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TEST AND EVALUATION OF ATCRBS ELECTRONIC SCAN ANTENNA (FIELD ENVIRONMENT TESTS)

Anthony D. Bradley

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INTERIM REPORT

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16. Abstract

The air traffic control radar beacon system (ATCRBS) electronic scan antenna (ESA) as designed and built consists of 56 array modules placed on a platform (ring) constructed around the top of an airport surveillance radar tower. A shelter beneath the tower provides an enclosure for the control and radiofrequency distribution system of the ESA.

This interim report covers the field environment testing to measure and evaluate the ability of the ESA to overcome siting problems in a representative field environment as compared to the existing ATCRBS in-service antennas (types FA-8043 and FA-8044).

It was concluded that the ATCRBS ESA improved the vertical lobing pattern over flat terrain and provided a matched directional and omnidirectional pattern in comparison with the ATCRBS in-service antennas. However, local environment conditions along one particular radial at the terminal radar/beacon test facility (TR/BTF) caused severe low-elevation angle interference (vertical lobing), and diffraction of the ATCRBS ESA directional and omnidirectional beam patterns were noted from a vertical obstruction.

Beam hopover, combined with improved side lobe suppression (ISLS) system operation, effectively eliminated reflections from a large aircraft hangar building, which were present when using the in-service ATCRBS antenna.

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INTRODUCTION

GENERAL.

The air traffic control radar beacon system (ATCRBS) electronic scan antenna (ESA) can be considered (1) a replacement for the existing 28-foot linear array beacon antenna; or (2) a flexible, agile beam antenna providing optimum capability when integrated with an Automated Radar Terminal System (ARTS); or (3) a data-link, phased array antenna for use with the discrete address beacon system (DABS). The results of the technical test program will be applicable, in part, to all three areas, but they are primarily intended to satisfy the requirements of the ATCRBS improvement program while providing base data for future testing. Test efforts will be developed under appropriate programs to meet other objectives.

This interim report covers the field environment tests performed in accordance with the National Aviation Facilities Experimental Center (NAFEC) product plan prepared under Agreement No. 03-152, ATCRBS Transmitter Site Improvements Program.

TEST PROGRAM OBJECTIVES. The objectives of the ATCRBS ESA technical test program are to:

1. Demonstrate and determine compliance with portions of the ESA engineering requirement (FAA-ER-240-013a) applicable to field testing and acceptance from the contractor (specification tests).

2. Measure and evaluate the ability of the ESA to overcome siting problems in a representative field environment as compared to the existing ATCRBS in-service antennas (field environment tests).

3. Recommend ESA specification changes which clarify and/or improve antenna characteristics. Verification of the improvements may require modification to the antenna and further testing.

TEST PROGRAM PROCEDURES. The requirements to accept the antenna from the contractor at NAFEC and to fulfill the objectives of the ATCRBS improvement program will be met through this test program. The test program was arranged to meet the objectives in a manner which would use available resources most efficiently and avoid duplication of test procedures. The test program was scheduled, with the exception of the preparatory tests, to start after completion of the installation and checkout procedures of the contractor.

The testing has been divided into four categories; they are (1) preparatory tests, (2) specification tests, (3) field environment tests, and (4) system tests.

PURPOSE.

FIELD ENVIRONMENT TEST OBJECTIVES. The objective of the field environment test is to measure and evaluate the ability of the ESA to overcome siting problems in a representative field environment as compared to the existing ATCRBS configuration.

METHOD FOR FIELD ENVIRONMENT TESTS. The method employed during the field environment tests was to compare (test-by-test) results of the ESA testing with those obtained from the existing ATCRBS configuration. The data base for the terminal radar/beacon test facility (TR/BTF), established by the preparatory tests (reference 1), was rechecked to confirm that the performance of both the airport surveillance radar-7 (ASR-7) and the existing ATCRBS had not been affected by the installation of the ESA.

BACKGROUND.

The FY-72 FAA/Systems Research and Development Service (SRDS) research and technical resume titled, "ATCRBS Transmitter Site Equipment," contained an SRDS development project 033-241-01C titled, "Development of ATCRBS Electronic Beam Antenna." This project, under the cognizance of the SRDS Detection Systems Branch, ARD-240, provided for the development and evaluation of a mechanically independent ESA. The antenna is electronically interfaced with the primary radar antenna and performs the function of an ATCRBS interrogating antenna including side lobe suppression (SLS) and improved side lobe suppression (ISLS).

A specification for the antenna (FAA-ER-240-013a, ATCRBS Electronic Scan Antenna) was prepared, and a contract (DOT-FA72WA-2704) for its development and installation at NAFEC was issued on September 10, 1971. The installation of the ESA was completed in January 1974.

DESCRIPTION OF EQUIPMENT.

ELECTRONIC SCAN ANTENNA. The ESA as designed and built consists of 56 array modules placed on a platform (ring) constructed around the top of an ASR tower (see figure 1). A shelter beneath the tower provides an enclosure for the control and radiofrequency (RF) distribution system of the ESA.

The ATCRBS ESA provides a fan beam at any one of 2,048 azimuth beam positions. Directional and omnidirectional antenna patterns are provided, as well as a difference-receiving pattern. Proper combinations of the directional and omnidirectional antenna pattern for both the normal SLS and ISLS interrogations can be formed by the ESA. The directional pattern can be lifted over nearby buildings to reduce reflections.

Performance monitoring is provided to indicate operational status, and a built-in test function is provided to isolate faults to replaceable modules. A more detailed description of the ATCRBS ESA is contained in reference 1.

FIGURE 1. THE ATCRBS ELECTRONIC SCAN ANTENNA

Specification tests were performed on the ESA to determine the characteristics of the antenna at the TR/BTF. An interim report was prepared during the test and evaluation effort concerning the performance of the basic antenna system (reference 2).

TERMINAL RADAR/BEACON TEST FACILITY CONFIGURATION. The siting of the ESA was critical to the anticipated test program to evaluate the expected improvements in system performance. Certain requirements, such as testing of the beam "hopover" feature, made it necessary to choose a site which violates correct siting practices. In fact, the site had been selected to present the ESA with undesirable terrain and obstacles which are characteristics of some in-service sites, but within the limits for which the antenna has been designed to produce improved performance.

The site selected at NAFEC is adjacent to the aircraft hangar (Bldg. 301) and the Atlantic City Municipal Terminal building as shown in figure 2. The site configuration, shown in figure 3, includes critical placement of the ASR-5-type equipment building, the 17-foot ASR antenna tower, and the ASR-7 radar fiberglass buildings (vans). The site provides a clear view of the airfield for vertical lobing measurements, and the aircraft hangar obstruction, which is approximately 12.0° wide and 3.1° high from the center of the ESA (for beam hopover and reflection experiments). The site provides coverage (less obstructions) to the approach to runways 13-31 and 4-22.

Channel A of the ASR-7, contained in the fiberglass building, is shown in figure 4. The ASR-5 type equipment building is located adjacent to, and partially under the ESA. The equipment placed in this building is shown in figure 5.

Panoramic horizon photographs were taken from the antenna position after the installation of the ASR-7 antenna and the ATCRBS in-service directional and omnidirectional antennas, types FA-8043 and FA-8044, respectively. The photographs are shown in figure 6. Additional towers and antennas were installed at the TR/BTF during the test and evaluation of ESA. The location of these towers, shown on the photographs, were selected to minimize interference with the ESA test program and still provide for critical placement of the other antennas for their evaluation.

DISCUSSION

TEST PROCEDURE AND RESULTS.

GENERAL. The test procedures for the field environment tests of the ESA included a recertification (flight tests) of the in-service Airport Surveillance Radar (ASR-7) and the air traffic control beacon interrogator (ATCBI-4) equipments at the TR/BTF. Vertical lobing measurements, reflection, and diffraction tests were conducted to determine on a test-by-test basis the performance of the ESA compared to the in-service ATCRBS. In addition, some antenna pattern anomalies, noted during the specification tests (reference 2), were investigated during this effort.

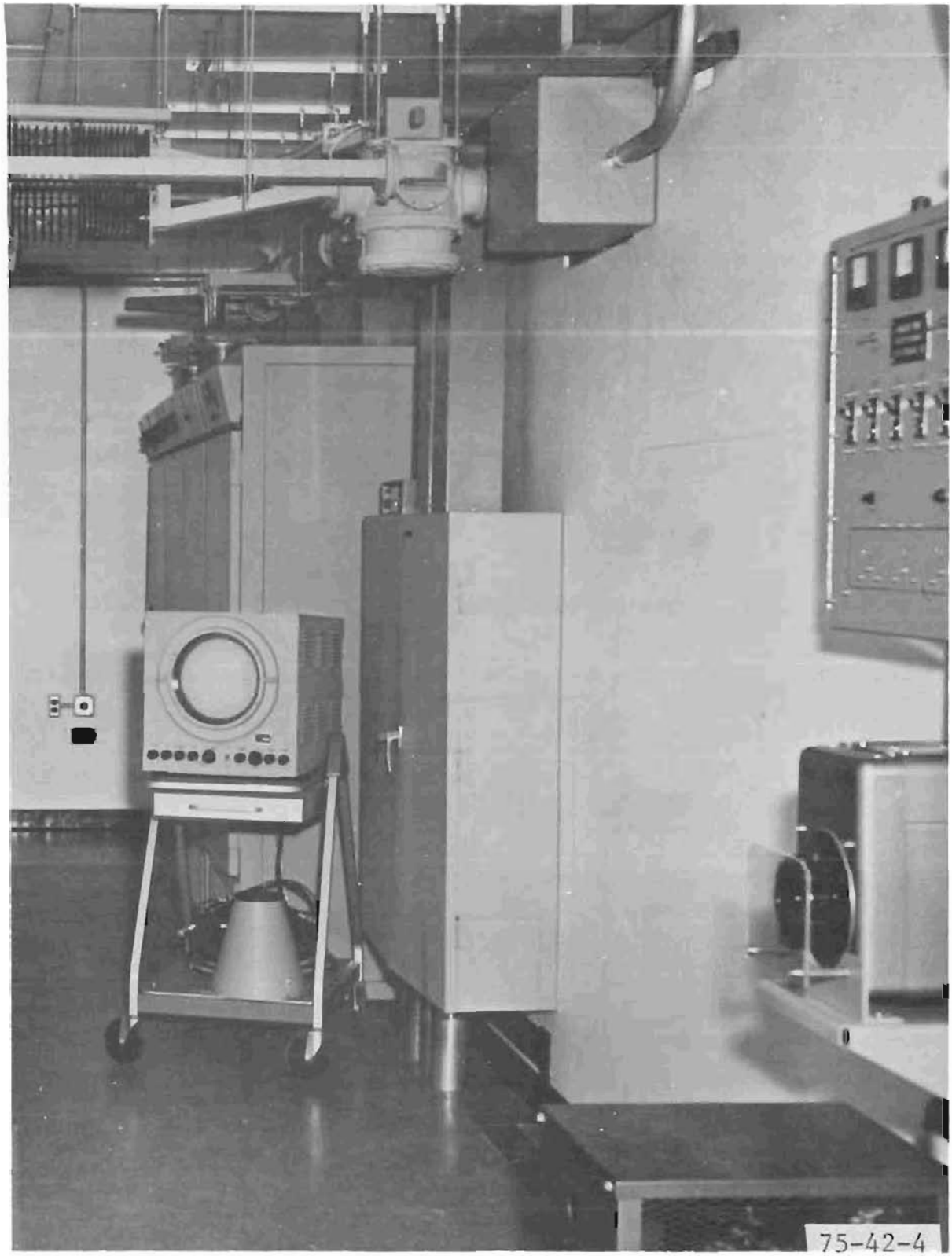


FIGURE 4. ASR-7 EQUIPMENT (CHANNEL A)

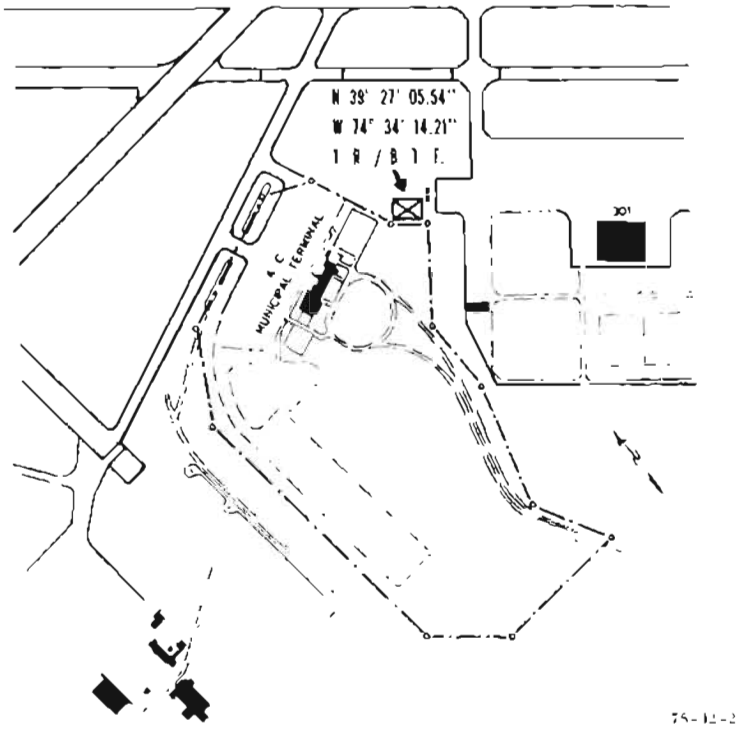


FIGURE 2. TERMINAL RADAR/BEACON TEST FACILITY SITE AT NAFEC

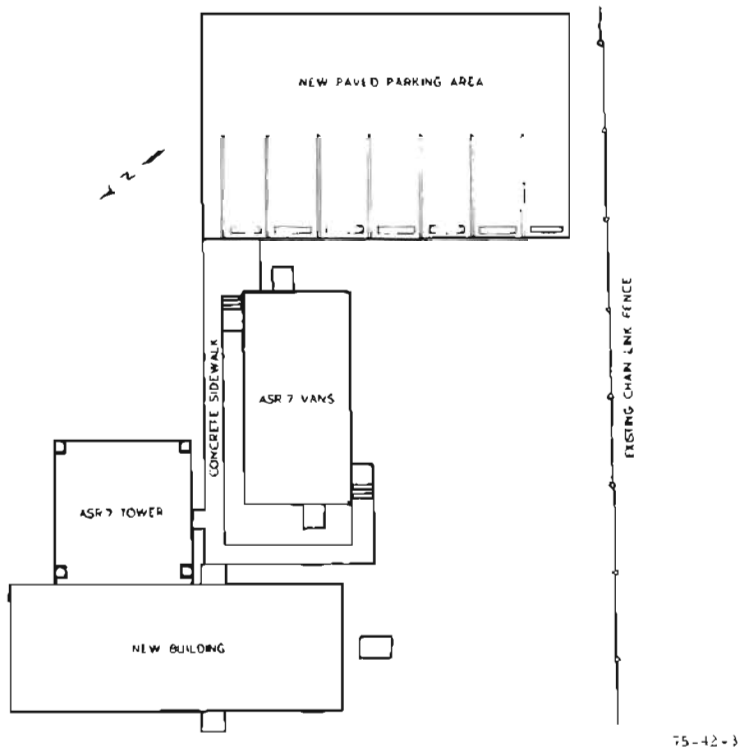


FIGURE 3. TERMINAL RADAR/BEACON TEST FACILITY CONFIGURATION

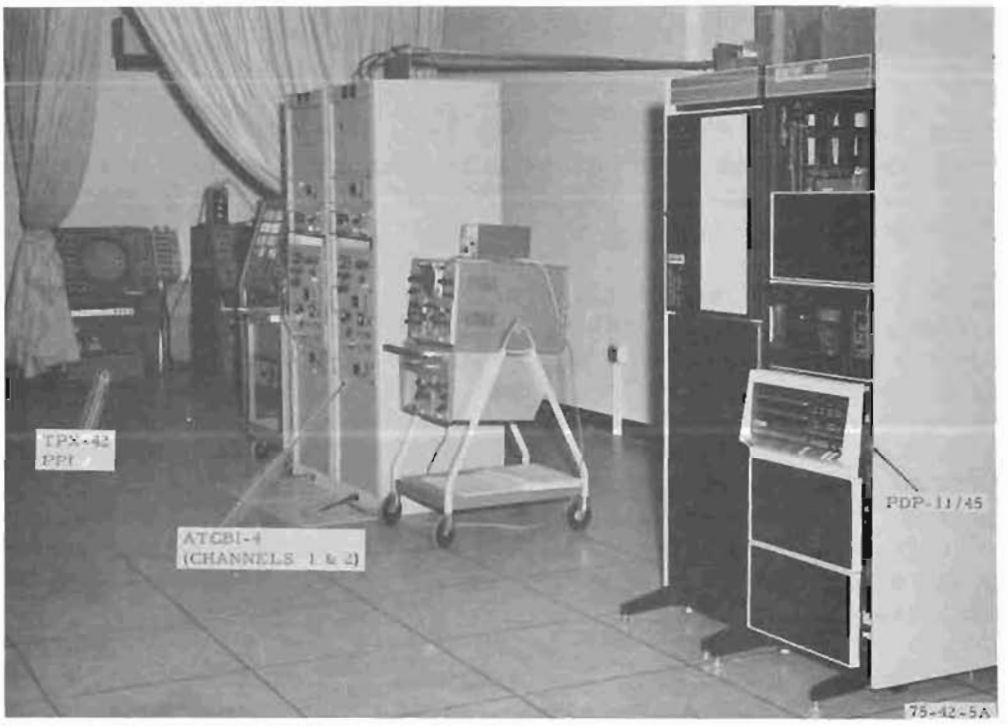


FIGURE 5. TERMINAL RADAR/BEACON TEST FACILITY EQUIPMENT

Data collection techniques for the test and evaluation of the ESA are comprised of various methods developed over the past few years to satisfy requirements to investigate the performance of the ATCRBS and to demonstrate the improvements made in the system through development efforts.

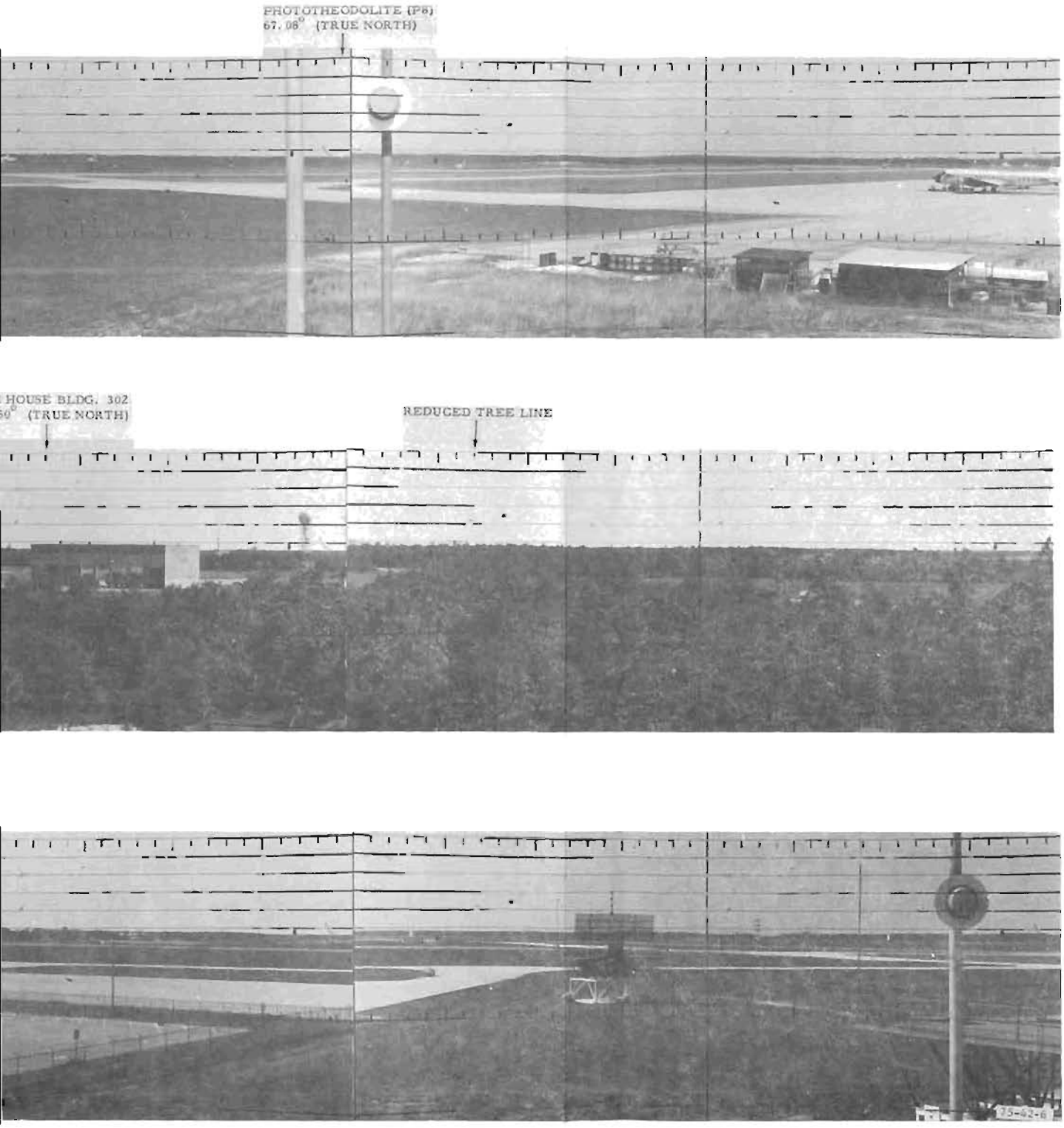
Some of the techniques are self-explanatory, such as recording equipment parameters, photographing plan position indicator (PPI), recording raw radar and beacon on the FR-950 video recorder, etc. Other techniques require further explanation. A detailed description of the data collection techniques is contained in reference 2.

AIRPORT SURVEILLANCE RADAR-7 FLIGHT TESTS. The procedure for the ASR-7 flight tests followed as closely as possible those described in the U.S. Standard Flight Inspection Manual, OAP 8200.1, section 215. All target grading and guidance information was accomplished on a direct-view PPI (SRDS type FA-7300) by air traffic control specialists.

All tests were performed with the ASR-7 equipment adjusted in accordance with the established parameters (table 1) and except where noted, with circular polarization (CP) and unstaggered pulse repetition frequency (PRF). Some tests were performed in linear polarization (LP). The moving target indicator (MTI) gate was set at 12 nautical miles (nmi) during the flight tests to eliminate ground-clutter returns.

A video recorder (FR 950) was used during the tests to obtain a permanent record of the ASR-7 performance before and after the installation of the ESA. Some breaks in the recorded data exist due to the time limitation of the recorder (approximately 30 minutes) and the need to change tape reels during the test. Test procedures for the ASR-7 included antenna tilt measurements, target grading of arrival and departure flights, fixed target identification, vertical coverage, and horizontal coverage. Target grading was determined by properly qualified personnel, using the following criteria:

Strength	Target Description	Explanation
4	Strong	Leaves definite trail.
3	Good	Target persists from scan to scan; weak or no trail.
2	Poor	Shows each scan; no persistence. Useable.
1	Weak	Target barely visible; possible miss. Not useable.
0	Miss	No visible target.



N TEST FACILITY PANORAMIC PHOTOGRAPHS

TABLE 1. EQUIPMENT SETTINGS

ASR-7

	Readings (dBm)
RF Power Output (Average)	+54.5
VSWR	1.22
Sensitivity	
Normal Channel A MDS	-112
MTI Channel A MDS	-110

STC-2 Curve (35 dB Curve)

Range NMI	Reduced Sensitivity (dB)
0	-35
1	-35
5	-12
10	- 6
15	0

PRF 1,050 pps

ATCBI-4

RF Pulse Shape		Microseconds
P_1 and P_3	Pulse Width	0.80
	Rise Time	0.03
	Fall Time	0.12
P_2 (Omni)	Pulse Width	0.80
	Rise Time	0.08
	Fall Time	0.10

RF Peak Power Output	Watts
P_1 and P_3	316
ISLS and P_1	158
ISLS and P_2	302

RF Pulse Spacing	Microseconds
Mode 1	3.1
Mode 2	5.0
Mode 3/A	8.1
B	17.0
C	21.0
D	25.0

VSWR	Ratios
Directional Antenna (type FA-8043)	1.3
Omni Antenna (type FA-8044)	1.1

Sensitivity	Readings (dBm)
Tangential (Receiver)	-89.0
Quantitized (Defruiter)	-87.0

STC Curve Range nmi	Reduced Sensitivity (dBm)
1	-36.0
2	-24.5
4	-19.5
8	-11.3
12	- 5.0
16	- 0

PRF 350 pps

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The results of the ASR-7 flight tests confirmed that the performance of the radar had not changed from the time of the preparatory tests and consequently, were not affected by the ESA installation.

AIR TRAFFIC CONTROL BEACON INTERROGATOR-4 FLIGHT TESTS. The flight tests employing the in-service directional and omnidirectional antennas for the ATCBI-4 system were accomplished during the time of the ASR-7 flight tests and followed, as closely as possible, the same procedures. All tests were conducted with the ATCBI-4 equipment adjusted in accordance with the parameters established in table 1. The aircraft used during the flight tests were both equipped with TRU-1-type transponders which undergo routine periodic checks to maintain their performance level. Test procedures for the ATCBI-4 included vertical and horizontal coverage. The results of the ATCBI-4 flight test demonstrated that the performance of the in-service beacon system had not been affected by the installation of the ESA.

VERTICAL LOBING MEASUREMENTS. The vertical lobing pattern for both the ATCRBS in-service antennas and ESA was measured using the pulse-amplitude printout technique (described in reference 2). The antenna under test was placed in a fixed (nonrotating) position and an instrumented aircraft flying at constant altitude was guided along the selected radial using the extended area instrumentation radar (EAIR) tracking radar. The 100° radial was chosen for this series of tests, since it presented a flat terrain with good reflection characteristics and available airspace.

Both the directional and omnidirectional signal level received in the aircraft was correlated in time with the aircraft's position (elevation angle or range from the ESA) determined by the EAIR. Data were recorded for the ATCRBS in-service antennas along the 100° radial at 1,500 feet as shown in figure 7. These data agreed with the data previously recorded for the directional antenna prior to the installation of the ESA (see figure 21 in reference 1). The P_1 (directional) and P_2 (omnidirectional) pulse amplitude data from flights conducted at 1,500 and 10,000 feet altitude on the 100° radial for the in-service antennas and the ESA (0°, 2°, and 4° beam hopover condition) were reduced and plotted against the elevation angle of the aircraft from the TR/BTF. The results are shown in appendix A, figures A-1 through A-8. The 0° to 5° elevation angle vertical lobing structure was obtained from the 1,500-foot altitude flights and the 5° to 55° elevation angle plots extracted from the 10,000-foot altitude flights. Also indicated on the graphs for the higher elevation angles is the position of the aircraft at which it deviated from the prescribed flightpath by 1° to 2°.

In addition, an adjustable tower was set at 1-foot increments from 30 to 75 feet above ground level at the field test site (55° radial) and the P_1 and P_2 antenna pattern recorded using the oscilloscope photograph technique. The low-elevation-angle vertical lobing pattern for the ESA (zero degree beam hopover) was determined by independently extracting the relative change in peak signal amplitude of the P_1 (directional) and P_2 (omnidirectional) pulses from photographs of the antenna beam patterns. The results depicting a constant range (ground-based) vertical lobing pattern for the ESA are shown in figure 8,

DATE : 2/21/75
TEST SITE : AIRCRAFT AT 1,500 FT ALTITUDE, 0TO 26 nmi
ON 100° RADIAL (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
TRANSMITTED PEAK POWER - 300 W
SLS - ON
FIXED ANTENNA POSITION
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT
CALIBRATION :
VERTICAL - 10.0 dB PER MAJOR DIVISION
HORIZONTAL - 4.0 nmi PER MAJOR DIVISION

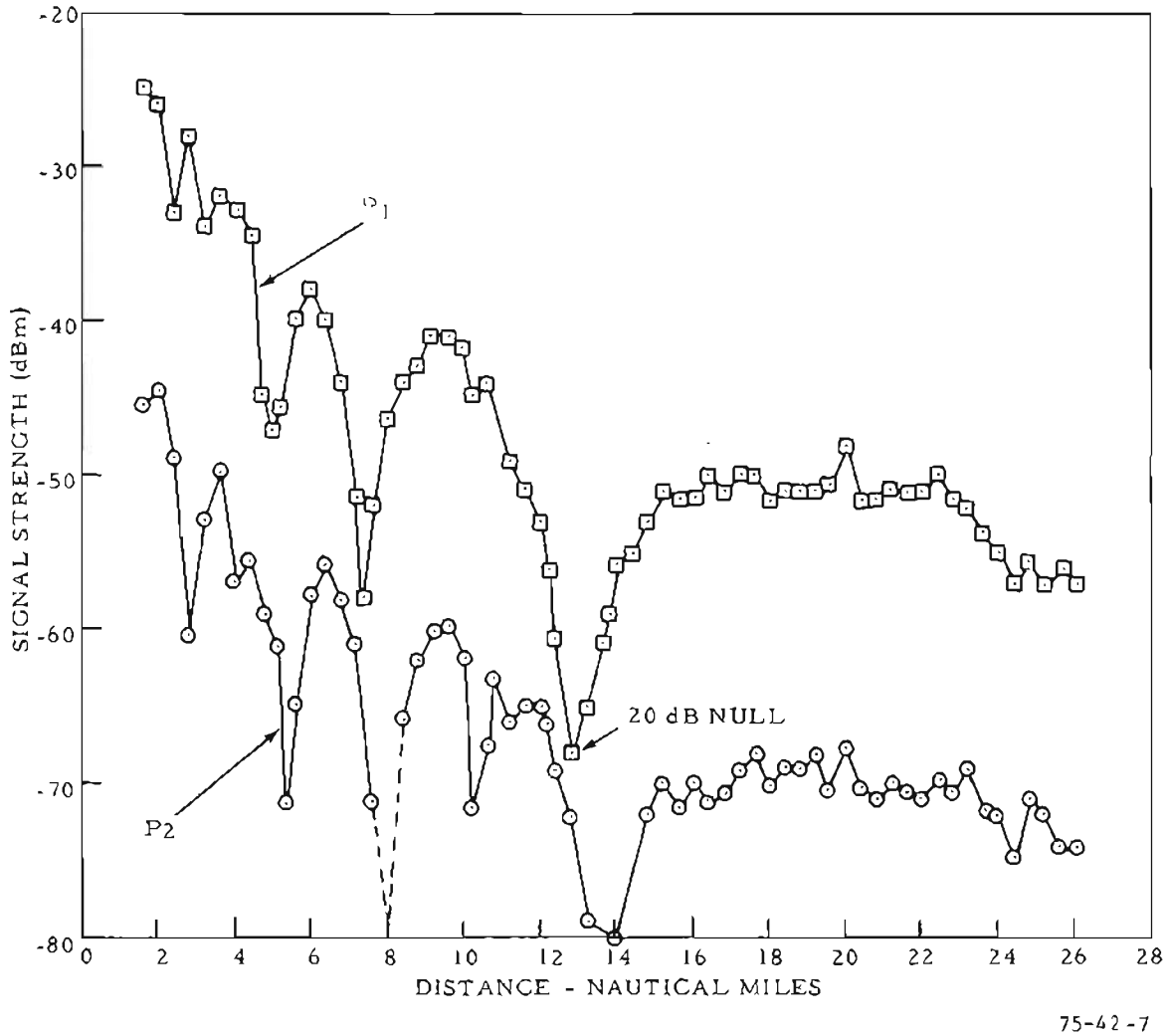

FIGURE 7. VERTICAL LOBING PATTERN FOR FA-8043 AND FA-8044 ATCRBS ANTENNAS

DATE : 7/29/74
TEST SITE : FIELD TEST SITE (55° RADIAL)
TEST CONDITIONS: MODE 3/A INTERROGATION
ISLS - ON
TRANSMITTED PEAK POWER - 600 W
0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE AND WAVEFORM MEASUREMENTS (PHOTOGRAPHS)
CALIBRATION :
VERTICAL - 5.0 FEET PER MAJOR DIVISION
HORIZONTAL - 1.0 dB PER MAJOR DIVISION

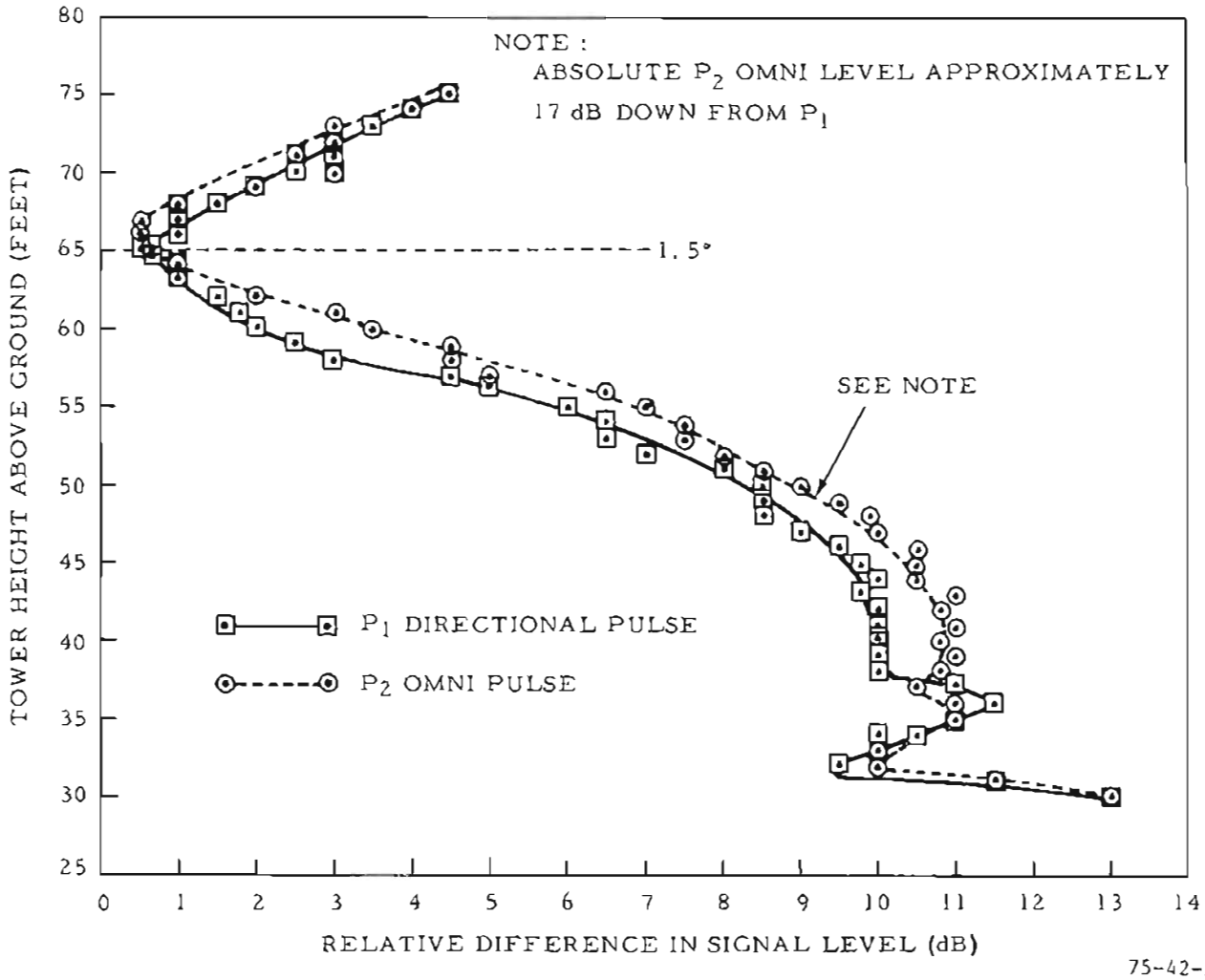

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FIGURE 8. GROUND-BASED VERTICAL LOBING PATTERN FOR ESA (ZERO DEGREE BEAM HOPOVER)

which indicates the relative change in signal level per foot above ground level for the directional and omnidirectional signals. The omnidirectional P_2 signal was plotted on the same relative scale to show the correspondence of its vertical lobing structure to that of the directional signal (P_1).

The results of the vertical lobing measurements confirmed that the vertical lobing characteristics of the ATCRBS in-service antennas were not affected by the installation of the ESA. The vertical lobing patterns for the ESA 0°, 2°, and 4° beam hopover condition (over flat terrain) demonstrated the reduction in low-elevation angle signal level (depth of first null) and also the fall off of signal level at high elevation angles (>30°). In addition, the vertical lobing pattern of the onmidirectional signal (P_2) from the ESA matched the directional signal (P_1), zero degree beam hopover, vertical lobing pattern over flat terrain.

REFLECTIONS. The NAFEC hangar was selected as the reflecting surface to be examined during the field environment tests. A flightpath (12-nmi range and 1,000 feet altitude) was established within the area of the reflected signal path from the western face of the building. A tangential flightpath permitted recording a sample of the reflected signal using the high-speed film technique combined with photographing of the TR/BTF's PPI display of both the direct and reflected transponder replies. In addition, the FR-950 video tape recorder was used to provide a permanent record of the received replies during the test.

The photographs of the PPI display (time exposures) were examined and correlated with the playback of the video information from the FR-950 video recorder to determine the reflection pattern. The results are shown in appendix B, figures B-1 through B-8, for the SLS and ISLS operation of the ATCRBS in-service antennas and the ESA with 0°, 2°, and 4° beam hopover applied to the azimuth span of the aircraft hangar, building 301, and the phototheodolite site (P-13). The copies of the PPI photographs depict the cumulative effect (time exposure) of the reflections from the aircraft hangar building to the aircraft proceeding along the flightpath.

In addition, the FR-950 video recording was replayed later, and the PPI display photographed scan-by-scan to examine the source of individual reflections. After viewing the returns on the PPI photographs, the aircraft's position (designated with letter) at which reflections were produced was noted along with comments regarding the presence of other extraneous replies.

Radial flights were conducted on April 15, 1975 (1,500-foot altitude), and April 10, 1975 (1,000-foot altitude), using SLS and ISLS operation, respectively, for both the in-service ATCRB antenna and the ESA. A flightpath was selected on the 295° radial from the EAIR tracking radar to place the aircraft along the reflected signal path from the hangar building. The results of the flights are shown in appendix C, figures C-1 through C-8. In addition, the transmitted direct and reflected signals were recorded on high-speed film in the aircraft. These data were correlated with the EAIR tracking radar, and the peak direct and reflected signal level plotted versus the aircraft range to the ESA. The results are shown in figures 9 through 12. A sample of the

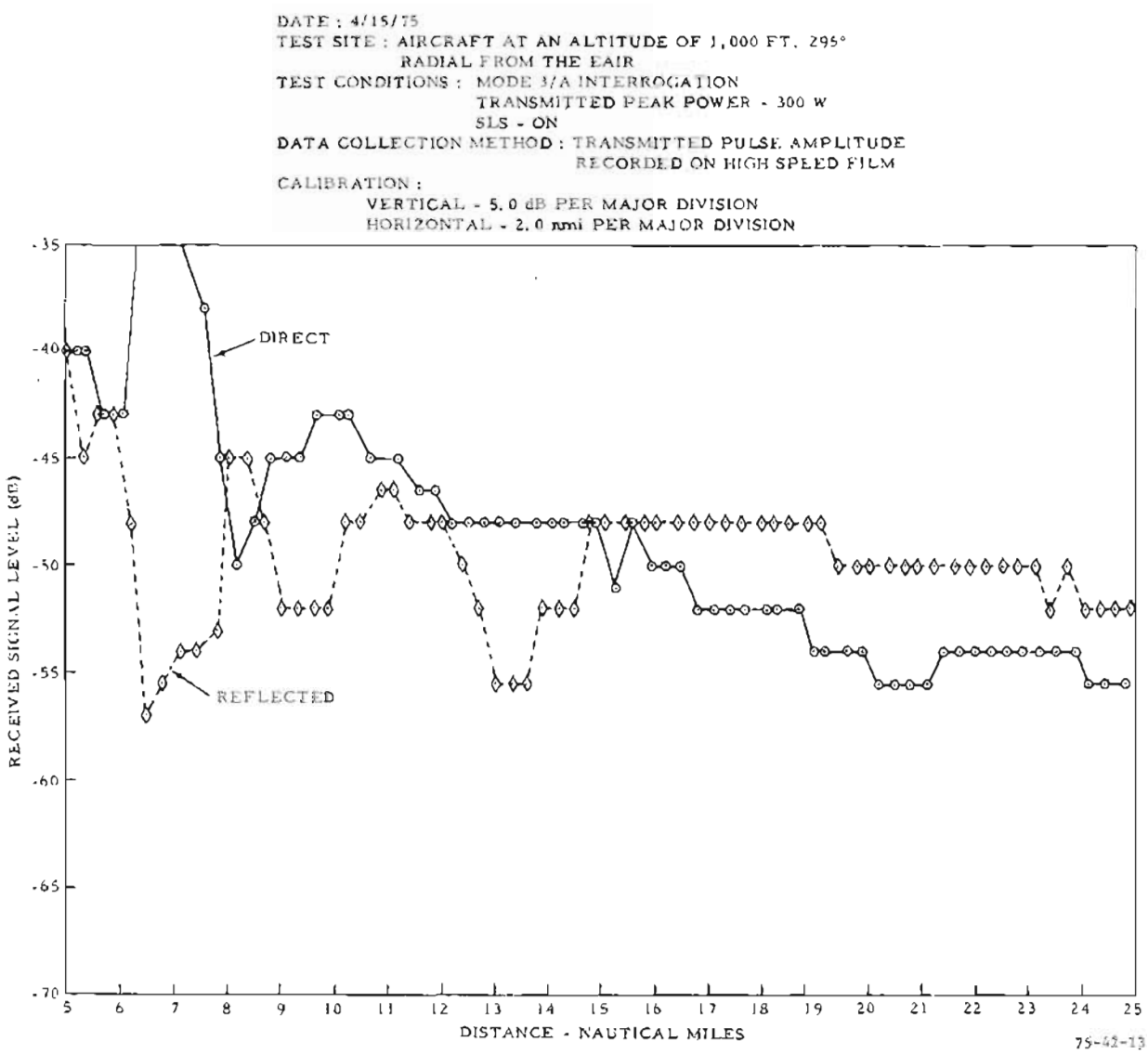


FIGURE 9. REFLECTED SIGNAL CHARACTERISTICS FROM NAFEC HANGAR FOR FA-8043 AND FA-8044 ATCRBS ANTENNAS

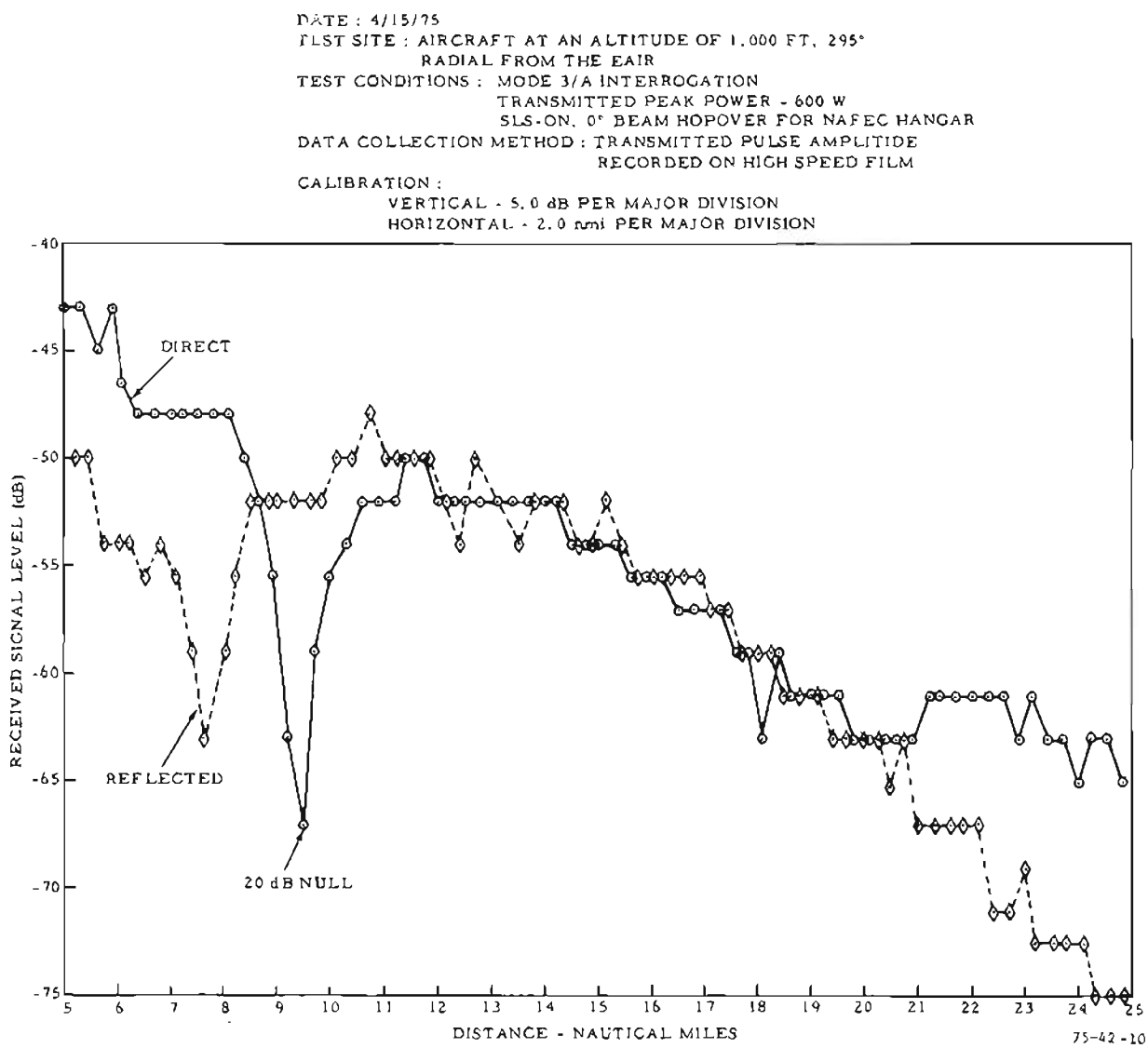


FIGURE 10. REFLECTED SIGNAL CHARACTERISTICS FROM NAFEC HANGAR FOR THE ESA (ZERO-DEGREE BEAM HOPOVER)

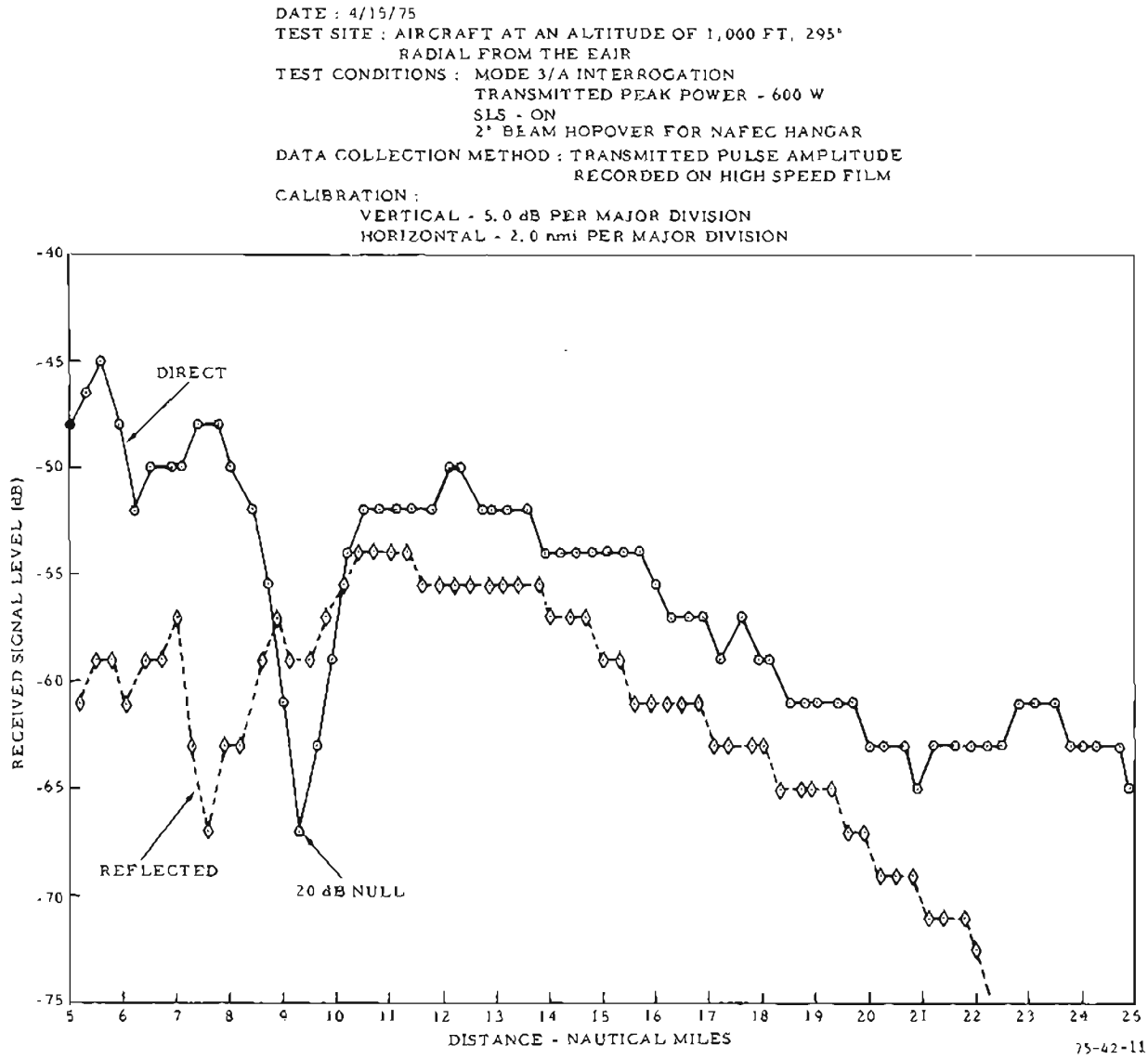


FIGURE 11. REFLECTED SIGNAL CHARACTERISTICS FROM NAFEC HANGAR FOR THE ESA (2° BEAM HOPOVER)

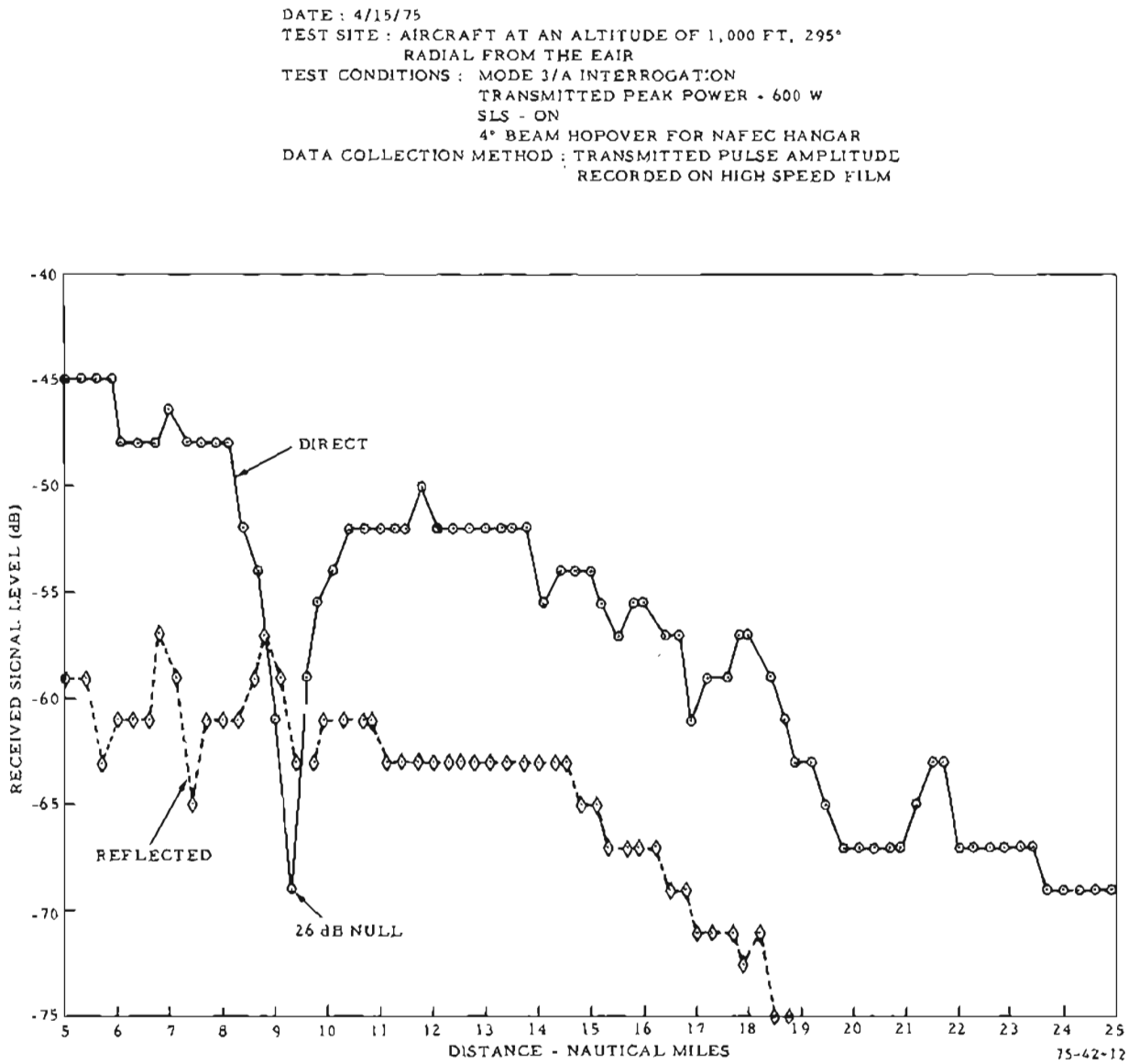


FIGURE 12. REFLECTED SIGNAL CHARACTERISTICS FROM NAFEC HANGAR FOR THE ESA (4° BEAM HOPOVER)

high-speed film for the ATCRBS in-service antenna and the ESA 0°, 2°, and 4° beam hopover operation is shown in figure 13. The direct beam and the reflected antenna pattern from the hangar building are shown on the film.

Several results were noted in the figures. The reflected signal from the NAFEC hangar for the ATCRBS antenna (shown in figure 9) is higher in amplitude than the direct interrogation path. In addition, the reflected signal vertical lobing pattern differs from the direct path vertical lobing pattern in that the nulls do not correspond in location or depth. The ESA data, presented in figures 10, 11, and 12 for 0°, 2°, and 4° beam hopover applied to the aircraft hangar, show a progressive reduction in signal strength for the reflection from the hangar. The difference noted for the ATCRBS antenna is also apparent between the vertical lobing patterns of the ESA direct and reflected signals.

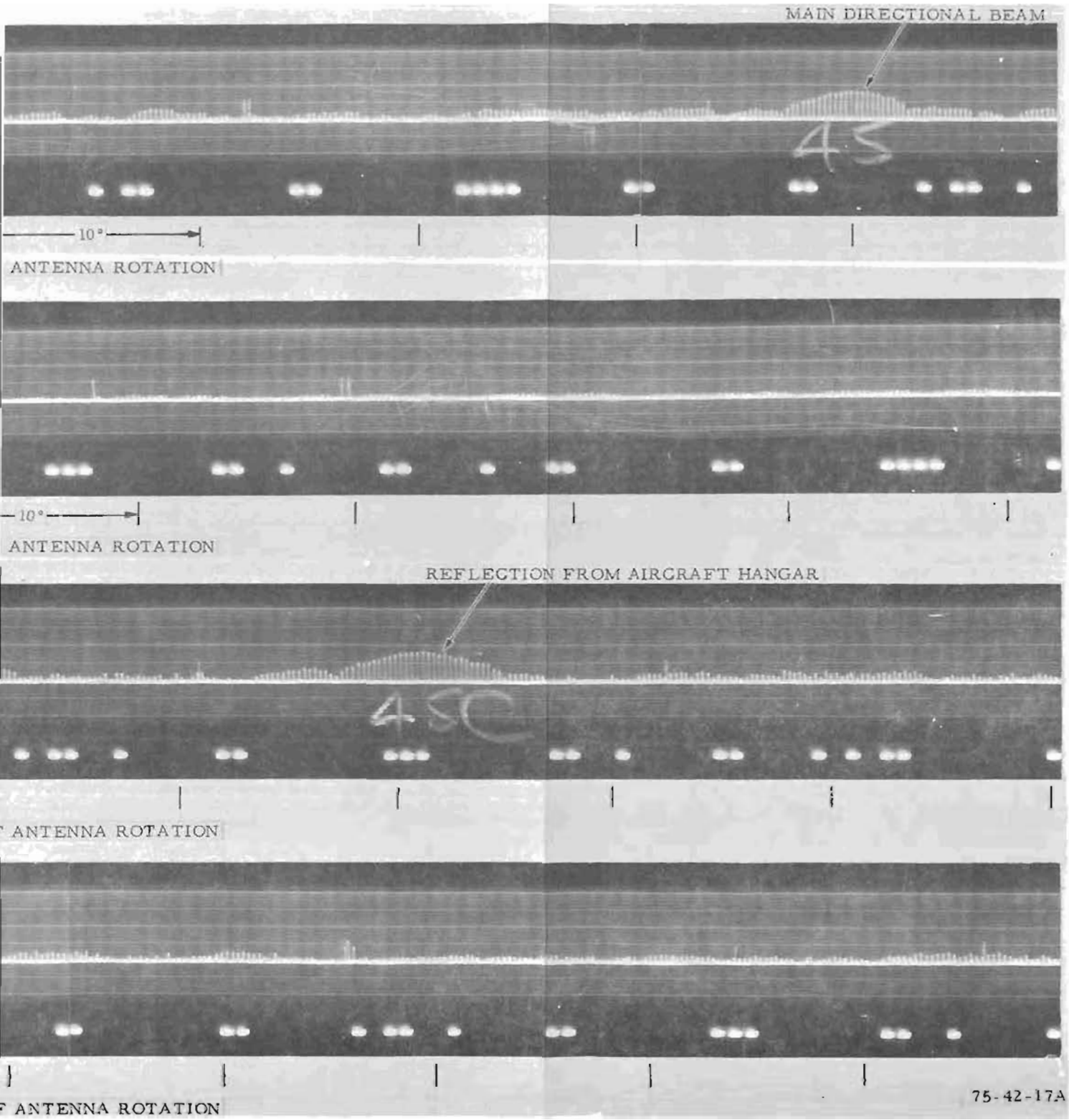
In the case of the ESA, two observations can be made which relate the results with other test data obtained during the field environment tests. The observations deal with the vertical lobing pattern of both the direct and reflected signals.

First, the predominant depth of the null (∿20 dB) in the direct signal vertical lobing structure can be traced to the anomaly in the signal characteristic experienced at the ASDE-2 platform site (covered in the Antenna Pattern Anomalies section of this report). The radial (295°) of the reflected signal from the NAFEC hangar was unintentionally coincident with the azimuth at which the ground multipath affected the direct interrogation path towards the ASDE-2 platform site.

The second observation deals with the reflected signal vertical lobing pattern in that it is similar to the patterns recorded for the ESA 0°, 2°, and 4° beam hopover recorded over flat terrain. The difference between the two vertical lobing patterns (direct and reflected) can be attributed to the characteristics of the ground topology along the radial to the aircraft and to the NAFEC hangar.

The figures in appendix B and C depict both the SLS and ISLS system operation for tangential and radial flights for the reflection radial of the NAFEC hangar. The tangential flights are shown in appendix B and the radial flights are shown in appendix C.

The tangential flight for the ATCRBS antennas employing SLS operation is shown in figure B-1. The main portion of the reflections noted for the flight extend from letter F to W on the illustration (for about an arc of 28° of the flightpath). Figures B-2, B-3, and B-4, for the ESA (SLS operation), demonstrate the effect of beam hopover on the reflections from the NAFEC hangar. (The extent of the arc for the flightpath was about 10°.) The corners of the aircraft hangar building were outlined in figure B-4 for points I and J and P and G on the aircraft flightpath.



FILM FOR DIRECT AND REFLECTED P_3 SIGNAL FROM
HE FA-8043 ATCRBS ANTENNA (Sheet 1 of 4)

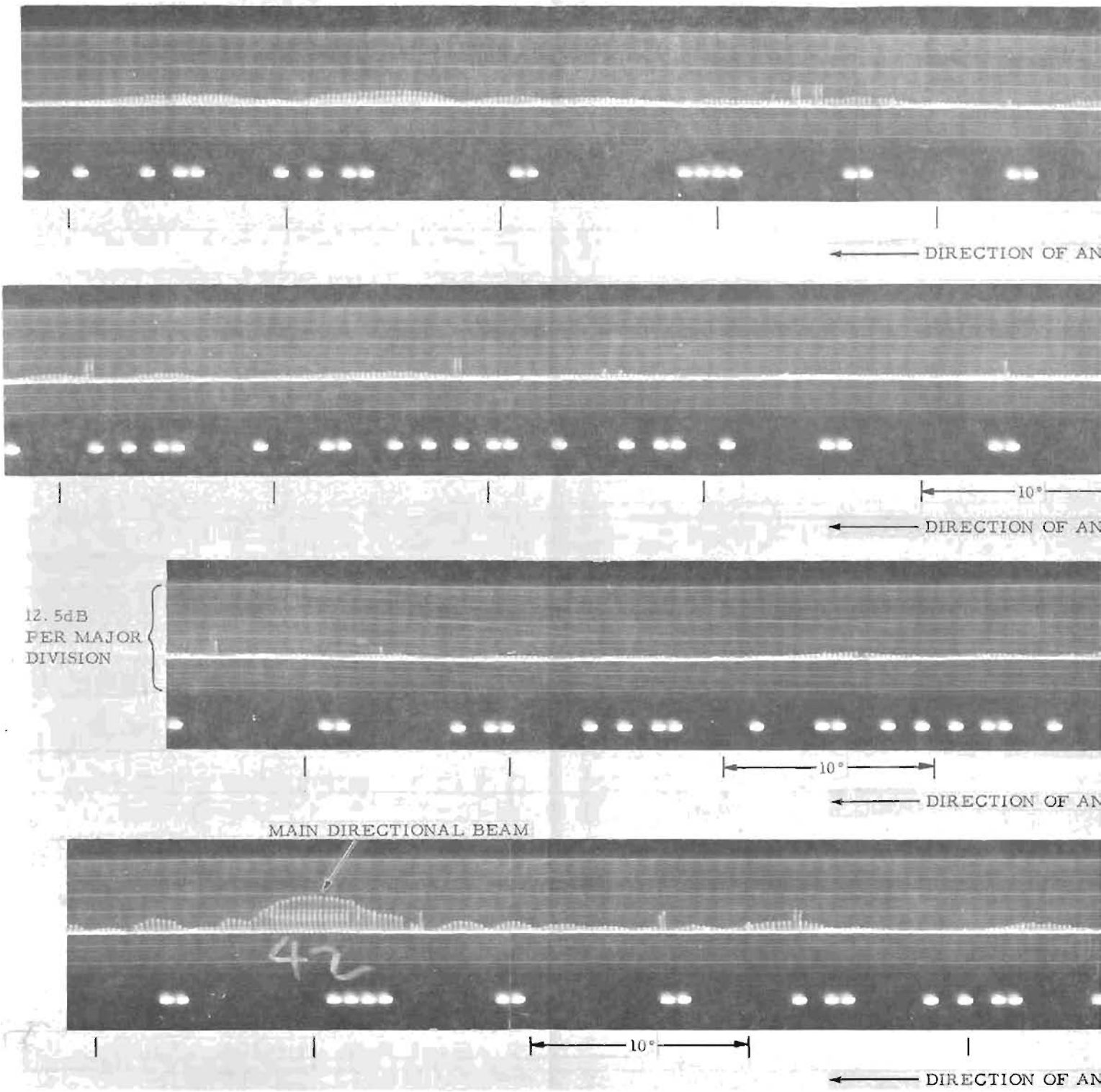
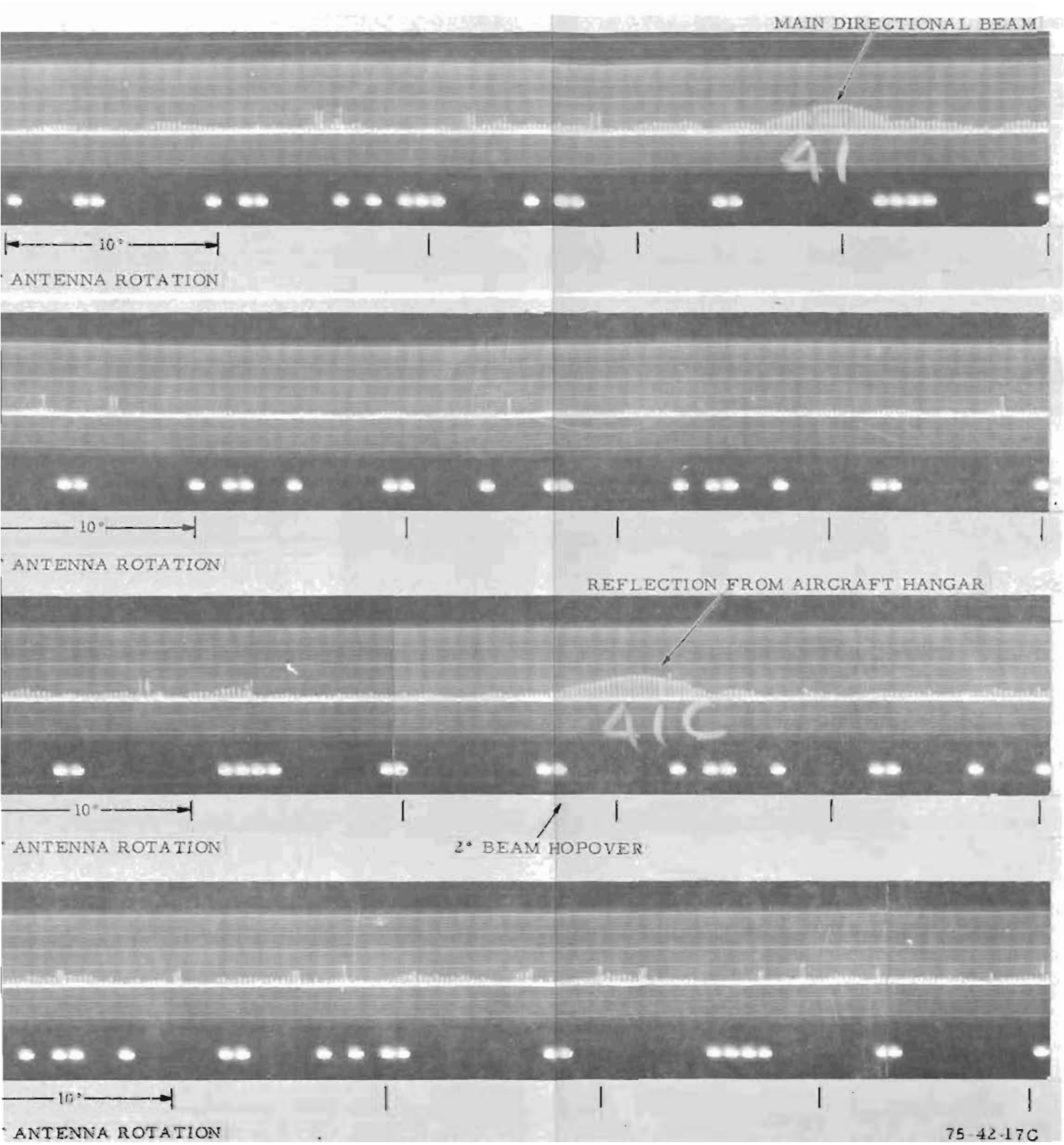


FIGURE 13b. SAMPLES OF HIGH-SPEED FILM FO
THE NAFEC HANGAR FOR THE ESA



LM FOR DIRECT AND REFLECTED P_3 SIGNAL FROM ESA (2° BEAM HOPOVER) (Sheet 3 of 4)

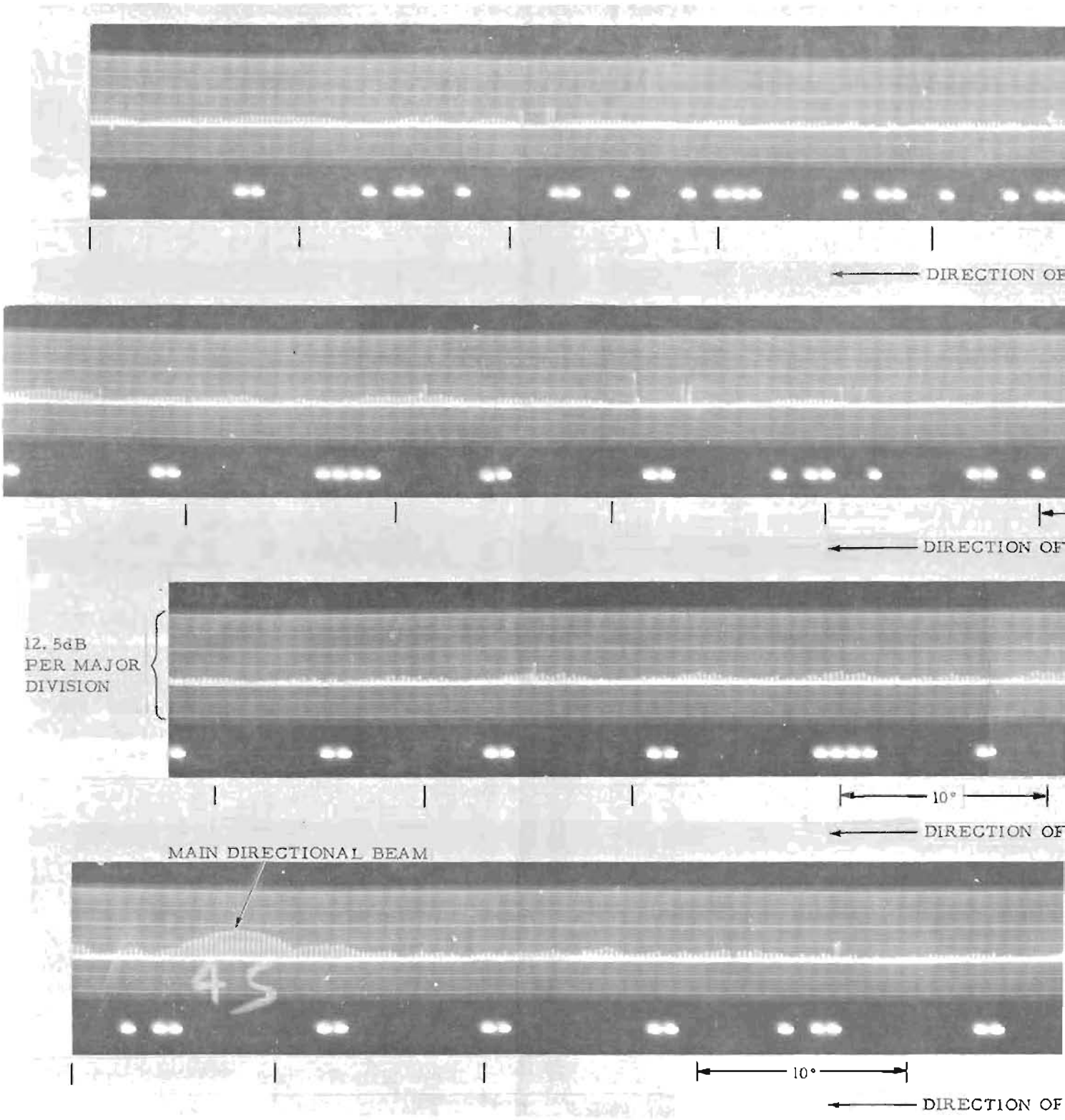


FIGURE 13d. SAMPLES OF HIGH-SPEED FILM F
THE NAFEC HANGAR FOR THE ESA

ISLS operation for the ATCRBS and ESA antennas was employed for the remaining tangential flightpaths (figures B-5 through B-8). The reflections were eliminated in the case of the ATCRBS and progressively reduced for the ESA 0°, 2°, and 4° beam hopover condition.

Radial flightpaths were flown for both SLS and ISLS operation (1,500-foot altitude in the SLS case, 1,000-foot altitude for ISLS). The reflections from the NAFEC hangar were photographed for SLS operation for both the ATCRBS antennas and ESA (figures C-1 and C-2). The effect of beam hopover (2° and 4°) is shown in figures C-3 and C-4. The flightpaths were repeated for ISLS operation and the reflections noted for the ATCRBS and ESA (0°, 2°, and 4°). Figures C-5 and C-6 demonstrates that the ISLS is range limited in the elimination of the reflections. The application of 2° and 4° beam hopover condition for the NAFEC hangar (figures C-7 and C-8) progressively reduced the range of the reflection to the effective range of the ISLS for ESA.

The results of the reflection tests indicate that the vertical lobing pattern along the radial of the reflecting surface is preserved for the reflected signal. ISLS system operation was effective for both the ATCRBS antenna and ESA in the elimination of reflections from the NAFEC hangar, but was limited in range. The ESA beam hopover feature decreased the range of the reflected signal to the effective range of the ISLS system operation (this was not possible with the ATCRBS in-service antennas).

DIFFRACTION. Measurements of the antenna characteristics using fixed-beam positions (static beam) were performed to demonstrate diffraction effects encountered in the field environment. Three radials were selected from the TR/BTF to examine the static beam under the following conditions:

1. Unobstructed view of antenna (100° radial).
2. Vertical plane obstructed (132° radial, side of aircraft hangar (bldg. 301)).
3. Horizontal plane obstructed (139° radial, top of aircraft hangar (bldg. 301)).

The aircraft was equipped with the pulse amplitude printout instrumentation and flown tangential to the static beam position at a range of approximately 12 nmi. The EAIR was employed to track the aircraft and provide guidance along the prescribed flightpath. The results of the test are shown in appendix D, figures D-1 through D-20, comparing the in-service ATCRBS antennas with the ESA for each of the conditions noted above. Comparisons were made at two different altitudes to illustrate the localized effects of obstacles on diffraction of the directional and omnidirectional antenna patterns. The ESA data includes the effects of beam hopover on the static beam antenna pattern for each of the beam positions. The data in appendix D is arranged in sequence to permit examination of the effect of a vertical and horizontal obstruction on a static antenna pattern. In summary, the vertical plane obstruction distorts the ATCRBS and ESA antenna patterns for both the directional and omnidirectional beams. In the case of the ATCRBS antenna, high side lobes are produced and the main beam distorted; the ESA patterns for 0°, 2°, and 4° beam hopover are likewise distorted compared to the unobstructed patterns. At a higher elevation angle above the obstruction, the distortion did not appear on the patterns. The horizontal plane obstruction has no distortion effects on the beam pattern, but did produce a lower signal level for this test (-4 dB for the ESA zero degree beam hopover condition).

BEAM HOPOVER. The beam hopover function of the ESA was tested during the 1030-MHz and 1090-MHz vertical pattern specification measurements (reference 2) and the vertical lobing, reflection, and diffraction tests described in this report.

In summary, the beam hopover function produced the desired reduction in signal strength at low-elevation angles. This reduced signal strength was approximately 8 dB at low-elevation angles for the 4° beam hopover vertical lobing pattern over flat terrain. The vertical lobing patterns are shown in appendix A, figures A-3 to A-8, for 0°, 2°, and 4° beam hopover.

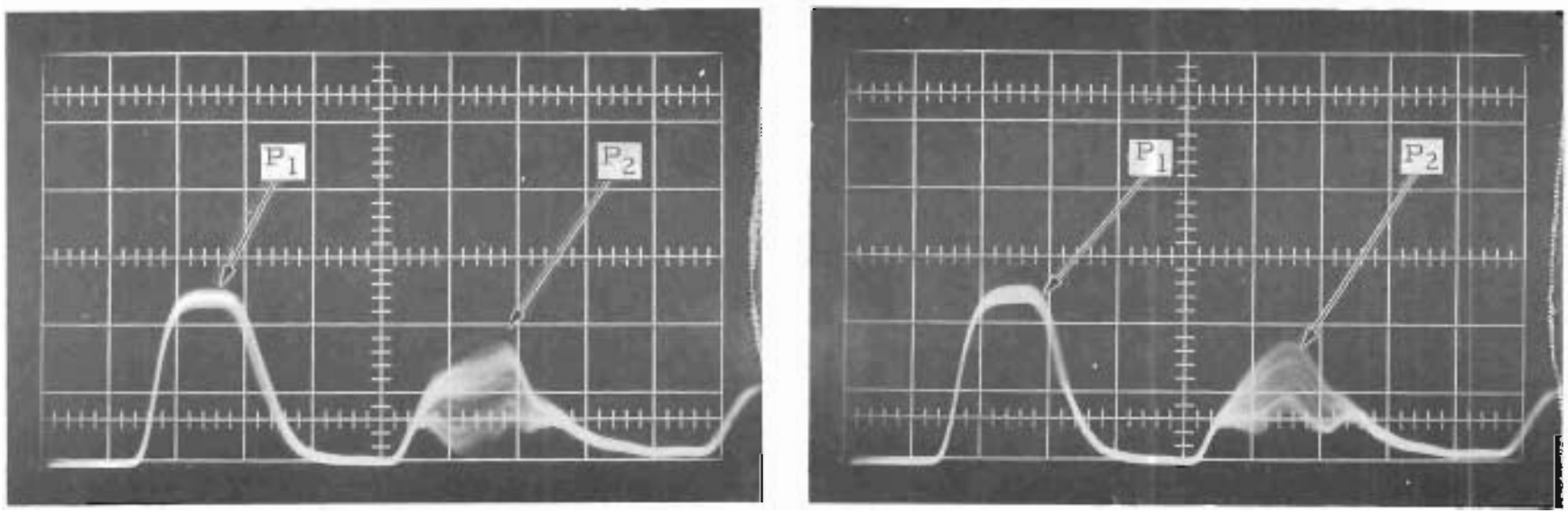
The effect of the beam hopover function on the reflections from the NAFEC hangar have been described in this report. It was demonstrated that the reflections are reduced in range by the application of a 2° and 4° beam hopover condition at the hangar radials. The results of the test may be extended to any reflecting surface above ground level by analysis of the reflection characteristics, the position and aspect of the reflecting surface with respect to the ESA, and the beam hopover condition applied at the azimuth of the reflecting surface. In addition, consideration should be given to the application of beam hopover to the omnidirectional beam (P_2) and the application of ILS to reduce reflections.

The effects of both vertical and horizontal obstructions on the beam patterns for 0°, 2°, and 4° beam hopover are shown in appendix D. The application of beam hopover (2° and 4°) to the vertical plane obstruction reduced the peak amplitude (4 and 7 dB, respectively) but did not improve the distortion of the main beam patterns (figures D-6, D-7, and D-8). The application of the 2° and 4° beam hopover to the horizontal plane obstruction reduced the signal level beyond the obstruction by 3 and 7 dB, respectively, without distorting the beam pattern.

ANTENNA PATTERN ANOMALIES. During the test and evaluation of the ATCRBS ESA, some antenna pattern anomalies which can be attributed to a multipath environment were noted during the specification tests (reference 2). The pattern anomalies noted at the airport surface detection equipment (ASDE-2) platform site involved a fluctuation in the omnidirectional (P_2) signal level and a pronounced side lobe on the directional (P_1) pattern.

The fluctuation in the omnidirectional P_2 pulse is shown in figure 14. The photographs were taken at the ASDE-2 platform site on May 16, 1974. The ESA was place in a fixed position (228°, not the ASDE-2 radial) and the oscilloscope adjusted to display the transmitted P_1 and P_2 pulse. The fluctuation P_2 signal level was traced to the reflection of the omnidirectional pattern. The reflections were isolated by substituting a standard gain horn for the ESA, pointing it towards the ASDE-2, and photographing the P_1 and P_2 transmitted pulses. The result is shown in figure 15. In addition to the multipath noted above, the trailing edge of the omnidirectional (P_2) pulse was observed from the reflection of the directional P_1 pulse off of the aircraft hangar Bldg. 301.

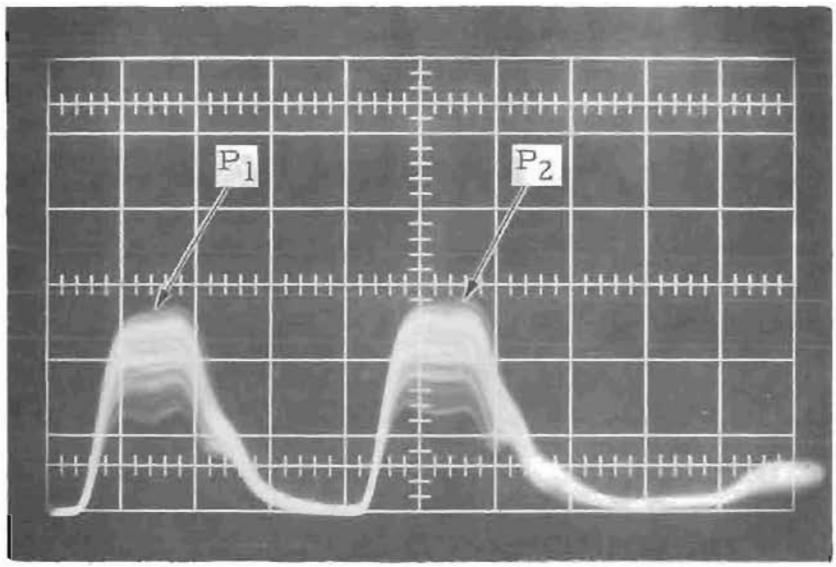
DATE : 5/16/74
TEST SITE : ASDE - 2 PLATFORM SITE
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER - 300 W
FIXED ANTENNA POSITION, 0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE AND WAVEFORM MEASUREMENTS (PHOTOGRAPHS)
CALIBRATION :
VERTICAL - 9.0 dB PER MAJOR DIVISION
HORIZONTAL - 0.5 μs PER MAJOR DIVISION



75-42-18

FIGURE 14. FLUCTUATION OF ESA OMNIDIRECTIONAL (P_2) PULSE AT ASDE-2 PLATFORM SITE

DATE : 5/16/74
TEST SITE : ASDE - 2 PLATFORM SITE
TEST CONDITIONS : P_1, P_2 & P_3 PULSES TRANSMITTED
TRANSMITTED PEAK POWER - 300 W
STANDARD GAIN HORN POINTED AT
TREE LINE
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
AND WAVEFORM MEASUREMENTS
(PHOTOGRAPHS)
CALIBRATION :
VERTICAL - 9.0 dB PER MAJOR DIVISION
HORIZONTAL - 0.5 μs PER MAJOR DIVISION



75-42-19

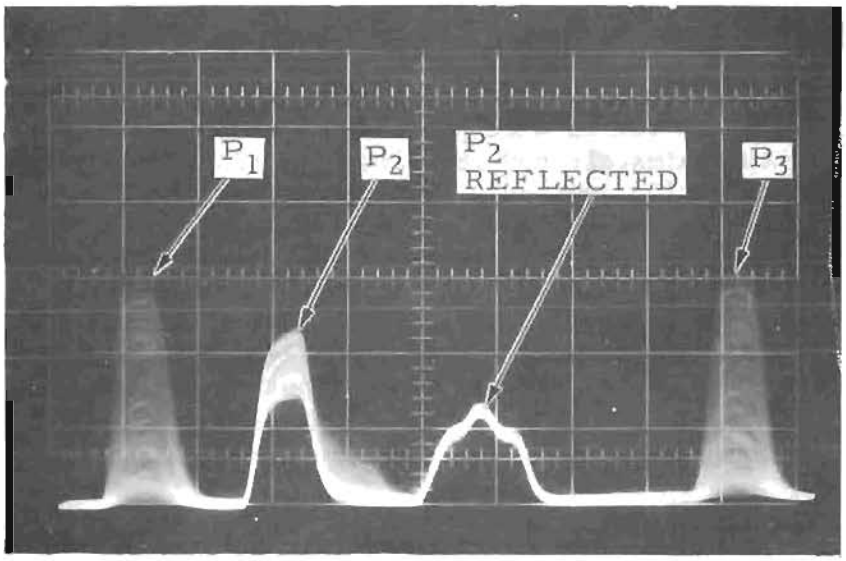
FIGURE 15. FLUCTUATION OF STANDARD GAIN HORN PATTERN AT ASDE-2 PLATFORM SITE

A photograph of the directional (P_1) pulse, the omnidirectional (P_2) pulse, the reflected omnidirectional pulse from the hangar (bldg. 301), and the directional P_3 pulse is shown in figure 16. The P_1 and P_3 pulses are varying in amplitude since the ESA was rotating through a full 360° scan. The interference of the reflected P_1 pulse from the hangar (bldg. 301) is noted on the photograph which was exposed over a 5.0 second interval. In addition, another photograph (figure 17) shows the directional P_1 and omnidirectional P_2 pulse as the main beam passed through the azimuths of the hangar. Figure 17 shows the effects on the trailing edge of the P_2 signal. Details of the reflected signal characteristics can be found under the reflection study in this report.

Another effect of multipath was noted on the directional P_1 antenna pattern at the ASDE-2 platform site. A high side lobe, shown in figure 18, appeared on the SLS pattern. This condition was investigated by the contractor and led to an analysis of the radiofrequency (RF) transmission path between the ESA and the ASDE-2 site. The study provided data which demonstrated that the reflected signal from the ground in front of the ESA was the major contributor to the distortion of the received signal at the ASDE-2 platform. In support of this analysis, a vertical lobing pattern was recorded at the site. The result is shown in figure 19.

Additional effort was directed towards isolating multipath as the direct cause of the high side lobe on the antenna pattern. A large (20X50 feet) metal screen was placed approximately 650 feet from the ESA to block the radiation into the ground (reflecting surface). The three conditions tested included no screening, partial screening, and full screening along the radial of the ASDE-2 platform site. The results are shown in figure 20 demonstrating the multipath effect on the SLS antenna pattern at the ASDE-2 platform site. The side lobe level decreased substantially as the screen blocked the ground interference signal. In addition, the omnidirectional signal level increased and stabalized when the screen was placed in front of the ESA.

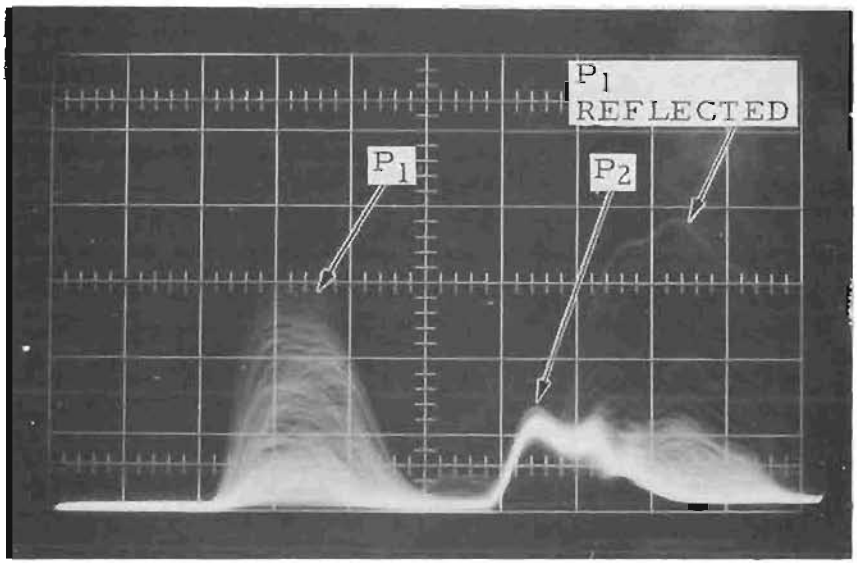
DATE : 5/ 21/74
TEST SITE : ASDE - 2 PLATFORM SITE
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER - 300 W
0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE AND WAVEFORM MEASUREMENTS (PHOTOGRAPHS)
CALIBRATION :
VERTICAL - 9.0 dB PER MAJOR DIVISION
HORIZONTAL - 1.0 μs PER MAJOR DIVISION



75-42-20

FIGURE 16. DIRECTIONAL (P_1) AND ONMIDIRECTIONAL (P_2) PULSES AND REFLECTIONS FROM NAFEC HANGAR

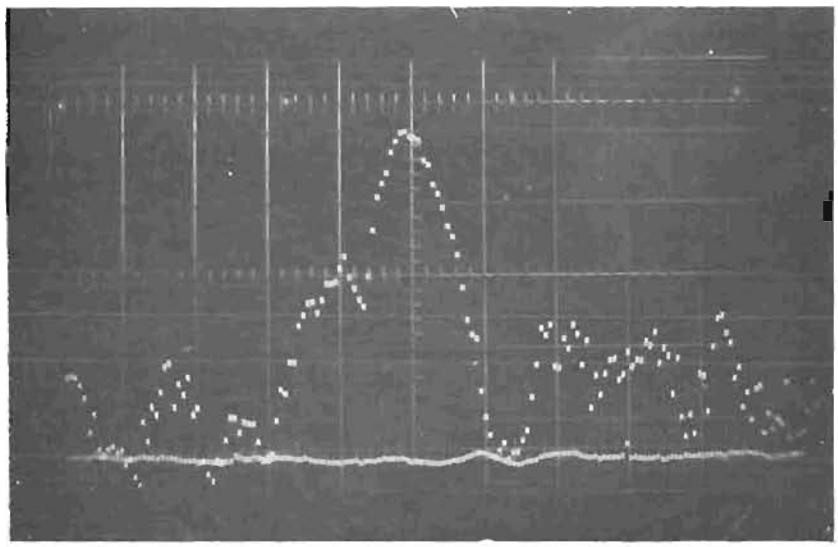
DATE : 7/9/74
TEST SITE : ASDE - 2 PLATFORM SITE
TEST CONDITIONS : MODE 3/A INTERROGATION
ISLS - ON
TRANSMITTED PEAK POWER - 600 W
0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE AND WAVEFORM MEASUREMENTS (PHOTOGRAPHS)
CALIBRATION :
VERTICAL - 9.0 dB PER MAJOR DIVISION
HORIZONTAL - 0.5 μs PER MAJOR DIVISION



75-42-21

FIGURE 17. FLUCTUATION OF ESA OMNIDIRECTIONAL (P_2) PULSE TRAILING EDGE AT ASDE-2 PLATFORM SITE

DATE : 10/2/74
TEST SITE : ASDE - 2 PLATFORM
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER - 300 W
0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE AND WAVEFORM MEASUREMENTS (PHOTOGRAPHS)
CALIBRATION :
VERTICAL- 5.0 dB PER MAJOR DIVISION
HORIZONTAL- 3.84 DEGREES PER MAJOR DIVISION



75-42-22

FIGURE 18. ESA SLS ANTENNA PATTERN AT ASDE-2 PLATFORM SITE

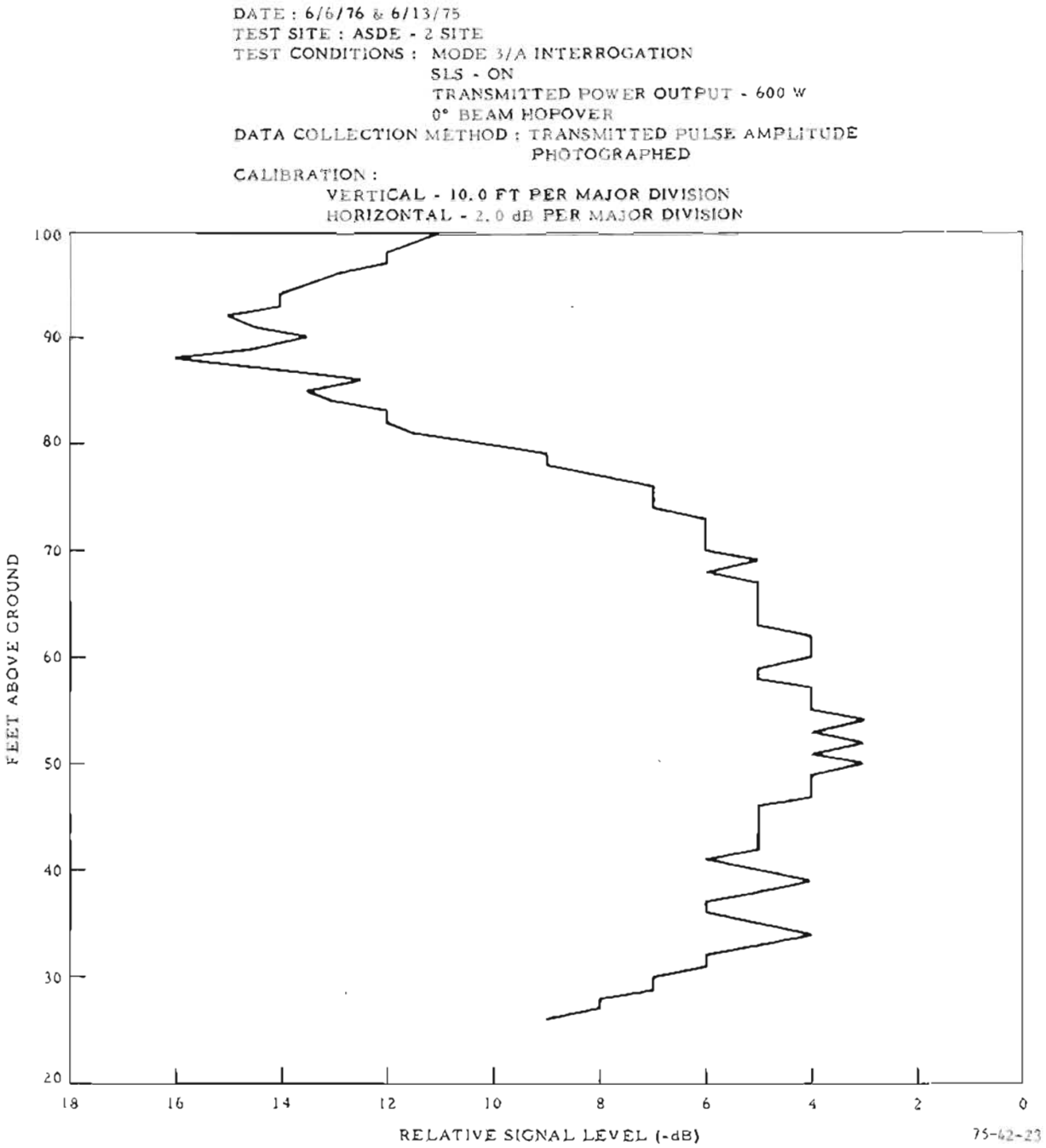
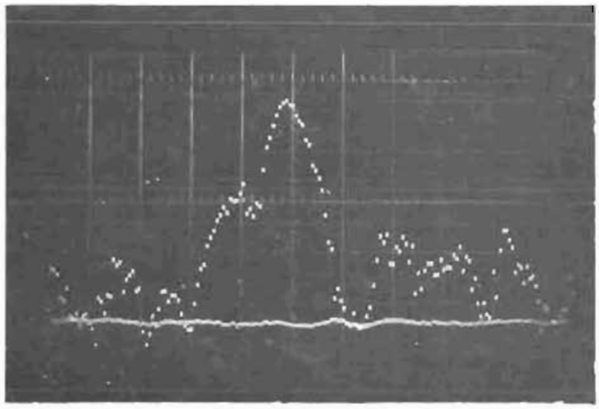
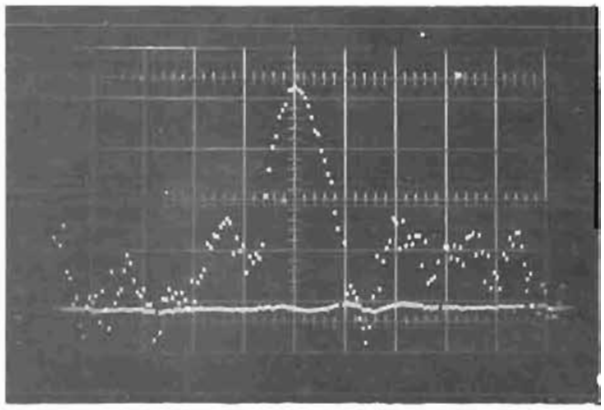


FIGURE 19. GROUND-BASED VERTICAL LOBING PATTERN AT ASDE-2 SITE

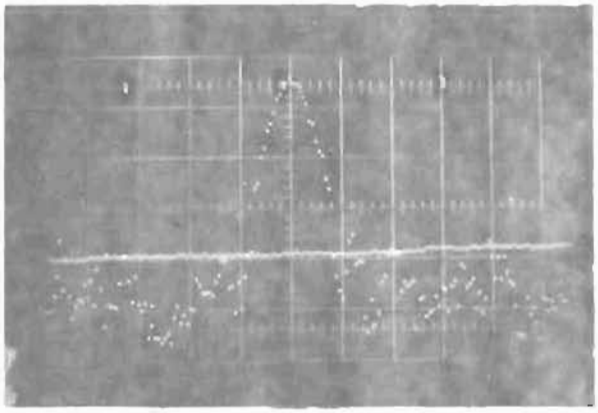
DATE : 10/2/75
TEST SITE : ASDE - 2 PLATFORM SITE
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER - 300 W
0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE AND WAVEFORM MEASUREMENTS (PHOTOGRAPHS)
CALIBRATION :
VERTICAL - 5.0 dB PER MAJOR DIVISION
HORIZONTAL - 3.84 DEGREES PER MAJOR DIVISION



a. NO SCREEN



b. PARTIAL SCREEN



c. FULL SCREEN

75-42-24

FIGURE 20. MULTIPATH EFFECT ON THE ESA SLS ANTENNA PATTERN AT ASDE-2 PLATFORM SITE

SUMMARY OF RESULTS

The results obtained during the field environment tests for the ASR-7, the ATCRBS in-service antennas, and the ATCRBS ESA are summarized as follows:

1. The ASR-7 and ATCBI-4 flight test data indicated coverage characteristics similar to those obtained before the installation of the ESA. In addition, the ATCRBS in-service antenna vertical lobing pattern measured during the field environment tests was typical of the ground interference pattern noted for the antenna before the ESA installation.

2. The vertical lobing patterns of both the ATCRBS in-service antennas and the ATCRBS ESA were compared over a flat terrain. The ESA substantially reduced the depth of the first null of the vertical pattern and effectively limited the ground interference signal to the first 2° of elevation angle at the TR/BTF. However, the ground reflection path on the 295° of the TR/BTF created a vertical lobing condition for the ESA which was comparable (20-dB null in vertical pattern) to the ATCRBS in-service antenna.

3. The ATCRBS ESA beam hopover function (4°) decreased the range of the reflected signal from the aircraft hangar building to the effective range of the ISLS system operation. In addition, the vertical lobing pattern along the reflecting surface radial was preserved along the reflection path.

4. The ESA directional (zero degree beam hopover) and omnidirectional vertical lobing patterns were matched over flat terrain.

5. Field environment conditions at the TR/BTF presented diffraction effects for the ATCRBS in-service and ESA antennas from both vertical and horizontal obstructions. Main beam and omnidirectional beam distortion was noted for the vertical obstruction. The horizontal obstruction (NAFEC hangar) reduced the signal level of the omnidirectional and the directional beam beyond the hangar. In addition, the application of beam hopover to the NAFEC hangar resulted in a reduction in signal strength beyond the horizontal obstruction.

CONCLUSIONS

Based on the results obtained during the field environment test at the terminal radar/beacon test facility (TR/BTF), it is concluded that:

1. The physical installation of the air traffic control radar beacon system (ATCRBS) electronic scan antenna (ESA) did not degrade the operational capability of either the airport surveillance radar (ASR-7) or the ATCRBS in-service antennas.

2. The ATCRBS ESA demonstrated an improvement in the vertical lobing pattern over flat terrain compared to the ATCRBS in-service antennas. The depth of the first null was substantially reduced and the matching of the directional and omnidirectional antenna vertical patterns achieved by employing the same radiating network for both beams. However, the field environment conditions (ground multipath) at the TR/BTF produced a null of 20 dB in the vertical lobing pattern for the ESA (on the 295° radial).

3. Reflections from the aircraft hangar building were effectively eliminated by a combination of 4° beam hopover and improved side lobe suppression (ISLS) system operation.

4. Diffraction effects from a vertical obstruction produced distortion of the directional and omnidirectional antenna beams for both the ESA and ATCRBS in-service antennas. The diffraction effects were localized by the position (range) and elevation angle of both the vertical and horizontal obstruction. In addition, the application of beam hopover to the NAFEC hangar resulted in a reduction in signal strength beyond the horizontal obstruction.

5. The field environment test compared the ESA with the ATCRBS in-service antenna at the TR/BTF. During the tests, the difference in height above ground of the antenna, RF losses in both distribution systems, and the difference in gain of the two antenna systems were considered in the comparison of the results from the ESA and the ATCRBS in-service antennas.

REFERENCES

1. Bradley, A. D., Test and Evaluation of ATCRBS Electronic Scan Antenna (Preparatory Test), Federal Aviation Administration, Washington, D.C., Interim Report FAA-RD-74-176, November 1974.

2. Bradley, A. D., Test and Evaluation of ATCRBS Electronic Scan Antenna (Specification Test), Federal Aviation Administration, Washington, D.C., Interim Report FAA-RD-75-212, January 1976.

APPENDIX A

VERTICAL LOBING PATTERNS

LIST OF ILLUSTRATIONS

Figure		Page
A-1	Vertical Lobing Pattern for ATCRBS Antenna (Zero to 5° Elevation Angle)	A-1
A-2	Vertical Lobing Pattern for ATCRBS Antenna (5° to 55° Elevation Angle)	A-2
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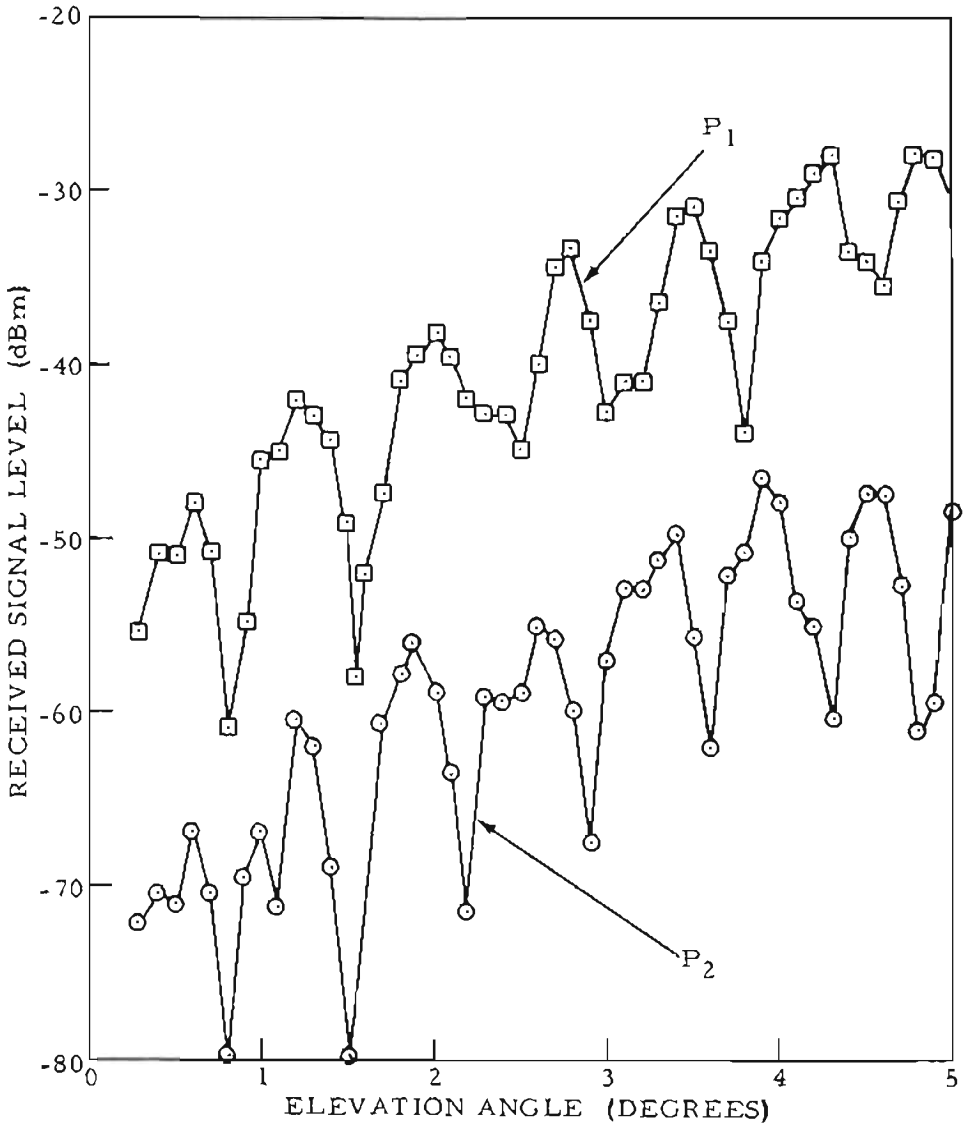
A-4	Vertical Lobing Pattern for ESA (Zero Degree Beam Hopover, 5° to 55° Elevation Angle)	A-4
A-5	Vertical Lobing Pattern for ESA (2° Beam Hopover, Zero to 5° Elevation Angle)	A-5
A-6	Vertical Lobing Pattern for ESA (2° Beam Hopover, 5° to 55° Elevation Angle)	A-6
A-7	Vertical Lobing Pattern for ESA (4° Beam Hopover, Zero to 5° Elevation Angle)	A-7
A-8	Vertical Lobing Pattern for ESA (4° Beam Hopover, 5° to 55° Elevation Angle)	A-8

DATE : 2/21/75
TEST SITE : AIRCRAFT AT 1,500 FT ALTITUDE, 0 TO 26 nmi
ON 100° RADIAL (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
TRANSMITTED PEAK POWER - 300 W
SLS - ON
FIXED ANTENNA POSITION
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT
CALIBRATION :
VERTICAL - 10.0 dB PER MAJOR DIVISION
HORIZONTAL - 1.0 DEGREES PER MAJOR DIVISION



75-42-D-1

FIGURE A-1. VERTICAL LOBING PATTERN FOR ATCRBS ANTENNA (ZERO TO 5° ELEVATION ANGLE)

DATE : 4/17/75
TEST SITE : AIRCRAFT AT 10,000 FT ALTITUDE, 0 TO 60 nmi
ON 100° RADIAL (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER -600 W
FIXED ANTENNA POSITION, 0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT
CALIBRATION :
VERTICAL - 10.0 dB PER MAJOR DIVISION
HORIZONTAL - 5.0 DEGREES PER MAJOR DIVISION

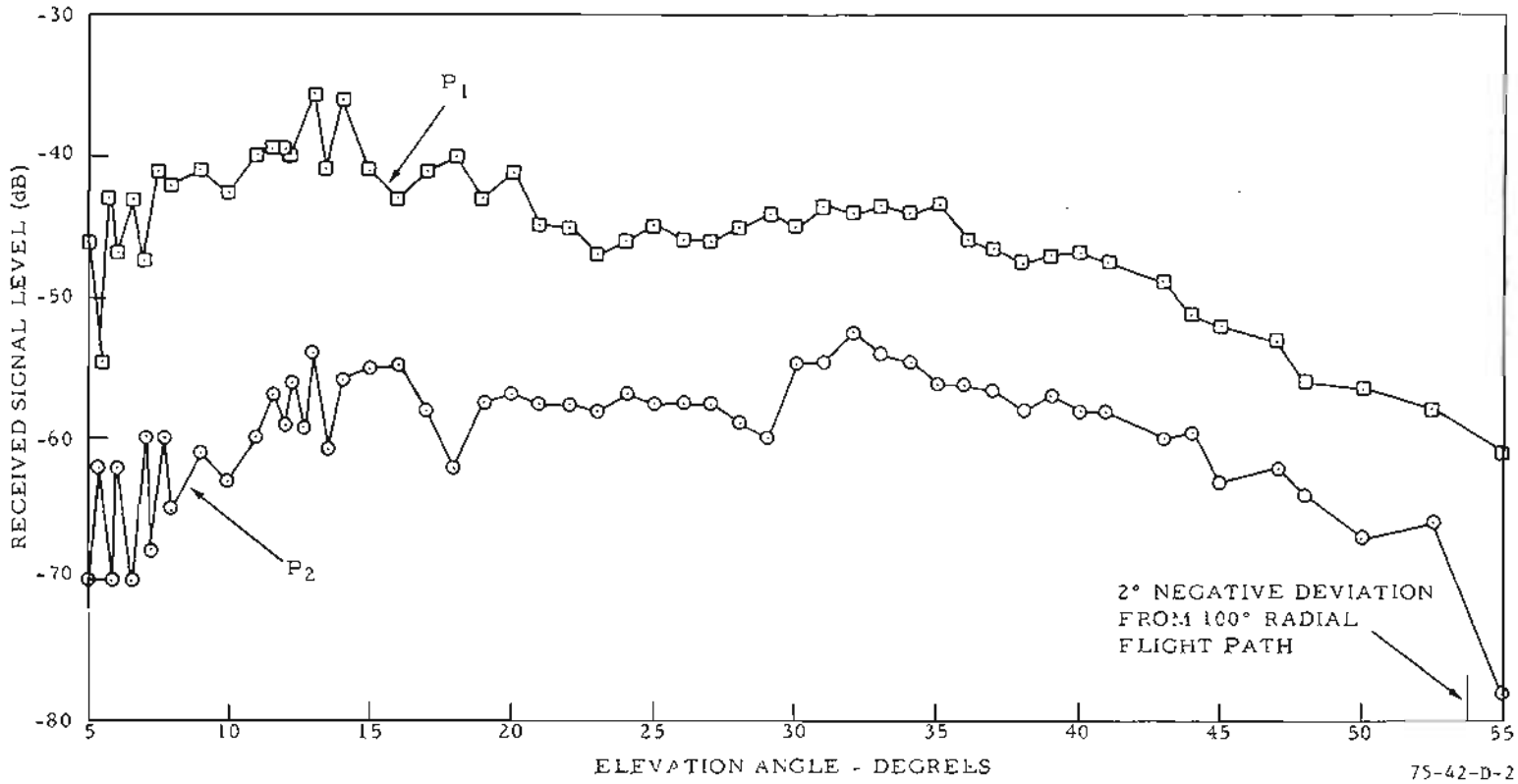


FIGURE A-2. VERTICAL LOBING PATTERN FOR ATCRBS ANTENNA (5° TO 55° ELEVATION ANGLE)

DATE : 3/7/75
TEST SITE : AIRCRAFT AT 1,500 FT ALTITUDE, 0- 25 nmi
ON 100° RADIAL (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
TRANSMITTED PEAK POWER - 600 W
SLS - ON
FIXED ANTENNA POSITION, 0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE PRINT OUT
CALIBRATION :
VERTICAL - 10.0 dB PER MAJOR DIVISION
HORIZONTAL - 1.0 DEGREES PER MAJOR DIVISION

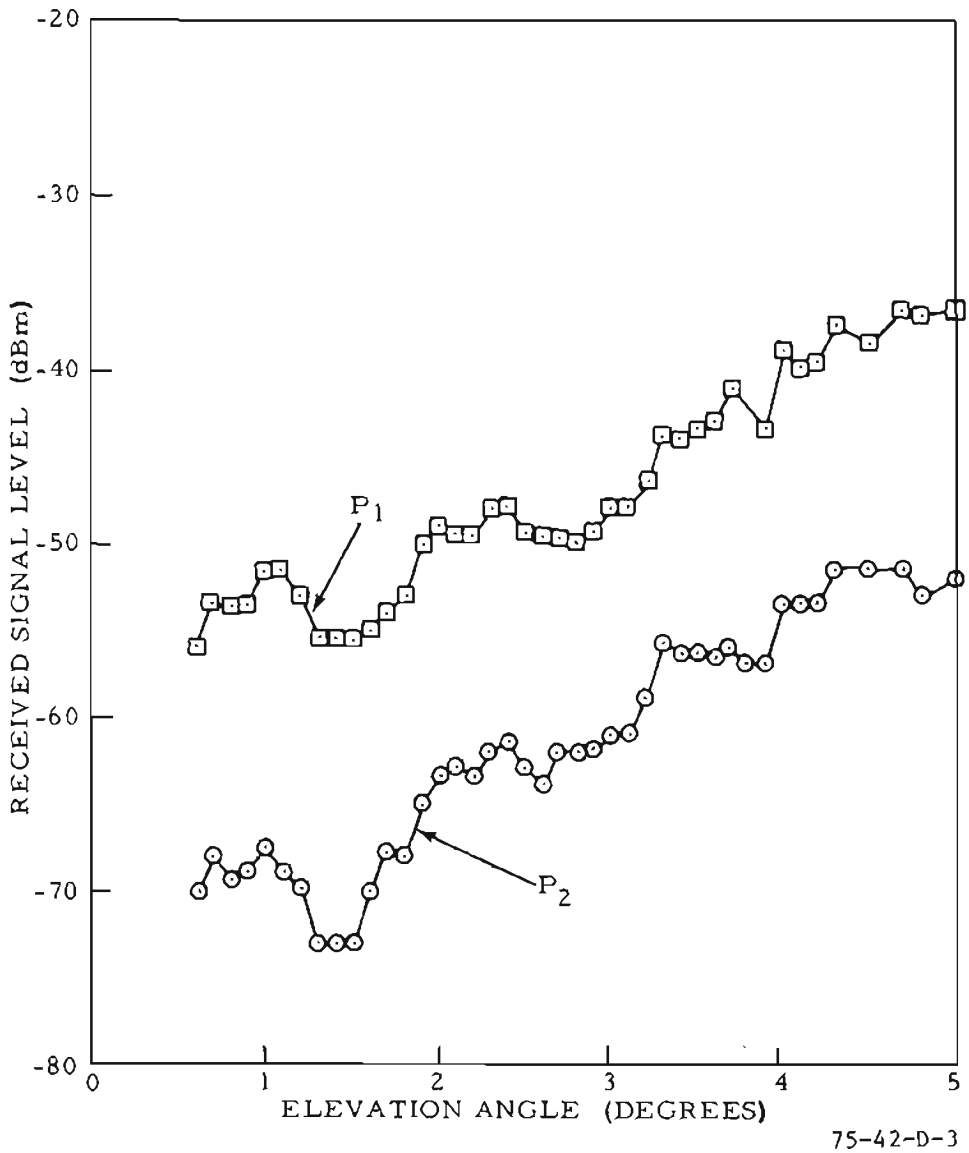


FIGURE A-3. VERTICAL LOBING PATTERN FOR ESA (ZERO DEGREE BEAM HOPOVER, ZERO TO 5° ELEVATION ANGLE)

DATE : 4/17/75
TEST SITE : AIRCRAFT AT 10,000 FT ALTITUDE, 0 TO 60 nmi
ON 100° RADIAL (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER - 600 W
FIXED ANTENNA POSITION, 0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT
CALIBRATION :
VERTICAL - 10.0 dB PER MAJOR DIVISION
HORIZONTAL - 5.0 DEGREES PER MAJOR DIVISION

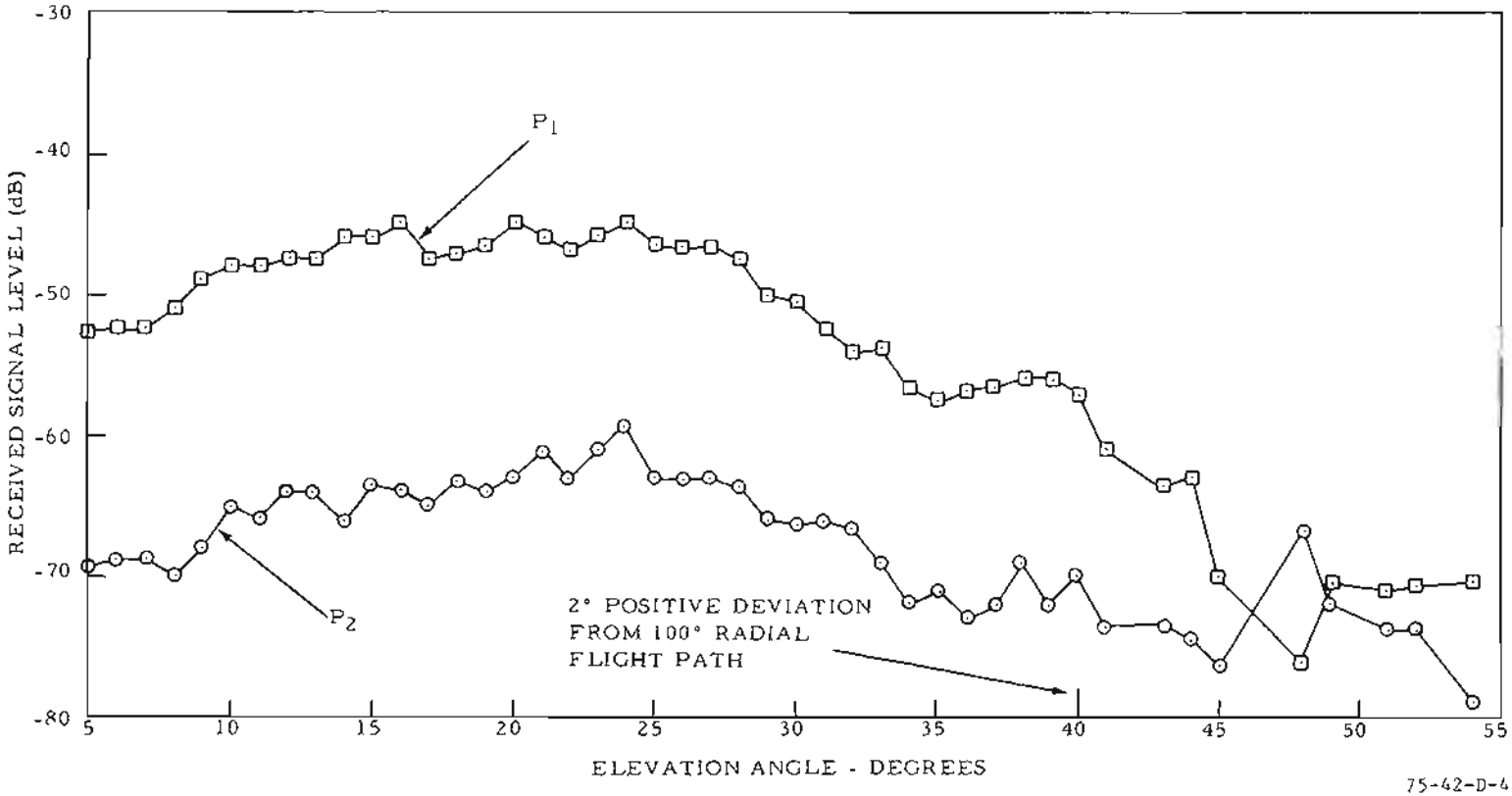
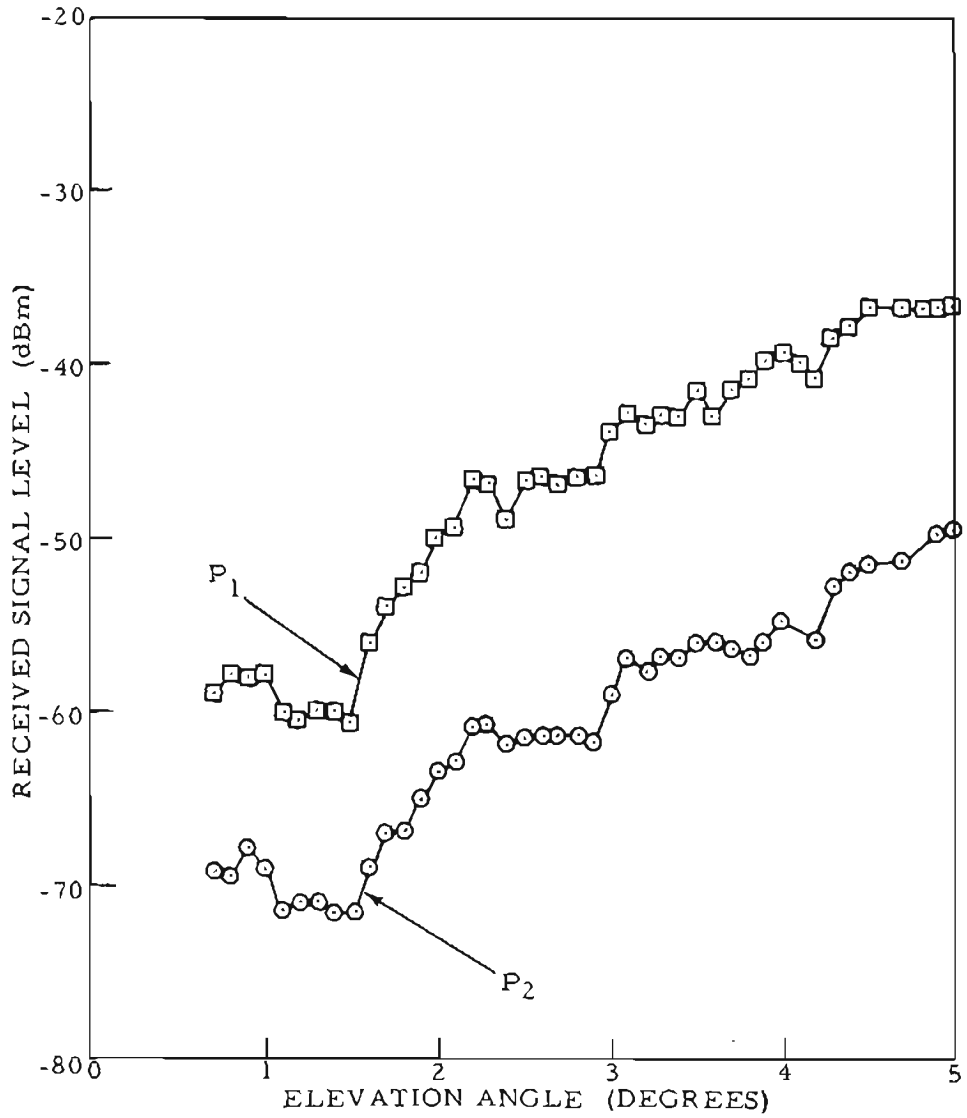


FIGURE A-4. VERTICAL LOBING PATTERN FOR ESA (ZERO DEGREE BEAM HOPOVER, 5° TO 55° ELEVATION ANGLE)

DATE : 3/7/75
TEST SITE : AIRCRAFT AT 1,500 FT ALTITUDE, 0 TO 25 nmi
ON 100° RADIAL (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
TRANSMITTED PEAK POWER - 600 W
SLS - ON
FIXED ANTENNA POSITION, 2° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT
CALIBRATION ;
VERTICAL - 10.0 dB PER MAJOR DIVISION
HORIZONTAL - 1.0 DEGREES PER MAJOR DIVISION



75-42-D-5

FIGURE A-5. VERTICAL LOBING PATTERN FOR ESA (2° BEAM HOPOVER, ZERO TO 5° ELEVATION ANGLE)

DATE : 4/17/75
TEST SITE : AIRCRAFT AT 10,000 FT ALTITUDE, 0 TO 60 nmi
ON 100° RADIAL (OUT BOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS- ON
TRANSMITTED PEAK POWER - 600 W
FIXED ANTENNA POSITION, 2° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT
CALIBRATION :
VERTICAL - 10.0 dB PER MAJOR DIVISION
HORIZONTAL - 5.0 DEGREES PER MAJOR DIVISION

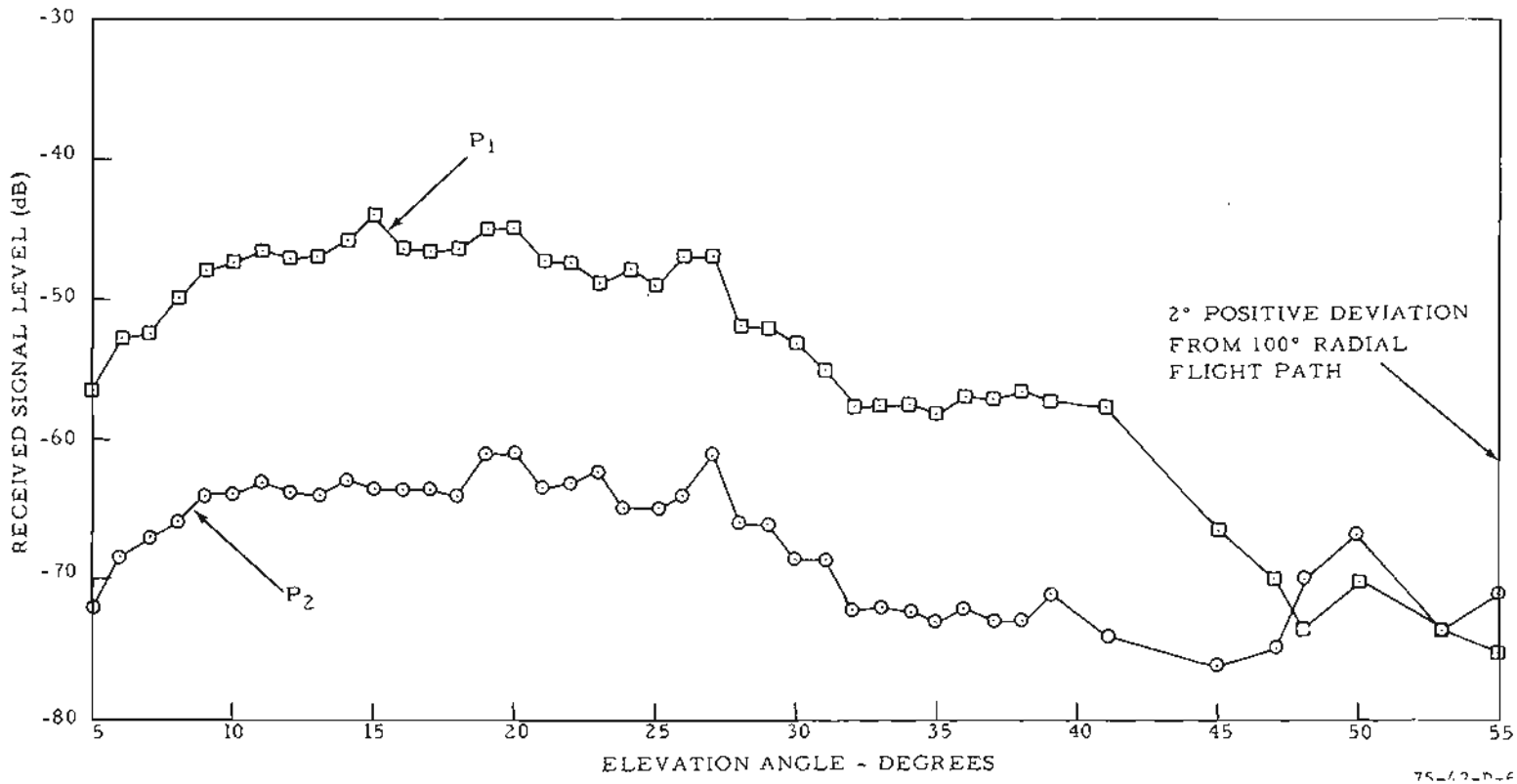


FIGURE A-6. VERTICAL LOBING PATTERN FOR ESA (2° BEAM HOPOVER, 5° TO 55° ELEVATION ANGLE)

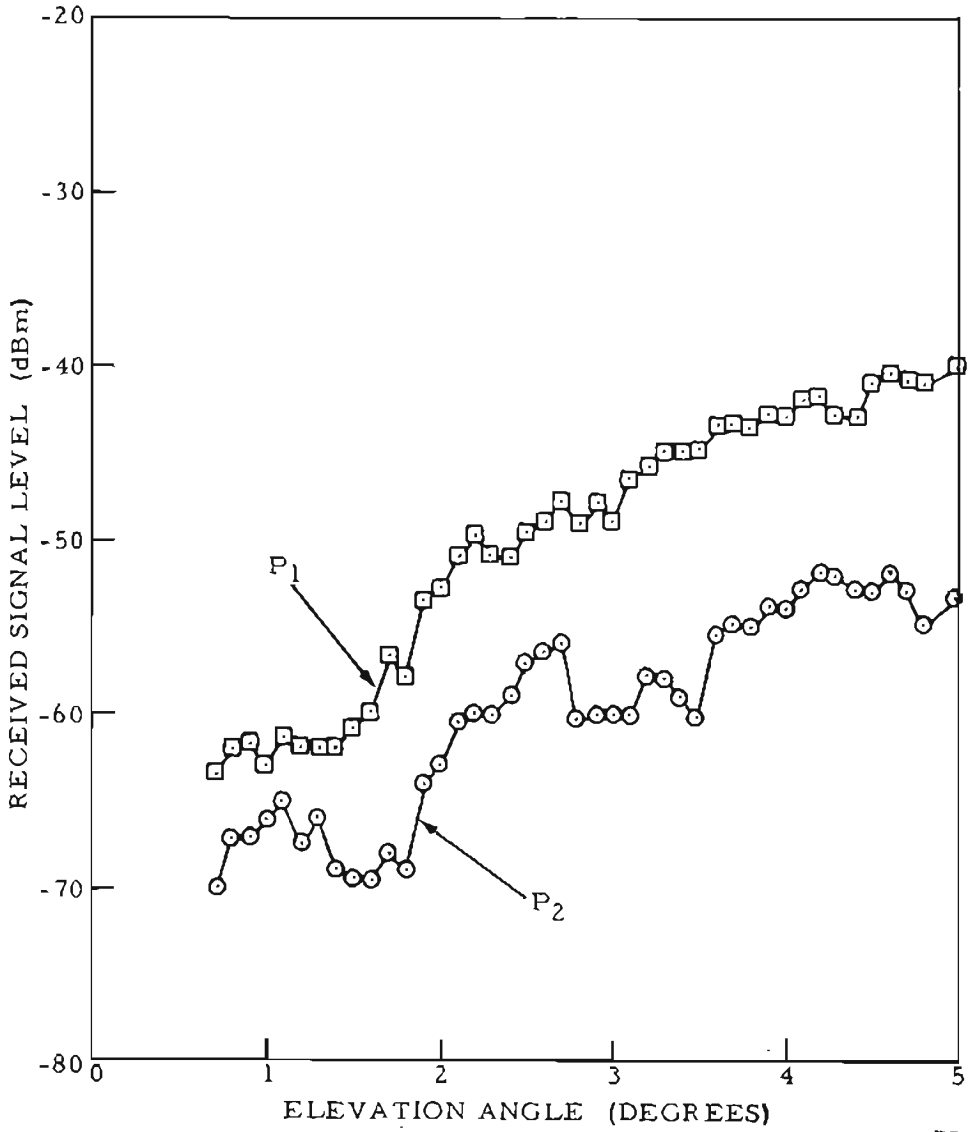
DATE : 3/7/75

TEST SITE : AIRCRAFT AT 1,500 FT ALTITUDE, 0 TO 25 nmi
ON 100° RADIAL (OUTBOUND)

TEST CONDITIONS : MODE 3/A INTERROGATION
TRANSMITTED PEAK POWER - 600 W
SLS - ON
FIXED ANTENNA POSITION, 4° BEAM HOPOVER

DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT

CALIBRATION :
VERTICAL 10.0 dB PER MAJOR DIVISION
HORIZONTAL - 1.0 DEGREES PER MAJOR DIVISION



75-42-D-7

FIGURE A-7. VERTICAL LOBING PATTERN FOR ESA (4° BEAM HOPOVER, ZERO TO 5° ELEVATION ANGLE)

DATE : 4/17/75
TEST SITE : AIRCRAFT AT 10,000 FT ALTITUDE, 0 TO 60 nmi
ON 100° RADIAL (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER - 600 W
FIXED ANTENNA POSITION, 4° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT
CALIBRATION :
VERTICAL - 10.0 dB PER MAJOR DIVISION
HORIZONTAL - 5.0 DEGREES PER MAJOR DIVISION

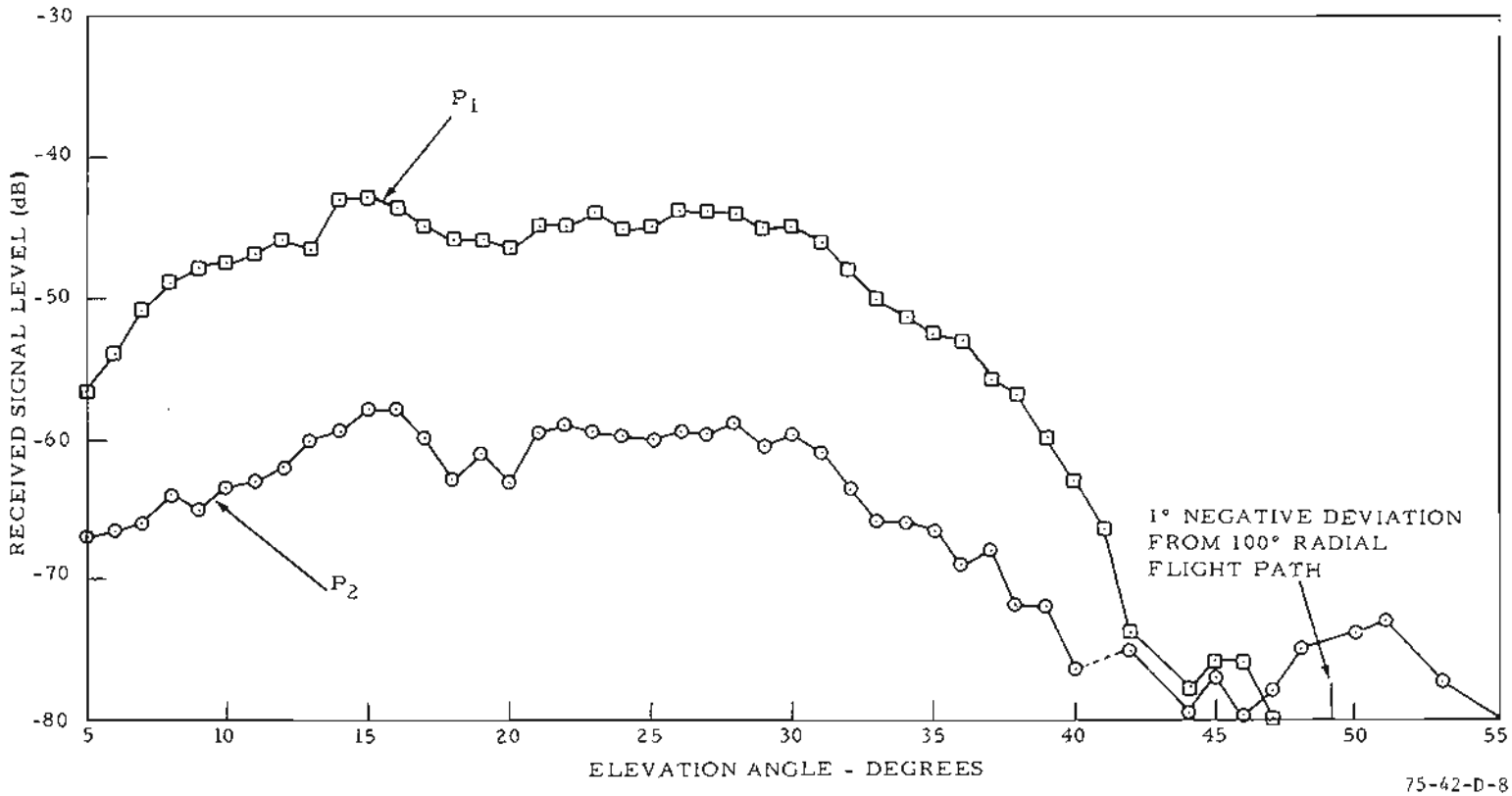


FIGURE A-8. VERTICAL LOBING PATTERN FOR ESA (4° BEAM HOPOVER, 5° TO 55° ELEVATION ANGLE)

APPENDIX B

REFLECTIONS FROM NAFEC HANGAR
(TANGENTIAL FLIGHT)

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B-8	Reflections from NAFEC Hangar for ESA (ISLS, 4° Beam Hopover, Tangential Flight)	B-8

DATE : 2/20/75
TEST SITE . AIRCRAFT AT 1,000 FT ALTITUDE, 12 nmi TANGENTIAL FLIGHT PATH TO 295° RADIAL
TEST CONDITIONS : MODE 3/A INTERROGATION, SLS - ON
TRANSMITTED PEAK POWER - 300 W
STC CURVE AT - 36 dB (15.8 dB AT 12 nmi)
DATA COLLECTION METHOD : PPI PHOTOGRAPH (TIME EXPOSURE)
FR-950 VIDEO RECORDING

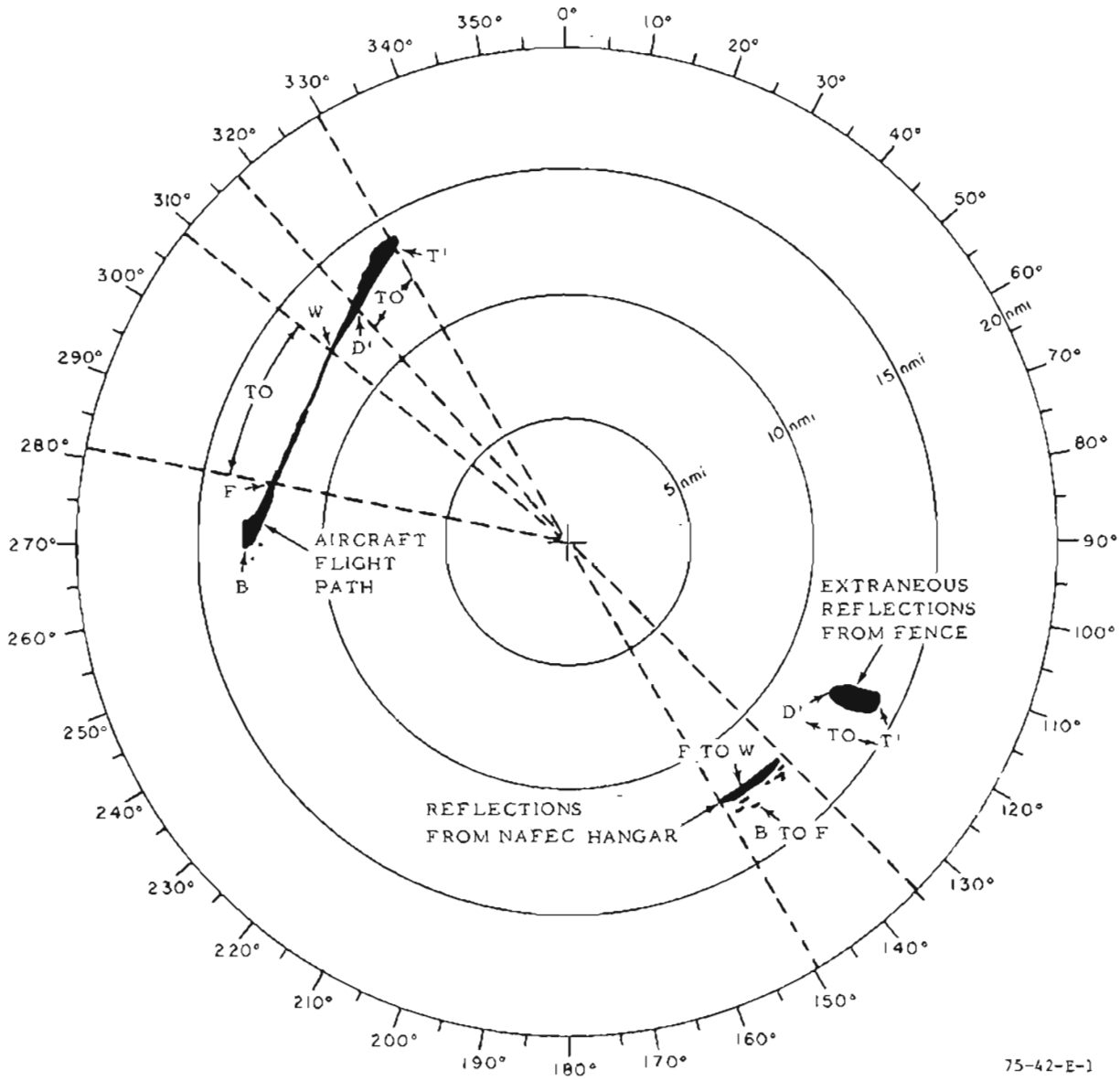

FIGURE B-1. REFLECTIONS FROM NAFEC HANGAR FOR ATCRBS ANTENNAS (SLS, TANGENTIAL FLIGHT)

DATE : 2/2075
TEST SITE : AIRCRAFT AT 1,000 FT ALTITUDE, 12 nmi TANGENTIAL FLIGHT PATH TO 295° RADIAL
TEST CONDITIONS : MODE 3/A INTERROGATION, SLS - ON
TRANSMITTED PEAK POWER - 500 W
STC CURVE AT - 42 dB (21.0 dB AT 12 nmi)
0° BEAM HOPOVER FOR NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)
FR-950 VIDEO RECORDING

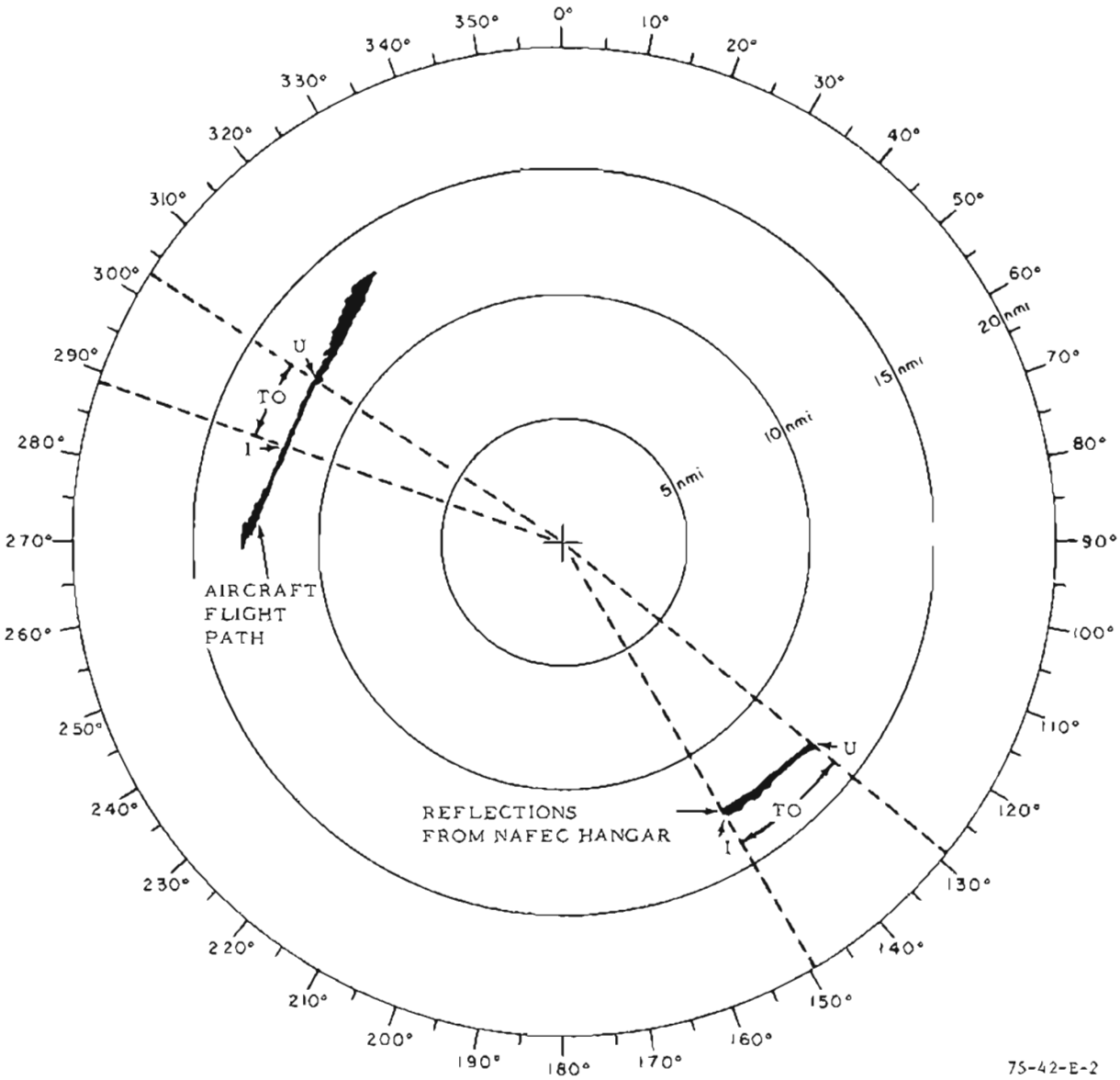

FIGURE B-2. REFLECTIONS FROM NAFEC HANGAR FOR ESA (SLS, ZERO DEGREE BEAM HOPOVER, TANGENTIAL FLIGHT)

DATE : 2/20/75
TEST SITE : AIRCRAFT AT 1,000 FT ALTITUDE, 12 nmi TANGENTIAL FLIGHT PATH TO 295° RADIAL
TEST CONDITIONS : MODE 3/A INTERROGATION, SLS - ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT - 42 dB (21.0 dB AT 12 nmi)
2° BEAM HOPOVER FOR NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)
FR-950 VIDEO RECORDING

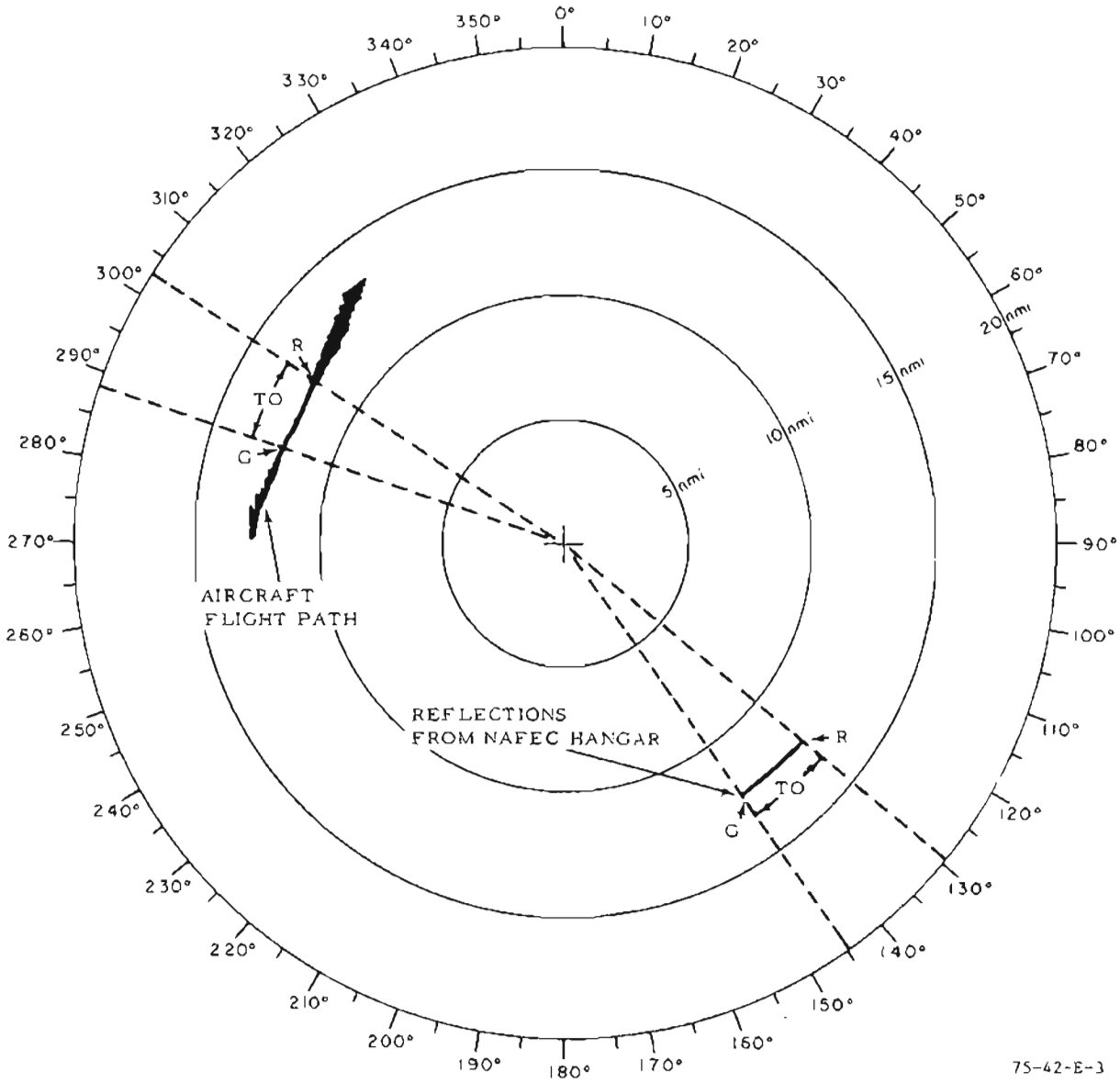

FIGURE B-3. REFLECTIONS FROM NAFEC HANGAR FOR ESA (SLS, 2° BEAM HOPOVER, TANGENTIAL FLIGHT)

DATE : 2/20/75
TEST SITE : AIRCRAFT AT 1,000 FT ALTITUDE, 12 nmi TANGENTIAL FLIGHT PATH TO 295° RADIAL
TEST CONDITIONS : MODE 3/A INTERROGATION, SLS- ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT - 42 dB (21.0 dB AT 12 nmi)
4° BEAM HOPOVER FOR NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPH (TIME EXPOSURE)
FR-950 VIDEO RECORDING

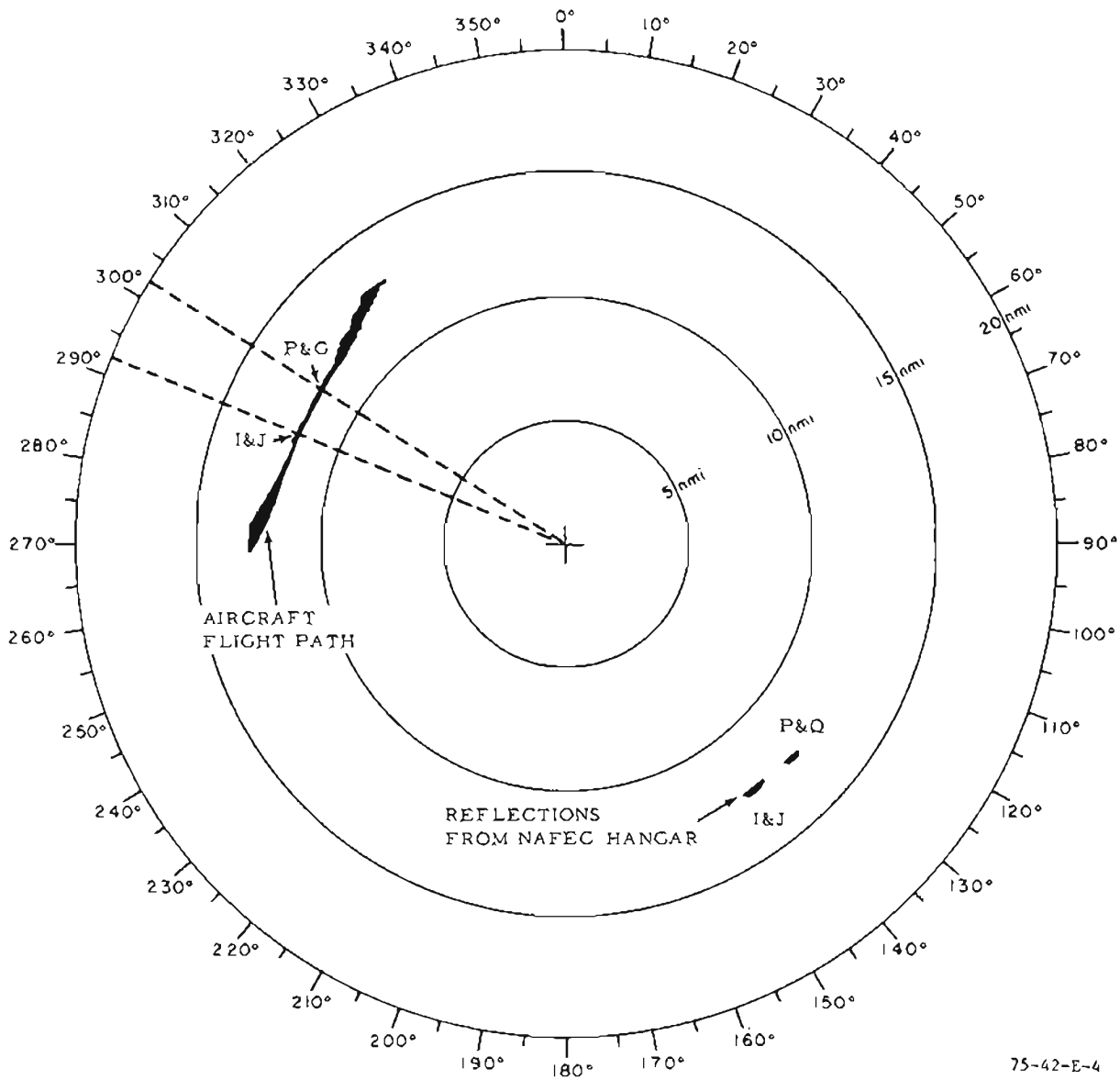

FIGURE B-4. REFLECTIONS FROM NAFEC HANGAR FOR ESA (SLS, 4° BEAM HOPOVER, TANGENTIAL FLIGHT)

DATE : 2/20/75
TEST SITE : AIRCRAFT AT 1,000 FT ALTITUDE, 12 nmi TANGENTIAL FLIGHT PATH TO 295° RADIAL
TEST CONDITIONS : MODE 3/A INTERROGATION, ISLS - ON
TRANSMITTED PEAK POWER - 300 W
STC CURVE AT - 36 dB (15.8 dB AT 12 nmi)
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)
FR-950 VIDEO RECORDING

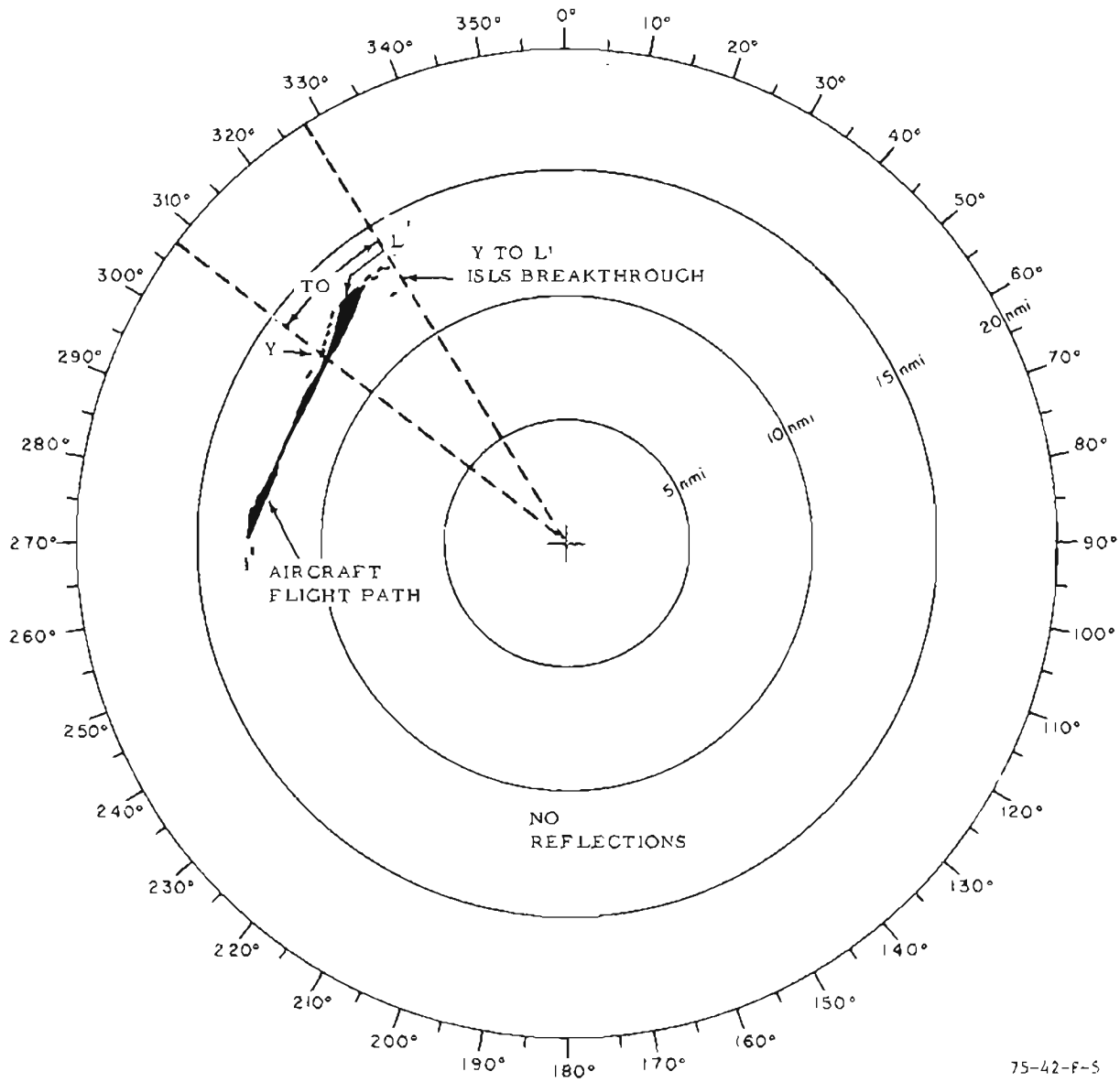

FIGURE B-5. REFLECTIONS FROM NAFEC HANGAR FOR ATCRBS ANTENNAS (ISLS, TANGENTIAL FLIGHT)

DATE : 2/20/75
TEST SITE : AIRCRAFT AT 1,000 FT ALTITUDE, 12 nmi TANGENTIAL FLIGHT PATH TO 295° RADIAL
TEST CONDITIONS : MODE 3/A INTERROGATION, ISLS - ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT -42 dB (21.0 dB AT 12 nmi)
0° BEAM HOPOVER AT NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)
FR-950 VIDEO RECORDING

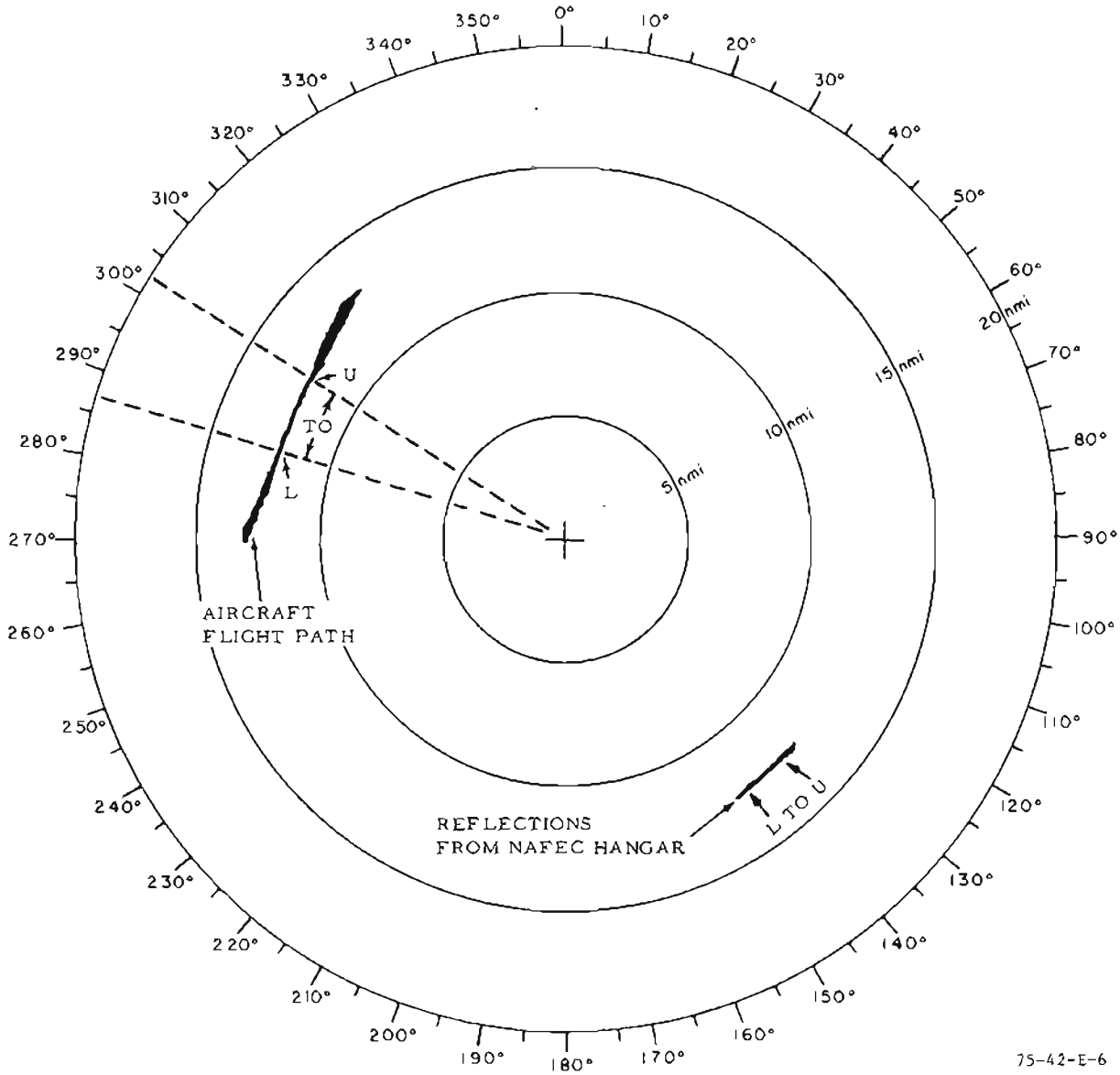

FIGURE B-6. REFLECTIONS FROM NAFEC HANGAR FOR ESA (ISLS, ZERO DEGREE BEAM HOPOVER, TANGENTIAL FLIGHT)

DATE : 2/20/75
TEST SITE : AIRCRAFT AT 1,000 FT ALTITUDE, 12 nmi TANGENTIAL FLIGHT PATH TO 295° RADIAL
TEST CONDITIONS : MODE 3/ A INTERROGATION, ISLS - ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT - 42 dB (12.0 dB AT 12 nmi)
2° BEAM HOPOVER AT NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)
FR-950 VIDEO RECORDING

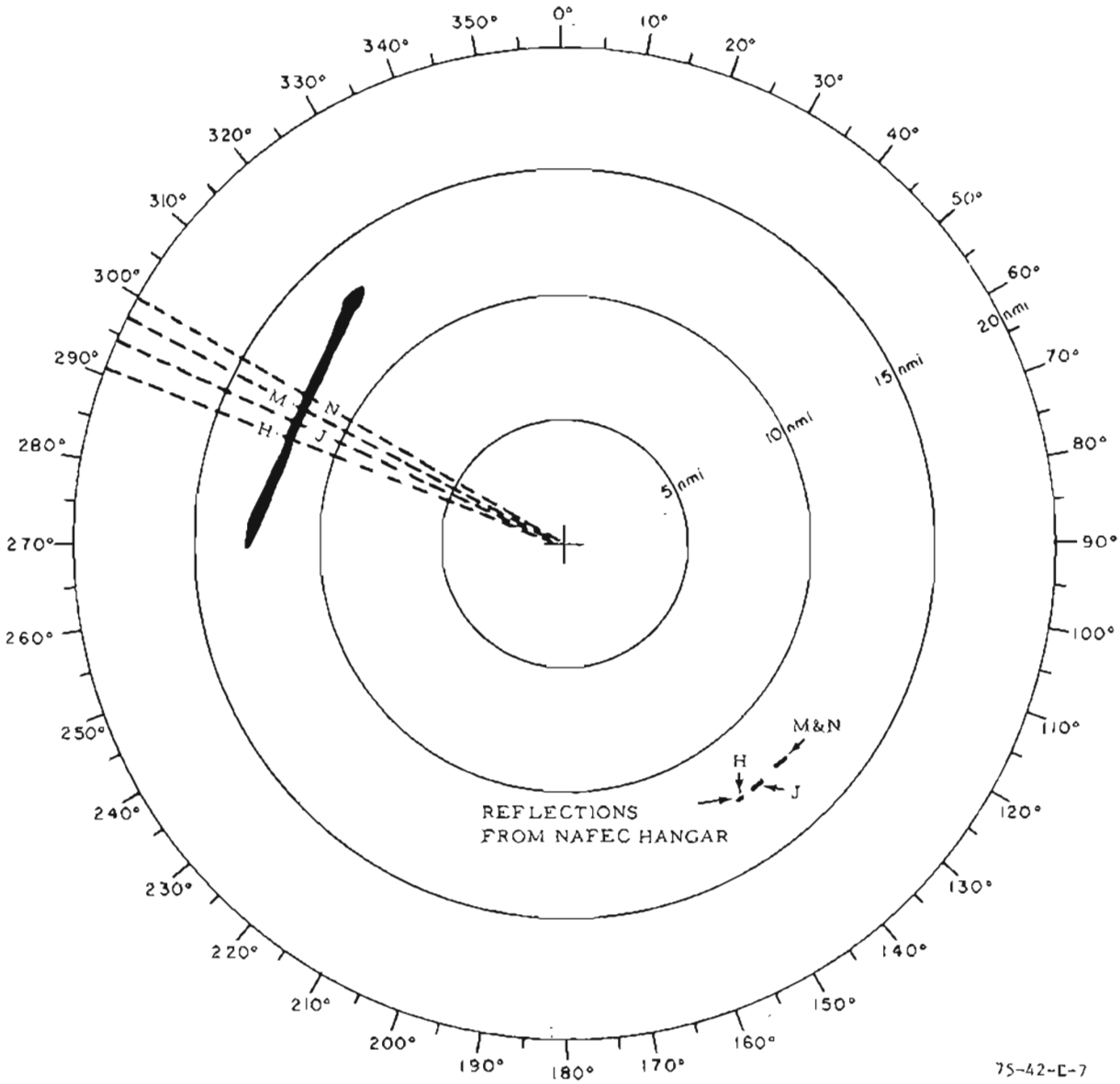

FIGURE B-7. REFLECTIONS FROM NAFEC HANGAR FOR ESA (ISLS, 2° BEAM HOPOVER, TANGENTIAL FLIGHT)

DATE : 2/20/75
TEST SITE : AIRCRAFT AT 1,000 FT ALTITUDE, 12 nmi TANGENTIAL FLIGHT PATH TO 295° RADIAL
TEST CONDITIONS : MODE 3/A INTERROGATION, ISLS - ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT -42 dB (21.0 dB AT 12 nmi)
4° BEAM HOPOVER AT NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)
FR-950 VIDEO RECORDING

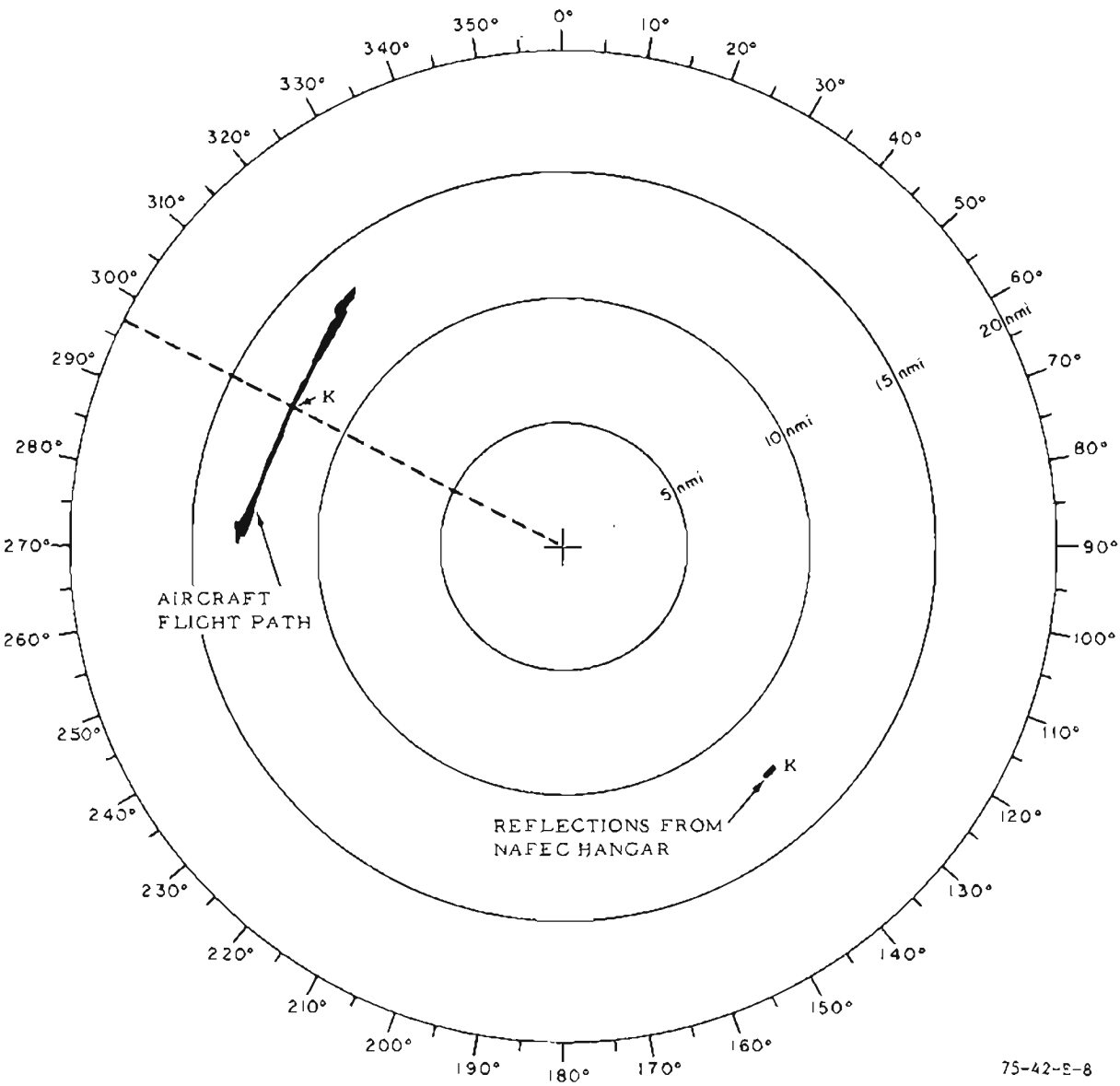

FIGURE B-8. REFLECTIONS FROM NAFEC HANGAR FOR ESA (ISLS, 4° BEAM HOPOVER, TANGNETIAL FLIGHT)

APPENDIX C

REFLECTIONS FROM NAFEC HANGAR
(RADIAL FLIGHT)

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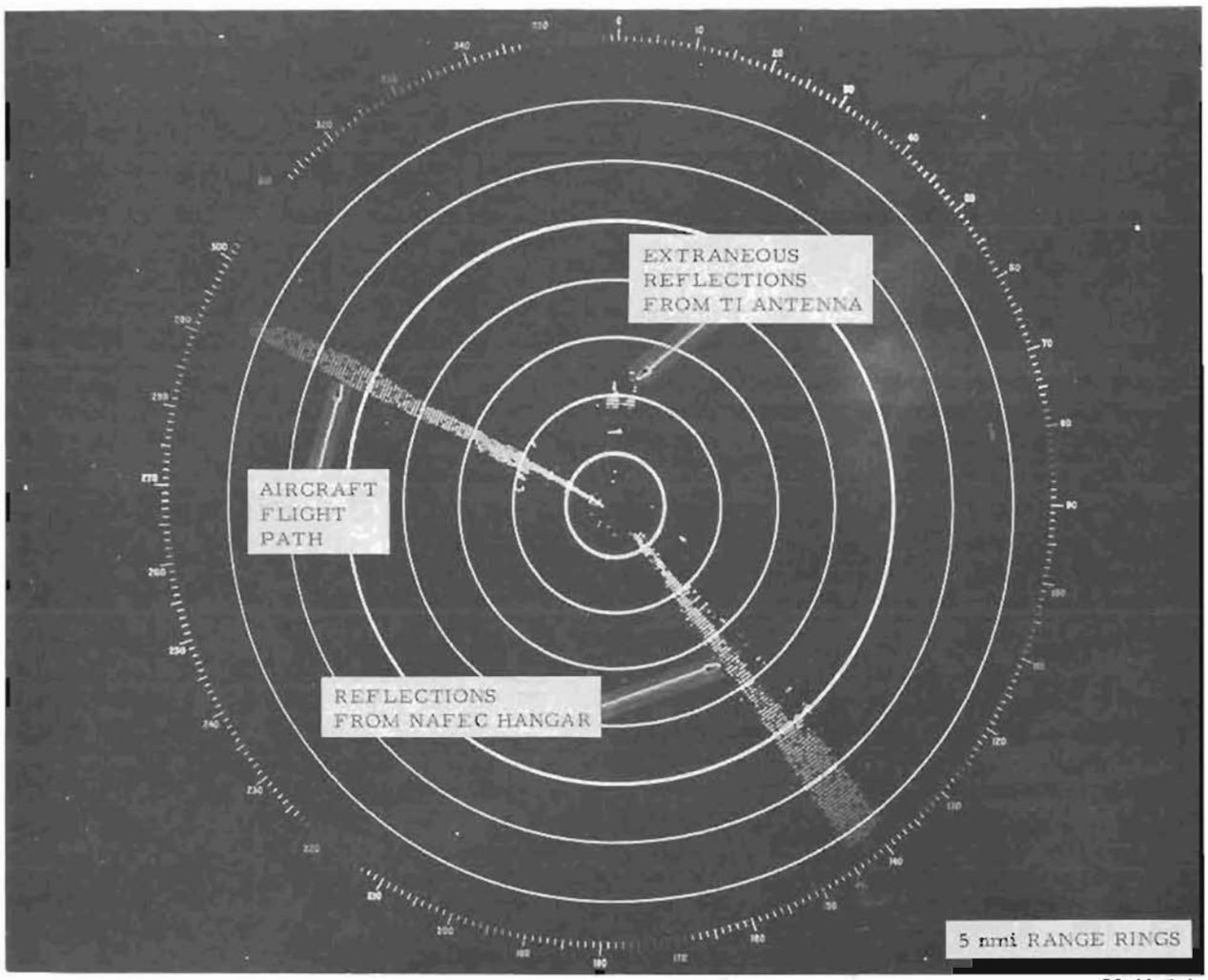
C-8	Reflections from NAFEC Hangar for ESA (ISLS, 4° Beam Hopover, Radial Flight)	C-8

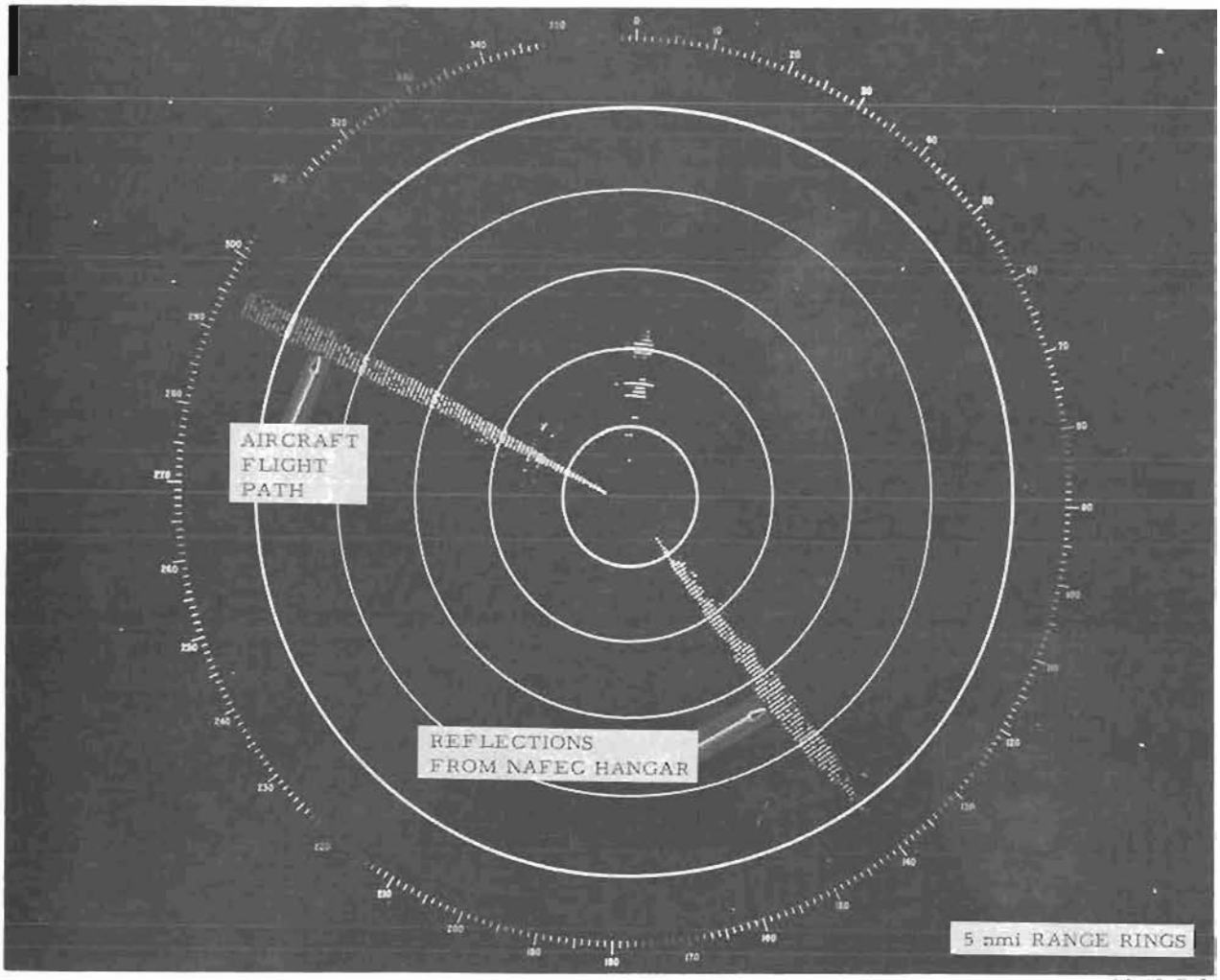
DATE : 4/15/75
TEST SITE : AIRCRAFT AT 1,500 FT, 295° RADIAL FROM EAIR FACILITY, 0 TO 35 nmi (OUTBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER - 300 W
STC CURVE AT - 36 dB
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)



75-42-F-1

FIGURE C-1. REFLECTIONS FROM NAFEC HANGAR FOR ATCRBS ANTENNA (SLS, RADIAL FLIGHT)

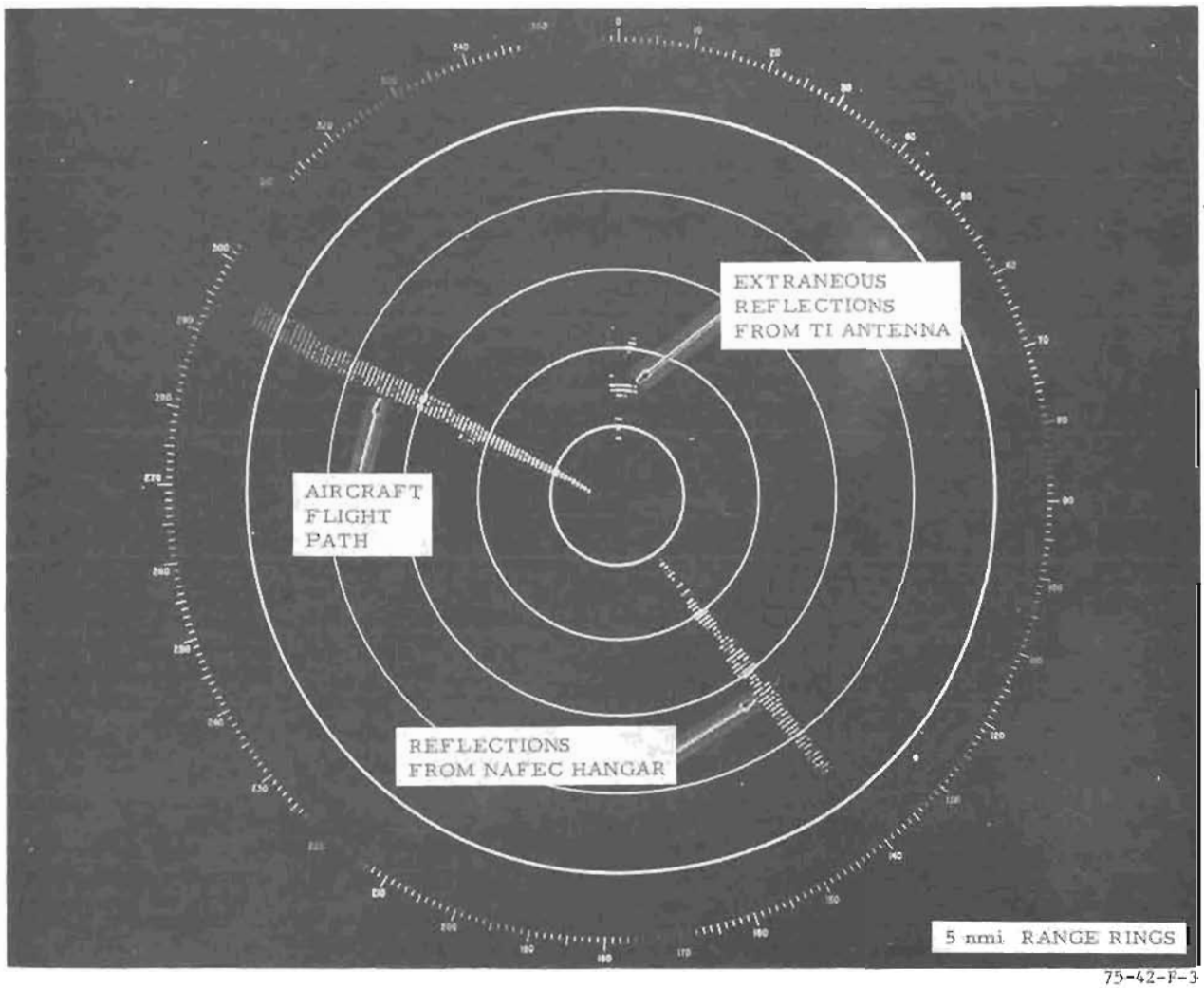
DATE : 4/15/75
TEST SITE : AIRCRAFT AT 1,500 FT, 295° RADIAL FROM EAIR FACILITY, 0 TO 25 nmi (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT - 36 dB
0° BEAM HOPOVER AT NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)



75-42-F-2

FIGURE C-2. REFLECTIONS FROM NAFEC HANGAR FOR ESA (SLS, ZERO DEGREE BEAM HOPOVER, RADIAL FLIGHT)

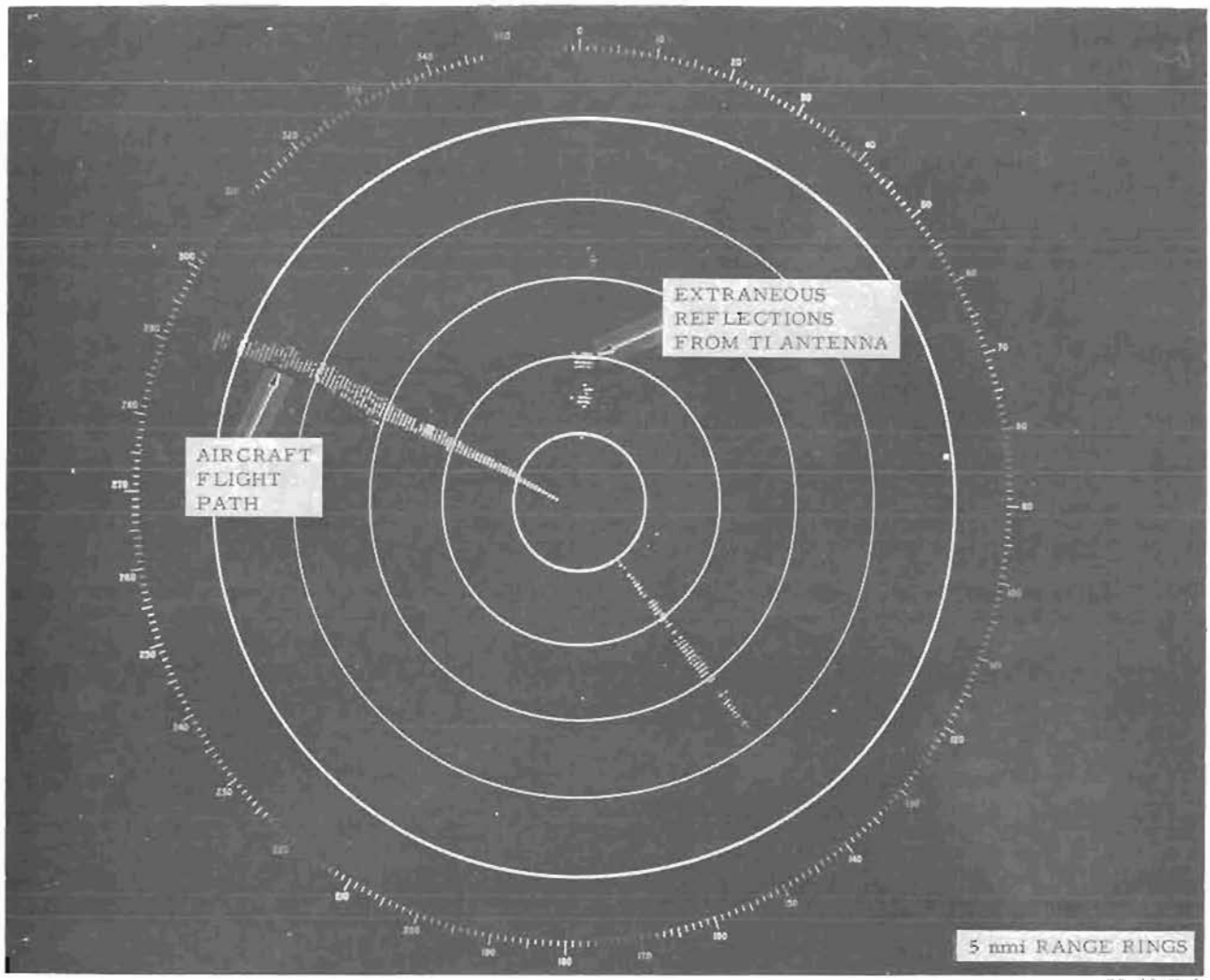
DATE : 4/15/75
TEST SITE : AIRCRAFT AT 1,500 FT ALTITUDE, 295° RADIAL
FROM EAIR FACILITY, 0 TO 25nmi (OUTBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS - ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT -36 dB
2° BEAM HOPOVER AT NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)



75-42-F-3

FIGURE C-3. REFLECTIONS FROM NAFEC HANGAR FOR ESA (SLS, 2° BEAM HOPOVER, RADIAL FLIGHT)

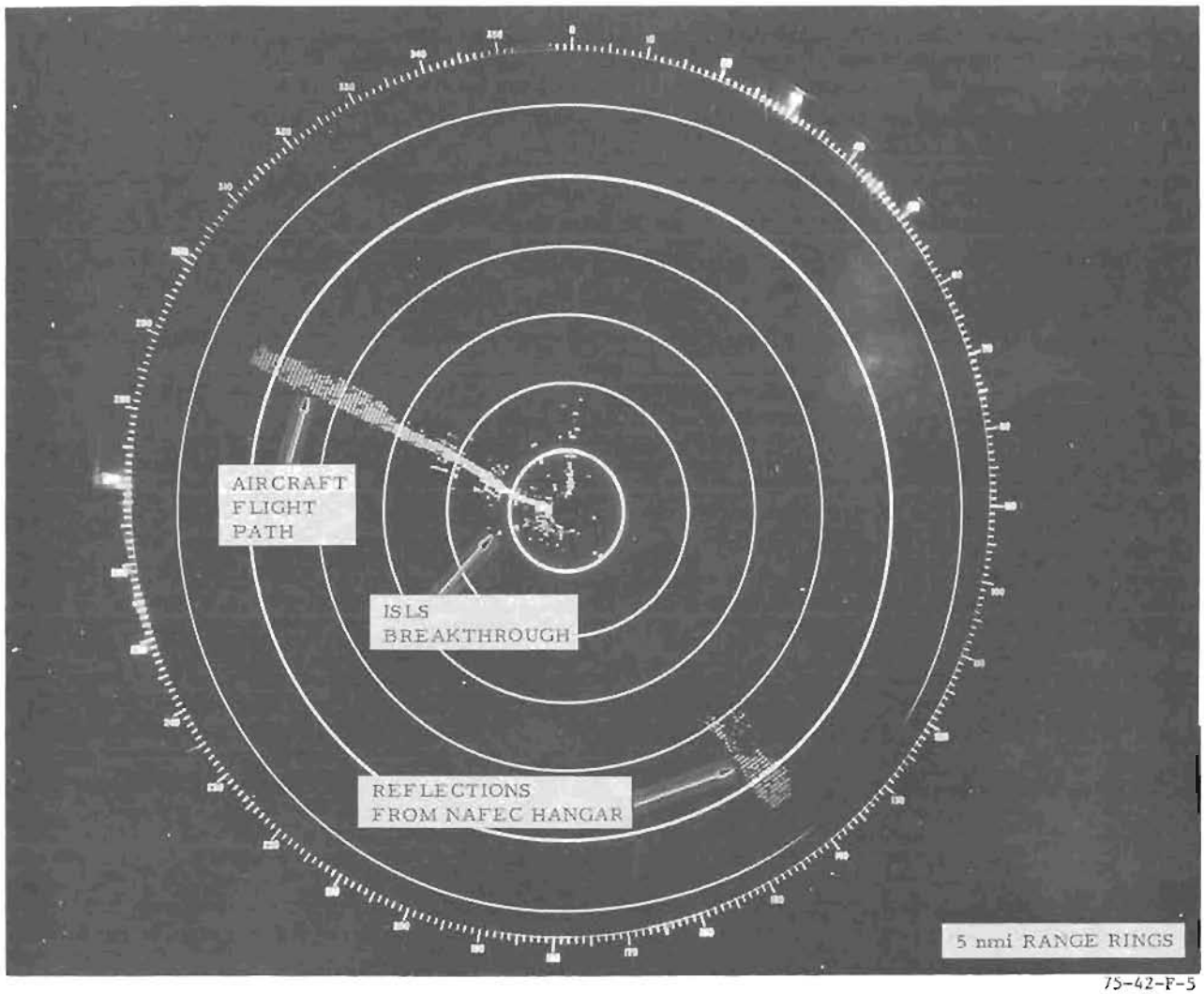
DATE : 4/15/75
TEST SITE : AIRCRAFT AT 1,500 FT ALTITUDE, 295° RADIAL
FROM EAIR FACILITY, 0 TO 25nmi (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
SLS- ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT - 36 dB
4° BEAM HOPOVER AT NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)



75-42-F-4

FIGURE C-4. REFLECTIONS FROM NAFEC HANGAR FOR ESA (SLS, 4° BEAM HOPOVER, RADIAL FLIGHT)

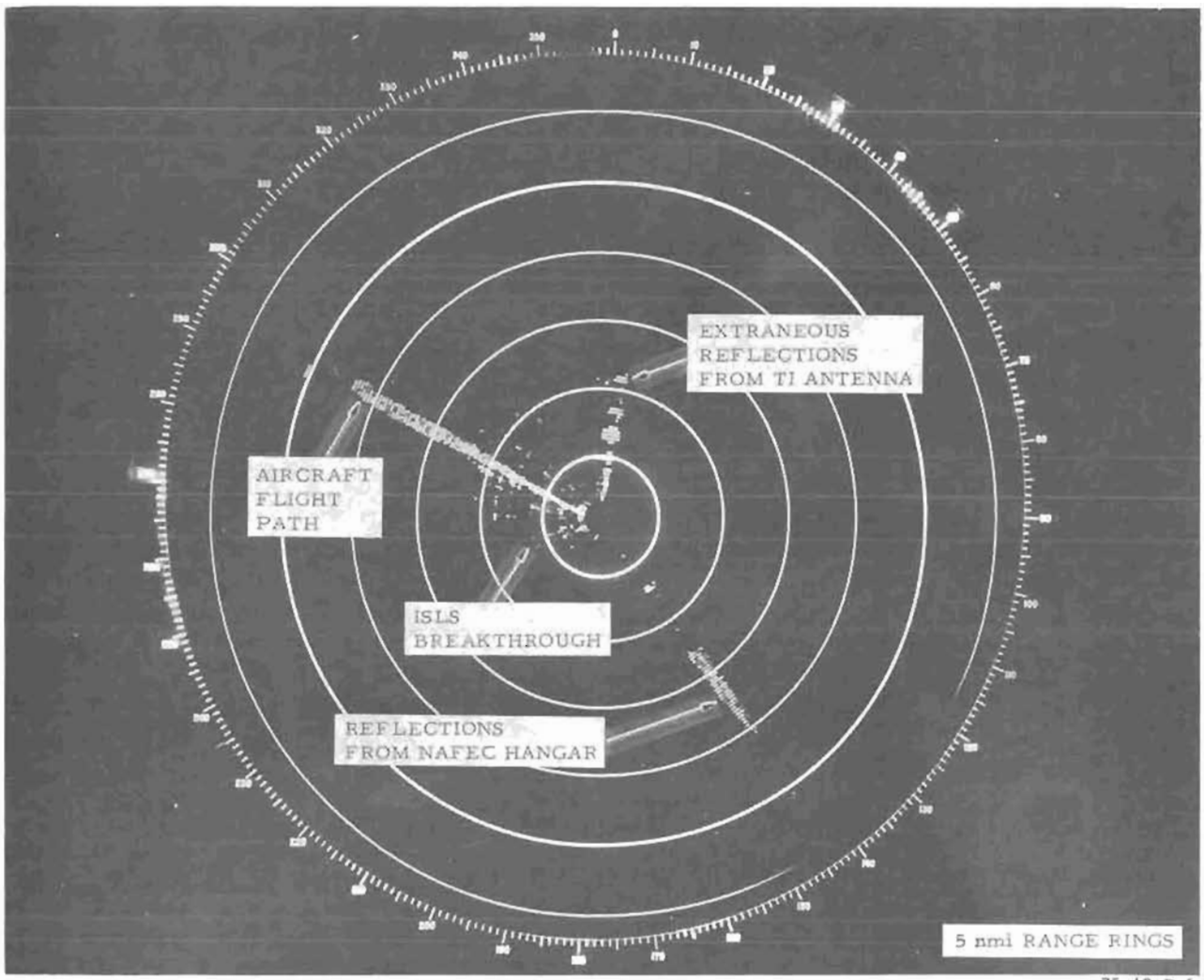
DATE : 4/10/75
TEST SITE : AIRCRAFT AT 1,000 FT, 295° RADIAL FROM EAIR FACILITY, 0 TO 30 nmi (OUTBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
ISLS - ON
TRANSMITTED PEAK POWER - 300 W
STC CURVE AT - 36 dB
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)



75-42-F-5

FIGURE C-5. REFLECTIONS FROM NAFEC HANGAR FOR ATCRBS ANTENNAS (ISLS, RADIAL FLIGHT)

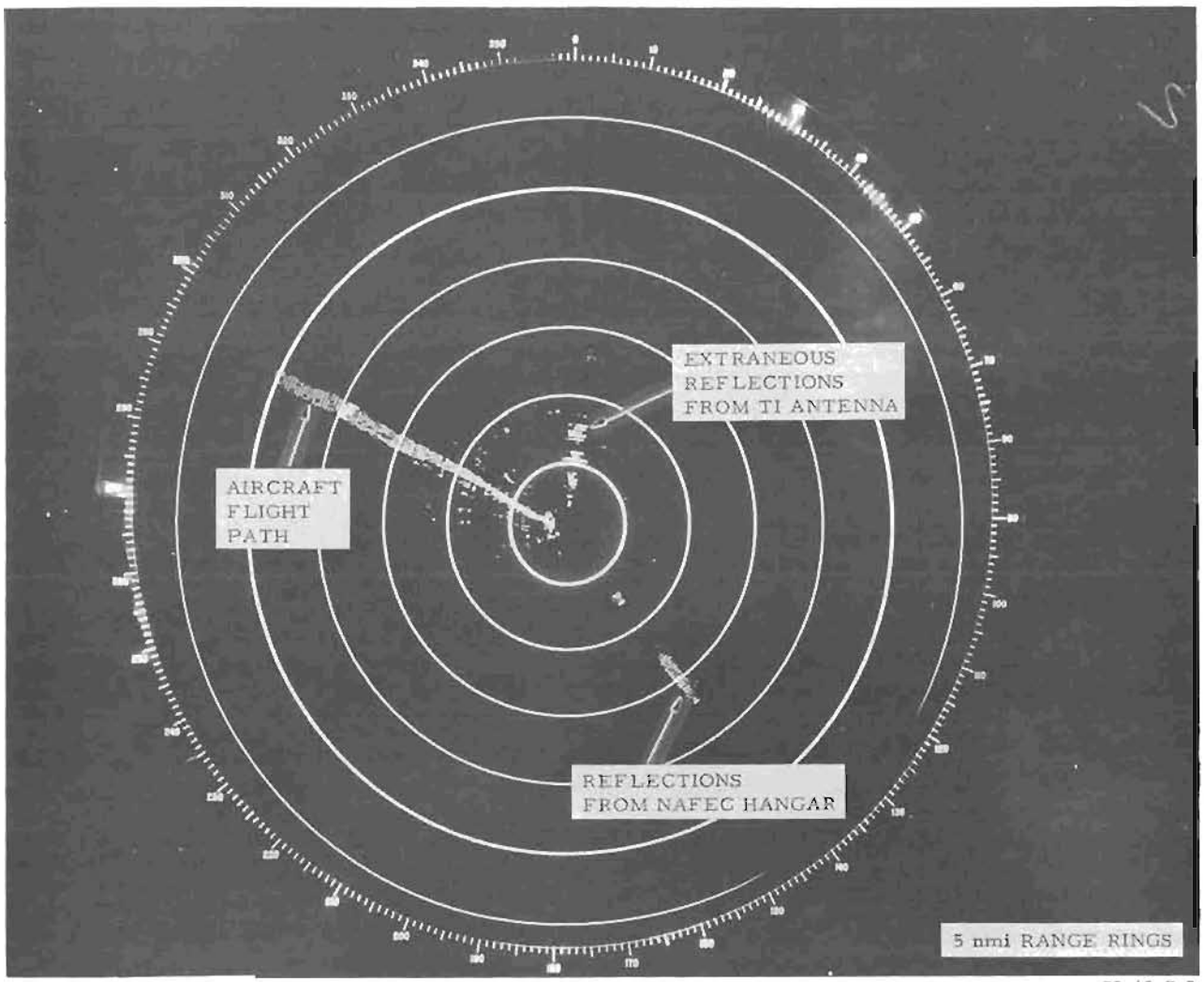
DATE : 4/10/75
TEST SITE : AIRCRAFT AT 1,000 FT, 295° RADIAL FROM EAIR FACILITY, 0 TO 30 nmi (INBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
ISLS - ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT - 36 dB
0 ° BEAM HOPOVER AT NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)



75-42--F-6

FIGURE C-6. REFLECTIONS FROM NAFEC HANGAR FOR ESA (ISLS, ZERO DEGREE BEAM HOPOVER, RADIAL FLIGHT)

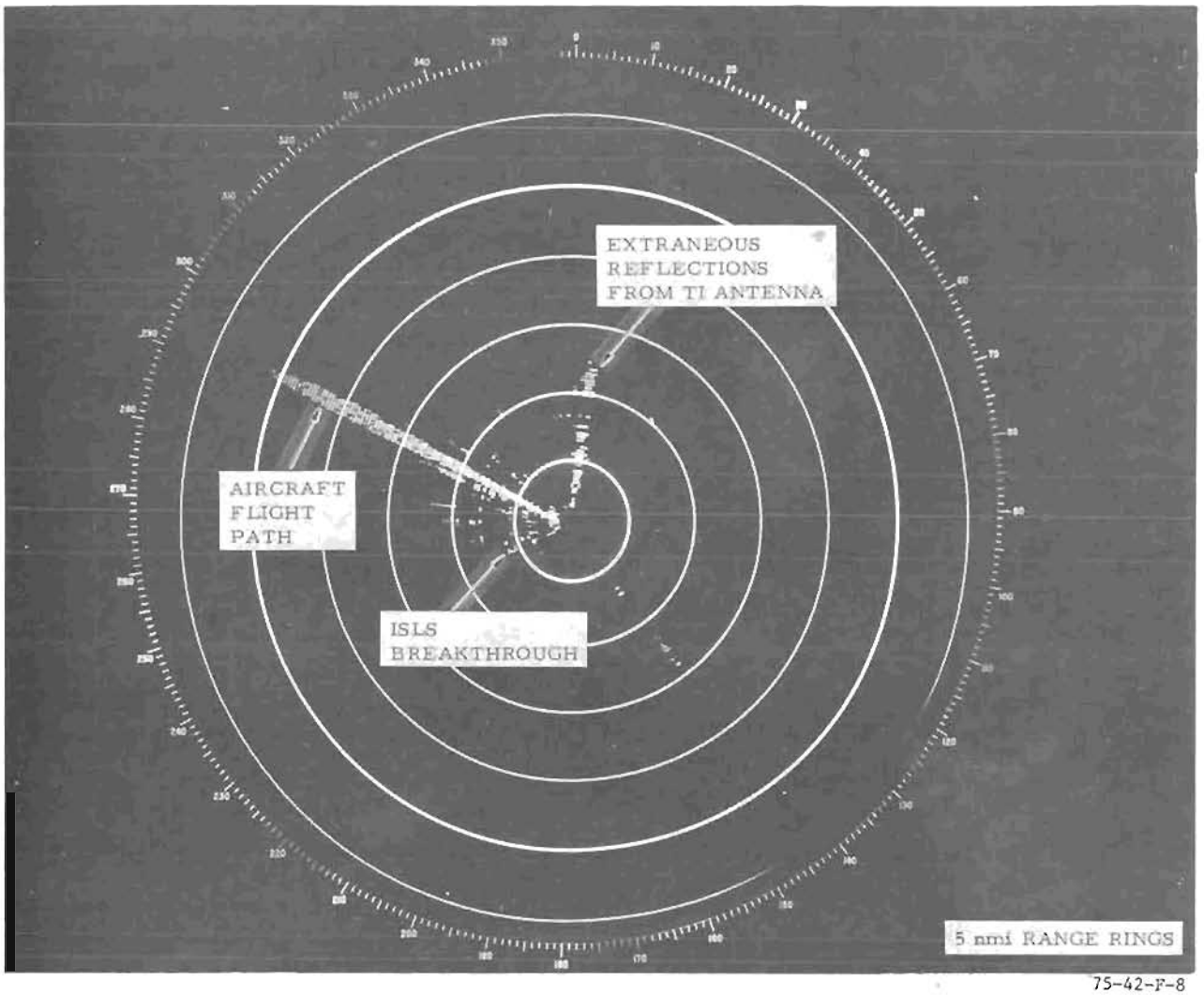
DATE : 4/10/75
TEST SITE : AIRCRAFT AT 1,000 FT, 295° RADIAL FROM EAIR FACILITY, 0 TO 25 nmi (OUTBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION
ISLS - ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT - 36 dB
2° BEAM HOPOVER AT NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSUE)



75-42-F-7

FIGURE C-7. REFLECTIONS FROM NAFEC HANGAR FOR ESA (ISLS, 2° BEAM HOPOVER, RADIAL FLIGHT)

DATE : 4/10/75
TEST SITE : AIRCRAFT AT 1,000 FT, 295° RADIAL FROM EAIR FACILTY, 0 TO 25 nmi (OUTBOUND)
TEST CONDITIONS : MODE 3/A INTERROGATION, ISLS - ON
TRANSMITTED PEAK POWER - 600 W
STC CURVE AT - 36 dB
4° BEAM HOPOVER AT NAFEC HANGAR
DATA COLLECTION METHOD : PPI PHOTOGRAPHS (TIME EXPOSURE)



75-42-F-8

FIGURE C-8. REFLECTIONS FROM NAFEC HANGAR FOR ESA (ISLS, 4° BEAM HOPOVER, RADIAL FLIGHT)

APPENDIX D

STATIC BEAM PATTERNS

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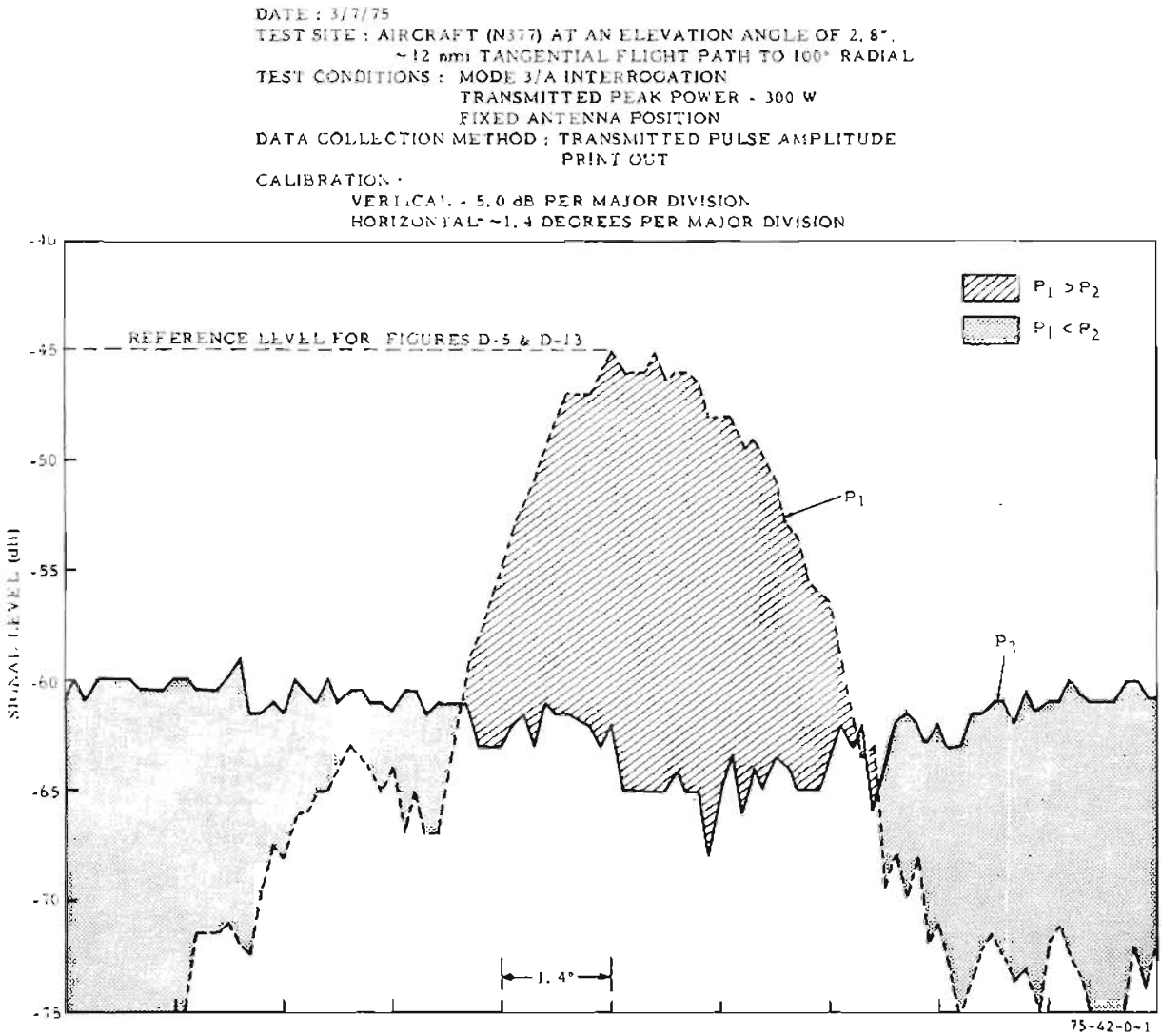

FIGURE D-1. ATCRBS ANTENNA STATIC BEAM PATTERN (NO OBSTRUCTIONS)

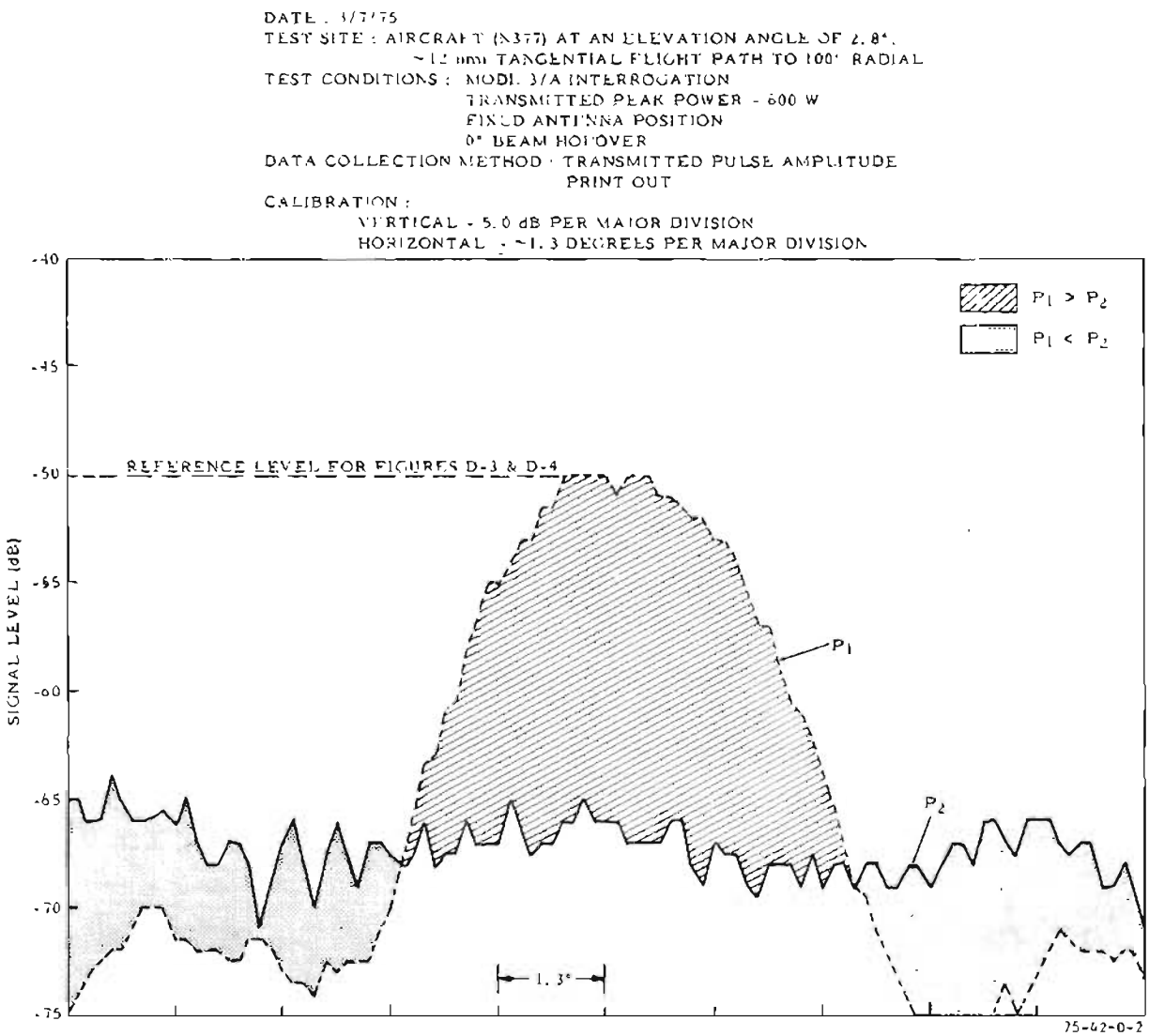

FIGURE D-2. ESA STATIC BEAM PATTERN FOR ZERO DEGREE BEAM HOPOVER (NO OBSTRUCTION)

DATE 3/7/75
TEST SITE AIRCRAFT (N377) AT AN AN

DATE : 3/7/75
TEST SITE : AIRCRAFT (N377) AT AN ELEVATION ANGLE OF 3.0°,
~12 nmi TANGENTIAL FLIGHT PATH TO 100° RADIAL
TEST CONDITIONS: MODE 3/A INTERROGATION
TRANSMITTED PEAK POWER - 600 W
FIXED ANTENNA POSITION
2° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT
CALIBRATION :
VERTICAL - 5.0 dB PER MAJOR DIVISION
HORIZONTAL - ~1.4 DEGREES PER MAJOR DIVISION

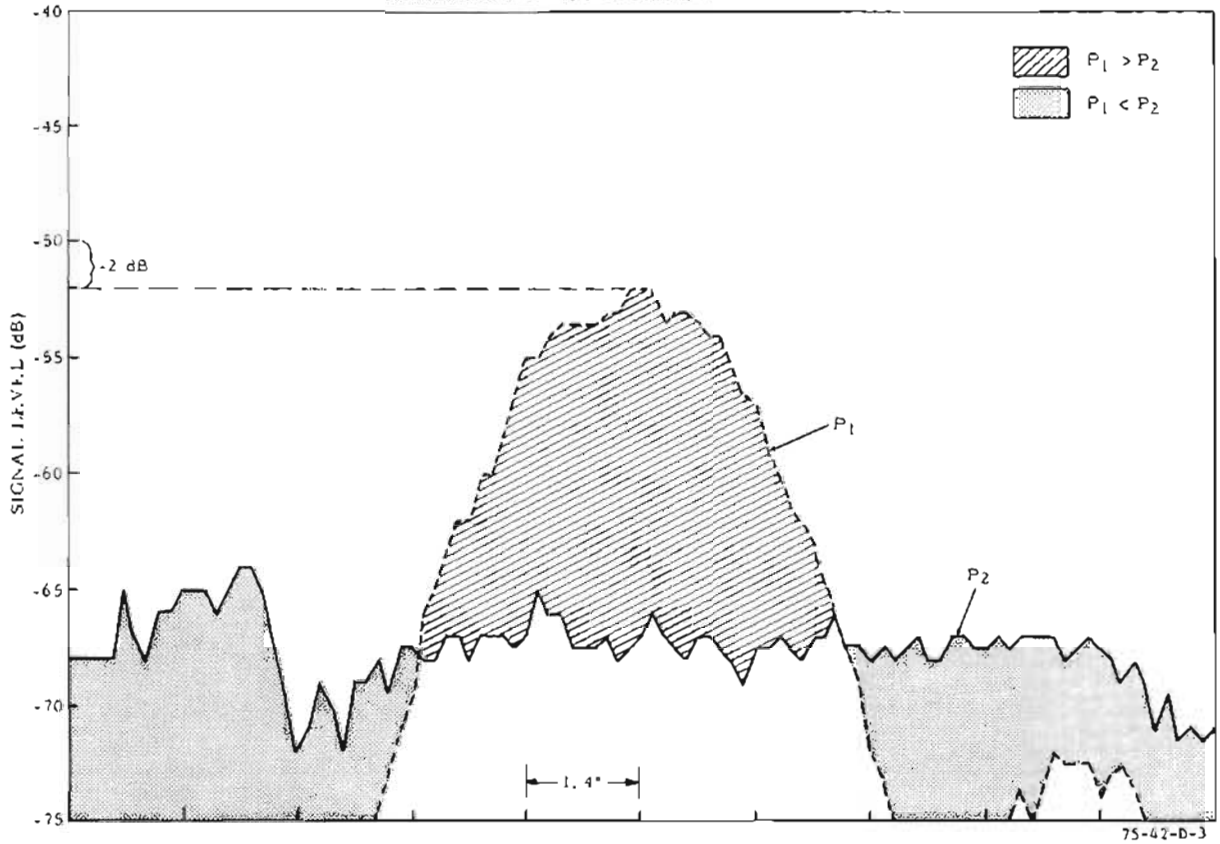

FIGURE D-3. ESA STATIC BEAM PATTERN FOR 2° Beam Hopover (NO OBSTRUCTION)

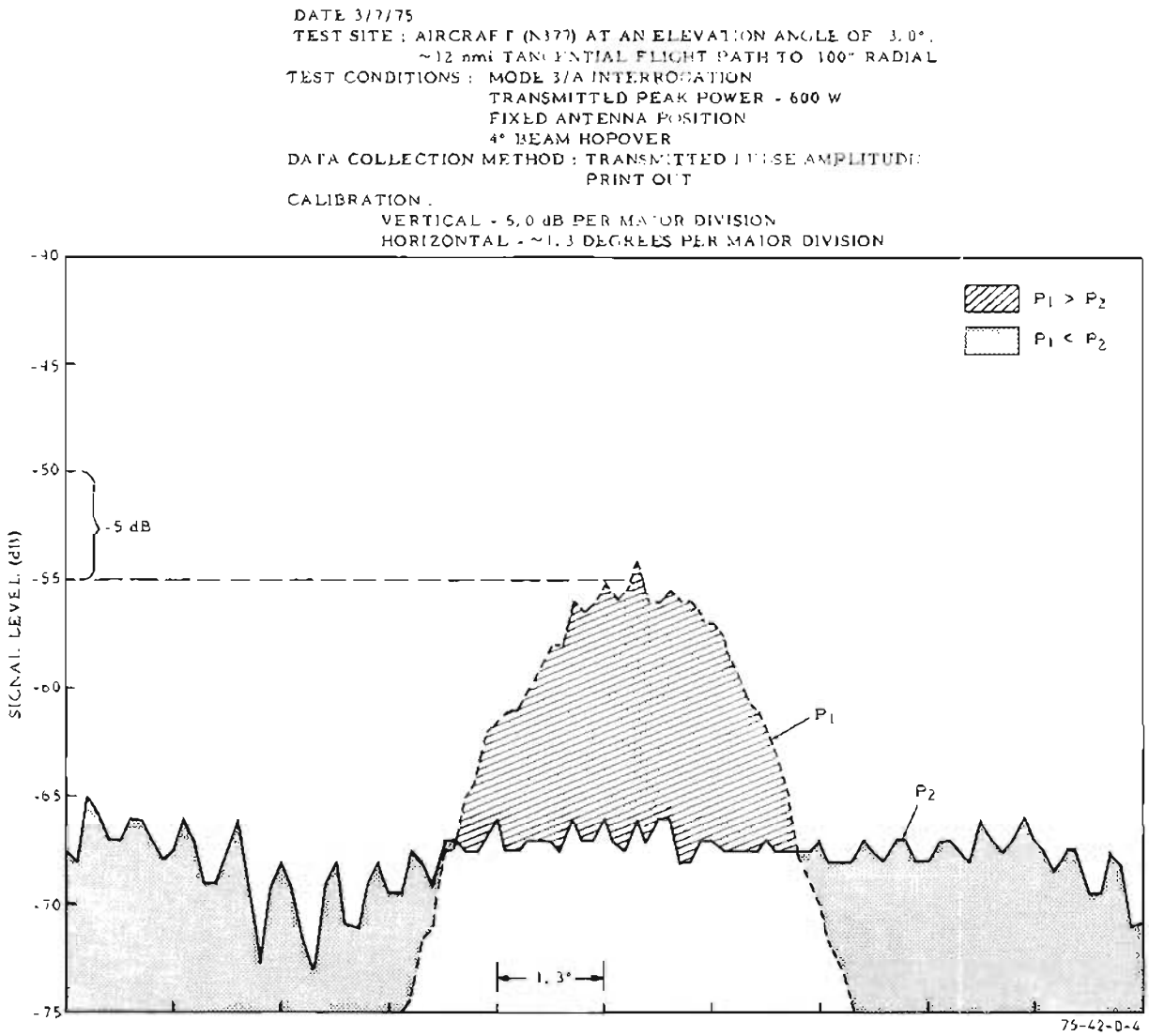

FIGURE D-4. ESA STATIC BEAM PATTERN FOR 4° BEAM HOPOVER (NO OBSTRUCTION)

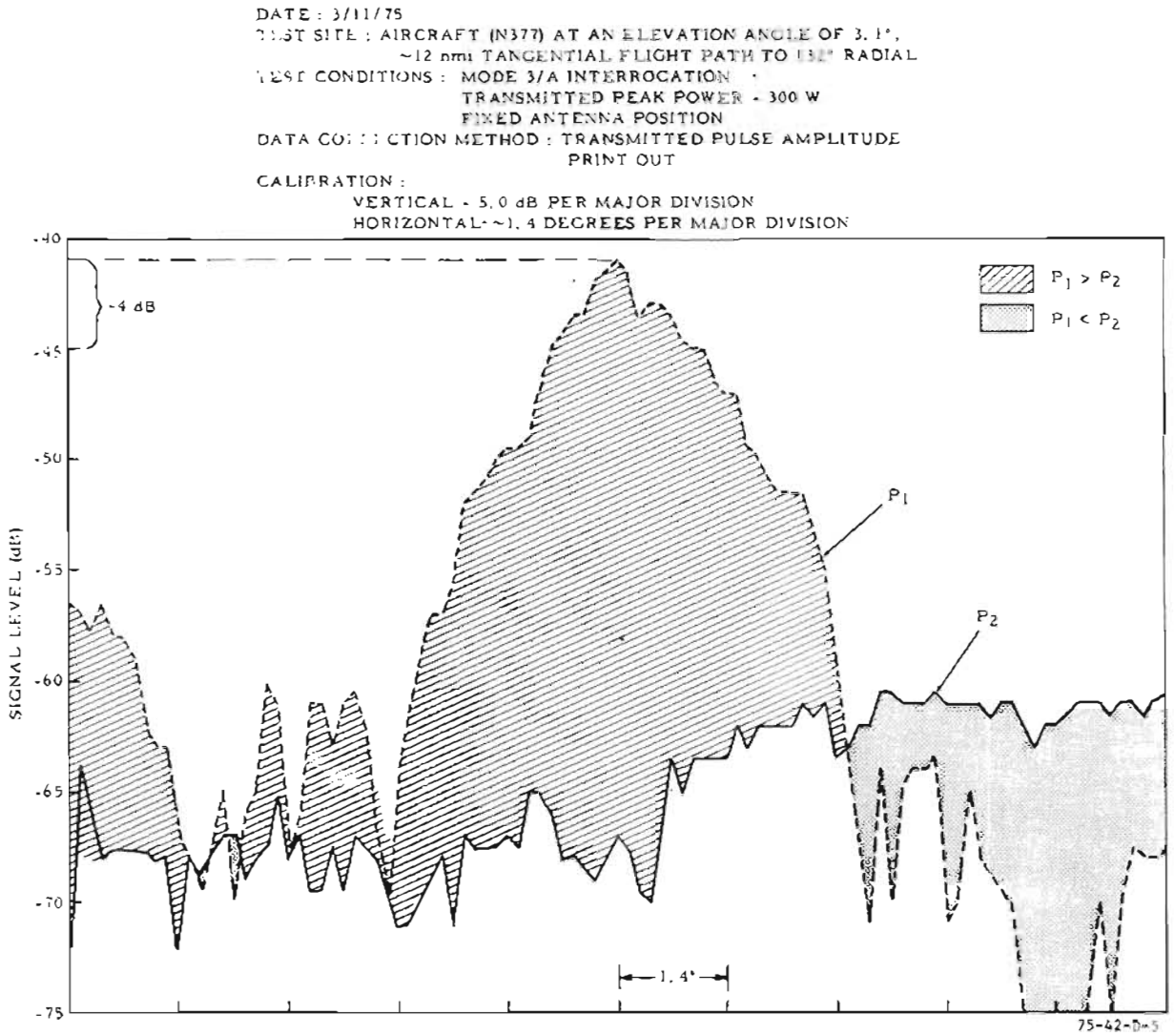

FIGURE D-5. ATCRBS ANTENNA STATIC BEAM PATTERN (VERTICAL PLAN OBSTRUCTION)

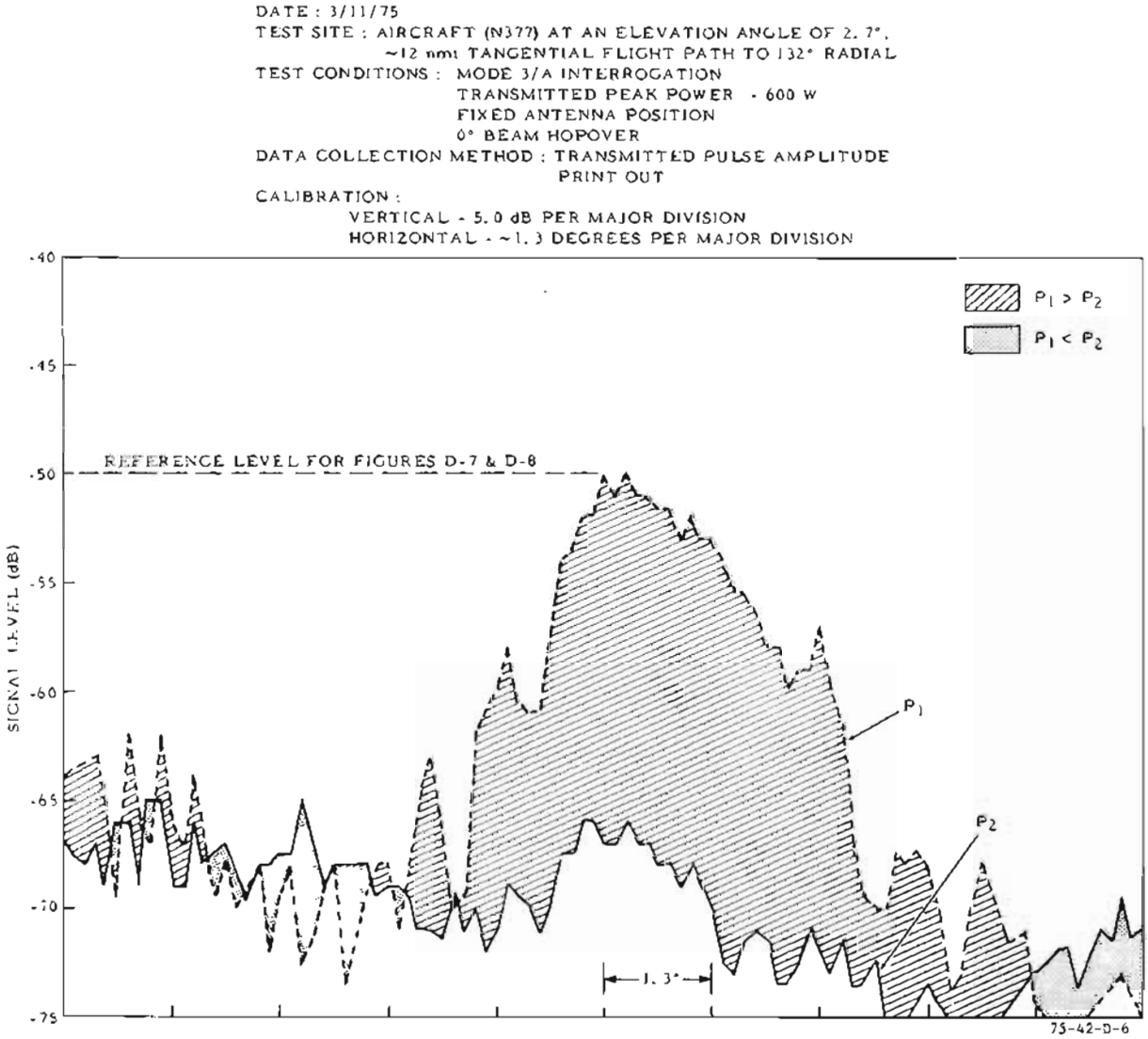

FIGURE D-6. ESA STATIC BEAM PATTERN FOR ZERO DEGREE BEAN HOPOVER (VERTICAL PLANE OBSTRUCTION)

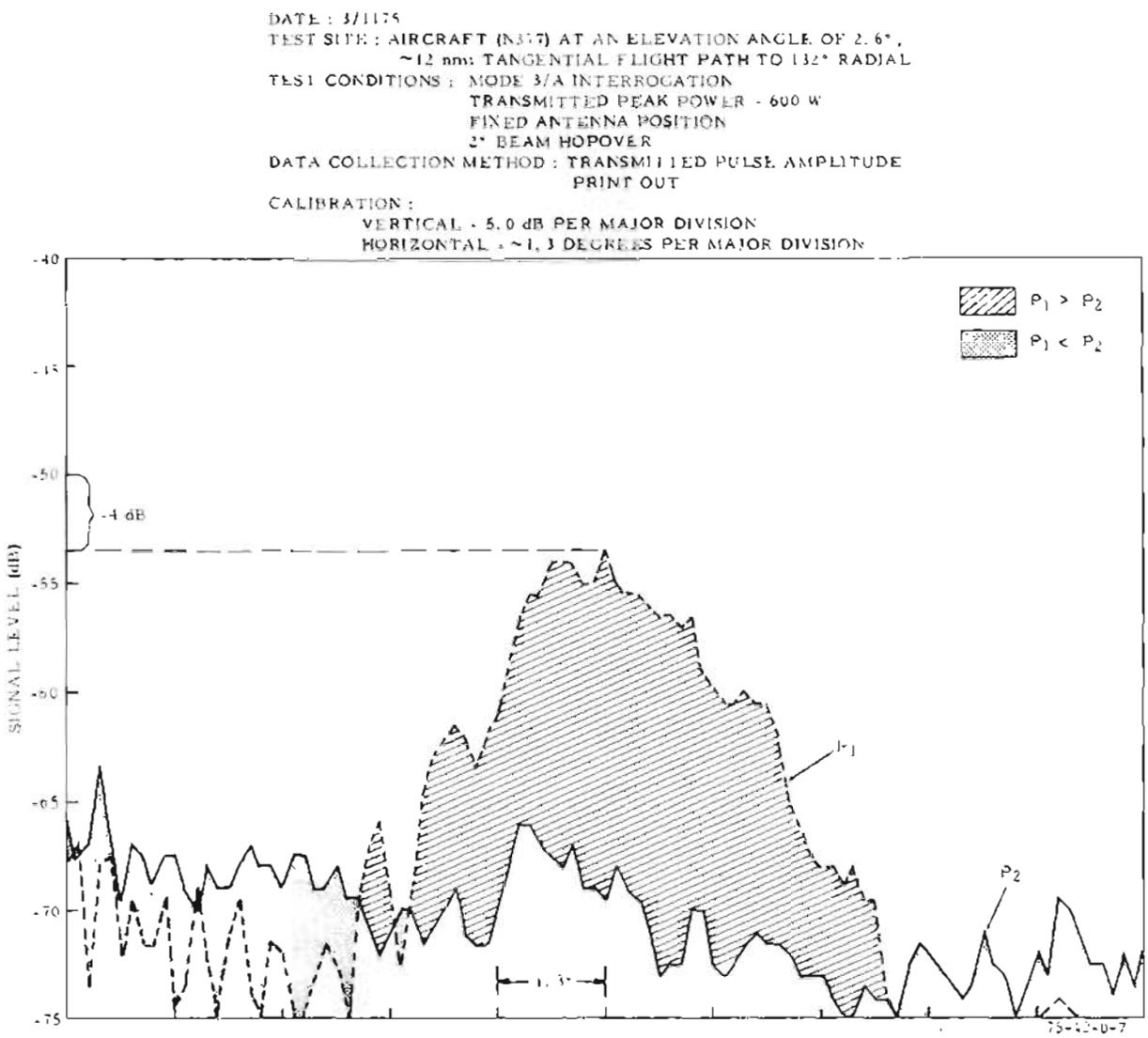

FIGURE D-7. ESA STATIC BEAM PATTERN FOR 2° BEAM HOPOVER (VERTICAL PLANE OBSTRUCTION)

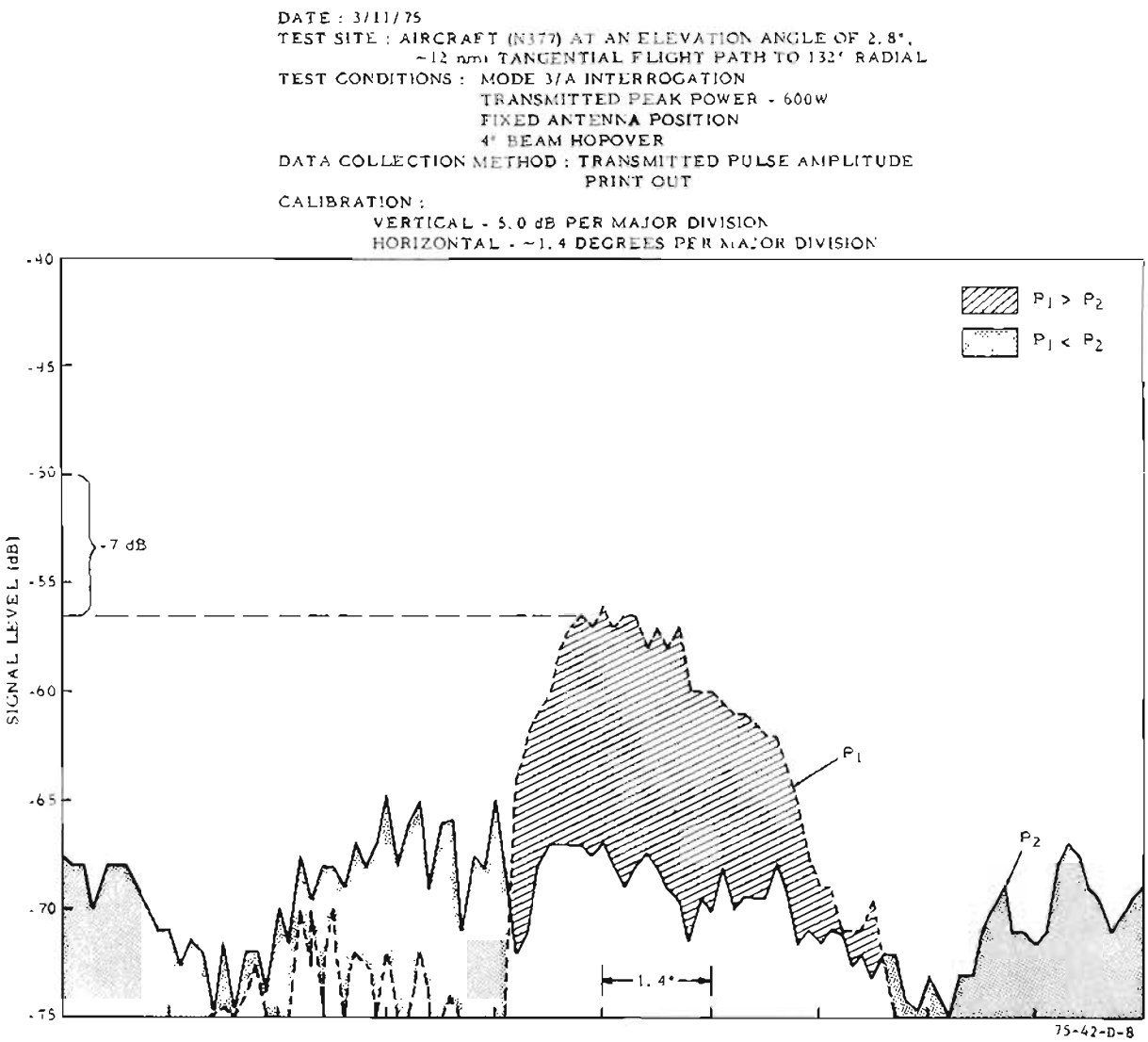

FIGURE D-8. ESA STATIC BEAM PATTERN FOR 4° BEAM HOPOVER (VERTICAL PLANE OBSTRUCTION)

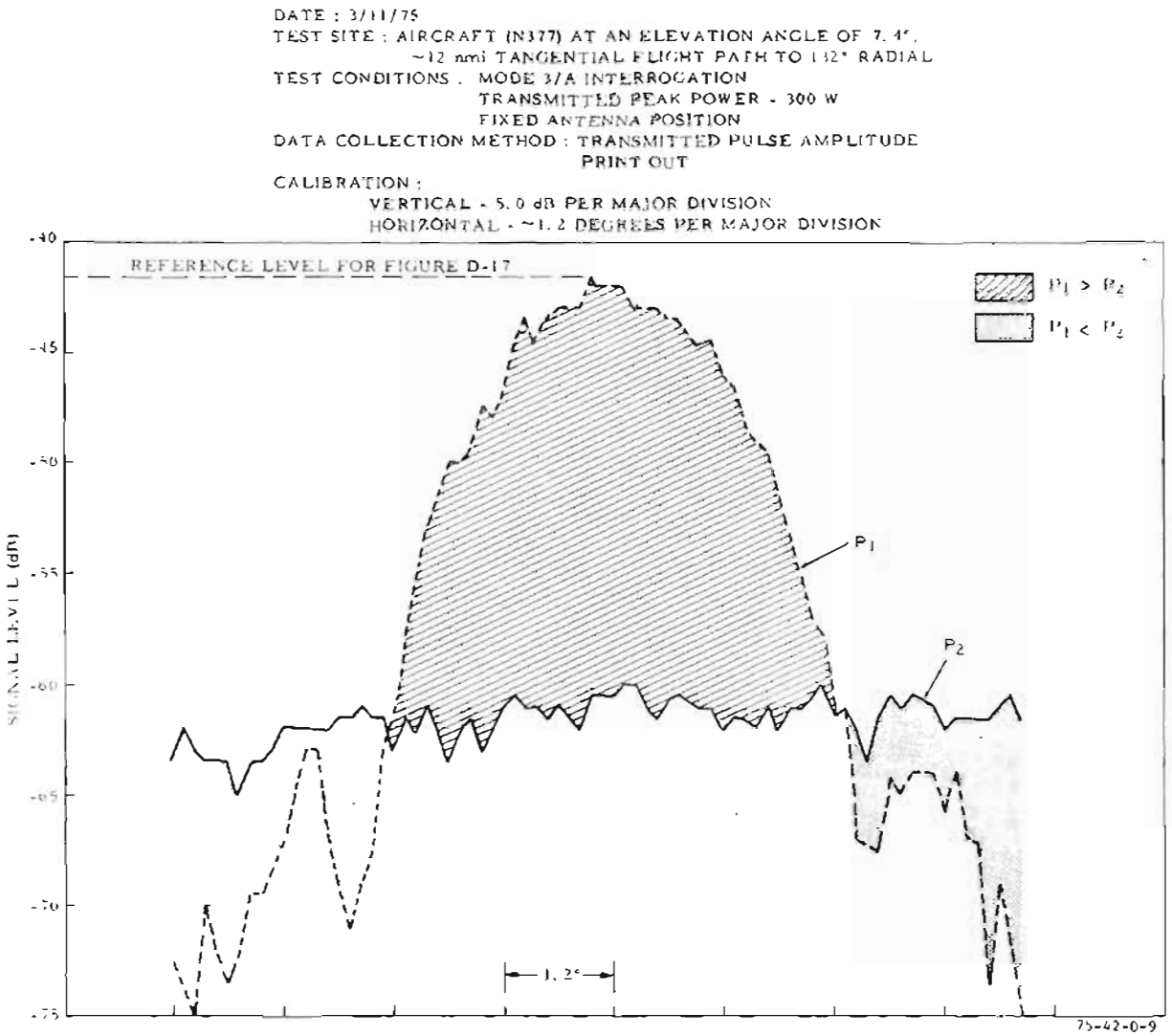

FIGURE D-9. ATCRBS ANTENNA STATIC BEAM POSITION (ABOVE VERTICAL PLANE OBSTRUCTION)

DATE : 3/11/75
TEST SITE : AIRCRAFT (N377) AT AN ELEVATION ANGLE OF 7.5°,
~12 nmi TANGENTIAL FLIGHT PATH TO 132° RADIAL
TEST CONDITIONS : MODE 3/A INTERROGATION
TRANSMITTED PEAK POWER - 600 W
FIXED ANTENNA POSITION
0° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE PRINT OUT
CALIBRATION :
VERTICAL - 5.0 dB PER MAJOR DIVISION
HORIZONTAL - ~1.2 DEGREES PER MAJOR DIVISION

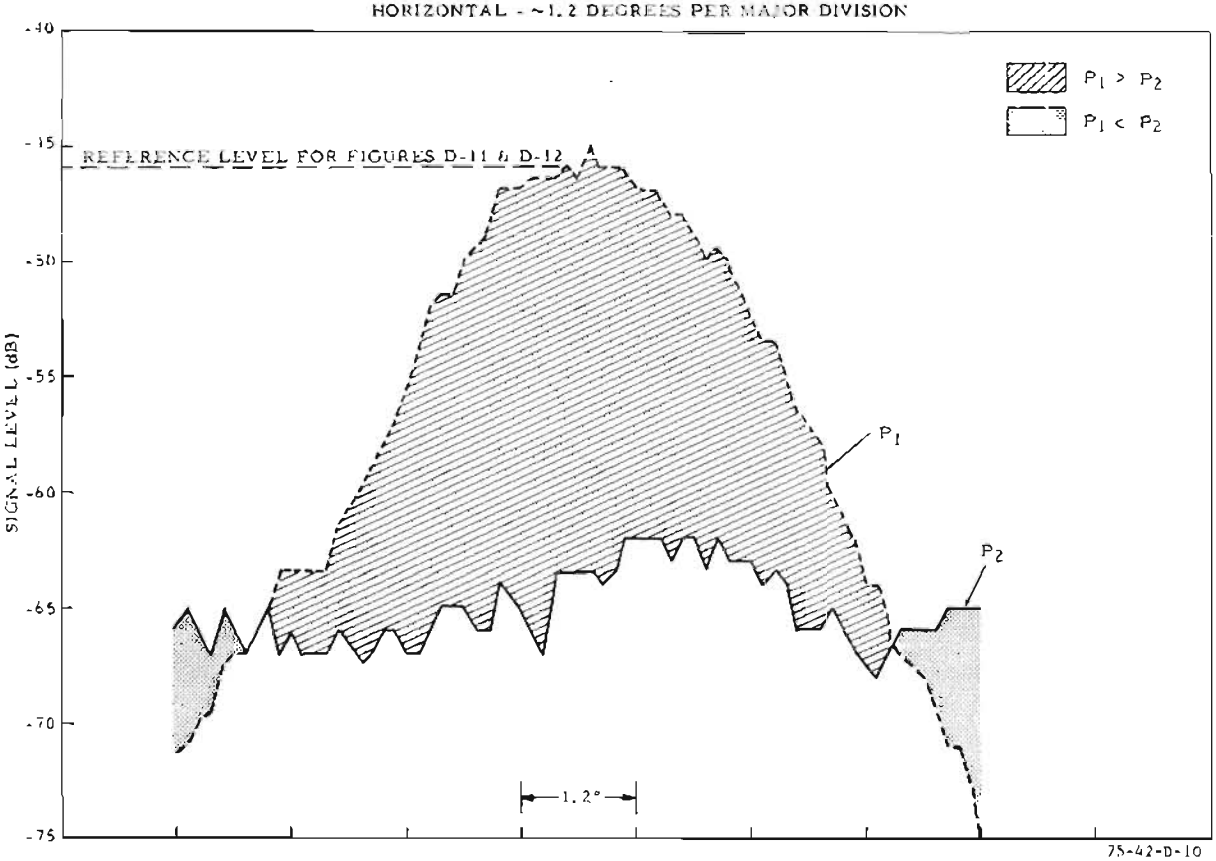

FIGURE D-10. ESA STATIC BEAM PATTERN FOR ZERO DEGREE BEAM HOPOVER (ABOVE VERTICAL PLANE OBSTRUCTION)

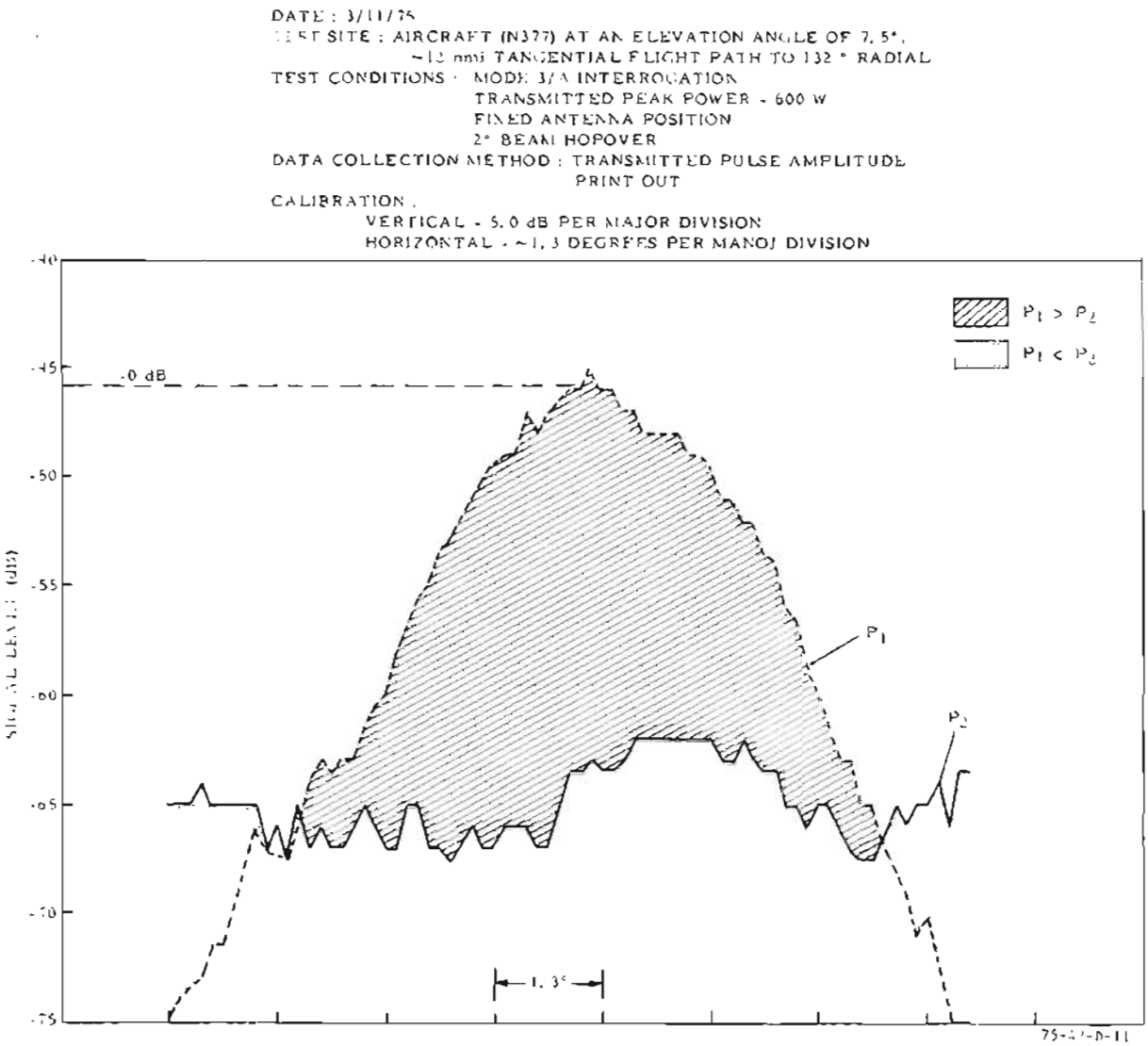

FIGURE D-11. ESA STATIC BEAM PATTERN FOR 2° BEAM HOPOVER (ABOVE VERTICAL PLANE OBSTRUCTION

DATE : 3/11/75
TEST SITE : AIRCRAFT (N377) AT AN ELEVATION OF 7.5°,
12 nmi TANGENTIAL FLIGHT PATH TO 132°

DATE : 3/11/75
TEST SITE : AIRCRAFT (N377) AT AN ELEVATION ANGLE OF 7.5°,
~12 nmi TANGENTIAL FLIGHT PATH TO 132° RADIAL
TEST CONDITIONS : MODE 3/A INTERROGATION
TRANSMITTED PEAK POWER - 600 W
FIXED ANTENNA POSITION
4° BEAM HOPOVER
DATA COLLECTION METHOD : TRANSMITTED PULSE AMPLITUDE
PRINT OUT
CALIBRATION :
VERTICAL - 5.0 dB PER MAJOR DIVISION
HORIZONTAL - ~1.3 DEGREES PER MAJOR DIVISION

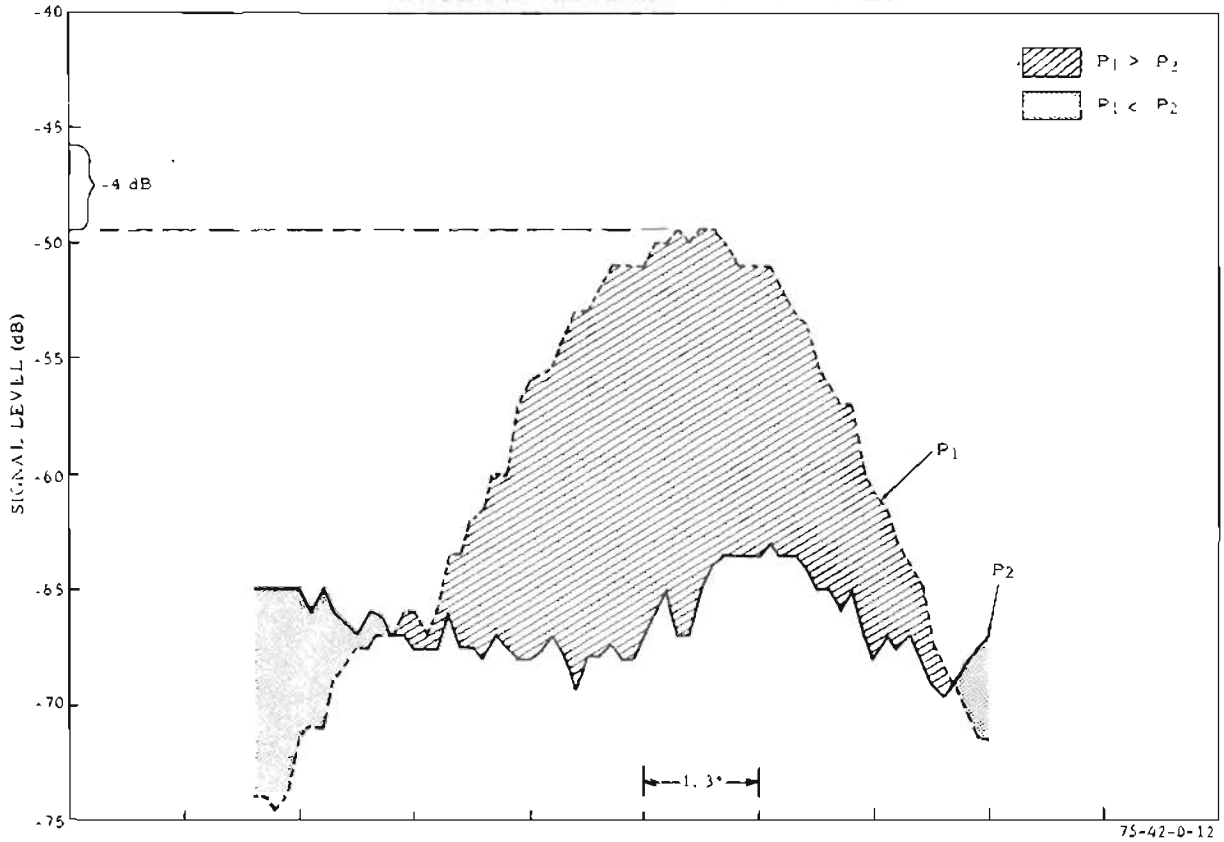

FIGURE D-12. ESA STATIC BEAM PATTERN FOR 4° BEAM HOPOVER (ABOVE VERTICAL PLANE OBSTRUCTION)

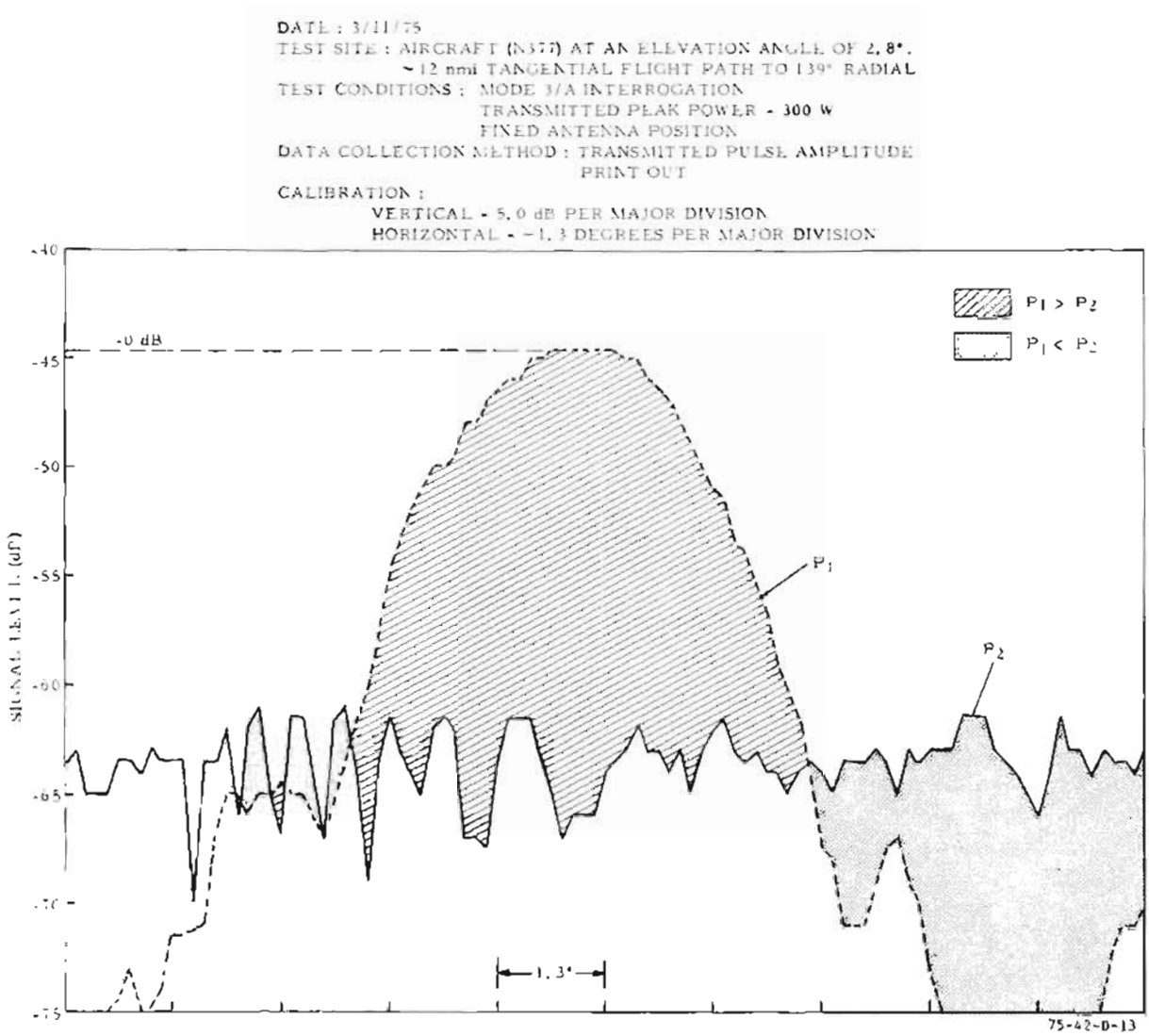

FIGURE D-13. ATCRBS ANTENNA STATIC BEAM POSITION (HORIZONTAL PLANE OBSTRUCTION)

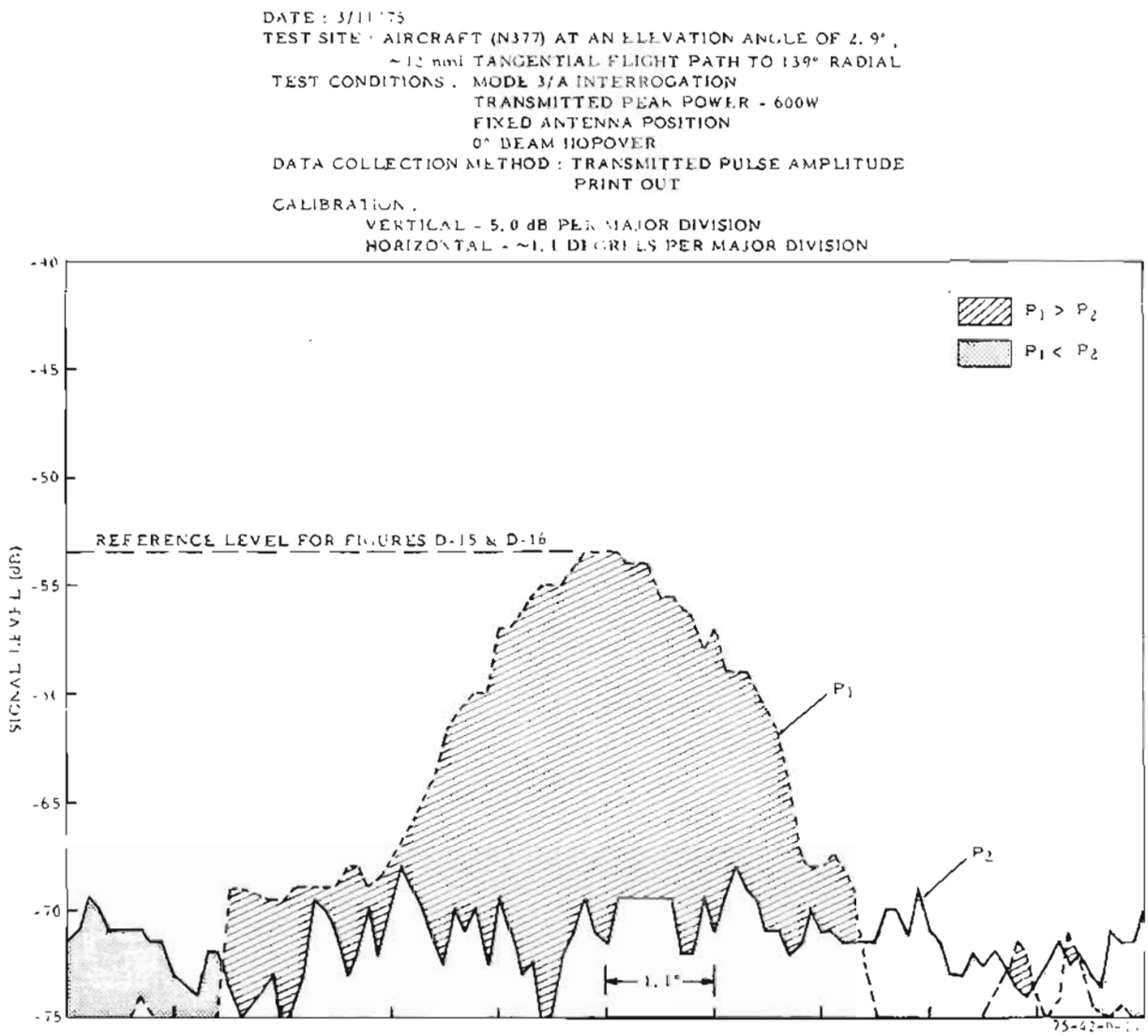

FIGURE D-14. ESA STATIC BEAM POSITION FOR ZERO DEGREE BEAM HOPOVER (HORIZONTAL PLANE OBSTRUCTION)

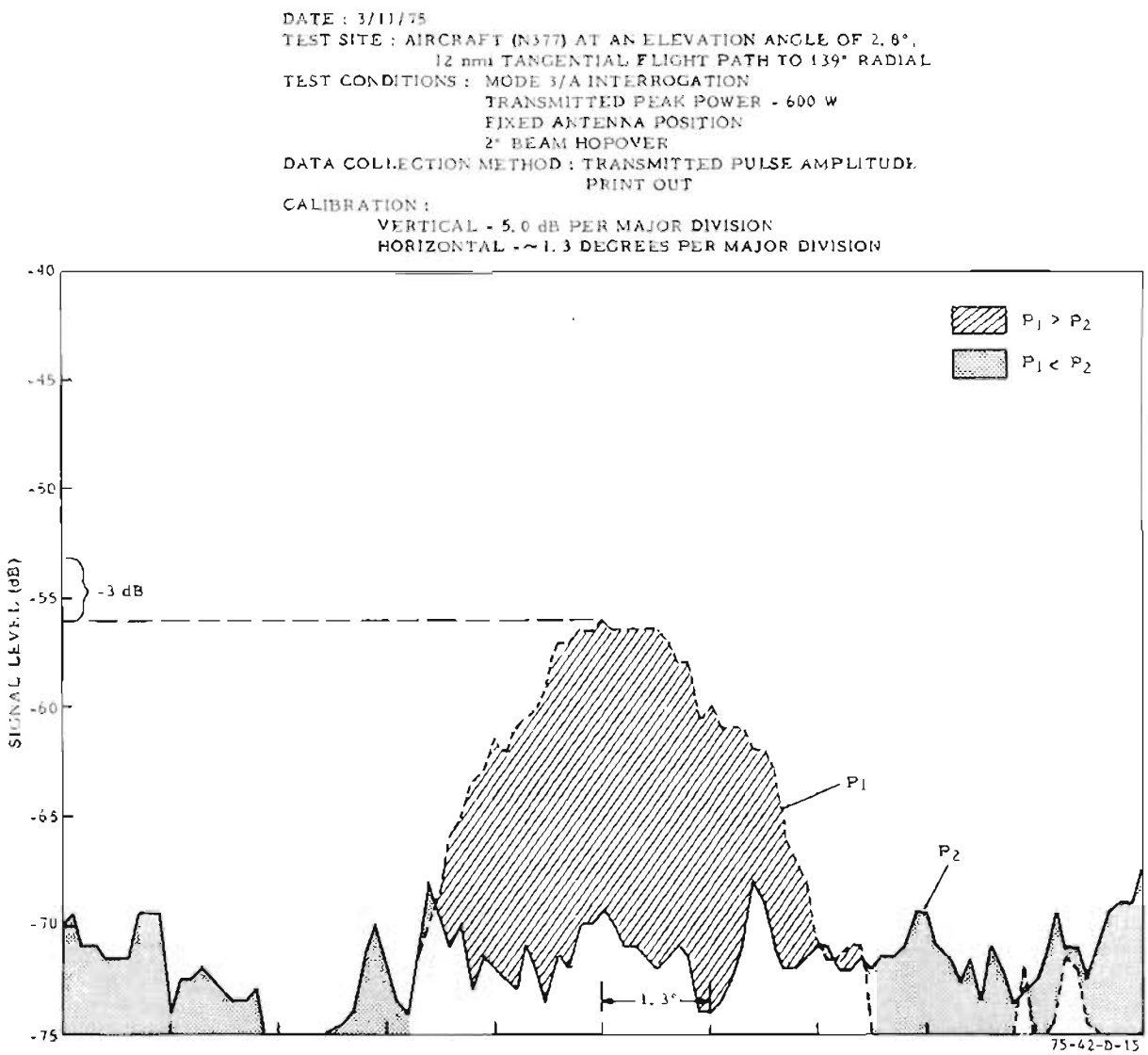

FIGURE D-15. ESA STATIC BEAM POSITION FOR 2° BEAM HOPOVER (HORIZONTAL PLANE OBSERVATION)

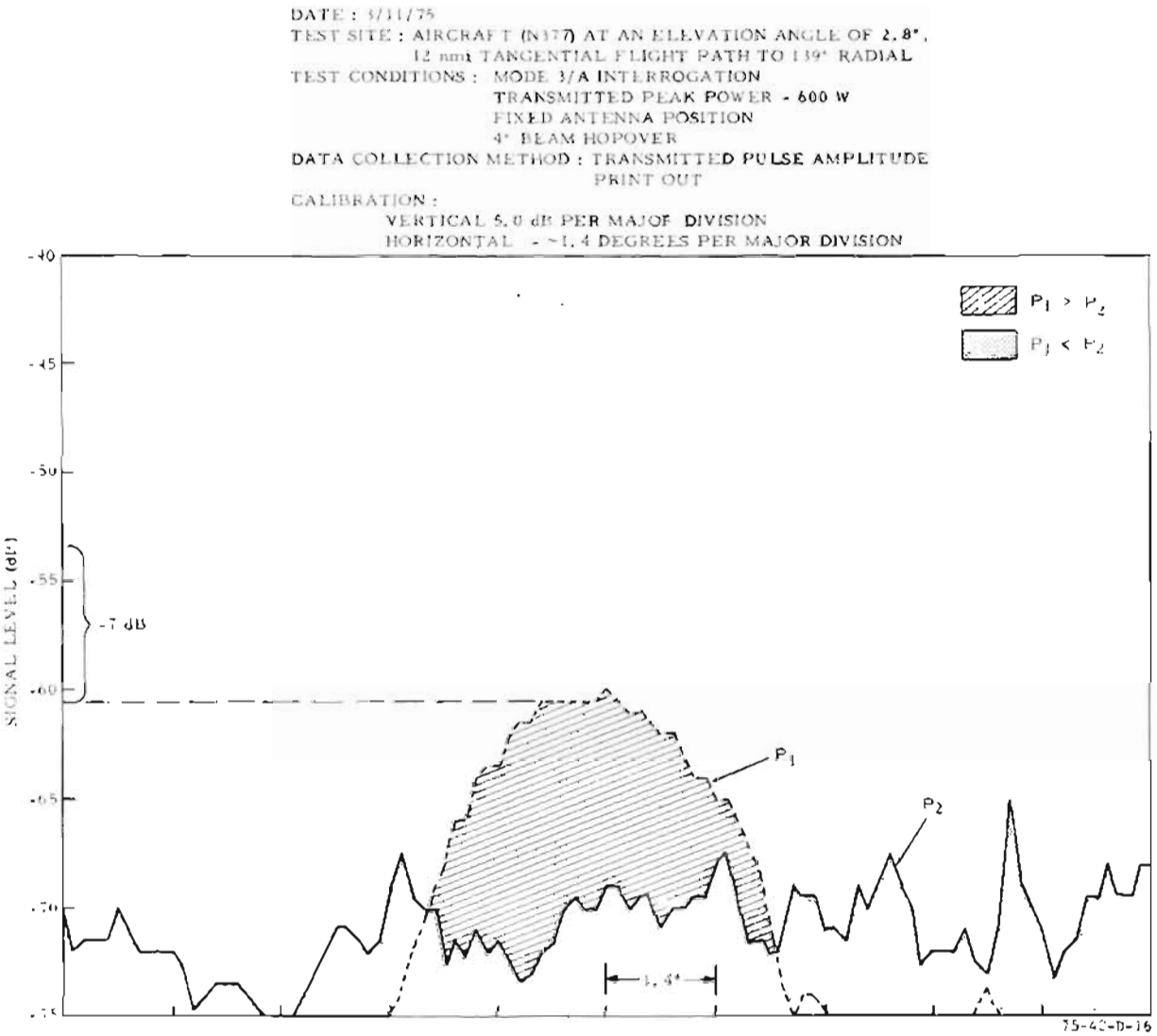

FIGURE D-16. ESA STATIC BEAM POSTION FOR 4° BEAM HOPOVER (HORIZONTAL PLANE OBSTRUCTION)

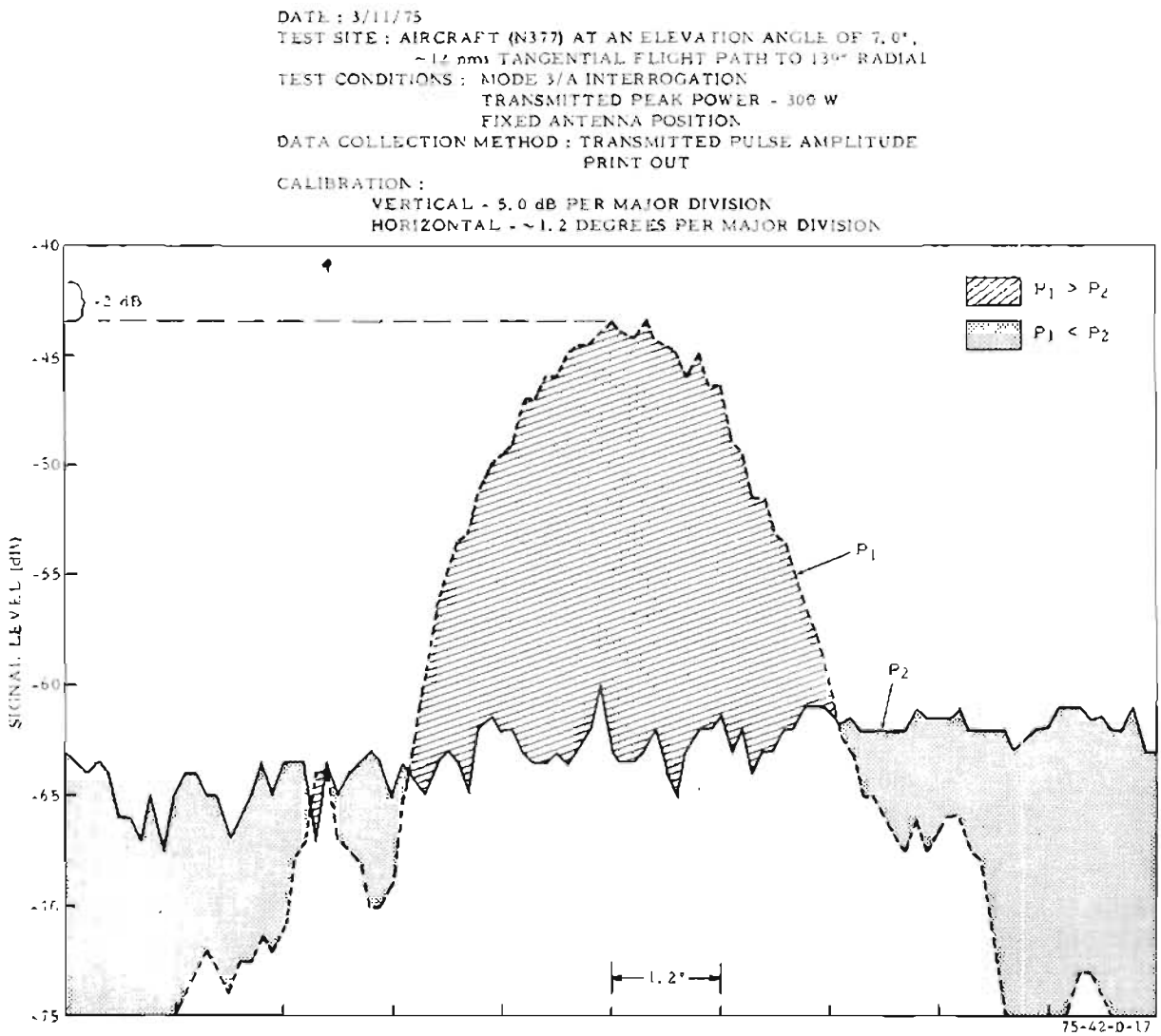

FIGURE D-17. ATCRBS ANTENNA STATIC BEAM POSITION (ABOVE HORIZONTAL PLANE OBSTRUCTION)

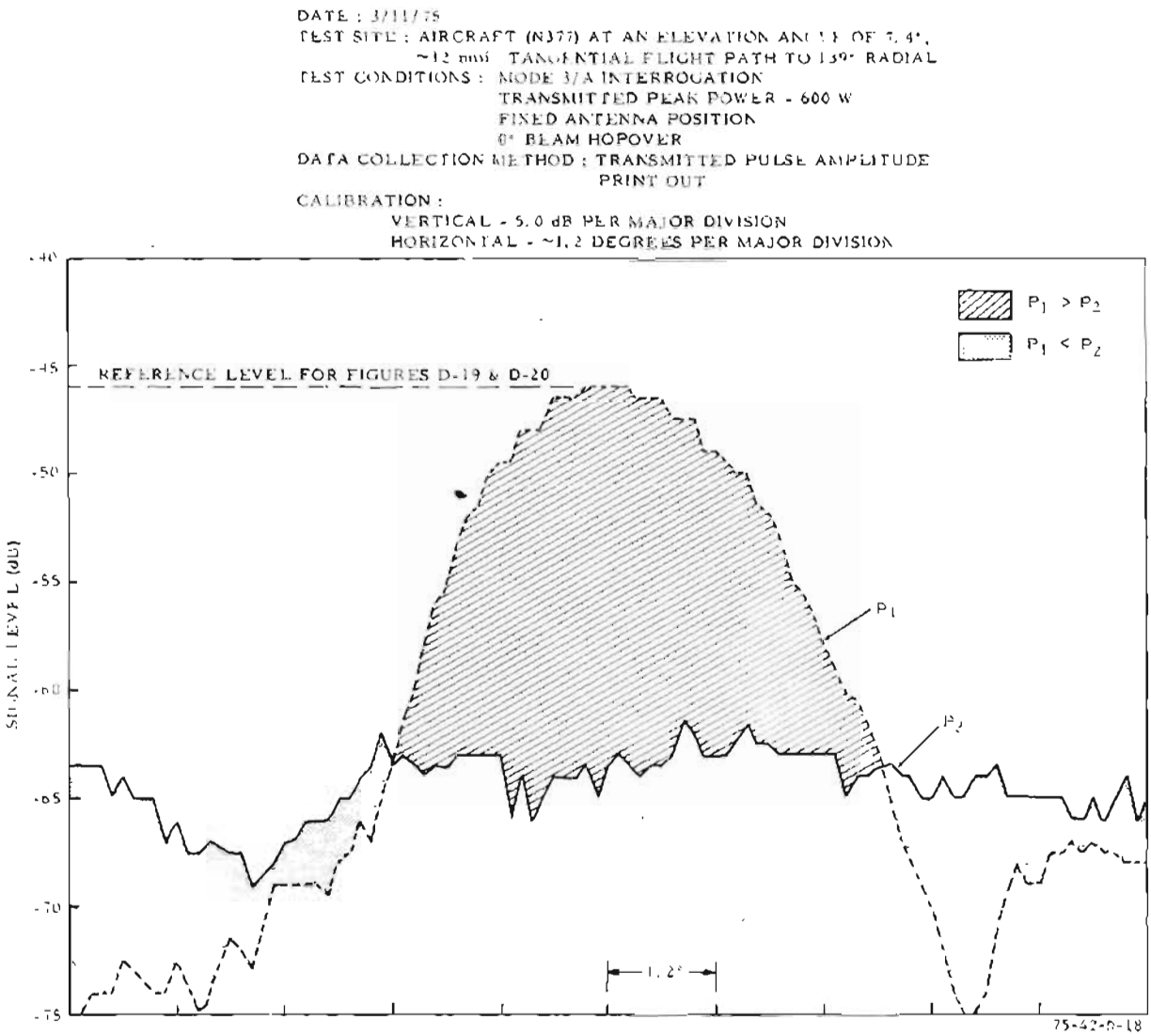

FIGURE D-18. ESA STATIC BEAM POSITION FOR ZERO DEGREE BEAM HOPOVER (ABOVE HORIZONTAL PLANE OBSTRUCTION)

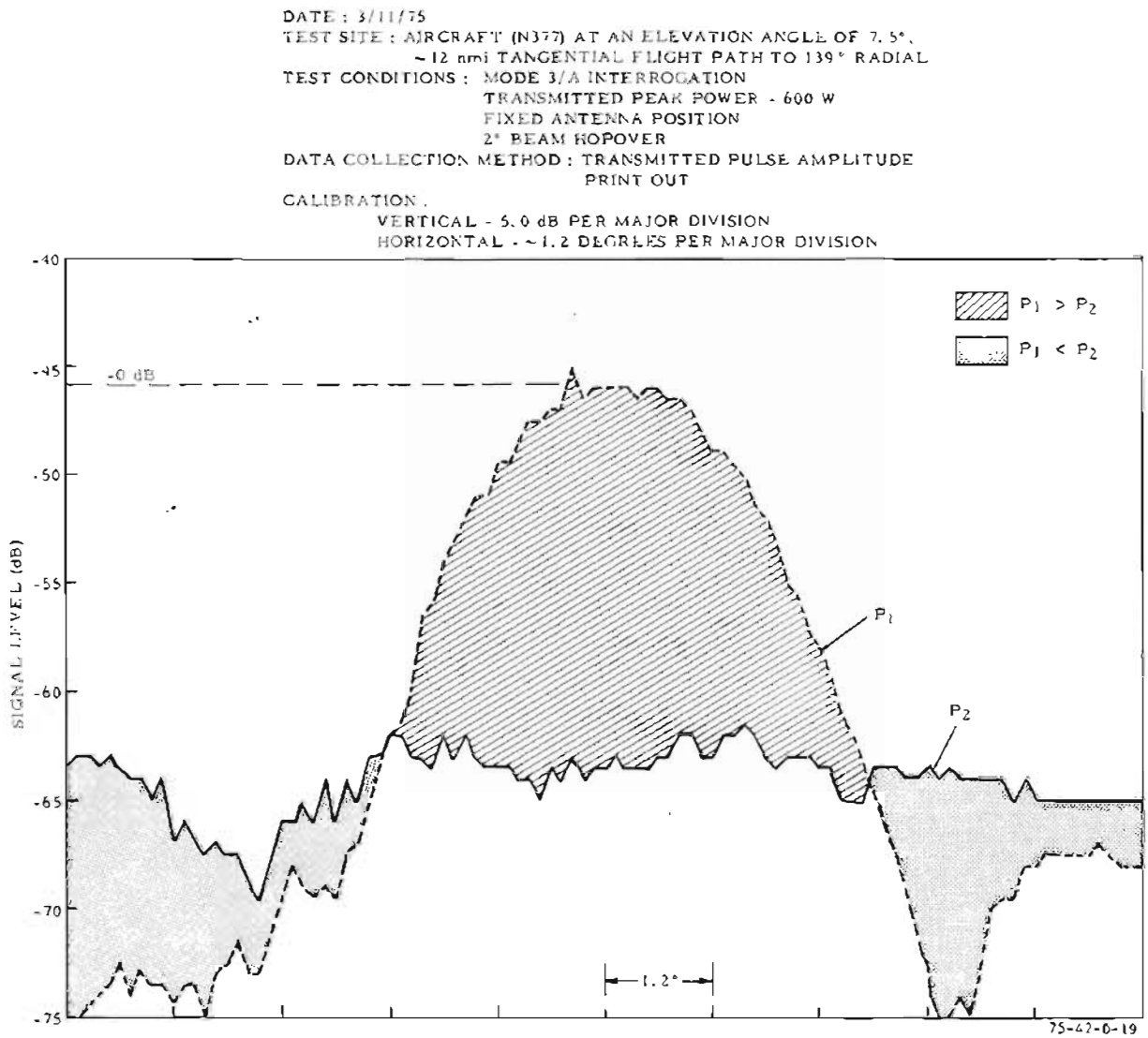

FIGURE D-19. ESA STATIC BEAM POSITION FOR 2° BEAM HOPOVER (ABOVE HORIZONTAL PLANE OBSTRUCTION)

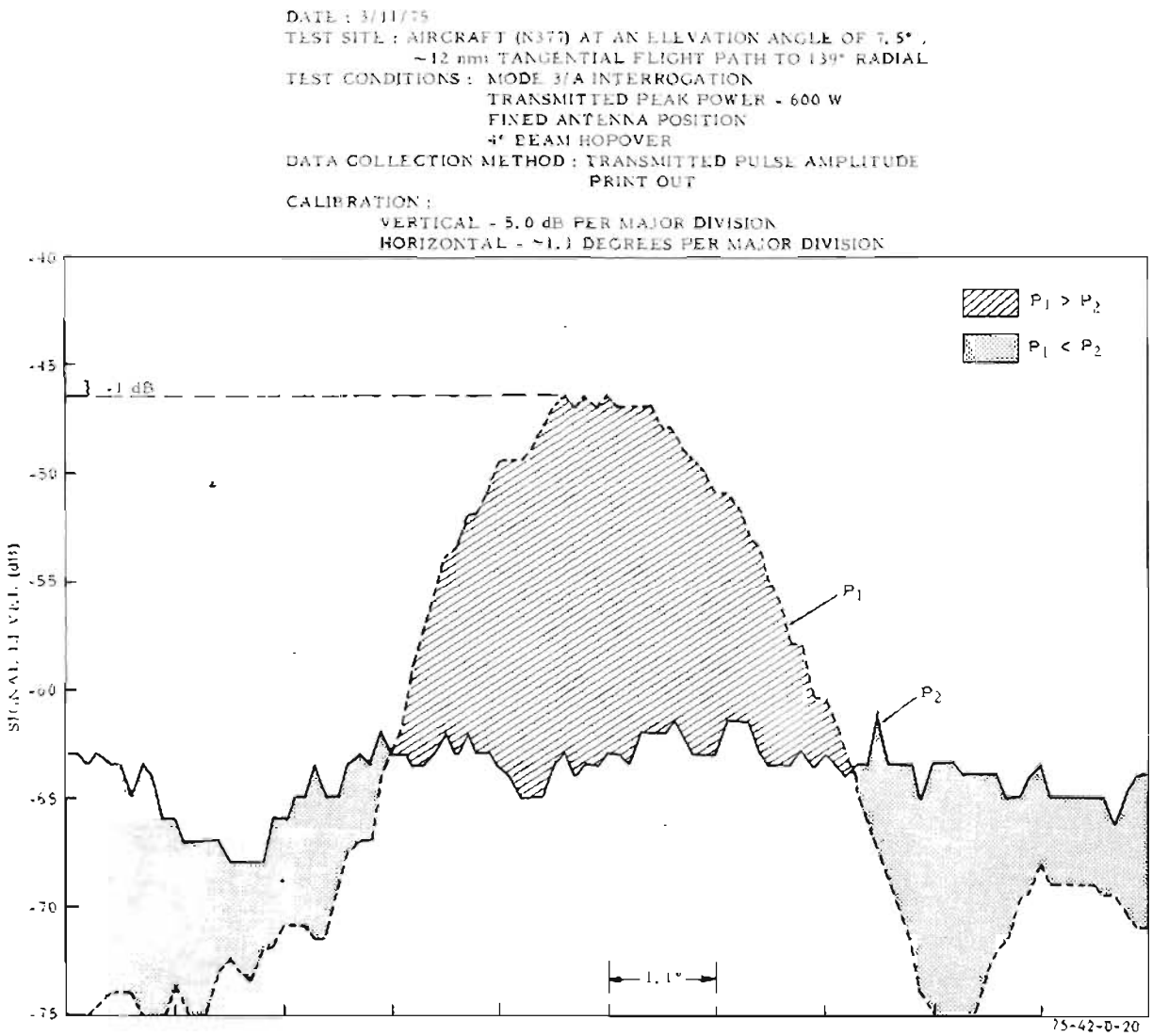

FIGURE D-20. ESA STATIC BEAM POSITION FOR 4° BEAM HOPOVER (ABOVE HORIZONTAL BEAM OBSTRUCTION)