTICAL TRACKER
HELIPAD (REF PT.)	M1- 9 -N	0	0	0.0	N	32	19	20.83135	W	96	54	44.65822	657.39	M1-9-N
MICROPHONE	M2- 1 -N	6000	0	6.0	N	32	19	12.61253	W	96	55	53.90705	663.42	M2-1-N
MICROPHONE	M2- 2 -N	4700	0	-6.8	N	32	19	14.39412	W	96	55	38.90271	650.60	M2-2-N
MICROPHONE	M2- 3 -N	4700	750	0.0										
MICROPHONE	M2- 4 -N	3850	0	12.2	N	32	19	15.55945	W	96	55	29.09195	669.61	M2-4-N
MICROPHONE	M2- 5 -N	3850	500	8.0	N	32	19	10.66187	W	96	55	28.26657	665.42	M2-5-N
MICROPHONE	M2- 6 -N	3850	1250	10.3	N	32	19	3.31485	W	96	55	27.03007	667.69	M2-6-N
MICROPHONE	M2- 7 -N	3000	0	12.8	N	32	19	16.72430	W	96	55	19.28244	670.19	M2-7-N
MICROPHONE	M2- 8 -N	3000	500	4.1	N	32	19	11.82580	W	96	55	18.45775	661.53	M2-8-N
MICROPHONE	M2- 9 -N	3000	1000	3.7	N	32	19	6.92827	W	96	55	17.63186	661.1	M2-9-N
MICROPHONE	M2- 10 -N	3000	1500	5.5	N	32	19	4.47930	W	96	55	17.22040	662.84	M2-10-N
MICROPHONE	M2- 1 -N	2250	0	4.1	N	32	19	17.75189	W	96	55	10.62660	661.5	M2-11-
MICROPHONE	M2- 12 -N	2250	1000	-5.8	N	32	19	7.95591	W	96	55	8.97678	651.63	M2-12-N
MICROPHONE	M2- 13 -N	1500	0	6.9	N	32	19	18.77880	W	96	55	1.97097	664.31	M2-13-N
MICROPHONE	M2- 14 -N	1500	1000	-6.3	N	32	19	8.98249	W	96	55	0.32160	651.1	M214-N
MICROPHONE	M2- 15 -N	1500	2000	-0.5	N	32	18	59.18746	W	96	54	58.67186	656.92	M2-15-N
MICROPHONE	M2- 16 -N	1000	0	9.0	N	32	19	19.46339	W	96	54	56.19945	666.34	M2-16-N
MICROPHONE	M2- 17 -N	1000	1000	-2.7	N	32	19	9.66805	W	96	54	54.55068	654.74	M2-17-N
MICROPHONE	M2- 18 -N	500	0	7.6	N	32	19	20.14842	W	96	54	50.42828	664.96	M2-18-N
MICROPHONE	M2- 19 -N	500	1000	-1.0	N	32	19	10.35275	W	96	54	48.78010	656.39	M2-19-N
MICROPHONE	M2- 20 -N	500	2000	0.4	N	32	19	0.55676	W	96	54	47.13017	657.77	M2-20-N
MICROPHONE	M2- 21 -N	0	500	-5.6	N	32	19	15.93471	W	96	54	43.83354	651.8	M2-21-N
MICROPHONE	M2- 22 -N	0	1000	-7.7	N	32	19	11.03666	W	96	54	43.00830	649.73	M2-22-N
MICROPHONE	M2- 23 -N	0	1500	-9.0	N	32	19	6.13841	W	96	54	42.18471	648.41	M2-23-N
MICROPHONE	M2- 24 -N	-500	0	-6.2	N	32	19	21.5169	W	96	54	38.86731	651.1	M2-24-N
MICROPHONE	M2- 25 -N	-500	500	-9.9	N	32	19	16.61952	W	96	54	38.06308	647.54	M2-25-N
MICROPHONE	M2- 26 -N	-500	1000	-	N	32	19	11.7217	W	96	54	37.23780	645.29	M2-26-N
MICROPHONE	M2- 27 -N	-500	1500	-14.2	N	32	19	6.82364	W	96	54	36.41440	643.16	M2-27-N
MICROPHONE	M2- 28 -N	-1000	0	-8.5	N	32	19	22.20200	W	96	54	33.1161	648.89	M2-28-N
MICROPHONE	M2- 29 -N	-1000	500	-12.0	N	32	19	17.30387	W	96	54	32.29135	645.38	M2-29-N
MICROPHONE	M2- 30 -N	-1000	1000	-15.3	N	32	19	12.40562	W	96	54	31.46783	642.08	M2-30-N
MICROPHONE	M2- 1 -B	3750	-492	22.0	N	32	19	20.51586	W	96	55	28.75024	675.43	M2-1-B
MICROPHONE	M2- 2 -B	3750	0	17.3	N	32	19	15.69668	W	96	55	27.93891	670.74	M2-2-B
MICROPHONE	M2- 3 -B	3750	492	13.2	N	32	19	10.87677	W	96	55	27.12704	666.63	M2-3-B
MICROPHONE	M2- 4 -B	3750	-492	18.0	N	32	19	20.51586	W	96	55	28.75024	675.43	M2-4-B
MICROPHONE	M2- 5 -B	3750	0	13.3	N	32	19	15.69668	W	96	55	27.93891	670.74	M2-5-B
MICROPHONE	M2- 6 -B	3750	492	9.2	N	32	19	10.87677	W	96	55	27.12704	666.63	M2-6-B
MICROPHONE	M2- 7 -B	7016	883	3.4	N	32	19	2.56470	W	96	56	4.44263	660.80	M2-7-B
MICROPHONE	M2- 8 -B	8287	1	11.	N	32	19	9.44156	W	96	56	20.59010	668.80	M2-8-B
GRND WEATHER STA.	V2- 1 -B	3500	800	8.6	N	32	19	8.20258	W	96	55	23.73319	666.01	V2-1-B

M2= MICROPHONE LOCATION, PHASE 2 TESTS
N= NASA LOCATION
B= BELL LOCATION
V= VAN LOCATION

X- DISTANCES ARE ALONG THE FLIGHT TRACK
Y- DISTANCES ARE PERPENDICULAR TO THE FLIGHT TRACK
Z- DISTANCES ARE VERTICAL HEIGHT ABOVE LANDING PAD
FLIGHT PATH RAN ROUGHLY EAST-WEST (75 DEG/255 DEG)

APPENDIX C

TEST SEQUENCE

TEST SEQUENCE / TEST ENGINEER'S FIELD NOTES

DATE	LOCAL TIME	XV-15 FLT#	NASA RUN #	BHTI SHIP REC#	BHTI COND'N. NO.	
10/10/95	749	161	101	8	101	question on tracking
10/10/95	755	161	104	9	103A	slow condition to check tracking range
10/10/95	802	161	102	10	102	tracking looks ok
10/10/95	809	161	103	11	103	"vertical guidance deviating"
10/10/95	815	161	105	12	104	
10/10/95	821	161	106	13	105	
10/10/95	829	161	107	14	106	helicopter interferes - circle XV-15, then come in
10/10/95	835	161	108	15	101	
10/10/95	840	161	109	16	107	
10/10/95	845	161	110	17	306	fixed wing a/c at end of record
						RTB - fuel
10/10/95	956	161	111	20	306	
10/10/95	1006	161	112	21	305	tracker set on wrong track - XV-15 circled, then good
10/10/95	1012	161	113	22	109	fixed wing jet overhead
10/10/95	1016	161	114	23	109	abort...XV-15 too high (100')
10/10/95	1020	161	115	24	109	
10/10/95	1024	161	116	25	110	
10/10/95	1027	161	117	26	111	"tracking dropouts" - posn looked good
10/10/95	1032	161	118	27	112	fixed wing jet
10/10/95	1036	161	119	28	113	altitude off - Bell mics overloaded
10/10/95	1041	161	120	29	113	
10/10/95	1047	161	121	-	101	Abort
						RTB - fuel
10/12/95	746	162	122	8	101	lined up with lights - pilot indicator shows right of course
10/12/95	752	162	123	9	108	Bell mics overloaded
10/12/95	756	162	124	10	108A	Quietest pass so far
10/12/95	801	162	125	11	304	
10/12/95	813	162	126	12	301	Pilot:"Nose high attitude - bad - unnatural condition"
10/12/95	818	162	127	13	302	
10/12/95	823	162	128	14	303	
10/12/95	829	162	129	15	315	BVI rating=3. XV-15 got very low to ground
10/12/95	835	162	130	16	314	BVI rating = 4. Tractor on Boz Rd. - XV-15 circled, then set up for this pass
10/12/95	845	162	131	17	311	BVI rating=2; Pilot: "Bad vibs & handling qualities"
						7:30 flt scheduled, but postponed for fuel contamination problem
10/13/95		163				
10/13/95	1350	163				
10/13/95	1406	163	132	8	101	Pilot: "Turbulent"
10/13/95	1413	163	133	9	312	Aborted run
10/16/95	745	x	-	-		
10/16/95	750	164	-	-	101	Abort - Housekeeping run
10/16/95	-	164	-	-	101	Abort - Housekeeping run
10/16/95	758	164	134	9	101	Housekeeping - still some question on tracking
10/16/95	806	164	135	10	312	BVI rating-1
10/16/95	814	164	136	11	313	BVI rating=3
10/16/95		164	137	12	310	BVI rating=3
10/16/95	828	164	138	13	307a	BVI rating=3
10/16/95	834	164	139	14	308	BVI rating=2
10/16/95	839	164	140	15	309	BVI rating=2
10/27/95	758	168a	141	8	101	Housekeeping
10/27/95	802	168a	142	9	324	Abort - no tracking info.
10/27/95	805	168a	143	10	322	BVI rating=4; went for 90 deg nacelle, got 80deg by mistake
10/27/95	812	168a	144	11	324	
10/27/95	824	168a	145	12	325	BVI rating=2; tracking question; 15-kt headwind.. slow pass
10/27/95	836	168a	146	13	326	BVI rating=2; tracking question early; Pilot: "comfortable approach"
10/27/95	844	168a	147	14	327	BVI rating-4
10/27/95	851	168a	148	15	323	BVI rating-4
10/27/95	857	168a	149	16	320	BVI rating-4
						RTB- fuel
10/27/95	1000	168b	150	21	101	Housekeeping point
10/27/95	1006	168b	151	22	321	BVI rating=2; high crab angle - nose north of track
10/27/95	1014	168b	152	23	319	BVI rating=4
10/27/95	1021	168b	153	24	316	Pilot: "can't see ground - nose high"
10/27/95	1026	168b	154	25	317	
10/27/95	1031	168b	155	26	318	BVI rating-3
10/27/95	1039	168b		27		hover - Nose @ 255 deg - checking tracking
10/27/95		168b				hover - Nose @ 255 deg
10/27/95	1049	168b	156	28	334	
10/28/95	852	169	157	2	101	
10/28/95	902	169	158	3	334	
10/28/95	908	169	159	4	334	
10/28/95	914	169	160	5	335	
10/28/95	919	169	161	6	335	
10/28/95	930	169	162	7	336	

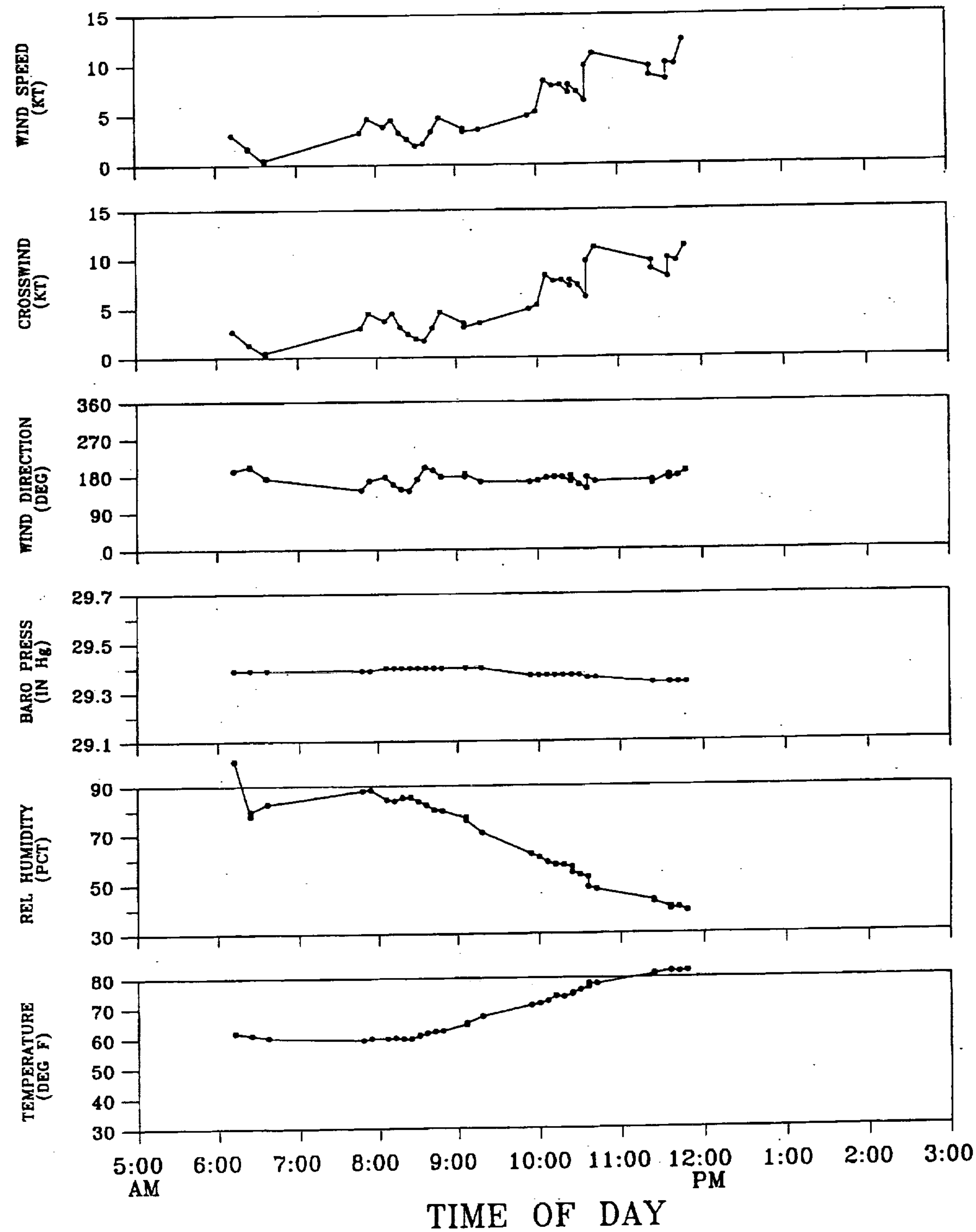
DATE	LOCAL TIME	XV-15 FLT#	NASA RUN #	BHTI SHIP REC#	BHTI COND'N. NO.	
11/01/95	955	170	163	5	101	
11/01/95	959	170	164	6	108	
11/01/95	1004	170	165	7	108	
11/01/95	1009	170	166	8	109	
11/01/95	1015	170	167	9	334	
11/01/95	1022	170	168	10	501	
11/01/95	1028	170	169	11	501	
11/01/95	1033	170	170	12	501a	
11/01/95	1039	170	171	13	502	
11/01/95	1043	170	172	14	115	
11/01/95	1050	170	173	15	116	
11/01/95	1056	170	174	16	117	
11/04/95	736	171a	175	18	101	
11/04/95	743	171a	176	19	334	
11/04/95	752	171a	177	20	335	
11/04/95	800	171a	178	21	336	
11/04/95	808	171a	179	22	337	
11/04/95	816	171a	180	23	307	
11/04/95	823	171a	180	24	307	
11/04/95	830	171a	181	25	308	
11/04/95	836	171a	182	26	108	
11/04/95	841	171a	183	27	109	
11/04/95	846	171a	184	28	501	
11/04/95	955	171b	185	33	101	
11/04/95	1000	171b	186	34	502	
11/04/95	1005	171b	187	35	344	
11/04/95	1012	171b	188	36	345	
11/04/95	1017	171b	189	37	342	
11/04/95	1021	171b	190	38	342	
11/04/95	1027	171b	191	39	343	
11/04/95	1033	171b	192	40	340	
11/04/95	1038	171b	193	41	341	
11/04/95	1235	171c	194	47	194	Abort - No guidance, no Bell data
11/04/95	-	171c	195	-	195	Abort- No guidance
11/04/95	-	171c	195	48	195	
						RTB- Rain moved in
11/07/95	806	172	196	10	331	
11/07/95	815	172	197	11	333	
11/07/95	821	172	198	12	329	
11/07/95	832	172	199	13	328	
11/07/95	840	172	200	14	101	
						RTB - Winds too high to continue
11/08/95	731	173a	201	8	101	
11/08/95	738	173a	202	9	354	
11/08/95	746	173a	203	10	355	
11/08/95	753	173a	204	11	356	
11/08/95	759	173a	205	12	352	
11/08/95	808	173a	206	13	353	
11/08/95	814	173a	207	14	350	
11/08/95	819	173a	208	15	351	
11/08/95	826	173a	209	16	347	
11/08/95	832	173a	210	17	348	
11/08/95	838	173a	211	18	349	
11/08/95	938	173b	212	22	101	
11/08/95	947	173b	213	23	332	
11/08/95		173b	214	24	331	
11/08/95	1001	173b	215	25	330	
11/08/95	1010	173b	216	26	330	
11/08/95	1015	173b	217	27	333	
11/08/95	1020	173b	218	28		hover
11/08/95	1032	173b	219	29		hover
11/08/95	1035	173b	220	30		hover
11/08/95	1042	173b	221	31	318	

DATE	LOCAL TIME	XV-15 FLT#	NASA RUN #	BHTI SHIP REC#	BHTI COND'N. NO.	
11/13/95	825	175	300	8	200	
11/13/95	835	175	301	9	200	
11/13/95	845	175	302	10	402	
11/13/95	853	175	303	11	402	
11/13/95	-	175	304	12	410	
11/13/95	-	175	305	13	471	
11/13/95	920	175	306	14	471	
11/14/95	805	176a	307	2	200	
11/14/95	810	176a	307	2	200	
11/14/95	817	176a	308	3	402	
11/14/95	-	176a	-	-	-	
11/14/95	825	176a	309	4	489	
11/14/95	833	176a	310	5	490	
11/14/95	-	176a	311	6	492	
11/14/95	843	176a	312	7	601	
11/14/95	846	176a	313	8	495	
11/14/95	852	176a	314	9	602	
						RTB - fuel
11/14/95	1005	176b	315	13	491	
11/14/95	1014	176b	316	14	603	
11/14/95	-	176b	317	15	493	
11/14/95	1021	176b	318	16	604	
11/14/95	1024	176b	319	17	494	
11/14/95	1030	176b	320	18	605	
11/14/95	1035	176b	321	19	492	
11/14/95	-	176b	322	20	605	
11/14/95	1045	176b	323	21	433	
11/14/95	1052	176b	324	22	422	
11/14/95	1059	176b	325	23	474	
11/14/95	1108	176b	326	24	475	
						RTB - fuel
11/14/95	1252	176c	327	29	469	
11/14/95	101	176c	328	30	470	
11/14/95	110	176c	329	31	606	
11/14/95	-	176c	330	32	471	
11/14/95	-	176c	331	33	607	
11/14/95	116	176c	332	34	472	
11/14/95	120	176c	333	35	608	
11/14/95	125	176c	334	36	473	
11/14/95	130	176c	335	37	841	
11/14/95	-	176c	336	38	843	
11/14/95	136	176c	337	40	821	
11/14/95	138	176c	338	41	822	
11/14/95	-	176c	339	42	823	
11/14/95	141	176c	340	43	824	
11/14/95	150	176c	341	44	478	
11/14/95	154	176c	342	45	609	
						RTB - fuel
11/16/95	905	177	343	8	200	
11/16/95	912	177	344	9	481	
11/16/95	915	177	345	10	610	
11/16/95	918	177	346	11	480	
11/16/95	921	177	347	12	611	
11/16/95	925	177	348	13	482	
11/16/95	928	177	349	14	612	
11/16/95	931	177	350	15	483	
11/16/95	934	177	351	16	613	
11/16/95	938	177	352	17	484	
11/16/95	941	177	353	18	614	
11/16/95	944	177	354	19	485	
11/16/95	947	177	355	20	615	
11/16/95	951	177	356	21	486	
11/16/95	955	177	357	22	616	
11/16/95	959	177	358	23	486	
11/16/95	1003	177	359	24	617	
11/16/95	1006	177	360	25	251	
11/16/95	1013	177	361	26	253	
						NOTES: Landing gear is up during descents above 90 kt. Landing gear is up during level flight passes Landing gear is down during descents below 90 kt.

APPENDIX D

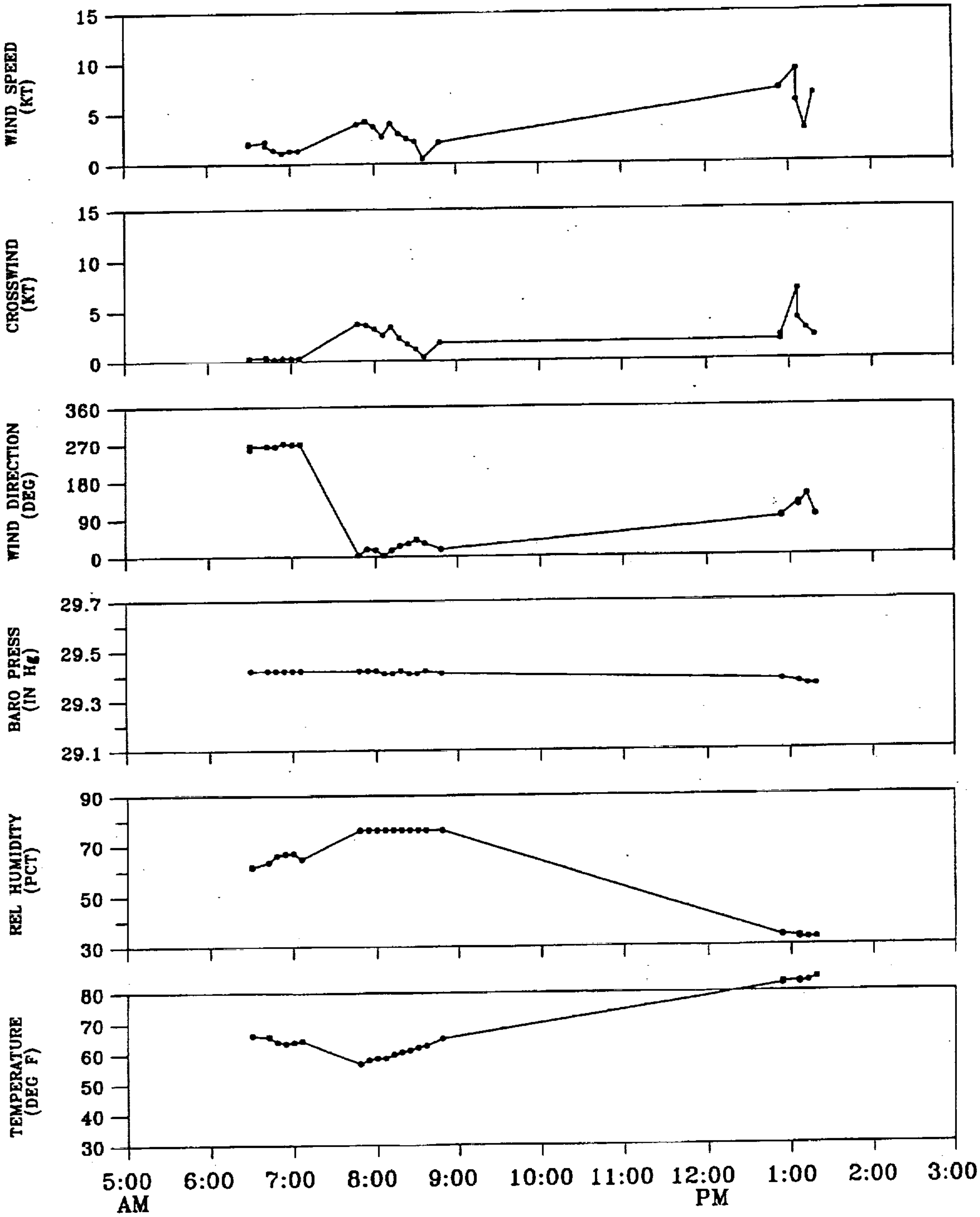
METEOROLOGICAL CONDITIONS

METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 1 TESTING
10 OCTOBER 1995



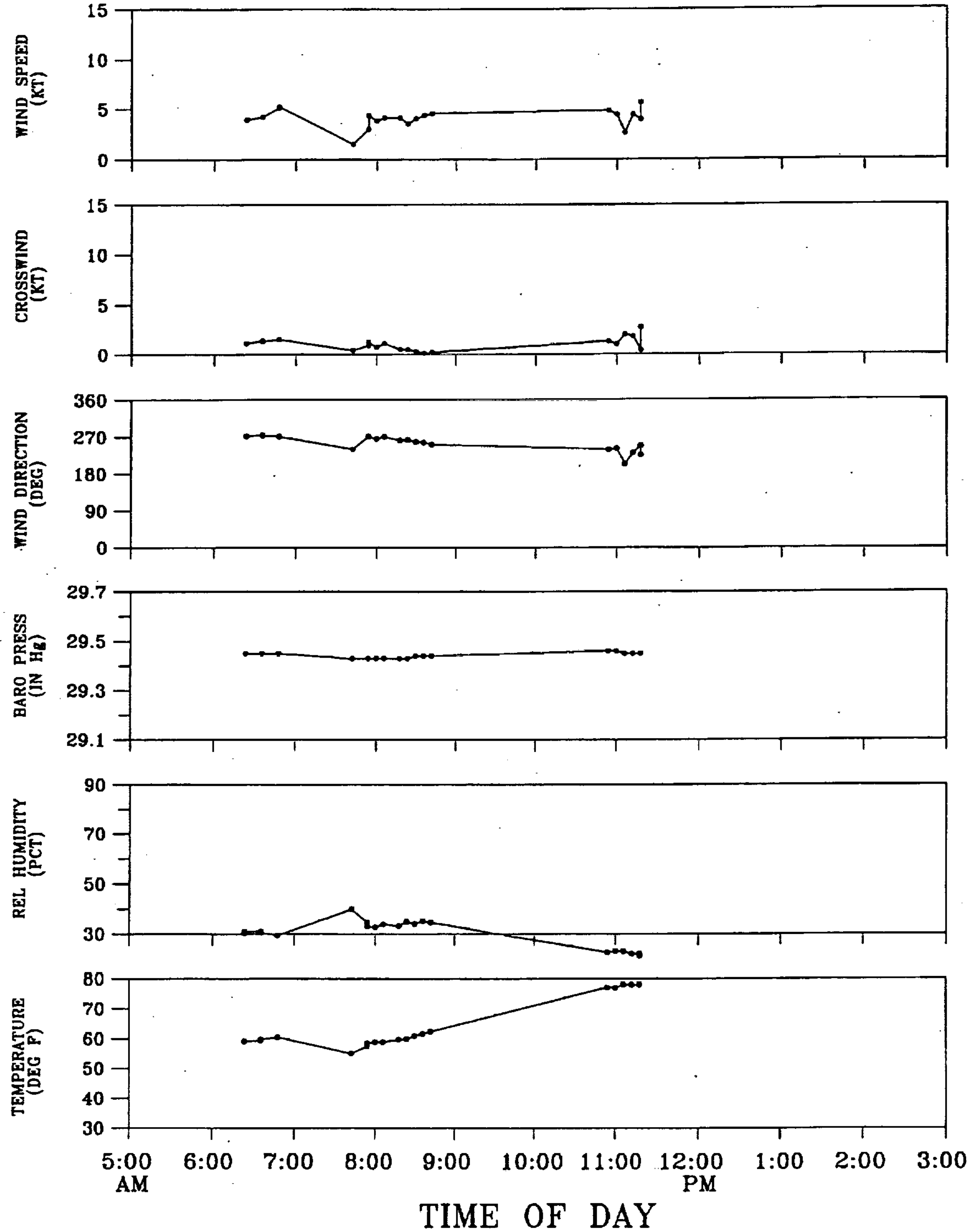
(LOCAL TIME)

METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 1 TESTING
12 OCTOBER 1995

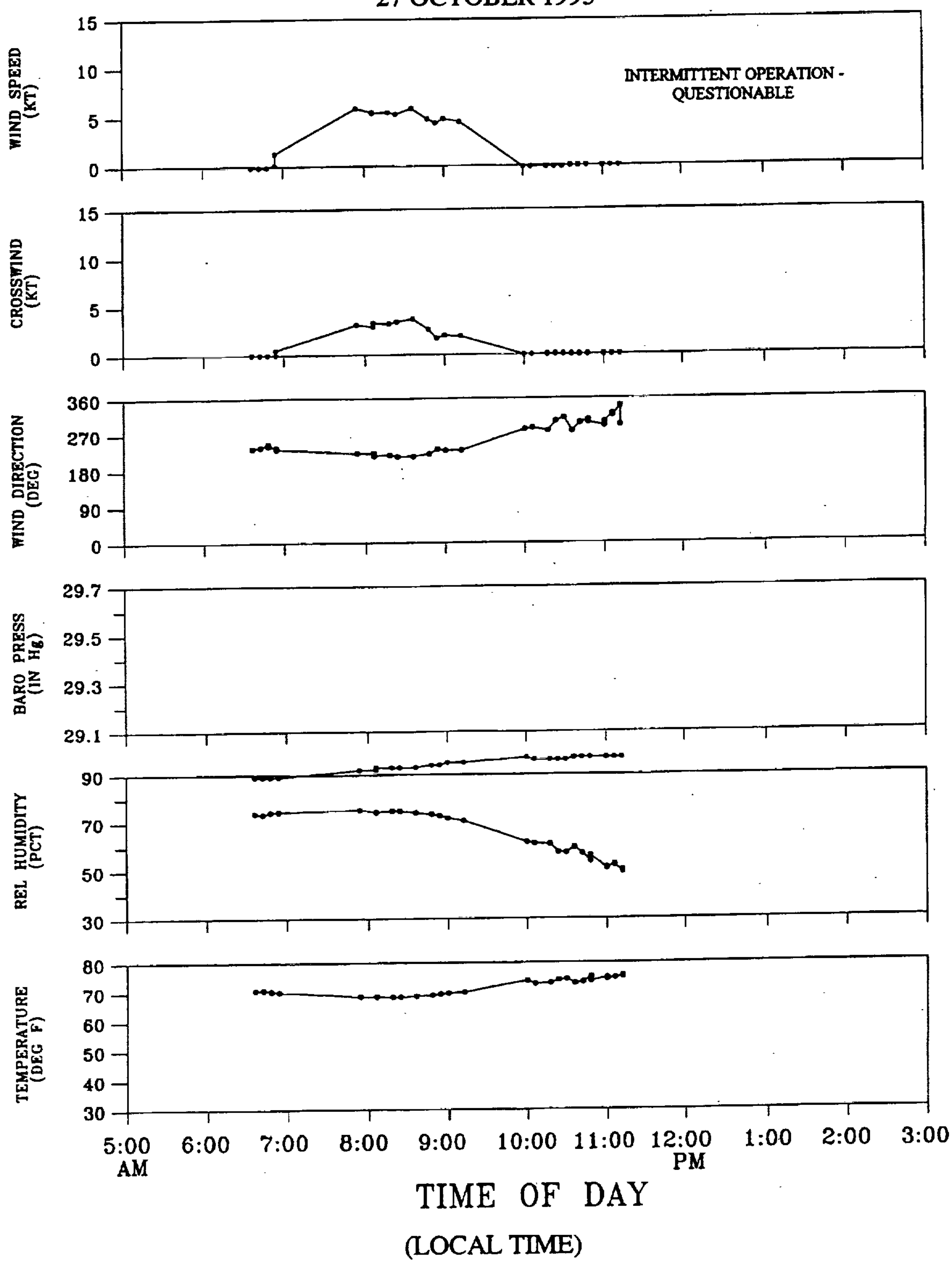


(LOCAL TIME)

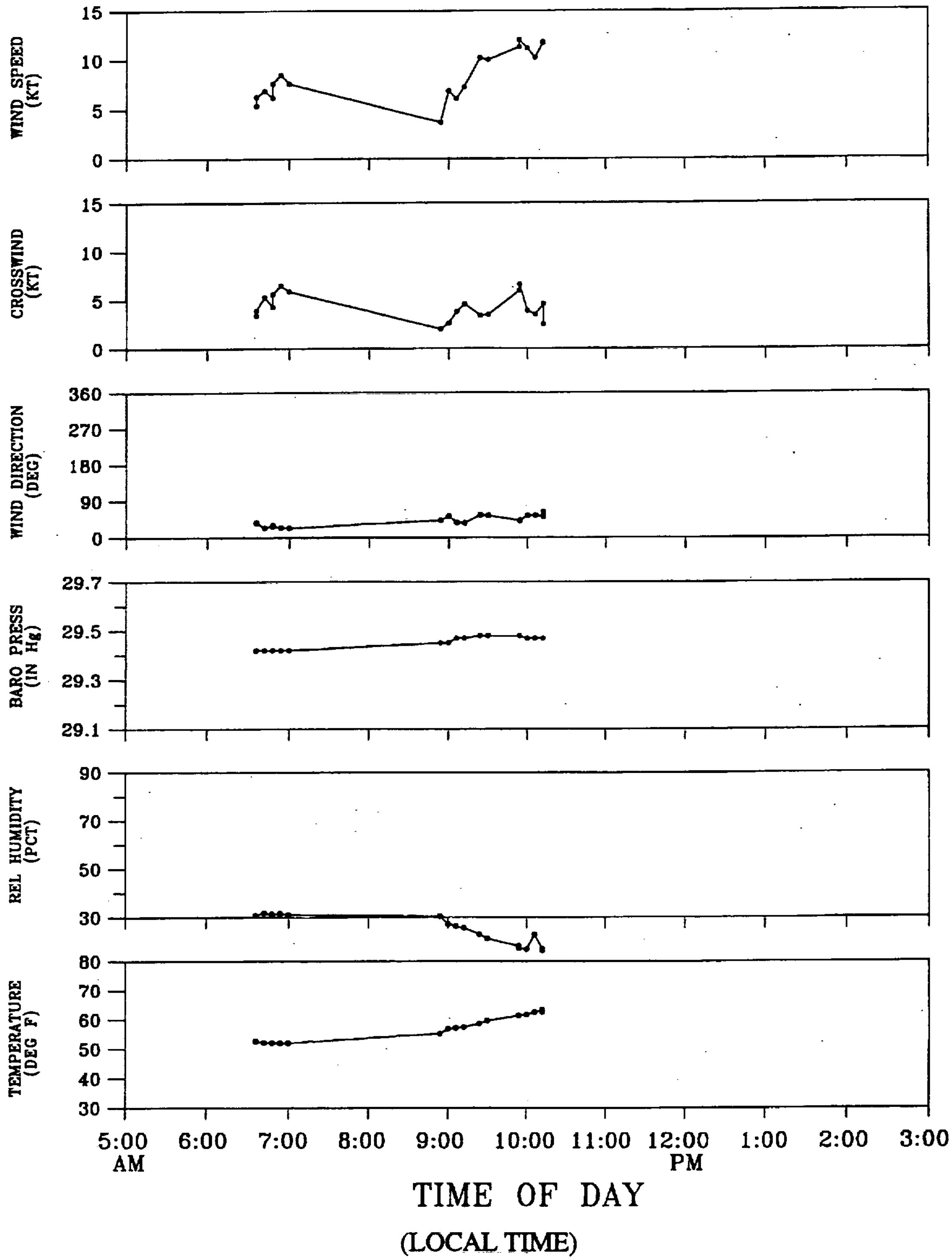
METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 1 TESTING
16 OCTOBER 1995



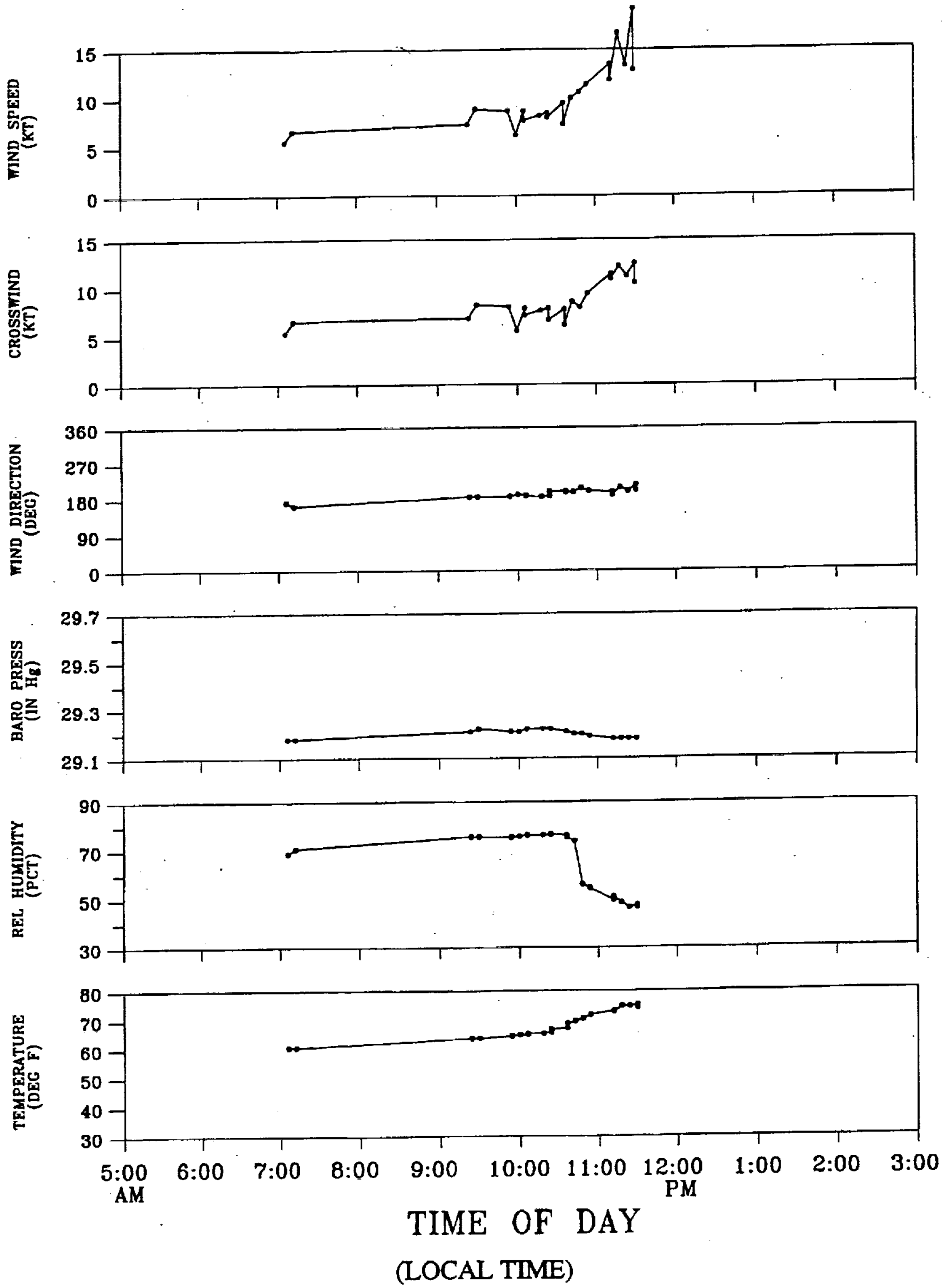
METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 1 TESTING
27 OCTOBER 1995

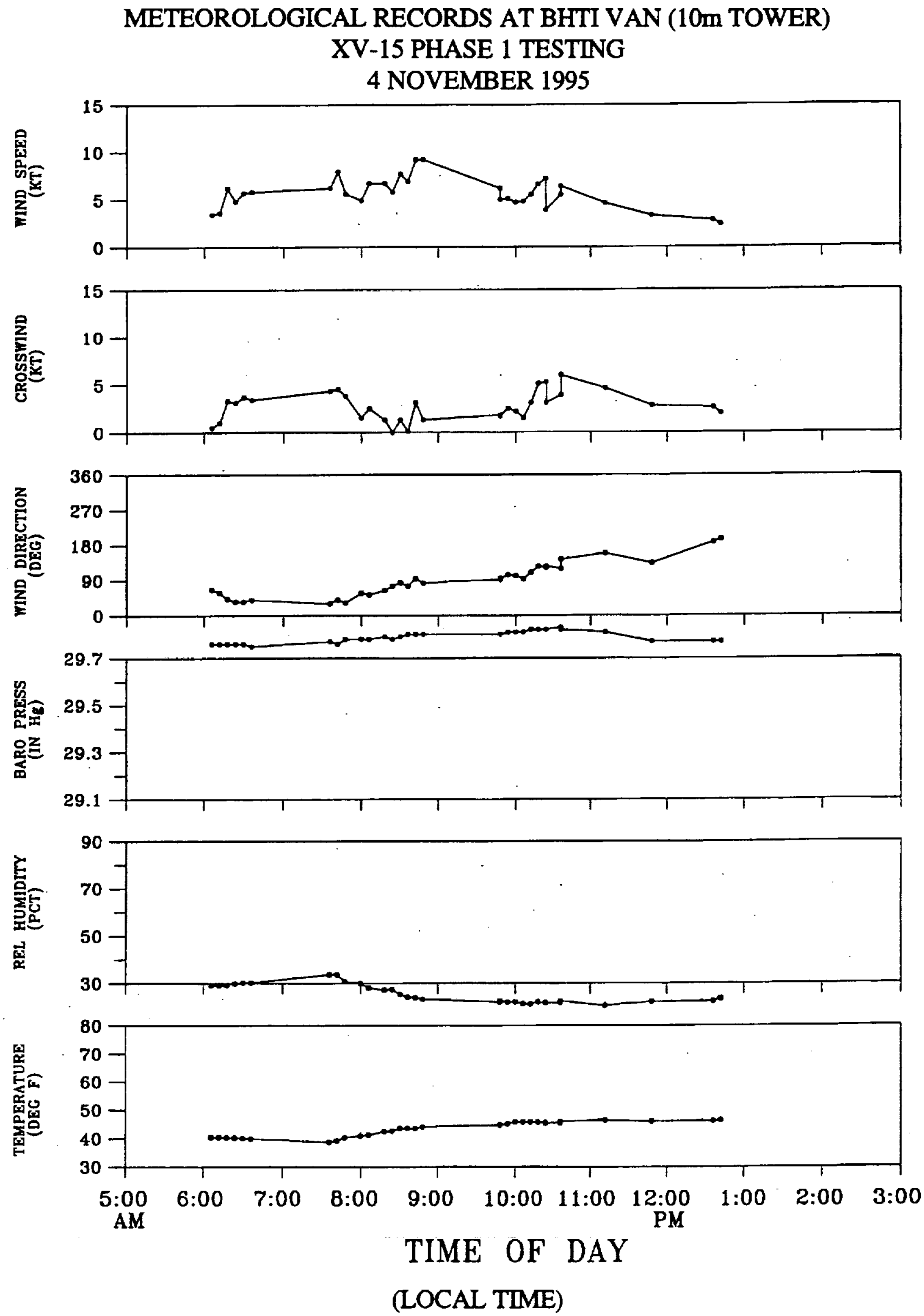


METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 1 TESTING
28 OCTOBER 1995

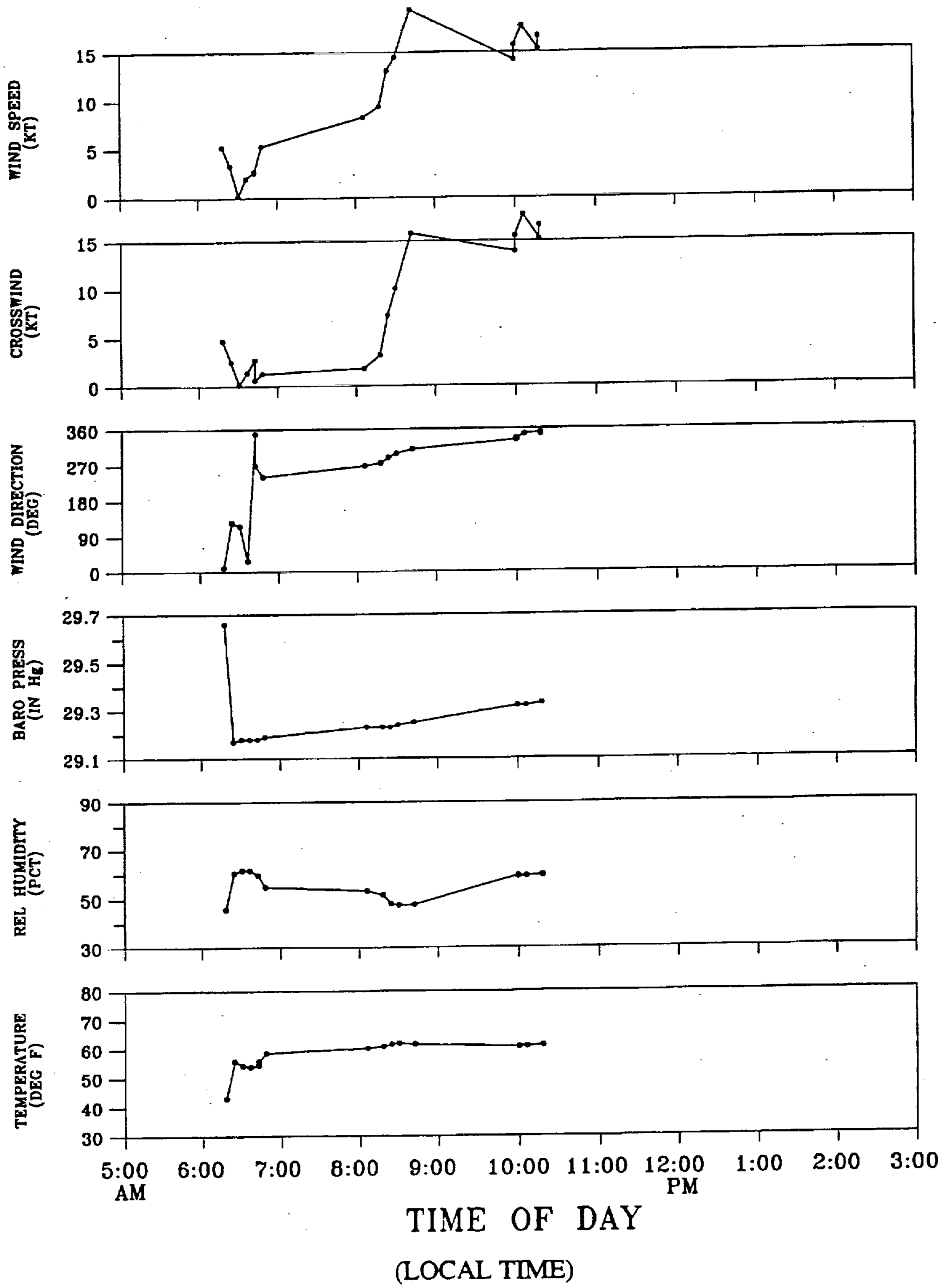


METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 1 TESTING
1 NOVEMBER 1995

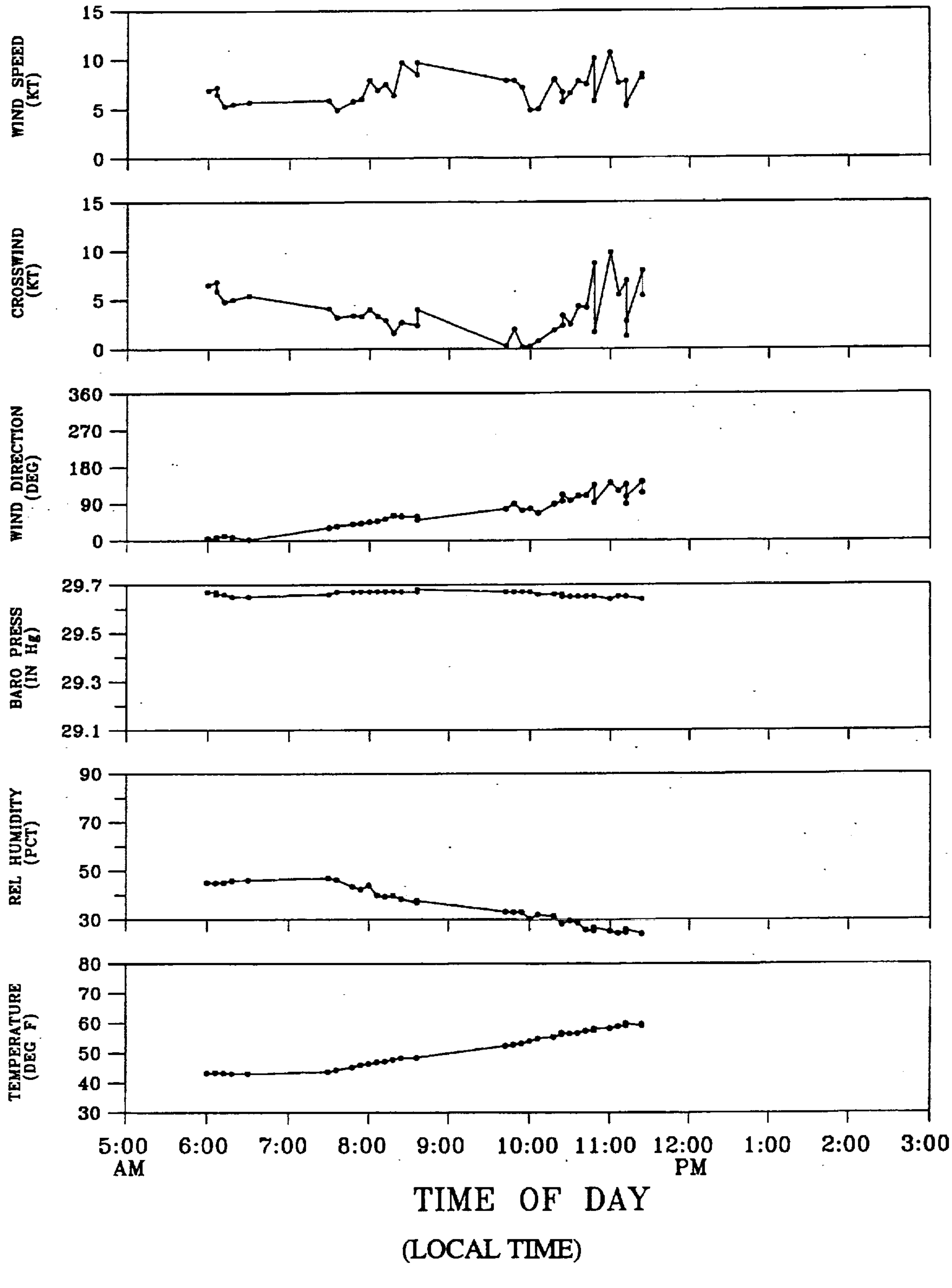



METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 1 TESTING
4 NOVEMBER 1995
WIND SPEED (KT)
CROSSWIND (KT)
WIND DIRECTION (DEG)
BARO PRESS (IN Hg)
REL HUMIDITY (PCT)
TEMPERATURE (DEG F)
5:00 AM
6:00
7:00
8:00
9:00
10:00
11:00
12:00 PM
1:00
2:00
3:00
TIME OF DAY
(LOCAL TIME)

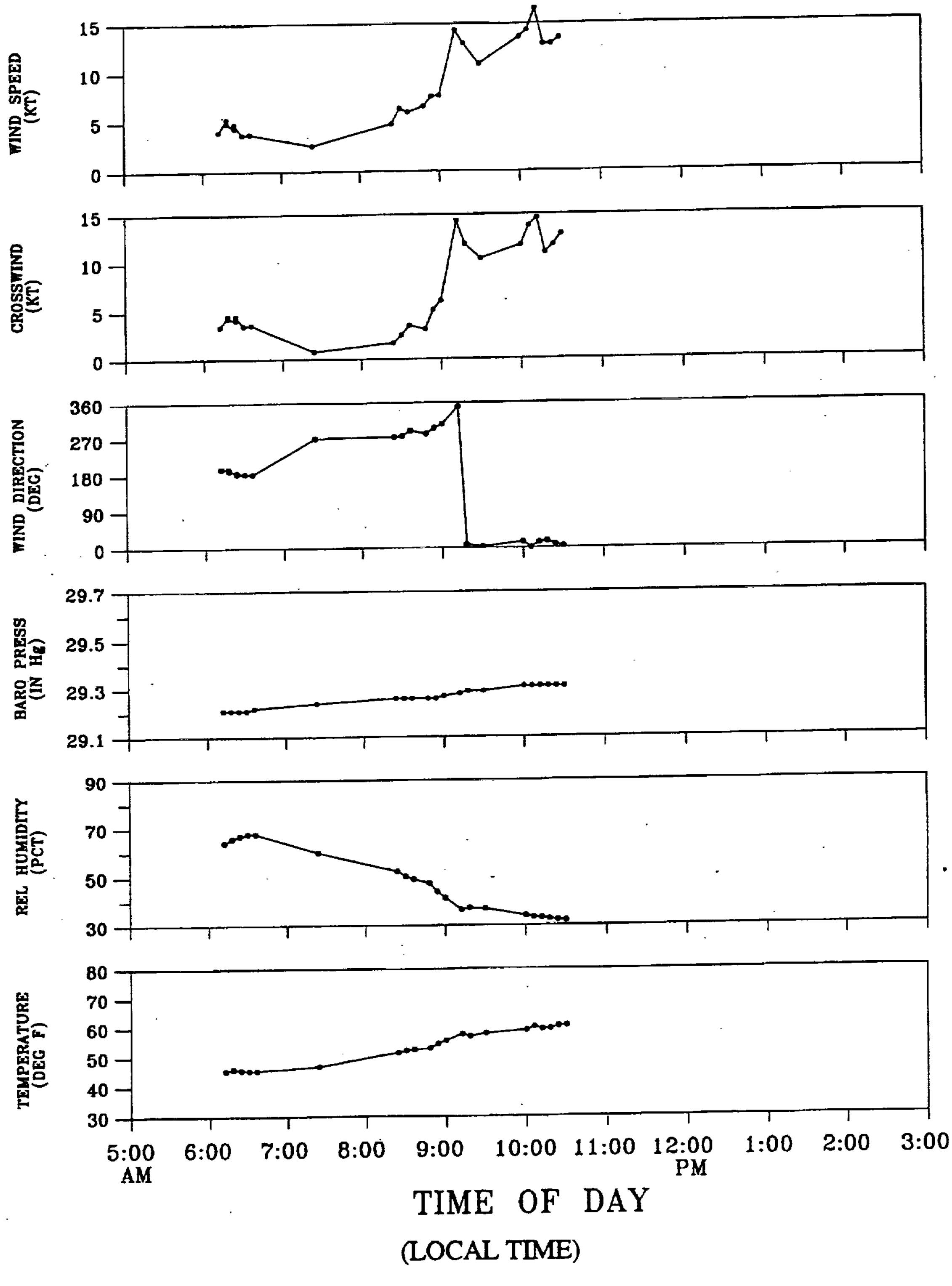
METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 1 TESTING
7 NOVEMBER 1995



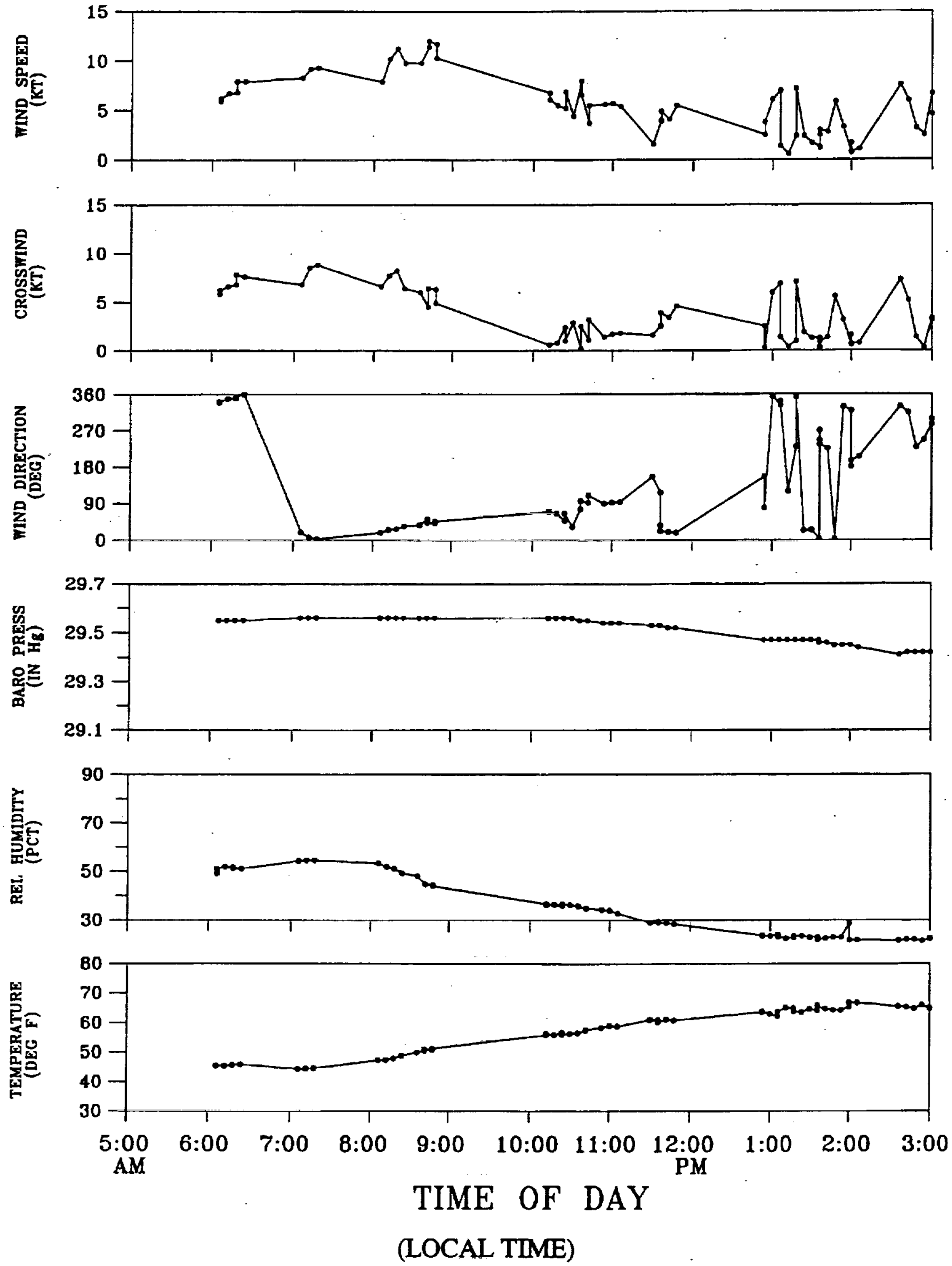
METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 1 TESTING
8 NOVEMBER 1995



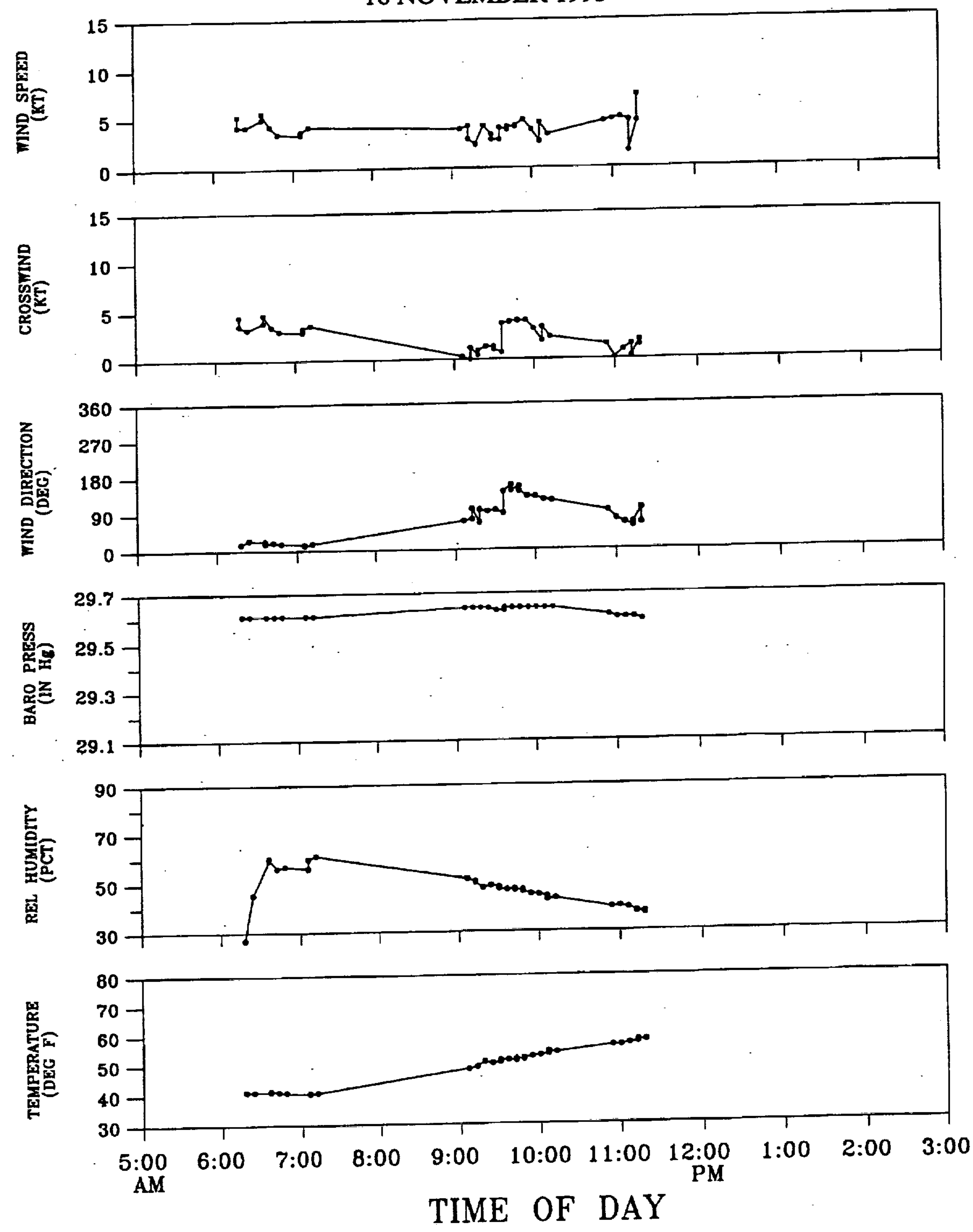
METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 2 TESTING
13 NOVEMBER 1995



METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 2 TESTING
14 NOVEMBER 1995



METEOROLOGICAL RECORDS AT BHTI VAN (10m TOWER)
XV-15 PHASE 2 TESTING
16 NOVEMBER 1995



APPENDIX E

FLIGHT CONDITIONS

TEST CONDITIONS, PHASE 1 TEST

CONDITIONS RUN WITH THE LINEAR MICROPHONE ARRAY

COND. NO.	XV-15 NOISE TEST - PHASE 1 FLT COND. STEADY FLIGHT COND'N	NACELLE (DEG)	AIRSPEED (KT)	FLIGHT ANGLE (DEG)	RPM (%RPM)	ALTITUDE (FT)	HEADING (DEG)	<<<<<<<<<<<< PLOT CARD >>>>>>>>>>>>>> FLIGHT #/DATE/COUNTER # T161 [illegible]OCT CTR #	T162 12OCT CTR #	T164 [illegible]OCT CTR #	T168 27OCT CTR #	T169 28OCT CTR #	T170 1-NOV CTR #	T171 4NOV CTR #	T172 7NOV CTR #	T173 8NOV CTR #
	LEVEL FLIGHT															
	PRIORITY 1 CONDITIONS															
101	LEVEL (HK)	80	90	0	98	394	255	8,15,30	8	x,x,9	8,21	2	5	18,33	14	8,22
102	LEVEL	90	70	0	98	394	255	10								
103	LEVEL	85	70	0	98	394	255	11								
103A	LEVEL	80	50	0	98	394	255	9								
104	LEVEL	80	70	0	98	394	255	12								
105	LEVEL	80	110	0	98	394	255	13								
106	LEVEL	60	70	0	98	394	255	14								
107	LEVEL	60	110	0	98	394	255	16								
108	LEVEL	60	140	0	98	394	255		9				6,7	26		
108A	LEVEL	0	120	0	86	394	255		10							
109	LEVEL	0	140	0	86	394	255	22,23,24					8	27		
110	LEVEL	0	180	0	86	394	255	25								
111	LEVEL	0	220	0	86	394	255	26								
112	LEVEL	0	140	0	86	1500	255	27								
113	LEVEL	0	220	0	86	1500	255	28,29								
	PRIORITY 2 CONDITIONS															
114	VOIDED NUMBER															
115	LEVEL	80	90	0	98	394	255						14			
116	LEVEL	80	110	0	92	394	255						15			
117	LEVEL	80	110	0	95	394	255						16			

COND. NO.	XV-15 NOISE TEST - PHASE 1 FLT COND. STEADY FLIGHT COND'N	NACELLE (DEG)	AIRSPEED (KT)	FLIGHT ANGLE (DEG)	RPM (%RPM)	ALTITUDE (FT)	HEADING (DEG)	<<<<<<<<<<<< PLOT CARD >>>>>>>>>>>>>> FLIGHT #/DATE/COUNTER # T161 [illegible]OCT CTR #	T162 12OCT CTR #	T164 [illegible]OCT CTR #	T168 27OCT CTR #	T169 28OCT CTR #	T170 1-NOV CTR #	T171 4NOV CTR #	T172 7NOV CTR #	T173 8NOV CTR #
	DESCENTS															
	PRIORITY 1 CONDITIONS															
301	DESCENTS	60	70	3	98	VAR.	255		12							
302	DESCENTS	60	90	3	98	VAR.	255		13							
303	DESCENTS	60	110	3	98	VAR.	255		14							
304	DESCENTS	70	70	3	98	VAR.	255		11							
305	DESCENTS	80	70	3	98	VAR.	255	21								
306	DESCENTS	90	70	3	98	VAR.	255	17,20								
307	DESCENTS	60	70	6	98	VAR.	255							23,24		
307A	DESCENTS	60	80	6	98	VAR.	255			13						
308	DESCENTS	60	90	6	98	VAR.	255			14				25		
309	DESCENTS	60	110	6	98	VAR.	255			15						
310	DESCENTS	70	70	6	98	VAR.	255			12						
311	DESCENTS	80	40	6	98	VAR.	255		17							
312	DESCENTS	80	50	6	98	VAR.	255			10						
313	DESCENTS	80	70	6	98	VAR.	255			11						
314	DESCENTS	85	70	6	98	VAR.	255		16							
315	DESCENTS	90	70	6	98	VAR.	255		15							
316	DESCENTS	60	70	9	98	VAR.	255				24					
317	DESCENTS	60	90	9	98	VAR.	255				25					
318	DESCENTS	60	110	9	98	VAR.	255				26					31
319	DESCENTS	70	70	9	98	VAR.	255				23					
320	DESCENTS	80	40	9	98	VAR.	255				16					
321	DESCENTS	80	50	9	98	VAR.	255				22					
322	DESCENTS	80	70	9	98	VAR.	255				10					
323	DESCENTS	85	70	9	98	VAR.	255				15					
324	DESCENTS	90	70	9	98	VAR.	255				x,11					
325	DESCENTS	95	40	9	98	VAR.	255				12					
326	DESCENTS	95	50	9	98	VAR.	255				13					
327	DESCENTS	95	60	9	98	VAR.	255				14					
328	DESCENTS	60	70	12	98	VAR.	255								13	
329	DESCENTS	70	70	12	98	VAR.	255								12	
330	DESCENTS	80	40	12	98	VAR.	255							x,x,48		25,26
331	DESCENTS	80	50	12	98	VAR.	255								10	24
332	DESCENTS	80	60	12	98	VAR.	255									23
333	DESCENTS	80	70	12	98	VAR.	255								11	27
334	DESCENTS	90	70	12	98	VAR.	255				28	x,4	9	19		
335	DESCENTS	95	40	12	98	VAR.	255					5		20		
336	DESCENTS	95	50	12	98	VAR.	255					6		21		
337	DESCENTS	95	60	12	98	VAR.	255							22		

XV-15 NOISE TEST - PHASE 1 FLT COND.

COND. NO.	STEADY FLIGHT COND'N	NACELLE (DEG)	AIRSPEED (KT)	FLIGHT ANGLE (DEG)	RPM (%RPM)	ALTITUDE (FT)	HEADING (DEG)	T161 10OCT CTR #	T162 12OCT CTR #	T164 18OCT CTR #	T168 27OCT CTR #	T169 28OCT CTR #	T170 1-NOV CTR #	T171 4NOV CTR #	T172 7NOV CTR #	T173 8NOV CTR #
	DESCENTS (CONTINUED)															
	PRIORITY 2 CONDITIONS															
340	DESCENTS	80	90	3	98	VAR.	255							40		
341	DESCENTS	80	110	3	98	VAR.	255							41		
342	DESCENTS	85	70	3	98	VAR.	255							37,38		
343	DESCENTS	85	90	3	98	VAR.	255							39		
344	DESCENTS	90	50	3	98	VAR.	255							35		
345	DESCENTS	90	90	3	98	VAR.	255							36		
346	VOIDED NUMBER															
347	DESCENTS	70	50	6	98	VAR.	255									16
348	DESCENTS	70	90	6	98	VAR.	255									17
349	DESCENTS	70	110	6	98	VAR.	255									18
350	DESCENTS	80	60	6	98	VAR.	255									14
351	DESCENTS	80	90	6	98	VAR.	255									15
352	DESCENTS	85	40	6	98	VAR.	255									12
353	DESCENTS	85	90	6	98	VAR.	255									13
354	DESCENTS	90	40	6	98	VAR.	255									9
355	DESCENTS	90	50	6	98	VAR.	255									10
356	DESCENTS	90	90	6	98	VAR.	255									11

XV-15 NOISE TEST - PHASE 1 FLT COND.

COND. NO.	STEADY FLIGHT COND'N	NACELLE (DEG)	AIRSPEED (KT)	FLIGHT ANGLE (DEG)	RPM (%RPM)	ALTITUDE (FT)	HEADING (DEG)	T161 10OCT CTR #	T162 12OCT CTR #	T164 18OCT CTR #	T168 27OCT CTR #	T169 28OCT CTR #	T170 1-NOV CTR #	T171 4NOV CTR #	T172 7NOV CTR #	T173 8NOV CTR #
	CLIMBS															
	PRIORITY 1 CONDITIONS															
501	CLIMB*	80	65	MAX ROC	98	VAR.	255						10,11	28		
501A	CLIMB*	80	75	MAX ROC	98	VAR.	255						12			
502	CLIMB*	60	75	MAX ROC	98	VAR.	255						13	34		
	HOVER															
	PRIORITY 1 CONDITIONS															
701	HOVER	90	0	N.A.	98	394	255				27					28,29,3
702	HOVER	90	0	N.A.	98	394	240									29,30
703	HOVER	90	0	N.A.	98	394	225									29,30
704	HOVER	90	0	N.A.	98	394	210				27					28,29,3
705	HOVER	90	0	N.A.	98	394	195									29,30
706	HOVER	90	0	N.A.	98	394	180									29,30
707	HOVER	90	0	N.A.	98	394	165									29,30
708	HOVER	90	0	N.A.	98	394	150									29,30
709	HOVER	90	0	N.A.	98	394	135									29,30
710	HOVER	90	0	N.A.	98	394	120									29,30
711	HOVER	90	0	N.A.	98	394	105									29,30
712	HOVER	90	0	N.A.	98	394	90									29,30
713	HOVER	90	0	N.A.	98	394	75									29,30

TEST CONDITIONS, PHASE 2

XV-15 NOISE TEST - PHASE 2 FLT CONDITIONS

								<<< PILOT CARD >>>>			<<< NASA RUN # >>>>		
								T175 13NOV CTR #	T176 14NOV CTR #	T177 16NOV CTR #	T175 13NOV CTR #	T176 14NOV CTR #	T177 16NOV CTR #

LEVEL FLIGHTS

COND #	FLT COND	NACELLE	A/S	GLIDESLOPE	RPM	ALTITUDE	HEADING	T175	T176	T177	T175	T176	T177
200	LEVEL	60	90	0	98	394	75	8x	2x	8	300x	307x	343
200.1	LEVEL	60	90	0	98	394	75	9	2x		301	307x	

LEVEL TURNS

COND #	FLT COND	NACELLE	A/S	GLIDESLOPE	RPM	ALTITUDE	HEADING	T175	T176	T177	T175	T176	T177
251	LEVEL RT TURN	60	90	0	98	394	75			25			360
253	LEVEL LT TURN	60	90	0	98	394	75			26			361

FIXED GLIDESLOPES TO 100FT WAVE-OFF

COND #	FLT COND	NACELLE	A/S	GLIDESLOPE	RPM	SETUP ALTITUDE	HEADING	T175	T176	T177	T175	T176	T177
402	DESCENT	60	90	3	98	1048	75	10x	3x		302x	306x	
402.1	DESCENT	60	90	3	98	1048	75	11	3x		303		
410	DESCENT	70	70	6	98	2100	75	12			304		
422	DESCENT	80	70	9	98	3168	75		22			324	
433	DESCENT	80	70	12	98	4250	75		21			323	

FIXED GLIDESLOPES TO FLARE/HOVER

COND #	FLT COND	NACELLE	A/S	GLIDESLOPE	RPM	SETUP ALTITUDE	HEADING	T175	T176	T177	T175	T176	T177
469	DESCENT	90 to 95	50 to 0	0/6	98	1665'	75		29			327	
470	DESCENT	80 to 95	70 to 0	0/6	98	1665'	75		30			328	
471	DESCENT	70 to 95	90 to 0	0/6	98	1665'	75	13x	32		305x	330	
471.1	DESCENT	70 to 95	90 to 0	0/6	98	1665'	75	14x	32		306x		
472	DESCENT	60 to 95	110 to 0	0/6	98	1665'	75		34			332	
473	DESCENT	80 to 95	70 to 0	0/3	98	830'	75		36			334	
474	DESCENT	80 to 95	70 to 0	0/9	98	2000'	75		23			325	
475	DESCENT	80 to 95	70 to 0	0/12	98	2000'	75		24			326	

SEGMENTED GLIDESLOPES TO FLARE/HOVER

COND #	FLT COND	NACELLE	A/S	GLIDESLOPE	RPM	SETUP ALTITUDE	HEADING	T175	T176	T177	T175	T176	T177
478	DESCENT	70 to 95	90 to 0	0/3/12	98	2000	75		44			341	

PILOT DISCRETION TO FLARE/HOVER

COND #	FLT COND	NACELLE	A/S	GLIDESLOPE	RPM	SETUP ALTITUDE	HEADING	T175	T176	T177	T175	T176	T177
480	APPROACH A	60	130, 110 const		86 to 98	1000	75			11			346
481	APPROACH B	60	decel, level att.		86 to 98	1000	75			9			344
482	APPROACH C	60	decel, level att.		86 to 98	1500	75			13			348
483	APPROACH D	60	150, 110 const		86 to 98	1500	75			15			350
484	APPROACH E	60	decel, level att.		98	1500	75			17			352
485	APPROACH F	75	150, 110 const	steep	86 to 98	1500	75			19			354
486	APPROACH G	95	const	steep	86 to 98	1500	75			21			356
486.1	APPROACH G	95	const	steep	86 to 98	1500	75			23			358
489	APPROACH A	60	130, 110 const		86 to 98	1000	75		4			309	
490	APPROACH B	60	decel, level att.		86 to 98	1000	75		5			310	
491	APPROACH C	60	decel, level att.		86 to 98	1500	75		6			311	
491.1	APPROACH C	60	decel, level att.		86 to 98	1500	75		19			321	
492	APPROACH D	60	150, 110 const		86 to 98	1500	75		13			315	
493	APPROACH E	60	150, 110 const		86 to 98	1500	75		8			313	
494	APPROACH F	75	150, 110 const	steep	86 to 98	1500	75		15			317	
495	APPROACH G	95	const	steep	86 to 98	1500	75		17			319	

XV-15 NOISE TEST - PHASE 2 FLT CONDITIONS

REVISED 5/31/96

TAKEOFF

COND #	FLT COND	NACELLE	A/S	GLIDESLOPE	RPM	ALTITUDE	HEADING	<<< PILOT CARD >>> T175 13NOV CTR #	T176 14NOV CTR #	T177 16NOV CTR #	<<< NASA RUN # >>> T175 13NOV CTR #	T176 14NOV CTR #	T177 16NOV CTR #
601	TAKEOFF A	VAR	VAR	VAR	VAR	VAR	255		7			312	
602	TAKEOFF B	VAR	VAR	VAR	VAR	VAR	255		9			314	
603	TAKEOFF C	VAR	VAR	VAR	VAR	VAR	255		14			316	
604	TAKEOFF D	VAR	VAR	VAR	VAR	VAR	255		16			318	
605	TAKEOFF E	VAR	VAR	VAR	VAR	VAR	255		18			320	
605	TAKEOFF E	VAR	VAR	VAR	VAR	VAR	255		20			322	
606	TAKEOFF F	VAR	VAR	VAR	VAR	VAR	255		31			329	
607	TAKEOFF G	VAR	VAR	VAR	VAR	VAR	255		33			331	
608	TAKEOFF H	VAR	VAR	VAR	VAR	VAR	255		35			333	
609	TAKEOFF I	VAR	VAR	VAR	VAR	VAR	255		45			342	
610	TAKEOFF J	VAR	VAR	VAR	VAR	VAR	255			10			345
611	TAKEOFF K	VAR	VAR	VAR	VAR	VAR	255			12			347
612	TAKEOFF L	VAR	VAR	VAR	VAR	VAR	255			14			349
613	TAKEOFF M	VAR	VAR	VAR	VAR	VAR	255			16			351
614	TAKEOFF N	VAR	VAR	VAR	VAR	VAR	255			18			353
615	TAKEOFF O	VAR	VAR	VAR	VAR	VAR	255			20			355
616	TAKEOFF P	VAR	VAR	VAR	VAR	VAR	255			22			357
617	TAKEOFF Q	VAR	VAR	VAR	VAR	VAR	255			24			359

IGE HOVER

COND #	FLT COND	NACELLE	A/S	GLIDESLOPE	RPM	ALTITUDE	HEADING	PILOT CARD T175	T176	T177	NASA RUN # T175	T176	T177
821	HOVER	90	0	0	98	20	255		40			337	
822	HOVER	90	0	0	98	20	165		41			338	
823	HOVER	90	0	0	98	20	75		42			339	
824	HOVER	90	0	0	98	20	345		43			340	

FLIGHT IDLE

COND #	FLT COND	NACELLE	A/S	GLIDESLOPE	RPM	ALTITUDE	HEADING	PILOT CARD T175	T176	T177	NASA RUN # T175	T176	T177
841	FLT IDLE	90	0	0	??	0	75		37			335	
843	FLT IDLE	90	0	0	??	0	255		38			336	

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	February 1998	Contractor Report

4. TITLE AND SUBTITLE
XV-15 Low-Noise Terminal Area Operations Testing

5. FUNDING NUMBERS
C NAS1-20094
TA 3
WU 538-07-15-10

6. AUTHOR(S)
B. D. Edwards

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Bell Helicopter Textron, Inc.
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8. PERFORMING ORGANIZATION REPORT NUMBER
BHTI Report No. 699-099-450

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Langley Research Center
Hampton, VA 23681-2199

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
NASA/CR-1998-206946

11. SUPPLEMENTARY NOTES
Langley Technical Monitor: David A. Conner

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified - Unlimited
Subject Category 71
Distribution: Nonstandard
Availability: NASA CASI (301) 621-0390

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

Test procedures related to XV-15 noise tests conducted by NASA-Langley and Bell Helicopter Textron, Inc. are discussed. The tests, which took place during October and November 1995, near Waxahachie, Texas, documented the noise signature of the XV-15 tiltrotor aircraft at a wide variety of flight conditions. The stated objectives were to:

-provide a comprehensive acoustic database for NASA and U.S. Industry
-validate noise prediction methodologies, and
-develop and demonstrate low-noise flight profiles.

The test consisted of two distinct phases. Phase 1 provided an acoustic database for validating analytical noise prediction techniques; Phase 2 directly measured noise contour information at a broad range of operating profiles, with emphasis on minimizing "approach" noise.

This report is limited to a documentation of the test procedures, flight conditions, microphone locations, meteorological conditions, and test personnel used in the test. The acoustic results are not included.

14. SUBJECT TERMS
XV-15, tiltrotor, noise prediciton

15. NUMBER OF PAGES
62

16. PRICE CODE
A04

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified		

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102