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EVALUATION OF U.S. COAST GUARD FORWARD-LOOKING AIRBORNE RADARS

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This report documents an evaluation of four candidate forward-looking airborne radars (FLARs) for their potential to fulfill Coast Guard HC-130 mission requirements.

16. Abstract

During CY 1983, the U.S. Coast Guard R&D Center conducted field experiments off Fort Pierce, FL and Oregon Inlet, NC to evaluate the small-target detection capabilities of three forward-looking airborne radars (FLARs): the AN/APS-127, the AN/APS-133, and the AN/APN-215. Field data from these experiments and from a West German field test of the AN/APN-134 FLAR were compared to each other and to theoretical detection range predictions promulgated by NADC. These data were used to analyze the potential of each system to fulfill the Coast Guard Search and Rescue (SAR) and Enforcement of Laws and Treaties (ELT) missions. Targets of 1-square meter and 100-square meter radar cross sections were considered in the analysis.

The AN/APS-134 was found to be clearly superior to the other three candidate FLAR systems in its capability to fulfill SAR and ELT mission requirements. In sea states 3 and above, the AN/APS-134 is the only FLAR among those evaluated with any significant ability to detect 1-square meter targets.

Recommendations are made for conducting FLAR search operations and for future research and development efforts.

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METRIC CONVERSION FACTORS

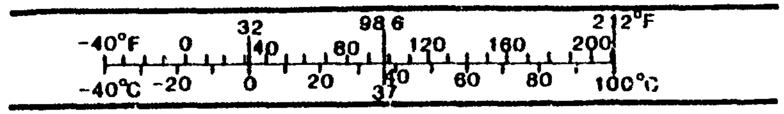
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures. Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

1. Background

The United States Coast Guard is considering acquisition of AN/APS-134 forward-looking airborne radars (FLARs) to enhance the ocean surveillance capabilities of its HC-130 aircraft. During 1983, field tests, literature research, and analysis were conducted to document and compare the detection performance of four candidate FLAR systems. Field tests were sponsored by the offices of Research and Development (G-DST) and Engineering (G-EAE) to evaluate three existing Coast Guard FLARs: the AN/APS-127, AN/APS-133, and AN/APN-215 systems. Literature research was conducted to compile theoretical performance predictions for all four candidate systems and to integrate APS-134 field test data (collected by the West German military) with Coast Guard field test data. All available data were analyzed to compare the relative search and rescue (SAR) and enforcement of laws and treaties (ELT) mission performance capabilities of the candidate FLAR systems. Results of this analysis were evaluated to determine whether:

a. Any of these FLAR systems are capable of fulfilling the variety of Coast Guard mission requirements and

b. Acquisition of the relatively expensive APS-134 FLAR is warranted based upon its anticipated operational mission performance.

2. FLAR System Descriptions

The three existing Coast Guard FLAR systems that were evaluated during this study are all X-band radars with both surface search/mapping and weather display capabilities.

The APS-133 and APN-215 radars are currently installed aboard the Coast Guard's HC-130 aircraft. Both the APS-133 and APN-215 have multi-function displays with three-color target strength indication. The APS-133 display is a 180-degree sector scan; the APN-215 display is a 120-degree sector scan.

The APS-127 is a search/navigation radar installed aboard some of the Coast Guard's HU-25A Falcon medium range surveillance (MRS) aircraft. Two distinct display modes of the APS-127 were evaluated: heading stabilized and ground stabilized.

The APS-134 is a state-of-the-art search/navigation radar presently in use aboard West German military patrol aircraft. It is an updated version of the APS-116 search radar used aboard U.S. Navy S-3 antisubmarine warfare (ASW) aircraft. The sophisticated signal processing and display hardware used in the APS-134 are designed to maximize target signal strength while suppressing clutter for conditions up to sea state 5.

RESULTS

1. FLAR Detection Performance Analysis

- The APS-134 FLAR detected a target of 1-m^2 (meter square) radar cross section at ranges of 20.0 to 35.9 nm in sea states 1 through 3.
- The APS-127 FLAR detected 1-m^2 targets at ranges of 1.2 to 12.3 nm in sea states 1 and 2.
- The APS-133 and APN-215 FLARs detected 1-m^2 targets at ranges 0.4 to 5.9 nm in sea states 1 and 2.
- None of the three existing Coast Guard FLARs demonstrated significant detection capability for 1-m^2 targets in sea state 3.
- Field data were not adequate to determine maximum detection ranges against 50- to 100-m^2 targets for the APS-127, APS-133, and APN-215 FLAR systems.

- o The APS-134 proved capable of initial target detection of 100-m^2 targets at ranges of 74.0 to 80.5 nm in sea states 1 through 3.

- o Field test data used in this report agreed well with theoretical detection range predictions developed by NADC.

2. Mission Analyses

- o SAR mission times projected for APS-134-equipped aircraft were significantly lower than those projected for the other FLAR systems or for visual search alone.

- o Resource requirements for maintaining an ELT barrier patrol against 100-m^2 targets are significantly lower for APS-134-equipped aircraft than for aircraft equipped with any of the other FLAR systems evaluated or for surface craft.

CONCLUSIONS

1. FLAR Detection Performance

- o Of the FLAR systems evaluated, only the APS-134 can be expected to satisfy the Coast Guard criterion of detecting a 1-m^2 target in sea state 3 or greater. All systems evaluated (APS-127, APS-133, APS-134, and APN-215) are capable of detecting a 1-m^2 target in sea states 1 and 2.

- o The APS-134 can be expected to detect 1-m^2 targets at ranges of 20 nautical miles or mor in sea states 1 through 3. The APS-127 ground-stabilized display mode can be expected to make most 1-m^2 target detections at ranges up to 10 nautical miles. In sea states 1 and 2, the APS-133 and APN-215 FLARs can be expected to make most 1-m^2 target detections at ranges up to 5 nautical miles.

2. Mission Performance

- o Compared to an APS-127-equipped HU-25A, an HC-130 equipped with the APS-134 can be expected to achieve a 55-percent reduction in the time required to detect and classify 1-m^2 or larger targets in low traffic density search areas (sea state 1 assumed). In high traffic density search areas, the APS-134-equipped aircraft can be expected to achieve a 28-percent reduction in required mission time.

- o In sea state 3 or higher, only the APS-134 FLAR can be expected to provide an improvement over visual search alone when the search object has a 1-m^2 radar cross section.

- o If utilized to its full potential, the APS-134 FLAR should be capable of maintaining a barrier against 100-m^2 targets with 32 percent fewer patrols than the APS-127 in sea state 1 and 36 percent fewer patrols in sea state 3. Based upon theoretical performance predictions, only the APS-134 can be expected to have any significant detection capability against these targets in sea state 5. Conventional surface vessel resources well beyond current or projected Coast Guard levels would be required to maintain equivalent barrier surveillance.

RECOMMENDATIONS

1. FLAR System Selection

Results of this analysis indicate that APS-134 FLAR will improve substantially the radar surveillance performance of the Coast Guard HC-130 aircraft. This system is the only one among those evaluated that is capable of satisfying the Coast Guard's criterion of detecting 1-m^2 targets in sea state 3. Further, the APS-134 could provide significant law enforcement surveillance capabilities not presently available to the Coast Guard.

2. FLAR System Employment

- o The APS-127 should be operated in ground-stabilized mode when searching for small (1-m^2) targets.

- o FLAR displays should be adjusted to optimize the detection of desired search objects while en route to the search/patrol area. Thereafter, adjustments should be kept to a minimum while over open water due to the lack of suitable reference targets.

- o Range scale should be selected on the basis of the expected detection range for the search object. Use of a longer-than-necessary range scale only results in overloading the operator with extraneous targets and reduces their size on the FLAR display.

3. Recommendations for Future Research and Development

- o Tactics and command/control/communication systems should be developed to exploit the enhanced search/detection capabilities of the APS-134 FLAR. Specifically, the following should be considered:

  - Classification/identification of targets,
  - Prosecution of targets, and
  - Coordination of resources to support the HC-130 aircraft in these roles.

- o Operational sensor employment guidance should be developed for the APS-134 on a mission-by-mission basis. Training and documentation should be provided to APS-134 operators to ensure this guidance is implemented.

- o The capabilities of the APS-134 FLAR should be compared to those of the APS-135 SLAR to determine if both radars are necessary on a single aircraft to fulfill Coast Guard mission requirements.

- o Operational sweep widths for FLARs should be developed through field data collection and analysis. These sweep widths should be provided to Coast Guard search planners in the form of a computer data base and SAR Manual tables. As an interim measure, the cumulative detection probability (CDP) curves developed in this report should be used to develop "ballpark" sweep width estimates for inclusion in Chapter 8 of the National SAR Manual. These search planning data should include the full range of environmental conditions over which FLAR has a demonstrated detection capability.

CHAPTER 1
BACKGROUND

1.1 SCOPE

The United States Coast Guard is considering acquisition of AN/APS-134 forward-looking airborne radars (FLARs) to enhance the ocean surveillance capabilities of its HC-130 aircraft. During 1983, field tests, literature research, and analysis were conducted to document and compare the detection performance of four candidate FLAR systems. Field tests were sponsored by the offices of Research and Development (G-DST) and Engineering (G-EAE) to evaluate three existing Coast Guard FLARs: the AN/APS-127, AN/APS-133, and AN/APN-215 systems. Literature research was conducted to compile theoretical performance predictions for all four candidate systems and to integrate APS-134 field test data (collected by the West German military) with Coast Guard field test data. All available data were analyzed to compare the relative mission performance capabilities of the four candidate FLAR systems.

The Coast Guard estimates that for a FLAR system to perform effectively in a majority of Coast Guard missions, it should be capable of detecting a target with approximately 1-square meter radar cross section in sea state 3. This analysis compared the detection performance achieved by each FLAR with this mission performance criterion and also with the performance of the other candidate systems. Results of this analysis were evaluated to determine whether:

1. Any of these FLAR systems are capable of fulfilling the variety of Coast Guard mission requirements and

2. Acquisition of the relatively expensive APS-134 FLAR is warranted based upon its anticipated operational mission performance.

While detection performance is not the sole criterion for choosing a FLAR system, it is a major parameter to consider due to its impact on aircraft mission capability. During this analysis, emphasis was placed on quantifying the detection performance of each system and evaluating its impact on overall search and rescue (SAR) and enforcement of laws and treaties (ELT) mission performance.

1.2 FLAR SYSTEM DESCRIPTIONS

Three existing Coast Guard FLAR systems (AN/APS-127, AN/APS-133, and AN/APN-215) were evaluated during this study. All are X-band radars with both surface search/mapping and weather display capabilities.

The APS-133 and APN-215 radars are currently installed aboard the Coast Guard's HC-130 aircraft. Both the APS-133 and APN-215 have multi-function displays with three-color target strength indication. The APS-133 display is a 180-degree sector scan; the APN-215 display is a 120-degree sector scan. The APN-215 was operated in the MAP-1 mode (surface search) for this evaluation; the APS-133 was operated in the SEARCH-1 (no clutter rejection) or SEARCH-2 (clutter rejection enabled) modes as appropriate.

The APS-127 is a search/navigation radar installed aboard some of the Coast Guard's HU-25A Falcon medium range surveillance (MRS) aircraft. Two distinct display modes of the APS-127 were evaluated: heading stabilized and ground stabilized. The heading-stabilized display provides a conventional plan position indicator (PPI) presentation, wherein targets and terrain move relative to the sweep origin which represents aircraft position. The position of the sweep origin can be selected by the FLAR operator via a joystick control. The advantage of this display mode is that a constant "moving envelope" of area relative to the aircraft is always surveyed (in a manner similar to visual search) with no operator action required. The disadvantage of heading-stabilized mode is that, when operating on short (5- to 10-nautical mile) range scales and flying at 200-knot search speeds, target "blips" move very rapidly across the display. Scan-to-scan "eyeball integration" of these targets is difficult, and they are often mistaken for clutter. The ground-stabilized display mode of the APS-127 provides an unchanging view of the earth's surface as long as the selected area remains within radar range. In this mode, the sweep origin moves across the display, representing the aircraft's ground track. The advantage of this mode for searching is that slow-moving or stationary targets appear in the same location from scan to scan, enabling the operator to distinguish them from fluctuating clutter. The disadvantage of ground-stabilized mode is that the operator must frequently adjust the sweep origin position to ensure that an adequate amount of area ahead of the aircraft is being displayed.

The APS-134 is a state-of-the-art search/navigation radar presently in use aboard West German military patrol aircraft. It is an updated version of the APS-116 search radar used aboard U.S. Navy S-3 antisubmarine warfare (ASW) aircraft. The sophisticated signal processing and display hardware used in the APS-134 are designed to maximize target signal strength while suppressing even heavy sea clutter. The transmitted waveform is frequency modulated over a 500-Hz bandwidth, permitting high average power target illumination. The received waveform is pulse-compressed to effectively decrease the amount of sea surface illuminated, reducing clutter signal strength by approximately 23 dB. Fast scan (150 rpm or 40 rpm) processing is employed to decorrelate slowly fluctuating sea clutter through scan-to-scan integration, further enhancing the relative target signal strength. The digital scan converter incorporates multilevel processing, which allows preservation of a low-intensity background map to aid the operator in discriminating small (but more intense) targets from clutter.

Table 1-1 provides salient information on each of the four FLAR systems evaluated. More detailed system descriptions can be found in References 1 through 7.

1.3 DESCRIPTION OF EXPERIMENTS

1.3.1 Exercise Areas

During February 1983, searches were conducted in the Atlantic Ocean off Fort Pierce, Florida, in a 15- by 30-nautical mile area centered at 27°32.6' N, 80°09.0' W with a major axis of 161 degrees magnetic (see Figure 1-1). During August and September 1983, searches were conducted in the Atlantic Ocean off Oregon Inlet, North Carolina, in a 15- by 30-nautical mile area centered at 35°50.3' N, 75°22.1' W with a major axis of 170 degrees magnetic (see Figure 1-2). Actual search areas and search patterns assigned to the aircraft in each location depended upon specific data collection objectives and target type.

Table 1-1. FLAR System Specifications

FLAR System	Current Aircraft Application	Manufacturer	Range Scales (nm)	Peak Power (KW)	Scan Rate (deg/sec)	Pulse Width(s) [PRF(s)]	Weight (lb)
AN/APS-127	USCG HU-25A	Texas Instruments	5, 10, 20 40, 80, 160	200	720 72	0.5 μs, 2.5 μs [1600 Hz, 400 Hz]	295.5
AN/APS-133(V)	USCG HC-130	Bendix	5, 25, 50 150, 300	65	45	0.5 μs, 5 μs [200 Hz]	114
AN/APN-215(V)	USCG HC-130	Bendix	10, 20, 40 80, 160, 240	10	24	0.5 μs, 2.35 μs [800 Hz, 200 Hz]	37
AN/APS-134(V) (AN/APS-116)	W. German Air Force Atlantique (U.S. Navy S-3)	Texas Instruments	4, 8, 16, 32 64, 150	500	900 240 36	0.5 μs [2000 Hz, 500 Hz]	527

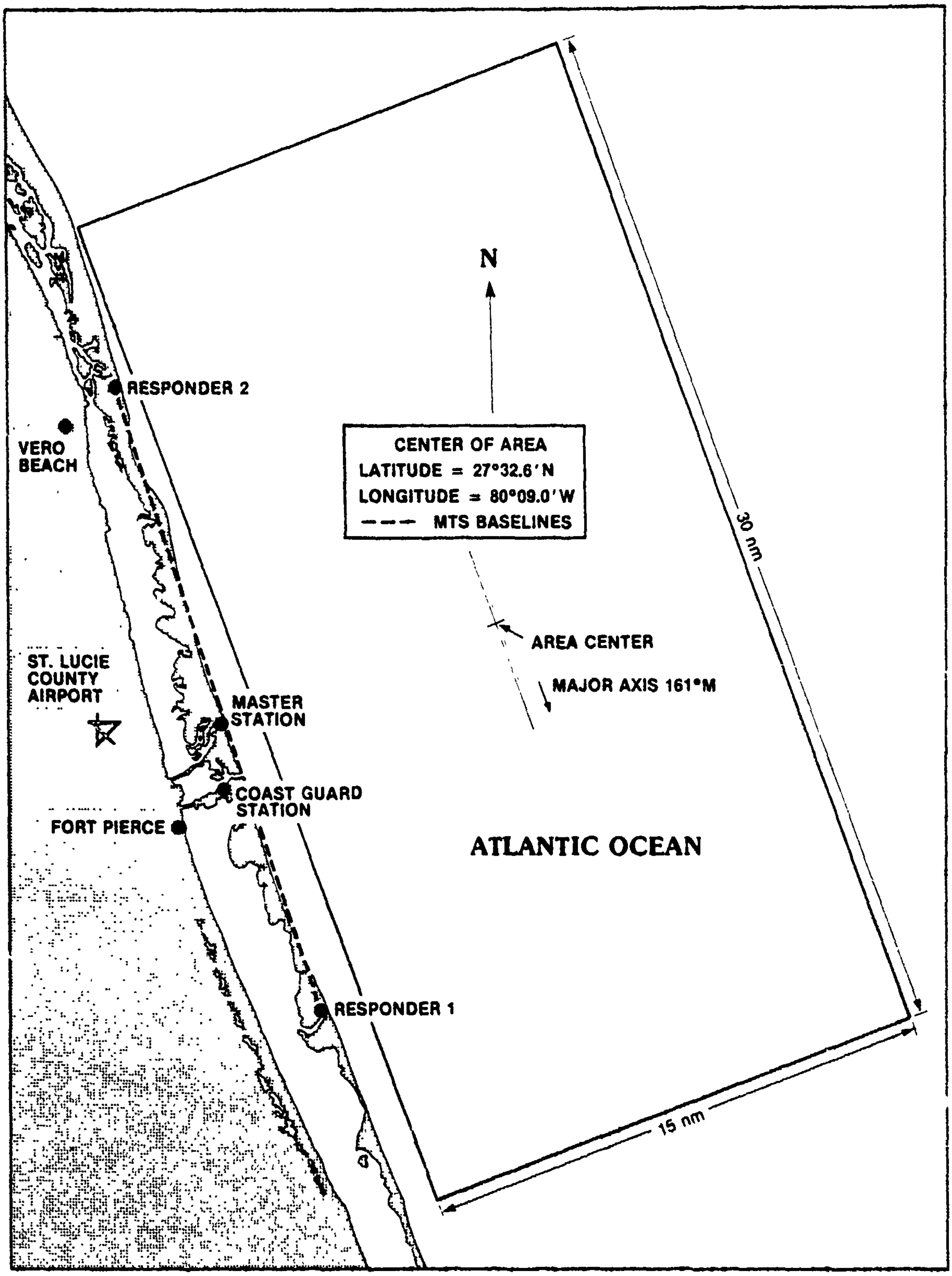

Figure 1-1. Fort Pierce, Florida, Exercise Area

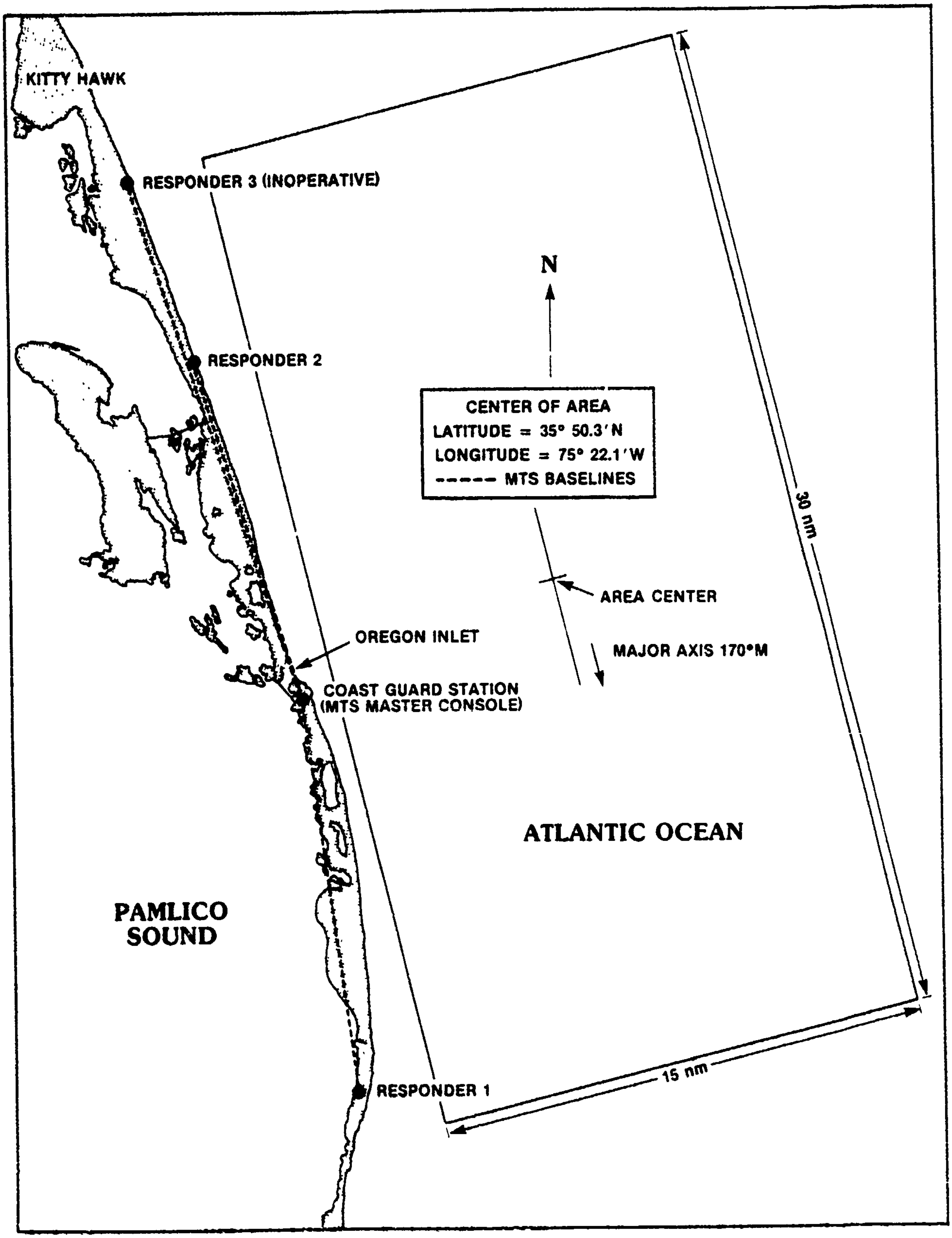

Figure 1-2. Oregon Inlet, North Carolina, Exercise Area

1.3.2 Participants

The primary search aircraft were as follows:

1. HU-25A number 2110 from the Coast Guard Aircraft Repair and Supply Center (AR&SC), Elizabeth City, North Carolina. During the Ft. Pierce, Florida experiment, CG2110 was based at Coast Guard Air Station (CGAS) Miami, Florida, and flown by Miami aircrews. During the Oregon Inlet, North Carolina experiment, AR&SC aircrews operated the aircraft. CG2110 was equipped with an APS-127 FLAR.

2. HC-130 number 1703 from CGAS Clearwater, Florida, was used during the Oregon Inlet, North Carolina experiment. It was flown by an aircrew from the Coast Guard Aircraft Procurement Office, Marietta, Georgia. CG1703 was equipped with an APS-133 FLAR.

3. HC-130 number 1501 from CGAS Elizabeth City, North Carolina, was used during the Oregon Inlet, North Carolina experiment and flown by Air Station Elizabeth City aircrews. CG1501 was equipped with an APN-215 FLAR.

A summary of the aircraft, locations, systems tested, and number of detection opportunities realized may be found in Figure 1-3.

During the Fort Pierce, Florida experiment, Coast Guard Station Fort Pierce provided communications support, docking facilities, and shore facilities for the on-scene monitor vessel (a 42-foot research boat leased from Florida Institute of Technology) and Research and Development (R&D) Center equipment. Station Fort Pierce also provided the services of one of its 41-foot utility boats (UTBs) when needed for target deployment and retrieval.

During the Oregon Inlet, North Carolina experiment, communications support, docking facilities, and shore facilities for the R&D Center's 42-foot UTB and field team equipment were provided by Coast Guard Station Oregon Inlet. Station Oregon Inlet also provided the services of its 30-foot and 41-foot UTBs and its 44-foot motor life boat (MLB) to deploy and retrieve targets as needed. In addition, Coast Guard Group Cape Hatteras, North Carolina provided communications assistance and personnel as needed.

SUMMARY OF FIELD DATA COLLECTION

SYSTEM TESTED	DATES & LOCATIONS	NO. OF TARGET DETECTION OPPORTUNITIES
AN/APS-127 (HDG. STAB. MODE)	February 1983 (Fort Pierce, FL) August 1983 (Oregon Inlet, NC)	160
AN/APS-127 (GND. STAB. MODE)	September 1983 (Oregon Inlet, NC)	99
AN/APS-133 (MAP-1 MODE)	September 1983 (Oregon Inlet, NC)	138
AN/APN-215 (SRCH.-1 OR SRCH.-2 MODE)	August/September 1983 (Oregon Inlet,NC)	126

RESOURCES UTILIZED

AN/APS-127:	HU-25A CG2110	AR&SC AND CGAS MIAMI
AN/APS-133:	HC-130 CG1703	CGAS CLEARWATER AND APO, MARIETTA, GA
AN/APN-215:	HC-130 CG-1501	CGAS ELIZABETH CITY

Figure 1-3. Summary of Data Collected and Resources Utilized

The Coast Guard R&D Center provided tracking equipment, targets, a 42-foot utility boat with crew, and other logistics support to the R&D Center Field Team, which controlled the experiment.

1.3.3. Experiment Design and Conduct

FLAR searches conducted during the Coast Guard field tests were detection runs designed to collect data for developing cumulative detection probability (CDP) versus range curves (see Reference 8 and Section 1.4.1). This measure of effectiveness (MOE), unlike sweep width, is not directly usable for search planning purposes. It is, however, an efficient and useful means of comparing the detection performance of a number of sensors under actual field conditions, and was well suited to the constraints and objectives of this evaluation.

During the Ft. Pierce, Florida, experiment, an HU-25A aircraft collected APS-127 detection data independently. This first experiment was designed primarily as an evaluation of HU-25A visual and FLAR search capabilities and was not originally intended to support the evaluation reported upon here. During the Oregon Inlet, North Carolina, field experiments, two or all three test aircraft searched simultaneously. This approach ensured that similar environmental conditions were encountered by all three of the Coast Guard FLAR systems being evaluated.

Detection run searches were conducted along straight tracklines for targets placed at 4- to 5-nautical mile intervals. The range and bearing of initial target detections were reported to an onboard observer, and visual confirmation of each reported contact was attempted by the aircrew as an aid to data analysis. During detection runs, the FLAR operators were semi-alerted; that is, they had some knowledge of where and when to expect radar contacts to occur. This approach was necessary to eliminate a large number of extraneous targets (primarily sport fishing vessels) from consideration and provided an upper bound on estimates of operational system performance. Subjective observations made during previous CDP experiments have indicated that this semi-alertment does not significantly alter operator behavior.

Display intensity, gain, and other selectable parameters were generally set as recommended by manufacturer's representatives. However, with the exception of range scale selection, operators were free to adjust these settings as they deemed necessary. Operator training and experience in small-target search techniques varied a great deal, with the more experienced personnel tending to make fewer adjustments during searches.

Figure 1-4 illustrates the search pattern used during FLAR searches. Search legs were aligned so that target detection opportunities occurred in the down-wind, up-wind, and cross-wind directions. This methodology was designed to average the effect, if any, of relative ocean wind/wave direction on FLAR detection performance. Each leg of the search pattern was begun at a distance beyond the expected initial detection range for the first target on that leg, ensuring that maximum target detection range could be identified.

1.3.4 Targets and Radar Reflectors

During both experiments, the primary search objects were anchored, 13- to 18-foot open fiberglass boats without engines or other substantial metal equipment, similar fiberglass boats with a 5-foot wooden post and radar reflector, and 4- to 6-man canopied rubber/fabric life rafts with and without radar reflectors. On any given search day, four to six targets were set on two search legs as depicted in Figure 1-4.

A total of 294 useable detection opportunities were obtained for targets with radar reflectors and a total of 229 useable detection opportunities were obtained for targets without reflectors.

In addition, some on-scene monitor vessels (usually UTBs) were occasionally available as targets of opportunity. A limited amount of detection data was collected using these targets for comparison with theoretical range predictions.

1.3.5 Range of Significant Search Parameters

At both locations, environmental conditions ranged from fair to excellent on days that data were collected. Wave heights were in the 1- to 5-foot range with wind speeds to 20 knots. This range of conditions is representative of Douglas sea states 1, 2, and 3.

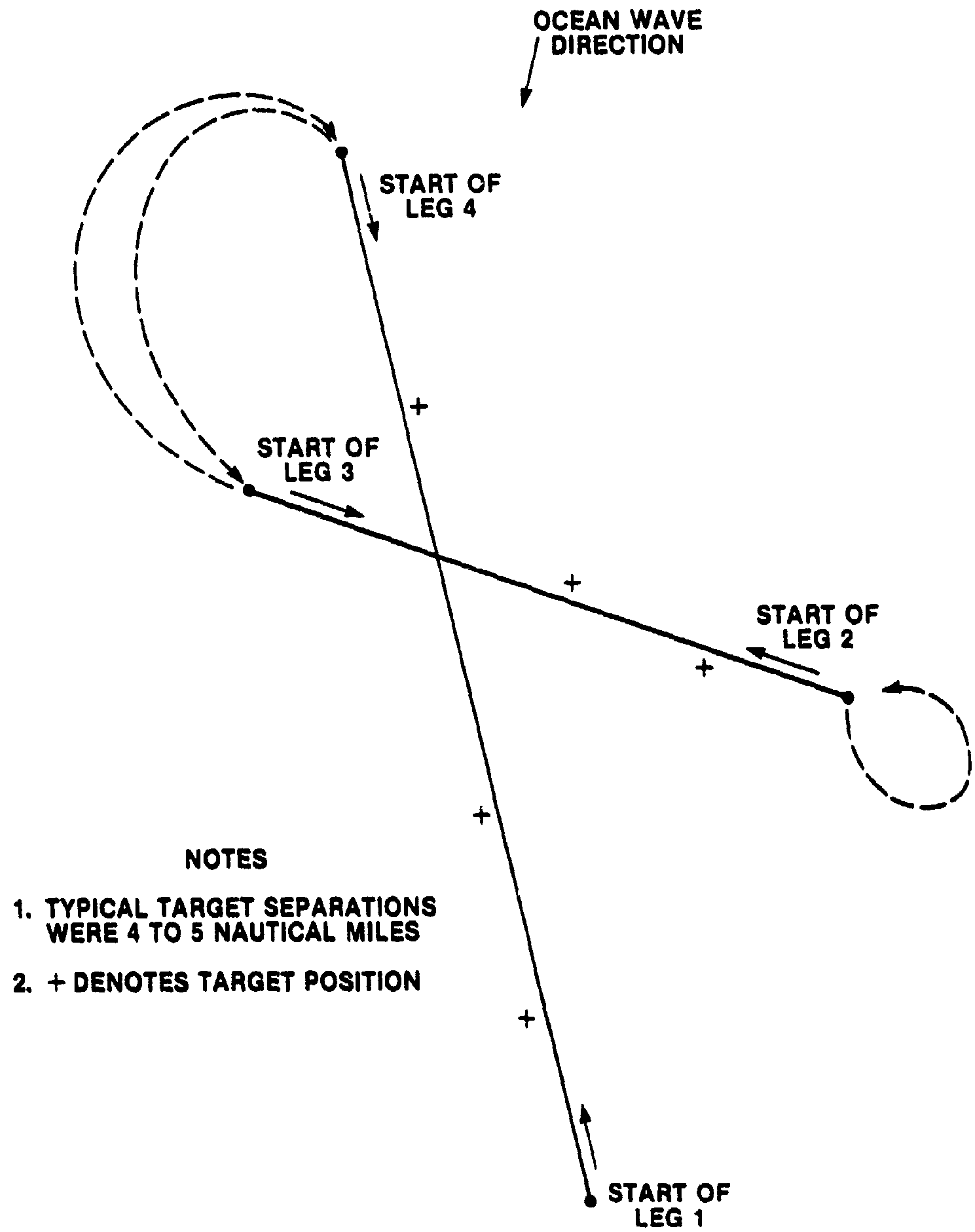

Figure 1-4. Example of FLAR Search Pattern Used for Detection Runs

Operator experience varied a great deal, with the more experienced FLAR operators available at Oregon Inlet. Search speed and altitude were maintained within narrow limits to provide a more uniform data base. Figure 1-5 summarizes the range of environmental conditions and significant search parameters represented in the field test data.

1.3.6 Tracking and Reconstruction

Target location and search unit positions were monitored using an automated Microwave Tracking System (MTS) consisting of a Motorola MiniRanger III mobile tracking system coupled with a Hewlett-Packard 9845B mini-computer and 9872A plotter. This system was developed by the Coast Guard R&D Center for the Probability of Detection in Search and Rescue (POD in SAR) Project to provide target position and search track reconstruction accurate to better than 0.1 nautical mile. Its operation is described in detail in Reference 9.

At Fort Pierce, the MTS master station was located on the roof of the Sea Palms Condominiums. Two secondary stations were located in Vero Beach (to the north) and Stuart (to the south). These locations, which facilitated line-of-sight tracking of searcher and target positions, are depicted in Figure 1-1.

At Oregon Inlet, the MTS master station was located on the Station Oregon Inlet Radiobeacon tower. Two secondary MTS stations were located in Nags Head (to the north) and Waves (to the south). These locations are depicted in Figure 1-2.

Target positions were marked by the on-scene monitor vessel(s) (equipped with MTS transponders) when the targets were first anchored, and again when they were picked up. Positions of the transponder-equipped search units were monitored continuously by the MTS and recorded on magnetic tape every 10 to 30 seconds. Outputs of the MTS included a real-time CRT display of the search area, target positions, and search unit track; a hard copy of searcher, target, and monitor vessel positions; and an 11- by 17-inch position/time plot of each search. An example of a real-time MTS display is shown in Figure 1-6.

RANGE OF ENVIRONMENTAL CONDITIONS ENCOUNTERED

SEA STATES (Douglas)	SIGNIFICANT WAVE HEIGHT (ft)	WIND SPEEDS (knots)
1	< 1.0	0 to 5.5
2	1.0 to 2.5	7 to 12
3	3.0 to 4.5	6 to 19

RELATIVE WIND DIRECTION -- Good mix of up-, down-, and cross-wind search legs.

PRECIPITATION -- None or negligible.

OTHER SEARCH PARAMETERS

ALTITUDES -- 300 to 500 feet.

GROUND SPEED -- 180 to 200 knots.

OPERATOR EXPERIENCE LEVELS

FLAR SYSTEM	HOURS OF SPECIFIC EXPERIENCE
AN/APS-127	1 to 100
AN/APS-133	40 to 100
AN/APN-215	6 to 300

Figure 1-5. Range of Significant Search Parameters

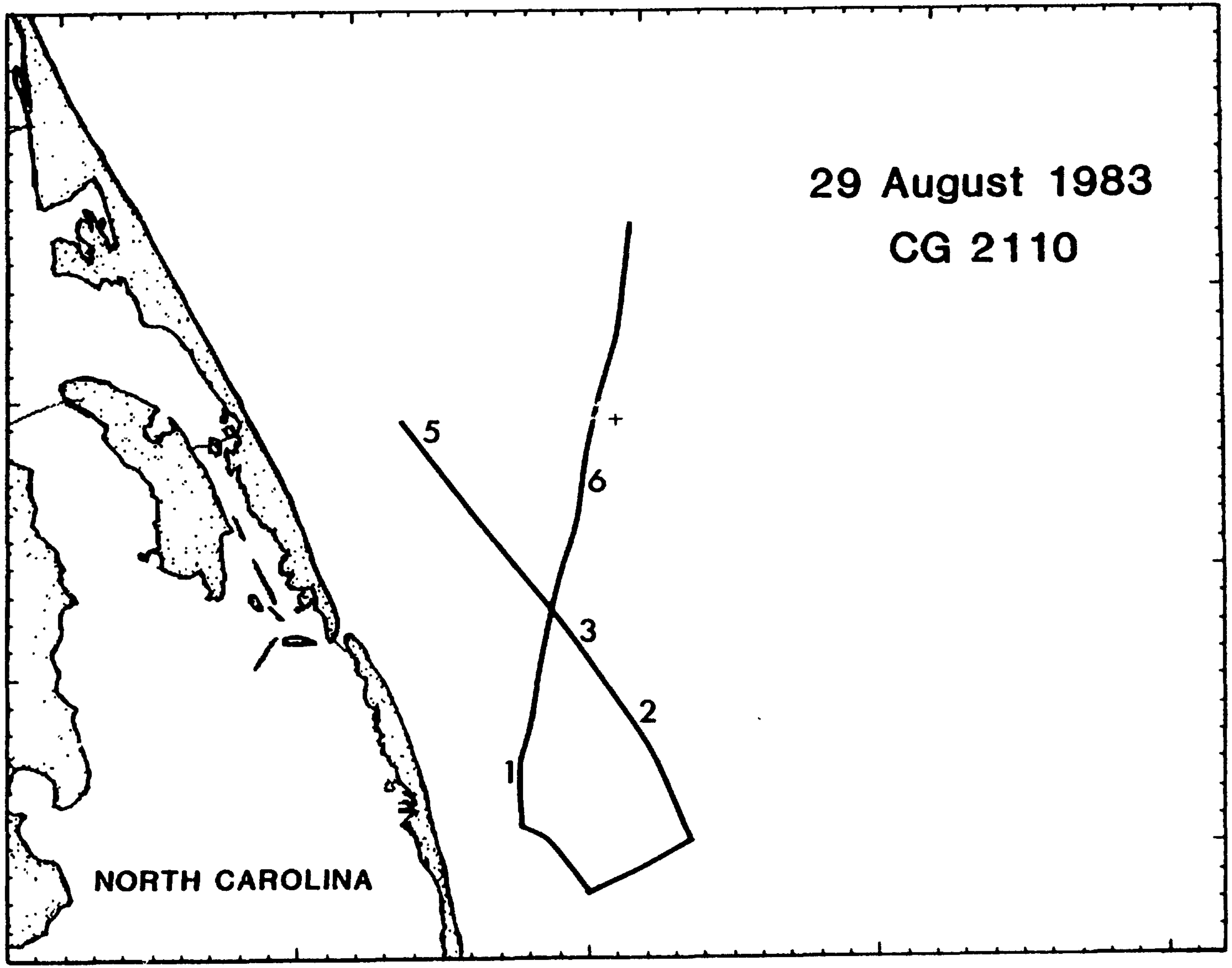

Figure 1-6. Example of MTS Real-Time Display

Detection and closest point of approach (CPA) ranges were determined for each target opportunity by referring to detection logs kept by the observer onboard each search unit and MTS position/time plots. When the range and relative bearing of a contact reported by the radar operator agreed with the MTS plot, a target detection was recorded. Actual detection ranges were measured on the MTS plot directly from the search unit's plotted position at time of contact to the target position. CPA ranges were measured from the target to the nearest point on the search unit trackline.

1.4 ANALYSIS APPROACH

1.4.1 Cumulative Detection Probability

The primary MOE used in this study to evaluate the three existing Coast Guard FLAR systems was cumulative detection probability (CDP) as a function of range. CDP is a useful measure of sensor detection performance because it provides a better picture of how target detection probability increases as sensor-to-target range closes than do detection range statistics alone. CDP computation considers targets missed as well as those detected. Stated simply, CDP is defined as the probability that a target will have been detected by the time it closes to a given range; it is a monotonically increasing function of closing range.

Figure 1-7 illustrates the CDP-versus-range function for a typical radar. The slope of the CDP curve is steepest over the range interval where most detections occur. Horizontal portions of a CDP curve indicate range intervals where no additional targets are detected. It is quite common for a radar CDP curve to exhibit a horizontal segment at very close range where heavy sea clutter or ground return masks targets.

The reader will note that CDP curves are not to be confused with lateral range curves, and cannot be used to compute sweep width for direct use by Coast Guard search planners. CDP is, however, a very efficient means of comparing the detection performance of two or more sensors under field conditions, and was well-suited to the requirements of this study.

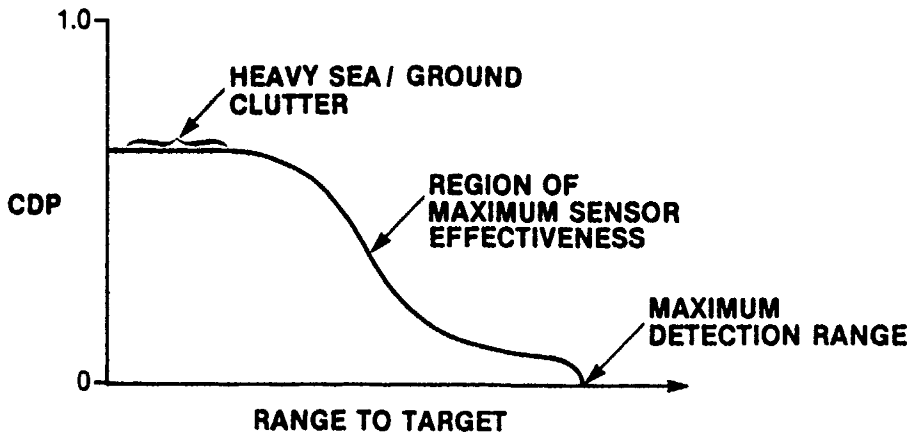

Figure 1-7. Typical CDP-versus-Range Curve for Radar

1.4.2 Analysis of Field Test Data

The primary objective of this data analysis was to quantify the small target detection performance of existing Coast Guard FLAR systems so they could be compared to the APS-134. Field test data collected with the APS-127, APS-133, and APN-215 FLARs were analyzed to quantify and compare detection performance as a function of sea state, target type, and (in the case of APS-127) display mode. Other potentially influential search parameters such as aircraft speed and altitude, relative wind direction, and range scale selection were carefully controlled during the experiments to reduce required data quantities and simplify analysis.

Two data analysis techniques were employed to compare the performance of the three Coast Guard FLAR systems. First, data were sorted according to FLAR system, sea state (1, 2, and 3), target type (with/without radar reflector), and display mode (heading or ground stabilized: APS-127 only). For each data subgroup, mean target detection range and percent of targets detected were computed as rough indicators of radar performance. These statistics were compared using a computer routine which performs two-way analysis of variance (ANOVA) for unbalanced data (Reference 10) to identify which variable(s) exerted statistically significant influences on either or both performance indicators. Next, CDP was plotted as a function of range for each FLAR system/target type/sea state combination of interest. These CDP curves, which appear in Chapter 2, graphically depict the differences in system detection performance exhibited during the field tests. A detailed description of the computer algorithm used to generate these CDP curves appears in Appendix B of Reference 11.

Finally, field test performance of the three Coast Guard FLAR systems was compared to that achieved in West German field tests of the APS-134 during 1980. Detection ranges only were compared between the two data sets. Differences in data collection methods and the limited quantity of available West German field data precluded generation of CDP curves or ANOVA tables for the APS-134.

To validate the detection range comparison, field test detection ranges achieved by the APS-127, APS-133, and APS-134 FLARs were compared to theoretical range predictions for these systems prepared by the Naval Air Development Center (Reference 3). In all three cases, field test data were found to be in good agreement with theoretical range predictions for a 1-square meter (m^2) target. On the basis of this result, it was concluded that legitimate comparisons could be made between the detection ranges achieved during U.S. Coast Guard and West German Air Force field tests, even though slightly different targets and data collection methods were used.

1.4.3 Mission Analysis

The principal objective of this analysis was to determine the expected mission effectiveness for each of the FLAR systems evaluated. Two missions were investigated, SAR and ELT. For each mission, target detection and target classification were determined to be the salient measures of mission effectiveness.

For the SAR mission, targets 16 to 25 feet long were considered to be representative search objects. Targets of this type equate to an approximate radar cross section of 1 m^2. For ELT, drug interdiction represents the most significant problem, with the primary target being "mother ships" 60 to 300 feet long. To represent these targets, an intermediate value for radar cross section of 100 m^2 was selected.

The target radar cross sections selected (1 m^2 for SAR and 100 m^2 for ELT) are consistent with the nominal values used in Reference 3 to compute theoretical FLAR detection range predictions. Selecting these radar cross sectional values allowed the theoretical detection range predictions to be incorporated into this mission analysis.

Target detection alone is important as a sensor measure of effectiveness, but Coast Guard SAR and ELT mission requirements render it a necessary, but not sufficient, one. Once targets are detected, they must be classified to determine whether (in the case of the SAR mission) a target is in fact the distressed vessel in question, and (in the case of the ELT mission), whether the vessel is suspicious. In both cases (SAR and ELT), in an area that can be covered with a high probability of detection, a small fraction of the targets detected by FLAR will be classified at the same time. For example, in the case of a daylight search, some contacts will pass close enough to the aircraft's track to be classified visually. To classify the remainder of the targets detected, the aircraft must take one of three approaches:

1. Pass the targets' locations to another search unit that classifies the contacts,

2. Divert from the pre-assigned track to overfly the target, or

3. Complete the search of the assigned area, and then overfly the targets to classify them.

Approach 1 is probably not possible in a large area, particularly if the target locations are passed to surface units, because of the transit time required for classifications. Approach 2 is most suitable when the contact density is low (as with visual searches presently conducted for most offshore SAR missions), while Approach 3 is a reasonable one to assume for medium- to high-density contact situations.

Given the above discussion, the following MOEs were selected to compare FLAR systems for this mission analysis:

SAR

1. Sweep widths for a 1-m^2 target for several environmental conditions.

2. Time to complete one search (detection only) of a given size area for a 1-m^2 target.

3. Time to complete one search (detection and classification) of a given size area for a 1-m^2 target, assuming both medium and high contact densities.

ELT

1. Sweep widths for a 100-m^2 target for several environmental conditions.

2. Maximum lengths of a fixed barrier that the FLAR-equipped aircraft could effectively patrol.

3. Number of aircraft patrols per day required to maintain a desired detection probability.

For this mission analysis, the predicted detection performance of the FLAR systems is based upon field test results, supplemented with theoretical performance predictions where field test data are not yet available (as described in Section 1.4.2). Theoretical predictions are based upon those developed in Reference 3 and are not reproduced here.

To estimate "sweep width" predictions from available detection data, the area under the CDP curves (described in Section 1.4.1) was determined.* For cases where a CDP curve was not available, an estimated CDP curve was developed using the theoretical detection range predictions of Reference 3 along with the CDP curve shape from the most similar field test data available.

*The definition of sweep width is the area under the lateral range curve, not the CDP curve. Because of the nature of the CDP curve development (e.g., semi-alerted operator, close CPAs) the "sweep widths" estimated for this analysis represent an upper bound on the operational FLAR sweep widths to be expected.

CHAPTER 2
RESULTS

2.1 INTRODUCTION

This chapter discusses the results of two analysis efforts. Section 2.2 presents an analysis, including ANOVA and CDP curves, of data collected during Coast Guard field tests of the APS-127, APS-133, and APN-215 radars. The results of this analysis are then compared to published results of West German APS-134 field tests and to theoretical detection range predictions. Section 2.3 presents an analysis of SAR and ELT mission performance predictions for the FLAR systems.

2.2 ANALYSIS OF FIELD TEST DATA

2.2.1 Analyses of Variance

Raw data from the field test detection runs were sorted with respect to radar type, display mode (APS-127 only), sea state, and target type. The sorted data (a total of 24 subsets) appear in Table 2-1.

To identify detection performance differences among data groups, the percent targets detected and detection range statistics were input to a computer ANOVA routine (described in Section 1.4.2). This computer routine was applied only to data collected in sea states 1 and 2 because the sample sizes for sea state 3 data were insufficient to support ANOVA calculations. The criterion established for identifying meaningful performance differences between data groups was the .10 level of significance. If the ANOVA routine calculated a 10-percent or less probability that two data groups being compared were representative of the same detection data population, they were considered to be significantly different.

Table 2-2 presents ANOVA comparisons among the four FLAR system/operating mode combinations evaluated. Table 2-2 indicates that, in sea state 1, the APS-127

Table 2-1. Sorted Raw Data (Coast Guard Field Tests)

FLAR SYSTEM AND OPERATING MODE	SEA STATE	SMALL TARGETS WITH RADAR REFLECTOR			SMALL TARGETS WITHOUT RADAR REFLECTOR		
		No. Detected/ Total	Percent Detect.	Mean Detection Range	No. Detected/ Total	Percent Detect.	Mean Detection Range
APS-127 HDG. STAB. MODE	1	12/20	60	2.8	14/27	52	2.2
	2	14/33	42	2.4	8/22	36	2.4
	3	1/4	25	2.2	6/54	11	2.6
APS-127 GND. STAB. MODE	1	16/20	80	4.4	5/10	50	4.5
	2	24/37	65	5.0	8/18	44	3.0
	3	2/7	29	2.4	0/7	0	--
APS-133 MAP-1 MODE	1	22/24	92	4.2	12/12	100	3.9
	2	30/65	46	3.3	11/31	35	2.8
	3	0/3	0	--	0/3	0	--
APN-215 SRCH.-1 OR SRCH.-2 MODE	1	27/33	82	3.6	18/25	72	2.5
	2	22/42	52	3.5	8/15	53	1.9
	3	0/6	0	--	0/5	0	--

Table 2-2. FLAR System Performance Comparisons (Present Coast Guard FLARs)

SYSTEMS COMPARED	SEA STATE 1	SEA STATE 2
APS-127 GND. STAB./SHORT PULSE MODE VS APS-127 HDG. STAB./SHORT PULSE MODE	GND. STAB./SHORT PULSE • Achieved significantly longer detection ranges.	GND. STAB./SHORT PULSE • Achieved sigificantly longer detection ranges. • Detected a significantly higher percentage of targets.
APS-133 MAP-1 MODE VS APS-127 HDG. STAB./SHORT OR LONG PULSE MODE	APS-133 • Achieved significantly longer detection ranges. • Detected a significantly higher percentage of targets.	APS-133 • Achieved significantly longer detection ranges.
APN-215 SRCH.-1 OR SRCH.-2 MODE VS APS-127 HDG. STAB./SHORT OR LONG PULSE MODE	APN-215 • Achieved significantly longer detection ranges. • Detected a significantly higher percentage of targets.	NO SIGNIFICANT DIFFERENCES
APS-127 GND. STAB./SHORT PULSE MODE VS APS-133 MAP-1 MODE	APS-133 • Detected a significantly higher percentage of targets.	APS-127 • Achieved significantly longer detection ranges. • Detected a significantly higher percentage of targets.
APS-127 GND. STAB./SHORT PULSE MODE VS APN-215 SRCH.-1 OR SRCH.-2 MODE	APS-127 • Achieved significantly longer detection ranges.	APS-127 • Achieved significantly longer detection ranges.
APS-133 MAP-1 MODE VS APN-215 SRCH.-1 OR SRCH.-2 MODE	APS-133 • Achieved significantly longer detection ranges. • Detected a significantly higher percentage of targets.	NO SIGNIFICANT DIFFERENCES
SUMMARY	• APS-133 detected highest percentage of targets. • APS-127 (GND. STAB.) and APS-133 consistently outperformed other system/mode combs. • APN-215 outperformed APS-127 (HDG. STAB.).	• APS-127 (GND. STAB.) consistently outperformed all other systems.

DETERMINED BY ANALYSIS OF VARIANCE AT THE .10 LEVEL OF SIGNIFICANCE OR BETTER ground-stabilized mode and the APS-133 achieved significantly longer detection ranges and/or significantly higher percent targets detected than did the APN-215 and APS-127 heading-stabilized mode. The APS-133 achieved target detection percentages significantly better than the other three system/mode combinations in sea state 1. In contrast to the ground-stabilized mode, the APS-127 heading-stabilized mode attained detection ranges and/or target detection percentages that were significantly lower than those achieved by the other three system/mode combinations.

In sea state 2, the APS-127 ground-stabilized mode demonstrated its superior clutter processing capabilities by consistently outperforming the other three system/mode combinations. No significant performance differences were identified between the APN-215 and the APS-127 heading-stabilized mode or between the APN-215 and the APS-133. The APS-133 achieved significantly longer detection ranges than the APS-127 heading-stabilized mode in sea state 2.

Data collected in sea state 3, while not sufficient to support ANOVA computations, indicated that none of the three systems tested are capable of satisfactory small target detection performance under those conditions.

2.2.2 CDP Curves for Present Coast Guard FLAR Systems

Four sets of CDP versus range curves were plotted from the field test data. Figures 2-1 through 2-4 depict the CDP attained by the four FLAR system/display mode combinations in sea states 1 and 2 using targets with and without radar reflectors.

The curves in Figure 2-1 (sea state 1, targets with radar reflector) demonstrate that, even though the APS-133 attains about the same CDP as the APS-127 ground-stabilized mode, the APS-127 makes about half of its detections at longer ranges than the APS-133. This capability translates into more available time for the FLAR operator to recognize the presence of a target on his display, which, in turn, enhances detection probability. The detection ranges and CDP achieved by the APN-215 were slightly below those of the APS-133. The performance of the APS-127 heading-stabilized mode was clearly inferior to that of the other three system/mode combinations. The reader should note, however, that some of the performance degradation exibited by the APS-127

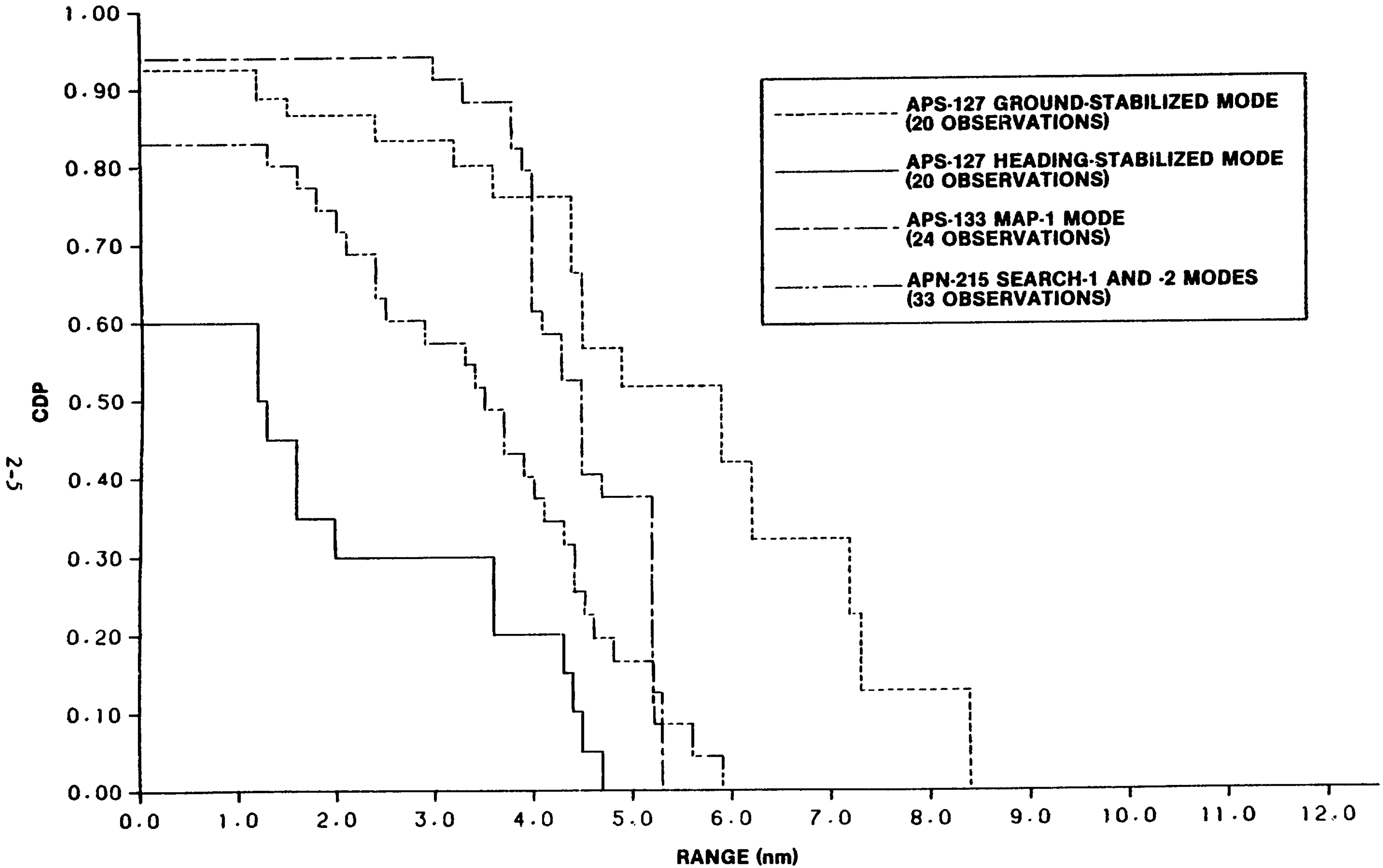

Figure 2-1. CDP Curves for Targets with Radar Reflectors; Sea State 1 (Coast Guard Field Tests)

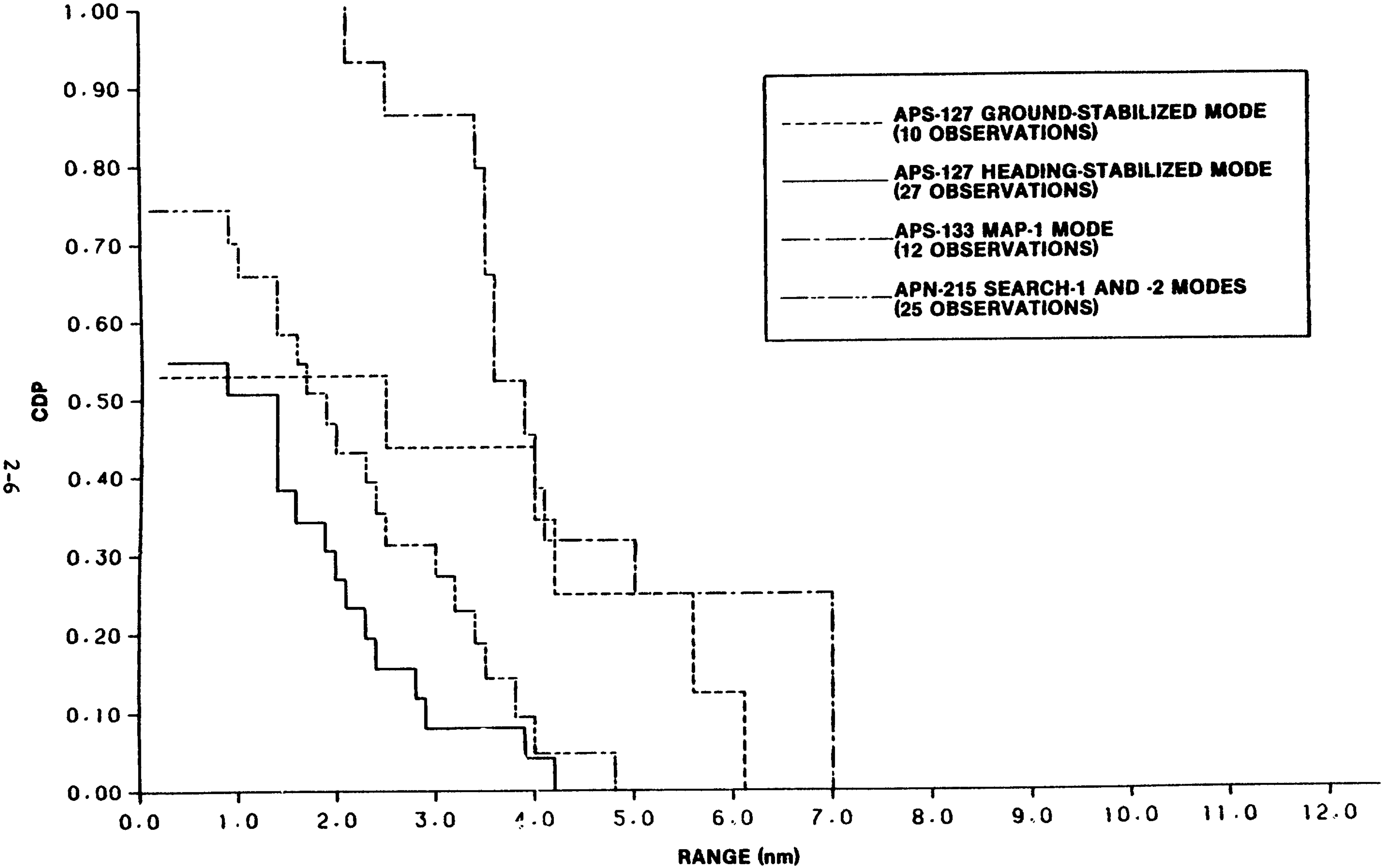

Figure 2-2. CDP Curves for Targets without Radar Reflectors; Sea State 1 (Coast Guard Field Tests)

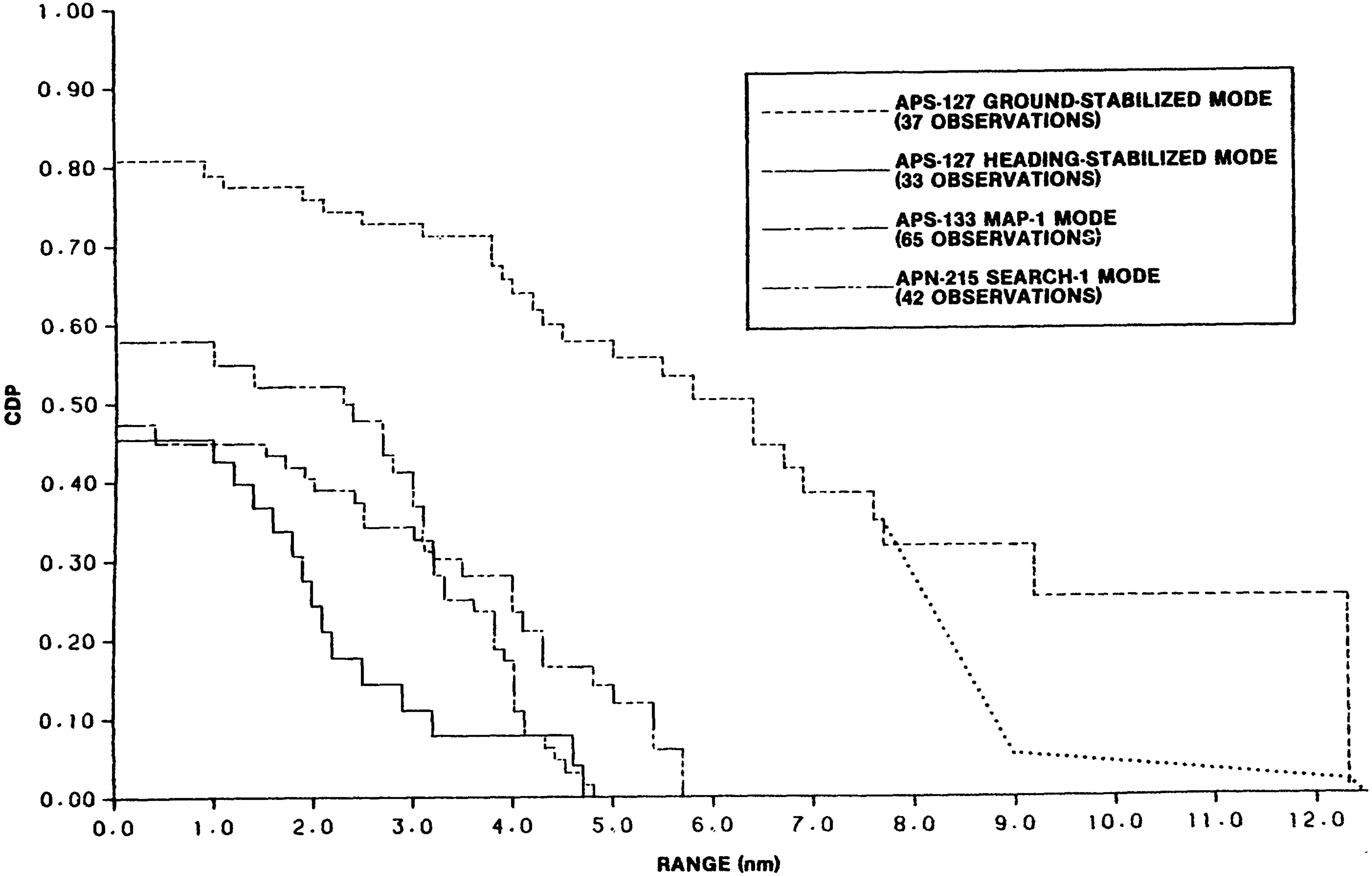

Figure 2-3. CDP Curves for Targets with Radar Reflectors; Sea State 2 (Coast Guard Field Tests)

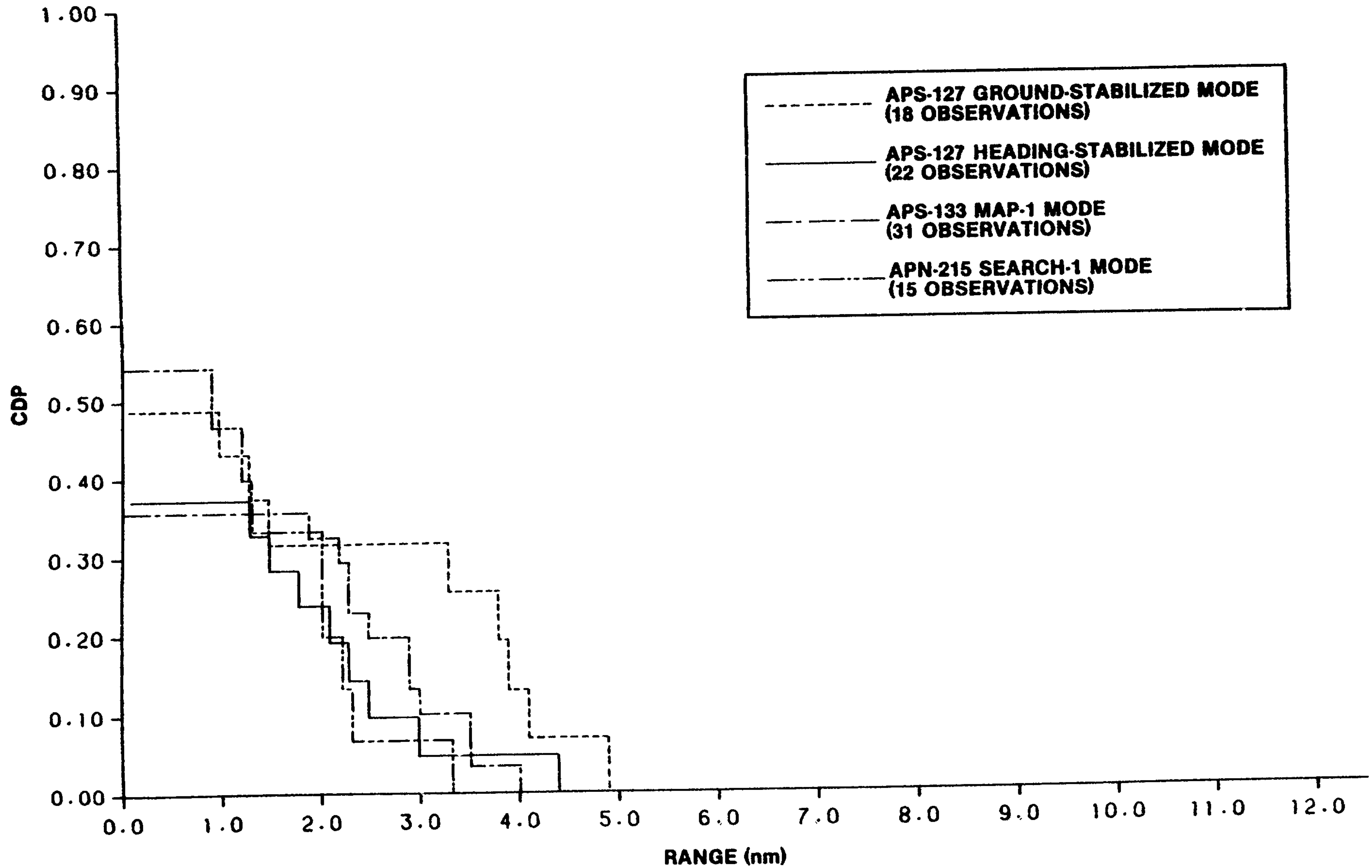

Figure 2-4. CDP Curves for Targets without Radar Reflectors; Sea State 2 (Coast Guard Field Tests)

heading-stabilized mode may be attributable to lack of operator experience. Almost all of the data collected in heading-stabilized mode involved operators who had limited (5 to 35 hours) prior experience with the APS-127. Operator inexperience, coupled with the fairly complex adjustment requirements of the APS-127 display, could have contributed to the relatively poor detection performance achieved in heading-stabilized mode. This performance discrepancy was exhibited in all four CDP data groups, but will not be discussed repeatedly.

Figure 2-2 presents CDP curves for targets without a radar reflector in sea state 1. Figure 2-2 indicates that the APS-133 and the APS-127 ground-stabilized mode make detections of these targets at ranges as long as 6 to 7 nautical miles. On the basis of limited data (only 12 detection opportunities), it appears that the APS-133 is substantially more capable of detecting weak targets in calm seas than the other system/mode combinations evaluated. Particularly surprising is the fact that both the APS-133 and the APN-215 operators achieved higher CDP than those using the two APS-127 display modes; theoretical calculations (Reference 3) indicate that the APS-127 should have outperformed the other two FLARs. The most plausible explanation for this discrepancy is that the color displays on the APS-133 and APN-215 are easier to adjust and interpret than the APS-127 display (a direct view storage tube), making weak targets more visible even to inexperienced operators in an environment where clutter processing is not required.

Figure 2-3 (sea state 2, targets with a radar reflector)* demonstrates the advantage that the clutter processing capabilities of the APS-127 ground-stabilized mode provide in even light wind/sea conditions. The APS-127 ground-stabilized mode achieves substantially higher CDP and longer detection ranges than the other three system/mode combinations. The APS-133 and APN-215 FLARs achieved similar performance, while the APS-127 heading-stabilized mode again provided the least detection capability.

*NOTE: The dotted line in Figure 2-3 is an estimate of what the APS-127 ground-stabilized mode CDP curve would look like if all 37 targets encountered were opportunities for detection at ranges of 8 to 12 nautical miles. The field data collection runs often started inside these ranges, providing a very small data set beyond 8 nautical miles. This characteristic caused unusually high CDP steps at the longer ranges (e.g., the initial step to 25-percent CDP represents a single detection out of only 4 target opportunities.

Figure 2-4 represents the poorest circumstances in which sufficient field data were collected to develop CDP curves: targets without a radar reflector in sea state 2. As the curves demonstrate, none of the system/mode combinations evaluated achieved detection ranges beyond 5 nautical miles or CDPs greater than 55 percent. The APS-127 ground-stabilized mode again achieved the longest detection ranges, but little difference in performance among the four system/mode combinations was demonstrated in the data.

In summary, the APS-127 ground-stabilized mode achieved the best detection performance against targets with a radar reflector, especially in sea state 2. The APS-133 bettered the performance of the APS-127 against targets without a radar reflector in sea state 1. The APS-127 heading-stabilized mode achieved CDPs and detection ranges that were consistently below those of the other three system/mode combinations tested.

2.2.3 Comparisons of U. S. Coast Guard and West German Field Test Data with Theoretical Predictions

In order to incorporate the APS-134 FLAR into this evaluation, a basis for comparing the field test data sets had to be established. This basis was established by compiling and comparing available field test data with theoretical detection performance predictions to determine how well the two data groups correlated. If both Coast Guard and West German field data agreed well with theoretical predictions, it could be assumed that the targets and data collection methods used to generate the two independent field data sets were similar enough so that these data could be compared quantitatively. Further, it could be assumed that the theoretical calculations were accurate enough for use in extrapolating field test results to conditions not actually represented in the data bases.

Table 2-3 summarizes the data sources that were available for use in this study. West German field test data were obtained from References 12 and 13. Note that there are some dissimilarities between the assumptions made in performing the theoretical calculations and the actual conditions under which field test data were collected. These dissimilarities were not considered serious enough to invalidate the comparisons made during this analysis.

Table 2-3. Available Field Test Data and Theoretical Performance Estimates

SOURCE	FLAR SYSTEM(S)	DESCRIPTION	CONDITIONS/ASSUMPTIONS
USCG R&D CENTER FIELD TESTS (1983)	AN/APS-127 AN/APS-133 AN/APN-215	Detection runs conducted with 16-foot fiberglass boats, 4- to 6- man canopied life rafts, and a 42-foot UTB. Small boats and rafts were tested with and without radar reflectors of advertised cross section of up to 11 m^2	300- to 500- foot search altitudes Large data sets (~100 targets each system)
WEST GERMAN AIR FORCE FLIGHT TESTS (1980)	AN/APS-134	Blip/scan runs conducted with 1-m^2 and 12-m^2 Luneberg lens targets and a 100-ft tug.	1500-foot search altitude (small targets) 5000-foot search altitude (large target) Small data set (~25 targets)
NADC PERFORMANCE ESTIMATES (1982)	AN/APS-127 AN/APS-133 AN/APS-134	Plots of minimum detectable radar cross section versus sea state and range to target.	P_{detect}= .90 1000-foot search altitude (small targets) 7500-foot search altitude (large targets)
NADC PERFORMANCE ESTIMATES (1977)	AN/APS-127	Plots of minimum detectable radar cross section versus sea state and range to target.	P_{detect}= .50 500-foot search altitude

NOTE: P_{detect} = instantaneous detection probabilities

The data in Table 2-4 demonstrate general agreement between theoretical range predictions and field test results.* The detection ranges listed in the table for a 1-m^2 target (USCG R&D field tests) are those achieved against targets with a radar reflector. Targets without a radar reflector were not generally detected at these ranges and were assumed to have radar cross sections well below 1-m^2. In most cases, field test detection ranges are slightly better than those predicted by theory. This may be due to the more favorable search altitudes and lower instantaneous detection probabilities that characterized the field test data as compared to the theoretical assumptions.

Because of the acceptable agreement obtained between theory and field data, it was concluded that the Coast Guard and West German tests were similar enough to justify a direct comparison of detection performance data. Section 2.3 details the results of a mission analysis conducted to compare these data by applying them to two Coast Guard operational requirements.

2.3 RESULTS OF MISSION ANALYSIS

As stated in Section 1.4.3, the MOEs to be used in evaluating each of the FLAR systems were the following:

<u>SAR</u>

1. Sweep widths for a 1-m^2 target for several environmental conditions,

2. Time to complete one search (detection only) of a given size area for 1-m^2 targets, and

3. Time to complete one search (detection <u>and</u> classification) of a given size area for 1-m^2 targets in both medium and high traffic density areas.

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*NOTE: The field data for 50-m^2 targets cannot be directly compared with theoretical predictions. This limitation occurred because the FLAR range scales in use were selected to optimize small (1-m^2) target search performance during the Coast Guard field tests. The 5- to 10-nautical mile range scales in use were not adequate for determining the maximum detection range for a 50-m^2 target.

Table 2-4. Predicted versus Actual Detection Ranges (nautical miles)

TARGET CROSS SECTION	THEORETICAL PREDICTIONS						FIELD TEST PERFORMANCE					
	SOURCE	SYSTEM	SS-1	SS-2	SS-3	SS-5	SOURCE	SYSTEM	SS-1	SS-2	SS-3	SS-5
1 m^2 SMALL TARGETS (<20 ft)	NADC (1982)	APS-134	20	--	20	1.5	W. GERMAN FLT. TESTS (1980)	APS-134 (MODE I)	20 - 22.3	--	24 - 35.9	--
	"	APS-133	4 - 5	--	0	0	USCG R&D FIELD TESTS (1983)	APS-133	3 - 5.3	0.4 - 4.8	--	--
	"	APS-127	4 - 7	--	0	0		APS-127 (GND STAB)	1.2 - 8.4	0.9 - 12.3	0.9 - 3.9	--
	NADC (1977)	APS-127	12	7	5	--						
50 m^2 40- TO 60-FOOT TARGETS	NADC (1982)	APS-133	20 +	--	2.5	0	USCG R&D FIELD TESTS (1983)	APS-133	--	1.7 - 4.9*	--	--
	"	APS-127	>25	--	0-4.5 & 22-25	0		APS-127 (GND STAB)	--	1.8 - 10.0*	--	--
	NADC (1977)	APS-127	>25	>25	>25	--						
100 m^2 ~100- FOOT TARGETS	NADC (1982)	APS-134	60 +	--	60 +	60 +	W. GERMAN FLT. TESTS (1980)	APS-134 (MODES I & II)	75 - 80.5 (7 RUNS)	--	74 - 75.6 (4 RUNS)	--

***Limit of range scale used**

NOTE: Instantaneous detection probabilities assumed in the theoretical calculations ranged from 50 to 90 percent. Actual "instantaneous" detection probabilities were likely well below this level (although they were not computed during the R&D tests) except in the case of the APS-134.

ELT

1. Sweep widths for a 100-m^2 target for several environmental conditions,

2. Maximum length of a fixed barrier that the FLAR-equipped aircraft could effectively patrol, and

3. Number of aircraft patrols per day required to maintain a desired minimum detection probability.

2.3.1 SAR Mission Analysis

Figure 2-5 shows the estimated FLAR sweep widths for 1-m^2 targets in sea states 1, 3, and 5. The sweep width estimates for sea states 1 and 3 are based upon both field test results and theoretical predictions (see Section 2.2) while the sea state 5 estimates are based solely upon the theoretical predictions of Reference 3.

As Figure 2-5 shows, the APS-134 FLAR detection performance is clearly superior to that of the other FLAR systems evaluated. For sea state 1, the APS-134 sweep width is 4 to 6 times greater than the sweep widths of the other FLAR systems. For sea states of 3 or greater, the APS-134 is the only FLAR system with any meaningful detection capability for a 1-m^2 target.

As discussed in Section 1.4.3, to support the SAR mission, the FLAR-equipped aircraft must not only detect these targets but also classify them (e.g., determine whether the contact is the subject of the SAR case). Beyond the size of the "blip" on the display and, in the case of the APN-215 and APS-133, the intensity of the blip as indicated by its color, the FLAR systems provide little information to aid in classifying the contact. Other sensors (e.g., visual scanners, FLIR) must be used to determine whether the FLAR contacts are targets of interest. To determine the expected performance of each of these FLAR systems in detecting and classifying SAR targets, the following scenario was established:

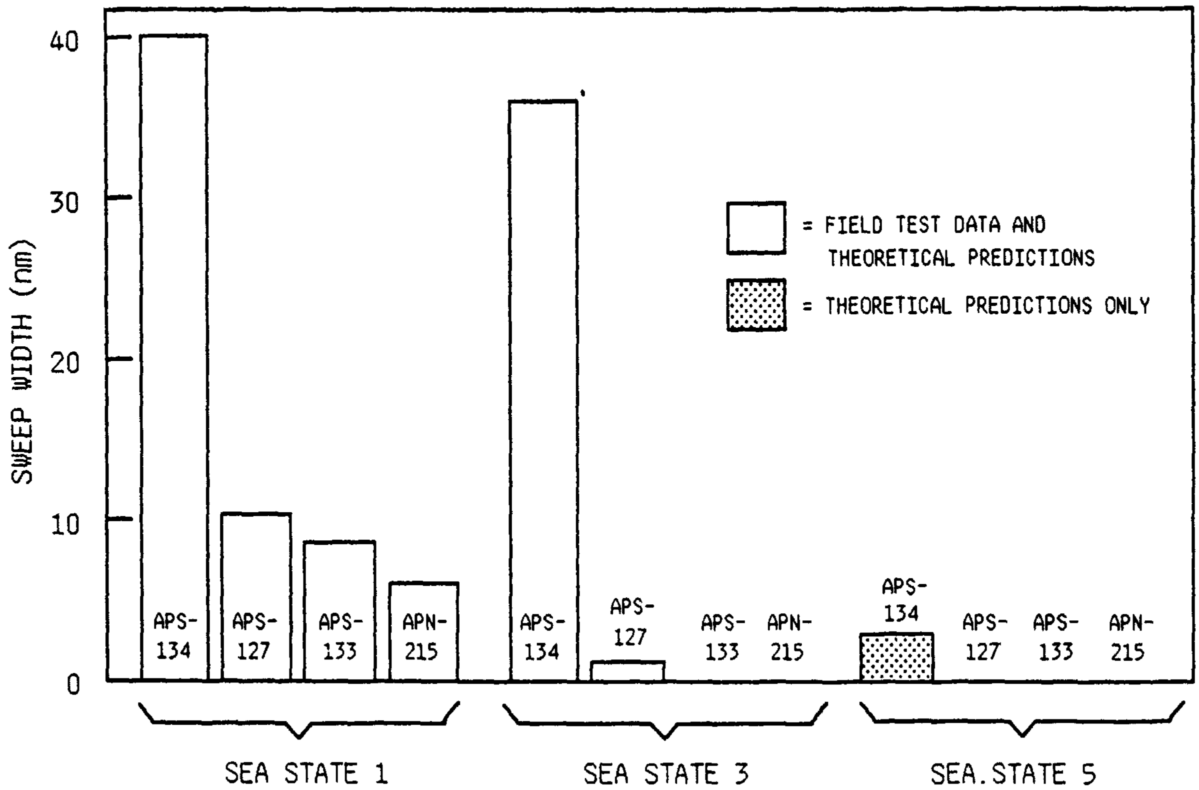


Figure 2-5. FLAR Sweep Widths for 1-m^2 Targets

1. A 75-nm x 75-nm area is to be searched with a coverage factor of 2.0 (i.e., greater than 95-percent POD), using a paral.el track search.

2. The target of interest is a 16- to 18-foot white boat with a radar cross section of approximately 1 m^2.

3. Two traffic densities will be considered: 10 contacts in the area (one contact every 560 nm^2) and 50 contacts in the area (one contact every 110 nm^2).

4. Contacts are uniformly distributed in the search area. The tactic used by the FLAR-equipped aircraft is to mark the position of targets detected and, upon completion of the search, to conduct a point-to-point fly-over of targets to classify them (visually or with FLIR) as described in Section 1.4.3.

5. Targets that are within 0.5 nautical mile of the aircraft's track will be classified during the initial parallel track search; other contacts will be classified through the point-to-point fly-over.

6. Aircraft search speed is 200 knots.

Table 2-5 shows the predicted times for FLAR-equipped aircraft to complete one search of this 75-nm x 75-nm area in sea states 1 and 3. As can be seen from Table 2-5, the APS-134 FLAR provides the best performance (least time to complete the search) with the APS-127 providing somewhat better performance than the APS-133 and APN-215 FLARs.

Figure 2-6 provides a comparison of the APS-134 and APS-127 FLAR systems to one another and to visual search for the three cases evaluated:

- o Detection only,
- o Detect and classify (10 contacts in the search area), and
- o Detect and classify (50 contacts in the search area).

As can be seen from Figure 2-6, the APS-134 performance advantage is greatest for the detection-only case (visual search time is 13 times that of the APS-134 and APS-127 search time is 4 times that of APS-134). The requirement of classification as well as detection reduces the APS-134 performance advantage considerably. For the 50-contact case, the visual search time is 2.1 times that of the APS-134 and the APS-127 search time is 1.3 times that of the APS-134.

Table 2-5. Predicted Time for FLAR-Equipped Aircraft to Complete One Search of a 75-nm x 75-nm Area (1-m^2 Target)*

FLAR TYPE	SEA STATE (Douglas)	TIME TO COMPLETE (hours)			
		DETECTION ONLY		DETECT AND CLASSIFY	
		VISUAL**	FLAR	10 CONTACTS	50 CONTACTS
APN-215	1	18.4	9.4	10.6	15.7
APS-133	1	18.4	6.7	8.2	13.9
APS-127	1	18.4	5.6	7.1	13.0
APS-134	1	18.4	1.4	3.2	10.1
APN-215	3	55.9	---	55.9	55.9
APS-133	3	55.9	---	55.9	55.9
APS-127	3	55.9	~56	55.9	55.9
APS-134	3	55.9	1.7	3.5	10.4

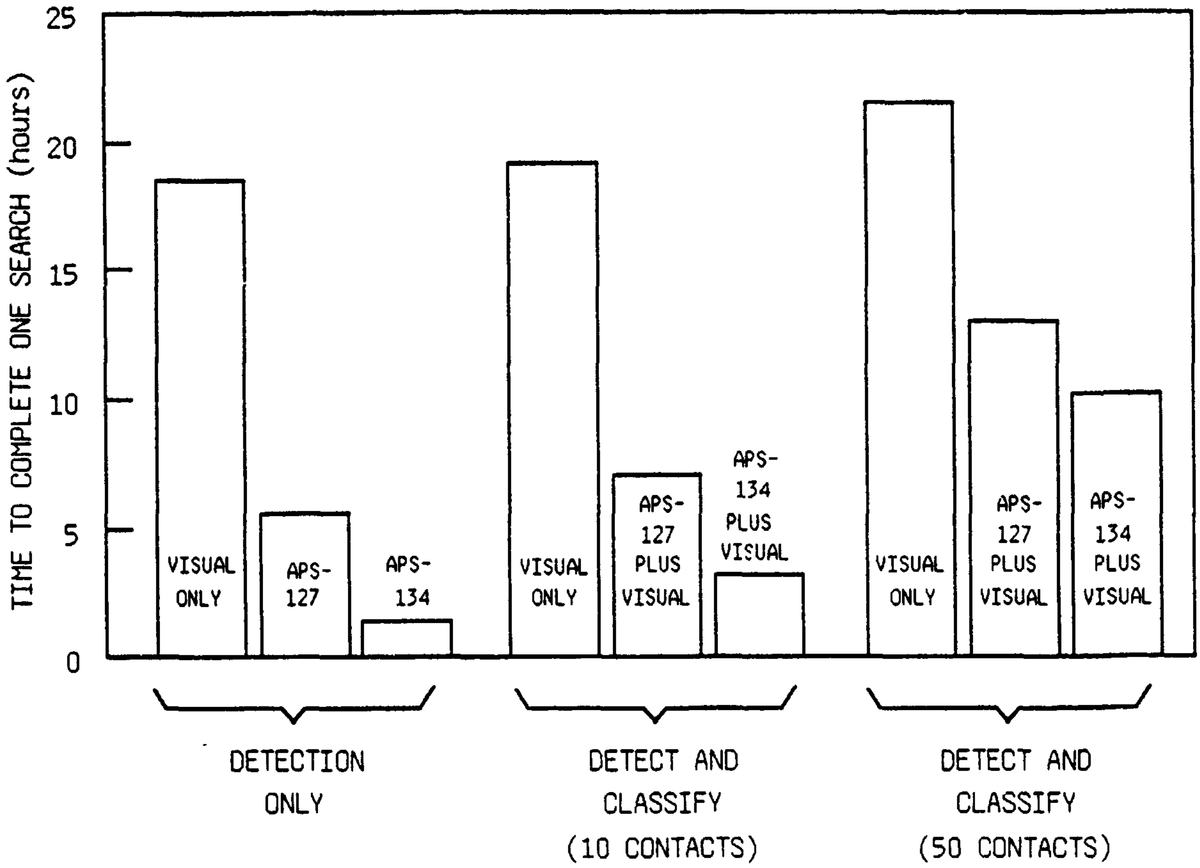
* Coverage factor of 2.0, search speed = 200 knots.

** Based upon visual sweep width predictions from Reference 9. Environmental conditions assumed were as follows:

Sea State 1 - visibility > 10 nm, cloud cover = 50%, wind spd. = 10 knots, sig. wave ht. = 1 ft
Sea State 3 - visibility > 10 nm, cloud cover = 0%, wind spd. = 20 knots, sig. wave ht. = 4.5 ft

NOTE

In cases where FLAR sweep width estimates fell below those for visual search, a visual search was assumed in estimating total mission time.



*COVERAGE FACTOR = 2.0; RADAR CROSS SECTION = 1 m^2

Figure 2-6. Time to Complete One Search of a 75-nm x 75-nm Area for a 16- to 18-Foot White Boat (Sea State 1)

Figure 2-7 shows that, as environmental conditions deteriorate to sea state 3, the APS-134 performance advantage over other FLAR systems and visual search increases. For the detection-only case, the time to complete the search for both visual and APS-127 searchers is 33 times that of the APS-134. For the detect-and-classify case (50 contacts), the time to complete both the visual and APS-127 searches is 5 times greater than the APS-134 search time.

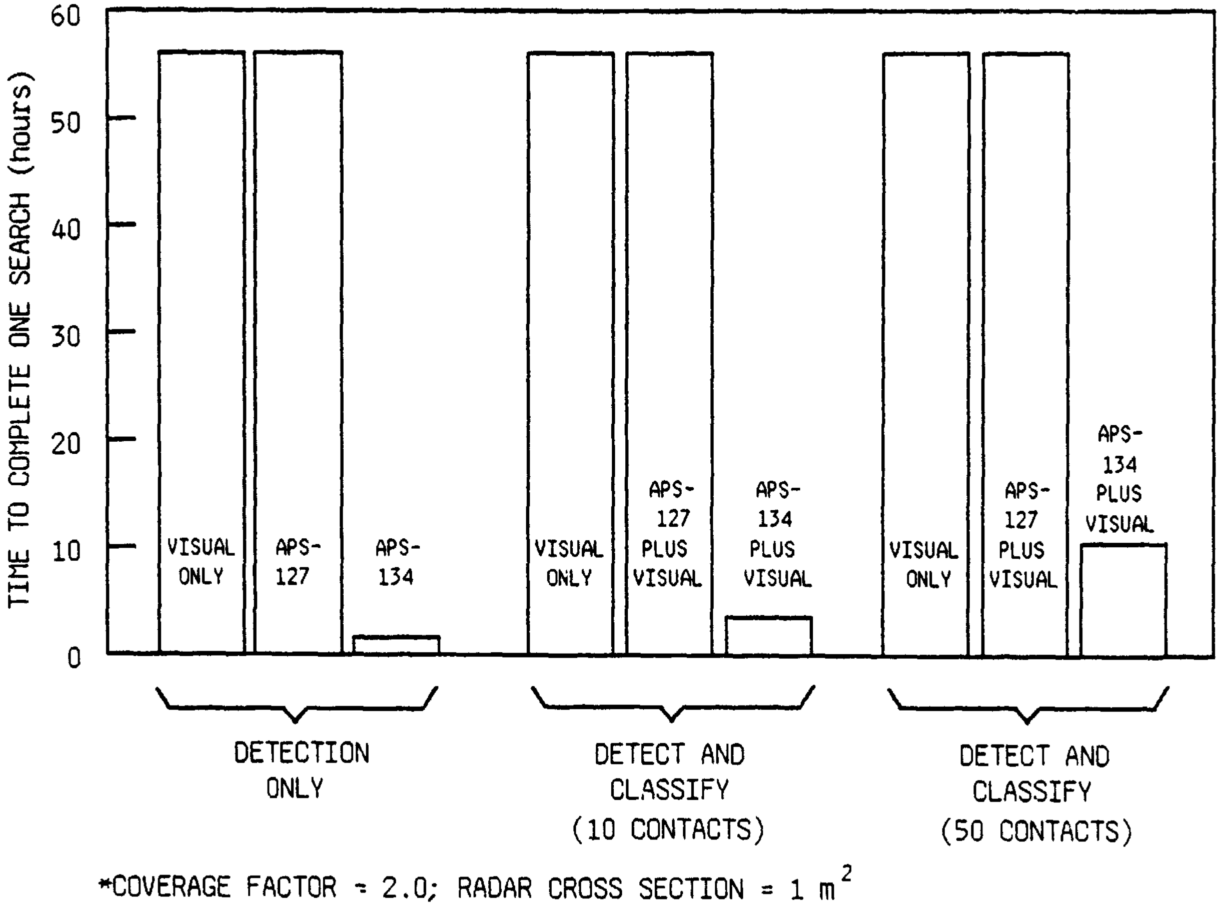


Figure 2-7. Time to Complete One Search of a 75-nm x 75-nm Area for a 16- to 18-Foot White Boat (Sea State 3)

2.3.2 ELT Mission Analysis

Figure 2-8 shows FLAR sweep width estimates for 100-m^2 targets in sea states 1, 3, and 5. All three FLAR systems evaluated (APS-134, APS-127, and APS-133) provide considerable detection capability for those targets in good to moderate conditions (sea states 1 and 3), while only the APS-134 provides any capability in sea state 5. In sea state 1, the APS-134 provides a 65-percent performance improvement over the APS-133, while the APS-127 provides a 13-percent improvement. In sea state 3, the APS-134 provides an 86-percent improvement over the APS-133 and the APS-127 a 20-percent improvement.

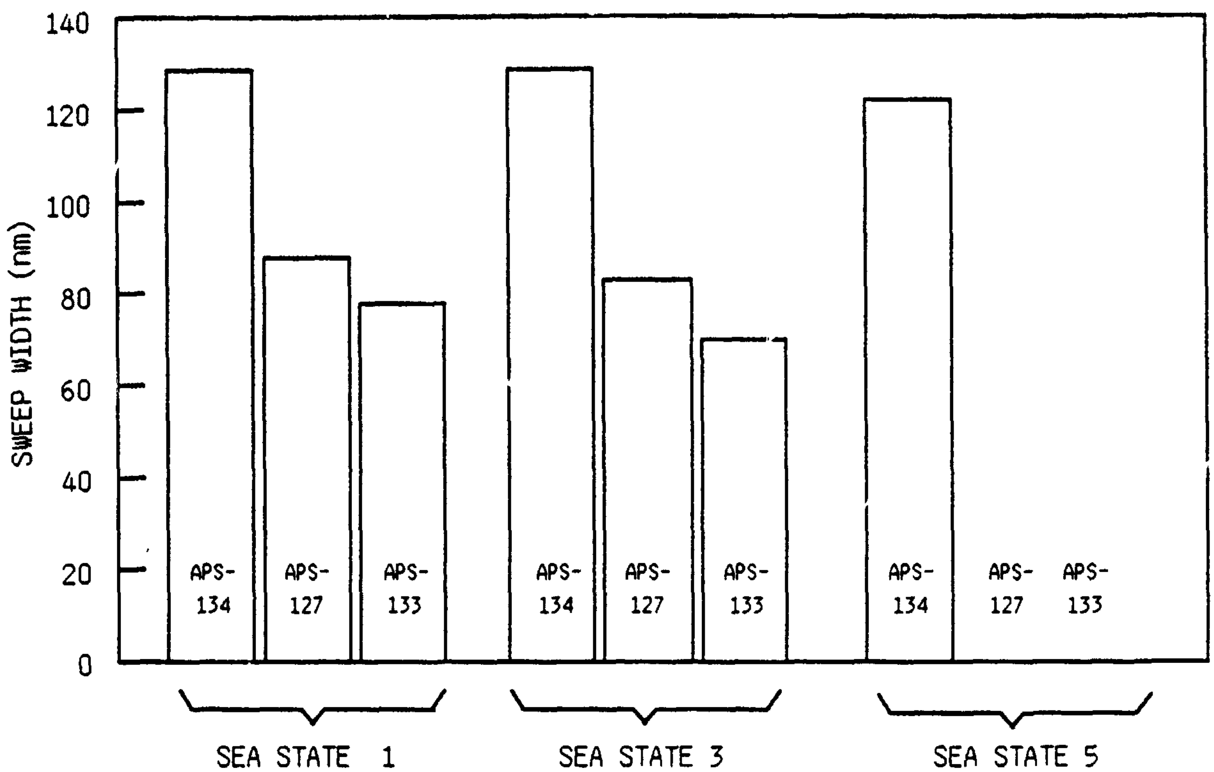


Figure 2-8. FLAR Sweep Widths for 100-m^2 Targets

To translate these sweep widths (Ws) into a measure that is more directly related to the ELT mission, a fixed-barrier patrol scenario (shown in Figure 2-9) was established. The following assumptions were made with respect to this scenario:

1. The barrier width is equal to the sweep width (e.g., the minimum POD for a target inside the barrier is 78 percent).

2. Two target speeds of advance (SOAs) were considered: 15 knots and 30 knots.

3. Aircraft search speed is 250 knots.

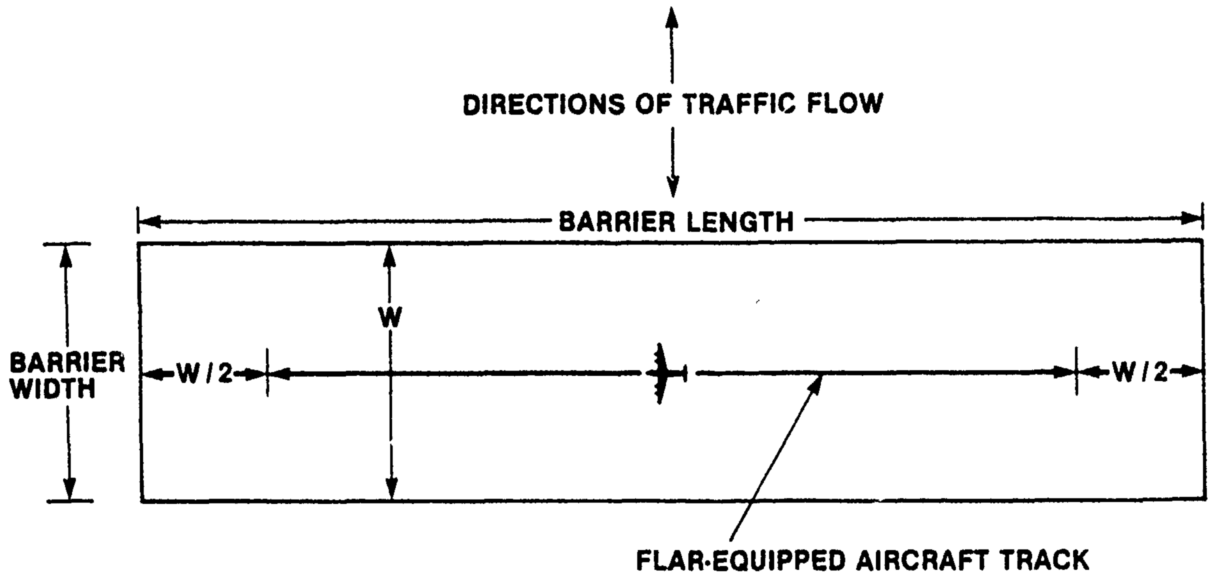


Figure 2-9. ELT Barrier Patrol Scenario (W denotes sweep width)

Given these assumptions, the maximum barrier length (L_{max}) that can be patrolled is computed to be:

$$L_{max} = \frac{W \times \text{aircraft speed}}{2 \times \text{target SOA}} + W .$$

Figure 2-10 shows the maximum barrier lengths that could be patrolled with a minimum 78-percent POD for each combination of FLAR system and environmental conditions evaluated.

In order to relate these maximum barrier lengths to an operational need, three Caribbean choke points (Yucatan Channel, Windward Passage, and Mona Passage) will be considered. Figure 2-11 illustrates these choke points. The measure of effectiveness to be used in evaluating FLAR system alternatives will be the number of aircraft patrols per day required to provide continuous coverage of all three choke points with a minimum POD of 78 percent. As a point of comparison, the number of WMECs required to provide the same effectiveness will also be determined. A 15-knot search speed and a radar sweep width of 20 nautical miles will be assumed for the WMECs.

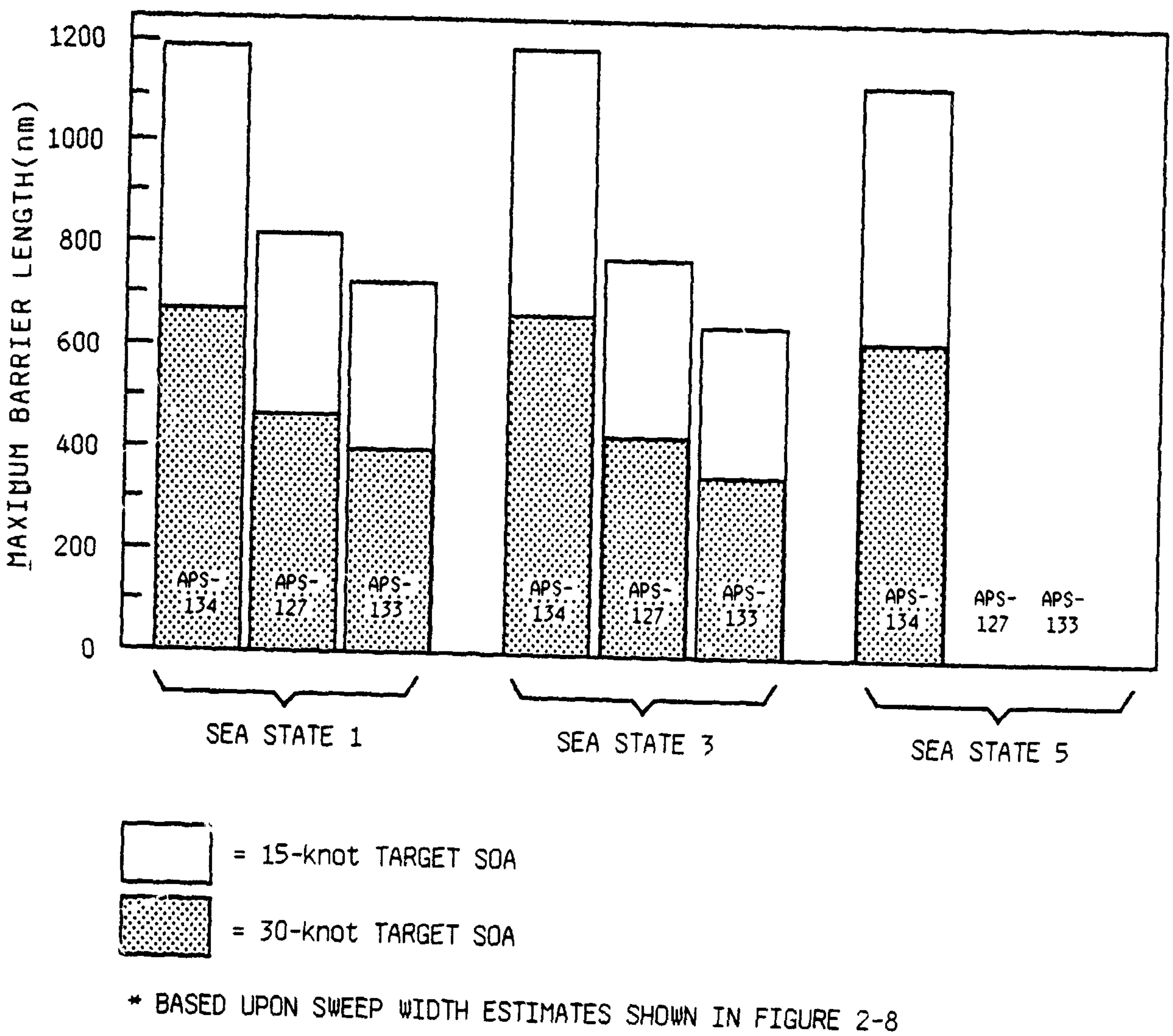


Figure 2-10. Maximum Barrier Lengths for 100-m^2 Targets*

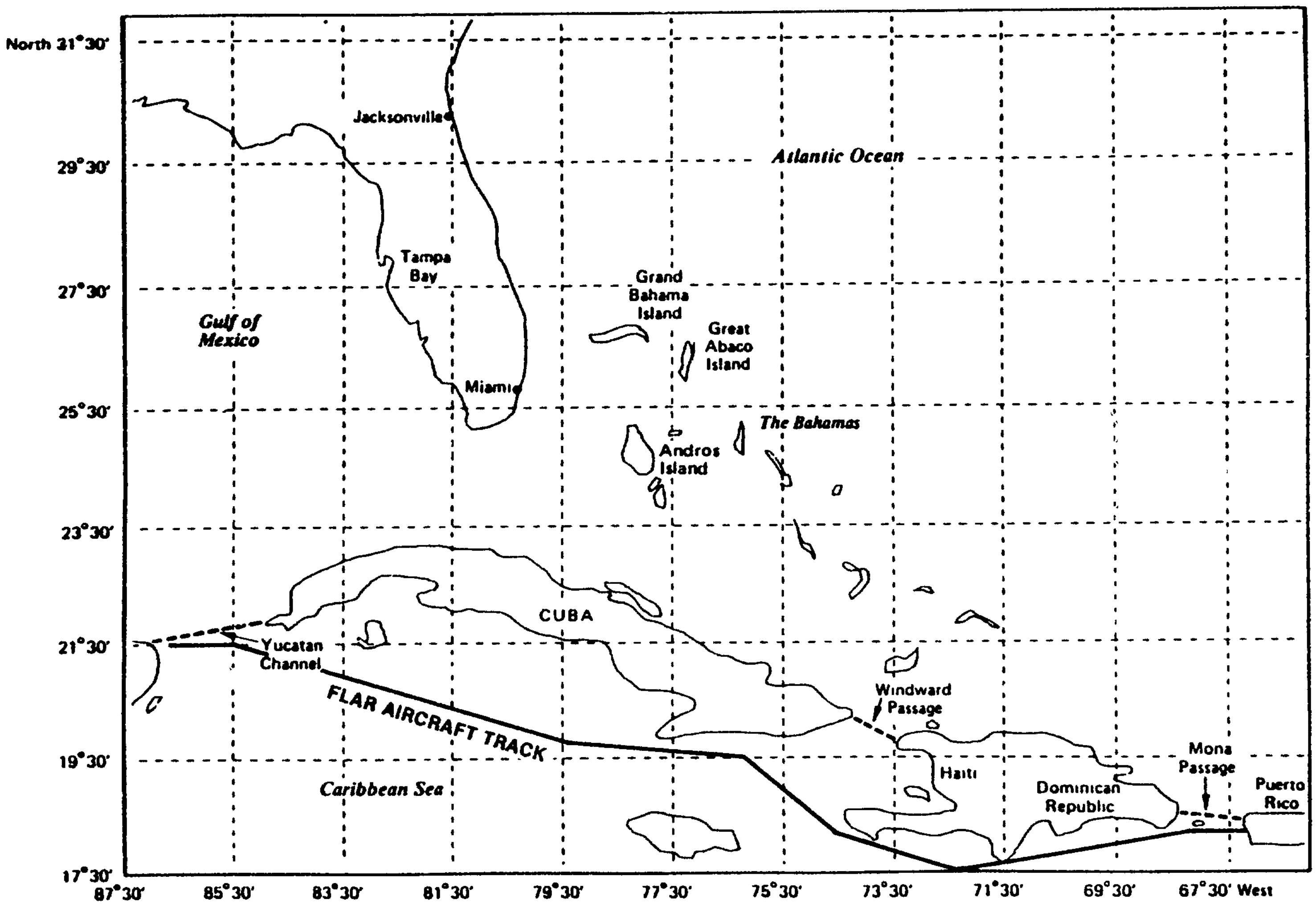


Figure 2-11. Caribbean Choke Points

The track postulated for FLAR-equipped aircraft to conduct a barrier patrol of the three Caribbean choke points is also shown in Figure 2-11. The total length of this barrier is approximately 1170 nautical miles -- very close to the maximum APS-134 barrier length for a 15-knot, 100-m^2 target in sea states 1 through 5 (see Figure 2-10). The flight track required to patrol this barrier is 2 times (1170 nm - W), or about 2084 nm long for an APS-134-equipped aircraft.

The time required to complete the barrier patrol at 250 knots is 8.34 hours (2084 nm/250 knots). Given a maximum aircraft endurance of approximately 12 hours at 250 knots (Reference 14), an HC-130 aircraft deployed from Guantanamo, Cuba, or Borinquen, Puerto Rico, could complete one patrol of this barrier without refueling.

With a sweep width of 128 nautical miles and an assumed target SOA of 15 knots, an aircraft must pass any given point along the barrier once every 8.53 hours (128 nm/15 knots) in order to maintain the desired 78-percent minimum detection probability. Since a single aircraft can complete only one full patrol of the barrier, this implies that a new patrol must be started every 8.53 hours, or about three times per 24-hour day. Another way of viewing this situation is that, since the time required to complete one patrol is 8.34 hours (about equal to the required patrol frequency), one aircraft must be flying at all times to cover the three Caribbean choke points.

Applying this same approach to the other combinations of FLAR systems and environmental conditions shown in Figure 2-8, Table 2-6 shows the number of aircraft required to maintain an effective barrier of these choke points. Table 2-6 shows that, for sea states 1 to 3, an additional 1.3 to 2.4 patrols per day would be required if the APS-127 or APS-133 were used in lieu of the APS-134. For sea state 5, the requirement for APS-134-equipped aircraft remains essentially the same as for sea states 1 and 3, while the APS-127 and APS-133 could not provide an effective barrier no matter how many aircraft were available.

Table 2-6. Resources Required to Maintain an Effective Barrier in Caribbean Choke Points*

SENSOR TYPE	SEA STATE (Douglas)	NUMBER OF PATROLS PER DAY
APS-134	1	2.8
APS-127	1	4.1
APS-133	1	4.7
APS-134	3	2.8
APS-127	3	4.4
APS-133	3	5.2
APS-134	5	3.0
APS-127	5	no capability
APS-133	5	no capability
WMEC	1 to 3	19.3

* Assuming a 15-knot target speed of advance and 100-m^2 radar cross section.

To identify the WMEC resources required to provide the same barrier effectiveness discussed above, the required patrol distances must first be determined. The approximate minimum distances across the choke points (shown by the dashed lines or Figure 2-11) are:

Yucatan Channel - 120 nautical miles,
Windward Passage - 60 nautical miles, and
Mona Passage - 70 nautical miles.

Using the 15-knot search speed and 20-nautical mile sweep width assumed earlier for the WMEC, each cutter can effectively maintain a 30-nautical mile barrier against a 15-knot target. The number of WMECs required to provide an effective barrier at each of these choke points is then:

Yucatan Channel	- 4
Windward Passage	- 2
Mona Passage	- 2.3
TOTAL	8.3

The actual number of WMECs required would be higher than 8.3 because of other ELT mission requirements (e.g., classify, intercept, board, seize, escort, and divert to other operations). Reference 15 indicates that about 43 percent of a typical WMEC's patrol profile is dedicated to search. This would imply that 19.3 (8.3/.43) WMECs would be required to provide a barrier with the same effectiveness as the number of FLAR-equipped HC-130s shown in Table 2-6.

It should be noted that, if FLAR-equipped HC-130s were used to provide ELT barrier patrols, at least one WMEC (or WHEC) would still be required at each choke point to receive the FLAR detection data and to perform subsequent ELT tasks (classify, intercept, board, seize, escort).*

*To estimate the surface resources required to fulfill these ELT mission phases, detailed data concerning traffic density, vessel speeds, and other factors would be required. Such an analysis would undoubtedly prove valuable to Coast Guard planners, but is beyond the scope of this study.

CHAPTER 3
CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

Based upon analysis of field data and theoretical detection performance predictions, the following conclusions are drawn:

- Of the FLAR systems evaluated, only the APS-134 can be expected to satisfy the Coast Guard criterion of detecting a 1-m^2 target in sea state 3 or greater. All systems evaluated (APS-127, APS-133, APS-134, and APN-215) are capable of detecting a 1-m^2 target in sea states 1 and 2.

- The APS-134 can be expected to detect 1-m^2 targets at ranges of 20 nautical miles or more in sea states 1 through 3. The APS-127 ground-stabilized display mode can be expected to make most 1-m^2 target detections at ranges up to 12 nautical miles in sea states 1 and 2 and up to 5 nautical miles in sea state 3. In sea states 1 and 2, the APS-133 and APN-215 FLARs can be expected to make most 1-m^2 target detections at ranges up to 5 nautical miles.

- Compared to an APS-127-equipped HU-25A, an HC-130 equipped with the APS-134 can be expected to achieve a 55-percent reduction in the time required to detect and classify 1-m^2 or larger targets in low traffic density search areas (sea state 1 assumed). In high traffic density search areas, the APS-134-equipped aircraft can be expected to achieve a 28-percent reduction in required mission time.

- In sea state 3 or higher, only the APS-134 FLAR can be expected to provide an improvement over visual search alone when the search object has a 1-m^2 radar cross section.

- If utilized to its full potential, the APS-134 FLAR should be capable of maintaining a barrier against 100-m^2 targets with 32 percent fewer patrols than the APS-127 in sea state 1 and 36 percent fewer patrols in sea state 3.

Based on theoretical calculations presented in Reference 3, only the APS-134 can be expected to have any significant detection capability against these targets in sea state 5. Conventional surface vessel resources well beyond current or projected Coast Guard levels would be required to maintain equivalent barrier surveillance.

3.2 RECOMMENDATIONS

3.2.1 FLAR System Selection

Results of this analysis indicate that use of the APS-134 FLAR will improve substantially the radar surveillance performance of Coast Guard HC-130 aircraft. This system is the only one among those evaluated that is capable of satisfying the Coast Guard's criterion of detecting 1-m^2 targets in sea state 3. Further, the APS-134 could provide significant law enforcement surveillance capabilities not presently available to the Coast Guard.

3.2.2 FLAR System Employment

The following recommendations are made on the basis of field data analysis and radar detection theory. These recommendations apply to all three existing Coast Guard FLARs unless otherwise stipulated. Recommendations for operational employment of the APS-134 FLAR will be developed when field tests of the system have been conducted by the Coast Guard. It is expected that many of the general recommendations made here will also apply to the APS-134 system.

- The APS-127 should be operated in ground-stabilized mode when searching for small (1-m^2) targets.

- FLAR displays should be adjusted to optimize the detection of desired search objects while en route to the search/patrol area. Thereafter, adjustments should be kept to a minimum while over open water due to the lack of suitable reference targets.

- o Range scale should be selected on the basis of the expected detection range for the search object. Use of a longer-than-necessary range scale only results in overloading the operator with extraneous targets and reduces their size on the FLAR display. Table 3-1 demonstrates that, during the Coast Guard field tests, switching to a longer range scale under even the most favorable search conditions did not substantially improve target detection ranges or detection probability.

3.2.3 Recommendations for Future Research and Development

The following recommendations for additional study are based upon this analysis and consideration of operational needs:

- o Tactics and command/control/communication systems should be developed to exploit the enhanced search/detection capabilities of the APS-134 FLAR. Specifically, the following should be considered:
  - Classification/identification of targets,
  - Prosecution of targets, and
  - Coordination of resources to support the HC-130 aircraft in these roles.
- o Operational sensor employment guidance should be developed for the APS-134 on a mission-by-mission basis. Training and documentation should be provided to APS-134 operators to ensure this guidance is implemented.
- o The capabilities of the APS-134 FLAR should be compared to those of the APS-135 SLAR to determine if both radars are necessary on a single aircraft to fulfill Coast Guard mission requirements.
- o Operational sweep widths for the FLARs should be developed through field data collection and analysis. These sweep widths should be provided to Coast Guard search planners in the form of a computer data base and SAR Manual tables. As an interim measure, the CDP curves developed in this report should be used to develop sweep width estimates for inclusion in Chapter 8 of the National SAR Manual.

Table 3-1. Detection Performance versus Range Scale

FLAR SYSTEM & OPERATING MODE	RANGE SCALE					
	5 nm		10 nm		25 nm	
	Dets./Opps.	Mean Det. Range (nm)	Dets./Opps.	Mean Det. Range (nm)	Dets./Opps.	Mean Det. Range (nm)
AN/APS-127[5] (HDG. STAB./ LONG PULSE MODE)	52/142 (37%)	2.4	3/26 (12%)	2.6[1]	--	--
AN/APS-127[5] (GND. STAB./ SHORT PULSE MODE)	27/47 (57%)	4.6	28/49 (57%)	4.2[2]	--	--
AN/APS-133 (MAP-1 MODE)	63/120 (52%)	3.4	--	--	12/18 (67%)	4.5[3]
AN/APN-215 (SRCH.-1 OR SRCH.-2 MODE)	36/59 (61%)	3.0	39/67 (58%)	3.2[4]	--	--

<u>NOTES</u>

1. All detections made at <5-nm range.
2. 7 detections made at >5-nm range.
3. 2 detections made at >5-nm range.
4. 5 detections made at >5-nm range.
5. Detection is possible at ranges up to double the selected APS-127 range scale.

- The ability of the APS-134 FLAR to detect 1-m^2 targets in conditions up to sea state 3 and 100-m^2 targets in conditions up to sea state 5 should be verified in the field to the extent that safe operating practice permits. Theoretical detection range predictions should be used to extrapolate search performance predictions to conditions beyond those in which field data can be collected safely.

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APPENDIX A
FLAR SEARCH DATA

This appendix contains computer files of raw field experiment data. The following is a key to the format of the data:

Column 1:	Detection (1 = yes, 0 = no)
Column 2:	Range from start of search leg to target (nautical miles)
Column 3:	Range of detection/closest point of approach for miss (nautical miles)
Column 4:	Radar range scale (nautical miles; 0 denotes unknown)
Column 5:	Wind speed (knots)
Column 6:	Significant wave height (feet)
Column 7:	Precipitation (0 = none; 1 = light/moderate rain; 2 = heavy rain)
Column 8:	Relative humidity (percent)
Column 9:	Relative wind direction (-1 = not recorded; 0 = opposite vessel course; 1 = with vessel course; 2 = perpendicular to vessel course)
Column 10:	Target type (see below)
Column 11:	Search speed (knots)
Column 12:	Altitude (feet)

FLAR TARGET TYPES

1	-	indicates 16-foot fiberglass boat without radar reflector
6 or 8	-	indicates 16-foot fiberglass boat with radar reflector
30	-	indicates 4- to 6-man canopied life raft
32	-	indicates 4- to 6-man canopied life raft with radar reflector
42	-	indicates 42-foot Coast Guard utility boat

HU-25A	AN/APS-127	HDG.	STAB.	10 FEB 83							
0	3.30	0.20	10.00	19.00	4.50	0.00	74.00	1.00	1.00	180.00	300.00
0	13.70	0.10	10.00	19.00	4.50	0.00	74.00	1.00	30.00	180.00	300.00
0	3.40	0.10	10.00	19.00	4.50	0.00	74.00	2.00	30.00	180.00	300.00
0	7.30	0.10	10.00	19.00	4.50	0.00	74.00	2.00	30.00	180.00	300.00
1	6.20	2.50	10.00	19.00	4.50	0.00	74.00	0.00	30.00	180.00	300.00
1	17.10	2.20	10.00	19.00	4.50	0.00	74.00	0.00	6.00	180.00	300.00
0	16.50	0.20	10.00	19.00	4.50	0.00	74.00	0.00	1.00	180.00	300.00
0	3.90	0.20	10.00	19.00	4.50	0.00	74.00	1.00	1.00	180.00	500.00
0	8.30	0.00	10.00	19.00	4.50	0.00	74.00	1.00	6.00	180.00	500.00
0	14.20	0.00	10.00	19.00	4.50	0.00	74.00	1.00	30.00	180.00	500.00
0	2.00	0.00	10.00	19.00	4.50	0.00	74.00	2.00	30.00	180.00	500.00
0	5.10	0.20	10.00	19.00	4.50	0.00	74.00	2.00	1.00	180.00	500.00
0	4.00	0.00	10.00	19.00	4.50	0.00	74.00	2.00	1.00	180.00	500.00
0	7.20	0.00	10.00	19.00	4.50	0.00	74.00	2.00	30.00	180.00	500.00
1	3.20	3.20	10.00	19.00	4.50	0.00	74.00	2.00	30.00	180.00	500.00
0	13.50	0.10	10.00	19.00	4.50	0.00	74.00	0.00	1.00	180.00	500.00
0	4.50	0.10	10.00	19.00	4.50	0.00	74.00	1.00	1.00	180.00	1000.00
0	14.80	0.00	10.00	19.00	4.50	0.00	74.00	1.00	30.00	180.00	1000.00
0	3.30	0.00	10.00	19.00	4.50	0.00	74.00	2.00	30.00	180.00	1000.00
0	6.60	0.10	10.00	19.00	4.50	0.00	74.00	2.00	1.00	180.00	1000.00
0	3.90	0.40	10.00	19.00	4.50	0.00	74.00	2.00	1.00	180.00	1000.00
0	7.00	0.30	10.00	19.00	4.50	0.00	74.00	2.00	30.00	180.00	1000.00
0	1.90	0.30	10.00	19.00	4.50	0.00	74.00	0.00	30.00	180.00	1000.00
0	12.00	0.40	10.00	19.00	4.50	0.00	74.00	0.00	1.00	180.00	1000.00

HU-25A AN/APS-127 HDG. STAB. 15 FEB 83

0	3.50	0.30	5.00	8.50	4.50	0.00	76.00	2.00	1.00	180.00	300.00
0	4.60	0.00	5.00	8.50	4.50	0.00	76.00	0.00	1.00	180.00	300.00
1	9.40	3.10	5.00	8.50	4.50	0.00	76.00	0.00	30.00	180.00	300.00
0	12.30	0.60	5.00	8.50	4.50	0.00	76.00	0.00	30.00	180.00	300.00
0	4.90	0.60	5.00	8.50	4.50	0.00	76.00	1.00	30.00	180.00	300.00
1	7.80	1.70	5.00	8.50	4.50	0.00	76.00	1.00	30.00	180.00	300.00
0	12.60	0.10	5.00	8.50	4.50	0.00	76.00	1.00	1.00	180.00	300.00
0	8.40	0.30	5.00	8.50	4.50	0.00	76.00	2.00	30.00	180.00	300.00
0	13.50	0.30	5.00	8.50	4.50	0.00	76.00	2.00	1.00	180.00	300.00
0	11.00	0.30	5.00	8.00	4.50	0.00	76.00	2.00	1.00	180.00	500.00
0	16.10	0.20	5.00	8.00	4.50	0.00	76.00	2.00	30.00	180.00	500.00
1	4.40	2.00	5.00	8.00	4.50	0.00	76.00	1.00	1.00	180.00	500.00
0	9.10	0.20	5.00	8.00	4.50	0.00	76.00	1.00	30.00	180.00	500.00
0	12.10	0.60	5.00	8.00	4.50	0.00	76.00	1.00	30.00	180.00	500.00
0	4.00	0.70	5.00	8.00	4.50	0.00	76.00	0.00	30.00	180.00	500.00
0	6.80	0.20	5.00	8.00	4.50	0.00	76.00	0.00	30.00	180.00	500.00
0	11.70	0.00	5.00	8.00	4.50	0.00	76.00	0.00	1.00	180.00	500.00
0	4.70	0.40	5.00	8.00	4.50	0.00	76.00	2.00	30.00	180.00	500.00
0	9.70	0.40	5.00	8.00	4.50	0.00	76.00	2.00	1.00	180.00	500.00
0	10.80	0.30	5.00	5.50	3.50	0.00	72.00	2.00	1.00	180.00	300.00
0	16.00	0.20	5.00	5.50	3.50	0.00	72.00	2.00	30.00	180.00	300.00
0	5.70	0.10	5.00	5.50	3.50	0.00	72.00	1.00	1.00	180.00	300.00
0	10.50	0.20	5.00	5.50	3.50	0.00	72.00	1.00	30.00	180.00	300.00
0	13.30	0.60	5.00	5.50	3.50	0.00	72.00	1.00	30.00	180.00	300.00
0	4.70	0.60	5.00	5.50	3.50	0.00	72.00	0.00	30.00	180.00	300.00
0	7.60	0.10	5.00	5.50	3.50	0.00	72.00	0.00	30.00	180.00	300.00
0	12.30	0.00	5.00	5.50	3.50	0.00	72.00	0.00	1.00	180.00	300.00
0	6.20	0.30	5.00	5.50	3.50	0.00	72.00	2.00	30.00	180.00	300.00
0	11.20	0.30	5.00	5.50	3.50	0.00	72.00	2.00	1.00	180.00	300.00
0	6.10	0.30	5.00	5.50	3.50	0.00	72.00	2.00	1.00	180.00	500.00
0	11.10	0.30	5.00	5.50	3.50	0.00	72.00	2.00	30.00	180.00	500.00
1	3.50	3.00	5.00	5.50	3.50	0.00	72.00	0.00	1.00	180.00	500.00
0	8.30	0.20	5.00	5.50	3.50	0.00	72.00	0.00	30.00	180.00	500.00
0	11.20	0.60	5.00	5.50	3.50	0.00	72.00	0.00	30.00	180.00	500.00
0	8.20	0.70	5.00	8.00	3.50	0.00	68.00	1.00	30.00	180.00	500.00
0	11.10	0.20	5.00	8.00	3.50	0.00	68.00	1.00	30.00	180.00	500.00
0	16.00	0.00	5.00	8.00	3.50	0.00	68.00	1.00	1.00	180.00	500.00
0	7.70	0.40	5.00	8.00	3.50	0.00	68.00	2.00	30.00	180.00	500.00
0	12.80	0.30	5.00	8.00	3.50	0.00	68.00	2.00	1.00	180.00	500.00

HU-25A AN/APS-127 HDG. STAB. 25 FEB 83

1	14.00	2.00	5.00	8.00	1.50	0.00	52.00	2.00	8.00	180.00	300.00
0	3.80	0.20	5.00	8.00	1.50	0.00	52.00	2.00	8.00	180.00	300.00
0	4.70	0.10	5.00	8.00	1.50	0.00	52.00	1.00	30.00	180.00	300.00
0	10.00	0.00	5.00	8.00	1.50	0.00	52.00	1.00	8.00	180.00	300.00
0	11.60	0.00	5.00	8.00	1.50	0.00	52.00	0.00	8.00	180.00	300.00
0	17.00	0.10	5.00	8.00	1.50	0.00	52.00	0.00	30.00	180.00	300.00
0	7.70	0.20	5.00	8.00	1.50	0.00	52.00	2.00	30.00	180.00	300.00
1	5.30	1.30	5.00	8.00	1.50	0.00	52.00	1.00	30.00	180.00	500.00
1	10.70	1.40	5.00	8.00	1.50	0.00	52.00	1.00	8.00	180.00	500.00
1	18.40	2.50	5.00	8.00	1.50	0.00	52.00	2.00	8.00	180.00	500.00
0	1.80	0.30	5.00	8.00	1.50	0.00	52.00	2.00	30.00	180.00	500.00
0	5.60	0.20	5.00	8.00	1.50	0.00	52.00	2.00	8.00	180.00	500.00
0	8.90	0.00	5.00	8.00	1.50	0.00	52.00	0.00	8.00	180.00	500.00
0	14.10	0.10	5.00	8.00	1.50	0.00	52.00	0.00	30.00	180.00	500.00
0	6.90	0.30	5.00	8.00	1.50	0.00	52.00	2.00	30.00	180.00	500.00
0	12.30	0.30	5.00	8.00	1.50	0.00	52.00	2.00	30.00	180.00	500.00
1	6.70	1.80	5.00	8.00	1.50	0.00	52.00	1.00	30.00	180.00	500.00
1	11.90	2.20	5.00	8.00	1.50	0.00	52.00	1.00	8.00	180.00	500.00
1	6.50	2.10	5.00	12.00	1.50	0.00	55.00	2.00	30.00	180.00	500.00
1	11.90	1.50	5.00	12.00	1.50	0.00	55.00	2.00	30.00	180.00	500.00
1	18.20	1.80	5.00	12.00	1.50	0.00	55.00	2.00	8.00	180.00	500.00
1	5.00	1.00	5.00	8.00	1.50	0.00	52.00	2.00	8.00	180.00	500.00
0	11.20	0.20	5.00	8.00	1.50	0.00	52.00	2.00	30.00	180.00	500.00
0	16.50	0.30	5.00	8.00	1.50	0.00	52.00	2.00	30.00	180.00	500.00
0	11.40	0.00	5.00	12.00	1.50	0.00	55.00	0.00	8.00	180.00	500.00
0	16.80	0.10	5.00	12.00	1.50	0.00	55.00	0.00	30.00	180.00	500.00

HU-25A AN/APS-127 HDG. STAB. 29 AUG 83

0	4.60	1.90	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	8.20	4.70	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	12.20	4.20	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	13.40	3.90	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	17.40	4.50	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	21.30	1.40	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	5.70	2.90	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	9.40	0.00	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
0	13.40	0.40	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	18.50	0.90	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
0	6.50	0.40	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
0	11.50	0.30	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	19.40	0.90	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	15.50	0.40	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
0	4.80	0.70	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	10.20	0.70	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
0	15.40	0.70	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	5.60	0.60	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	11.00	1.30	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
0	16.30	0.70	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	3.60	1.60	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	7.40	1.60	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	11.30	1.40	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	16.40	1.20	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	6.20	1.60	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
0	11.20	1.80	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	15.20	3.60	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
0	19.20	0.30	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	4.20	0.70	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	9.50	1.20	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
0	14.80	0.70	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	8.30	2.80	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	13.60	0.70	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	19.00	2.40	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	.30	2.10	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	8.20	2.00	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	12.10	2.00	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	17.30	3.60	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	6.40	4.40	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	11.50	2.30	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	15.60	0.20	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	19.50	1.90	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	2.20	0.60	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	13.00	1.40	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00

HC-130 AN/APN-215 29 AUG 83

1	3.40	3.40	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	7.30	3.90	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	11.30	3.80	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	16.40	4.00	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	3.10	1.40	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	8.50	3.70	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	13.80	3.20	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	5.40	2.50	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	9.20	4.30	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	13.20	4.00	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	16.40	4.10	5.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	2.30	1.70	10.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	7.70	5.90	10.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	13.00	1.90	10.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	5.60	4.60	10.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
1	13.30	3.00	10.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00
0	9.40	0.10	10.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	16.40	3.30	10.00	0.00	0.00	0.00	-1.00	-1.00	6.00	200.00	500.00
1	3.50	1.60	5.00	0.00	0.00	0.00	-1.00	-1.00	30.00	200.00	500.00

HU-25A AN/APS-127 HDG. STAB. 12 SEPT 83

0	11.00	0.30	5.00	12.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	15.10	0.40	5.00	12.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	4.30	0.70	10.00	10.00	2.50	0.00	-1.00	1.00	32.00	200.00	500.00
0	8.80	0.70	10.00	10.00	2.50	0.00	-1.00	1.00	6.00	200.00	500.00

HC-130 AN/APN-215 12 SEPT 83

0	17.20	1.00	10.00	10.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	21.40	5.70	10.00	10.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	11.80	0.60	10.00	11.00	2.50	0.00	-1.00	0.00	32.00	200.00	500.00
0	3.10	1.90	10.00	11.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	3.90	1.70	10.00	11.00	2.50	0.00	-1.00	2.00	32.00	200.00	500.00
0	6.90	1.80	10.00	11.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	11.60	2.00	10.00	11.00	2.50	0.00	-1.00	2.00	32.00	200.00	500.00

HU-25A AN/APS-127 HDG. STAB. 13 SEPT 83

0	3.30	0.70	5.00	15.00	3.00	0.00	-1.00	1.00	32.00	200.00	500.00
0	7.90	0.70	5.00	15.00	3.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	12.40	0.90	5.00	15.00	3.00	0.00	-1.00	1.00	30.00	200.00	500.00

HU-25A AN/APS-127 GND. STAB. 13 SEPT 83

0	12.90	1.00	20.00	15.00	3.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	17.10	0.60	20.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	7.30	1.00	5.00	15.00	3.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	11.70	0.70	5.00	15.00	3.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	16.30	0.70	5.00	15.00	3.00	0.00	-1.00	0.00	32.00	200.00	500.00
0	1.50	0.20	5.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	5.60	3.90	5.00	15.00	3.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	10.40	0.40	20.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	9.80	0.40	10.00	15.00	3.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	14.60	0.20	10.00	15.00	3.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	18.70	0.20	10.00	15.00	3.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	3.00	0.80	10.00	15.00	3.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	7.50	0.90	10.00	15.00	3.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	12.00	0.90	10.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00

HC-130 AN/APS-133 13 SEPT 83

0	11.00	0.10	5.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	15.70	0.10	5.00	15.00	3.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	20.00	0.10	5.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	2.10	0.40	5.00	15.00	3.00	0.00	-1.00	1.00	32.00	200.00	500.00
0	6.70	0.40	5.00	15.00	3.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	11.00	0.20	5.00	15.00	3.00	0.00	-1.00	1.00	30.00	200.00	500.00

HC-130 AN/APN-215 13 SEPT 83

0	10.10	0.40	5.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	15.00	0.60	5.00	15.00	3.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	19.20	0.60	5.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	4.10	0.90	5.00	15.00	3.00	0.00	-1.00	1.00	32.00	200.00	500.00
0	8.70	0.90	5.00	15.00	3.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	13.10	1.90	5.00	15.00	3.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	10.50	0.20	5.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	15.30	0.50	5.00	15.00	3.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	19.50	0.40	5.00	15.00	3.00	0.00	-1.00	2.00	30.00	200.00	500.00

HU-25A AN/APS-127 GND. STAB. 17 SEPT 1983

1	10.70	1.50	12.30	12.00	2.00	0.00	-1.00	1.00	30.00	200.00	500.00
1	15.30	12.30	12.30	12.00	2.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	9.50	1.10	12.30	12.00	2.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	13.90	1.00	12.30	12.00	2.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	7.10	3.10	12.30	12.00	2.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	11.50	1.90	12.30	12.00	2.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	5.30	0.10	12.30	12.00	2.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	9.60	0.20	12.30	12.00	2.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	14.20	0.20	12.30	12.00	2.00	0.00	-1.00	0.00	30.00	200.00	500.00
1	8.80	4.10	12.30	12.00	2.00	0.00	-1.00	1.00	30.00	200.00	500.00
1	13.40	5.80	12.30	12.00	2.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	17.80	0.20	12.30	12.00	2.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	9.50	0.80	12.30	12.00	2.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	14.00	0.80	12.30	12.00	2.00	0.00	-1.00	2.00	32.00	200.00	500.00
0	7.40	0.80	12.30	10.00	2.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	11.90	2.50	12.30	10.00	2.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	0.90	0.10	12.30	10.00	2.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	5.00	0.20	12.30	10.00	2.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	9.50	1.00	12.30	10.00	2.00	0.00	-1.00	0.00	30.00	200.00	500.00

HU-25A 42-FT UTB AN/APS-127 GND. STAB. 17 SEPT 83

0	17.10	3.40	12.30	12.00	2.00	0.00	-1.00	1.00	42.00	200.00	500.00
1	4.50	3.70	12.30	12.00	2.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	17.10	1.80	12.30	12.00	2.00	0.00	-1.00	2.00	42.00	200.00	500.00

HC-130 AN/APS-133 17 SEPT 83

0	10.40	0.00	5.00	12.00	2.00	0.00	-1.00	1.00	30.00	200.00	500.00
1	15.00	3.60	5.00	12.00	2.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	10.30	0.30	5.00	12.00	2.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	14.80	0.30	5.00	12.00	2.00	0.00	-1.00	2.00	32.00	200.00	500.00
0	7.40	0.30	5.00	12.00	2.00	0.00	-1.00	2.00	32.00	200.00	500.00
0	11.80	0.30	5.00	12.00	2.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	5.70	0.10	5.00	12.00	2.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	10.00	0.10	5.00	12.00	2.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	14.60	0.10	5.00	12.00	2.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	10.10	0.50	5.00	12.00	2.00	0.00	-1.00	1.00	30.00	200.00	500.00
1	14.70	4.00	5.00	12.00	2.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	19.00	0.50	5.00	12.00	2.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	11.00	0.20	5.00	12.00	2.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	15.40	0.30	5.00	12.00	2.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	8.00	0.40	5.00	10.00	2.00	0.00	-1.00	2.00	32.00	200.00	500.00
0	12.40	0.20	5.00	10.00	2.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	5.60	0.60	5.00	10.00	2.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	9.90	0.60	5.00	10.00	2.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	14.50	0.60	5.00	10.00	2.00	0.00	-1.00	0.00	30.00	200.00	500.00
1	10.00	1.90	5.00	10.00	2.00	0.00	-1.00	1.00	30.00	200.00	500.00
1	14.70	3.30	5.00	10.00	2.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	19.00	0.80	5.00	10.00	2.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	11.00	0.00	5.00	10.00	2.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	15.50	0.00	5.00	10.00	2.00	0.00	-1.00	2.00	32.00	200.00	500.00

HC-130 42-FT UTR AN/APS-133 17 SEPT 83

1	6.00	3.70	5.00	12.00	2.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	18.50	4.00	5.00	12.00	2.00	0.00	-1.00	1.00	42.00	200.00	500.00
1	17.80	4.20	5.00	10.00	2.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	6.50	4.30	5.00	10.00	2.00	0.00	-1.00	0.00	42.00	200.00	500.00
0	16.90	2.90	5.00	10.00	2.00	0.00	-1.00	1.00	42.00	200.00	500.00
1	5.60	1.70	5.00	10.00	2.00	0.00	-1.00	2.00	42.00	200.00	500.00

HU-25A AN/APS-127 GND. STAB. 18 SEPT 83

1	8.10	6.40	9.20	12.00	2.50	0.00	-1.00	1.00	6.00	200.00	500.00
1	17.00	3.80	9.20	12.00	2.50	0.00	-1.00	1.00	30.00	200.00	500.00
0	4.00	1.00	9.20	12.00	2.50	0.00	-1.00	2.00	32.00	200.00	500.00
1	11.10	4.50	9.20	12.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	15.80	3.80	9.20	12.00	2.50	0.00	-1.00	2.00	32.00	200.00	500.00
0	1.50	0.10	9.20	12.00	2.50	0.00	-1.00	0.00	30.00	200.00	500.00
0	10.40	0.30	9.20	12.00	2.50	0.00	-1.00	0.00	6.00	200.00	500.00
0	8.30	0.70	9.20	12.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	5.60	0.10	9.20	12.00	2.50	0.00	-1.00	0.00	6.00	200.00	500.00
1	8.20	6.70	9.20	12.00	2.50	0.00	-1.00	1.00	6.00	200.00	500.00
1	13.00	9.20	9.20	12.00	2.50	0.00	-1.00	1.00	6.00	200.00	500.00
0	17.10	0.20	9.20	12.00	2.50	0.00	-1.00	1.00	30.00	200.00	500.00
0	13.00	0.70	9.20	12.00	2.50	0.00	-1.00	2.00	30.00	200.00	500.00
0	7.70	0.70	9.20	12.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	3.10	1.00	9.20	12.00	2.50	0.00	-1.00	2.00	32.00	200.00	500.00

HC-130 AN/APS-133 18 SEPT 83

1	8.90	1.70	5.00	12.00	2.50	0.00	-1.00	1.00	6.00	200.00	500.00
0	18.00	0.60	5.00	12.00	2.50	0.00	-1.00	1.00	30.00	200.00	500.00
0	12.00	0.80	5.00	12.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	10.00	1.50	5.00	12.00	2.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	3.20	1.00	5.00	12.00	2.50	0.00	-1.00	0.00	30.00	200.00	500.00
0	7.40	0.90	5.00	12.00	2.50	0.00	-1.00	0.00	6.00	200.00	500.00
0	12.10	1.00	5.00	12.00	2.50	0.00	-1.00	0.00	6.00	200.00	500.00
0	9.50	1.20	5.00	12.00	2.50	0.00	-1.00	1.00	6.00	200.00	500.00
0	14.30	1.10	5.00	12.00	2.50	0.00	-1.00	1.00	6.00	200.00	500.00
0	18.50	1.30	5.00	12.00	2.50	0.00	-1.00	1.00	30.00	200.00	500.00
0	7.20	0.40	5.00	12.00	2.50	0.00	-1.00	2.00	32.00	200.00	500.00
1	14.70	2.40	5.00	12.00	2.50	0.00	-1.00	2.00	32.00	200.00	500.00
0	3.50	0.30	5.00	12.00	2.50	0.00	-1.00	2.00	32.00	200.00	500.00

HU-25A AN/APS-127 HDG. STAB. 19 SEPT 83

0	16.40	0.80	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	2.00	1.90	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	6.00	2.10	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	11.00	2.50	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	3.50	0.80	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	8.00	4.60	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	13.30	2.30	5.00	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	6.00	0.70	5.00	7.00	1.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	11.40	0.70	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	15.90	0.80	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	1.60	1.60	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	5.70	3.20	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	10.60	4.40	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	6.20	0.30	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	13.20	0.30	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	17.20	1.20	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	3.70	2.90	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	8.00	4.70	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	13.40	3.00	5.00	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	6.40	0.60	5.00	10.50	1.50	0.00	-1.00	0.00	30.00	200.00	500.00
0	11.80	0.60	5.00	10.50	1.50	0.00	-1.00	0.00	6.00	200.00	500.00
0	16.30	0.80	5.00	10.50	1.50	0.00	-1.00	0.00	6.00	200.00	500.00
0	1.20	0.20	5.00	10.50	1.50	0.00	-1.00	2.00	32.00	200.00	500.00
0	5.20	0.20	5.00	10.50	1.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	10.20	0.20	5.00	10.50	1.50	0.00	-1.00	2.00	30.00	200.00	500.00

HU-25A 42-FT UTR AN/APS-127 HDG. STAB. 19 SEPT 83

1	15.80	5.30	5.80	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	3.00	3.00	5.80	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	15.30	4.70	5.80	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	3.50	3.50	5.80	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	15.00	5.80	5.80	10.50	1.50	0.00	-1.00	2.00	42.00	200.00	500.00

HU-25A AN/APS-127 GND. STAB. 19 SEPT 83

0	7.40	0.10	7.70	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	12.40	7.70	7.70	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.50	6.40	7.70	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	4.00	3.90	7.70	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	8.50	7.60	7.70	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	13.90	3.90	7.70	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00
1	7.90	4.90	7.70	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	12.90	5.00	7.70	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	17.00	4.00	7.70	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00

HU-25A 42-FT UTB AN/APS-127 GND. STAB. 19 SEPT 83

1	10.00	10.00	10.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	6.00	8.00	10.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00

HC-130 AN/APS-133 19 SEPT 83

0	7.60	0.10	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	12.70	0.20	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	16.70	0.20	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	4.50	1.90	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	8.90	3.80	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	14.30	2.90	5.00	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	10.10	0.70	5.00	7.00	1.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	15.40	0.70	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	20.00	0.70	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	5.70	0.20	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	9.70	3.90	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	14.70	3.50	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	11.30	0.10	25.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	16.30	0.00	25.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	20.30	0.00	25.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
0	7.80	0.10	25.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	12.30	3.80	25.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	17.70	0.30	25.00	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	8.20	0.40	5.00	7.00	1.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	13.40	0.40	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	18.10	0.30	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	6.20	4.50	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	10.20	4.40	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	15.20	3.50	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	8.70	0.20	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	13.80	3.30	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	17.90	2.50	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	7.10	2.00	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	11.70	3.00	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	17.00	4.00	5.00	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	5.50	0.40	5.00	10.50	1.50	0.00	-1.00	0.00	30.00	200.00	500.00
0	10.80	0.40	5.00	10.50	1.50	0.00	-1.00	0.00	6.00	200.00	500.00
0	15.30	0.30	5.00	10.50	1.50	0.00	-1.00	0.00	6.00	200.00	500.00
1	6.50	4.60	5.00	10.50	1.50	0.00	-1.00	2.00	32.00	200.00	500.00
1	10.50	4.10	5.00	10.50	1.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	15.50	2.50	5.00	10.50	1.50	0.00	-1.00	2.00	30.00	200.00	500.00
1	9.20	2.30	5.00	10.50	1.50	0.00	-1.00	2.00	30.00	200.00	500.00
0	14.20	0.80	5.00	10.50	1.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	18.20	2.50	5.00	10.50	1.50	0.00	-1.00	2.00	32.00	200.00	500.00
1	6.40	3.20	5.00	10.50	1.50	0.00	-1.00	1.00	6.00	200.00	500.00
1	11.00	4.00	5.00	10.50	1.50	0.00	-1.00	1.00	6.00	200.00	500.00
1	16.30	2.90	5.00	10.50	1.50	0.00	-1.00	1.00	30.00	200.00	500.00
0	6.70	0.80	5.00	10.50	1.50	0.00	-1.00	0.00	30.00	200.00	500.00
0	11.90	0.80	5.00	10.50	1.50	0.00	-1.00	0.00	6.00	200.00	500.00
0	16.40	0.60	5.00	10.50	1.50	0.00	-1.00	0.00	6.00	200.00	500.00
1	11.00	4.00	5.00	10.50	1.50	0.00	-1.00	2.00	6.00	200.00	500.00

HC-130 42-FT UTB AN/APS-133 19 SEPT 83

1	3.00	2.50	5.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	19.50	4.50	5.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	6.60	4.80	25.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	20.00	4.90	5.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	4.10	4.00	5.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	20.20	4.70	5.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	4.40	3.90	5.00	10.50	1.50	0.00	-1.00	2.00	42.00	200.00	500.00

HC-130 AN/APN-215 19_SEPT 83

0	8.10	0.30	10.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	13.10	0.20	10.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	17.20	0.20	10.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
0	7.10	0.50	10.00	7.00	1.00	0.00	-1.00	0.00	30.00	200.00	500.00
1	12.40	2.30	10.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	17.00	0.30	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	5.70	4.10	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	9.70	3.00	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	14.70	2.20	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	17.50	0.60	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	8.90	3.20	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	13.40	3.50	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	18.70	1.20	5.00	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	5.90	0.40	5.00	7.00	1.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	11.20	0.40	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	15.70	0.30	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	7.10	0.90	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	11.00	4.00	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.00	3.30	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	9.00	1.20	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	14.00	1.20	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	18.10	3.00	5.00	7.00	1.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	6.90	1.00	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	11.40	3.10	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	16.80	0.90	5.00	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	5.50	0.00	5.00	10.50	1.50	0.00	-1.00	0.00	30.00	200.00	500.00
1	10.80	4.30	5.00	10.50	1.50	0.00	-1.00	0.00	6.00	200.00	500.00
0	15.30	0.10	5.00	10.50	1.50	0.00	-1.00	0.00	6.00	200.00	500.00
1	7.20	5.40	10.00	10.50	1.50	0.00	-1.00	2.00	32.00	200.00	500.00
1	8.00	4.00	5.00	10.50	1.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	11.10	2.70	5.00	10.50	1.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.10	2.30	5.00	10.50	1.50	0.00	-1.00	2.00	30.00	200.00	500.00
1	8.40	2.00	5.00	10.50	1.50	0.00	-1.00	2.00	30.00	200.00	500.00
1	13.40	4.80	5.00	10.50	1.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	17.50	3.10	5.00	10.50	1.50	0.00	-1.00	2.00	32.00	200.00	500.00
1	6.80	2.40	5.00	10.50	1.50	0.00	-1.00	1.00	6.00	200.00	500.00
1	11.30	4.30	5.00	10.50	1.50	0.00	-1.00	1.00	6.00	200.00	500.00
1	16.70	2.00	5.00	10.50	1.50	0.00	-1.00	1.00	30.00	200.00	500.00
0	16.60	1.60	5.00	10.50	1.50	0.00	-1.00	2.00	6.00	200.00	500.00

HC-130 42-FT UTB AN/APN-215 19 SEPT 83

0	3.40	0.00	10.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	19.40	4.10	5.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	4.60	4.10	5.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	20.70	4.50	5.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	4.30	4.00	5.00	7.00	1.00	0.00	-1.00	2.00	42.00	200.00	500.00
1	20.80	3.90	5.00	10.50	1.50	0.00	-1.00	2.00	42.00	200.00	500.00
1	3.90	3.50	5.00	10.50	1.50	0.00	-1.00	2.00	42.00	200.00	500.00

HU-25A AN/APS-127 HDG. STAB. 20 SEPT 83

0	6.30	0.60	5.00	5.50	0.50	0.00	-1.00	2.00	30.00	200.00	500.00
0	11.50	0.50	5.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.00	4.30	5.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00

HU-25A AN/APS-127 GND. STAB. 20 SEPT 83

1	8.20	6.10	10.00	0.00	0.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	13.30	0.10	10.00	0.00	0.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	17.40	8.40	10.00	0.00	0.00	0.00	-1.00	0.00	32.00	200.00	500.00
1	3.60	3.20	10.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	8.10	7.20	10.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	13.30	0.70	10.00	0.00	0.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	6.30	2.50	10.00	0.00	0.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	11.50	0.70	10.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.10	4.40	10.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	1.20	1.20	10.00	0.00	0.00	0.00	-1.00	1.00	32.00	200.00	500.00
1	5.20	3.60	10.00	0.00	0.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	10.30	4.00	10.00	0.00	0.00	0.00	-1.00	1.00	30.00	200.00	500.00
0	7.50	0.30	5.50	0.00	0.00	0.00	-1.00	0.00	30.00	200.00	500.00
1	12.60	4.50	5.50	0.00	0.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	16.70	0.10	5.50	0.00	0.00	0.00	-1.00	0.00	32.00	200.00	500.00
1	5.50	4.40	5.50	5.50	0.50	0.00	-1.00	1.00	6.00	200.00	500.00
0	10.50	0.20	5.50	5.50	0.50	0.00	-1.00	1.00	30.00	200.00	500.00
1	1.50	1.20	5.50	5.50	0.50	0.00	-1.00	1.00	32.00	200.00	500.00
0	7.60	0.30	10.00	5.50	0.50	0.00	-1.00	0.00	30.00	200.00	500.00
1	12.70	4.90	10.00	5.50	0.50	0.00	-1.00	0.00	6.00	200.00	500.00
0	16.80	0.10	10.00	5.50	0.50	0.00	-1.00	0.00	32.00	200.00	500.00
1	3.40	2.40	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	7.90	6.20	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	13.10	4.20	10.00	5.50	0.50	0.00	-1.00	2.00	30.00	200.00	500.00
0	6.70	0.70	10.00	5.50	0.50	0.00	-1.00	2.00	30.00	200.00	500.00
1	11.70	7.30	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.20	5.90	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	1.50	1.50	10.00	5.50	0.50	0.00	-1.00	1.00	32.00	200.00	500.00
1	5.60	4.50	10.00	5.50	0.50	0.00	-1.00	1.00	6.00	200.00	500.00
1	10.60	5.60	10.00	5.50	0.50	0.00	-1.00	1.00	30.00	200.00	500.00
1	7.40	1.30	5.50	7.00	1.00	0.00	-1.00	0.00	30.00	200.00	500.00
1	12.50	4.20	5.50	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	16.50	2.10	5.50	7.00	1.00	0.00	-1.00	0.00	32.00	200.00	500.00
1	3.50	3.80	5.50	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	7.90	6.90	5.50	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	13.10	3.30	5.50	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	4.20	0.30	5.50	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	4.60	0.60	5.50	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	9.00	5.50	5.50	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	1.30	0.90	5.50	7.00	1.00	0.00	-1.00	1.00	32.00	200.00	500.00
1	5.30	4.30	5.50	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	10.40	0.20	5.50	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00

HU-25A 42-FT UTR AN/APS-127 GND. STAB. 20 SEPT 83

1	3.70	2.50	10.00	0.00	0.00	0.00	-1.00	0.00	42.00	200.00	500.00
1	15.00	8.40	10.00	0.00	0.00	0.00	-1.00	1.00	42.00	200.00	500.00
1	2.90	2.60	5.50	0.00	0.00	0.00	-1.00	0.00	42.00	200.00	500.00
1	15.30	3.60	5.00	5.50	0.50	0.00	-1.00	1.00	42.00	200.00	500.00
1	2.90	2.90	10.00	5.50	0.50	0.00	-1.00	0.00	42.00	200.00	500.00
1	15.20	9.20	10.00	5.50	0.50	0.00	-1.00	1.00	42.00	200.00	500.00
1	2.80	2.20	5.50	7.00	1.00	0.00	-1.00	0.00	42.00	200.00	500.00

HC-130 AN/APS-133 20 SEPT 83

1	9.30	4.00	5.00	0.00	0.00	0.00	-1.00	0.00	30.00	200.00	500.00
1	14.40	4.00	5.00	0.00	0.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	18.50	3.30	5.00	0.00	0.00	0.00	-1.00	0.00	32.00	200.00	500.00
1	5.60	4.00	5.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	10.30	4.30	5.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	15.60	3.60	5.00	0.00	0.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	7.20	3.40	5.00	0.00	0.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	12.30	4.00	5.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	17.00	3.80	5.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	5.10	3.90	5.00	0.00	0.00	0.00	-1.00	1.00	32.00	200.00	500.00
1	9.10	4.50	5.00	0.00	0.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	14.20	3.60	5.00	0.00	0.00	0.00	-1.00	1.00	30.00	200.00	500.00
1	9.50	3.90	25.00	0.00	0.00	0.00	-1.00	0.00	30.00	200.00	500.00
1	14.60	3.00	25.00	0.00	0.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	18.70	5.20	25.00	0.00	0.00	0.00	-1.00	0.00	32.00	200.00	500.00
1	5.90	3.80	25.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	10.20	5.20	25.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	15.50	3.50	25.00	0.00	0.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	7.20	7.00	25.00	5.50	0.50	0.00	-1.00	2.00	30.00	200.00	500.00
1	12.50	5.30	25.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	17.10	4.10	25.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	7.40	0.50	25.00	5.50	0.50	0.00	-1.00	1.00	32.00	200.00	500.00
1	11.50	4.70	25.00	5.50	0.50	0.00	-1.00	1.00	6.00	200.00	500.00
1	16.50	5.00	25.00	5.50	0.50	0.00	-1.00	1.00	30.00	200.00	500.00
1	9.10	4.10	5.00	5.50	0.50	0.00	-1.00	0.00	30.00	200.00	500.00
0	14.20	0.80	5.00	5.50	0.50	0.00	-1.00	0.00	6.00	200.00	500.00
1	18.20	4.50	5.00	5.50	0.50	0.00	-1.00	0.00	32.00	200.00	500.00
1	7.00	4.50	5.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	11.40	4.00	5.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.70	3.50	5.00	5.50	0.50	0.00	-1.00	2.00	30.00	200.00	500.00
1	6.50	2.50	5.00	5.50	0.50	0.00	-1.00	2.00	30.00	200.00	500.00
1	11.70	4.00	5.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.30	4.30	5.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	6.30	4.00	5.00	5.50	0.50	0.00	-1.00	1.00	32.00	200.00	500.00
1	10.10	4.50	5.00	5.50	0.50	0.00	-1.00	1.00	6.00	200.00	500.00
1	14.90	2.10	5.00	5.50	0.50	0.00	-1.00	1.00	30.00	200.00	500.00
1	7.40	2.30	5.00	7.00	1.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	12.40	1.40	5.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
0	16.40	1.40	5.00	7.00	1.00	0.00	-1.00	0.00	32.00	200.00	500.00
1	7.60	4.70	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	12.10	4.30	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	17.40	3.00	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	5.70	0.30	5.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	11.00	4.00	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	15.50	3.10	5.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	6.60	3.80	5.00	7.00	1.00	0.00	-1.00	1.00	32.00	200.00	500.00
1	10.50	4.10	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	15.60	2.20	5.00	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00
1	7.50	3.20	5.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00

HC-130 42-FT UTR AN/APS-133 20 SEPT 83

1	4.80	4.60	5.00	0.00	0.00	0.00	-1.00	0.00	42.00	200.00	500.00
1	19.00	4.60	5.00	0.00	0.00	0.00	-1.00	1.00	42.00	200.00	500.00
1	4.90	4.60	25.00	0.00	0.00	0.00	-1.00	0.00	42.00	200.00	500.00
1	21.20	3.90	25.00	5.50	0.50	0.00	-1.00	1.00	42.00	200.00	500.00
1	4.50	3.50	5.00	5.50	0.50	0.00	-1.00	0.00	42.00	200.00	500.00
1	19.60	4.20	5.00	5.50	0.50	0.00	-1.00	1.00	42.00	200.00	500.00
1	2.90	2.70	5.00	5.50	0.50	0.00	-1.00	0.00	42.00	200.00	500.00

HC-130 AN/APN-215 20 SEPT 83

1	5.20	2.90	5.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	10.80	0.50	5.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.10	1.40	5.00	0.00	0.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	4.80	0.10	10.00	0.00	0.00	0.00	-1.00	0.00	30.00	200.00	500.00
1	9.90	3.70	10.00	0.00	0.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	14.00	4.50	10.00	0.00	0.00	0.00	-1.00	0.00	32.00	200.00	500.00
1	6.60	3.50	10.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	11.20	4.80	10.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	16.40	3.50	10.00	0.00	0.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	7.60	1.40	10.00	0.00	0.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	15.80	5.20	10.00	0.00	0.00	0.00	-1.00	2.00	32.00	200.00	500.00
1	4.10	2.40	10.00	0.00	0.00	0.00	-1.00	1.00	32.00	200.00	500.00
1	8.20	2.10	10.00	0.00	0.00	0.00	-1.00	1.00	6.00	200.00	500.00
1	13.30	2.00	10.00	0.00	0.00	0.00	-1.00	1.00	30.00	200.00	500.00
1	10.50	2.30	10.00	0.00	0.00	0.00	-1.00	0.00	30.00	200.00	500.00
0	15.50	0.00	10.00	0.00	0.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	19.60	5.20	10.00	0.00	0.00	0.00	-1.00	0.00	32.00	200.00	500.00
1	5.40	3.40	10.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	9.80	5.60	10.00	0.00	0.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	15.00	0.70	10.00	0.00	0.00	0.00	-1.00	2.00	30.00	200.00	500.00
1	7.30	2.40	10.00	5.50	0.50	0.00	-1.00	2.00	30.00	200.00	500.00
1	12.70	4.40	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
0	17.10	0.80	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	6.80	4.60	10.00	5.50	0.50	0.00	-1.00	1.00	32.00	200.00	500.00
0	10.80	0.00	10.00	5.50	0.50	0.00	-1.00	1.00	6.00	200.00	500.00
0	16.00	0.10	10.00	5.50	0.50	0.00	-1.00	1.00	30.00	200.00	500.00
0	13.10	0.10	10.00	5.50	0.50	0.00	-1.00	0.00	30.00	200.00	500.00
0	18.20	0.00	10.00	5.50	0.50	0.00	-1.00	0.00	6.00	200.00	500.00
1	22.30	2.50	10.00	5.50	0.50	0.00	-1.00	0.00	32.00	200.00	500.00
1	8.40	2.00	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	12.90	1.30	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	18.20	0.90	10.00	5.50	0.50	0.00	-1.00	2.00	30.00	200.00	500.00
0	7.70	0.40	10.00	5.50	0.50	0.00	-1.00	2.00	30.00	200.00	500.00
1	13.00	4.40	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	17.50	1.80	10.00	5.50	0.50	0.00	-1.00	2.00	6.00	200.00	500.00
1	8.10	2.40	10.00	5.50	0.50	0.00	-1.00	1.00	32.00	200.00	500.00
1	12.20	1.60	10.00	5.50	0.50	0.00	-1.00	1.00	6.00	200.00	500.00
0	17.30	0.40	10.00	5.50	0.50	0.00	-1.00	1.00	30.00	200.00	500.00
1	11.40	1.00	10.00	5.50	0.50	0.00	-1.00	0.00	30.00	200.00	500.00
0	16.50	0.30	10.00	7.00	1.00	0.00	-1.00	0.00	6.00	200.00	500.00
1	20.60	1.40	10.00	7.00	1.00	0.00	-1.00	0.00	32.00	200.00	500.00
0	8.20	0.90	10.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	12.70	2.80	10.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	18.00	1.30	10.00	7.00	1.00	0.00	-1.00	2.00	30.00	200.00	500.00
0	6.60	0.70	10.00	7.00	1.00	0.00	-1.00	2.00	36.00	200.00	500.00
1	11.80	2.70	10.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
0	16.40	0.80	10.00	7.00	1.00	0.00	-1.00	2.00	6.00	200.00	500.00
1	6.70	5.00	10.00	7.00	1.00	0.00	-1.00	1.00	32.00	200.00	500.00
0	10.70	0.50	10.00	7.00	1.00	0.00	-1.00	1.00	6.00	200.00	500.00
0	15.80	0.60	10.00	7.00	1.00	0.00	-1.00	1.00	30.00	200.00	500.00

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1	17.80	4.20	10.00	0.00	0.00	0.00	-1.00	1.00	42.00	200.00	500.00
1	5.90	4.80	10.00	0.00	0.00	0.00	-1.00	0.00	42.00	200.00	500.00
1	20.70	3.40	10.00	5.50	0.50	0.00	-1.00	1.00	42.00	200.00	500.00
1	6.50	7.90	10.00	5.50	0.50	0.00	-1.00	0.00	42.00	200.00	500.00
1	21.90	4.40	10.00	5.50	0.50	0.00	-1.00	1.00	42.00	200.00	500.00
1	6.80	2.90	10.00	5.50	0.50	0.00	-1.00	0.00	42.00	200.00	500.00

APPENDIX B
METRIC CONVERSION FACTORS

1. Feet to Meters

1 foot = 0.3048 meters

Thus:

3 to 4 foot swells ≈ 1 meter swells,
a 16-foot boat ≈ a 5-meter boat, and
an altitude of 500 feet ≈ a 150 meter altitude

2. Nautical Miles to Kilometers

1 nautical mile (nm) = 1.852 kilometers (km)

Thus:

10 nm visibility ≈ 18.5 km visibility, and
a 2 nm range ≈ 3.7 km range.

3. Knots to Meters/Second and Kilometers per Hour

1 knot = 0.5144 meters per second
1 knot ≈ 1.852 kilometers per hour

Thus:

a 10-knot wind speed ≈ 5 meter per second wind speed,
and a 10-knot search speed ≈ 18 kilometer per hour search speed.