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AN INVESTIGATION INTO THE CAPABILITY OF MONITORING A PHASED OPE--ETC(U)
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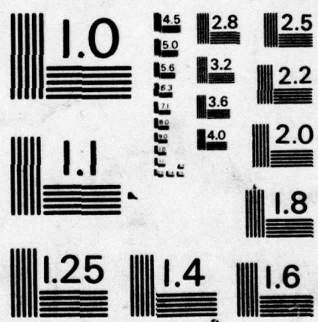

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Report No. FAA-RD-76-150

INVESTIGATION INTO THE CAPABILITY OF MONITORING A PHASED OPEN-ARRAY ANTENNA

NICHOLAS J. TALOTTA

OCTOBER 1976

FINAL REPORT

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Washington, D.C. 20590

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16. Abstract

A requirement exists to develop a monitoring capability for air traffic control radar beacon system ground station equipments. The National Aviation Facilities Experimental Center has conducted tests of the Hazeltine open-array antenna to determine if it can be monitored in the electrical near-field of the antenna. Comparison-type data were obtained in the electrical near- and far-field of the antenna. The data indicate that the antenna can be monitored in the near-field.

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PREFACE

The author acknowledges Mr. Donald Rogers for his significant contribution to the accomplishment of this effort.

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INTRODUCTION

PURPOSE.

The purposes of the tests conducted at the National Aviation Facilities Experimental Center (NAFEC) were to determine if a failure of the Hazeltine open-array beacon antenna could be detected in the electrical near-field of the antenna; and if so, whether the near-field electrical characteristics of the failure could be monitored.

BACKGROUND.

A requirement for a monitoring capability of the air traffic control radar beacon system (ATCRBS) has been established by the Federal Aviation Administration (FAA).

In February 1972, NAFEC prepared a working paper titled, "Status and Concept of an ATCRBS Ground Station Performance Monitor." In June of the same year, the Systems Research and Development Service (SRDS) requested NAFEC to design and develop a prototype Radar Beacon Performance Monitor (RBPM). NAFEC has undertaken that effort and has developed a demonstrable RBPM; however, during the initial phase of development at NAFEC, it was indicated by data collected that an antenna system could fail without affecting azimuth or any other parameters. This has pointed to the need for an antenna system monitoring capability, in addition to monitoring specified operational parameters in the requirement. The design objective of this effort has been to determine if such a monitor could be developed for use in the near-field of the antenna. Tests and results obtained using the NAFEC-developed antenna system monitor with the Hazeltine directional array antenna are contained in this report.

DISCUSSION

TEST OBJECTIVES.

The tests were designed to determine if changes in beam width, side lobes, beam shape, and azimuth due to failure of the open-array directional antenna could be detected, and if these changes were of sufficient magnitude to allow automatic monitoring via hardware.

The nature of the experiment required that a failure to the antenna be introduced for the various tests. Therefore, by definition, antenna failures were created rather than azimuth errors. However, the tests were designed to determine if the antenna failures could possibly be defined operationally as azimuth errors. This was accomplished by observing first a far-field transponder and later a controlled NAFEC test flight, in addition to targets of opportunity.

DESCRIPTION OF TESTS INSTRUMENTATION.

All tests were conducted at the Terminal Facility for Automation Surveillance Testing (TFAST) facility located at NAFEC. The tests were performed with the objective that the resulting antenna monitoring would be accomplished in the near-field rather than the far-field of the antenna. This approach would simplify installation and maintenance procedures for the required equipment. Testing was conducted in the near-field and far-field in order to establish (near-field/far-field) correlation.

The near-field pattern differences were detected by using the antenna system monitor of the RBPM, while the far-field effects were detected and recorded by an ARTS III system.

A diagram indicating the physical mounting relationship of the antennas is shown in figure 1. The monitor dipole pickup antenna was mounted on a 2-foot offset arm with the capability of being rotated 360°.

The electrical configuration of equipments for the tests is shown in figure 2. An RBPM monitor pickup dipole antenna was installed on the roof of the TFAST site in close proximity to the rotating open-array antenna. This monitor probe was adjustable in height, azimuth, and distance, in order to determine if these physical parameters were critical to near-field monitoring performance. As the parameters were varied and/or the antenna was failed, the near-field antenna beam was detected by the probe, amplified by a 1030 MHz receiver, and photographed from the oscilloscope. In detail, the transmitted radiofrequency (RF) energy radiated from the open-array antenna was detected by the test dipole and routed to a directional coupler by means of a coaxial cable (refer to figure 2). The -20 decibel (dB) port on the directional coupler was routed to a 1030 megahertz (MHz) log receiver via an attenuator. The output of the receiver was then applied to the vertical input of the oscilloscope where a photographic technique was used to extract the data from the oscilloscope presentation. The vertical input of the oscilloscope was comprised of P_1, P_2, and P_3 information. A pulse generator triggered by beacon sync supplied a 100-nanosecond (ns) pulse to the Z-axis of the oscilloscope. This 100-ns pulse was then delayed until it coincided with the center of the radiated and detected P_3 pulse. By making the proper level adjustments, the oscilloscope trace was deintensified except during 100-ns of the center of P_3 time. The "plus gate" output signal from the oscilloscope was used to electronically close the camera shutter at the end of each sweep. The oscilloscope trigger was provided by the north pulse which supplied a trigger once each antenna scan. Thus, each photograph shows the peaks of the detected P_3 pulses or the antenna pattern in the near-field.

The feed-through output port of the directional coupler was coupled through an attenuator to a 1030-MHz log receiver within the RBPM. The attenuator was adjusted to pass a signal 10 dB down from the peak of the beam. A detector/video amplifier-type automatic gain control(AGC) receiver within the RBPM was adjusted within predetermined limits to detect the RF signal (near-field antenna beam) acquired by the pickup probe. Circuitry within the

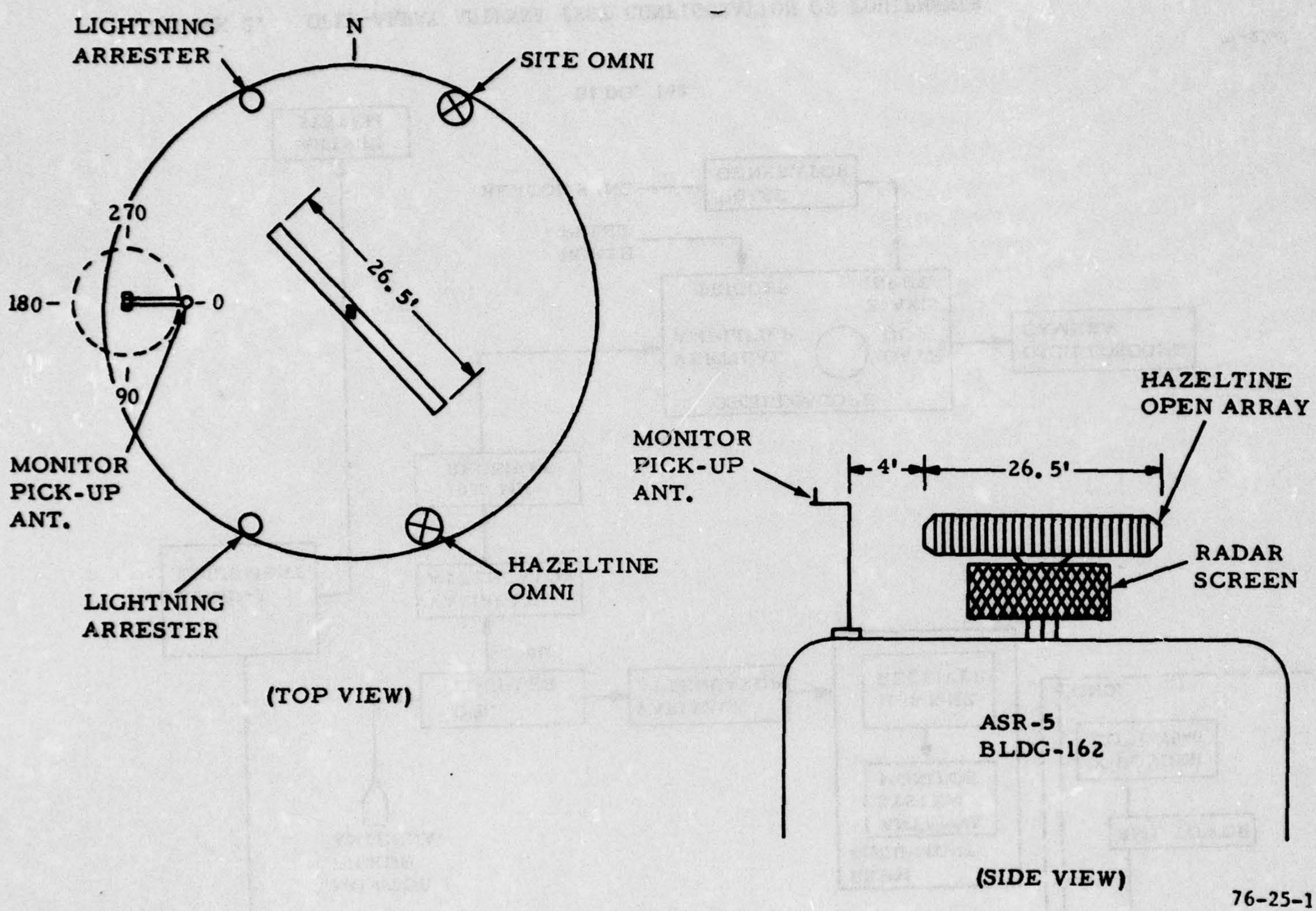


FIGURE 1. PHYSICAL MEASUREMENTS OF OPEN-ARRAY TEST CONFIGURATION

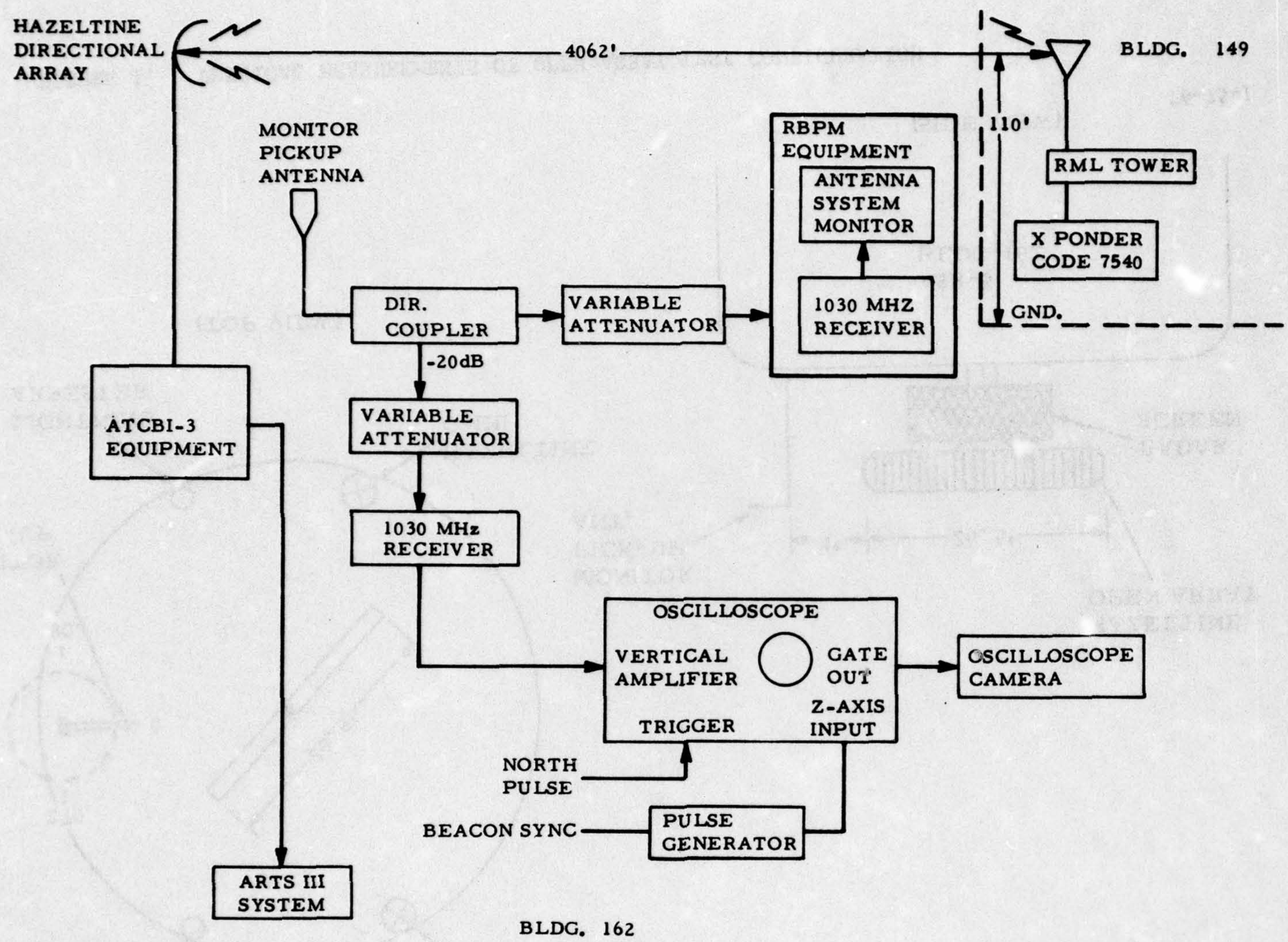


FIGURE 2. OPEN-ARRAY ANTENNA TEST CONFIGURATION OF EQUIPMENTS

RBPM antenna system monitor was then used to detect and determine the resulting open-array pattern changes, including beam width, side lobe and beam shape. Figure 2 also indicates the instrumentation used for the collection of far-field data from a "perched" transponder. The transponder was located in building 149 with its antenna on the radar microwave link (RML) tower at NAFEC. The air traffic control beacon interrogator (ATCBI-3) interrogated the transponder from the TFAST site, and the reply was processed by the ARTS III system. Software was then used in conjunction with the ARTS III to extract the perched far-field target's range, azimuth, number of hits, and runlength for the various antenna tests.

DESCRIPTION OF EQUIPMENT.

HAZELTINE 4-FOOT OPEN-ARRAY ANTENNA. The Hazeltime open-array directional antenna used for the test is shown in figure 3. The antenna is 4 feet high by 26 feet long and consists of 252 radiating elements located on 36 columns. An expanded detailed drawing illustrating the physical aspects of the antenna is shown in figure 4. The dipoles are mounted on 2-inch-diameter tubes which also house the coaxial feed cable for each column. Tuned reflectors, used to suppress backlobe radiation, are mounted between each of the columns. Power dividing networks, which feed each of the columns, are located in the channel on the bottom of the structure.

Figure 5 schematically shows how the power is distributed to the elements within the antenna. During the testing, the azimuth cables (as noted in figure 5) were disconnected at the elevation network in order to simulate various antenna failures. It is recognized that many other types of failures could have been performed. However, due to many limitations, such as time, facilities, and equipment, the azimuth failure was chosen, because it would be more easily identifiable with previous testing of other types of ATCRBS antennas and the RBPM.

Proper operation of the antenna prior to installation was determined by performing relative power measurements between each of the dipoles. The measured relative power distribution for the antennas is shown in figure 6.

It is noted that the right side dipole located on column 18, row 6, was removed so that it could be used as a pickup antenna to make the relative power distribution measurements in this test (on recommendation of the antenna manufacturer).

RBPM ANTENNA SYSTEM MONITOR. Circuitry for an antenna system monitor was designed into the RBPM equipment unit. The antenna system monitor was an integral part of the RBPM and derived its input, timing, and control signals from the RBPM. A photograph of the RBPM is shown in figure 7.

The antenna monitor can be divided into two major functions. One is a minimum hit detector which ensures that a predetermined number of interrogations (in terms of detected P_3's) are received by the monitor pickup probe as the

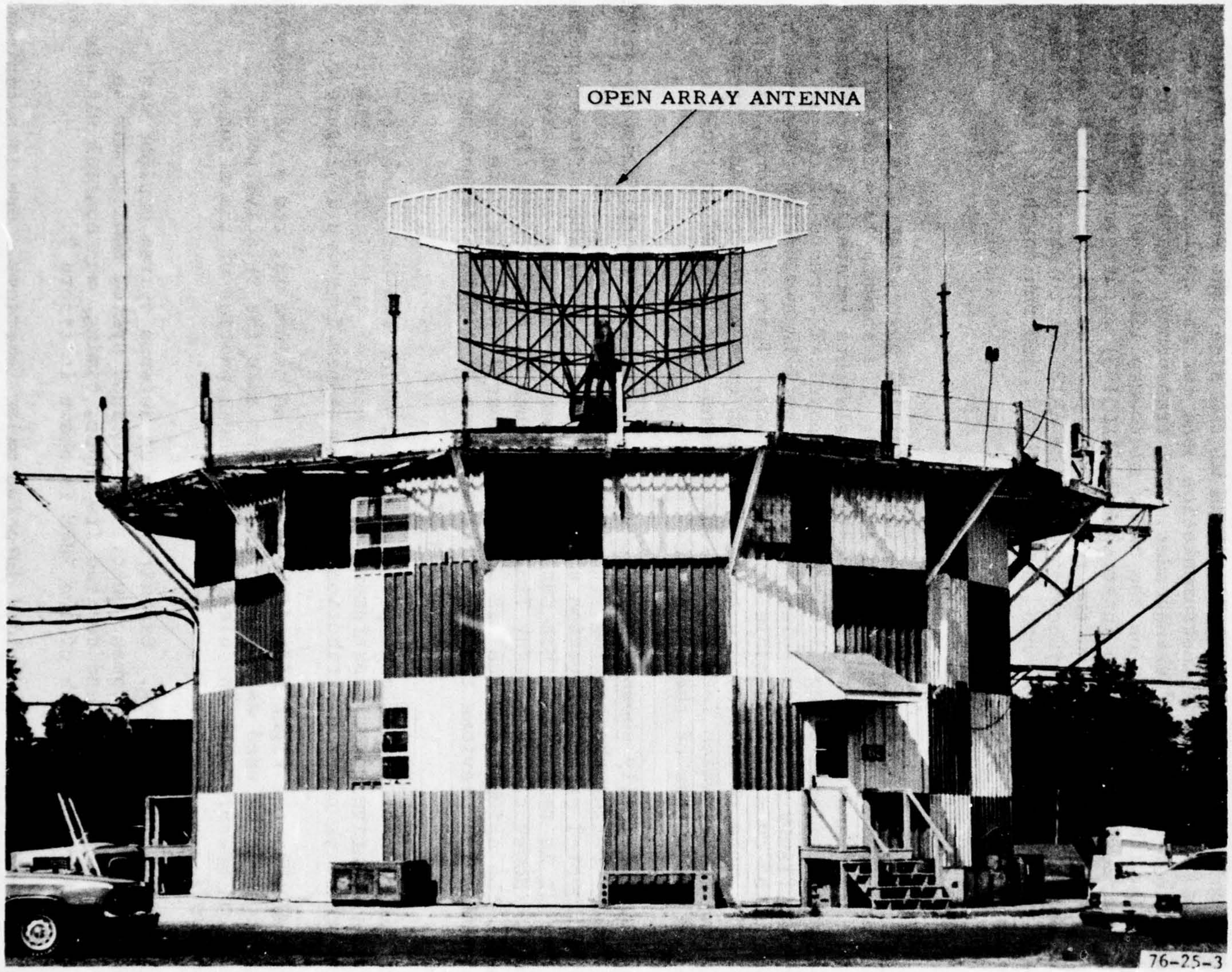
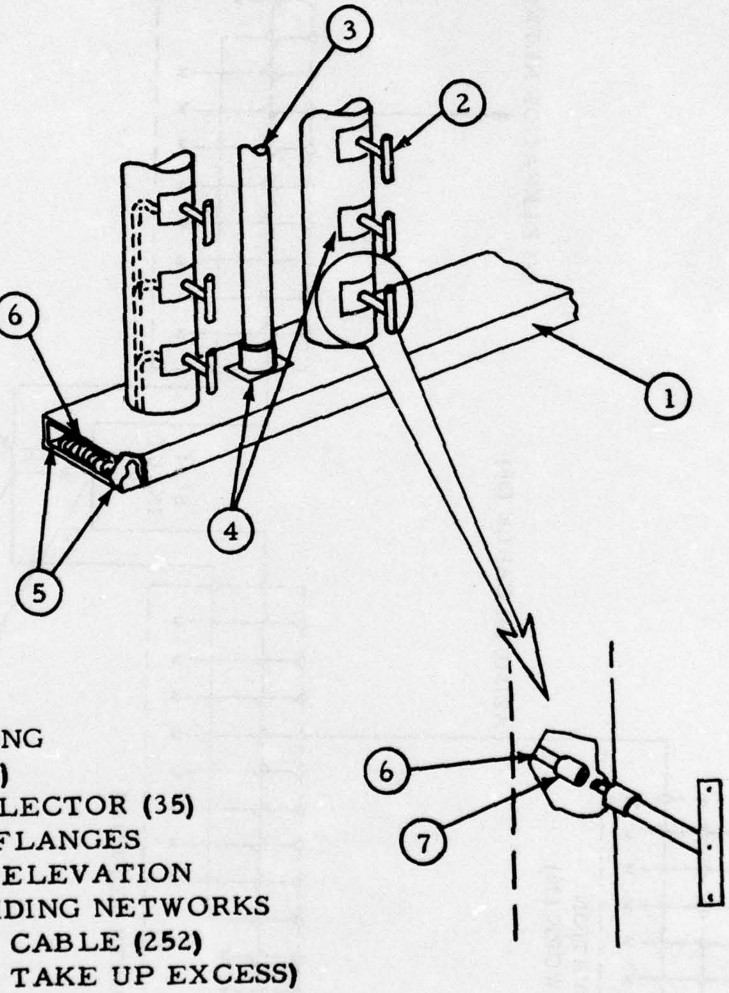


FIGURE 3. HAZELTINE 4-FOOT OPEN-ARRAY ATCRBS ANTENNA ON AN ASR REFLECTOR AT THE TFAST FACILITY



1 FEED HOUSING
2 DIPOLE (252)
3 TUNED REFLECTOR (35)
4 MOUNTING FLANGES
5 AZIMUTH & ELEVATION POWER DIVIDING NETWORKS
6 ELEVATION CABLE (252) (COILED TO TAKE UP EXCESS)
7 SMA CONNECTOR

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FIGURE 4. EXPLODED VIEW OF OPEN-ARRAY ANTENNA

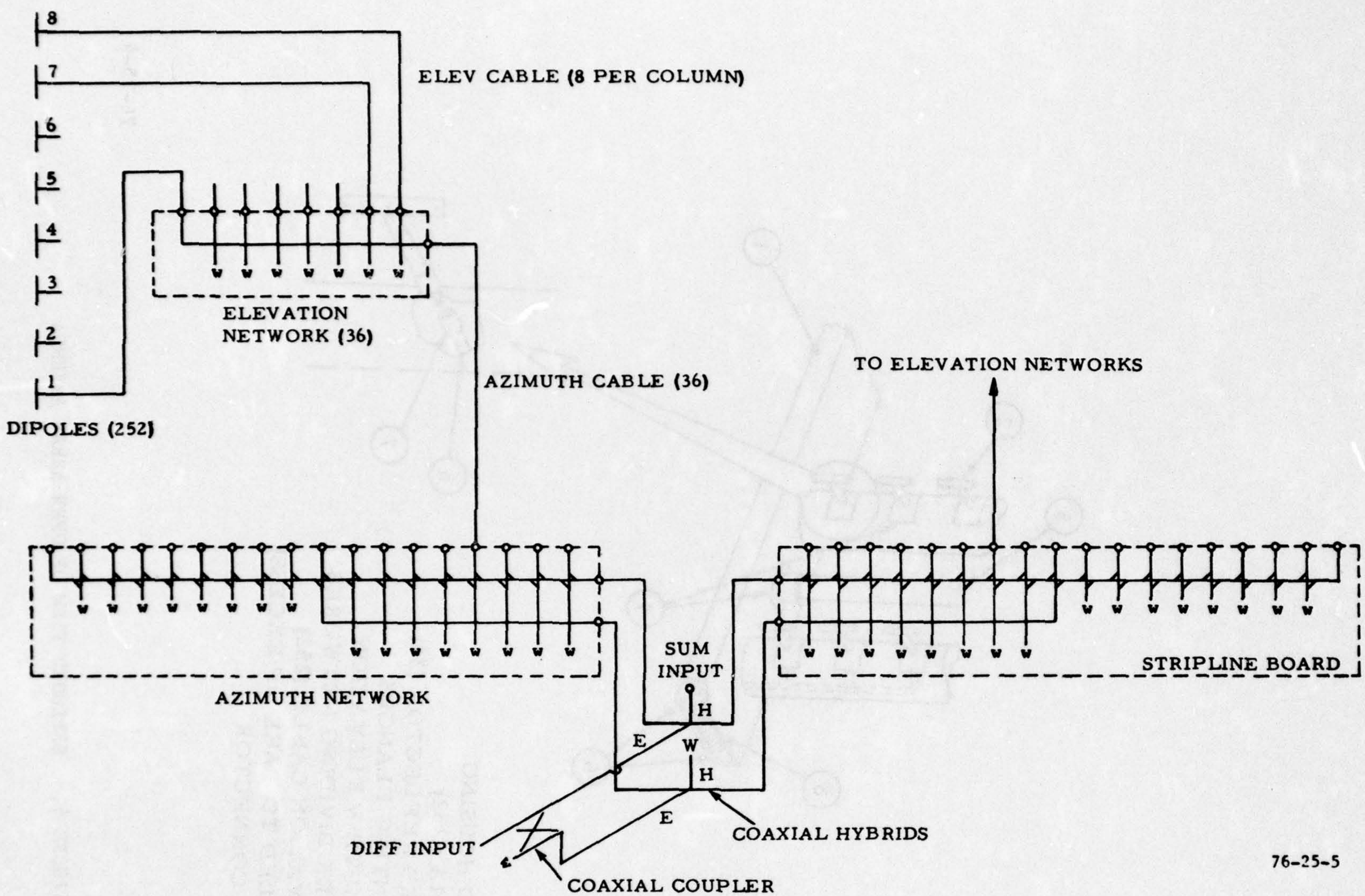

FIGURE 5. DIRECTIONAL ARRAY SCHEMATIC

R.F. LEVEL - RELATIVE dB (VIEW FROM FRONT)

	Left																		Right																		
ROW	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	ROW
1							30	27	24	24	27	22	22	21	21	19	19	20	22	20	20	20	23	21	22	26	24	25	28	28							1
2				40	31	30	25	24	22	21	21	19	18	19	17	17	17	18	18	17	19	18	18	19	19	20	21	24	24	25	27	32	34				2
3	24	26	23	21	16	14	16	14	12	11	10	10	8	8	9	7	7	7	8	8	7	8	8	9	8	10	11	12	13	14	16	18	20	23	25	26	3
4	18	18	15	14	12	9	9	7	6	5	4	3	1	2	1	0	0	0	0	1	1	1	2	1	2	4	5	6	7	9	10	12	13	15	18	18	4
5	16	18	16	13	13	10	10	8	7	6	5	4	2	3	3	2	2	2	1	2	2	2	3	3	4	5	6	8	7	11	10	12	13	16	17	15	5
6	23	24	22	19	18	16	16	12	12	11	11	10	9	10	9	8	8	8	8	8	8	9	9	9	9	10	9	13	13	15	16	18	19	23	24		6
7				38	33	37	27	31	31	29	22	24	25	22	23	23	23	24	20	22	20	22	22	25	29	27	25	26	27	30	30	32	34				7
8							23	30	26	20	20	20	18	17	16	16	15	17	16	17	17	17	17	17	17	20	19	21	23	24							8

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FIGURE 6. DIRECTIONAL ARRAY ANTENNA

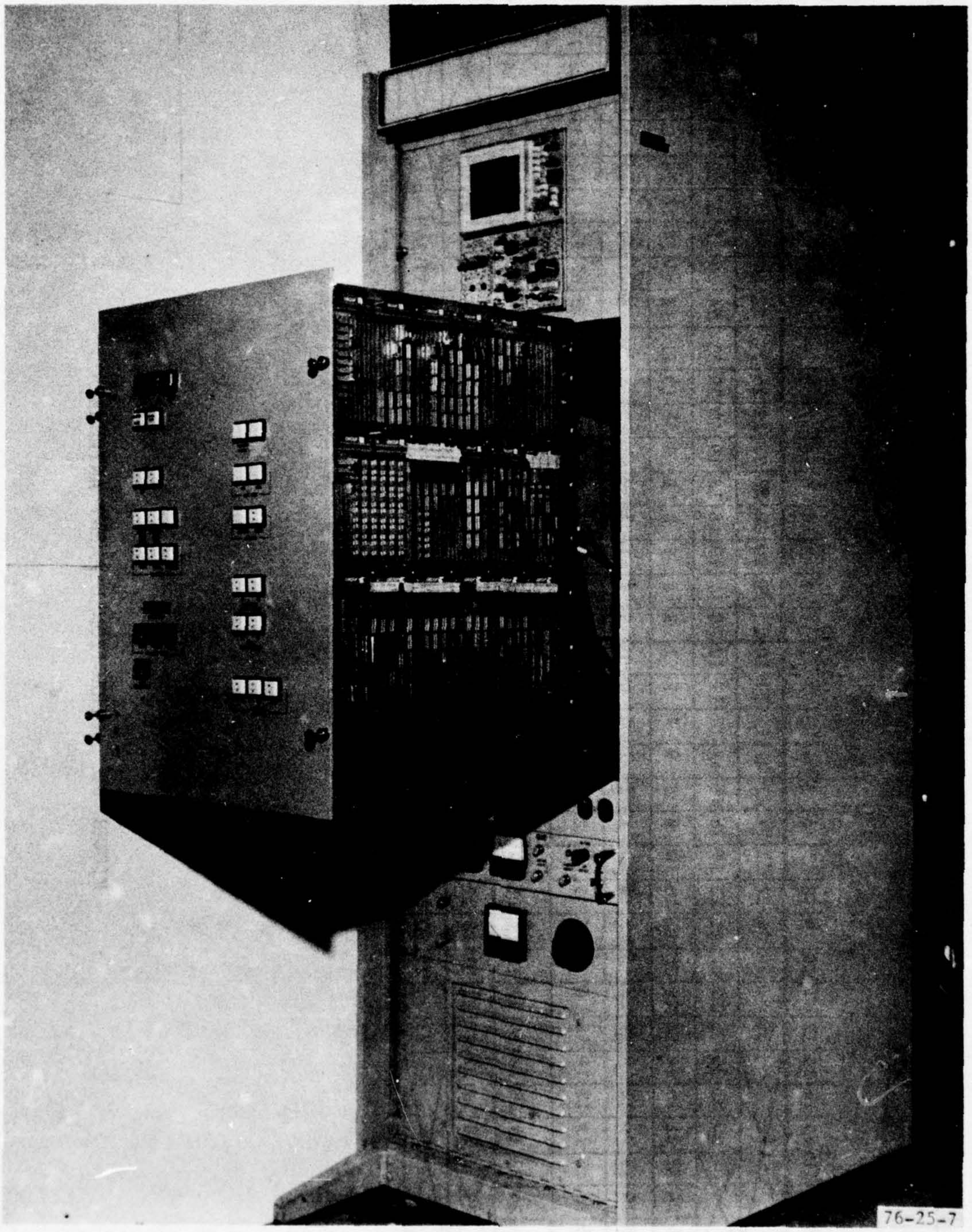


FIGURE 7. RADAR BEACON PERFORMANCE MONITOR EQUIPMENT

directional beam passes through it. The other major function determines that a predetermined maximum runlength (in terms of azimuth change pulses (ACP,s)) of the antenna beam is not exceeded. The design of the monitor is such that the two major functions must coexist. A simplified block diagram of the antenna system monitor is shown in figure 8.

The directional antenna beam is acquired by the pickup probe and crystal detected, video amplified, and quantized by the receiver. The receiver/quantizer is adjusted such that P_3 interrogations which are 10 dB to 15 dB below the nose of the beam are quantized. This was determined to be the level where the near-field beam was most symmetrical and had the sharpest skirts.

The quantized beam video is then routed to a down-counter and a lead edge beam detector. The down-counter is preset at reference pulse time to some predetermined minimum number of interrogations. As each quantized P_3 is received at or above the predetermined level, the down-counter is decremented until the prescribed minimum number of hits has been attained and the latch is SET. If the predetermined number of hits is not attained, the scan integrator is incremented once-per-scan by the reference pulse until an error criterion is met and an error indicated.

The beam detector determines when the lead and trail edges of the near-field antenna beam have occurred. During the time interval when the directional beam is looking at the pickup probe, the beam detector allows the down-counter to be decremented by ACP's. The down-counter is preset at reference pulse time to a predetermined runlength, in terms of ACP's, which should be equal to the near-field antenna beam-width (± some tolerance). During the scan, if the beam-width is out of tolerance, the latch is SET, and the scan integrator is incremented. A runlength error is declared when a predetermined number of scan errors is determined by the scan integrator.

TEST RESULTS

Physical and electrical parameters were varied during the testing in order to establish a baseline. Testing was then performed and data were obtained in both the near- and far-field of the open-array antenna. In addition, far-field data were obtained for both a perched transponder target and an operational test flight target.

BASE LINE DATA.

Initial system performance of the radar beacon interrogator and the beacon performance monitor over a transmitter power variation was verified. The data in table A-1 of appendix A show the RBPM antenna monitor performance perturbation as the ATCBI-3 transmitter power was varied under controlled test conditions. The photographic data in figure A-1 show similar results as the power was varied via an attenuator at the input to the RBPM.

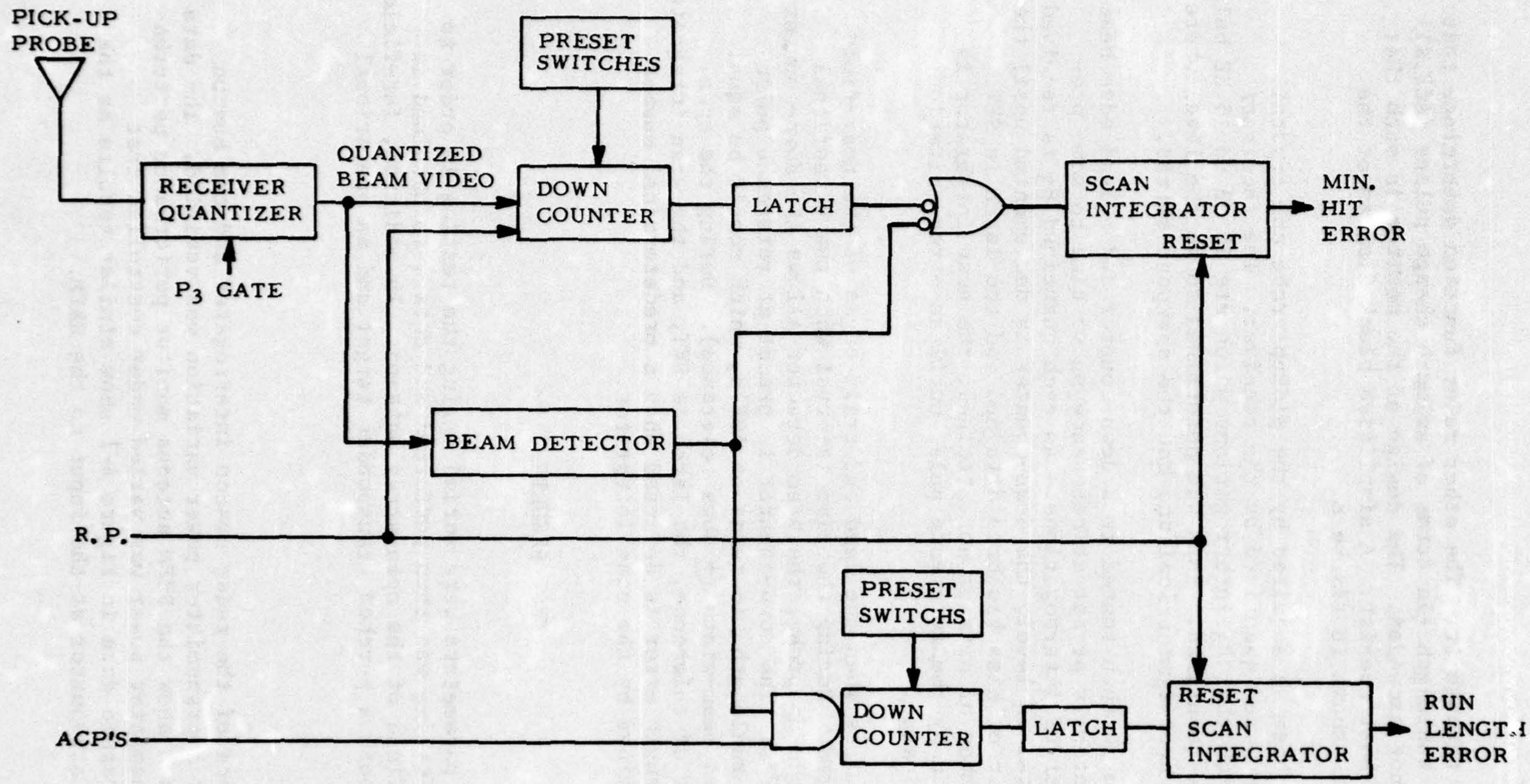


FIGURE 8. SIMPLIFIED BLOCK DIAGRAM RBPM ANTENNA SYSTEM MONITOR

The data in figure A-2, of appendix A, show the variations in the detected antenna pattern as the physical parameters of the pickup probe were changed. The resulting photographs were obtained as the monitor pickup probe was rotated about its axis as depicted in figure 1. There were 36 photographs taken, one for each 10° of pickup antenna rotation. Only a representative sampling of the photographs was used in this report, one for each 30° of antenna rotation.

The data indicated the physical placement of the monitor probe on the antenna platform was not critical for near-field monitoring of the open-array antenna.

NEAR- AND FAR-FIELD MONITORING DATA.

Electrical parameters were varied during the tests by introducing failures into the antenna. Three levels of antenna failure were introduced by disconnecting from one to three azimuth elevation networks of the antenna. As can be observed in figure 6, most of the transmitted power is concentrated near the center of the antenna. One test was performed with elevation networks 3, 4, and 5 removed. A second test was made with only elevation network No. 3 disconnected, and a third test, with only elevation network No. 12 removed. The third test was intended to determine the sensitivity of the RBPM antenna system monitor. Since the No. 12 network possessed relatively low transmitted power in relation to the total output of the antenna, no effects in the far-field were expected. Data resulting from these tests can be found in appendix B.

The ARTS III system software was modified to permit extraction of the desired data. Tables B-3, B-4, B-5, and B-6 show the far-field raw data which were obtained using this method with the various antenna test configurations. The data were recorded manually from the software modified display of the ARTS III plan position indicator (PPI). The data indicate the azimuth of the perched transponder expressed in ACP's and the target runlength expressed as a number of interrogations based upon the Pulse Repetition Frequency (PRF). The numeric data on the display were presented in the octal (base 8) number system. The data tables list the decimal equivalent together with the corresponding number of degrees. The averages of the far-field data were also recorded in tables B-1 and B-2.

Similarly, the near-field data were manually recorded from the antenna system monitor switch settings. During these tests, the near-field monitor was aligned to extremely tight tolerances, such that a single unit switch change would indicate an alarm. The averages of the hexidecimal switch data are recorded in table B-1, and the decimal equivalent is listed in table B-2. Therefore, table B-1 lists the averages of both the near- and far-field data in the number base which was recorded during the testing. Table B-2 lists the reduced data in a decimal number base format.

The photographs in figure B-1 show the near-field open array antenna patterns obtained for various antenna configurations using the test equipment setup as shown in figure 2.

The compilation of data in table B-2 indicates the RBPM antenna system monitor will effectively monitor the open-array antenna for failures in the near-field. Specifically, the near-field runlength monitor is normally expected to operate in the range of 571 ACP's. The data show that with column 3 disconnected, the count of the runlength monitor increased to 651. Thus, even if the RBPM were aligned to tolerate a ±1 dB change in radiated power, the monitor could detect a degradation of the antenna performance. Similarly, when only column 12 (physically located near the outside edge of the antenna) was disconnected, the minimum-hit monitor count decreased to a count of 204 from a normally expected count of 220. Thus, even a slight antenna performance degradation could be detected when probabilities and error integration were considered. In contrast, from the data in table B-2, the far-field transponder target was not capable of detecting the lesser antenna failures by either hit counts or changes in azimuth.

OPERATIONAL FLIGHT TEST DATA.

As the far-field transponder testing neared completion, the data indicated that additional testing using a controlled aircraft was required. This was indicated in two primary ways when lesser type antenna failures were introduced during the previous testing. First, the far-field perched transponder data did not indicate any system problem when the near-field monitor did in fact, recognize the antenna failure which was introduced. Second, the broadband video as presented on the plan position indicator (PPI) during this phase of the testing appeared to be abnormal; i.e., the target runlength and hit count of operational targets appeared to be inconsistent as a function of range and azimuth. The photograph in figure C-11 shows the ARTS III display with antenna columns 3, 4, and 5 disconnected, and is an exaggerated example of the phenomenon which occurred with lesser type antenna failures.

Therefore, a flight test was performed in which a test aircraft was flown at a radial of 215° from the TFAST facility at altitudes of 1,000 feet, 3,000 feet, and 5,000 feet, with the various antenna test configurations. The resulting data are included in appendix C.

The test was performed using the improved side lobe suppressions (ISLS) feature with the ATCBI-3 and the ARTS III system. The ARTS III software was further modified (due to the excessively long target runlengths and large target holes caused by the failed antenna) to display and record the required information.

The raw data as recorded by the ARTS system for the various flight altitudes and antenna configurations are included in tables C-1 through C-5. The data list the test aircraft range, azimuth, hit count -1, and runlength -1, for the outbound and inbound flight for each test.

The test aircraft runlength versus range data from the tables were plotted and illustrated in figures C-1 through C-10. Ideally, the plot should be nearly flat. However, when all the illustrations are considered together with the photographic data, there appears to be a phenomenon which occurs as a function of elevation angle from the antenna. This phenomenon might be described as elevation angle lobing, which is a combination of both side lobes and vertical lobes. As can be observed from the data in appendix C, this phenomenon is evident at close range for the test aircraft at low alitude and moves out in range as the aircraft altitude increases. Also, the intensity of the phenomenon increases or decreases in direct proportion to the degree of antenna failure. In addition, the effects of the phenomenon are least pronounced at the lowest elevations. Also significant is that the phenomenon created apparent system azimuth errors and target splits due to the asymmetrical, deformed antenna beam and lobing.

SUMMARY

Data were obtained using a near-field monitor, a far-field perched transponder, and an operational flight test aircraft. Three failed antenna conditions were simulated by disabling azimuth networks. The near-field monitor was capable of detecting the antenna failures under all test conditions. The far-field perched transponder used in conjunction with an ARTS III system could detect only the more severe antenna failures. In addition, a phenomenon was observed when the antenna was failed which occurred as a function of elevation angle from the transmitter site.

CONCLUSIONS

Based on the data collected and presented in this document, it is concluded that:

1. Failures of the phased open-array antenna can be monitored via hardware in the near-field.

2. An antenna beam shape phenomenon occurs when the phased open-array antenna fails, such that a far-field transponder cannot be used as a monitor with any degree of certainty for all conditions of antenna failure.

3. The phenomenon which occurs with an antenna failure could appear to the observer of a PPI to be other system problems such as side lobes, reflections, vertical lobes, azimuth shifts, and/or target splits.

4. It is unlikely that a phased array antenna could fail in such a way as to cause a true electrical azimuth error, i.e., the radiated energy uniformly beamed in a horizontal direction other than boresight.

RECOMMENDATIONS

From the data and conclusions obtained in an investigation into the capability of monitoring a phased open-array antenna, it is recommended that:

1. A near-field technique be employed when monitoring a phased open-array antenna.

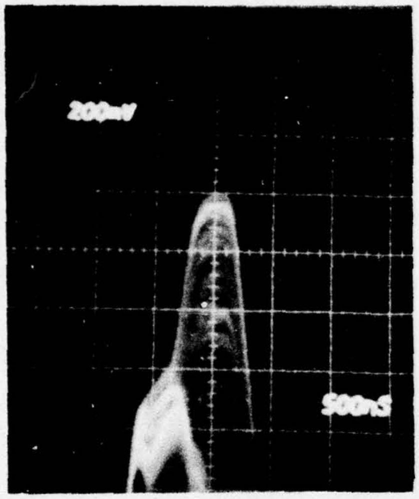
2. A statistical solution to antenna system monitoring be investigated using automated system hardware and software.

APPENDIX A

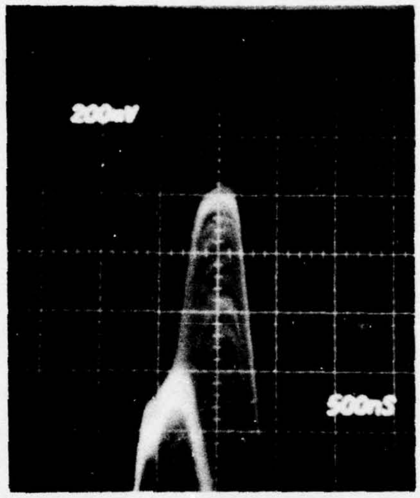
BASELINE DATA

LIST OF ILLUSTRATIONS

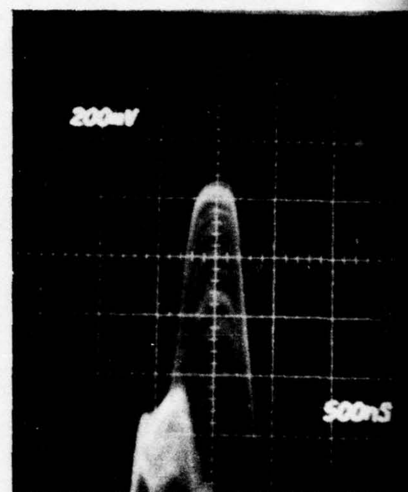
TABLE



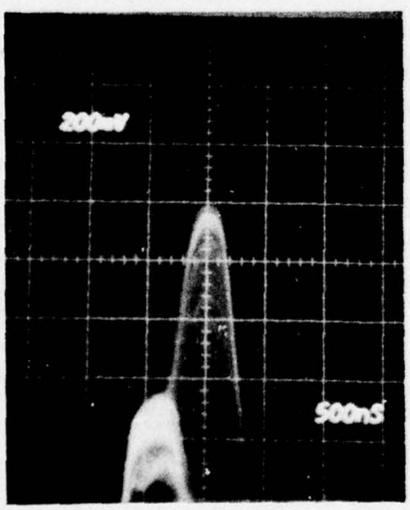
200 WATTS
14 dB ATTENUATION
-2 dB



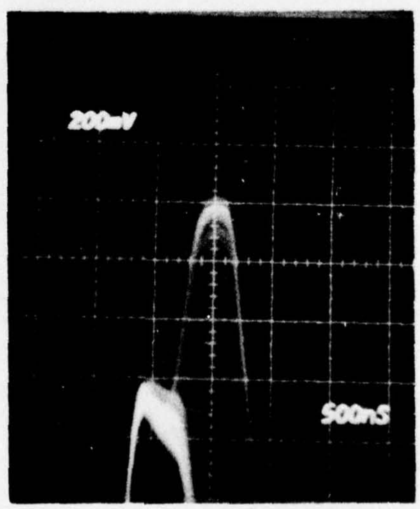
200 WATTS
13 dB ATTENUATION
-1 dB



200 WATTS
12 dB ATTENUATION
0 dB REFERENCE

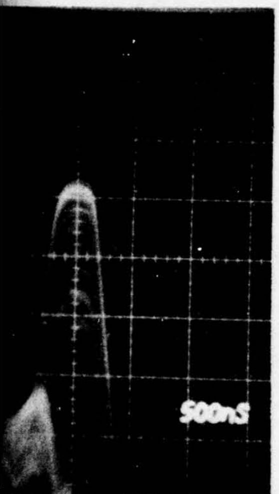


126 WATTS
-2 dB

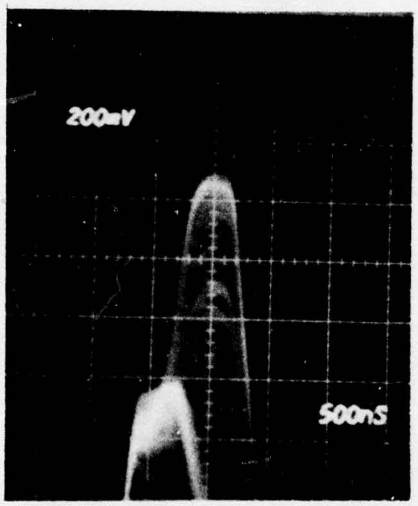


159 WATTS
-1 dB

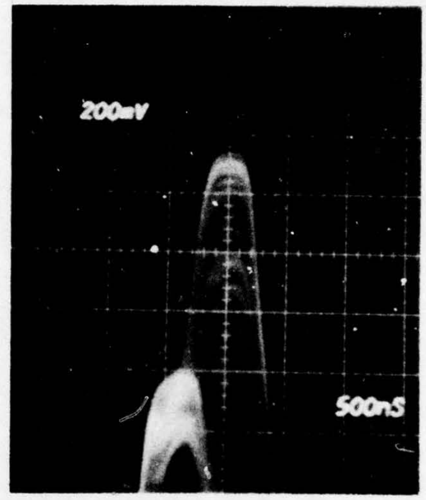
FIGURE A-1. POWER VARIATION BAS



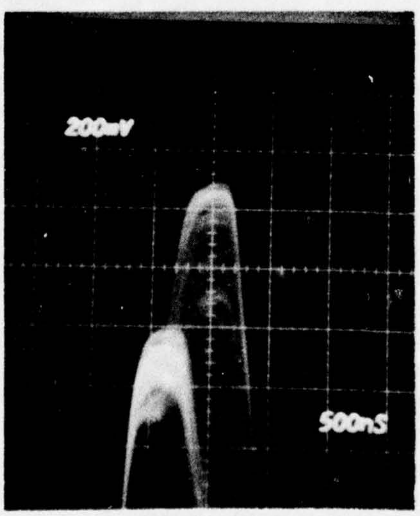
ATTS
B ATTENUATION
REFERENCE



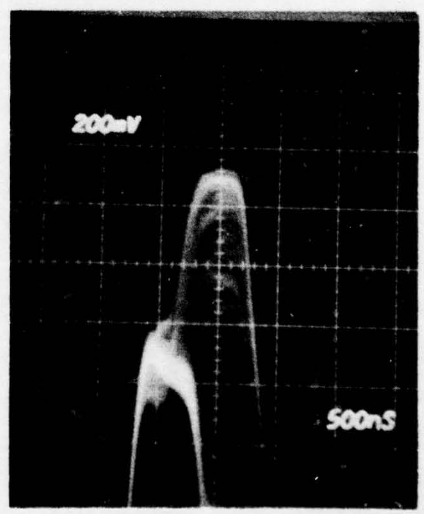
200 WATTS
11 dB ATTENUATION
+1 dB



200 WATTS
10 dB ATTENUATION
+2 dB



252 WATTS
+1 dB



317 WATTS
+2 dB

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OWER VARIATION BASELINE DATA

2

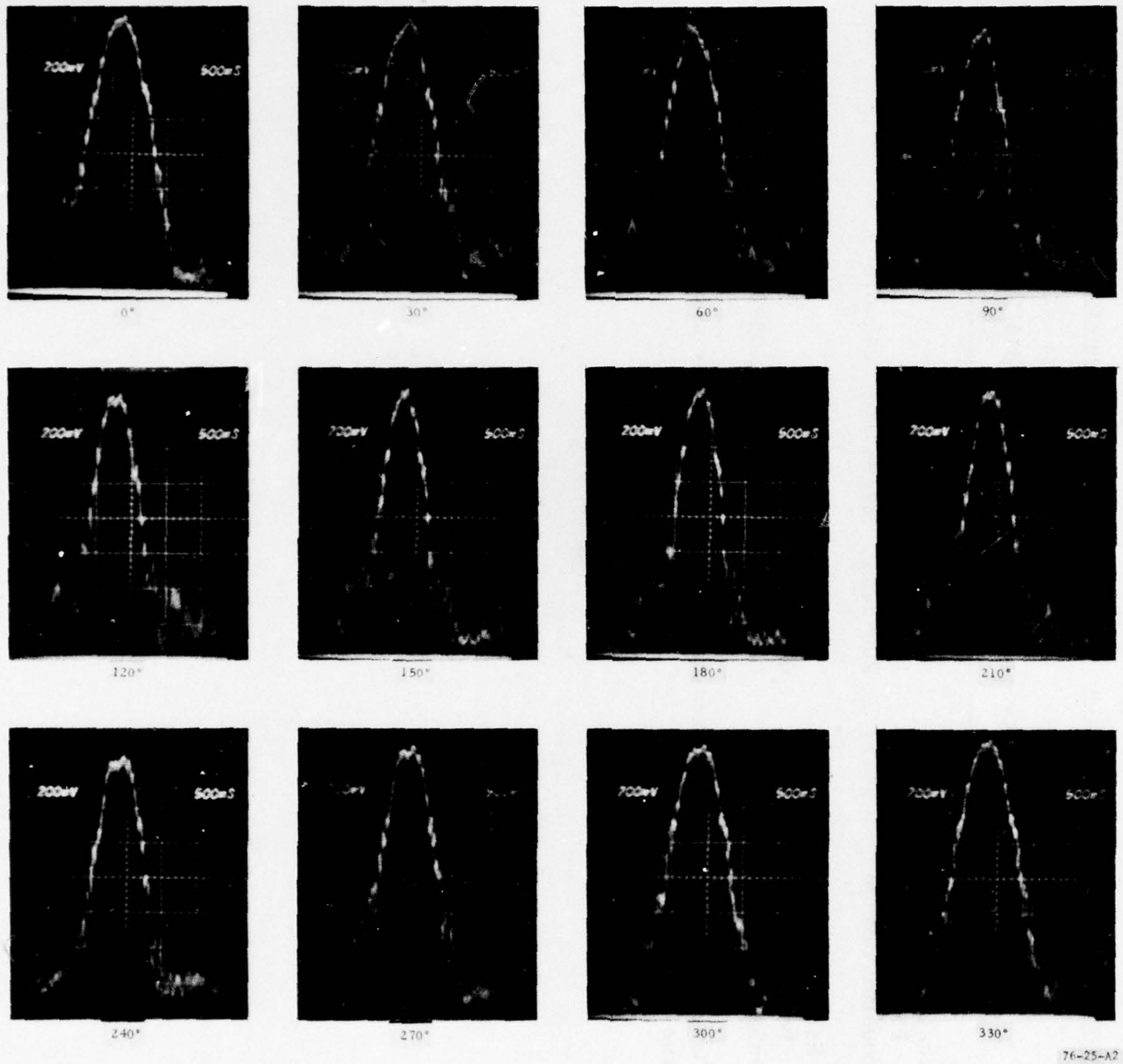


FIGURE A-2. ROTATION OF MONITOR PICKUP PROBE

TABLE A-1. TRANSMITTER POWER VARIATION BASELINE DATA

Transmitter Power = 200 Watts   In Line Attenuator = 12 dB

	126 Watts -2 dB	158 Watts -1 dB	251 Watts +1 dB	316 Watts +2 dB	200 Watts
Runlength (ACP's)					
Power Change	1BF=447	205=517	261=609		23E=574
Attenuator Change	1C5=453	20D=525	277=631	2A4=676	
Minimum Hit (P_3 Interrogations)					
Power Change	0B3=179	0C8=200	0EE=238		0DE=222
Attenuator Change	0C0=192	0D3=211	0F8=231	10B=267	

NOTE: Data are represented in hexidecimal format together with the decimal equivalent.

APPENDIX B

NEAR- AND FAR-FIELD MONITORING CAPABILITY DATA

LIST OF TABLES

ILLUSTRATION

TABLE B-1. RAW DATA OF NEAR AND FAR-FIELD RELATIONSHIPS AS A FUNCTION OF ANTENNA FAILURE

		NEAR-FIELD (All Data in Number Base 16)							FAR-FIELD (All Data in Number Base 8)			
Parameter	Date	Normal	Column 3,4,5	Column 3	Column 12	-2 dB 126 Watts	-1 dB 158 Watts	+ dB 251 Watts	+2 dB 316 Watts	Normal	Column 3,4,5	Column 3	Column 12
Runlength (ACP's)	8-29	23F	21F										
	9-3	239		28B									
	9-5	238			216								
	9-10	23E				1C5	20D	277	2A4				
	9-12					1BF	205	261					
	9-17												
Minimum Hit (P_3 Inter)	8-29	OD8	098										
	9-3	ODC		OE3									
	9-5	ODC			OCC								
	9-10	ODE											
	9-12												
	9-17									23.64	19.25	23.00	23.46
Azimuth (ACP's)	8-29	AFE	AF3										
	9-3	AFE		AF3									
	9-5	AFE			BOF								
	9-10					OCO	OD3	OF8	10B				
	9-12					OB3	OC8	OEE					
	9-17									503.5	504.4	503.5	503.5

LEGEND:

A = 10
B = 11
C = 12
D = 13
E = 14
F = 15

Transmitter Power = 200 Watts
PRF = 343 Inter/Sec
Scan = 12.75 Sec
Raw Data
4-FOOT OPEN ARRAY ANTENNA TEST DATA

TABLE B-2. REDUCED DATA OF NEAR AND FAR-FIELD RELATIONSHIPS AS A FUNCTION OF ANTENNA FAILURES.

		NEAR-FIELD								FAR-FIELD			
Parameter	Date	Normal	Column 3,4,5	Column 3	Column 12	-2 dB 126 Watts	-1 dB 158 Watts	+1 dB 251 Watts	+2 dBB 316 Watts	Normal	Column 3,4,5	Column 3	Column 12
Runlength (ACP's)	8-29	574	543										
	9-3	569		651									
	9-5	568			534								
	9-10	574				453	525	631	676				
	9-12					447	517	609					
	9-17												
Minimum Hit (P3 Inter)	8-29	216	152										
	9-3	220		227									
	9-5	220			204								
	9-10	222				192	211	231	267				
	9-12					179	200	238					
	9-17									19.6	15.9	19.0	19.5
Azimuth (ACP's)	8-29	2814	2803										
	9-3	2814		2803									
	9-5	2814			2820								
	9-10												
	9-12												
	9-17									323.5	324.4	323.5	323.5

Transmitter Power = 200 Watts
PRF = 343 Inter/Sec
Scan = 12.75 Sec
Reduced Data - Number Base 10

4-FOOT OPEN ARRAY ANTENNA TEST DATA

TABLE B-3. FAR-FIELD PERCHED TRANSPONDER DATA WITH A NORMAL ANTENNA

Antenna Type - Hazeltine Directional Array
Antenna Configuration - Normal
Date - September 17, 1975
Test - Fixed Transponder - Select Code 7540

FAR-FIELD
DATA AS PROCESSED BY THE ARTS III

	AZIMUTH (ACP)		RUNLENGTH (PRF)	
	DECIMAL NUMBER	= DEGREES	DECIMAL NUMBER	= DEGREES
	323	28.33	20	4.46
	323	28.33	20	4.46
	322	28.25	20	4.46
	325	28.51	19	4.24
	322	28.25	18	4.01
	324	28.42	21	4.68
	323	28.33	20	4.46
	324	28.42	20	4.46
	323	28.33	20	4.46
	325	28.51	19	4.24
	324	28.42	19	4.24
Average	323.5	28.37	19.6	4.37

TABLE B-4. FAR-FIELD PERCHED TRANSPONDER DATA WITH ANTENNA COLUMNS 3, 4, AND 5 OPEN

Antenna Type - Hazeltine Directional Array
Antenna Configuration - Columns 3, 4, and 5 open
Date - September 17, 1975
Test - Fixed Transponder - Select Code 7540

FAR-FIELD
DATA AS PROCESSED BY THE ARTS III

	AZIMUTH (ACP)		RUNLENGTH (PRF)	
	DECIMAL NUMBER	= DEGREES	DECIMAL NUMBER	= DEGREES
	324	28.42	16	3.57
	326	28.60	17	3.79
	323	28.33	16	3.57
	325	28.51	14	3.12
	325	28.51	16	3.57
	324	28.42	17	3.80
	326	28.60	15	3.35
	326	28.60	17	3.80
	323	28.33	15	3.35
	327	28.68	15	3.35
	321	28.16	17	3.80
	323	28.33	16	3.57
Average	324.4	28.46	15.92	3.55

TABLE B-5 FAR-FIELD PERCHED TRANSPONDER DATA WITH ANTENNA COLUMN 3 OPEN

Antenna Type - Hazeltine Directional Array
Antenna Configuration - Column 3 Open
Date - September 17, 1975
Test - Fixed Transponder Select Code 7540

FAR-FIELD
DATA AS PROCESSED BY THE ARTS III

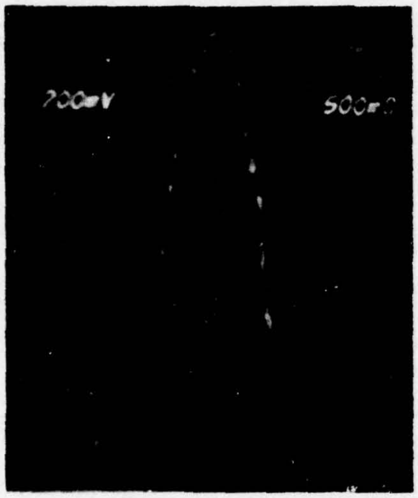
	AZIMUTH (ACP)		RUNLENGTH (PRF)	
	DECIMAL NUMBER	= DEGREES	DECIMAL NUMBER	= DEGREES
	325	28.51	18	4.01
	322	28.25	19	4.24
	325	28.51	17	3.79
	323	28.33	19	4.24
	325	28.51	20	4.46
	322	28.25	19	4.24
	324	28.42	20	4.46
	323	28.33	19	4.24
	326	28.60	19	4.24
	323	28.33	19	4.24
	323	28.33	19	4.24
	323	28.33	20	4.46
	322	28.25	20	4.46
Average	323.5	28.38	19.0	4.33

TABLE B-6. FAR-FIELD PERCHED TRANSPONDER DATA WITH ANTENNA COLUMN 12 OPEN

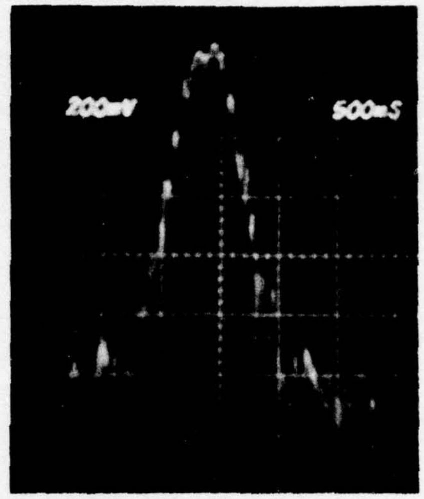
Antenna Type - Hazeltine Directional Array
Antenna Configuration - Column 3 Open
Data - September 17, 1975
Test - Fixed Transponder Select Code 7540

FAR-FIELD
DATA AS PROCESSED BY THE ARTS III

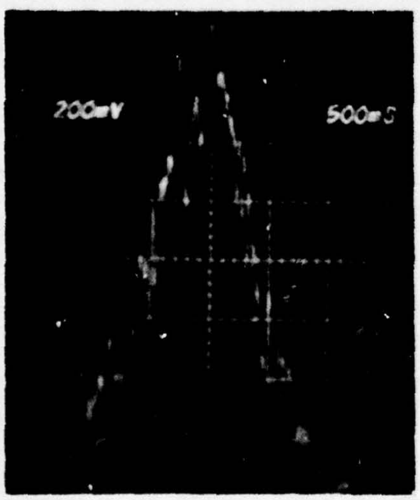
	AZIMUTH (ACP)		RUNLENGTH (PRF)	
	DECIMAL NUMBER	= DEGREES	DECIMAL NUMBER	= DEGREES
	322	28.25	18	4.01
	323	28.33	20	4.46
	324	28.42	20	4.46
	322	28.25	18	4.01
	320	28.07	19	4.24
	323	28.42	19	4.24
	324	28.42	20	4.46
	325	28.51	19	4.24
	325	28.51	19	4.24
	323	28.33	21	4.68
	325	28.51	19	4.24
	325	28.51	20	4.46
	324	28.42	17	4.68
Average	323.54	28.38	19.46	4.34



NORMAL ANTENNA
RUNLENGTH 23F=575 ACP
MIN. HIT OD8=216 P3
AZIMUTH AFE=2814 ACP
DATE 8/29/75



NORMAL
RUNLEN
MIN. HI
AZIMUT
DATE 9/

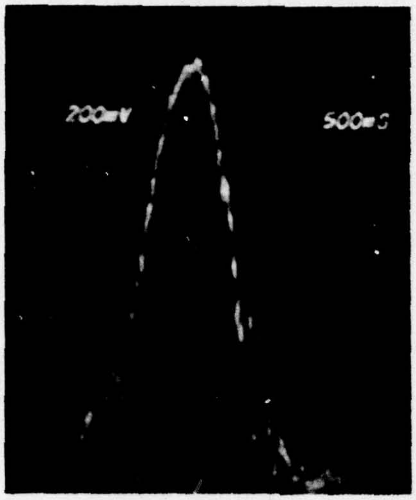


COLUMN 3-4-5 OPEN
RUNLENGTH 21F=543 ACP
MIN. HIT 098=152 P3
AZ=AF3=2803 ACP
DATE 8/29/75

COLUM
RUNLEN
MIN. HI
AZIMUT
DATE 9/

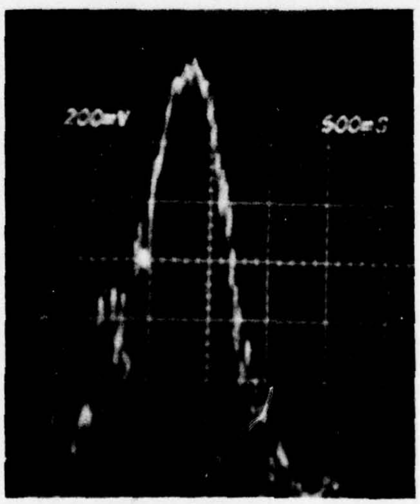
FIGURE B-1. NEAR-FIELD ANTENNA PAT
ANTENNA FAILURES

NORMAL ANTENNA
RUNLENGTH 239=569 ACP
MIN. HIT ODC=220 P3
AZIMUTH AFE=2814 ACP
DATE 9/3/75



NORMAL ANTENNA
RUNLENGTH 238=568 ACP
MIN. HIT ODC=220 P3
AZIMUTH AFE=2814 ACP
DATE 9/5/75

COLUMN NO. 3 OPEN
RUNLENGTH 28B=651 ACP
MIN. HIT OE3=227 P3
AZIMUTH AF3=2803 ACP
DATE 9/3/75



COLUMN NO. -12 OPEN
RUNLENGTH 216=534 ACP
MIN. HIT OCC=204 P3
AZIMUTH BOF=2820 ACP
DATE 9/5/75

ANTENNA PATTERNS AS A FUNCTION OF
LURES

2

APPENDIX C

OPERATIONAL DATA

LIST OF ILLUSTRATIONS

LIST OF TABLES

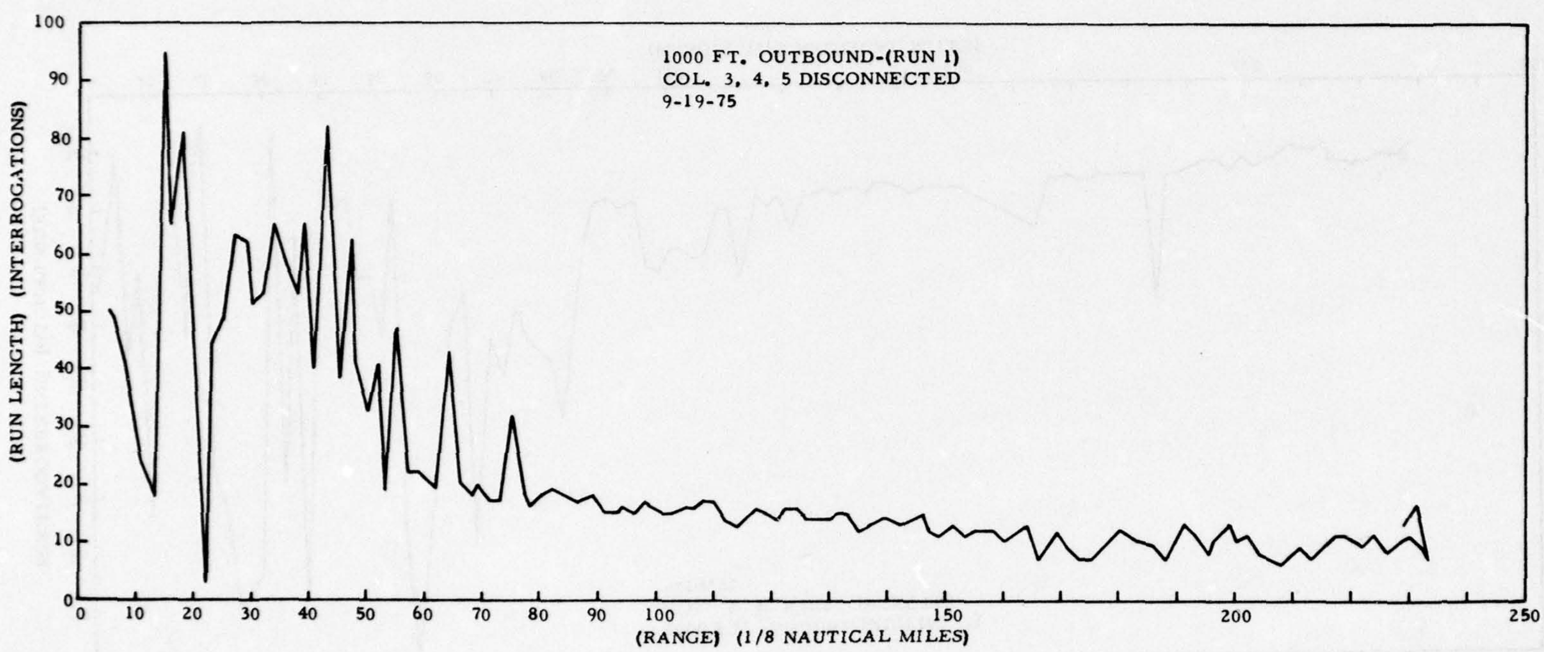
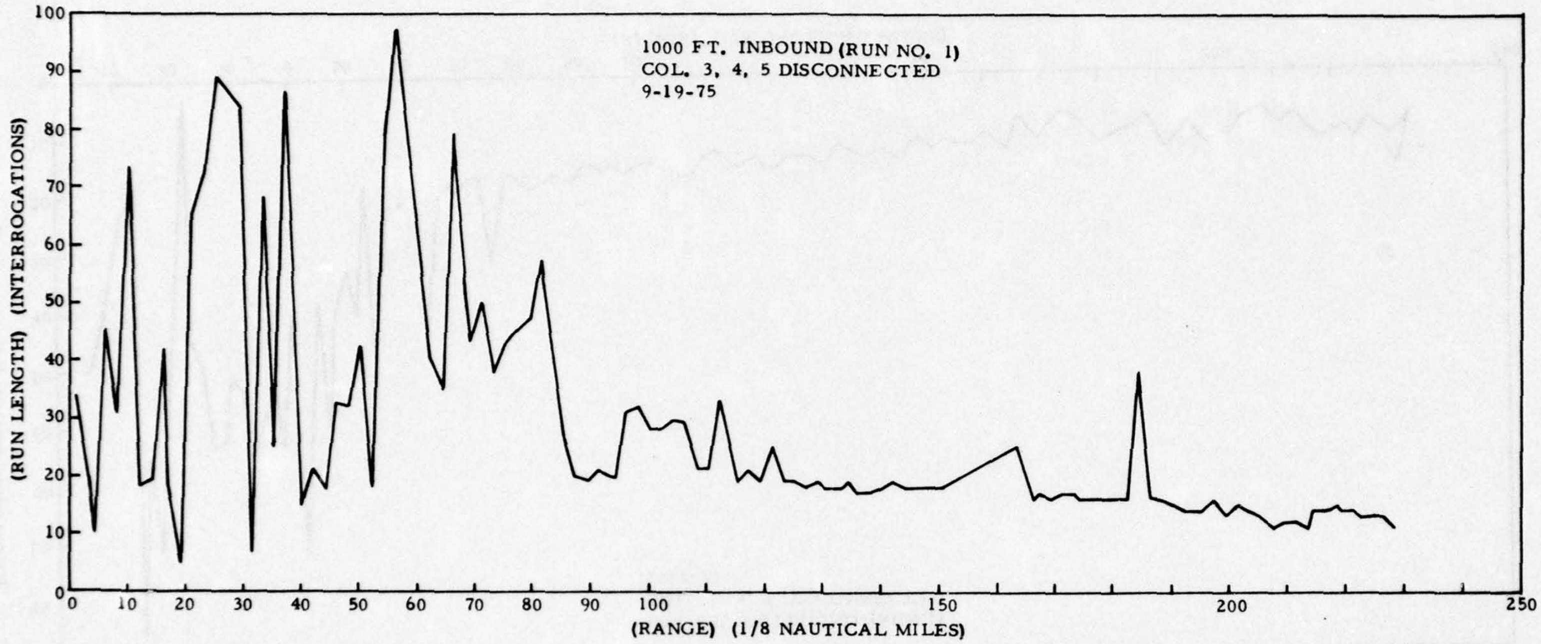


FIGURE C-1. RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-1



76-25-C2

FIGURE C-2. RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-1

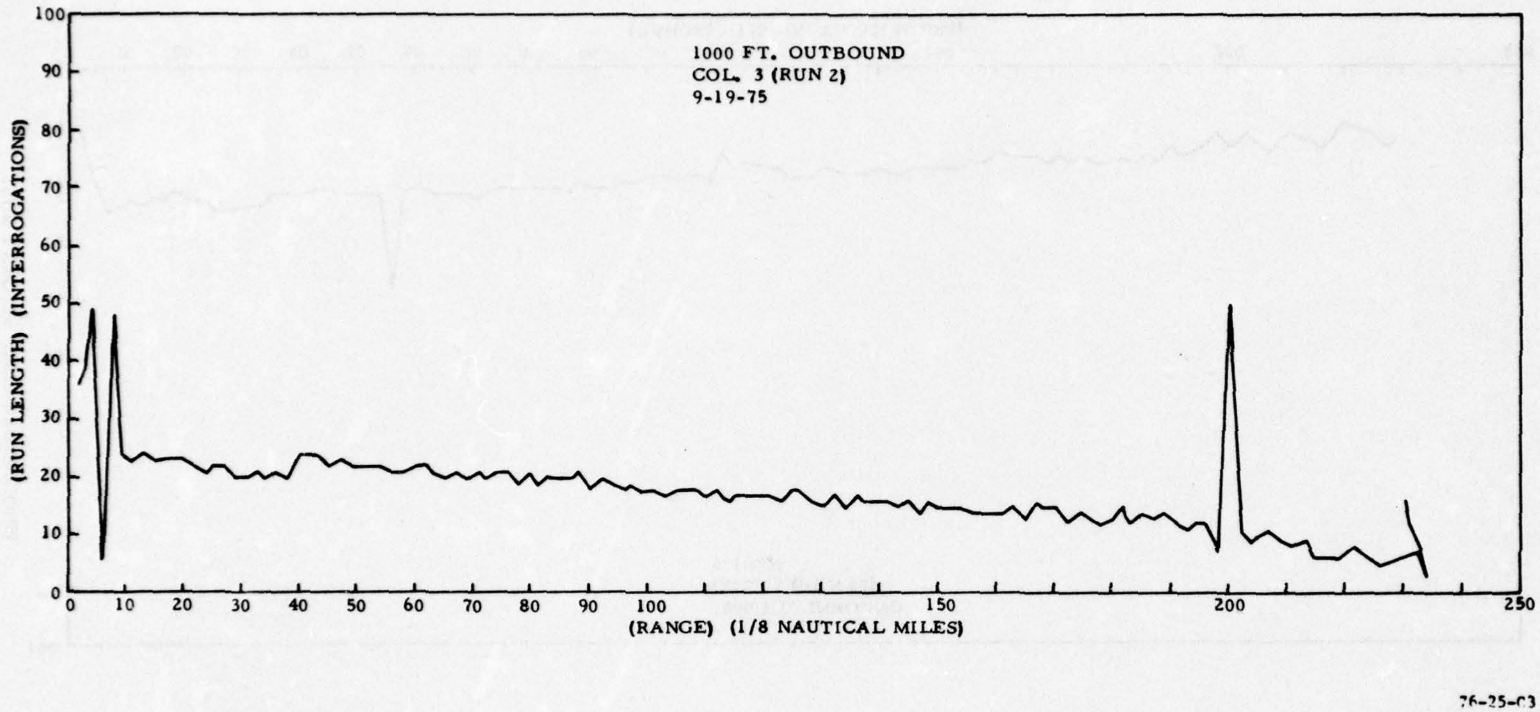
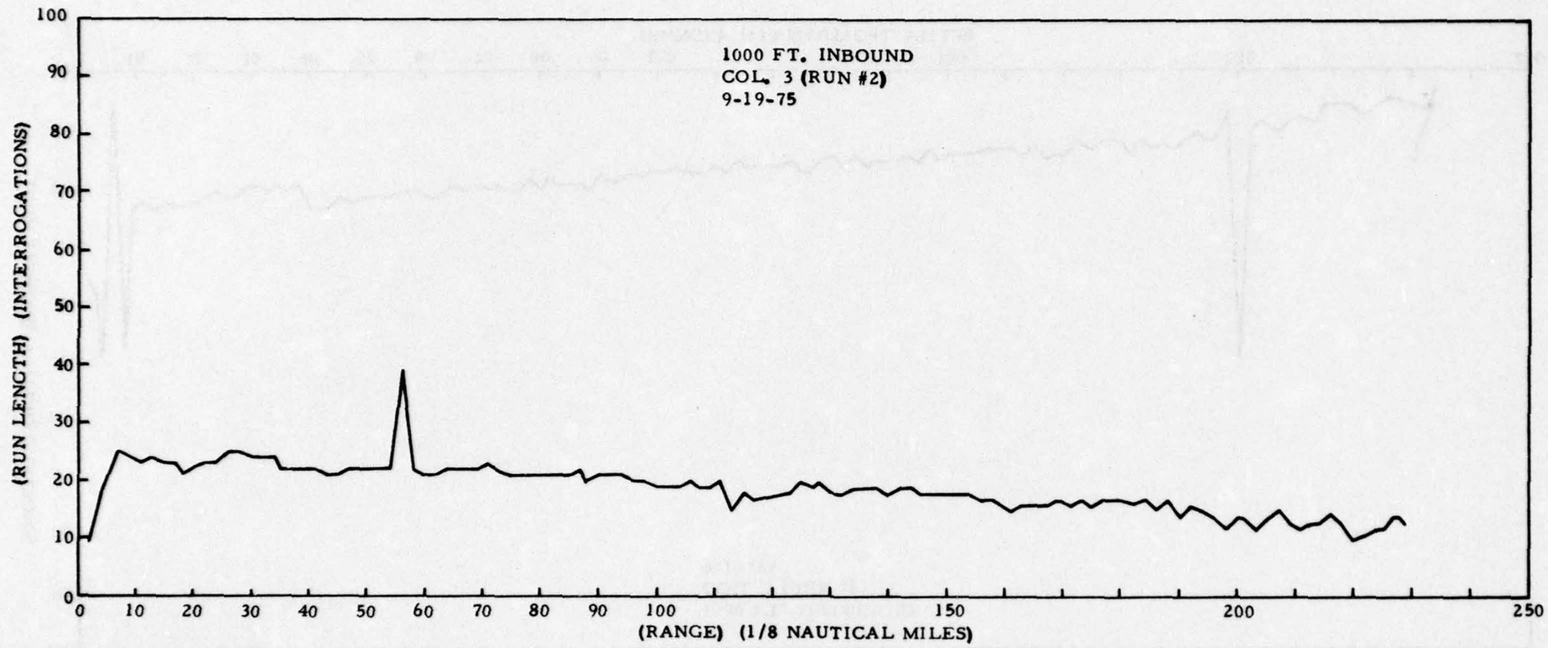


FIGURE C-3. RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-2



76-25-C4

FIGURE C-4. RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-2

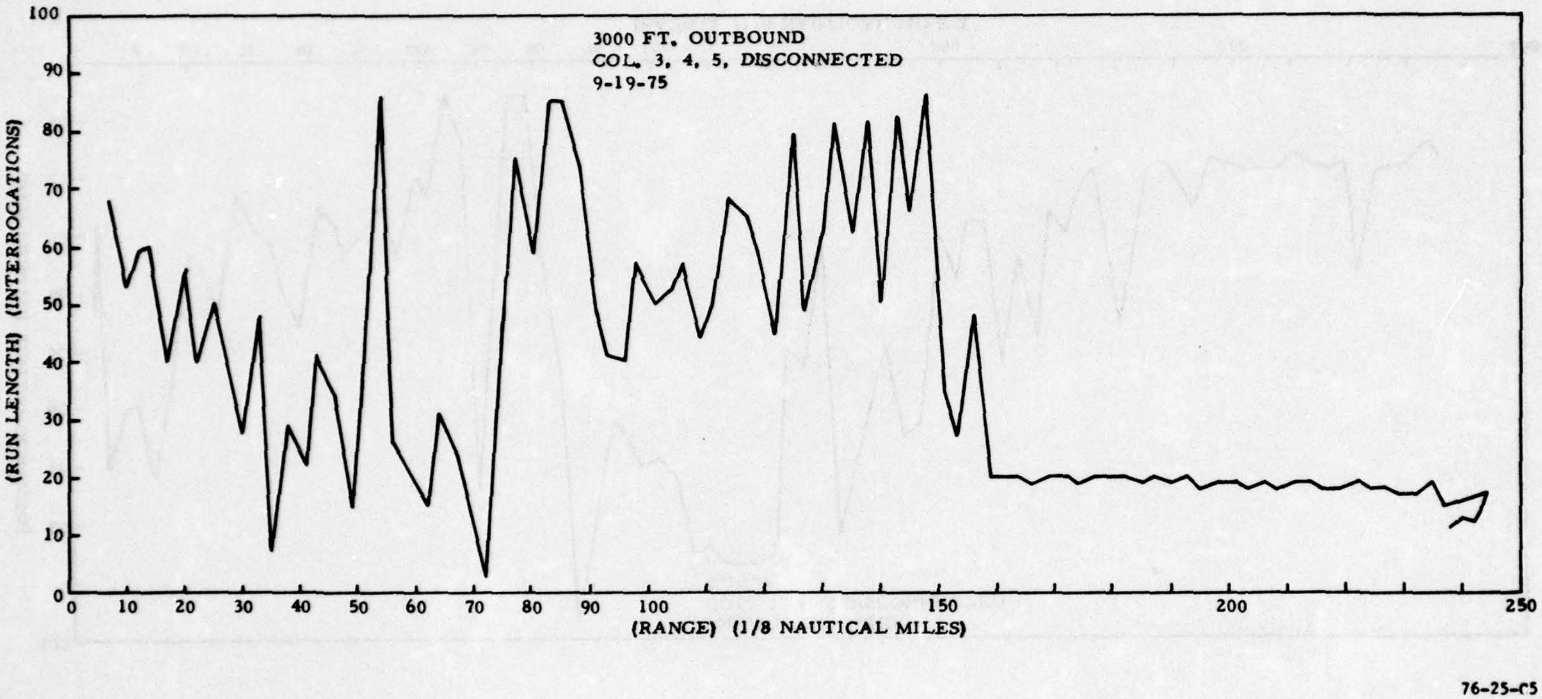


FIGURE C-5. RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-3

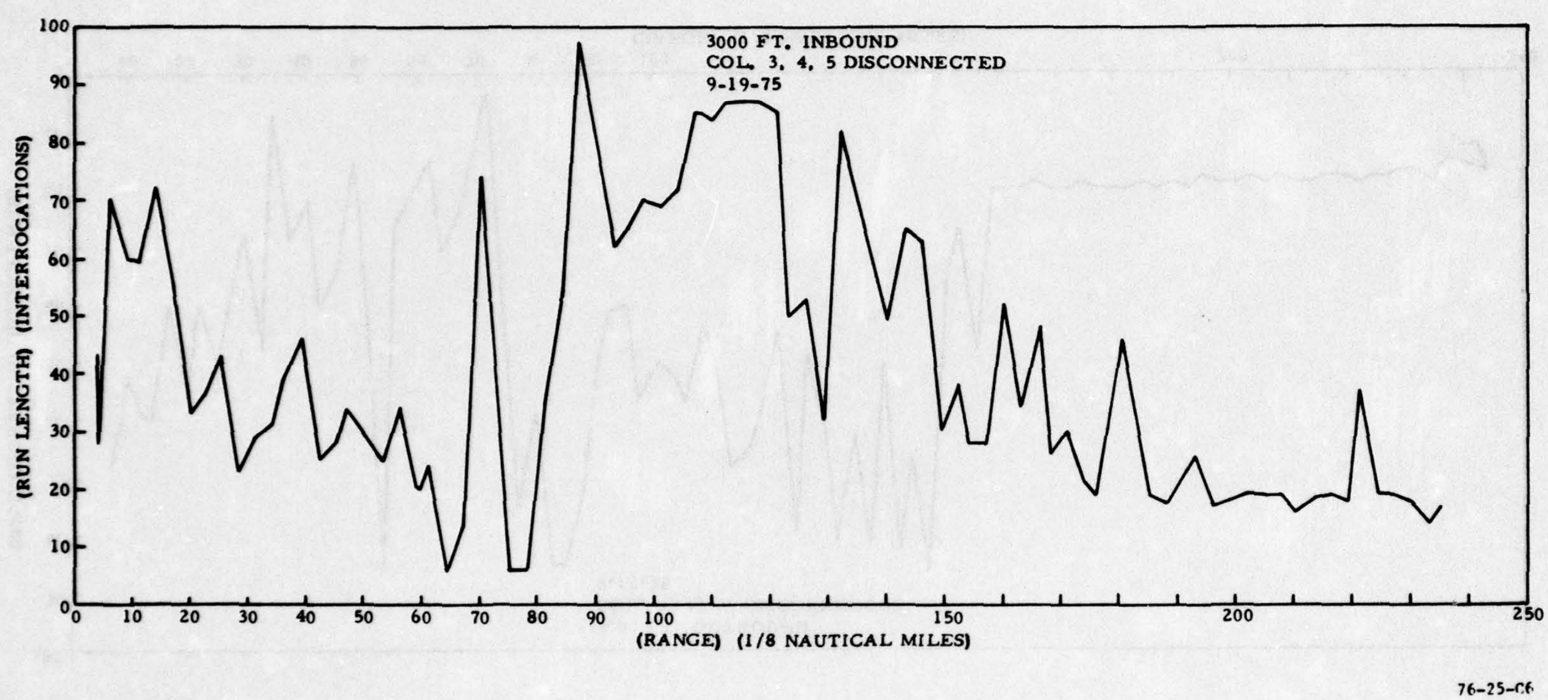


FIGURE C-6. RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-3

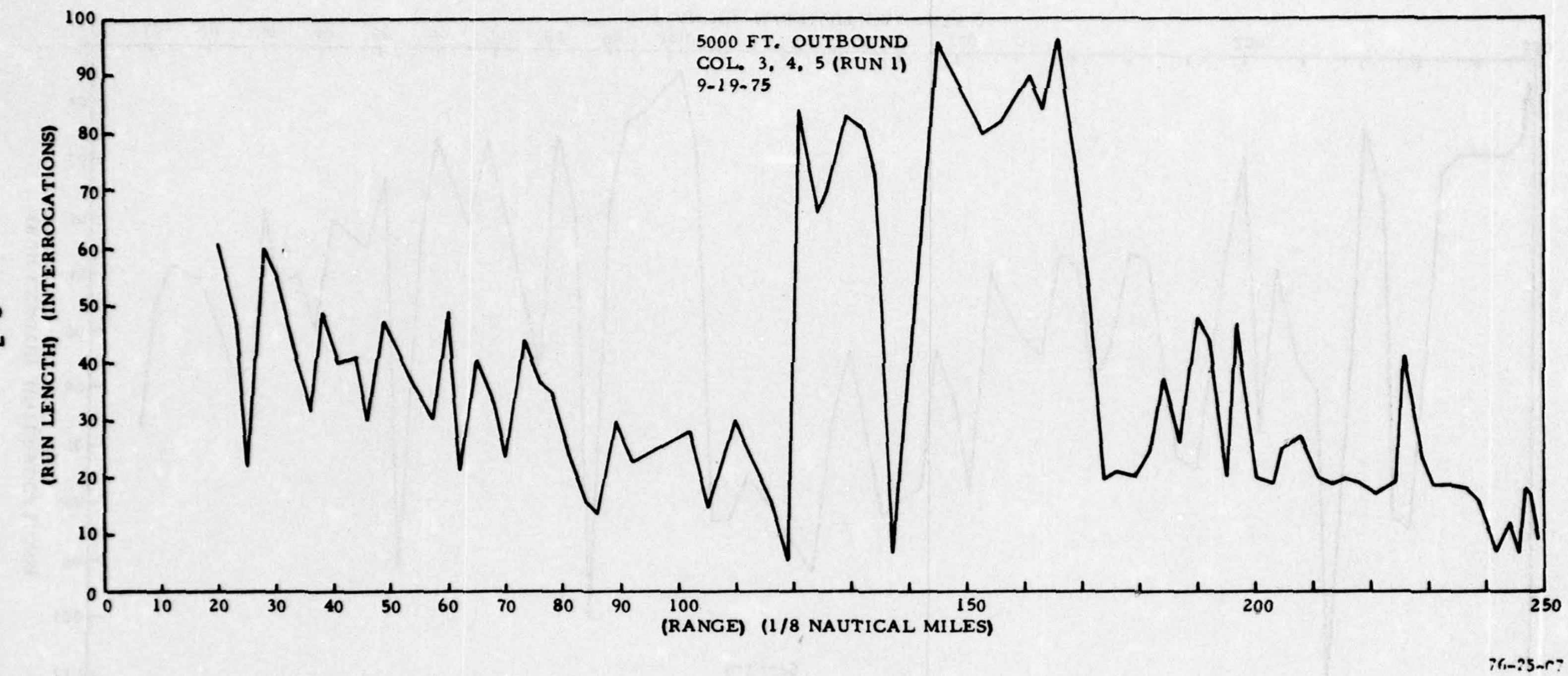


FIGURE C-7. RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-4

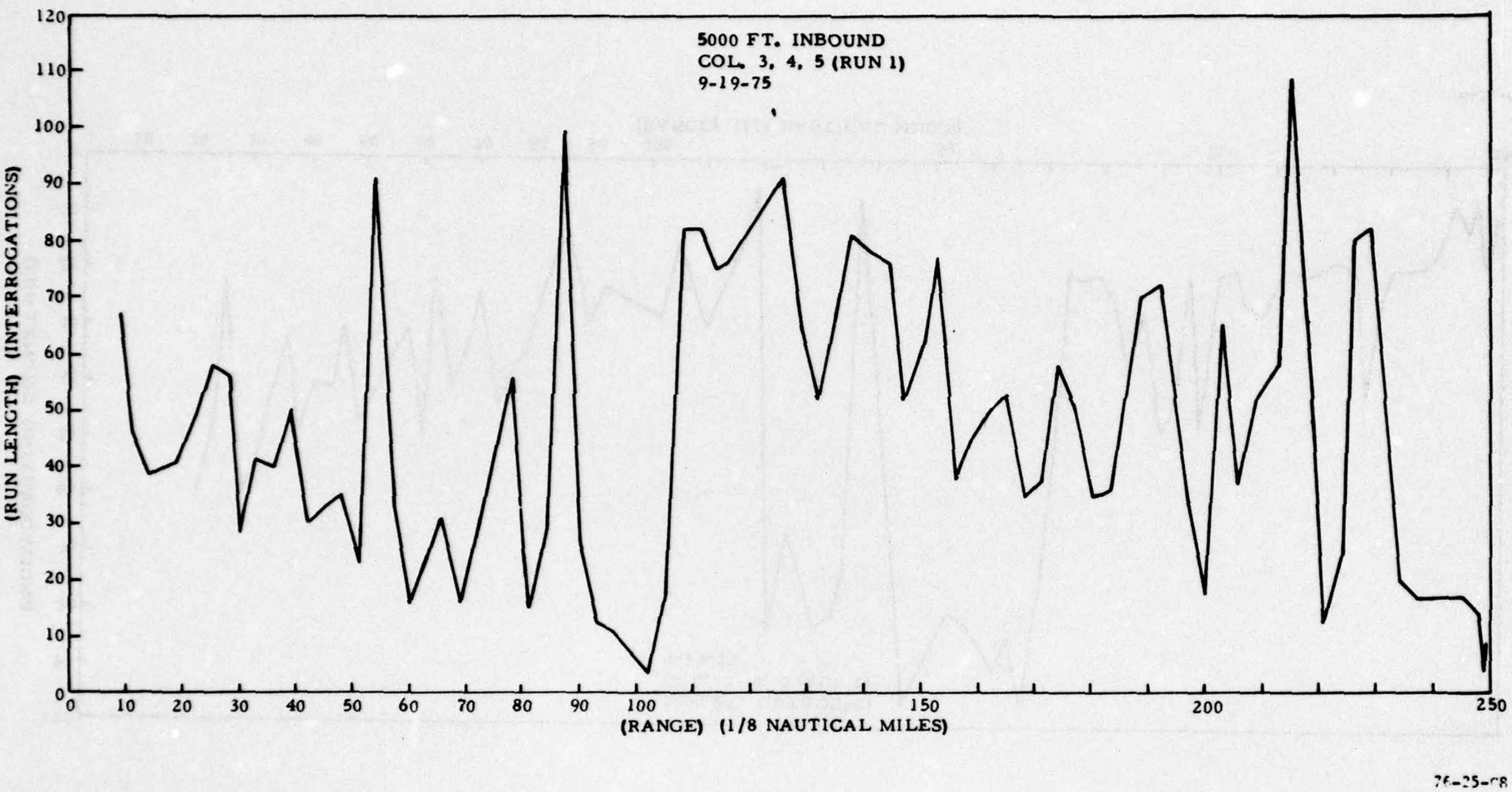
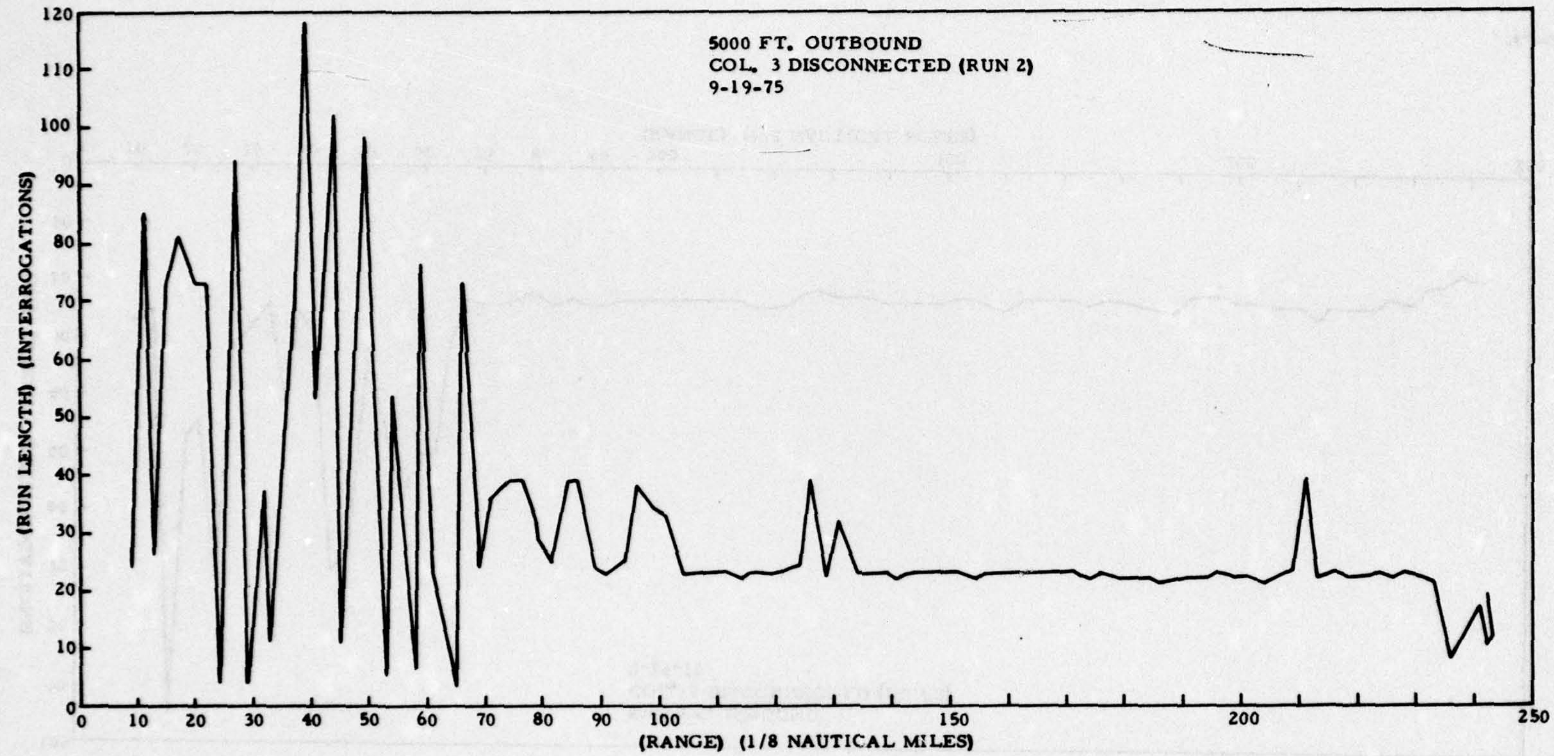
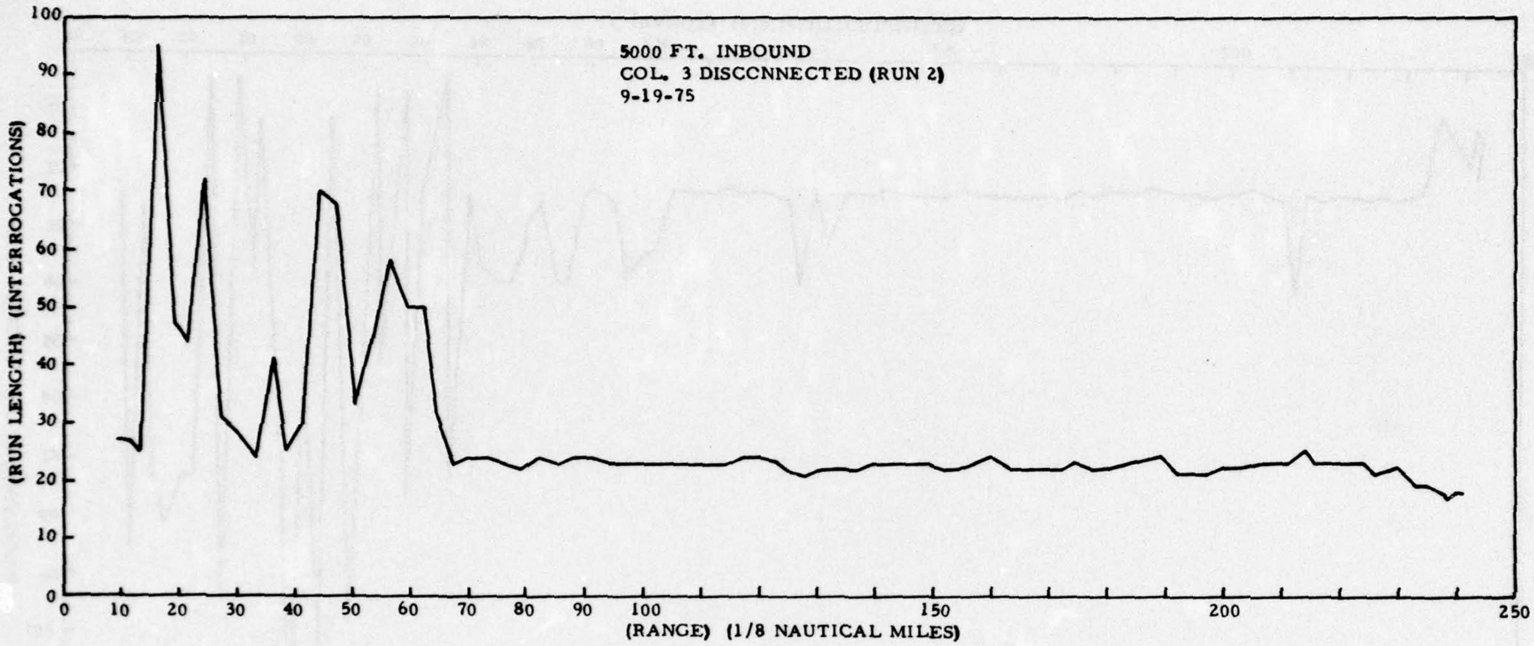


FIGURE C-8. RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-4



76-25-C9

FIGURE C-9 RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-5



76-25-C10

FIGURE C-10. RUNLENGTH VS. RANGE GRAPH OF DATA FROM TABLE C-5

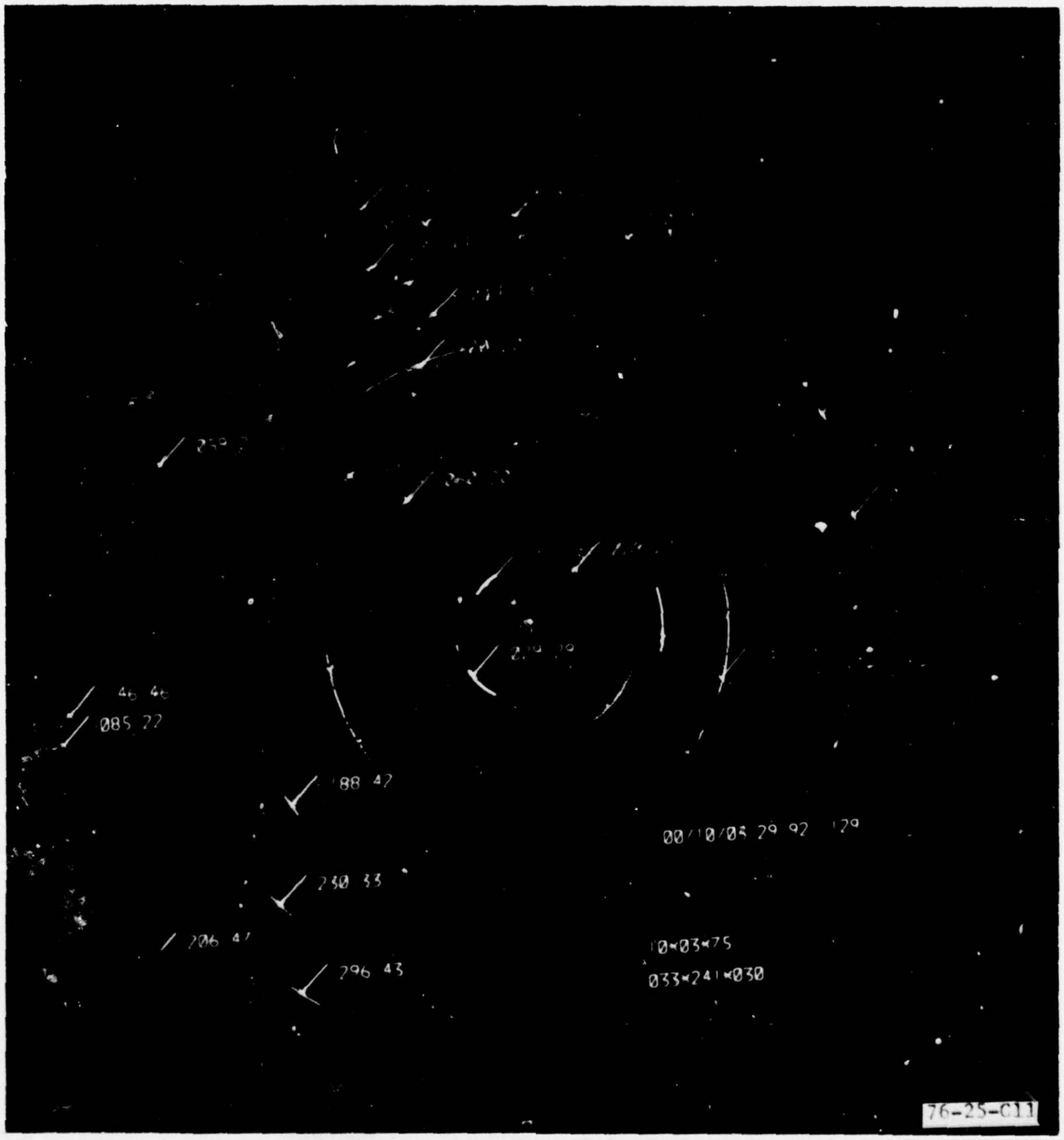


FIGURE C-11. PHOTOGRAPH OF OPERATIONAL ARTS III DISPLAY WITH ANTENNA COLUMNS 3, 4, AND 5 OPEN

TABLE C-1 1000 FT. ANTENNA COLUMNS 3, 4, AND 5 OPEN

LEGEND

:	10	N	30
;	11	O	31
<	12	P	32
=	13	Q	33
>	14	R	34
?	15	S	35
@	16	T	36
A	17	U	37
B	18	V	38
C	19	W	39
D	20	X	40
E	21	Y	41
F	22	Z	42
G	23	[	43
H	24	/	44
I	25	]	45
J	26	∧	46
K	27	_	47
L	28	|	48
M	29	a	49

OUTBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
[illegible]	[illegible]	[illegible]	[illegible]

INBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
228	H76	011	011
226	H75	013	013
224	H69	013	013
223	H69	013	013
221	H65	014	014
219	H62	014	014
218	H59	015	015
216	H56	014	014
214	H58	014	014
213	H49	011	011
211	H50	012	012
209	H50	012	012
207	H49	011	011
205	H48	012	013
203	H50	014	014
201	H49	015	015
199	H51	013	013
197	H50	016	016
195	H52	014	014
193	H49	014	014
192	H54	014	014
190	H52	015	015
188	H50	016	016
186	H51	016	016
184	H50	016	038
182	H51	016	016
180	H50	016	016
178	H52	016	016
176	H51	015	016
174	H52	016	016
173	H50	015	017
171	H53	017	017
169	H51	016	016
167	H52	017	017
165	H50	014	016
163	H53	018	025
163	H53	018	025
163	H52	018	025
163	H53	018	025
163	H53	018	025
163	H53	018	025
163	H53	018	025
150	H51	018	018
148	H50	017	018
146	H50	017	018
144	H52	018	018
142	H52	018	019
140	H52	017	018
138	H53	010	017
136	H54	017	017
134	H51	019	019
133	H54	018	018
131	H53	018	018
129	H51	019	019
127	H55	018	018
125	H53	019	019
123	H52	017	019
121	H50	021	025
119	H55	018	019
117	H54	021	021
115	H54	019	019
115	H54	019	019
112	H60	020	033
110	H55	020	021
108	H54	021	021
106	H58	017	019
104	H45	029	030
102	H49	025	028
100	H51	026	028
098	H63	022	032
096	H62	021	031
094	H61	019	019
093	H62	020	020
091	H63	020	021
089	H65	017	019
087	H65	020	020
085	H58	025	027
085	H58	025	027
081	H72	030	057
079	H81	033	047
077	H80	030	045
075	H78	026	043
073	H93	028	038
071	H92	029	050
069	H62	038	043
068	H59	038	051
066	H73	045	079
064	H83	026	035
062	I03	035	040
062	I03	035	040
062	I03	035	040
056	H80	067	097
054	I04	066	079
052	J05	011	018
050	I89	042	042
048	I86	027	032
046	J06	029	033
044	J12	007	018
042	J13	013	021
040	J20	008	015
040	J20	008	015
037	I16	002	086
035	J05	014	025
033	I21	058	088
031	J18	006	007
029	I44	080	084
028	I44	080	084
025	I38	077	089
023	I72	052	072
021	I54	053	065
019	J43	005	005
017	J70	012	018
016	J58	037	042
014	J99	016	019
012	K15	015	018
010	K08	048	073
008	K54	027	031
006	K98	044	045
004	H34	010	010
003	H86	018	019
001	H85	028	034

1000 FT. ALTITUDE (RUN NO. 1) 9/19/75

TABLE C-1 1000 FT. ANTENNA COLUMNS 3, 4, AND 5 OPEN

LEGEND

:	10	N	30
;	11	O	31
<	12	P	32
=	13	Q	33
>	14	R	34
?	15	S	35
@	16	T	36
A	17	U	37
B	18	V	38
C	19	W	39
D	20	X	40
E	21	Y	41
F	22	Z	42
G	23	[	43
H	24	/	44
I	25	]	45
J	26	∧	46
K	27	_	47
L	28	ǀ	48
M	29	a	49

OUTBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
005	L60	052	053
006	K86	037	039
008	K39	038	041
010	K39	019	023
011	J04	018	024
013	J90	013	018
015	I57	063	095
016	I76	051	065
018	I57	050	081
020	I67	043	052
022	I51	035	063
023	I06	036	044
025	H96	037	049
027	I00	033	063
029	I06	038	062
030	H93	027	051
032	H87	038	053
034	H72	044	065
036	I01	039	058
038	H82	040	053
039	H94	035	065
041	H97	032	040
043	H81	034	082
045	H98	033	039
047	I05	041	062
048	H65	032	041
050	H72	031	033
052	I05	029	041
053	H89	019	019
055	I10	020	047
057	H96	021	022
059	H96	021	022
061	H98	020	030
062	I01	019	019
064	I09	022	043
066	I04	020	020
068	I07	018	013
069	I06	020	020
071	I08	017	017
073	I08	016	017
075	I14	020	032
077	I09	019	019
078	I09	014	016
080	I10	018	016
082	I11	018	019
084	I12	016	018
086	I13	017	017
087	I14	017	017
089	I15	018	018
091	I14	015	015
093	I11	015	015
094	I10	016	016
096	I07	015	015
098	I03	017	017
099	I04	016	016
101	I01	015	015
103	I00	014	015
105	H96	016	016
107	H95	016	016
108	H95	016	017
110	H96	016	017
112	H91	014	014
114	H86	013	013
115	H85	014	014
117	H88	016	016
119	H86	015	015
121	H83	014	014
122	H82	015	016
124	H81	016	016
126	H78	013	014
128	H76	014	014
130	H79	014	014
131	H75	015	015
133	H72	014	015
135	H73	012	012
137	H75	013	013
139	H75	014	014
140	H71	014	014
142	H69	013	013
144	H71	014	014
146	H69	015	015
147	H67	011	012
149	H67	009	011
151	H64	013	013
153	H64	011	011
155	H64	009	012
157	H64	011	012
158	H64	011	012
160	H63	009	010
162	H60	011	011
164	H61	011	013
166	H60	006	007
168	H61	009	010
169	H61	012	012
171	H59	008	009
173	H57	006	007
175	H59	005	007
177	H57	009	009
179	H53	011	011
180	H58	011	012
182	H56	011	011
184	H55	008	010
186	H54	008	009
188	H56	007	007
190	H54	010	011
191	H55	012	013
193	H53	011	011
195	H52	006	008
197	H52	011	011
199	H52	013	013
200	H54	007	010
202	H52	010	011
204	H52	007	008
206	H52	007	007
208	H54	005	006
210	H52	006	006
211	H50	008	009
213	H51	007	007
213	H51	007	007
217	H49	011	011
219	H51	009	011
221	H50	009	010
222	H50	009	009
224	H51	009	011
226	H51	007	008
228	H51	010	010
230	H52	010	011
232	H53	009	009
232	H53	009	009
232	H53	009	009
232	H53	009	009
232	H53	009	009
232	H53	009	009
232	H53	009	009
232	H53	009	009
232	H53	009	009
231	H84	005	007
231	H82	015	016
229	H76	013	013

INBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
228	H76	011	011
226	H72	013	013
223	H69	013	013
221	H65	014	014
219	H62	015	015
218	H59	015	015
216	H56	014	014
214	H56	011	014
213	H49	011	014
211	H50	012	012
209	H50	012	012
207	H49	012	013
205	H48	012	013
203	H50	014	014
201	H50	013	014
199	H51	013	015
197	H50	016	016
195	H52	014	014
194	H52	014	014
192	H54	014	014
190	H52	015	015
188	H51	015	016
186	H50	016	016
184	H51	016	038
182	H51	016	016
180	H50	016	016
178	H52	016	016
176	H51	015	016
175	H51	015	016
173	H50	015	017
171	H53	017	017
169	H51	016	016
167	H52	017	018
165	H50	014	016
163	H53	018	025
163	H53	018	025
163	H53	018	025
163	H53	018	025
163	H53	018	025
163	H53	018	025
150	H51	018	018
148	H50	017	018
146	H52	017	018
144	H52	017	018
142	H52	017	018
140	H53	016	018
138	H53	016	017
136	H54	017	017
134	H51	019	019
133	H54	018	018
131	H53	018	018
129	H51	019	019
127	H55	018	018
125	H53	019	019
123	H52	017	019
121	H50	021	025
119	H55	018	019
117	H54	021	021
115	H54	019	019
115	H54	019	019
112	H60	020	033
110	H55	020	021
108	H54	021	021
106	H58	017	019
104	H65	029	030
102	H49	025	028
100	H51	026	028
098	H63	022	032
096	H62	021	031
094	H61	019	019
093	H62	020	020
091	H63	020	021
089	H65	017	019
087	H65	020	020
085	H58	025	027
085	H58	025	027
081	H72	030	057
079	H81	033	047
077	H80	030	045
075	H70	026	043
073	H93	028	038
071	H92	029	050
069	K62	038	043
068	H59	038	051
066	H73	045	079
064	H83	026	035
062	I03	035	040
062	I03	035	040
062	I03	035	040
056	H80	067	097
054	I04	066	079
052	J05	011	018
050	I09	042	042
048	I86	027	032
046	J06	029	033
044	J12	007	018
042	J13	013	021
040	J20	008	015
040	J20	008	013
037	I16	082	086
035	J05	014	025
033	I21	058	068
031	J18	006	007
029	I44	080	084
029	I44	080	084
025	I30	077	089
023	I72	052	072
021	I54	053	065
019	J43	005	005
017	J70	012	018
016	J58	037	042
014	J99	016	019
012	K15	015	018
010	K00	048	073
008	K54	027	031
006	K90	044	045
004	L34	010	010
003	L06	018	019
001	L85	028	034

1000 FT. ALTITUDE (RUN NO. 1) 9/19/75

TABLE C-2. 1000 FT. ANTENNA COLUMN 3 OPEN

LEGEND

:	10	N	30
;	11	O	31
<	12	P	32
=	13	Q	33
>	14	R	34
?	15	S	35
@	16	T	36
A	17	U	37
B	18	V	38
C	19	W	39
D	20	X	40
E	21	Y	41
F	22	Z	42
G	23	[	43
H	24	/	44
I	25	]	45
J	26	∧	46
K	27	_	47
L	28	ǀ	48
M	29	a	49

OUTBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
002	H94	013	036
003	L89	030	039
004	K73	041	040
006	K79	006	006
008	J22	039	048
009	I68	024	026
011	I52	023	023
013	I39	024	024
015	I29	022	023
016	I21	023	023
018	I17	022	023
020	I11	023	022
022	I06	022	022
024	I03	020	021
025	H99	021	022
027	H96	022	022
029	H93	019	020
031	H92	020	020
033	H89	021	021
034	H87	019	020
036	H87	020	021
038	H85	020	020
040	H81	020	020
042	H82	023	024
043	H81	022	024
045	H81	022	022
047	H80	021	022
049	H80	020	022
051	H81	021	022
053	H80	022	022
054	H80	022	022
056	H81	020	021
058	H79	020	021
060	H77	020	022
062	H78	021	021
063	H81	020	021
065	H79	020	020
067	H78	020	021
069	H75	020	020
071	H75	021	021
072	H74	020	020
074	H74	021	021
076	H74	021	021
078	H71	019	019
080	H73	020	021
081	H74	018	019
083	H71	020	020
085	H71	020	020
087	H71	020	020
088	H70	020	021
090	H68	020	020
092	H68	020	020
094	H69	019	019
096	H69	018	018
098	H69	018	018
099	H69	018	018
101	H69	018	018
103	H70	018	018
105	H70	018	018
106	H70	018	018
108	H71	016	016
110	H71	017	018
112	H69	018	018
114	H67	015	016
116	H66	017	017
117	H68	017	017
119	H69	017	017
121	H69	017	017
123	H68	017	017
125	H68	018	018
126	H71	018	018
128	H71	015	016
130	H71	015	015
132	H68	017	017
134	H70	015	015
135	H67	017	017
137	H70	015	016
139	H68	015	016
141	H68	015	015
143	H69	015	015
145	H69	016	016
147	H69	016	016
148	H70	016	016
150	H69	016	016
152	H69	015	015
154	H71	014	015
156	H74	014	014
158	H70	014	014
159	H70	014	015
161	H69	014	014
163	H68	014	015
165	H70	012	013
167	H68	015	015
168	H68	011	011
170	H69	015	015
172	H68	012	012
174	H73	015	014
176	H70	013	013
178	H74	011	012
180	H71	011	013
182	H72	013	013
183	H73	012	012
185	H73	014	014
187	H71	013	013
189	H73	014	014
191	H72	012	012
193	H73	010	011
194	H73	010	012
196	H75	012	012
198	H73	008	007
200	I30	036	050
202	H72	011	011
204	H74	009	009
205	H72	009	010
207	H71	010	011
209	H74	007	009
211	H75	006	008
213	H70	009	009
215	H71	004	006
217	H71	005	006
219	H72	005	006
219	H72	005	006
222	H73	008	008
224	H74	004	006
226	H73	005	005
226	H73	005	005
226	H73	005	005
226	H73	005	005
233	H71	006	007
233	H71	006	007
233	H71	006	007
233	H71	006	007
233	H71	006	007
233	H71	006	007
233	H71	006	007
233	H71	006	007
234	H95	003	003
233	H95	007	007
231	H90	012	012
230	H88	015	016

INBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
229	H83	013	013
228	H73	013	014
227	H71	013	014
225	H72	012	012
224	H68	012	012
222	H69	010	011
220	H68	010	010
218	H68	013	013
216	H70	015	015
214	H71	013	013
213	H70	013	013
211	H70	012	012
209	H69	013	013
207	H69	015	015
205	H69	014	014
203	H67	012	012
201	H68	013	014
200	H70	014	014
198	H69	012	012
196	H68	014	014
194	H69	015	015
192	H71	016	016
190	H70	014	014
188	H72	017	017
186	H72	015	015
184	H74	016	017
182	H74	016	016
180	H73	017	017
179	576	017	017
177	H73	017	017
175	H73	015	016
173	H72	017	017
171	H73	016	016
169	H72	017	017
167	H72	016	016
165	H73	015	016
163	H75	015	016
161	H75	015	015
159	H74	016	016
158	H73	017	017
156	H78	017	017
154	H76	018	018
152	H76	018	018
150	H78	017	018
148	H77	018	018
146	H78	018	018
144	H75	019	019
142	H77	019	019
140	H78	018	018
138	H75	018	019
136	H77	019	019
134	H77	018	019
132	H77	018	018
130	H78	017	018
128	H75	020	020
127	H76	018	019
125	H78	019	020
123	H75	017	018
123	H75	017	018
123	H75	017	018
117	H72	017	017
115	H73	017	018
113	H75	015	015
111	H74	020	020
109	H74	019	019
107	H73	019	019
106	H73	020	020
104	H73	018	019
102	H71	019	019
100	H71	019	019
098	H71	018	020
096	H69	020	020
094	H71	020	021
092	H68	019	021
090	E69	021	021
088	H68	019	020
087	H69	C21	022
085	H70	021	021
083	H66	019	021
081	H68	021	021
079	H67	021	021
077	H66	020	021
075	H65	021	021
073	H68	021	022
071	H66	021	023
069	H68	022	022
068	H67	022	022
066	H66	021	022
064	H66	021	022
062	H64	021	021
060	H63	020	021
058	H63	021	022
056	H69	023	039
054	H62	022	022
052	H63	020	022
051	H61	022	022
049	H60	022	022
047	H61	021	022
045	H59	021	021
043	H57	021	021
041	H58	022	022
039	H59	022	022
037	H57	022	022
035	H58	022	022
034	H57	024	024
032	H59	024	024
030	H58	023	024
028	H60	022	025
026	H61	024	025
024	H62	022	023
022	H66	023	023
020	H67	022	022
018	H73	021	021
017	H75	023	023
015	H80	022	023
013	H87	023	024
011	H96	021	023
009	I06	023	024
007	I22	024	025
005	I06	066	121
004	522	011	013
002	H53	010	010

1000 FT. ALTITUDE (RUN NO. 1) 9/19/75

TABLE C-3. 3000 FT. ANTENNA COLUMNS 3, 4, AND 5 OPEN

LEGEND

:	10	N	30
;	11	O	31
<	12	P	32
=	13	Q	33
>	14	R	34
?	15	S	35
@	16	T	36
A	17	U	37
B	18	V	38
C	19	W	39
D	20	X	40
E	21	Y	41
F	22	Z	42
G	23	[	43
H	24	/	44
I	25	]	45
J	26	∧	46
K	27	—	47
L	28	ǀ	48
M	29	a	49

RANGE	AZIMUTH	HIT-1	R.L.-1
007	K13	044	068
010	K43	048	053
012	K06	053	059
014	J65	054	060
017	J57	037	040
020	J30	050	056
022	J29	037	040
025	J04	046	050
027	J10	037	041
030	J09	028	028
033	I77	041	048
035	J23	006	007
038	I93	022	029
041	I96	017	022
043	I80	039	041
046	I83	029	034
049	I72	014	015
051	I56	033	039
054	H75	082	086
056	I82	025	026
059	I88	015	021
062	J00	011	015
064	I65	020	031
067	I77	014	024
067	I77	014	024
072	J15	003	003
075	H86	031	046
077	H82	049	075
080	H84	042	059
083	H82	058	085
085	H77	054	085
088	H83	051	074
091	H81	047	049
093	H84	040	041
096	H84	035	040
098	H80	039	057
101	H72	038	050
104	H87	029	052
106	H77	029	057
109	H72	031	044
111	H47	033	050
114	H47	040	068
117	H60	044	065
119	H72	031	059
122	H61	028	045
125	H45	045	079
127	H54	034	048
130	H55	035	062
132	H59	040	081
135	H62	025	062
138	H49	040	081
140	H76	027	050
143	H52	035	082
145	H51	031	066
148	H47	044	086
151	H68	023	035
153	H66	021	027
156	H76	025	048
159	H64	020	020
161	H65	020	020
164	H64	019	020
166	H65	019	019
169	H64	020	020
172	H64	019	020
174	H65	019	019
177	H65	020	020
180	H64	020	020
182	H65	020	020
185	H64	019	019
187	H63	020	020
190	H64	019	019
193	H62	018	020
195	H64	018	018
198	H64	019	019
201	H63	019	019
203	H62	017	018
206	H65	019	019
208	H64	018	018
211	H64	018	019
214	H62	018	019
216	H63	018	018
219	H64	018	018
222	H62	019	019
224	H64	018	018
227	H65	018	018
229	H64	017	017
232	H65	017	017
235	H64	018	019
237	H63	015	015
237	H63	015	015
237	H63	015	015
237	H63	015	015
244	H78	017	017
244	H78	017	017
243	H95	014	014
242	H98	012	012
240	I04	013	013
238	I09	009	011

OUTBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
235	I13	016	017
233	I14	013	014
230	I15	017	018
227	I13	019	019
224	I11	018	019
221	I29	026	037
219	I08	018	018
216	I06	018	019
213	I04	018	018
210	I03	015	016
208	I04	018	019
205	I03	018	019
202	I03	018	019
199	I07	018	018
196	I09	017	017
193	I12	019	026
193	I12	019	026
188	I11	016	018
185	I14	019	019
182	I22	024	038
180	I13	030	046
177	I20	018	019
174	I21	020	021
171	I13	027	030
168	I19	021	026
166	I42	024	048
163	I30	022	034
160	I43	023	052
157	I33	022	028
154	I33	022	028
152	I47	032	038
149	I43	025	030
146	I38	036	058
143	I41	025	065
140	I49	034	049
138	I49	025	056
135	I61	034	069
132	I50	048	082
129	I31	029	032
126	I61	039	053
123	I76	030	050
121	I63	046	085
118	I60	055	087
118	I60	055	087
112	I38	045	087
110	I56	055	084
107	I72	052	085
104	I65	060	072
101	I58	057	069
098	I63	053	070
095	I52	050	065
093	I51	038	062
090	I54	046	081
087	I60	063	097
084	I82	035	054
081	I51	024	035
078	I40	038	060
075	J56	003	006
075	J56	003	006
070	I60	044	074
067	J43	005	014
064	J61	006	006
061	J25	018	024
059	J43	014	020
056	J12	022	034
053	J12	014	025
053	J12	014	025
047	I90	023	034
045	J10	023	028
042	J26	022	025
039	J06	044	046
036	J11	031	039
034	J19	030	031
031	J38	028	029
028	J41	020	023
025	J20	037	043
022	J34	034	036
020	J52	030	033
017	J31	054	055
014	J51	052	072
011	J70	052	059
009	J91	057	080
006	K04	041	070
004	J80	028	028
004	J80	028	028
004	208	031	043

INBOUND

3000 FT. ALTITUDE 9/19/75

TABLE C-4. 5000 FT. ANTENNA COLUMNS 3,4, AND 5 OPEN

LEGEND

:	10	N	30
;	11	O	31
<	12	P	32
=	13	Q	33
>	14	R	34
?	15	S	35
@	16	T	36
A	17	U	37
B	18	V	38
C	19	W	39
D	20	X	40
E	21	Y	41
F	22	Z	42
G	23	[	43
H	24	/	44
I	25	]	45
J	26	Λ	46
K	27	_	47
L	28	|	48
M	29	a	49

OUTBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
020	I59	052	061
023	I66	041	047
025	J02	018	022
028	I45	053	060
030	I44	042	055
033	I52	039	043
036	I57	030	032
038	I32	045	049
041	I37	037	040
044	I50	037	041
046	I55	028	030
049	I35	041	047
052	I39	035	040
054	I43	033	036
057	I57	026	031
060	I31	044	049
062	I70	020	021
065	I52	037	040
068	I57	030	033
070	I53	022	024
073	I38	042	044
076	I38	031	037
078	I57	031	035
081	I61	023	024
084	I64	013	016
086	I78	013	014
089	I51	026	030
092	I61	022	023
092	I61	022	023
092	I61	022	023
092	I61	022	023
102	I55	017	028
105	I62	008	015
105	I62	008	015
110	I54	024	030
113	I65	012	022
116	I67	007	016
119	I85	004	006
121	H64	060	084
124	H67	050	066
126	H67	055	070
129	H62	061	083
132	H59	054	081
134	H50	053	073
137	I82	005	007
137	I82	005	007
137	I82	005	007
145	H45	049	096
145	H45	049	096
150	H49	058	085
153	H65	056	080
156	H77	059	082
158	H64	053	085
161	H57	054	090
163	H58	053	084
166	H53	049	096
169	H37	047	072
171	H71	024	053
174	H58	020	020
176	H59	020	021
179	H58	016	020
182	H62	021	025
184	H64	022	037
187	H64	022	026
190	H69	023	048
192	H62	020	044
195	H58	020	020
197	H67	022	047
200	H56	019	020
203	H56	018	019
205	H59	020	025
208	H52	022	027
211	H52	018	020
213	H56	017	019
216	H57	020	020
218	H55	018	019
221	H56	016	017
224	H57	018	019
226	H58	020	041
229	H56	017	024
231	H55	018	019
234	H55	018	019
237	H55	017	018
239	H56	016	016
242	H62	005	007
244	H64	011	012
246	H69	006	007
247	H75	018	018
248	H79	017	017
249	H84	008	009

INBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
249	H84	008	009
249	I01	003	004
248	I09	014	014
247	I10	014	015
245	I18	016	017
243	I21	016	017
240	I25	017	017
237	I29	016	017
234	I29	019	020
231	I50	034	053
229	I09	047	082
226	I29	046	080
224	I16	019	025
221	I91	007	012
219	I27	031	048
219	I27	031	048
215	H93	061	108
213	H97	044	058
213	H97	044	058
209	H84	028	052
206	H52	028	037
203	H56	028	065
200	H62	017	018
197	H66	021	034
197	H66	021	034
192	H77	039	072
189	H73	034	070
186	H55	035	052
183	H76	026	036
180	H79	027	035
177	H71	040	051
174	H81	041	058
171	H78	027	038
168	H79	030	035
165	H77	026	053
162	H76	030	050
159	H71	033	045
156	H63	030	038
153	H76	034	077
150	I01	033	061
147	H70	029	052
144	H72	038	076
141	H84	054	078
138	H81	052	081
135	H80	046	067
132	H75	046	052
129	H94	051	065
126	H92	056	091
126	H92	056	091
126	H92	056	091
117	H90	048	076
114	I02	046	075
111	H94	052	082
108	H84	062	082
105	I98	006	017
102	J17	003	004
102	J17	003	004
096	I78	009	011
093	J05	007	013
090	I66	021	027
087	H83	070	099
084	I89	011	029
081	J00	014	015
078	I72	030	056
075	I78	022	044
072	I91	018	030
069	I95	010	016
066	I67	025	031
063	I71	016	024
060	I81	008	016
057	I52	025	033
054	H70	075	091
051	I68	011	023
048	I46	029	035
045	I63	030	033
042	I74	025	030
039	I56	038	050
036	I59	035	040
033	I71	034	041
030	I75	025	029
028	I61	046	056
025	I84	051	058
022	I94	044	049
019	I94	033	041
019	I94	033	041
014	J29	035	039
011	J58	043	047
009	I65	041	067
009	I65	041	067

5000 FT. ALTITUDE (RUN NO. 1) 9/19/75

TABLE C-5. 5000 FT. ANTENNA COLUMN NO. 3 OPEN

LEGEND

:	10	N	30
;	11	O	31
<	12	P	32
=	13	Q	33
>	14	R	34
?	15	S	35
@	16	T	36
A	17	U	37
B	18	V	38
C	19	W	39
D	20	X	40
E	21	Y	41
F	22	Z	42
G	23	[	43
H	24	/	44
I	25	]	45
J	26	∧	46
K	27	—	47
L	28	‘	48
M	29	a	49

OUTBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
009	068	022	024
011	H28	043	085
013	086	025	026
015	H11	032	073
017	H13	031	081
020	H39	041	073
022	H41	039	073
024	I58	003	004
027	076	066	094
029	I49	004	004
032	I03	023	037
033	362	011	011
037	064	045	068
039	I31	048	118
041	H32	027	053
044	H41	050	102
045	369	010	011
049	098	037	098
053	372	004	005
054	H15	029	054
058	367	003	006
059	H23	028	076
061	H18	023	023
065	371	004	004
066	H42	035	073
069	H21	024	024
071	H26	023	036
074	H35	032	039
076	H23	028	049
079	H20	026	029
081	H24	023	025
084	H28	025	039
086	H39	031	039
089	H25	024	024
091	H25	023	023
094	H27	024	025
096	H32	027	038
099	H29	025	034
101	H27	022	033
104	H26	022	023
106	H29	023	023
109	H27	023	023
111	H32	021	023
114	H30	021	022
116	H30	021	023
119	H30	023	023
121	H30	023	023
124	H29	024	024
126	H37	026	039
129	H32	021	022
131	H33	024	032
134	H30	022	023
136	H30	021	023
139	H31	022	023
141	H31	022	022
144	H31	021	023
146	H32	023	023
149	H33	023	023
151	H30	022	023
154	H33	022	022
156	H32	023	023
159	H33	023	023
161	H33	023	023
164	H33	022	023
166	H33	023	023
169	H34	022	023
171	H33	022	023
174	H34	021	022
176	H35	023	023
179	H34	022	022
181	H35	022	022
184	H35	021	022
186	H36	019	021
186	H36	019	021
191	H37	022	022
194	H37	021	022
196	H38	023	023
199	H39	022	022
201	H37	022	022
204	H40	021	021
206	H39	021	022
209	H40	023	023
211	H42	024	039
213	H40	022	022
216	H40	023	023
218	H40	022	022
221	H39	021	022
224	H40	023	023
226	H39	021	022
228	H41	023	023
231	H42	022	022
233	H39	021	021
236	H43	008	008
236	H43	008	008
236	H43	008	008
241	H53	017	017
242	H57	008	010
243	H65	008	012
242	H73	019	019

INBOUND

RANGE	AZIMUTH	HIT-1	R.L.-1
241	H78	017	018
240	H86	018	018
238	H89	016	017
235	H91	019	019
233	H96	017	019
230	H98	021	022
227	H96	021	021
224	H91	023	023
221	H84	019	023
219	H84	021	023
216	H80	023	023
214	H77	024	025
211	H72	022	023
208	H70	022	023
206	H64	023	023
203	H61'	022	022
200	H58	022	022
197	H57	020	021
195	H55	021	021
192	H53	021	021
189	H56	023	024
189	H56	023	024
183	H57	022	023
180	H55	020	022
177	H57	022	022
174	H57	023	023
172	H59	022	022
169	H58	020	022
166	H61	021	022
163	H60	021	022
160	H61	024	024
157	H63	022	023
154	H63	021	022
152	H64	020	022
149	H62	022	023
146	H61	019	023
143	H65	022	023
140	H64	022	023
137	H64	021	022
134	H65	021	022
131	H68	022	022
128	H63	020	021
125	H63	021	022
123	H65	021	023
120	H66	021	024
117	H65	023	024
114	H64	022	023
111	H64	021	023
108	H64	022	023
105	H65	022	023
102	H65	022	023
099	H65	019	023
096	H63	021	023
094	H66	021	023
091	H66	021	024
088	H65	023	024
085	H62	019	023
082	H65	022	024
079	H62	020	022
076	H65	019	023
073	H67	021	024
070	H65	022	024
067	H64	021	023
064	H66	022	032
062	H67	026	050
059	H75	025	050
056	H59	029	058
053	H80	032	045
050	H49	028	033
047	H74	030	068
044	H80	031	070
041	H52	027	030
038	H55	021	025
036	H52	032	041
033	H53	024	024
030	H46	026	028
027	H43	025	031
024	H78	035	072
021	H44	030	044
019	H50	029	047
016	H72	042	095
013	H36	024	025
011	H31	024	027
009	H19	022	027
009	H19	022	027
009	H19	022	027
009	H19	022	027

5000 FT. ALTITUDE (RUN NO. 2) 9/19/75

TABLE C-6. TARGET RUNLENGTH AND HIT COUNT AS A FUNCTION OF AZIMUTH

			RUN NO. 1 (3,4,5, OPEN)				RUN NO. 2 (NO. 3 OPEN)			
			HITS		Run Length		HITS		Run Length	
Degrees	Alt.	nmi	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
1	1000	9.4	26	20	43	32	21	21	21	21
	3000	28.3	19	18	19	18				
	5000	47.2								
2	1000	4.7	2	40	6	53	22	20	22	20
	3000	14.1	45	40	87	68				
	5000	23.6	34	23	70	48	23	22	24	22
3	1000	3.1	77	37	89	49	24	21	25	22
	3000	9.4	3	31	6	46				
	5000	15.7	56	55	91	70	21	26	22	39
4	1000	2.4	5	50	5	81	21	22	21	23
	3000	7.1	22	25	34	26				
	5000	11.8	9	22	11	23	21	24	23	25
5	1000	1.9	37	03	42	95	22	22	23	23
	3000	5.7	23	29	28	34				
	5000	9.4	22	31	44	37	19	28	23	49
6	1000	1.6	15	13	18	14	23	24	24	24
	3000	4.7	44	22	46	29				
	5000	7.9	16	20	24	21	26	23	50	23
7	1000	1.4	48	19	73	23	21	21	23	23
	3000	4.1	28	41	29	48				
	5000	6.8	75	33	91	36	32	29	45	54
8	1000	1.2	48	19	73	21	21	24	24	24
	3000	3.5	20	37	23	41				
	5000	5.9	29	28	35	30	30	37	68	98
9	1000	1.1	27		31	41	23	39	24	48
	3000	3.2	37	46	43	50				
	5000	5.3	25	37	30	40	27	27	30	53
10	1000	.9	27		31	41	24	39	25	48
	3000	2.8	34	37	36	40				
	5000	4.7	38	45	50	49	21	45	25	68
12	1000	.8	44	37	45	39	24	06	25	06
	3000	2.4	30	50	33	56				
	5000	4.0	25	42	29	55	26	23	28	37
13	1000	.7	44	37	45	39	24	06	25	06
	3000	2.2	54	37	55	40				
	5000	3.7	25	42	29	55	26	4	28	4
14	1000	.7	44	52	45	53	24	06	25	06
	3000	2.0	54	37	55	40				
	5000	3.4	46	53	56	60	25	66	31	94
15	1000	.6	44	52	45	53	66	41	121	49
	3000	1.9	52	54	72	60				
	5000	3.2	51	18	58	22	35	3	72	4
16	1000	.6	10	52	10	53	66	41	121	49
	3000	1.8	52	54	72	60				
	5000	3.0	51	41	58	47	35	3	72	4
17	1000	.6	10	52	10	53	66	41	121	49
	3000	1.7	52	54	72	60				
	5000	2.8	44	41	49	47	30	39	44	73
18	1000	.5	10	52	10	53	11	41	13	49
	3000	1.6	52	53	72	59				
	5000	2.7	44	52	49	61	30	39	44	73
19	1000	.5	10		10		11	41	13	49
	3000	1.5	52	53	59	59				
	5000	2.5	33	52	41	61	29	41	47	73
20	1000	.5	10		10		11	41	13	49
	3000	1.4	52	53	59	59				
	5000	2.4