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**DAVID W. TAYLOR NAVAL SHIP
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Bethesda, Md. 20084



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INVESTIGATION INTO THE SEAKEEPING CHARACTERISTICS
OF THE U.S. COAST GUARD 140-FT WTGB CLASS

CUTTERS: SEA TRIAL ABOARD THE
USCGC MOBILE BAY

by

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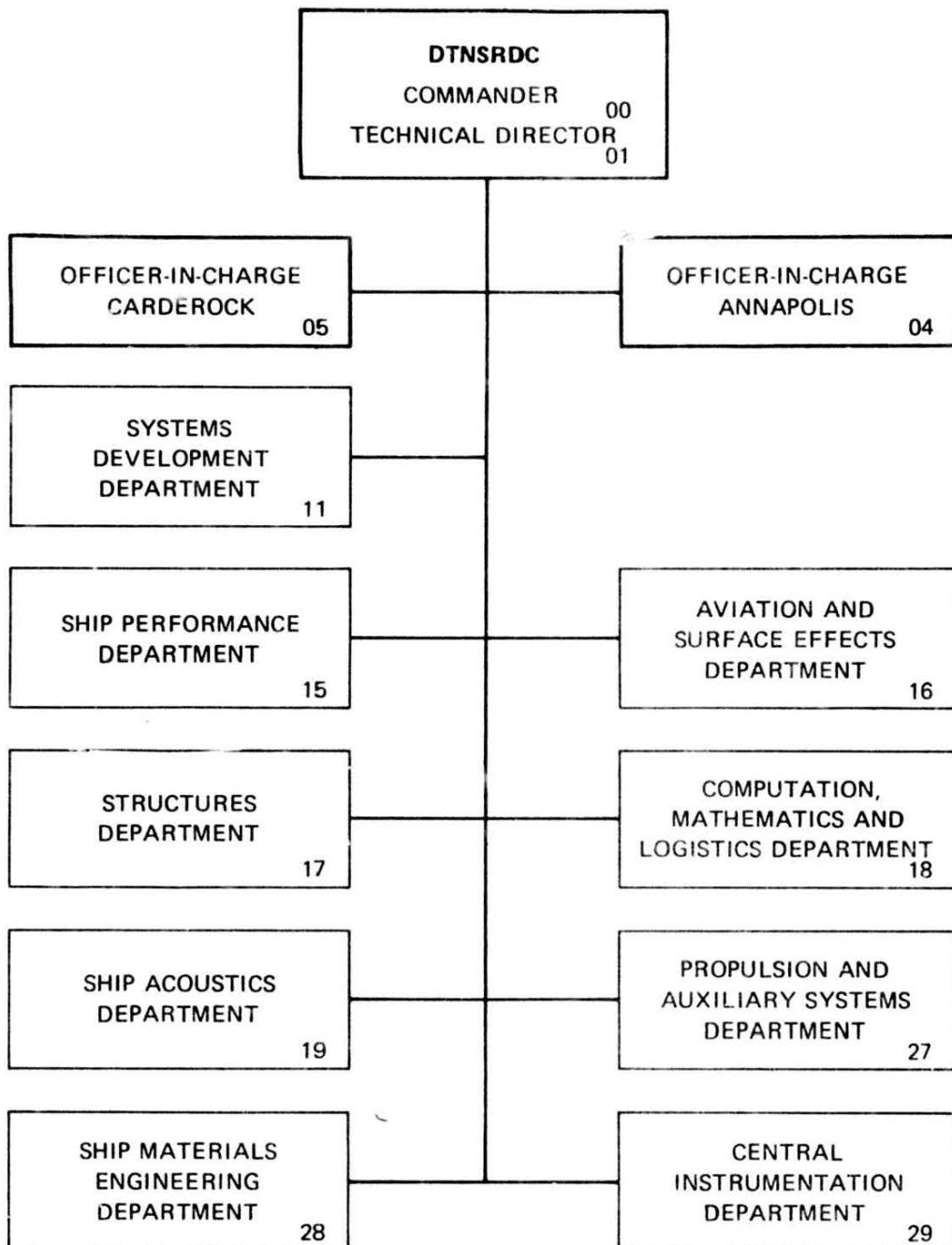
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INVESTIGATION INTO THE SEAKEEPING CHARACTERISTICS OF THE U.S. COAST GUARD
140-FT WTGB CLASS CUTTERS: SEA TRIAL ABOARD THE USCGC MOBILE BAY

DTNSRDC/SPD-0938-01

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

14 REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER DTNSRDC/SPD-0938-01		2. GOVT ACCESSION NO. AD-A097758	
3. TITLE (and Subtitle) INVESTIGATION INTO THE SEAKEEPING CHARACTERISTICS OF THE U.S. COAST GUARD 140-FT WTGB CLASS CUTTERS: SEA TRIAL ABOARD THE USCGC MOBILE BAY.		4. RECIPIENT'S CATALOG NUMBER 9	
5. AUTHOR(s) T. R. Applebee / T. M. McNamara / A. E. Baitis		6. TYPE OF REPORT & PERIOD COVERED Final rept.	
7. PERFORMING ORGANIZATION NAME AND ADDRESS Ship Performance Department David W. Taylor Naval Ship R&D Center Bethesda, Maryland 20084		8. PERFORMING ORG. REPORT NUMBER	
9. CONTROLLING OFFICE NAME AND ADDRESS U. S. Coast Guard 2100 2nd Street, S.W. Washington, D.C. 20590		10. CONTRACT OR GRANT NUMBER(s)	
11. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 121 105		11. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS USCG MIPR-Z70099-9-95618-0B Work Unit No. 1568-032	
12. DISTRIBUTION STATEMENT (of this Report) APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED		12. REPORT DATE Mar 1980	
13. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		13. NUMBER OF PAGES 103	
14. SUPPLEMENTARY NOTES		14. SECURITY CLASS. (of this report) UNCLASSIFIED	
15. KEY WORDS (Continue on reverse side if necessary and identify by block number) Seakeeping Characteristics 140-ft WTGB Class Cutter Ship Response Predictions Performance Assessment Ship Motion Measurement		15. DECLASSIFICATION/DOWNGRADING SCHEDULE	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The four day sea trial was conducted aboard the United States Coast Guard Cutter MOBILE BAY (WTGB-103) for the purpose of assessing the seakeeping performance characteristics of this vessel class. Time correlated ship motion measurements as well as crew performance data were obtained. Trial results indicate that excessive wetness and rolling as well as substantial crew performance impairments will occur in even mild seas of 6-foot significant. (Continued on reverse side)			

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wave height. A simple method for collecting crew performance data was demonstrated. Results demonstrate the best speed/heading combinations and highlight ship locations where habitation may be a problem. Analytical predictions for the WTGB were made and compared to those of the 95-ft WPB Class cutter whose motion responses represent a known baseline of seakeeping qualities. Analytical results demonstrate that the 140-ft WTGB exhibits less ship motion than the 95-ft WPB except in roll, where sensitivity to natural roll period and the modal wave periods of the seaways become a factor. Predicted human performance data indicates a general superiority of the WTGB in all but quartering seas. An additional sea trial is recommended to compare directly the 140-ft WTGB and the 95-ft WPB in order to validate the analytical seasickness results presented herein.

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ABSTRACT

The four day sea trial was conducted aboard the United States Coast Guard Cutter MOBILE BAY (WTGB-103) for the purpose of assessing the sea-keeping performance characteristics of this vessel class. Time correlated ship motion measurements as well as crew performance data were obtained. Trial results indicate that excessive wetness and rolling as well as substantial crew performance impairments will occur in even mild seas of 6-foot significant wave height. A simple method for collecting crew performance data was demonstrated. Results demonstrate the best speed/heading combinations and highlight ship locations where habitation may be a problem. Analytical predictions for the WTGB were made and compared to those of the 95-ft WPB Class cutter whose motion responses represent a known baseline of seakeeping qualities. Analytical results demonstrate that the 140-ft WTGB exhibits less ship motion than the 95-ft WPB except in roll, where sensitivity to natural roll period and the modal wave periods of the seaways become a factor. Predicted human performance data indicates a general superiority of the WTGB in all but quartering seas. An additional sea trial is recommended to compare directly the 140-ft WTGB and the 95-ft WPB in order to validate the analytical seasickness results presented herein.

ADMINISTRATIVE INFORMATION

This investigation was authorized by the United States Coast Guard under MIPR Z70099-9-95618-OB and is identified at David W. Taylor Naval Ship Research and Development Center as Work Unit 1568-032.

INTRODUCTION

David W. Taylor Naval Ship Research and Development Center (DTNSRDC) was requested to conduct a full-scale sea trial aboard the United States Coast Guard (USCG) Cutter MOBILE BAY (WTGB-103) in September 1979. The objective of this trial was to evaluate the seakeeping characteristics of this USCG 140-ft WTGB Class Cutter. This new generation icebreaker-tug is designed primarily for operations in the Great Lakes. It is also being considered for deployment on the east coast of the United States. Investigation of this cutter's open-ocean seakeeping characteristics was

required since its offshore mission necessitates adequate seakeeping performance and because there existed some doubt as to its capabilities in this area. These doubts were based on analytical predictions^{1*} which compared a similar 140-ft WAPB hull design to the 95-ft WPB Class currently performing this type of mission. These nondimensional comparisons suggested that the 95-ft WPB Class, whose seakeeping qualities are known to be poor,² may have better performance characteristics than the new 140-ft WTGB.

The sea trial, which was conducted off the coast of Virginia near Hampton Roads, was to evaluate the WTGB as a complete system; that is, not just an investigation of ship motions in a seaway, but also the effect of these motions on ship personnel. This "system evaluation" was accomplished by outfitting the vessel at the center of gravity and in two habitation areas with electronic measuring devices while soliciting from crew members an assessment of their physical and mental condition through the use of a questionnaire.

It was intended that the motion and human factors results would be compared to the data recently acquired in sea trials for the 95-ft WPB.² Unfortunately, marked differences in encountered seaways between the two trials prevented a meaningful comparison. Therefore, the relative merits of the open-ocean seakeeping qualities of these two cutters, as based on direct measurements, are in some doubt. However, analytical, computer-implemented ship motions and performance assessments were predicted for the two ships. Seaways were modeled closely to those encountered during the MOBILE BAY trial. While all the seakeeping trial results are presented in this report, time and cost considerations limited the extent of the analysis. Primary thrust was given to comparison of the two vessels for the most severe seaway encountered during the 140-ft WTGB trial. Likewise, when a specific location on the ship was needed for evaluation, particularly human performance, the pilot house was chosen as an area constantly inhabited and of considerable operational importance.

* A complete listing of references is given on page 97.

PROCEDURE AND METHODS

FULL-SCALE TRIAL

Prior to the seakeeping trials aboard the MOBILE BAY, an agenda was proposed outlining how the experiment was to be conducted. Two major areas of measurement were to be investigated: ship motions and crew performance. This, it was felt, would present an overall assessment of the ship as a system. To that end, instrumentation was placed in various "habitation" areas as well as at a location near the center of gravity. The latter would provide the stabilized, earth-referenced surge, sway, heave, roll, pitch, and yaw motions. Hard-mounted accelerometers in the "habitation" areas would measure ship-referenced lateral and vertical accelerations which will henceforth be referred to as transverse and normal accelerations, respectively. These transverse and normal accelerations are direct measurements of the ship motion induced forces experienced by the crew.

In addition, the crew performance measurements were to be made by the crew members themselves using the DTNSRDC Performance Assessment Questionnaire. This evaluation document contained a variety of questions for individual crewmen, department heads, and the commanding officer aimed at ascertaining motion- and/or seasickness-induced impairment (see Appendix A).

To obtain meaningful seakeeping data, a variety of headings, speeds, and sea states would be needed. An octagonal course pattern was determined to best meet the measurement requirements. Each octagonal pattern would be conducted for a constant ship speed. Each "leg" of the octagon would last 30 minutes during which time the ship would maintain a steady course. At the end of 30 minutes, the ship would turn 45 degrees to port and obtain measurements for another 30-minute time period. Head seas, considered the most severe in terms of seasickness (i.e., vertical accelerations), was to be the first leg of each octagon (see Figure 1).

Originally, it had been planned to conduct three octagonal patterns per day at a high, medium, and low speed, respectively. Each octagon would be preceded by a half-hour wave height collection run. However, it became quickly apparent that due to the long transit times necessary to reach the operating location, two octagons was the maximum number which could reasonably be performed in a single day.

The high speed octagon was to be run at the maximum possible speed for each leg. Specifically, it was intended that both the limiting speed and the physical cause for this speed limitation be established for each course during the pattern and for each of the seaways encountered. It is considered that the physical cause for the speed limitation may be hydrodynamic--such as slamming, excessive deck wetness, pitch and vertical accelerations, roll and lateral accelerations--or direct consequences of these hydrodynamic factors--such as actual or potential ship system failures, human factors (seasickness, crew fatigue, degradation in performance of light or heavy manual tasks, mental tasks, etc.).

Placement of the electronic equipment to be used to measure the ship motions became important in the context of evaluation of ship and crew as a complete system. Two areas were chosen as primary habitation locations: the pilot house (bridge) and the crew's mess. To measure transverse and normal accelerations in the pilot house, two Donner model #4310 forced-balanced accelerometers were hard-mounted to the helm post. Likewise, two Donner #4310 accelerometers were mounted to the bulkhead separating the crew's mess and galley. To provide earth-referenced motion measurements, a Humphrey Model SA07-0128-1 pitch/roll gyroscope with Donner 4310 accelerometers was located near the center of gravity in the engine room. Table 1 provides the precise locations of these measuring devices.

The ship motion data acquired from the above equipment was filtered, amplified, and recorded on strip chart and analog tape. The amplification and recording equipment was mounted in computer racks located in the ship's Engineering Control Center (ECC). A Datawell wave buoy was used throughout the trial to acquire seaway characteristics before each of the octagons. A 30-minute period of wave data acquisition was considered sufficient to develop a complete and realistic spectra of the seaway. The wave data was transmitted from the buoy via telemetry to the recording instruments in the Engineering Control Center.

In order to minimize wave distortion, a depth of water of at least 100 feet (30.5 m) was required. Thus a 3 to 4 hour transit period was necessary from the USCG Station in Portsmouth, Virginia to the test location off Hampton Roads in the Atlantic Ocean. Upon arrival at the trial site, the MOBILE BAY remained on station while the wave buoy was

deployed from the fantail. It remained tethered to the ship throughout the 30-minute data acquisition period. Intermittent maneuvering of the MOBILE BAY was required to avoid interference with or towing of the wave buoy. Figure 2 presents the wave spectra measured during the 4-day trial period. During the wave measurement period the Performance Assessment Questionnaires were distributed to the crew. The first page of the questionnaire was completed during the wave measurement period. Once the wave buoy was recovered and secured, the octagon pattern was initiated with a "head seas" course. At 30-minute intervals thereafter course changes of 45 degrees to port were made, and the crew was instructed to complete the appropriate pages of the Performance Assessment Questionnaire. When all eight sides of the octagonal pattern had been completed, the questionnaires were collected.

This pattern was repeated for each octagon. As previously stated, circumstances limited the number of octagons to two per day and a 24-hour period between test days was allowed for a change in seaway to occur, and for crew rest, refueling, and general ship maintenance.

A complete commentary of the MOBILE BAY sea trial is provided in Appendix B.

ANALYTICAL

To analytically compare the seakeeping qualities of the 140-ft WTGB and the 95-ft WPB in identical seaways, the Standard Ship Motion Program, SMP,* developed at DTNSRDC, was employed. This computer program predicts frequency-domain ship responses in regular and irregular seas for ship headings around the clock in 15-degree increments.

Regular wave ship motion response amplitude operators (RAO's) were generated for the WTGB at speeds of 0, 5, 10, and 15 knots and for the WPB at speeds of 0, 5, 10, 15, and 20 knots. These RAO's were then used together with long-crested Bretschneider³ sea spectra to obtain ship motions in irregular seas. The sea spectra used corresponded closely in significant wave height and modal period to the actual seaways encountered during the 4-day trial (see Table 2).

Selected final results are presented as speed polar plots in Appendix C.

*Meyers, W.G. et al., "User's Manual for the Standard Ship Motion Program, SMP," Report DTNSRDC/SPD-0936-01 (in preparation).

Figure 3 and Table 3 present the computed hull configurations, derived from the ship offsets, and ship particulars used in this investigation.

In keeping with the philosophy that the ship motions are only one-half the seakeeping story, DTNSRDC is currently developing a computer program to predict the effects of these motions on the ship personnel. This program, referred hereafter as ACLIM, is aimed at computing Motion Sickness Incidence (MSI), and determining rates at which crew members are impaired from performing their duties due to the necessity to maintain their balance, or "hang on." The frequency of these Motion Induced Interruptions (MII) measures to some extent the severity of the crew's ability to perform a wide variety of small and large motor (manual) tasks.

MSI, as developed and defined in Reference 4, is a function of vertical acceleration and its related period. To determine the need to "hang on," lateral and vertical accelerations as well as roll are used to compute ship referenced transverse and normal accelerations and the resulting incidence of tipping over, sliding, or lifting off the deck.⁵ These methods used in ACLIM provided an estimate of occurrence of sickness and the number of times personnel might be interrupted by ship motion within a 30-minute leg of an octagon.

RESULTS AND DISCUSSION

SHIP PERFORMANCE

The RMS ship responses for the 140-ft WTGB as measured during the trial are presented in Table 4. Note that 0 degrees denotes the head sea condition (the first leg of the octagon) and 180 degrees denotes following seas. Table 5 lists the results of the Performance Assessment Questionnaire. This tabulation breaks down each of the main questions by its various answers and correlates the actual responses of the ship's crew in percentages. These reported percentages are based on all members of the crew. Thus, for example, the six percent answer for the fourth question on Table 5, Octagon 3, starboard beam seas, indicates that six percent of the entire crew had significant impairment in the performance of their duties.

Appendix C presents examples of the analytical RMS ship motion comparison of the 140-ft WTGB and 95-ft WPB in the form of speed polar plots. Several

significant points should be made about these results. First, for point locations not on the centerline (see Table 1), the speed polar plots lose their symmetry for vertical accelerations. Points located on the weather side of the ship experience larger vertical accelerations than the corresponding points on the lee side.

Second, it is very important to realize that the lateral accelerations presented in the speed polars are referenced, as are all predicted frequency-domain motions, to the earth system. As reported in Reference 5, a sizable increase in lateral acceleration in the ship reference system (transverse acceleration) can be expected due to the additional gravity component contributed by roll. This transverse acceleration is much larger than the earth-referenced lateral acceleration even when roll motions are relatively small. Therefore, caution should be exercised in drawing conclusions using this lateral acceleration data. For instance, predicted personnel performance, particularly the number of interruptions a crew member may experience in order to maintain his balance, is a function of the transverse accelerations.

Reviewing the speed polar plots clearly illustrates that generally the 95-ft WPB exhibits much larger motions for the seaways investigated than does the 140-ft WTGB; that is, for all motions except roll. For seaways of 9 and 11-second modal periods, the predicted roll motion for the 140-ft WTGB is actually greater than that of the 95-ft WPB. Referring to pages 66 and 67, a significant wave height of 3.7 feet (1.13 meters) and modal period of 11 seconds produces a maximum predicted roll angle of about 4 degrees for the WTGB while producing only a 2-degree roll angle for the WPB. However, a seaway represented by an almost identical wave height of 3.9 feet (1.19 meters) with a modal period of 7 seconds (see pages 88 and 89) produces only a maximum of 4 degrees for the WTGB while producing 5 degrees for the WPB. This dramatic difference in trends is due to the substantial difference in natural roll periods of the two ships. Excitation in beam seas of a ship whose natural roll period is close to the modal period of the seaway will result in large roll angles. In the case of the 140-ft WTGB whose natural period in roll is 8.25 seconds, 9-second and 11-second modal periods have a much more significant effect on the magnitude of roll than for the 95-ft WPB whose natural

roll period is near 4 seconds. Therefore, as the modal period decreases to 7 seconds or below (approaching the natural roll period of the WPB), the 95-ft WPB will exhibit larger and larger roll angles while the WTGB roll motion will fall off. To illustrate this point further, RMS/T_{OE}^* responses have been presented in Tables 6 through 13 for both ships. These tables are for the four significant wave heights investigated over a range of modal periods. Though the modal periods presented are not always identical between the two ships, the tables illustrate that in beam seas the 140-ft WTGB is much more sensitive at 9 seconds, near its natural roll period, and the WPB more so at 5 seconds.

CREW PERFORMANCE

The ability of the crew to perform their duties in an accurate and timely manner is dependent on their mental and physical state. Certainly seasickness is recognized as a major contributor to performance impairment in both of these areas. But excessive ship motions alone can dramatically affect a crew member's performance because of time lost in maintaining his balance and through fatigue.

To illustrate the comparative severity between the 140-ft WTGB and 95-ft WPB in regard to ship motion induced interference with crew performance, Figures 4, 5, and 6 have been prepared from the analytical results of ACLIM. Figures 4 and 5 show the number of interruptions a crew member might experience during a 30-minute leg at the pilot house location (see Table 1) in a long-crested seaway of 6.1 feet (1.86 meters) significant wave height and 9-second modal period. Figure 4, the 15-knot case, shows a significant difference between the two ships in bow and beam seas. At the lower speed of 10 knots, in Figure 5, the WTGB shows a somewhat curious increase in the number of interruptions in the quartering sea case. Illustrating this quartering sea phenomenon more clearly, Figure 6 shows the number of interruptions to be expected for both ships at the pilot house for modal periods 7 and 9 seconds and speeds of 0, 5, 10, and 15 knots. Though there is a consistent trend of

* T_{OE} refers to the encountered modal period.

95-ft WPB being substantially worse in the bow and beam sea cases, the 140-ft WTGB data is almost always larger in the quartering sea case.

The explanation for this pattern may once again be traced to the difference in natural roll periods. As previously stated, ACLIM uses the RMS roll angle and vertical and lateral accelerations to predict the MII occurrences. Trends in vertical and lateral accelerations show the 95-ft WPB larger in bow and beam seas, while more comparable to the 140-ft WTGB values in quartering seas. However, referring to Tables 7 and 11 for the WPB and WTGB respectively, roll in quartering seas of 7 and 9-second modal periods for the WTGB are larger than the WPB except for the 7-second, 0 knot case. Due to the differing characteristics of the RAO's at speed, the WTGB is more sensitive to the encountered sea spectra at 7 and 9 seconds in quartering seas than the WPB. As speed increases in quartering seas, the frequency of encounter of the waves decreases, and the wave spectral energy peak (T_{OE}) moves away from the natural roll period of the 95-ft WPB. However, the 140-ft WTGB still "sees" enough spectral energy at its natural roll frequency under these conditions to produce more roll motion than the WPB. This sensitivity to roll in quartering seas, therefore, accounts for the degraded performance of the WTGB at those headings.

In order to substantiate the 140-ft WTGB's propensity to roll in quartering seas, refer to the full-scale trial results of Table 4. The RMS values for roll at headings of 135 and 225 degrees are usually of comparable magnitude to the beam sea roll angles (sometimes larger). Obviously, a direct comparison between these sea trial results and the predicted values can not be made due to the differences in sea spectra. But the trial data does tend to substantiate the predicted rolling behavior of the WTGB in quartering seas, at speed, and in seaways of 7, 9, and even 11-second modal periods.

A summary of the reported performance impairment for Day 2 is presented in Figure 7. Two octagons, one at 14.7 knots and the other at 10 knots, were conducted in a 6.1-foot (1.86-meter) significant wave height and 8-second modal period seaway. A breakdown by complaint is provided for each octagon in Figures 8 and 9. These figures show the percentage of crew members who reported impairment in performing their

duties from both seasickness and excessive motions, from seasickness alone, and from excessive ship motions alone.

Figure 10 presents a breakdown of Day 2 into specific areas of the ship, the number of crew members in each area, and the number reporting some sort of physical and/or mental difficulties. These graphs tend to reinforce a general observation made during the sea trials. At headings of relative comfort, the attitudes and mobility of crew members are usually quite good. At less favorable headings, socializing diminishes and crew members abandon areas of discomfort (e.g., the crew's mess) for more accommodating locations (e.g., berthing). Without a doubt, quartering and following seas for this day presented a much more comfortable ride as shown from the percentage of crew complaining of impairment (see Figure 7) and as noted by the commanding officer.

Motion sickness incidence as recorded during the sea trial, as well as the analytical predictions for both the 140-ft WTGB and 95-ft WPB, are presented in Figures 11 and 12. Figure 11 represents the percent of crew members in the pilot house who experienced motion sickness on Day 2, Octagon 2, and Octagon 3 is shown in Figure 12. The seaway that day was characterized by a 6.1-foot (1.86-meter) significant wave height and an 8-second modal period. The speed for Octagon 2 was 14.7 knots, and 10 knots for Octagon 3. The pilot house was chosen because it is a critical center for crew performance and an area which is constantly inhabited. Day 2 was chosen because of the severity of the seaway.

Several outstanding trends can be perceived from these two figures. First, the analytical prediction of seasickness grossly underpredicts, by a factor of two or more, actual sickness incidence for headings which produce motion sickness. However, both predicted and measured MSI trends clearly indicate that MSI decreases to zero in quartering and following seas. The trend of MSI with ship heading is thus somewhat similar. It also appears from the predicted results that both the WPB and WTGB will have very similar rates of MSI although surprisingly the larger WTGB may exhibit slightly worse MSI characteristics.

In addressing differences between measured and predicted MSI, it should be noted that the analytical percentages are computed using a statistical sampling in a controlled environment based on sinusoidal

vertical accelerations and periods only (see Reference 4). The trial results are based on irregular sea motions and a small, fluctuating number of individuals, all with varying degrees of susceptibility to seasickness (see Table 14), and all experiencing a variety of motions. Thus, the measurements do not discredit the usefulness of the analytical methods to predict motion sickness incidence. The general trends exhibited by the predictions are those of the observed trial results. Furthermore, the seaway model used for the analytical computations cannot match in detail the actual seaway encountered during the trial. Comparison of the RMS vertical accelerations between the sea trial and the prediction model show the predicted values to be smaller than the measured responses. For example, at 15 knots:

Heading	Pilot House Normal Accelerations (g)	
	Full-Scale	Predicted
0	0.1705	0.1570
45	0.1328	0.1313
90	0.0757	0.0397
135	-	0.0081
180	0.0159	0.0034
225	0.0306	0.0080
270	0.0902	0.0386
315	0.1704	0.1309

Moreover, though the seaway predominated from a single direction (i.e., similar to the long-crested prediction model), other components of this seaway could have affected the vertical acceleration frequency. Vertical acceleration frequency has a major impact on seasickness incidence, as documented in Reference 4 and as used in the analytical computations. A spectral analysis of the vertical acceleration trial data is needed to confirm this possibility.

This sensitivity to frequency appears to account for the analytical pattern of greater motion sickness occurrence for the WTGB over the WPB. Though magnitude-wise the 95-ft WPB consistently predicts larger vertical

accelerations in all but quartering and following seas, the difference of one second in the computed vertical acceleration periods between the two ships appears to drive the 140-ft WTGB to a higher incidence of seasickness. This phenomenon is demonstrated in Table 4 of Reference 4 where an RMS vertical acceleration of 0.333 g and period of 3 seconds produces 13 percent less motion sickness than an acceleration of 0.222 g and a period of 4 seconds. The general pattern revealed by this table appears to be that periods of 4.0 to 6.0 seconds produce maximum MSI. Four seconds is the predicted vertical acceleration period for the 140-ft WTGB in head and bow seas.

SEA TRIAL OBSERVATIONS

The comments of the commanding officer of the WTGB MOBILE BAY are considered important and useful, and have been tabulated in Table 15. Several areas of concern to him can be elaborated upon. For example, deck wetness was a constantly recurring problem (see Figures 13 through 16), and a potentially hazardous one. For Octagons 2 and 3 of Day 2 (see Figure 14), deck wetness was particularly intense, with spray entering the stack and reaching as far aft as the fantail at some headings. The commanding officer had serious reservations about operating in a seaway so severe had it not been for the investigation. Even in an emergency such as a life and death search and rescue mission, it was his judgment that a small boat could not be launched. Furthermore, operations under these wetness conditions for this day in freezing weather would have been impossible.

Slamming, while not a structural concern on this type of vessel, did contribute to the vibration of the ship. Vibration, particularly in the pilot house, was an annoying irritant to the point where the commanding officer felt it might have an affect on his crew's performance during Octagon 7. This run, performed at night when one tends to be more aware of sound, was for high speed in a high Sea State 2.

Steering difficulty, if not directly stated by the commanding officer in his comments, was interpreted from his records of the amount of rudder the helmsman used and the drifting of the ship from its true course. For instance, if it was necessary to move the rudder by large angles, say

+15 degrees, in order to maintain course, or if the course varied +5 degrees or more, it was considered difficult to steer. Most difficulty usually appeared to be in beam and quartering seas.

CONCLUSIONS

Based on the data analysis presented, the following conclusions are reached:

FULL-SCALE TRIAL

1. Limiting speed was not attained at any heading in the encountered seas. However, the hydrodynamic characteristic of deck wetness would be a limiting speed factor in freezing temperatures.
2. Excessive deck wetness was found to be a problem in even a relatively low sea state of 6-foot significant wave height. A large amount of rolling, especially in quartering seas, was measured, posing potentially hazardous and fatiguing conditions to crew members.
3. The DTNSRDC Performance Assessment Questionnaire proved an adequate tool for obtaining human factors information. Observations and discussions with MOBILE BAY personnel as well as subsequent data reduction have produced a new and improved questionnaire for future trials (see Appendix D).
4. Substantial motion impairment of crew members was reported in a low Sea State 4: 80 percent or more of the crew at the more severe headings and nearly 40 percent at the most accommodating headings (Figure 7).
5. Lack of similar encountered seaways prevented a direct comparison of measured ship motions and human factors data between the MOBILE BAY (WTGB-103) and the CAPE CORWIN (WPB-95326)².

ANALYTICAL

6. Motion responses (except roll) of the 140-ft WTGB are substantially less than those of the much smaller displacement 95-ft WPB.
7. Similarly, the rates of motion induced interruptions (MII) are, in general, substantially less for the larger 140-ft cutter

than the 95-ft cutter. These results suggest the WTGB will provide a less fatiguing ship ride than the WPB.

8. Though the roll motion of the large 140-ft WTGB may be greater than the 95-ft WPB in longer period waves, shorter, more common seas will reverse this trend in favor of the WTGB.
9. The predicted motion sickness incidence (MSI) rate of the WTGB is comparable to that of the much smaller WPB. This surprising result indicates that the actual MSI for the WTGB may be as poor as that of the WPB. In order to determine if MSI is a problem with this new class cutter, a side-by-side comparison between these two vessels is necessary.

RECOMMENDATIONS

Based on the above conclusions, the following recommendations are proposed:

1. It is recommended that a four day side-by-side sea trial between the 140-ft WTGB Class cutter and the 95-ft WPB Class cutter be conducted.
2. It is recommended that the feasibility of minor above-water hull shape modifications be examined in order to alter the spray pattern and reduce the resulting deck wetness on the WTGB.
3. Reduction in roll at speed could probably be best accomplished with a rudder roll stabilization (RRS) System.⁷ Such a system has advantages over other conventional roll reduction systems in that it does not necessitate hull protrusions incompatible with icebreakers. The overdesigned steering system already present would be compatible with hardware requirements for an RRS system.
4. It is recommended that further analytical work be performed on the MOBILE BAY sea trial data, particularly in the area of spectral analysis of the motions. Moreover, additional prediction work should be performed to investigate differences between the WTGB and WPB Class cutters for a wider range of modal periods and significant wave heights.

ACKNOWLEDGMENT

The authors wish to gratefully acknowledge the cooperation and dedication of Lt. Commander Lawson Brigham and the crew of the MOBILE BAY in the performance of the sea trial.

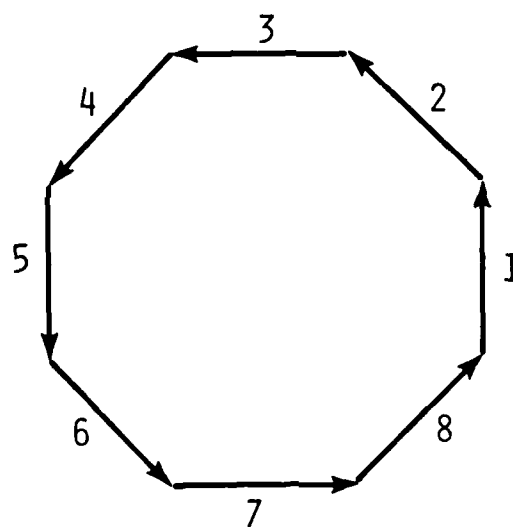
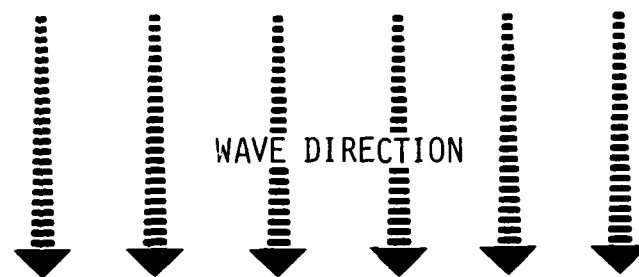


Figure 1 - Octagonal Course Pattern Used for the USCGC MOBILE BAY Sea Trial

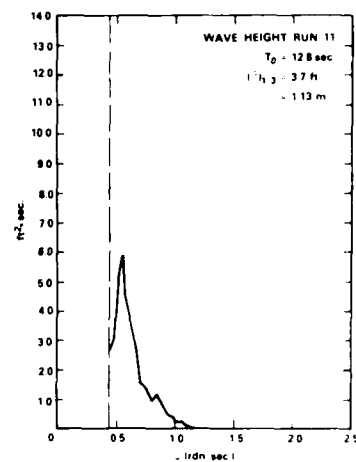
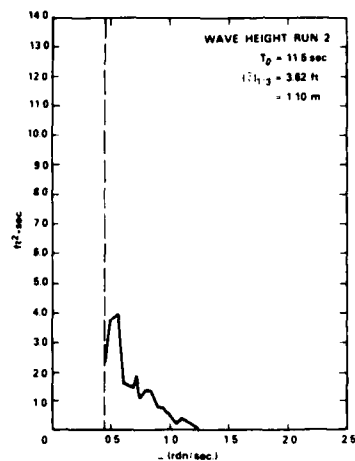


Figure 2a - Wave Spectra From Day One of Trial

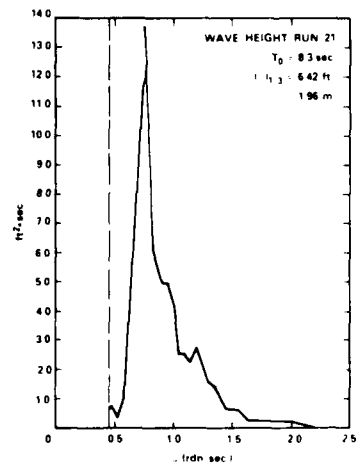
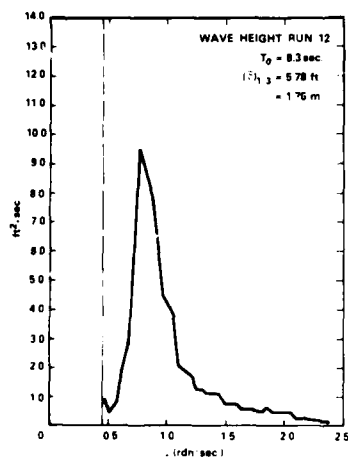


Figure 2b - Wave Spectra From Day Two of Trial

Figure 2 - Wave Spectra as Measured During MOBILE BAY Sea Trial

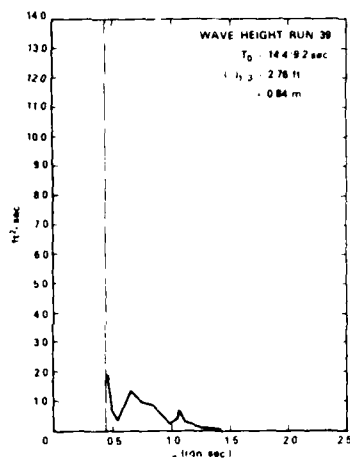
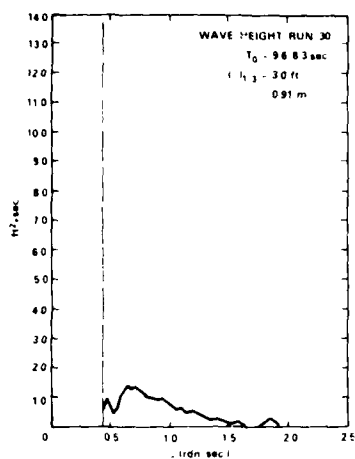


Figure 2c - Wave Spectra for Day Three of Trial

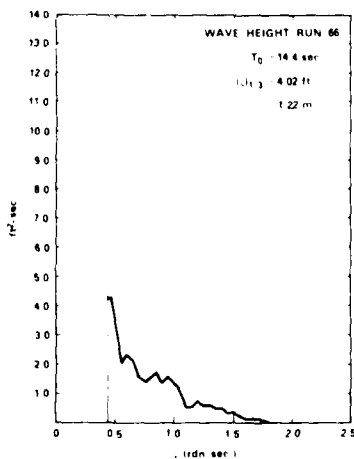
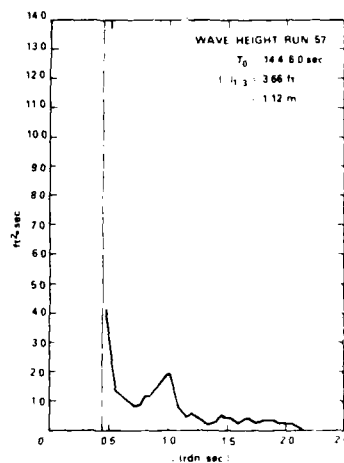
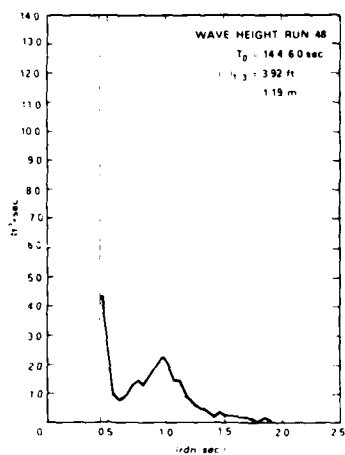


Figure 2d - Wave Spectra for Day Four of Trial

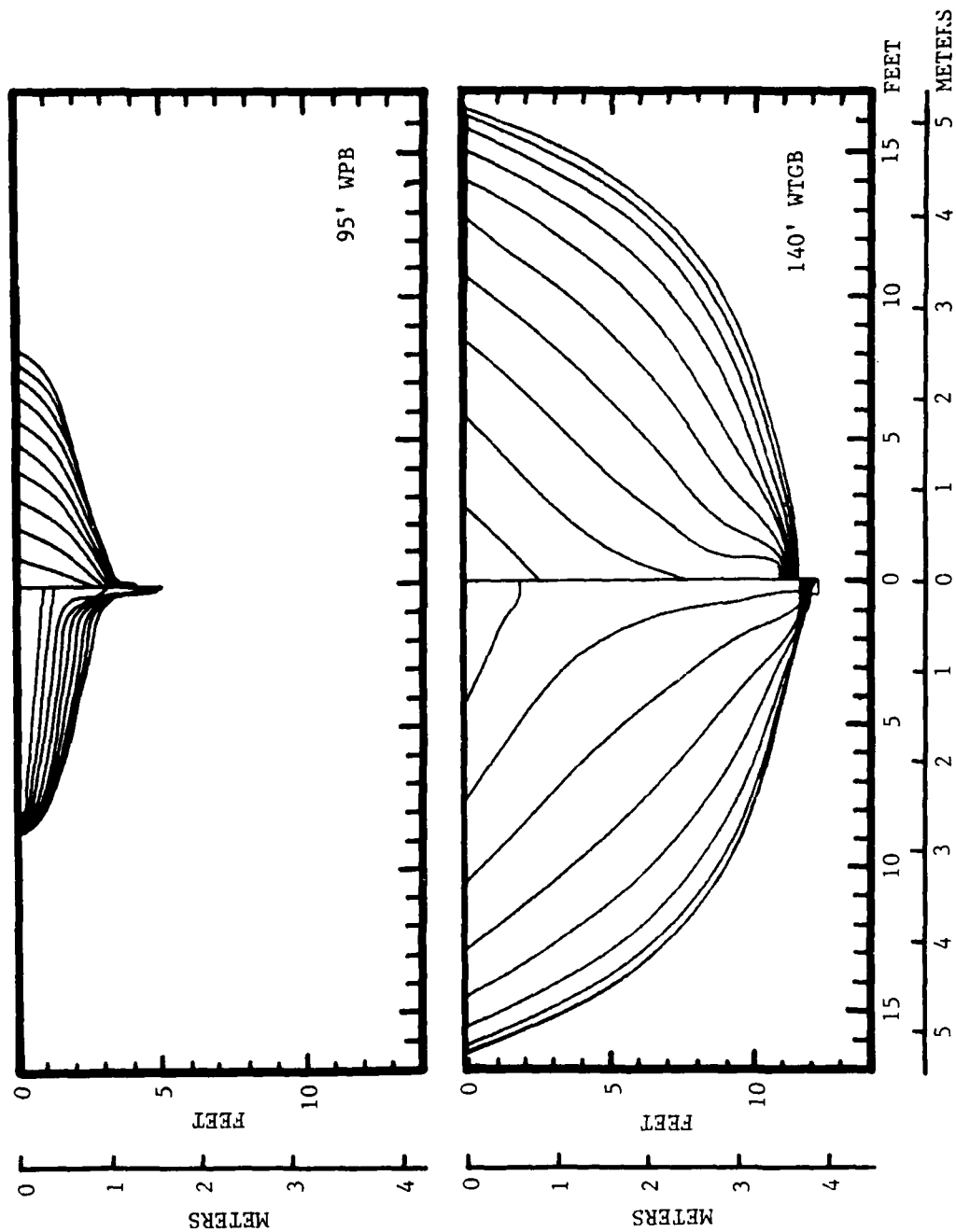


Figure 3 - Computed Hull Configurations for the 95' WPB and 140' WTGB

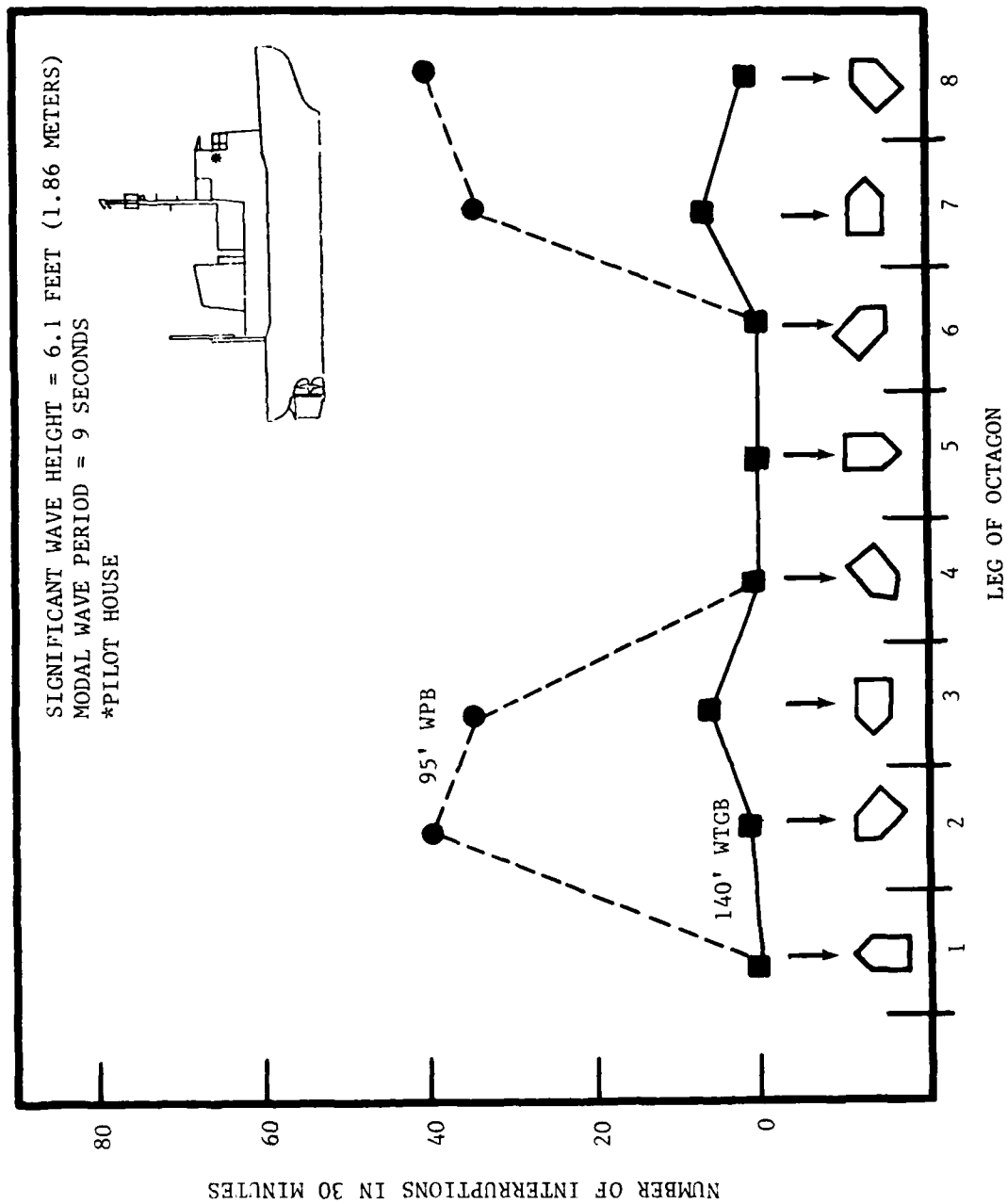


Figure 4 - Comparison Between the 140' WTGB and the 95' WPB of the Predicted Number of Interruptions Experienced by Crew Members in the Pilot House at 15 Knots

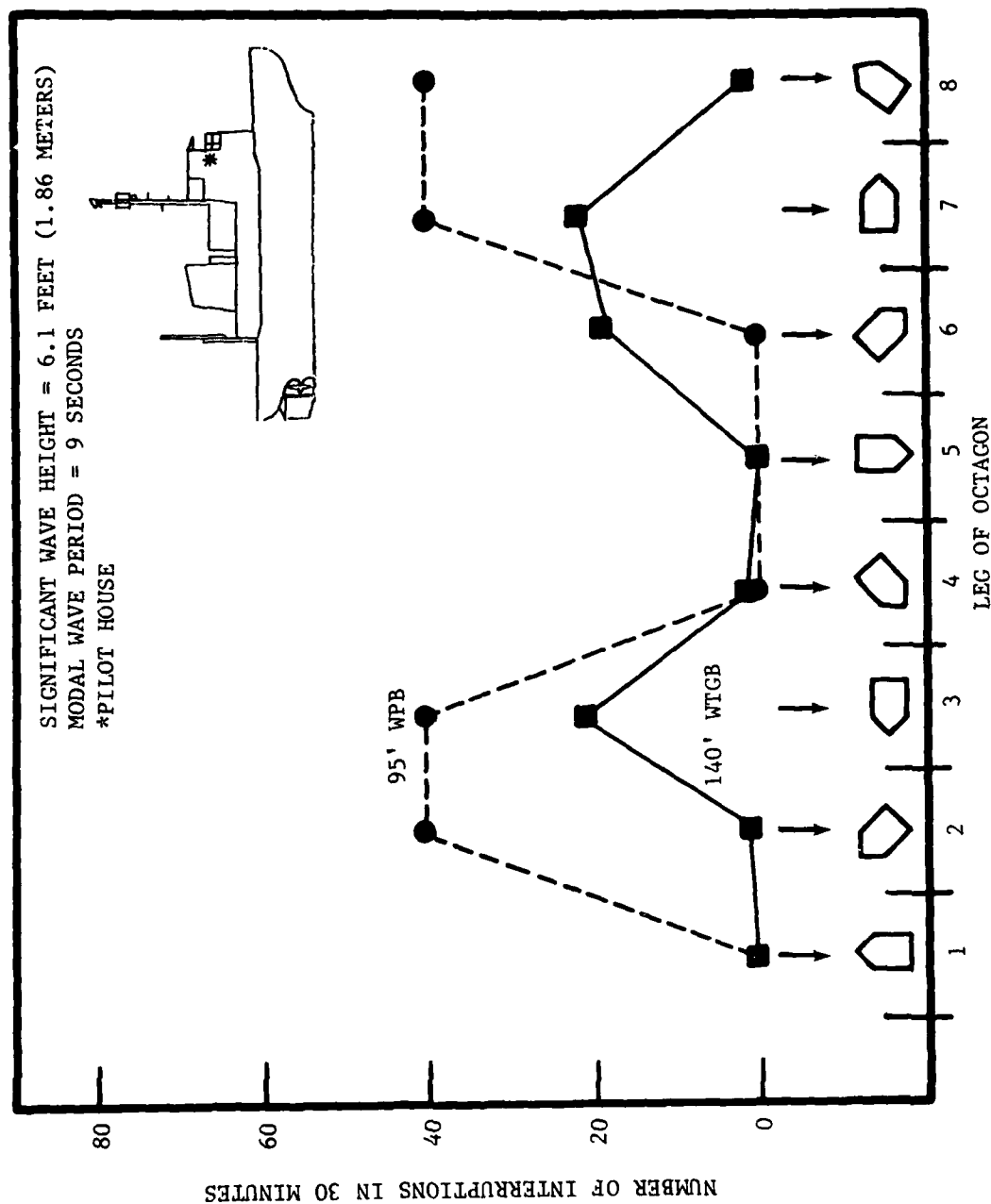


Figure 5 - Comparison Between the 140' WTGB and the 95' WPB of the Predicted Number of Interruptions Experienced by Crew Members in the Pilot House at 10 Knots

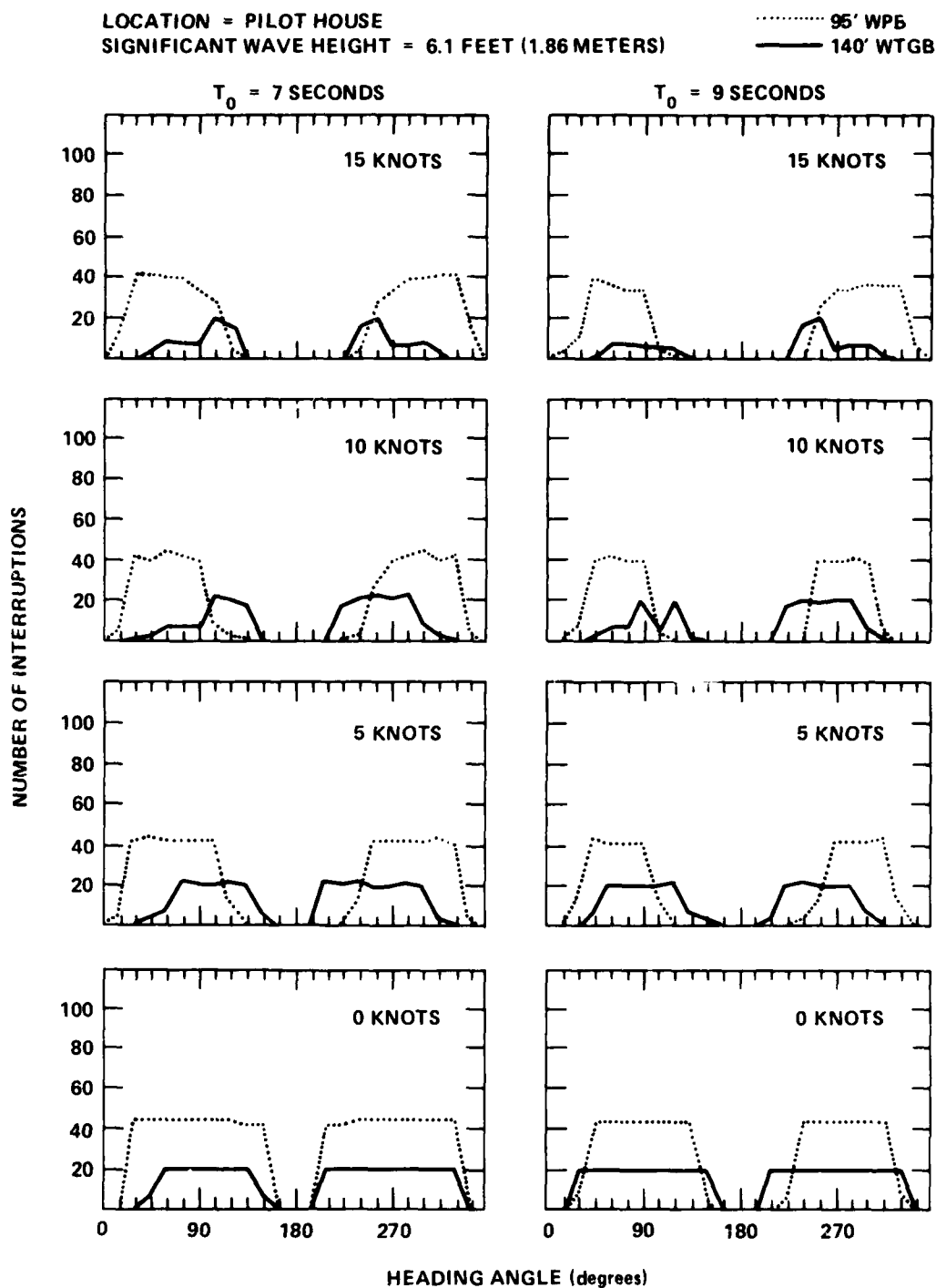


Figure 6 - Comparison of Predicted, Motion-Induced Interruptions of Crew Members in the Pilot House Between the 140' WTGB and 95' WPB at All Speeds in Two Seaways

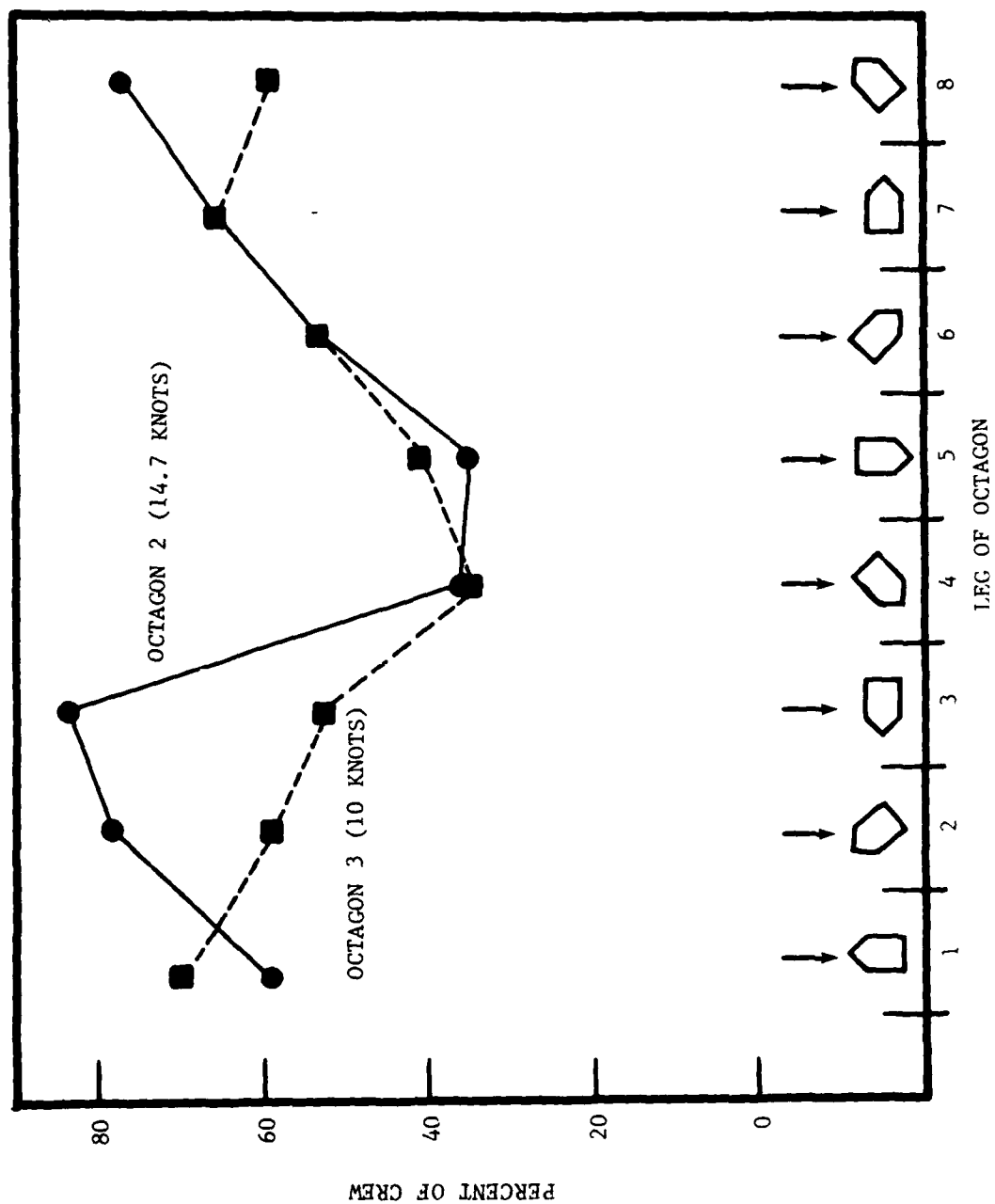


Figure 7 - Percentage of Crew Members Complaining of Some Degree of Impairment on Day 2 of the MOBILE BAY Sea Trial

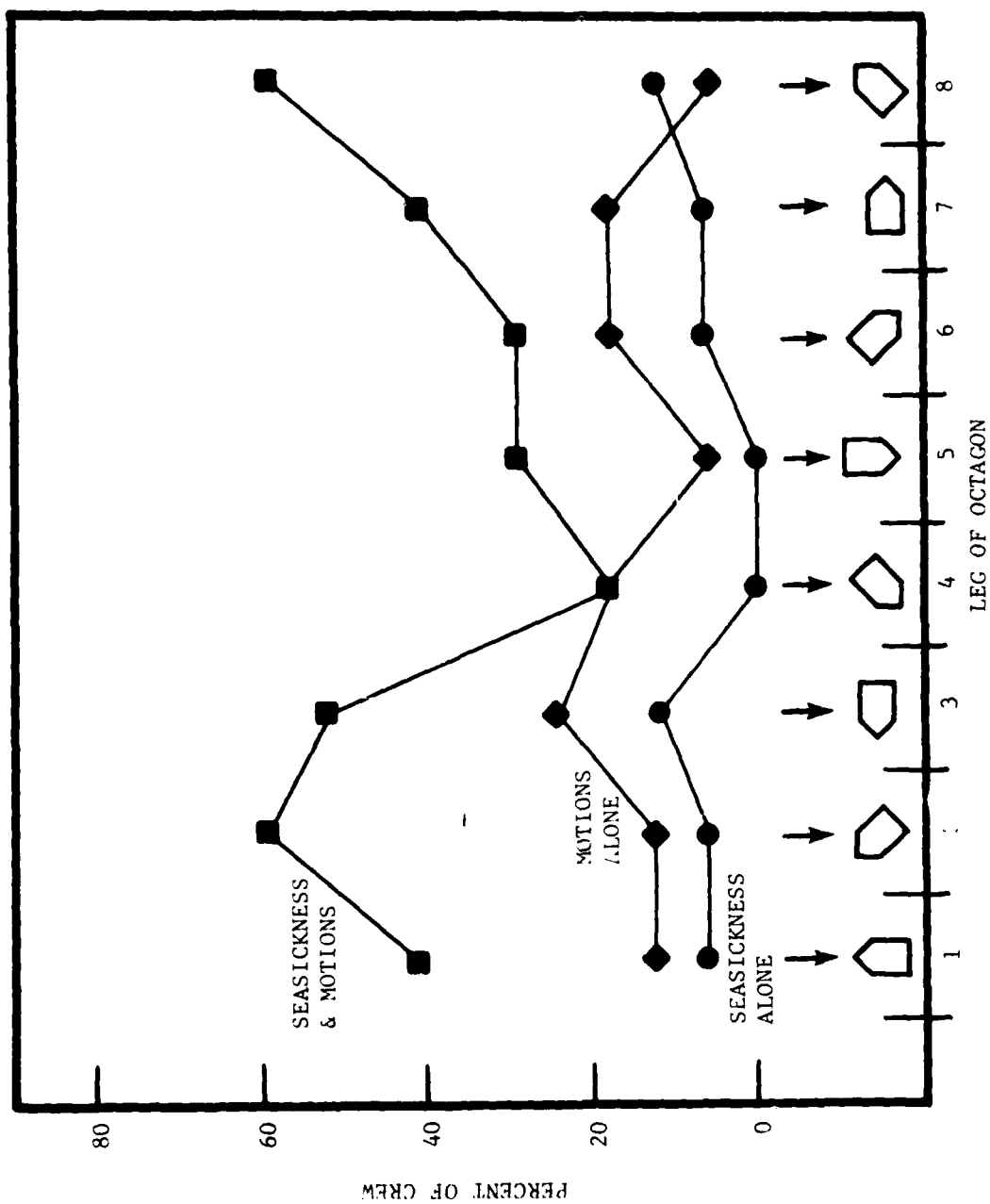


Figure 8 - Breakdown by Complaint of the Percentage of Crew Members Impaired During Octagon 2, Day 2 of the MOBILE BAY Sea Trial

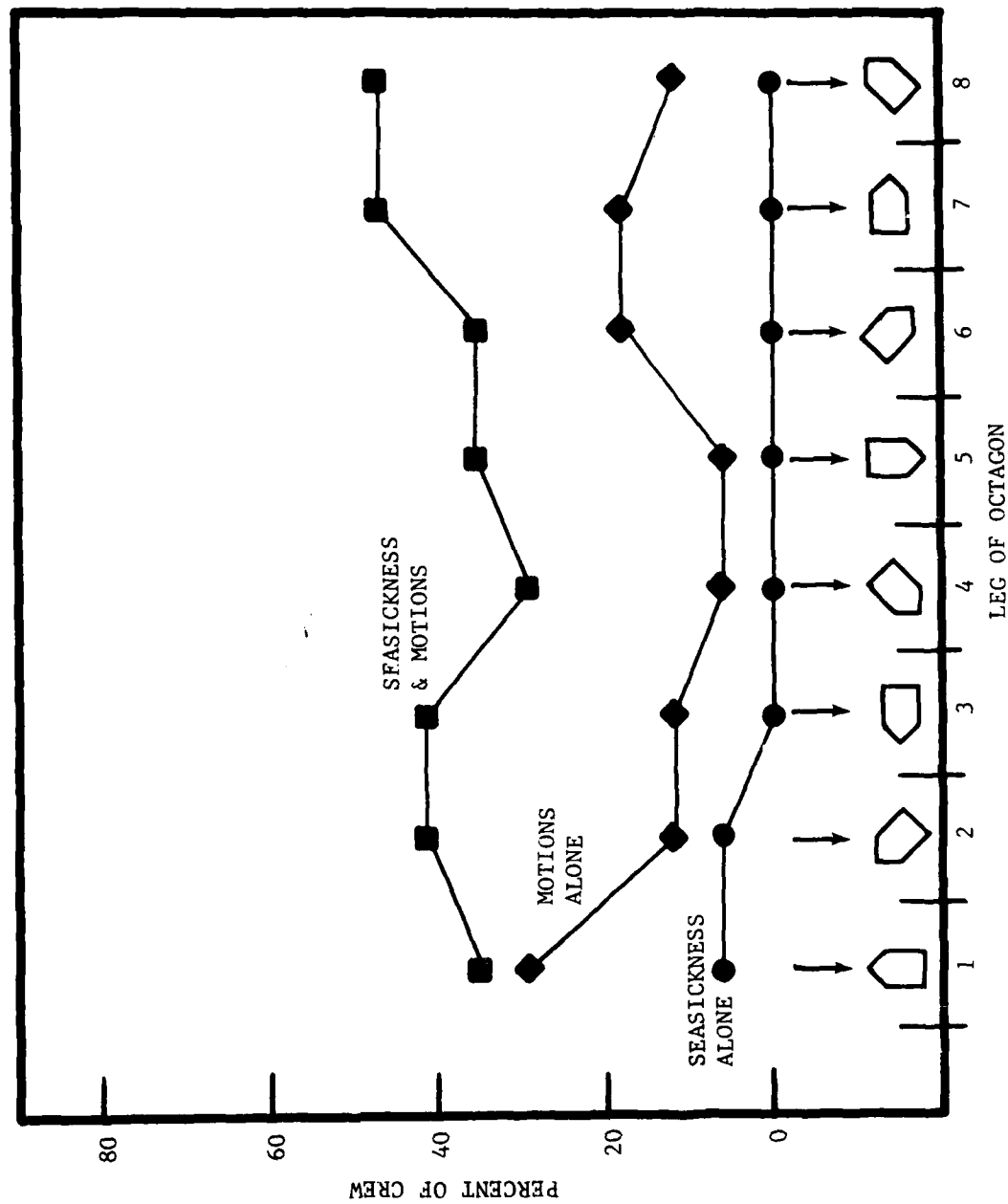


Figure 9 - Breakdown by Complaint of the Percentage of Crew Members Impaired During Octagon 3, Day 2 of the MOBILE BAY Sea Trial

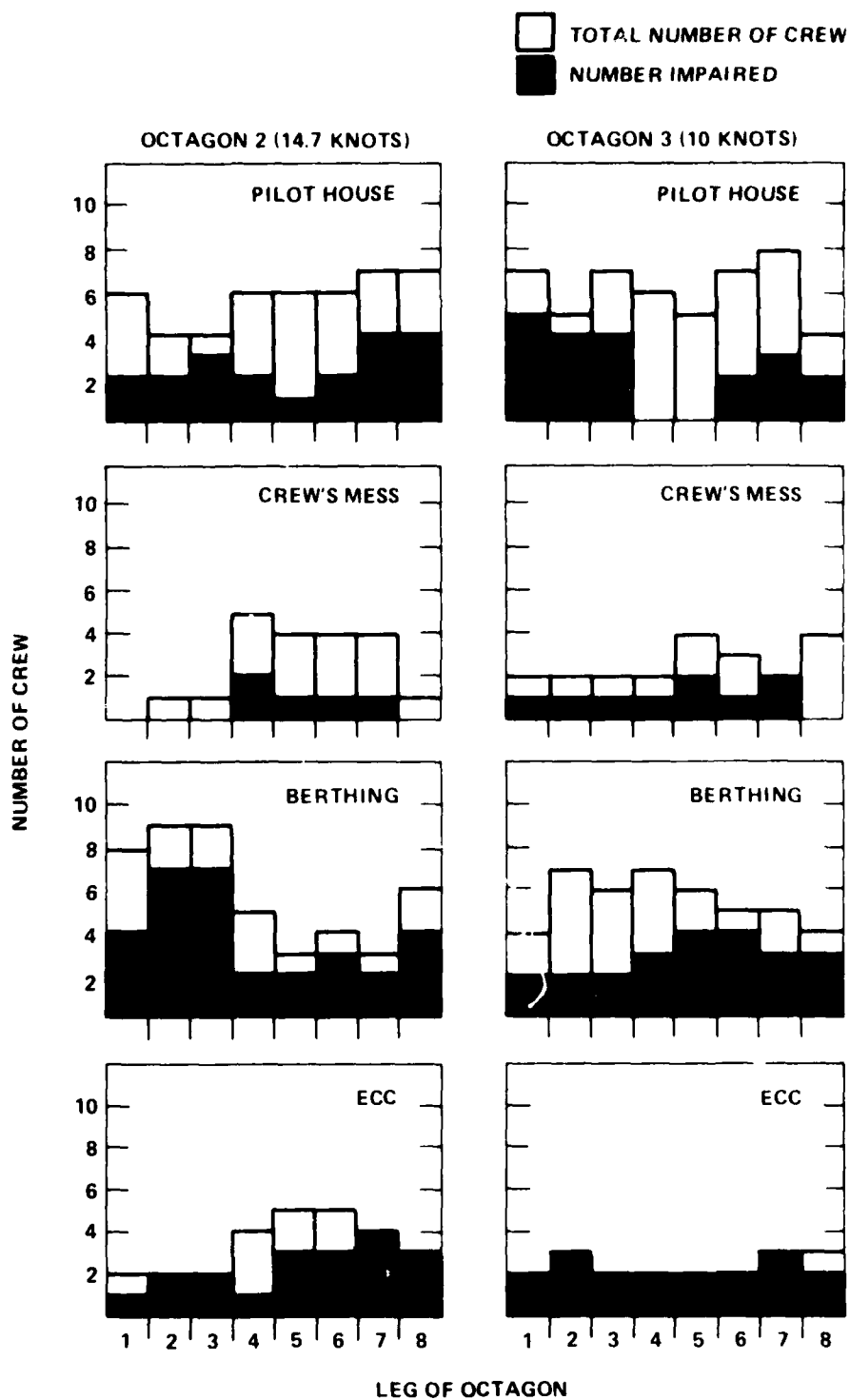


Figure 10 - Reported Crew Locations and Impairment in Four Ship Areas During Day 2

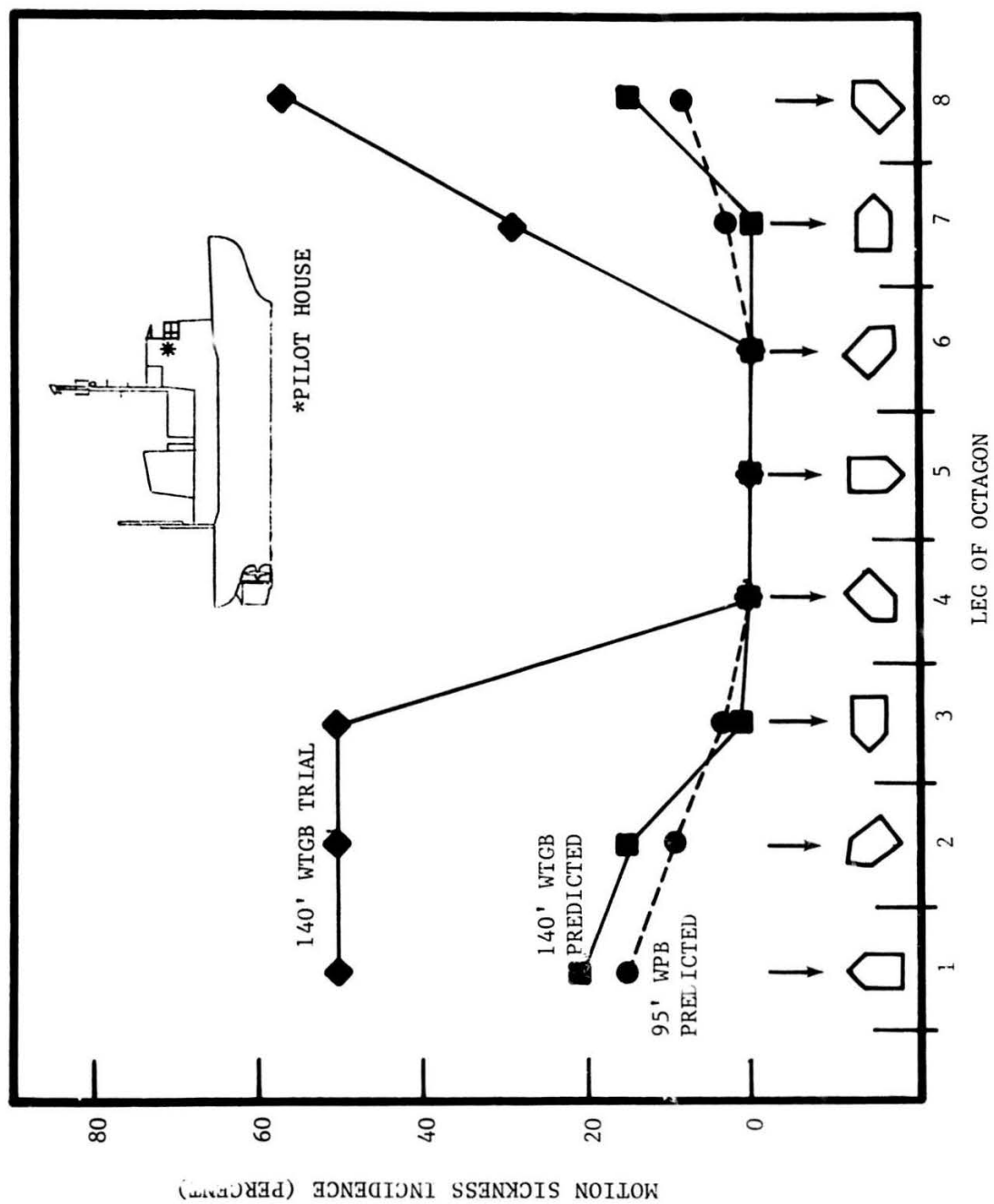


Figure 11 - Motion Sickness Incidence as Measured in the Pilot House During Day 2, Octagon 2 of the MOBILE BAY Sea Trial Compared to Predicted Occurrences for the 140' WTGB and 95' WPB

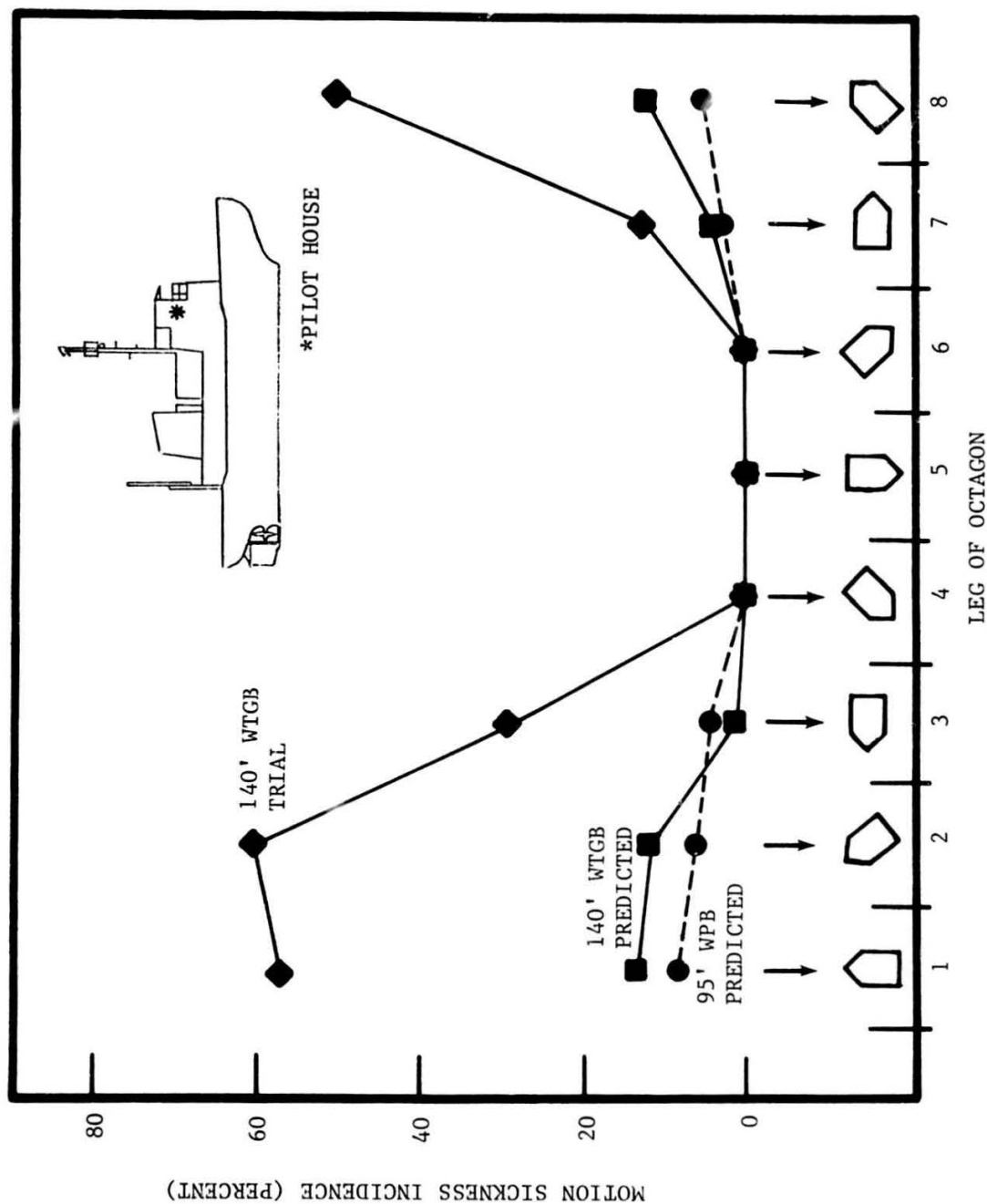


Figure 12 - Motion Sickness Incidence as Measured in the Pilot House During Day 2, Octagon 3 of the MOBILE BAY Sea Trial Compared to Predicted Occurrences for the 140' WTGB and 95' WPB

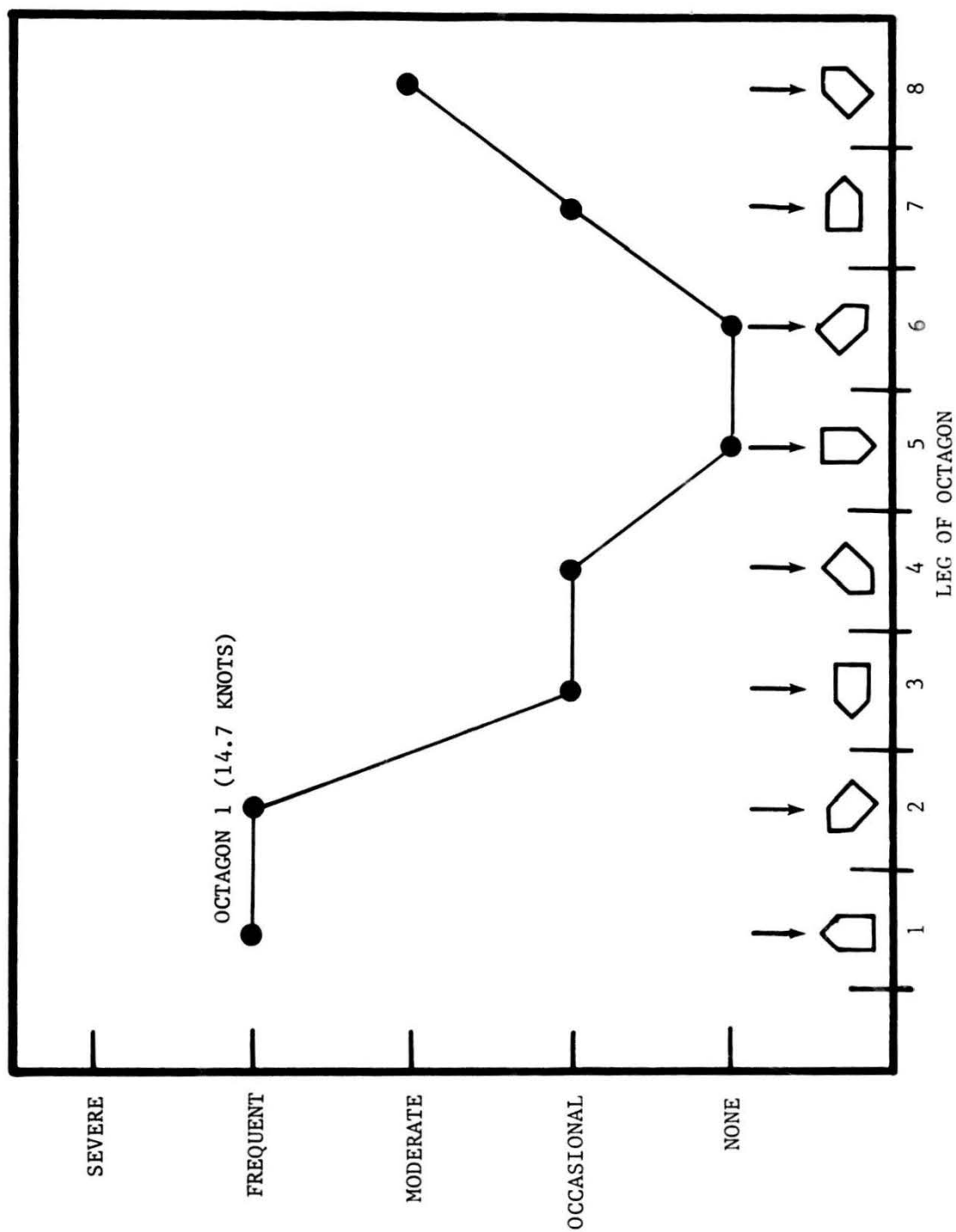


Figure 13 - Deck Wetness Observations for Day 1

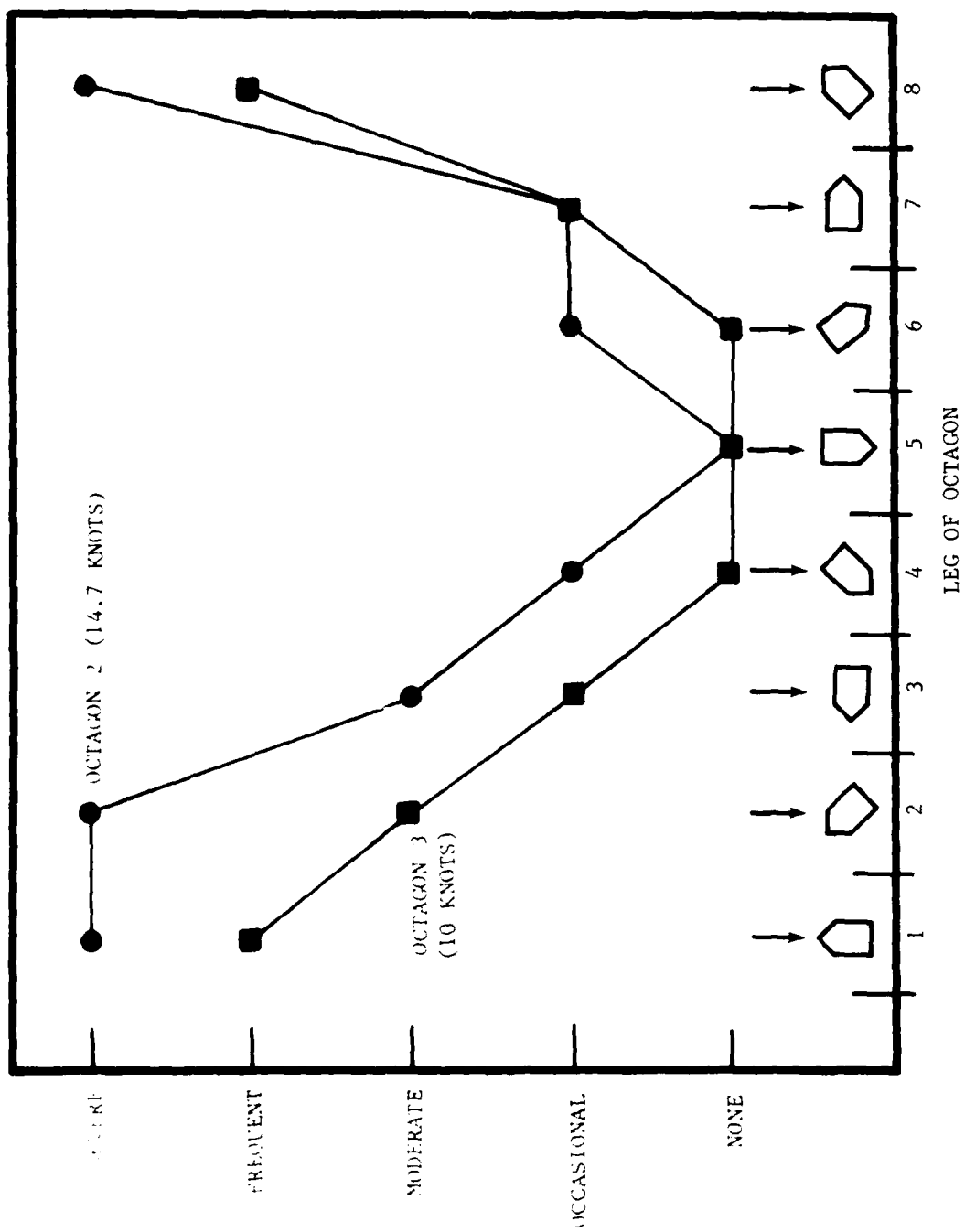


Figure 14 - Deck Wetness Observations for Day 2

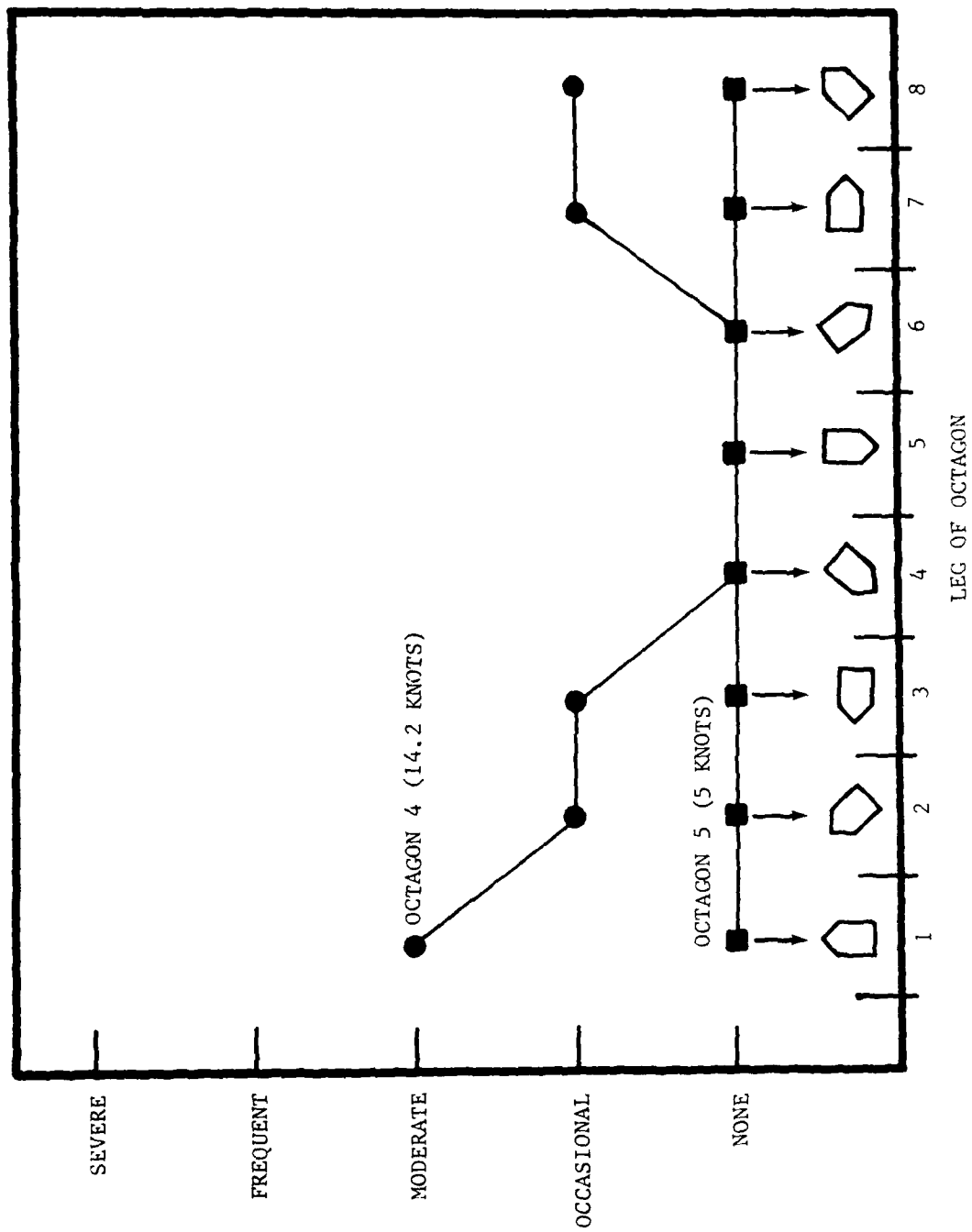


Figure 15 - Deck Wetness Observations for Day 3

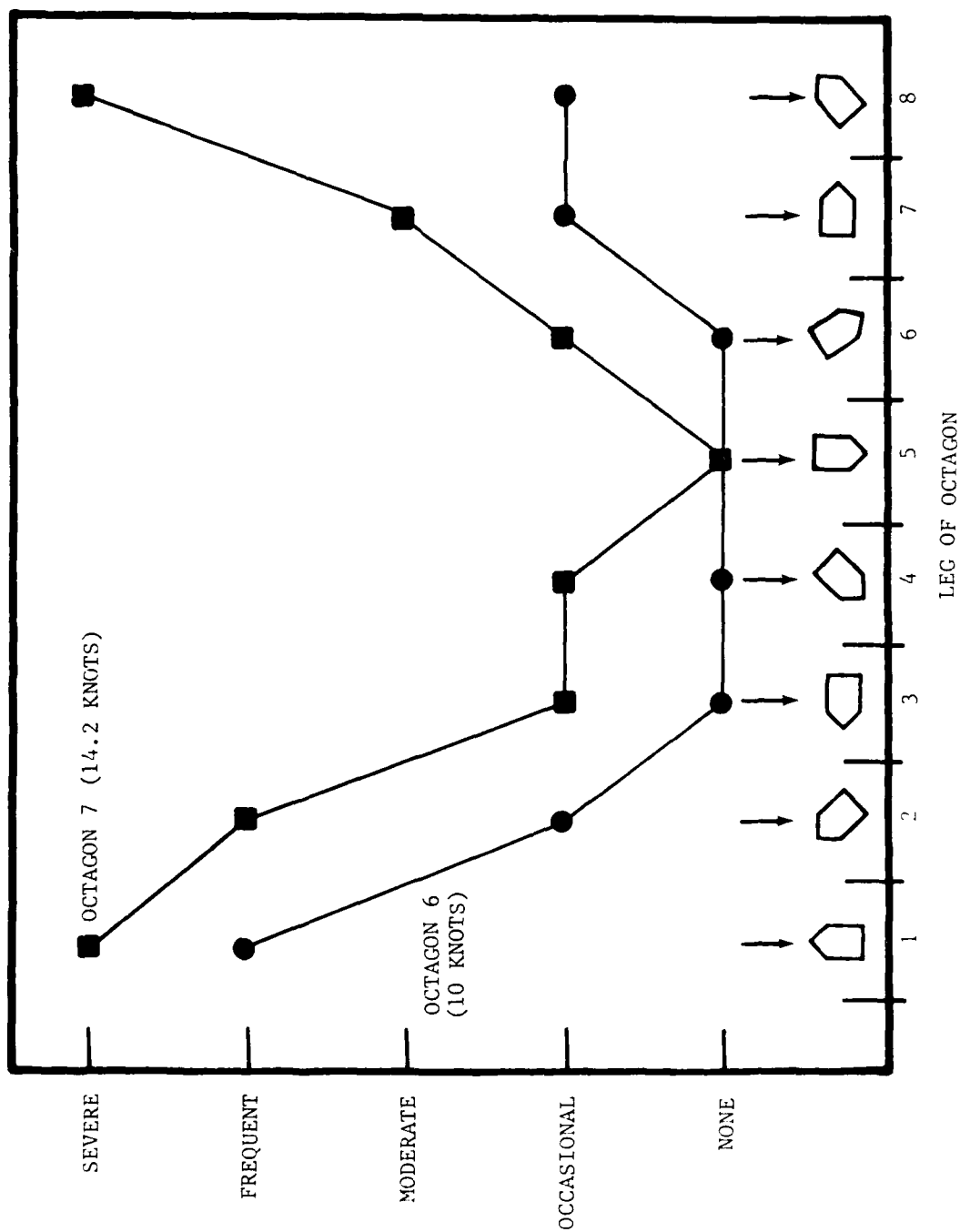


Figure 16 - Deck Wetness Observations for Day 4

TABLE 1 - SHIP POINT LOCATIONS

Ship	Point Description	X-Distance From AP (feet/meters)	Y-Distance From CL* (feet/meters)	Z-Distance From BL (feet/meters)
140' WTGB**	Origin	62.03/18.91	0.00/ 0.00	11.59/ 3.53
	Engine room (gyro)	64.94/19.79	1.20/ 0.37	7.90/ 2.41
	Crew's mess	71.70/21.85	4.15/ 1.26	18.10/ 5.52
	Pilot house (helm)	34.58/10.54	-0.75/-0.23	32.85/10.01
95' WPB	Origin	40.34/12.30	0.00/ 0.00	5.51/ 1.68
	Engine room	51.12/15.58	1.36/ 0.41	5.90/ 1.80
	Crew's mess	64.98/19.81	2.67/ 0.81	6.13/ 1.87
	Pilot house (helm)	38.70/11.80	-0.75/-0.23	21.10/ 6.43

*Positive to port of centerline

**Points correspond to both full-scale and analytical locations

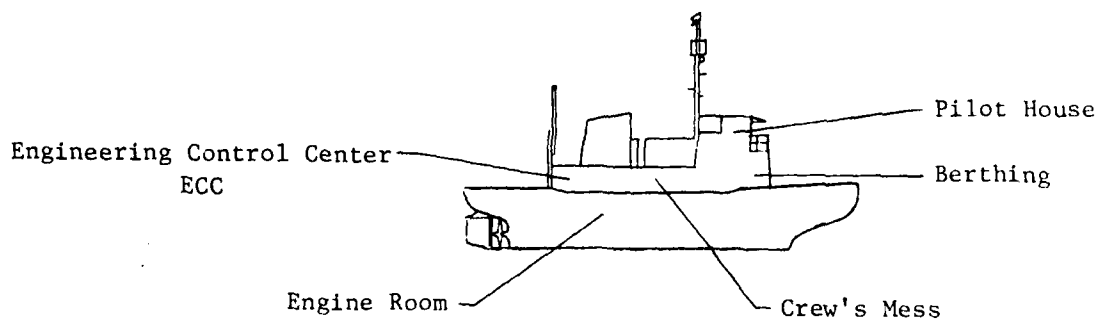


TABLE 2 - SEAWAY PARTICULARS

Day	Sea State	Significant Wave Height	Modal Period*	
			Full-Scale	Analytical
1	High 2	3.7 feet (1.13 meters)	12 seconds	11 seconds
2	Low 4	6.1 feet (1.86 meters)	8 seconds	9 seconds
3	Medium 2	2.9 feet (0.88 meters)	9 seconds	9 seconds
4	High 2	3.9 feet (1.19 meters)	6 seconds	7 seconds

*Note: Analytical modal periods may differ from observed full-scale periods due to computer program restrictions.

TABLE 3 - COMPUTED SHIP PARTICULARS

	140' WTGB	95' WPB
Length Between Perpendiculars, LPP	130.00 feet (39.62 meters)	90.00 feet (27.43 meters)
Beam at Midships, B	33.80 feet (10.30 meters)	17.94 feet (5.47 meters)
Draft, T	11.54 feet (3.52 meters)	5.37 feet (1.64 meters)
Displacement, Δ	645 L. tons (655 m. tons)	97 L. tons (99 m. tons)
Vertical Center of Gravity, KG	13.14 feet (4.01 meters)	8.51 feet (2.59 meters)
Metacentric Height, GM	3.68 feet (1.12 meters)	5.04 feet (1.54 meters)
Longitudinal Center of Gravity, LCG*	67.97 feet (20.72 meters)	49.66 feet (15.14 meters)
Roll Gyradius	13.86 feet (4.22 meters)	7.25 feet (2.21 meters)
Pitch Gyradius (.25B)	32.50 feet (9.91 meters)	22.50 feet (6.86 meters)
Yaw Gyradius (.25B)	32.50 feet (9.91 meters)	22.50 feet (6.86 meters)
Roll Period	8.25 seconds	4.06 seconds
Block Coefficient	.45	.39
Section Coefficient	.76	.59
Prismatic Coefficient	.58	.67

*Referenced to F.P.

TABLE 4 - 140' WTGB RMS* RESPONSES AS MEASURED DURING THE MOBILE BAY SEA TRIAL

Run #	Day	Octagon	Ship Speed (knots)	Heading* (deg)	Surge Acceleration (g)	Sway Acceleration (g)	Heave Acceleration (g)	Roll (deg)	Pitch (deg)	Pilot House (Helm) Accelerations (g)		Crew's Mess Accelerations (g)	
										Transverse	Normal	Transverse	Normal
1	1												
2													
3		1	14.7	0	0.0104	0.0181	0.0476	1.85	0.95	0.0511	0.0086	0.0208	0.0513
4				45	0.0125	0.0158	0.0418	1.53	1.11	0.0498	0.0098	0.0234	0.0599
5				90	0.0141	0.0170	0.0270	3.32	0.66	0.0961	0.0058	0.0114	0.0385
6				135	0.0096	0.0125	0.0108	2.03	0.60	0.0490	0.0028	0.0058	0.0176
7				180	0.0090	0.0112	0.0036	1.07	0.53	0.0238	0.0128	0.0038	0.0105
8				225	0.0090	0.0113	0.0108	1.38	0.63	0.0287	0.0116	0.0038	0.0103
9				270	0.0100	0.0134	0.0270	2.12	0.53	0.0591	0.0279	0.0006	0.0029
10				315	0.0123	0.0158	0.0418	2.40	0.61	0.0691	0.0501	0.0142	0.0420
11													
12	2												
13		2	14.7	0	0.0139	0.0144	1.0747	1.15	2.04	0.0409	0.1705	0.0212	0.1115
14				45	0.0134	0.0166	0.8956	3.13	1.48	0.1135	0.1328	0.0153	0.099
15				90	0.0127	0.0162	0.5537	5.66	1.12	0.1518	0.0757	0.0203	0.0615
16				135	-	-	-	4.39	1.70	-	-	-	-
17				180	0.0130	0.0118	0.0411	2.11	0.75	0.0464	0.0159	0.0050	0.0139
18				225	0.0128	0.0130	0.0466	5.03	1.11	0.0948	0.0306	0.0086	0.0282
19				270	0.0119	0.0154	0.7710	6.01	1.16	0.1228	0.0902	0.0218	0.0858
20				315	0.0118	0.0134	1.0188	2.35	2.12	0.0950	0.1704	-	0.1199
21													
22		3	10.0	0	0.0255	0.0120	0.8258	3.21	2.38	0.1005	0.1406	-	0.0739
23				45	0.0192	0.0259	0.8379	7.47	1.85	0.1925	0.1312	-	0.0895
24				90	0.0179	0.0262	0.5369	6.59	1.25	0.1981	0.0709	-	0.0520
25				135	0.022	0.0122	0.2038	3.36	1.35	0.0834	0.0295	-	0.0207
26				180	0.0207	0.0107	0.1772	2.79	1.29	0.1017	0.0196	0.0054	0.0199
27				225	0.0183	0.0265	0.5116	6.77	1.23	0.1723	0.0560	0.0122	0.0565
28				270	0.0196	0.0273	0.8443	7.32	1.68	0.2077	0.1061	0.0279	0.0895
29				315	0.0279	0.0165	0.9071	3.49	2.51	0.1115	0.1393	0.0416	0.0869
30	3												
31		4	14.2	0	0.0081	0.0094	0.0319	0.74	1.62	0.0267	0.0635	0.0187	0.0430
32				45	0.0105	0.0116	0.0352	1.51	1.43	0.0468	0.0552	0.0160	0.0395
33				90	0.0109	0.0117	0.0369	2.02	1.03	0.0559	0.0368	0.0103	0.0267
34				135	0.0098	0.0114	0.0372	1.35	0.85	0.0370	0.0129	0.0037	0.0110
35				180	0.0087	0.0093	0.0373	0.91	0.79	0.0213	0.0653	0.0020	0.0070
36				225	0.0088	0.0114	0.0366	1.46	0.77	0.0393	0.1246	0.0035	0.0151
37				270	0.0071	0.0117	0.0320	1.66	1.00	0.0497	0.0038	0.0100	0.0316
38				315	0.0082	0.0105	0.0322	1.43	1.32	0.0444	0.0528	0.0167	0.0382
39													
40		5	5.0	0	0.0044	0.0063	0.0284	1.90	1.92	0.0548	0.0469	0.0153	0.0226
41				45	0.0040	0.0068	0.0470	2.83	1.52	0.0788	0.0439	0.0129	0.0251
42				90	0.0082	0.0102	0.0242	3.14	1.15	0.0846	0.0294	0.0079	0.0194
43				135	0.0097	0.0056	0.0142	2.17	1.18	0.0570	0.0159	0.0045	0.0114
44				180	0.0086	0.0058	0.0167	2.56	1.06	0.0657	0.0137	0.0040	0.0127
45				225	0.0080	0.0105	0.0217	3.10	1.12	0.0854	0.0251	0.0068	0.0221
46				270	0.0091	0.0140	0.0236	2.67	1.45	0.0758	0.0407	0.0114	0.0278
47				315	0.0121	0.0137	0.0149	1.40	1.96	0.0437	0.0485	0.0151	0.0251
48	4												
49		6	10.0	0	0.0114	0.0124	0.0518	2.25	2.08	0.0719	0.0773	0.0222	0.0443
50				45	0.0106	0.0101	0.0504	2.67	1.79	0.0735	0.0653	0.0194	0.0353
51				90	0.0096	0.0091	0.0387	2.13	1.41	0.0635	0.0605	0.0140	0.0331
52				135	0.0117	0.0051	0.0179	2.39	1.37	0.0647	0.0263	0.0069	0.0189
53				180	0.0102	0.0083	0.0063	2.55	1.18	0.0686	0.0171	0.0040	0.0178
54				225	0.0091	0.0145	0.0179	2.35	1.21	0.0672	0.0354	0.0088	0.0298
55				270	0.0100	0.0187	0.0387	2.69	1.65	0.0777	0.0555	0.0155	0.0369
56				315	0.0121	0.0243	0.0504	1.53	2.19	0.0504	0.0771	0.0222	0.0461
57													
58		7	14.2	0	0.0099	0.0175	0.0245	1.64	2.12	0.0566	0.0930	0.0268	0.0657
59				45	0.0088	0.0124	0.0289	2.61	1.69	0.0733	0.0686	0.0203	0.0462
60				90	0.0095	0.0121	0.0257	1.96	1.68	0.0563	0.0642	0.0187	0.0449
61				135	0.0094	0.0076	0.0240	2.33	1.47	0.0677	0.0353	0.0088	0.0285
62				180	0.0097	0.0034	0.0169	2.14	1.27	0.0525	0.0136	0.0038	0.0132
63				225	0.0098	-	0.0253	2.38	1.08	0.0687	-	0.0078	0.0319
64				270	0.0096	0.0219	0.0511	2.14	1.67	0.1213	0.0238	0.0320	0.0452
65				315	0.0100	0.0153	0.0546	2.03	2.05	0.0657	0.0323	0.0231	0.0583
66													

Note: *Significant single amplitude response = 2xRMS

**0 degrees denotes head seas

TABLE 5 - TABULATION OF CREW RESPONSES TO THE PERFORMANCE ASSESSMENT QUESTIONNAIRE DURING THE MOBILE BAY SEA TRIAL

	Day 1								Day 2								Day 3								Day 4																							
	Octagon 1								Octagon 2								Octagon 3								Octagon 4								Octagon 6								Octagon 7							
	1 Head	2 Starbd. Bow	3 Starbd. Beam	4 Starbd. Qtr.	5 Following	6 Port Qtr.	7 Port Beam	8 Port Bow	1 Head	2 Starbd. Bow	3 Starbd. Beam	4 Starbd. Qtr.	5 Following	6 Port Qtr.	7 Port Beam	8 Port Bow	1 Head	2 Starbd. Bow	3 Starbd. Beam	4 Starbd. Qtr.	5 Following	6 Port Qtr.	7 Port Beam	8 Port Bow	1 Head	2 Starbd. Bow	3 Starbd. Beam	4 Starbd. Qtr.	5 Following	6 Port Qtr.	7 Port Beam	8 Port Bow																
Did You Experience a Loss in Your Ability to Perform Your Duties?	21	21	17	0	0	0	0	6	41	65	65	18	35	41	53	53	47	53	65	71	71	53	35	41	17	11	6	11	0	0	6	13																
	79	79	83	100	100	100	100	94	59	35	35	82	82	65	59	47	47	53	65	71	71	53	35	41	83	89	94	100	100	100	94	87																
What Was the Cause of Your Performance Degradation?	26	26	22	6	11	6	11	53	65	65	29	29	41	47	59	41	47	41	29	29	41	53	47	29	12	12	12	12	12	12	12	24																
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																
What Was the Cause of Your Mental and/or Physical Impairment?	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																
	69	74	78	94	89	94	80	33	47	35	35	71	71	59	53	41	29	53	59	71	71	59	47	53	71	88	88	88	88	88	76	82																
To What Degree Were You Impaired?	16	16	22	6	6	6	0	11	6	6	12	0	0	6	6	12	6	6	0	0	0	0	0	0	0	6	6	0	0	0	0	0																
	21	21	6	0	0	0	0	0	41	59	47	18	29	41	59	35	41	41	29	35	35	47	47	24	18	12	18	6	6	12	18	12																
How Would You Rate Your Level of Concentration?	0	0	0	0	0	0	0	0	12	12	24	18	6	18	18	6	29	12	12	6	6	18	18	12	6	0	12	12	6	6	0	0	6															
	63	63	72	94	94	94	100	83	41	22	17	64	65	47	35	23	30	41	47	65	59	47	35	41	70	76	82	82	82	82	82	76																
	0	0	0	0	0	0	0	0	6	18	12	6	6	6	12	0	12	18	18	24	18	24	24	24	0	0	0	0	0	0	0	0																
	5	0	6	0	0	0	0	0	18	18	12	6	6	12	18	24	12	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6																
	10	10	12	0	0	0	0	0	12	24	24	6	6	12	29	29	24	18	12	6	6	12	24	18	11	6	6	0	0	0	0	6																
	21	21	12	6	6	6	24	18	12	29	18	18	18	12	6	18	12	12	0	12	18	0	0	0	11	11	6	11	11	6	12	18																
	63	68	71	94	94	94	94	71	47	29	24	65	65	41	35	29	41	53	71	59	47	47	53	72	78	83	83	83	83	83	71	88																
	5	0	6	0	0	0	0	0	18	24	24	6	12	24	12	12	18	18	12	12	12	18	18	6	6	6	6	6	6	6	6	0																
How Would You Rate Your Level of Concentration?	26	26	24	12	12	12	18	18	35	47	47	24	29	29	47	53	35	29	6	12	12	24	29	18	18	18	18	18	18	18	12	12																
	69	67	67	76	71	71	71	59	35	18	24	65	47	41	35	18	35	24	47	47	53	65	41	29	71	59	59	59	65	71	65	71																
	59	53	65	59	53	47	53	71	88	82	71	76	71	65	71	88	82	71	88	82	71	76	71	65	71	88	82	71	65	71	65	71																

TABLE 6 - PREDICTED ROLL RMS/T_{CE} RESPONSES FOR THE 95' WPB, DAY 1

[illegible]

TABLE 7 - PREDICTED ROLL RMS/T_{OE} RESPONSES FOR THE 95' WPB, DAY 2

LONGCRESTED SIGNIFICANT WAVE HEIGHT = 6.10 FEET																
ROLL ANGLE (DEG)																
ROOT MEAN SQUARE (RMS) / ENCOUNTERED MODAL PERIOD (TOE)																
SHIP HEADING ANGLE IN DEGREES																
		STBD BEAM														
		90														
		105														
		120														
		135														
		150														
		165														
		180														
		FOLLOW														
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TABLE 8 - PREDICTED ROLL RMS/T_{OE} RESPONSES FOR THE 95' WPB, DAY 3

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 2.90 FEET

ROLL ANGLE
(DEG)

ROOT MEAN SQUARE (RMS) / ENCOUNTERED MODAL PERIOD (TOE)

SHIP HEADING ANGLE IN DEGREES

STBD BEAM

V	TO	HEAD 0	SHIP HEADING ANGLE IN DEGREES										FOLLOW 180	
			15	30	45	60	75	90	105	120	135	150		165
0	3	0.00/..	1.30/ 4	2.32/ 4	3.16/ 4	3.55/ 4	3.43/ 4	3.89/ 4	4.28/ 4	3.90/ 4	3.13/ 4	2.17/ 4	1.17/ 4	0.00/..
	5	0.00/..	2.10/ 4	3.60/ 4	4.72/ 4	5.18/ 4	5.14/ 4	5.62/ 4	6.19/ 4	5.96/ 4	4.98/ 4	3.58/ 4	1.99/ 4	0.00/..
	7	0.00/..	1.46/ 4	2.58/ 4	3.41/ 4	3.76/ 4	3.76/ 4	4.10/ 4	4.53/ 4	4.37/ 4	3.64/ 4	2.58/ 4	1.40/ 4	0.00/..
	9	0.00/..	1.01/ 4	1.83/ 4	2.44/ 4	2.70/ 4	2.70/ 4	2.95/ 4	3.27/ 4	3.15/ 4	2.60/ 4	1.82/ 4	.97/ 4	0.00/..
	11	0.00/..	.73/ 4	1.35/ 4	1.82/ 4	2.02/ 4	2.02/ 4	2.21/ 4	2.45/ 4	2.36/ 4	1.94/ 4	1.34/ 4	.70/ 4	0.00/..
	13	0.00/..	.55/ 4	1.03/ 4	1.40/ 4	1.56/ 4	1.56/ 4	1.71/ 4	1.90/ 4	1.83/ 4	1.49/ 4	1.02/ 4	.52/ 4	0.00/..
	15	0.00/..	.43/ 4	.81/ 4	1.11/ 4	1.24/ 4	1.24/ 4	1.36/ 4	1.52/ 4	1.46/ 4	1.18/ 4	.80/ 4	.41/ 4	0.00/..
	17	0.00/..	.34/ 4	.65/ 4	.90/ 4	1.01/ 4	1.01/ 4	1.11/ 4	1.24/ 4	1.19/ 4	.96/ 4	.65/ 4	.32/ 4	0.00/..
5	3	0.00/..	.13/ 3	.33/ 3	.67/ 3	1.20/ 3	1.70/ 3	2.52/ 4	3.89/ 4	2.54/ 4	1.12/ 5	.46/ 6	.17/ 6	0.00/..
	5	0.00/..	1.12/ 4	2.12/ 4	2.92/ 4	3.64/ 4	3.96/ 4	3.94/ 4	4.02/ 4	2.61/ 4	1.45/ 6	.80/ 6	.36/ 7	0.00/..
	7	0.00/..	1.02/ 4	1.89/ 4	2.49/ 4	2.89/ 4	2.97/ 4	2.77/ 4	2.62/ 4	1.76/ 4	.78/ 6	.64/ 6	.30/ 7	0.00/..
	9	0.00/..	.73/ 4	1.35/ 4	1.77/ 4	2.04/ 4	2.07/ 4	1.91/ 4	1.78/ 4	1.22/ 4	.79/ 6	.49/ 7	.24/ 7	0.00/..
	11	0.00/..	.53/ 4	.98/ 4	1.28/ 4	1.47/ 4	1.49/ 4	1.38/ 4	1.27/ 4	.90/ 5	.60/ 9	.38/ 9	.19/10	0.00/..
	13	0.00/..	.39/ 4	.73/ 4	.96/ 4	1.10/ 4	1.12/ 4	1.04/ 4	.96/ 4	.64/ 5	.47/10	.30/10	.15/11	0.00/..
	15	0.00/..	.30/ 4	.56/ 4	.74/ 4	.85/ 4	.87/ 4	.81/ 4	.75/ 4	.59/ 4	.38/12	.25/12	.12/12	0.00/..
	17	0.00/..	.24/ 4	.45/ 4	.59/ 4	.68/ 4	.69/ 4	.65/ 4	.60/ 4	.44/12	.31/13	.20/13	.10/13	0.00/..
0	3	0.00/..	.05/ 2	.13/ 2	.30/ 2	.66/ 2	1.15/ 3	1.78/ 4	1.69/ 4	1.04/ 7	.81/10	.40/16	.17/21	0.00/..
	5	0.00/..	.44/ 4	.91/ 4	1.61/ 4	2.44/ 4	2.96/ 4	3.03/ 4	2.20/ 5	1.62/ 7	1.38/10	.91/12	.43/13	0.00/..
	7	0.00/..	.59/ 4	1.15/ 4	1.71/ 4	2.29/ 4	2.50/ 4	2.32/ 4	1.73/ 6	1.37/ 7	1.15/10	.79/12	.39/13	0.00/..
	9	0.00/..	.49/ 4	.94/ 4	1.35/ 4	1.72/ 4	1.83/ 4	1.68/ 4	1.30/ 7	1.07/ 7	.89/10	.62/12	.31/13	0.00/..
	11	0.00/..	.38/ 4	.72/ 4	1.02/ 4	1.28/ 4	1.35/ 4	1.24/ 5	.99/ 8	.83/ 9	.69/10	.48/12	.24/13	0.00/..
	13	0.00/..	.29/ 4	.55/ 4	.78/ 4	.97/ 4	1.02/ 4	.95/ 7	.78/ 9	.65/10	.54/10	.38/12	.19/13	0.00/..
	15	0.00/..	.23/ 4	.44/ 4	.61/ 4	.76/ 4	.80/ 4	.75/ 8	.62/10	.53/10	.43/10	.30/12	.16/13	0.00/..
	17	0.00/..	.19/ 4	.35/ 4	.49/ 4	.61/ 4	.64/ 4	.60/10	.51/10	.43/10	.36/10	.25/12	.13/13	0.00/..
5	3	0.00/..	.03/ 2	.07/ 2	.18/ 2	.44/ 2	.89/ 2	1.41/ 4	2.42/ 5	1.89/12	.75/63	.48/ 4	.27/ 4	0.00/..
	5	0.00/..	.23/ 3	.52/ 4	.92/ 4	1.49/ 4	2.27/ 4	2.85/ 4	3.11/ 6	2.46/10	1.39/16	.81/30	.40/63	0.00/..
	7	0.00/..	.40/ 4	.83/ 4	1.28/ 4	1.73/ 4	2.17/ 4	2.37/ 5	2.32/ 6	1.85/10	1.17/14	.71/17	.35/22	0.00/..
	9	0.00/..	.39/ 4	.77/ 4	1.13/ 4	1.43/ 5	1.68/ 5	1.75/ 5	1.67/ 7	1.35/10	.90/14	.57/17	.26/20	0.00/..
	11	0.00/..	.32/ 4	.62/ 5	.90/ 5	1.11/ 5	1.27/ 5	1.31/ 6	1.24/ 7	1.01/10	.69/14	.44/17	.22/20	0.00/..
	13	0.00/..	.25/ 5	.49/ 5	.70/ 5	.87/ 5	.98/ 5	1.00/ 6	.94/ 7	.77/10	.54/14	.35/17	.17/20	0.00/..
	15	0.00/..	.20/ 5	.39/ 5	.56/ 5	.69/ 5	.77/ 5	.79/ 6	.74/ 7	.61/10	.41/14	.28/17	.14/20	0.00/..
	17	0.00/..	.16/ 5	.32/ 5	.45/ 5	.55/ 5	.62/ 5	.63/ 6	.60/ 7	.50/10	.36/14	.23/17	.12/20	0.00/..

TABLE 9 - PREDICTED ROLL RMS/T_{OE} RESPONSES FOR THE 95' WPB, DAY 4

LONGCRESTED SIGNIFICANT WAVE HEIGHT = 3.90 FEET														
ROLL ANGLE (DEG)														
ROOT MEAN SQUARE (RMS) / ENCOUNTERED MODAL PERIOD (TOE)														
			SHIP HEADING ANGLE IN DEGREES											
			STBD BEAM											
			15	30	45	60	75	90	105	120	135	150	165	FOLLOW 180
0	TO	HEAD												
	0	0.00/**	1.64/ 4	2.89/ 4	3.94/ 4	4.43/ 4	4.27/ 4	4.86/ 4	5.30/ 4	4.80/ 4	3.87/ 4	2.71/ 4	1.48/ 4	0.00/**
	3	0.00/**	2.63/ 4	4.47/ 4	5.83/ 4	6.40/ 4	6.35/ 4	6.94/ 4	7.64/ 4	7.34/ 4	6.15/ 4	4.45/ 4	2.51/ 4	0.00/**
	5	0.00/**	1.86/ 4	3.24/ 4	4.26/ 4	4.70/ 4	4.71/ 4	5.12/ 4	5.62/ 4	5.43/ 4	4.54/ 4	3.25/ 4	1.79/ 4	0.00/**
	7	0.00/**	1.30/ 4	2.31/ 4	3.07/ 4	3.40/ 4	3.42/ 4	3.72/ 4	4.10/ 4	3.95/ 4	3.28/ 4	2.32/ 4	1.25/ 4	0.00/**
	9	0.00/**	.95/ 4	1.72/ 4	2.30/ 4	2.56/ 4	2.57/ 4	2.80/ 4	3.09/ 4	2.97/ 4	2.46/ 4	1.72/ 4	.91/ 4	0.00/**
	11	0.00/**	.72/ 4	1.32/ 4	1.79/ 4	1.99/ 4	2.00/ 4	2.18/ 4	2.41/ 4	2.32/ 4	1.90/ 4	1.32/ 4	.68/ 4	0.00/**
	13	0.00/**	.56/ 4	1.05/ 4	1.42/ 4	1.59/ 4	1.60/ 4	1.75/ 4	1.94/ 4	1.86/ 4	1.52/ 4	1.04/ 4	.53/ 4	0.00/**
5	TO	HEAD												
	0	0.00/**	.45/ 4	.85/ 4	1.16/ 4	1.30/ 4	1.30/ 4	1.43/ 4	1.59/ 4	1.53/ 4	1.24/ 4	.84/ 4	.43/ 4	0.00/**
	3	0.00/**	.18/ 3	.44/ 3	.90/ 3	1.61/ 3	2.28/ 3	3.35/ 4	5.11/ 4	3.39/ 4	1.51/ 5	.61/ 6	.23/ 6	0.00/**
	5	0.00/**	1.50/ 4	2.82/ 4	3.89/ 4	4.83/ 4	5.24/ 4	5.22/ 4	5.32/ 4	3.49/ 4	1.95/ 6	1.07/ 6	.48/ 7	0.00/**
	7	0.00/**	1.36/ 4	2.52/ 4	3.32/ 4	3.85/ 4	3.95/ 4	3.70/ 4	3.50/ 4	2.36/ 4	1.45/ 6	.86/ 6	.41/ 7	0.00/**
	9	0.00/**	.98/ 4	1.81/ 4	2.37/ 4	2.72/ 4	2.76/ 4	2.56/ 4	2.38/ 4	1.64/ 4	1.06/ 6	.66/ 7	.32/ 7	0.00/**
	11	0.00/**	.71/ 4	1.31/ 4	1.72/ 4	1.97/ 4	2.00/ 4	1.85/ 4	1.71/ 4	1.21/ 5	.81/ 9	.51/ 9	.25/ 10	0.00/**
	13	0.00/**	.53/ 4	.98/ 4	1.29/ 4	1.47/ 4	1.50/ 4	1.39/ 4	1.29/ 4	.93/ 5	.63/ 10	.41/ 10	.20/ 11	0.00/**
10	TO	HEAD												
	0	0.00/**	.41/ 4	.76/ 4	1.00/ 4	1.14/ 4	1.17/ 4	1.09/ 4	1.00/ 4	.73/ 11	.51/ 12	.33/ 12	.16/ 12	0.00/**
	3	0.00/**	.32/ 4	.60/ 4	.79/ 4	.91/ 4	.93/ 4	.87/ 4	.81/ 4	.59/ 12	.42/ 13	.28/ 13	.14/ 13	0.00/**
	5	0.00/**	.07/ 2	.18/ 2	.41/ 2	.88/ 2	1.55/ 3	2.38/ 4	2.28/ 4	1.40/ 7	1.08/ 10	.54/ 16	.23/ 21	0.00/**
	7	0.00/**	.59/ 4	1.27/ 3	2.17/ 4	3.27/ 4	3.98/ 4	4.07/ 4	2.95/ 5	2.18/ 7	1.85/ 10	1.22/ 12	.58/ 13	0.00/**
	9	0.00/**	.79/ 4	1.54/ 4	2.30/ 4	3.07/ 4	3.35/ 4	3.12/ 4	2.33/ 6	1.84/ 7	1.55/ 10	1.06/ 12	.53/ 13	0.00/**
	11	0.00/**	.66/ 4	1.26/ 4	1.81/ 4	2.31/ 4	2.45/ 4	2.25/ 4	1.75/ 7	1.43/ 7	1.19/ 10	.83/ 12	.42/ 13	0.00/**
	13	0.00/**	.51/ 4	.97/ 4	1.37/ 4	1.71/ 4	1.81/ 4	1.67/ 5	1.34/ 8	1.11/ 9	.92/ 10	.65/ 12	.33/ 13	0.00/**
15	TO	HEAD												
	0	0.00/**	.39/ 4	.75/ 4	1.05/ 4	1.30/ 4	1.38/ 4	1.28/ 7	1.04/ 9	.88/ 10	.73/ 10	.51/ 12	.26/ 13	0.00/**
	3	0.00/**	.31/ 4	.59/ 4	.82/ 4	1.02/ 4	1.08/ 4	1.01/ 8	.83/ 10	.71/ 10	.58/ 10	.41/ 12	.21/ 13	0.00/**
	5	0.00/**	.25/ 4	.47/ 4	.66/ 4	.82/ 4	.87/ 4	.81/ 10	.63/ 10	.58/ 10	.48/ 10	.34/ 12	.17/ 13	0.00/**
	7	0.00/**	.04/ 2	.09/ 2	.24/ 2	.59/ 2	1.20/ 2	1.89/ 4	3.25/ 5	2.54/ 12	1.02/ 63	.64/ 4	.37/ 4	0.00/**
	9	0.00/**	.31/ 3	.70/ 4	1.23/ 4	2.01/ 3	3.05/ 4	3.82/ 4	4.18/ 6	3.31/ 10	1.87/ 16	1.09/ 30	.53/ 63	0.00/**
	11	0.00/**	.54/ 4	1.12/ 4	1.72/ 4	2.32/ 4	2.92/ 4	3.18/ 5	3.12/ 6	2.49/ 10	1.58/ 14	.96/ 17	.47/ 22	0.00/**
	13	0.00/**	.52/ 4	1.03/ 4	1.52/ 4	1.93/ 4	2.26/ 5	2.36/ 5	2.25/ 7	1.81/ 10	1.21/ 14	.71/ 17	.37/ 20	0.00/**
20	TO	HEAD												
	0	0.00/**	.43/ 4	.84/ 5	1.21/ 5	1.50/ 5	1.71/ 5	1.76/ 6	1.66/ 7	1.35/ 10	.93/ 14	.60/ 17	.29/ 20	0.00/**
	3	0.00/**	.34/ 5	.66/ 5	.95/ 5	1.16/ 5	1.32/ 5	1.35/ 6	1.27/ 7	1.04/ 10	.73/ 14	.47/ 17	.24/ 20	0.00/**
	5	0.00/**	.27/ 5	.53/ 5	.75/ 5	.92/ 5	1.04/ 5	1.06/ 6	1.00/ 7	.82/ 10	.59/ 14	.38/ 17	.19/ 20	0.00/**
	7	0.00/**	.22/ 5	.43/ 5	.61/ 5	.75/ 5	.84/ 5	.85/ 6	.80/ 7	.67/ 10	.48/ 14	.32/ 17	.16/ 20	0.00/**
	9	0.00/**	.18/ 4	.37/ 5	.55/ 5	.73/ 5	.87/ 6	.96/ 7	.90/ 8	.75/ 10	.54/ 13	.35/ 16	.20/ 20	0.00/**
	11	0.00/**	.14/ 4	.28/ 5	.43/ 5	.58/ 5	.70/ 6	.78/ 7	.73/ 8	.61/ 10	.44/ 13	.29/ 16	.17/ 20	0.00/**
	13	0.00/**	.11/ 4	.22/ 5	.34/ 5	.46/ 5	.56/ 6	.63/ 7	.59/ 8	.49/ 10	.34/ 13	.23/ 16	.14/ 20	0.00/**

TABLE 10 - PREDICTED ROLL RMS/T_{OE} RESPONSES FOR THE 140' WTGB, DAY 1

LONGCRESTED SIGNIFICANT WAVE HEIGHT = 3.70 FEET														
ROLL ANGLE (DEG)														
ROOT MEAN SQUARE (RMS) / ENCOUNTERED MODAL PERIOD (TOE)														
V	T0	HEAD 0	SHIP HEADING ANGLE IN DEGREES											
			STBD BEAM											
			15	30	45	60	75	90	105	120	135	150	165	FOLLOW 180
0	7	0.00/**	1.24/ 8	2.36/ 8	3.28/ 8	3.94/ 8	4.34/ 8	4.49/ 8	4.38/ 8	4.01/ 8	3.35/ 8	2.42/ 8	1.28/ 8	0.00/**
	9	0.00/**	1.52/ 8	2.90/ 8	4.02/ 8	4.83/ 8	5.32/ 8	5.50/ 8	5.37/ 8	4.91/ 8	4.11/ 8	2.97/ 8	1.57/ 8	0.00/**
	11	0.00/**	1.30/ 8	2.48/ 8	3.44/ 8	4.14/ 8	4.56/ 8	4.72/ 8	4.60/ 8	4.20/ 8	3.51/ 8	2.54/ 8	1.34/ 8	0.00/**
	13	0.00/**	1.03/ 8	1.97/ 8	2.73/ 8	3.29/ 8	3.63/ 8	3.76/ 8	3.66/ 8	3.34/ 8	2.79/ 8	2.01/ 8	1.06/ 8	0.00/**
	15	0.00/**	.81/ 8	1.55/ 8	2.16/ 8	2.61/ 8	2.88/ 8	2.97/ 8	2.90/ 8	2.65/ 8	2.21/ 8	1.59/ 8	.84/ 8	0.00/**
	17	0.00/**	.65/ 8	1.24/ 8	1.73/ 8	2.09/ 8	2.31/ 8	2.39/ 8	2.33/ 8	2.12/ 8	1.77/ 8	1.27/ 8	.67/ 8	0.00/**
	19	0.00/**	.53/ 8	1.01/ 8	1.41/ 8	1.70/ 8	1.88/ 8	1.94/ 8	1.90/ 8	1.73/ 8	1.44/ 8	1.04/ 8	.54/ 8	0.00/**
5	7	0.00/**	.44/ 8	.84/ 8	1.17/ 8	1.41/ 8	1.56/ 8	1.61/ 8	1.57/ 8	1.43/ 8	1.19/ 8	.86/ 8	.45/ 8	0.00/**
	9	0.00/**	.35/ 8	.73/ 8	1.15/ 8	1.62/ 8	2.02/ 8	2.60/ 8	3.26/ 8	3.06/ 8	3.16/ 8	2.78/ 8	1.59/ 8	0.00/**
	11	0.00/**	.66/ 8	1.31/ 8	1.93/ 8	2.53/ 8	2.81/ 8	3.15/ 8	3.63/ 8	3.05/ 8	2.81/ 8	2.28/ 8	1.25/ 8	0.00/**
	13	0.00/**	.70/ 8	1.34/ 8	1.91/ 8	2.43/ 8	2.59/ 8	2.74/ 8	3.03/ 8	2.47/ 9	2.18/ 8	1.71/ 8	.93/ 8	0.00/**
	15	0.00/**	.61/ 8	1.16/ 8	1.63/ 8	2.04/ 8	2.14/ 8	2.21/ 8	2.32/ 8	1.93/ 9	1.67/ 8	1.29/ 8	.70/ 8	0.00/**
	17	0.00/**	.50/ 8	.96/ 8	1.34/ 8	1.66/ 8	1.73/ 8	1.77/ 8	1.89/ 8	1.52/ 9	1.30/ 8	1.00/ 8	.54/ 8	0.00/**
	19	0.00/**	.41/ 8	.79/ 8	1.10/ 8	1.35/ 8	1.40/ 8	1.43/ 8	1.52/ 8	1.22/ 9	1.04/ 8	.80/ 8	.43/ 8	0.00/**
10	7	0.00/**	.34/ 8	.65/ 8	.91/ 8	1.11/ 8	1.15/ 8	1.17/ 8	1.24/ 8	.99/ 9	.85/ 8	.65/ 8	.35/ 8	0.00/**
	9	0.00/**	.29/ 8	.55/ 8	.76/ 8	.93/ 8	.96/ 8	.97/ 8	1.03/ 8	.82/ 9	.70/ 8	.53/ 8	.29/ 8	0.00/**
	11	0.00/**	.17/ 7	.36/ 7	.50/ 7	.60/ 7	.63/ 7	.63/ 7	.63/ 7	.63/ 7	.63/ 7	.63/ 7	.63/ 7	0.00/**
	13	0.00/**	.36/ 8	.74/ 8	1.14/ 8	1.56/ 8	1.97/ 8	2.31/ 8	2.59/ 9	2.89/ 8	2.49/ 10	1.20/ 12	.55/ 13	0.00/**
	15	0.00/**	.45/ 8	.90/ 8	1.32/ 8	1.67/ 8	1.95/ 8	2.08/ 8	2.16/ 9	2.20/ 8	1.83/ 10	.92/ 12	.42/ 13	0.00/**
	17	0.00/**	.44/ 8	.86/ 8	1.22/ 8	1.50/ 8	1.67/ 8	1.72/ 8	1.72/ 9	1.69/ 8	1.38/ 10	.71/ 12	.33/ 13	0.00/**
	19	0.00/**	.39/ 8	.75/ 8	1.05/ 8	1.27/ 8	1.39/ 8	1.40/ 9	1.37/ 9	1.32/ 8	1.07/ 10	.56/ 12	.26/ 13	0.00/**
15	7	0.00/**	.33/ 8	.64/ 8	.88/ 8	1.06/ 8	1.14/ 9	1.14/ 9	1.11/ 9	1.06/ 8	.85/ 10	.45/ 12	.21/ 13	0.00/**
	9	0.00/**	.28/ 8	.54/ 8	.74/ 9	.88/ 9	.95/ 9	.94/ 9	.91/ 9	.86/ 8	.69/ 10	.37/ 12	.18/ 13	0.00/**
	11	0.00/**	.24/ 8	.45/ 9	.63/ 9	.74/ 9	.80/ 9	.79/ 9	.76/ 9	.72/ 8	.58/ 10	.31/ 12	.15/ 13	0.00/**
	13	0.00/**	.11/ 5	.24/ 6	.40/ 6	.63/ 7	.58/ 7	1.53/ 8	2.50/ 8	3.78/ 10	1.87/ 14	1.02/ 17	.43/ 20	0.00/**
	15	0.00/**	.23/ 8	.48/ 8	.76/ 8	1.14/ 8	1.54/ 8	1.95/ 8	2.42/ 9	2.84/ 10	1.51/ 14	.88/ 17	.40/ 20	0.00/**
	17	0.00/**	.34/ 8	.68/ 8	1.03/ 9	1.36/ 9	1.63/ 9	1.82/ 9	1.99/ 9	2.11/ 10	1.18/ 14	.71/ 17	.33/ 20	0.00/**
	19	0.00/**	.37/ 9	.72/ 9	1.04/ 9	1.30/ 9	1.47/ 9	1.54/ 9	1.58/ 9	1.61/ 10	.92/ 14	.57/ 17	.27/ 20	0.00/**
	15	0.00/**	.34/ 9	.67/ 9	.94/ 9	1.14/ 9	1.25/ 9	1.27/ 9	1.26/ 9	1.25/ 10	.74/ 14	.46/ 17	.22/ 20	0.00/**
	17	0.00/**	.31/ 9	.59/ 9	.82/ 9	.97/ 9	1.05/ 9	1.04/ 9	1.02/ 9	1.00/ 10	.60/ 14	.38/ 17	.18/ 20	0.00/**
	19	0.00/**	.27/ 9	.51/ 9	.70/ 9	.83/ 9	.88/ 9	.87/ 9	.84/ 9	.82/ 10	.50/ 14	.31/ 17	.15/ 20	0.00/**
	21	0.00/**	.23/ 9	.43/ 9	.60/ 9	.70/ 9	.74/ 9	.73/ 9	.71/ 9	.68/ 10	.42/ 14	.26/ 17	.13/ 20	0.00/**

TABLE 12 - PREDICTED ROLL RMS/T_{OE} RESPONSES FOR THE 140' WTGB, DAY 3

LONGCRESTED
SIGNIFICANT WAVE HEIGHT = 2.90 FEET

ROLL ANGLE
(DEG)

ROOT MEAN SQUARE (RMS) / ENCOUNTERED MODAL PERIOD (TOE)

V TO	HEAD 0	SHIP HEADING ANGLE IN DEGREES STBD BEAM											FOLLOW 180
		15	30	45	60	75	90	105	120	135	150	165	
0	7	.97/ 8	1.85/ 8	2.57/ 8	3.10/ 8	3.42/ 8	3.53/ 8	3.45/ 8	3.15/ 8	2.64/ 8	1.90/ 8	1.00/ 8	0.00/ **
	9	1.20/ 8	2.28/ 8	3.16/ 8	3.81/ 8	4.20/ 8	4.34/ 8	4.23/ 8	3.87/ 8	3.23/ 8	2.34/ 8	1.23/ 8	0.00/ **
	11	1.02/ 8	1.95/ 8	2.70/ 8	3.26/ 8	3.59/ 8	3.72/ 8	3.62/ 8	3.31/ 8	2.76/ 8	1.99/ 8	1.05/ 8	0.00/ **
	13	.81/ 8	1.54/ 8	2.15/ 8	2.59/ 8	2.86/ 8	2.96/ 8	2.88/ 8	2.63/ 8	2.19/ 8	1.58/ 8	.83/ 8	0.00/ **
	15	.64/ 8	1.22/ 8	1.70/ 8	2.05/ 8	.26/ 8	2.34/ 8	2.28/ 8	2.08/ 8	1.73/ 8	1.25/ 8	.66/ 8	0.00/ **
	17	.51/ 8	.98/ 8	1.36/ 8	1.64/ 8	1.81/ 8	1.87/ 8	1.83/ 8	1.67/ 8	1.39/ 8	1.00/ 8	.52/ 8	0.00/ **
	19	.42/ 8	.79/ 8	1.11/ 8	1.34/ 8	1.48/ 8	1.53/ 8	1.49/ 8	1.36/ 8	1.13/ 8	.81/ 8	.43/ 8	0.00/ **
	21	.34/ 8	.66/ 8	.92/ 8	1.11/ 8	1.22/ 8	1.26/ 8	1.23/ 8	1.12/ 8	.94/ 8	.67/ 8	.35/ 8	0.00/ **
5	7	.28/ 8	.57/ 8	.90/ 8	1.27/ 8	1.58/ 8	2.04/ 8	2.56/ 8	2.40/ 8	2.48/ 8	2.18/ 8	1.25/ 8	0.00/ **
	9	.52/ 8	1.03/ 8	1.51/ 8	1.99/ 8	2.20/ 8	2.47/ 8	2.85/ 8	2.39/ 8	2.20/ 8	1.78/ 8	.98/ 8	0.00/ **
	11	.55/ 8	1.05/ 8	1.50/ 8	1.90/ 8	2.03/ 8	2.15/ 8	2.38/ 8	1.93/ 9	1.71/ 8	1.34/ 8	.73/ 8	0.00/ **
	13	.47/ 8	.91/ 8	1.28/ 8	1.60/ 8	1.68/ 8	1.73/ 8	1.88/ 8	1.51/ 9	1.31/ 8	1.01/ 8	.55/ 8	0.00/ **
	15	.39/ 8	.75/ 8	1.05/ 8	1.30/ 8	1.36/ 8	1.39/ 8	1.48/ 8	1.19/ 9	1.02/ 8	.79/ 8	.42/ 8	0.00/ **
	17	.32/ 8	.62/ 8	.86/ 8	1.06/ 8	1.10/ 8	1.12/ 8	1.19/ 8	.95/ 9	.81/ 8	.62/ 8	.33/ 8	0.00/ **
	19	.27/ 8	.51/ 8	.71/ 8	.87/ 8	.91/ 8	.92/ 8	.97/ 8	.78/ 9	.66/ 8	.51/ 8	.27/ 8	0.00/ **
	21	.22/ 8	.43/ 8	.59/ 8	.73/ 8	.75/ 8	.76/ 8	.81/ 8	.65/ 9	.55/ 8	.42/ 8	.22/ 8	0.00/ **
10	7	.13/ 7	.28/ 7	.47/ 7	.71/ 8	1.03/ 8	1.46/ 8	1.97/ 8	2.78/ 8	2.65/ 10	1.20/ 12	.53/ 13	0.00/ **
	9	.28/ 8	.59/ 8	.89/ 8	1.22/ 8	1.55/ 8	1.81/ 8	2.03/ 9	2.27/ 8	1.95/ 10	.94/ 12	.43/ 13	0.00/ **
	11	.36/ 8	.70/ 8	1.03/ 8	1.31/ 8	1.53/ 8	1.63/ 8	1.69/ 9	1.73/ 8	1.43/ 10	.72/ 12	.33/ 13	0.00/ **
	13	.35/ 8	.67/ 9	.96/ 8	1.17/ 9	1.31/ 8	1.35/ 8	1.34/ 9	1.32/ 8	1.08/ 10	.56/ 12	.26/ 13	0.00/ **
	15	.30/ 8	.59/ 9	.82/ 8	.99/ 9	1.09/ 9	1.10/ 9	1.07/ 9	1.03/ 8	.84/ 10	.44/ 12	.21/ 13	0.00/ **
	17	.26/ 8	.50/ 9	.69/ 8	.83/ 9	.90/ 9	.89/ 9	.87/ 9	.83/ 8	.67/ 10	.35/ 12	.17/ 13	0.00/ **
	19	.22/ 8	.42/ 9	.58/ 9	.69/ 9	.75/ 9	.74/ 9	.71/ 9	.67/ 8	.54/ 10	.29/ 12	.14/ 13	0.00/ **
	21	.19/ 8	.36/ 9	.49/ 9	.58/ 9	.63/ 9	.62/ 9	.59/ 9	.56/ 8	.45/ 10	.24/ 12	.12/ 13	0.00/ **
15	7	.09/ 5	.19/ 6	.32/ 6	.50/ 7	.77/ 8	1.20/ 8	1.96/ 8	2.97/ 10	1.46/ 14	.80/ 17	.34/ 20	0.00/ **
	9	.18/ 8	.38/ 8	.61/ 8	.89/ 8	1.21/ 8	1.53/ 9	1.89/ 9	2.23/ 10	1.19/ 14	.69/ 17	.31/ 20	0.00/ **
	11	.26/ 8	.53/ 9	.81/ 9	1.07/ 9	1.28/ 9	1.43/ 9	1.56/ 9	1.66/ 10	.92/ 14	.56/ 17	.26/ 20	0.00/ **
	13	.29/ 9	.56/ 9	.82/ 9	1.02/ 9	1.15/ 9	1.21/ 9	1.24/ 9	1.26/ 10	.75/ 14	.44/ 17	.21/ 20	0.00/ **
	15	.27/ 9	.52/ 9	.74/ 9	.89/ 9	.98/ 9	.99/ 9	.99/ 9	.98/ 10	.58/ 14	.36/ 17	.17/ 20	0.00/ **
	17	.24/ 9	.46/ 9	.64/ 9	.76/ 9	.82/ 9	.82/ 9	.80/ 9	.79/ 10	.47/ 14	.30/ 17	.14/ 20	0.00/ **
	19	.21/ 9	.40/ 9	.55/ 9	.69/ 9	.69/ 9	.68/ 9	.66/ 9	.64/ 10	.39/ 14	.25/ 17	.12/ 20	0.00/ **
	21	.18/ 9	.34/ 9	.47/ 9	.55/ 9	.58/ 9	.57/ 9	.55/ 9	.53/ 10	.33/ 14	.21/ 17	.10/ 20	0.00/ **

TABLE 13 - PREDICTED ROLL RMS/T_{OE} RESPONSES FOR THE 140' WTGB, DAY 4

LONGCRESTED SIGNIFICANT WAVE HEIGHT = 3.90 FEET												
ROLL ANGLE (DEG)												
ROOT MEAN SQUARE (RMS) / ENCOUNTERED MODAL PERIOD (TOE)												
V TO	HEAD 0	SHIP HEADING ANGLE IN DEGREES										FOLLOW 180
		15	30	45	60	75	90	105	120	135	150	165
0	7	1.31/ 8	2.43/ 8	3.45/ 8	4.15/ 8	4.57/ 8	4.72/ 8	4.67/ 8	4.22/ 8	3.53/ 8	2.55/ 8	1.34/ 8
	9	1.61/ 8	3.05/ 8	4.23/ 8	5.08/ 8	5.60/ 8	5.78/ 8	5.65/ 8	5.17/ 8	4.33/ 8	3.13/ 8	1.65/ 8
	11	1.37/ 8	2.61/ 8	3.62/ 8	4.36/ 8	4.80/ 8	4.96/ 8	4.84/ 8	4.43/ 8	3.70/ 8	2.67/ 8	1.41/ 8
	13	1.09/ 8	2.07/ 8	2.89/ 8	3.47/ 8	3.82/ 8	3.96/ 8	3.86/ 8	3.52/ 8	2.94/ 8	2.12/ 8	1.12/ 8
	15	.86/ 8	1.64/ 8	2.28/ 8	2.74/ 8	3.03/ 8	3.13/ 8	3.06/ 8	2.73/ 8	2.32/ 8	1.68/ 8	.89/ 8
	17	.69/ 8	1.31/ 8	1.82/ 8	2.20/ 8	2.43/ 8	2.51/ 8	2.45/ 8	2.23/ 8	1.86/ 8	1.34/ 8	.70/ 8
	19	.56/ 8	1.07/ 8	1.49/ 8	1.79/ 8	1.98/ 8	2.05/ 8	2.00/ 8	1.82/ 8	1.52/ 8	1.09/ 8	.57/ 8
5	7	.46/ 8	.88/ 8	1.23/ 8	1.49/ 8	1.64/ 8	1.70/ 8	1.65/ 8	1.51/ 8	1.26/ 8	.90/ 8	.47/ 8
	9	.37/ 8	.77/ 8	1.21/ 8	1.71/ 8	2.13/ 8	2.74/ 8	3.44/ 8	3.22/ 8	3.33/ 8	2.93/ 8	1.67/ 8
	11	.70/ 8	1.38/ 8	2.03/ 8	2.67/ 8	2.96/ 8	3.32/ 8	3.83/ 8	3.21/ 8	2.96/ 8	2.40/ 8	1.32/ 8
	13	.73/ 8	1.42/ 8	2.02/ 8	2.56/ 8	2.73/ 8	2.89/ 8	3.19/ 8	2.60/ 9	2.30/ 8	1.80/ 8	.98/ 8
	15	.64/ 8	1.22/ 8	1.72/ 8	2.15/ 8	2.25/ 8	2.33/ 8	2.52/ 8	2.03/ 9	1.76/ 8	1.36/ 8	.74/ 8
	17	.53/ 8	1.01/ 8	1.41/ 8	1.75/ 8	1.82/ 8	1.86/ 8	1.99/ 8	1.60/ 9	1.37/ 8	1.06/ 8	.57/ 8
	19	.44/ 8	.83/ 8	1.16/ 8	1.42/ 8	1.48/ 8	1.50/ 8	1.60/ 8	1.28/ 9	1.10/ 8	.84/ 8	.45/ 8
10	7	.36/ 8	.69/ 8	.95/ 8	1.17/ 8	1.22/ 8	1.23/ 8	1.31/ 8	1.05/ 9	.89/ 8	.68/ 8	.36/ 8
	9	.30/ 8	.57/ 8	.80/ 8	.98/ 8	1.01/ 8	1.03/ 8	1.08/ 8	.87/ 9	.74/ 8	.56/ 8	.30/ 8
	11	.18/ 7	.38/ 7	.63/ 7	.95/ 8	1.39/ 8	1.96/ 8	2.66/ 8	3.74/ 8	3.56/ 10	1.62/ 12	.71/ 13
	13	.38/ 8	.77/ 8	1.20/ 8	1.64/ 8	2.08/ 8	2.43/ 8	2.73/ 9	3.05/ 8	2.62/ 10	1.27/ 12	.58/ 13
	15	.48/ 8	.95/ 8	1.39/ 8	1.77/ 8	2.05/ 8	2.20/ 8	2.27/ 9	2.32/ 8	1.92/ 10	.97/ 12	.45/ 13
	17	.47/ 8	.90/ 9	1.29/ 8	1.58/ 9	1.77/ 8	1.81/ 8	1.81/ 9	1.78/ 8	1.45/ 10	.75/ 12	.35/ 13
	19	.41/ 8	.75/ 9	1.11/ 8	1.33/ 9	1.46/ 8	1.47/ 9	1.44/ 9	1.39/ 8	1.13/ 10	.59/ 12	.28/ 13
15	7	.35/ 8	.67/ 9	.93/ 8	1.11/ 9	1.21/ 9	1.20/ 9	1.17/ 9	1.11/ 8	.90/ 10	.43/ 12	.23/ 13
	9	.30/ 8	.57/ 9	.78/ 9	.93/ 9	1.00/ 9	.99/ 9	.96/ 9	.91/ 8	.73/ 10	.39/ 12	.19/ 13
	11	.25/ 8	.48/ 9	.66/ 9	.78/ 9	.84/ 9	.83/ 9	.80/ 9	.75/ 8	.61/ 10	.33/ 12	.16/ 13
	13	.12/ 5	.25/ 6	.43/ 6	.67/ 7	1.03/ 8	1.61/ 8	2.63/ 8	3.99/ 10	1.97/ 14	1.07/ 17	.46/ 20
	15	.24/ 8	.51/ 8	.82/ 8	1.20/ 8	1.62/ 8	2.06/ 9	2.55/ 9	3.00/ 10	1.59/ 14	.93/ 17	.42/ 20
	17	.36/ 8	.72/ 9	1.09/ 9	1.43/ 9	1.72/ 9	1.92/ 9	2.09/ 9	2.23/ 10	1.24/ 14	.75/ 17	.35/ 20
	19	.33/ 9	.76/ 9	1.10/ 9	1.37/ 9	1.55/ 9	1.62/ 9	1.67/ 9	1.69/ 10	.97/ 14	.60/ 17	.28/ 20
21	7	.36/ 9	.70/ 9	.99/ 9	1.20/ 9	1.32/ 9	1.33/ 9	1.33/ 9	1.32/ 10	.78/ 14	.48/ 17	.23/ 20
	9	.32/ 9	.62/ 9	.86/ 9	1.03/ 9	1.10/ 9	1.10/ 9	1.08/ 9	1.06/ 10	.63/ 14	.43/ 17	.19/ 20
	11	.28/ 9	.53/ 9	.74/ 9	.87/ 9	.93/ 9	.91/ 9	.89/ 9	.86/ 10	.52/ 14	.33/ 17	.16/ 20
	13	.24/ 9	.46/ 9	.63/ 9	.74/ 9	.78/ 9	.77/ 9	.74/ 9	.72/ 10	.44/ 14	.28/ 17	.14/ 20
	15	.12/ 5	.25/ 6	.43/ 6	.67/ 7	1.03/ 8	1.61/ 8	2.63/ 8	3.99/ 10	1.97/ 14	1.07/ 17	.46/ 20
	17	.24/ 8	.51/ 8	.82/ 8	1.20/ 8	1.62/ 8	2.06/ 9	2.55/ 9	3.00/ 10	1.59/ 14	.93/ 17	.42/ 20
	19	.36/ 8	.72/ 9	1.09/ 9	1.43/ 9	1.72/ 9	1.92/ 9	2.09/ 9	2.23/ 10	1.24/ 14	.75/ 17	.35/ 20

TABLE 14 - CUMULATIVE MEDICAL FACTORS AND SEASICKNESS SUSCEPTIBILITY
OF CREW MEMBERS DURING MOBILE BAY SEA TRIAL

PERCENT OF CREW SUSCEPTIBLE TO SEASICKNESS						
LEVEL OF SUSCEPTIBILITY	OCTAGON					
	1	2	3	4	6	7
VERY	15	22	28	17	18	18
MODERATELY	30	22	17	33	24	24
SLIGHTLY	45	50	50	44	53	53
NOT AT ALL	10	6	5	6	5	5
PERCENT OF CREW WHO USUALLY TAKE MEDICATION FOR SEASICKNESS - 12% (2 of 17)						
PERCENT OF CREW WHO SUFFER FROM DIZZINESS, LACK OF BALANCE, OR NAUSEA - 12% (2 of 17)						
PERCENT OF CREW WHO SUFFERED FROM COLDS, HAY FEVER, ETC. - 41% (7 of 17)						

TABLE 15 - TABULATION OF COMMANDING OFFICER'S COMMENTS MADE ON PERFORMANCE ASSESSMENT QUESTIONNAIRE

OCTAGON/LEG	DECK WETNESS	SLAMMING	DIFFICULTY STEERING	VIBRATION	CREW PERFORMANCE PROBLEMS	COMFORTABLE RIDE	OBSERVED SHIP'S ROLL (BY INCLINOMETER)	EQUIPMENT PROBLEMS	WOULD YOU MAINTAIN COURSE, SPEED?*	FREEZING LIMITATION
1/1 2 3 4 5 6 7 8	YES YES NO NO YES YES		YES		YES YES	NO YES YES YES NO NO				
2/1 2 3 4 5 6 7 8	YES YES YES YES NO YES YES YES	YES NO	NO YES YES YES YES NO	YES LESS	NO NO YES	YES	AVE 3-4 AVE 5-6 AVE 15-20 AVE 5 AVE 3-4 AVE 15 AVE 20-25	YES	NO NO YES NO NO	YES YES YES YES
3/1 2 3 4 5 6 7 8	YES YES YES NO NO SOME YES YES	YES YES	NO YES NO NO NO YES NO	LESS	YES YES YES NO YES YES YES	NO YES YES YES	AVE 5 AVE 20-25 AVE 25-28 AVE 5-6 AVE 15-20 AVE 24-29		YES YES NO	YES
4/1 2 3 4 5 6 7 8	YES SOME YES		NO		MINOR NO NO NO	YES YES YES YES YES	AVE 5-8 AVE 2-3			
6/1 2 3 4 5 6 7 8	YES YES NO YES YES		NO NO			YES YES YES YES	AVE 12-14 MAX 12 MAX 10		NO	
7/1 2 3 4 5 6 7 8	YES YES YES		NO	YES YES	YES YES	YES				

*NOTE: YES = SHIP LIMITS NOT REACHED
NO = APPROACHING SHIP LIMITS

APPENDIX A
THE MOBILE BAY SEA TRIAL PERFORMANCE ASSESSMENT QUESTIONNAIRE

The Performance Assessment Questionnaire is a measurement tool intended to record motion induced ship/crew performance degradations, as noted by the crew at the time that their effects are encountered. As a ship performance tool this questionnaire complements the time correlated ship motions measurements. Of necessity, the questionnaire is relatively short since the physical and mental condition of the individual filling out the form may be expected to be substantially degraded at various times.

It is considered central to the use of the questionnaire to record motion-induced crew and ship system performance impairments at the time that they occur, and not to depend on anyone's memory of just when, what, and how the impairments occurred. Similarly, it is assumed that the motion-induced impairments are perceived differently by the commanding officer on the bridge than the department heads and the individual crew members.

Thus, unlike most other types of seakeeping questionnaires, the current one asks all of the ship's crew as to their status when the actual ship motions/sea conditions are encountered. Not only is the ship's captain queried as to the perceived effects of the ship motion conditions at the "present time," on ship performance, but also, the various department heads are queried as to the ship motion effects on the task performance of their department at the time the motion conditions are encountered. Furthermore, all members of the crew are queried as to the encountered motion effects. This is unlike more rigorous ship motion/crew task experiments carried out by the USCG and USN^{2,6} in that the current questionnaire is opinion-based and involves less cost and effort. Clearly, this crew opinion-based information is the perceived performance as noted by the individuals. As a result, these opinion-based answers do not strictly relate back to "measured" task performance levels, and are less accurate than those obtained during the trials of References 2 and 6. Nevertheless, these are the actual tasks that are necessarily performed by the crew, and although the measurement controls are less, the scope of the tasks is substantially broadened and more realistic. Deficiencies

become easily recognized at the time of their occurrence and their importance noted.

The questionnaire is intended to reveal the correlation between task, shipboard location, motion sickness, ship motions, and motion-related ship degradations, such as wetness, slamming, etc. Correlations are obtained while the ship is undergoing a series of successive trial runs, at constant speed, with 45 degree to port course changes every one-half hour. The octagon pattern sea trial exposes the ship and crew to all possible motion conditions at the given speed attainable in the prevailing sea conditions. The 30-minute time duration of each leg of the trial pattern is sufficiently long such that the direct effects of the motions on the seasickness status of the crew are independent from the effects of each preceding leg.

To achieve the correlations desired, the questionnaire (see the back of this Appendix) was divided into four sections. Each section of the questionnaire addressed a specific area of human factors, and solicited information within the scope of that area. Section one, the first page of the questionnaire, requested background information and personal history from the individual. Such information provides a datum to which following performance degradation characteristics are related.

The second section of the questionnaire is composed of eight two-page subsections. Each two-page subsection is concerned with the motion induced ship/crew performance degradations for a particular leg of the octagon. The section is designed such that personal performance degradation, job function, cause and severity of degradation are assessed in a successive manner, followed by evaluations of the shipboard location of the job function. Thus, task and location are tied to the motion related degradation of both the ship and the individual.

Section three is intended to correlate the cumulative assessment of a department's crew with the assessment of their performance by their department supervisor. He is also to assess those job functions degraded, and the long range forecast of performance under conditions present during that leg of the octagon.

Section four, the commanding officer's assessment, is also to be completed following each leg of an octagon. Its intent is to determine

the reason for variance from the test speed or heading. In a second generation questionnaire the scope of this section is broadened to include operational limits not reached, including both ship speed and heading, and to solicit from the individual with primary responsibility the effects of longer term operations under present conditions. It provides insight into the justification of operational limits at various headings and seaways. Finally, there is provided an area for comments by the commanding officer in which he is free to voice his opinions on any aspect of the ship, crew, or operation performance.

As previously mentioned, a second generation questionnaire was developed as a result of the full-scale trial. In the second questionnaire (Appendix D), minor changes in wording and format were made to improve clarity and brevity, two areas of vital concern in such a questionnaire. Generally, the second questionnaire is expected to aid the crew member in more fully understanding the nature and meaning of the questionnaire, thereby producing more accurate and thorough results.

PERFORMANCE ASSESSMENT QUESTIONNAIRE

Name or Number:

Rank:

Length of Service:

Average Time Spent at Sea per Year (%):

Last Time at Sea: Date-

Type of Ship-

- 1) From your past experience, how susceptible do you honestly feel you are to seasickness?

☐ very susceptible ☐ moderately ☐ Slightly ☐ not susceptible

- 2) Do you usually take medication for seasickness?

☐ yes ☐ no

- 3) Are you currently suffering from an ear infection?

☐ yes ☐ no

- 4) Do you suffer from dizziness, lack of balance, or nausea?

☐ yes ☐ no

- 5) Are you currently suffering from a cold, hay fever, or other ailment?

☐ yes ☐ no

If yes, what? _____

- 6) Are you currently taking any medication?

☐ yes ☐ no

If yes, what? _____

PERFORMANCE ASSESSMENT QUESTIONNAIRE
SECTION TWO

Name or Number:
Rank:

7) Did you experience a loss in your ability to perform your duties?

☐
yes

☐
no

8) What were your duties?

Breifly describe: _____

9) If you did experience performance degradation, was it due to:

☐ your mental and/or physical condition

☐ equipment malfunction

☐ other: _____

10) If you experienced some sort of mental and/or physical impairment, was it due to:

☐ seasickness alone

☐ seasickness and excessive ship motions

☐ excessive ship motions alone

☐ ship-motion-related injury

(a) To what degree were you impaired?

☐ incapacitated ☐ significant ☐ moderate ☐ slight

(b) How would you rate your level of concentration?

☐ poor ☐ fair ☐ good

11) What area of the ship were you in? _____

(a) Was this area totally enclosed? (i.e., without a view of the sea or horizon)

☐
yes

☐
no

(b) How would you rate this area's

temperature? ☐ too hot ☐ comfortable ☐ too cold

PERFORMANCE ASSESSMENT QUESTIONNAIRE
SECTION TWO, PAGE TWO

ventilation?	☐ poor	☐ fair	☐ good
noise?	☐ loud	☐ moderate	☐ quiet
fuel odor?	☐ yes	☐ no	

PERFORMANCE ASSESSMENT QUESTIONNAIRE
SECTION THREE

DEPARTMENT HEADS ONLY

- 12) Was there a noticeable impairment in the performance of your department's crew?

☐
yes

☐
no

- 13) Was the major cause of impairment

- ☐ seasickness?
☐ ship motions?
☐ equipment failure?
☐ other? _____

- 14) Assess your department's performance:

- (a) there was a _____% degradation in performance having to do primarily with

- ☐ the speed at which duties were accomplished.
☐ the quality and accuracy with which duties were performed.

- (b) there were _____ (#of crew) too sick to function, and _____ (# of crew) sick but continued to function.

- 15) What functions of your department, if any, were affected by crew performance degradation?

- (a) _____
(b) _____
(c) _____
(d) _____

- 16) In your opinion, what would be your long-range forecast on the performance of your department, if this course and speed were to be maintained for a longer period of time?

PERFORMANCE ASSESSMENT QUESTIONNAIRE
SECTION FOUR

COMMANDING OFFICER ONLY

17) What were the reasons that ship speed was limited at this heading?

(a) _____

(b) _____

(c) _____

(d) _____

18) What was the most important factor?

☐

(a)

☐

(b)

☐

(c)

☐

(d)

APPENDIX B
FULL-SCALE TRIAL PROCEEDINGS

The full-scale evaluation of the USCGC MOBILE BAY took place from 7 September 1979 to 13 September 1979. During this period seven octagons and nine wave height runs were conducted. The wave spectra for each of the wave height runs is shown in Figure 2. Draft marks on the MOBILE BAY were read at the beginning and end of each day of trials. Except for the first day of trials, two octagons were performed per trial day. Only one octagon was performed the first trial day as a result of time delays, equipment malfunctions, and lengthy transit time to the trial site. The following is an account of the daily operations and factors involved in the seakeeping trials.

Octagon one was preceded by a 30-minute wave measurement period in which the seaway displayed a 3-1/2 foot (1.1 meter) significant wave height and a single predominant wave swell direction. The first leg of octagon one, a head seas course, was characterized by a large degree of deck wetness, as the foredeck remained awash. Each leg of each octagon was terminated with a course change of 45 degrees to port and instructions to the crew to complete the proper pages of their questionnaire. The commanding officer and trial personnel recorded the following observations regarding the first octagon. Deck wetness and vertical accelerations remained considerable through the starboard bow seas heading. During the starboard beam seas run the predominant ship motions changed from vertical accelerations to roll. The increase in roll at this heading was evidenced by the need to "hang on." As the octagon continued through the starboard quarter, following, and port quarter headings, the motions became much less severe and the sociability and performance of the crew improved. Deck wetness was either minimal or nonexistent at these headings. Port beam seas produced occasional deck wetness and roll motion less severe than did starboard beam seas. Vertical acceleration and deck wetness increased during the port bow sea heading, and appeared to be more severe than comparable starboard bow ship responses. With the completion of octagon one, the questionnaires were collected and another wave measurement run initiated to assess the change in sea state, if any. This second

wave run indicated no significant change in the seaway. In an effort to decrease transit time, the MOBILE BAY returned to berthing in Little Creek, Virginia, at the end of the first day of trials.

A 24-hour period for refueling, maintenance and rest occurred before the next set of octagons. Although only one octagon was completed the first day of trials, it provided a valuable learning experience in deployment and recovery of the wave buoy and in the operation of the octagon, as well as other operational aspects inherent with these trial procedures. It also indicated that completion of all sections of the questionnaire had not occurred. Closer supervision after each leg of an octagon was necessary to acquire the essential data; most especially from crew who were suffering from impairment due to seasickness.

Weather reports obtained from Norfolk Airport indicated 15 to 20 mph northeast winds with 3 to 6-foot seas for the second day of the trial. Sea conditions during transit supported this, and observations made during the wave height run reported a significant wave height of 6 feet (1.8 meters). Whitecaps and a single wave swell direction were predominant. Unfortunately, some towing of the wave buoy occurred because of the inability to maintain station adequately in these seas. Following distribution of the Performance Assessment Questionnaires, the MOBILE BAY advanced into head seas at 14.7 knots to begin octagon two. Extreme deck wetness and spray characterized this heading. Spray over the bridge and aft to the exhaust stacks was common. Occasional slamming and large vertical accelerations also occurred and had a deleterious effect on the crew as a whole. Deck wetness, slamming, and spray over the bridge remained apparent through the starboard bow seas heading. The commanding officer remarked that he would not operate the ship in this manner if it were not a test. Starboard beam seas brought on heavy rolls and, although slamming ceased, there was still water coming over the starboard bow and spray on the bridge windows. For the first time during this octagon the commanding officer felt that the vessel could be operated successfully with little damage at this heading and speed. A much smoother ride occurred during the starboard quarter seas run and the crew performance improved markedly. Steering was more difficult at this heading and more vibration was present also. Reduced roll of 5 degrees

average was present during the entire leg. The following seas run produced little change, although roll decreased and steering improved. The steering became more difficult and rolls increased significantly when the ship was brought into a port quartering sea. Roll was much larger than during the starboard quartering sea and the vibration noticeably greater. A minimal amount of deck wetness occurred. Generally, the quartering and following sea headings produced little or no deck wetness, and an improved ride over other headings. Port beam seas produced much the same situation as starboard beam seas; heavy rolls and deck wetness on the forecastle. The final leg of octagon two, port bow seas, appeared to overtax the power plant of the MOBILE BAY. Motor room temperature increased to 150°F. Motions were severe enough to break several cans of fire retardant foam. Often solid green water over the bow was evident. Several inches of water were reported in the forward lockers. Crew performance was poor because of the high vertical accelerations. Questionnaires from octagon two were collected and those for octagon three distributed during the wave height run. During this run, station keeping was much improved and minimal towing of the buoy occurred. Wave data acquired indicated a 6-1/2 foot (2 meter) significant wave height. A 10-knot speed was selected for octagon three and a course into head seas was laid. At this heading the foredeck remained awash 50 percent of the time and spray reached the bridge windows every seventh or eighth wave. At the reduced speed of 10 knots there was a minimal amount of slamming and much less vibration. However, the motions had detrimental effects on the crew. The course change to starboard bow seas brought on heavy rolling and little decrease in vertical motions. The foredeck remained awash 50 percent of the time and steering difficulty increased slightly. Comments by the commanding officer indicated that the vessel would be able to carry out its assigned duties at this heading and speed, but the crew would tire easily and quickly. Starboard beam seas had no large increase in roll and the ride appeared more comfortable without the severe vertical motions. Operations at this heading caused an increased effort to maintain balance. The foredeck remained partially awash. Starboard quarter and following seas produced a much smoother ride with slight roll. Deck wetness was nonexistent and steering became slightly more

difficult. The ship operated easily at these headings with the crew performance dramatically improved. Roll increased greatly in port quartering seas. Although the forecastle was not awash, there was slight spray. Steerage difficult increased and crew fatigue became apparent. Rolls increased again when the course was changed to port beam seas. There was a greater incidence of spray and the foredeck was partially awash. Watchstanders had difficulty in performing their duties because of the continuous need to "hang on." For the port bow seas course, deck wetness increased and some pounding was experienced. Once again the effect of the motions at this heading was detrimental to crew performance. At this time the MOBILE BAY set course for its berthing at Coast Guard Base Portsmouth. The commanding officer felt the second day of trials had reached the operational limits of the ship.

The third day of the trials included octagons four and five. Because of the low incidence of seasickness and impairment in octagon four, questionnaires were not completed for octagon five. The wave data obtained for octagon four measured a 3-foot (6.9 meter) significant wave height. The seaway was characterized by wind driven waves and swell competing at 45 to 90 degrees of one another. A speed of 14.2 knots and a head seas course into the wind driven waves was set.* With the swell off the starboard bow, roll was noticeable in the head seas run. Occasional spray and deck wetness from water over the starboard bow occurred. As the course changes proceeded through starboard bow and starboard beam seas, roll increased and deck wetness decreased. Crew performance remained good at these headings. Quartering and following seas brought about a decrease in roll and a continued smooth ride. No effect on steerage was noticeable throughout these headings. The wind gradually decreased through these headings and the competing swell became predominant thereafter. Port beam seas caused increased roll and slight wetness. However, as the ship came to a port bow heading, roll decreased slightly and occasional deck wetness returned.

*The reduced speed from the previous high speed of 14.7 knots was selected because of engine problems. A speed of 14.2 knots is considered, in normal operation, as maximum speed whereas 14.7 knots is equivalent to the RPM of maximum icebreaking capability.

The next wave height run showed a slight decrease in the significant wave height and the swell remained predominant over the decreased wind waves. Octagon five was performed at a ship speed of 5 knots. Head and bow seas produced more roll than usual for these headings. The competing wind and waves may have caused this. There was no deck wetness at these headings. Roll increased slightly in the starboard beam seas. The ride remained much the same during the quartering and following seas headings. Roll diminished slightly and there was no deck wetness. Port beam and bow seas produced increased roll, but no deck wetness, and the ride remained smooth. The MOBILE BAY returned to Coast Guard Base, Portsmouth for a 24-hour period of refueling, maintenance, and rest before the final day of trials.

The final day of trials saw two swell patterns competing at 45 degrees to one another. The wave height was measured at nearly 4 feet for octagon six. A medium speed of 10 knots was chosen for this octagon, with the hope that the seas would build for a top speed octagon next. The head sea was chosen to be the swell pattern most closely aligned to the wind direction. The ship appeared to be sluggish during the head sea run. Water over the bow was more often in the form of spray than "wash." The pitching motion appeared slower than previous octagons and a slight roll, induced by the competing swell, was present. The characteristic change in predominant ship motions was seen in octagon six when roll increased and deck wetness decreased as the ship moved into beam seas. Quartering and following seas had no adverse effect on the crew or ship and no occurrence of wetness. Once again, the wetness and motions increased when the port bow sea heading was set for the last leg of the octagon.

The wave height run for octagon seven was conducted during dusk at the end of the day. A single swell pattern was noted to have a 3-1/2 foot (1.1 meter) significant wave height. The test speed for octagon seven was 14.2 knots. Head seas caused a noticeable increase in water on the foredeck and pitch motion. Bridge windows were covered by spray almost continually. Vibration remained a problem at high speed. The foredeck remained awash and spray on the bridge windows continued through the starboard bow sea heading. By the time the starboard beam seas were

encountered, daylight had disappeared. Roll noticeably increased in beam seas and steerage was good. After dark, observations of deck wetness and other external characteristics were limited. Quartering and following seas had improved motions and slight wetness was observed. The continued existence of a secondary swell pattern was evidenced in the ship motions; however, poor visibility could not confirm this. As usual, beam seas produced more roll and slight wetness. The port bow sea heading caused a large amount of spray and combined with the darkness, visibility was nearly zero. Vibrations remained strong and became a concern as being potentially detrimental to crew performance. A final wave height run was performed to assess any sea state changes that may have occurred during the night octagon. It showed that the seas had increased to a 4-foot (1.2 meter) significant wave height and the presence of a slight secondary swell was detected.

All equipment was removed from the MOBILE BAY on the day after the last trial, and a final set of draft marks were read.

A particularly effective method of presenting RMS ship motion data for specific seaways is the speed polar plot. A graphical representation of RMS motion contours, the speed polar gives a visual display over all headings and speeds.

Table C-1 lists the motions, locations, sea conditions, and page numbers for the 140-ft WTGB speed polars, and Table C-2 provides the same information for the 95-ft WPB. It is purposely intended that WTGB and WPB speed polars for identical seaways and motions appear on opposite pages so that visual comparisons can be made. Also, note that each speed polar plot indicates the seaway, motion, and point location. For example:

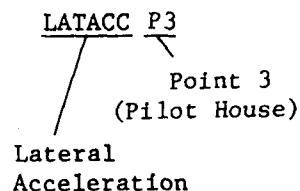


TABLE C-1 - LISTING OF PARAMETERS AND PAGE NUMBERS OF
THE SPEED POLAR PLOTS FOR THE 140-FT WTGB

Motion	Location*	Seaway**	Page Number
Roll (degrees)	Origin	1	66
Roll (degrees)	Origin	2	68
Roll (degrees)	Origin	3	70
Roll (degrees)	Origin	4	72
Lateral Acceleration (g)	Pilot House (P3)	1	74
Lateral Acceleration (g)	Pilot House (P3)	2	76
Lateral Acceleration (g)	Pilot House (P3)	3	78
Lateral Acceleration (g)	Pilot House (P3)	4	80
Vertical Acceleration (g)	Pilot House (P3)	1	82
Vertical Acceleration (g)	Pilot House (P3)	2	84
Vertical Acceleration (g)	Pilot House (P3)	3	86
Vertical Acceleration (g)	Pilot House (P3)	4	88

* See Table 1 for point location coordinates.

** Seaways are numbered by day; see Table 2 for definitions.

TABLE C-2 - LISTING OF PARAMETERS AND PAGE NUMBERS OF
THE SPEED POLAR PLOTS FOR THE 95-FT WPB

Motion	Location*	Seaway**	Page Number
Roll (degrees)	Origin	1	67
Roll (degrees)	Origin	2	69
Roll (degrees)	Origin	3	71
Roll (degrees)	Origin	4	73
Lateral Acceleration (g)	Pilot House (P3)	1	75
Lateral Acceleration (g)	Pilot House (P3)	2	77
Lateral Acceleration (g)	Pilot House (P3)	3	79
Lateral Acceleration (g)	Pilot House (P3)	4	81
Vertical Acceleration (g)	Pilot House (P3)	1	83
Vertical Acceleration (g)	Pilot House (P3)	2	85
Vertical Acceleration (g)	Pilot House (P3)	3	87
Vertical Acceleration (g)	Pilot House (P3)	4	89

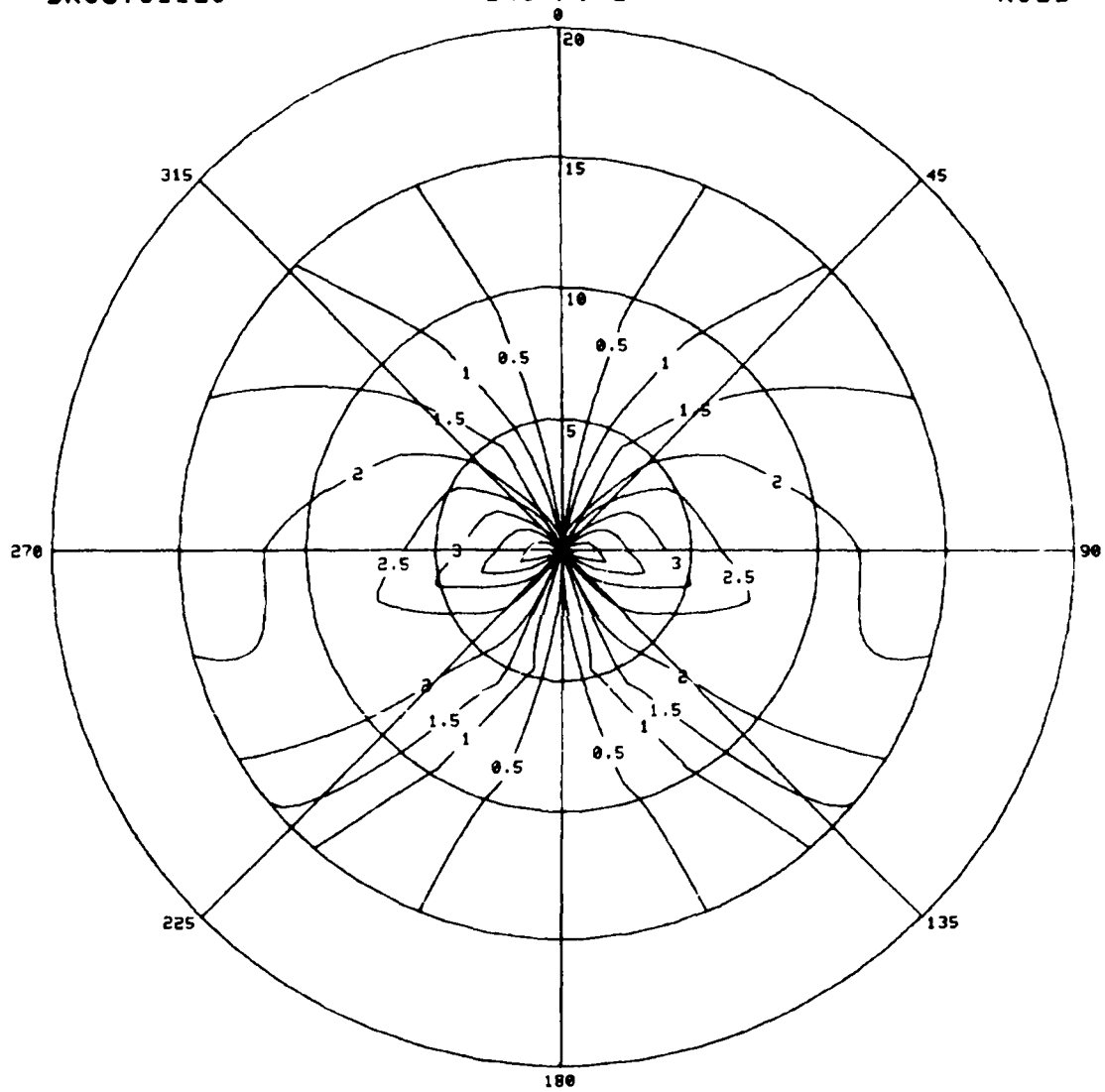
* See Table 1 for point location coordinates.

** Seaways are numbered by day; see Table 2 for definitions.

BR037011LC

140-FT U

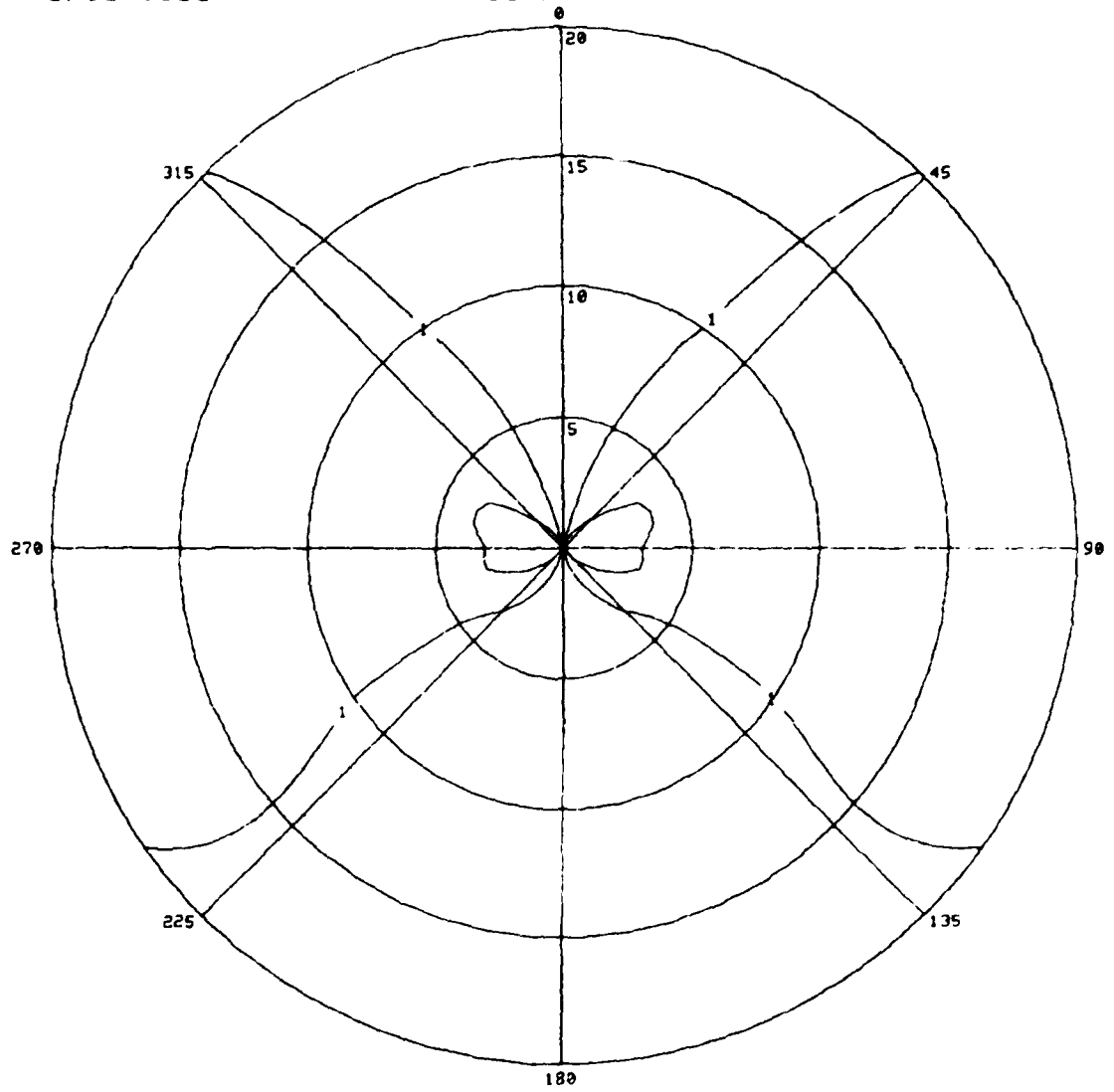
ROLL



BR037011LC

95-FT WP

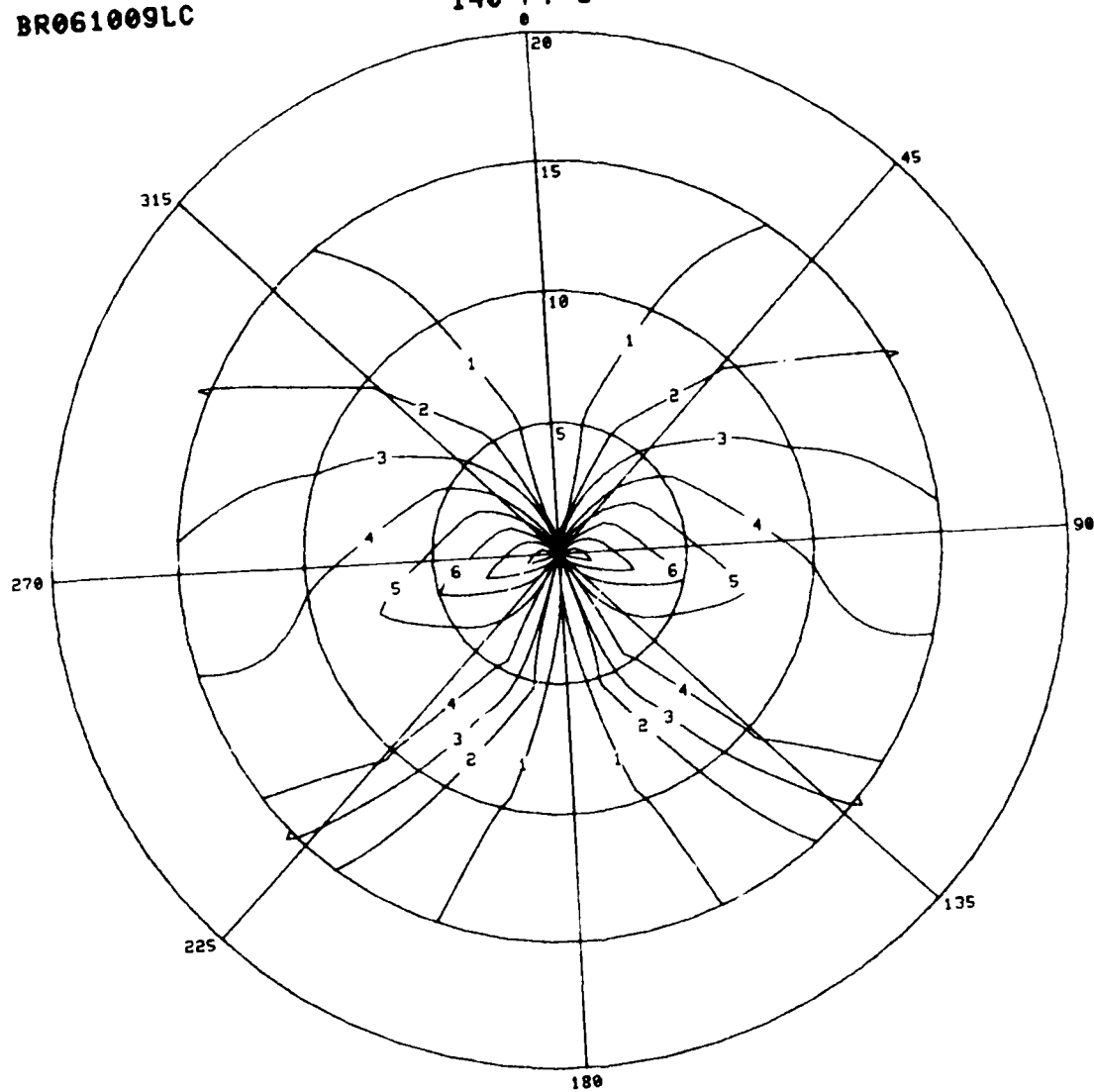
ROLL



BR061009LC

140-FT W

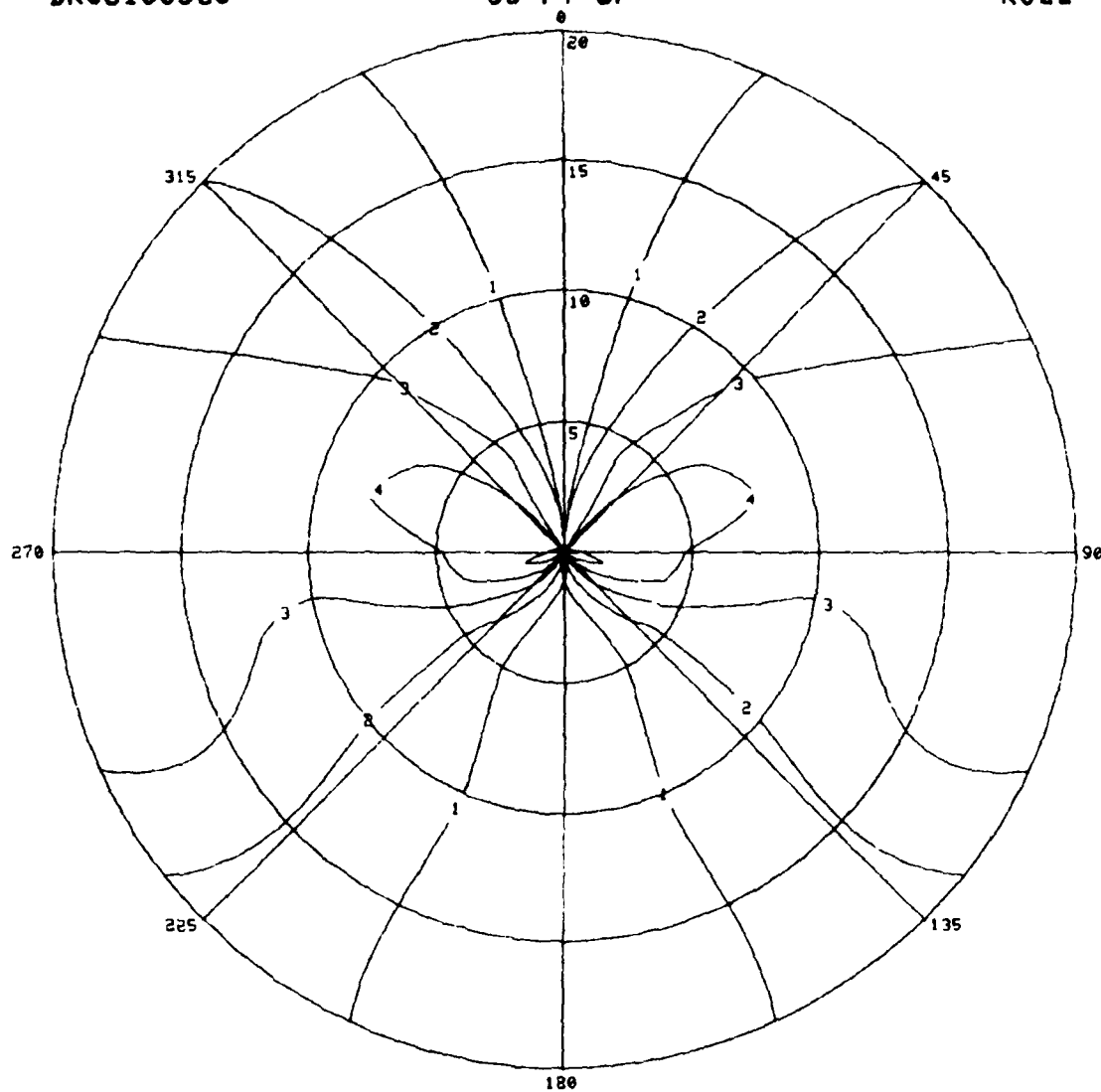
ROLL



BR061009LC

95-FT UP

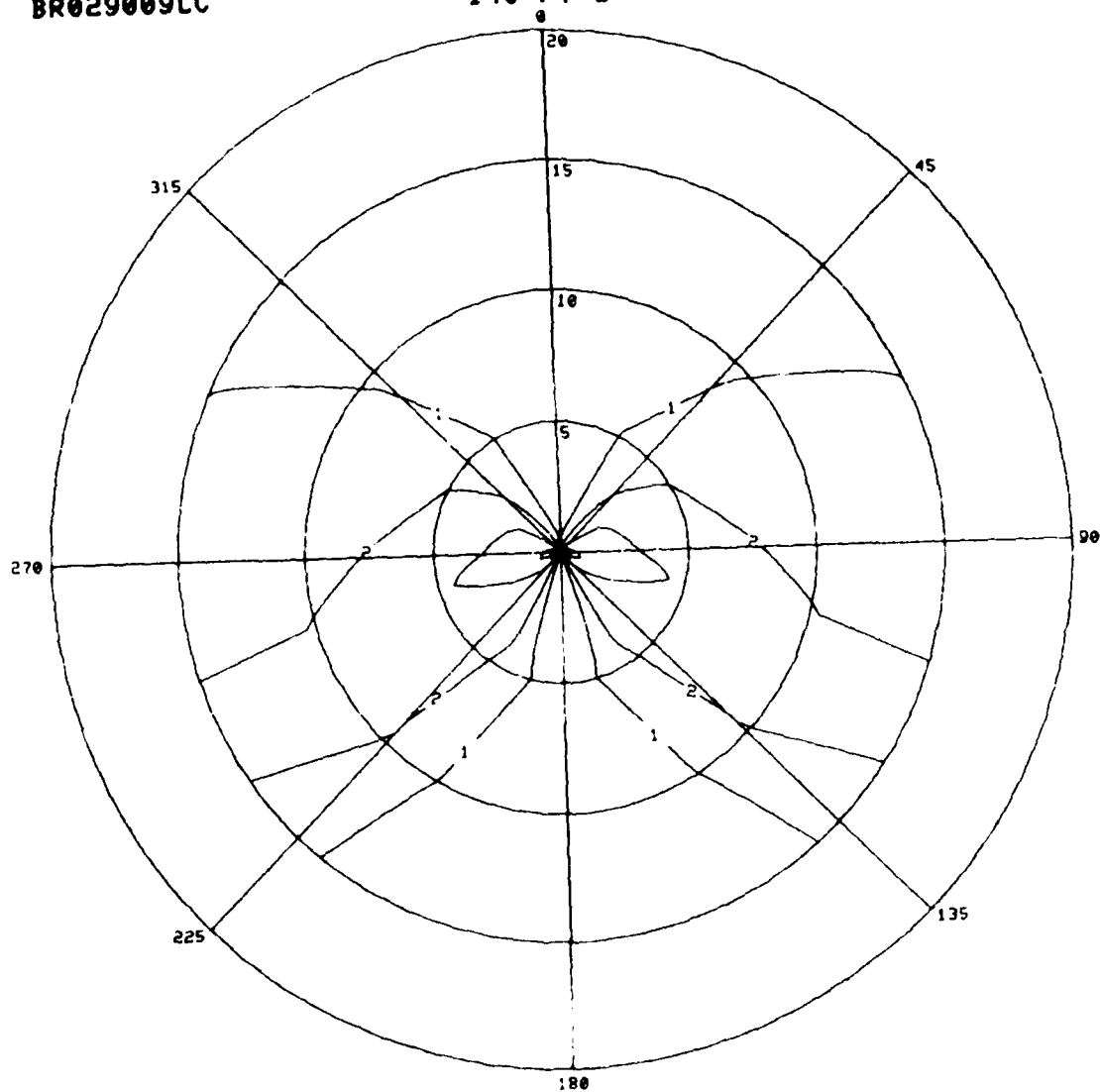
ROLL



BR029009LC

140-FT W

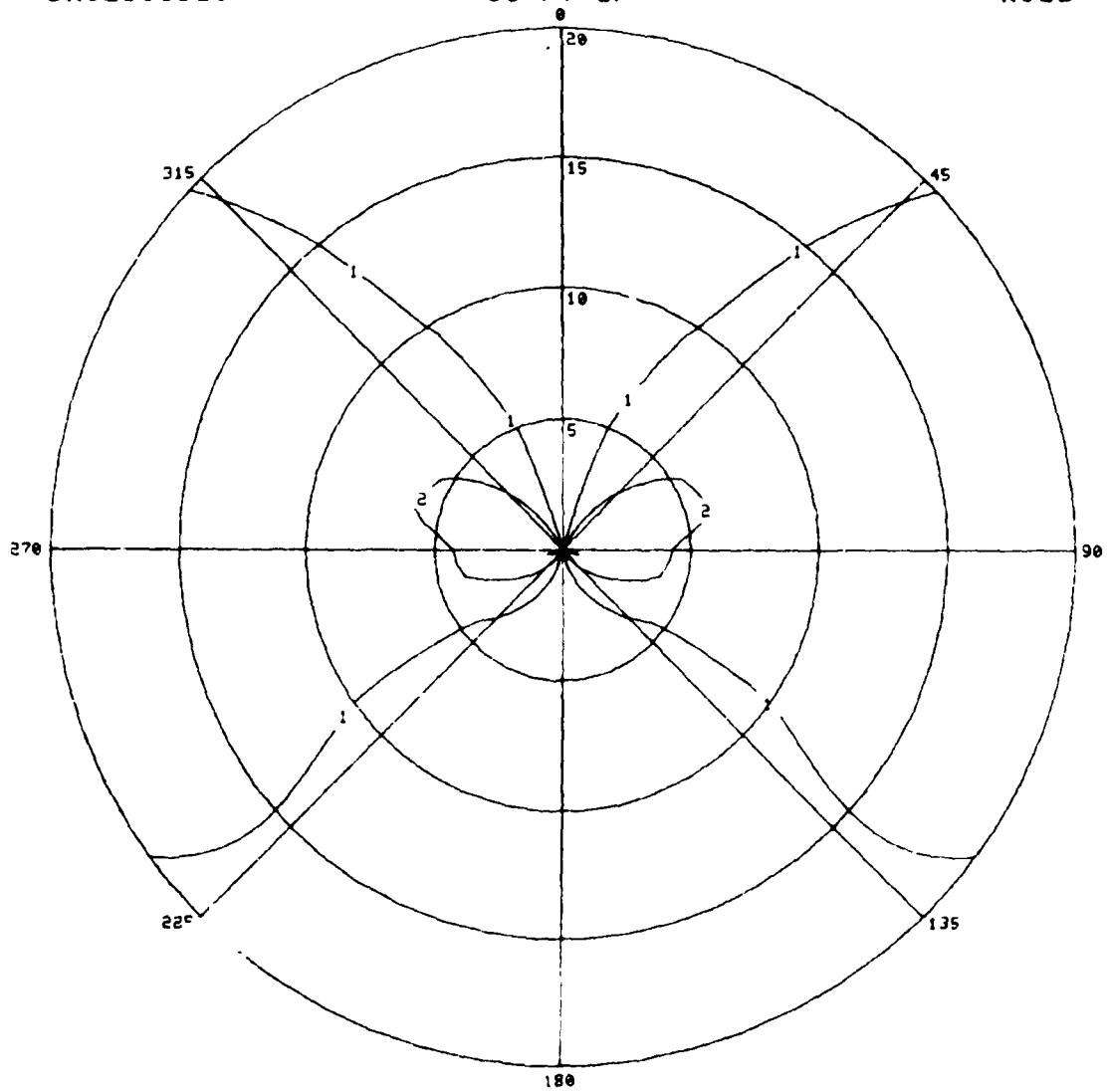
ROLL



BR029009LC

95-FT UP

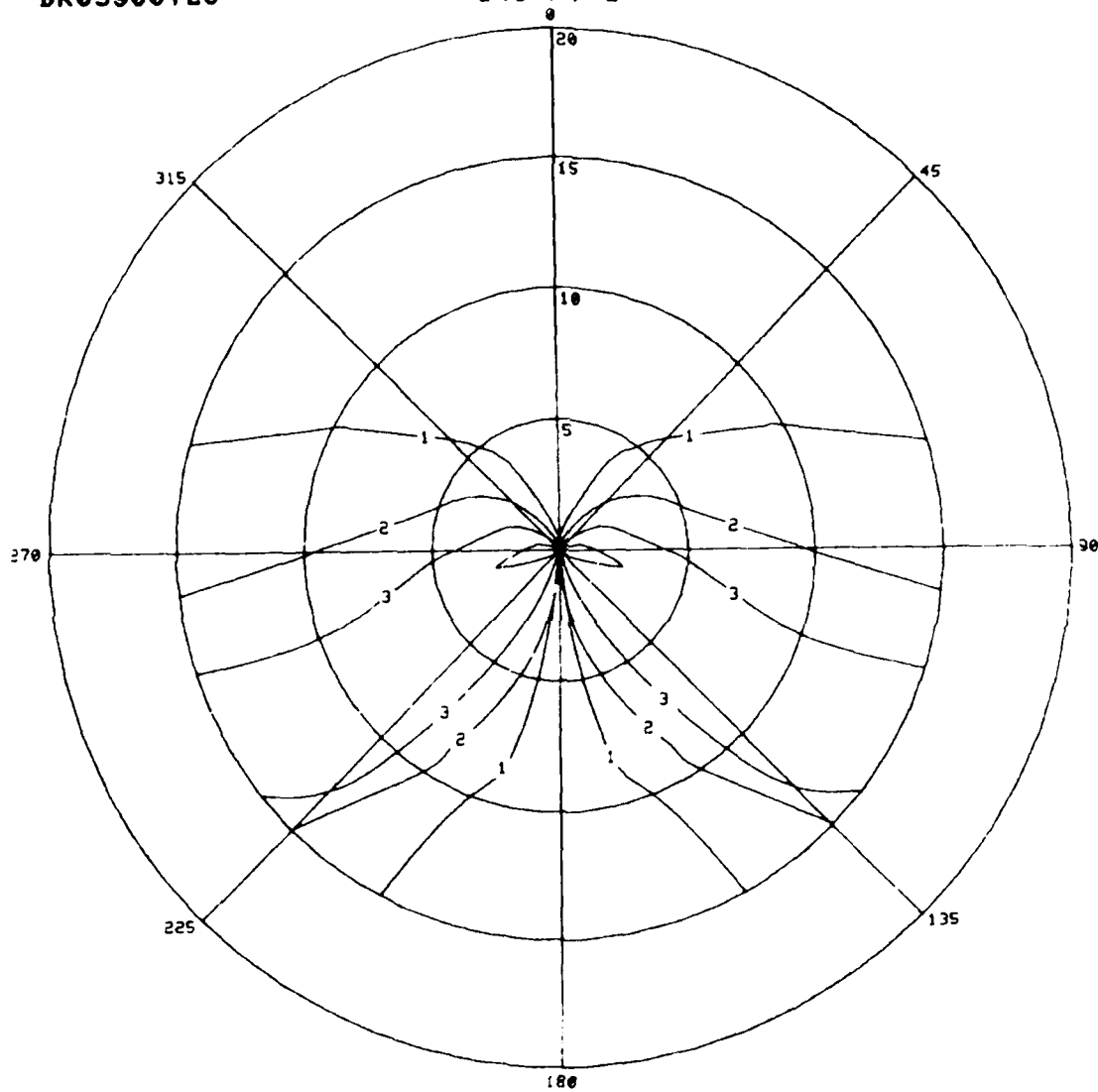
ROLL



BR039007LC

140-FT W

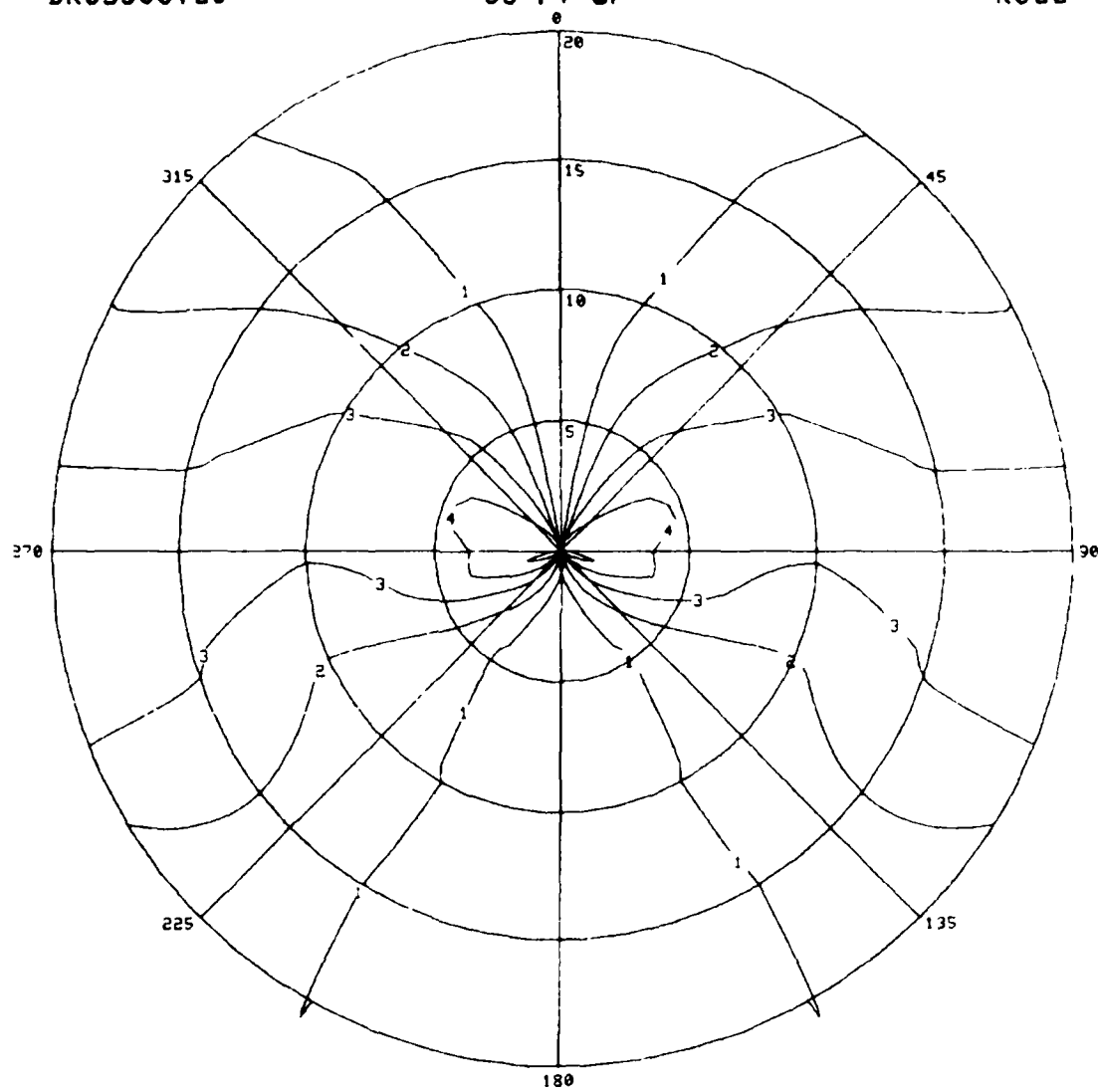
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BR039007LC

95-FT UP

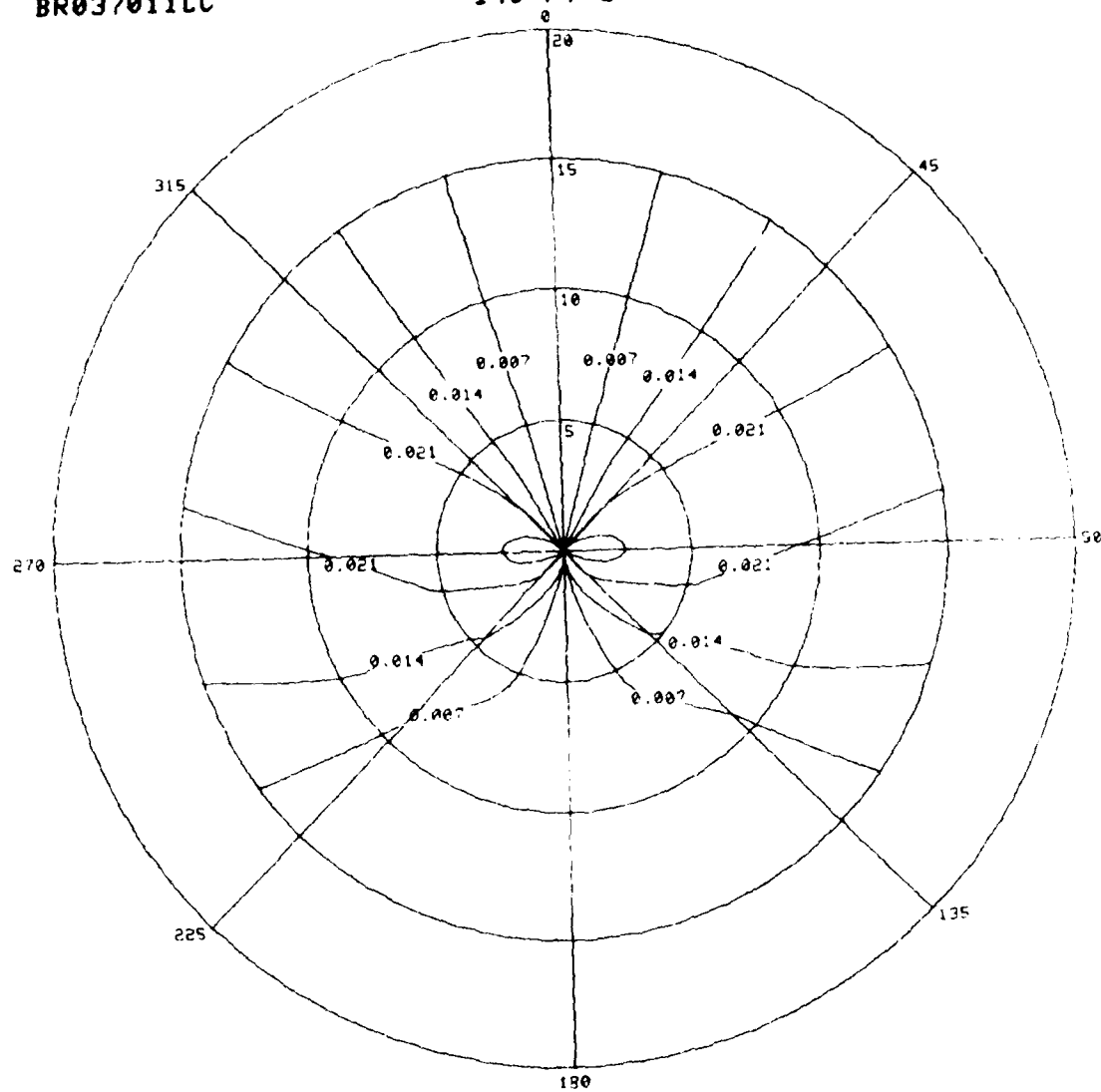
ROLL



BR037011LC

140-FT W

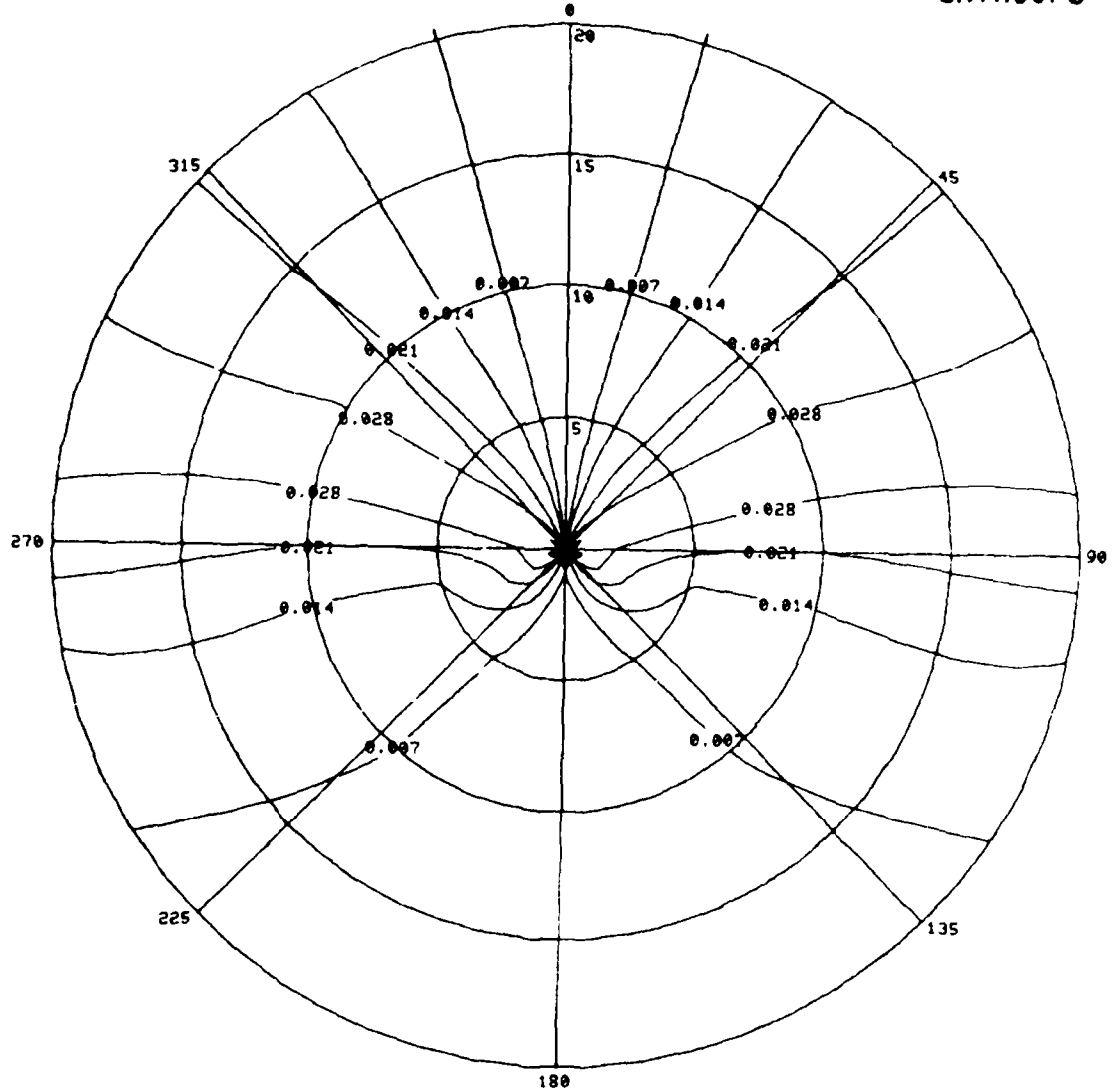
LATACCP3



BR037011LC

95-FT UP

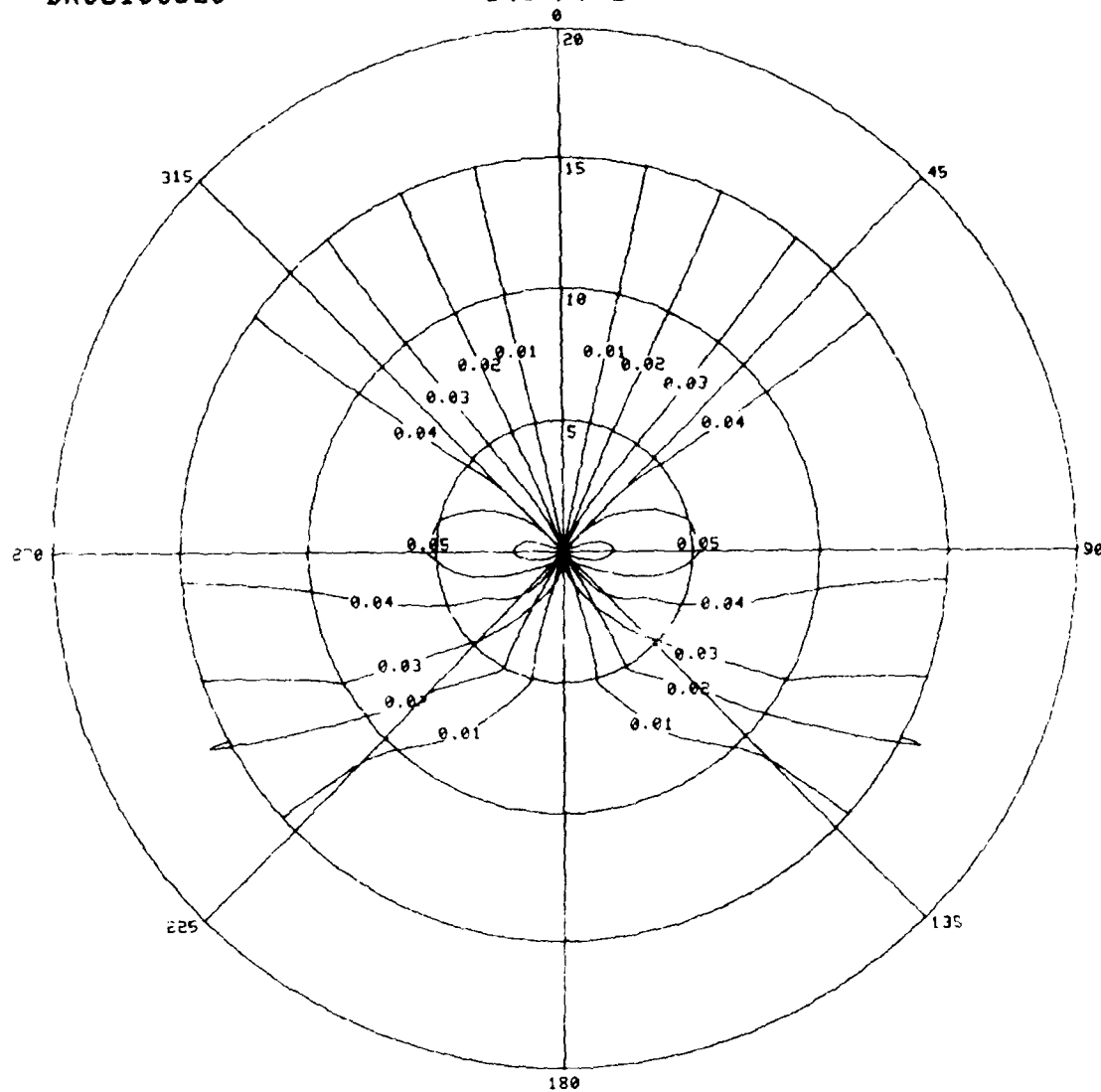
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BR061009LC

140-FT W

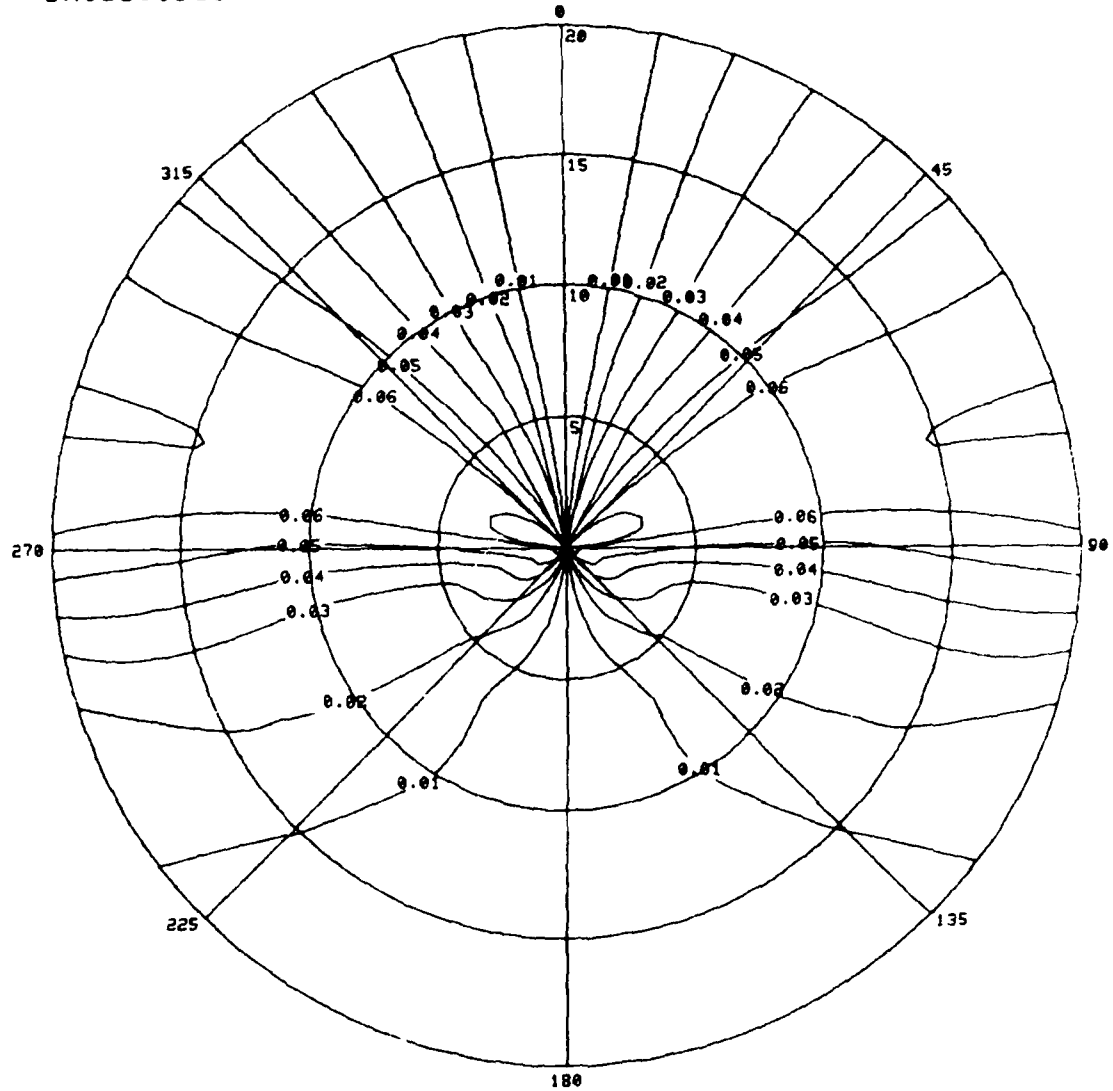
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95-FT UP

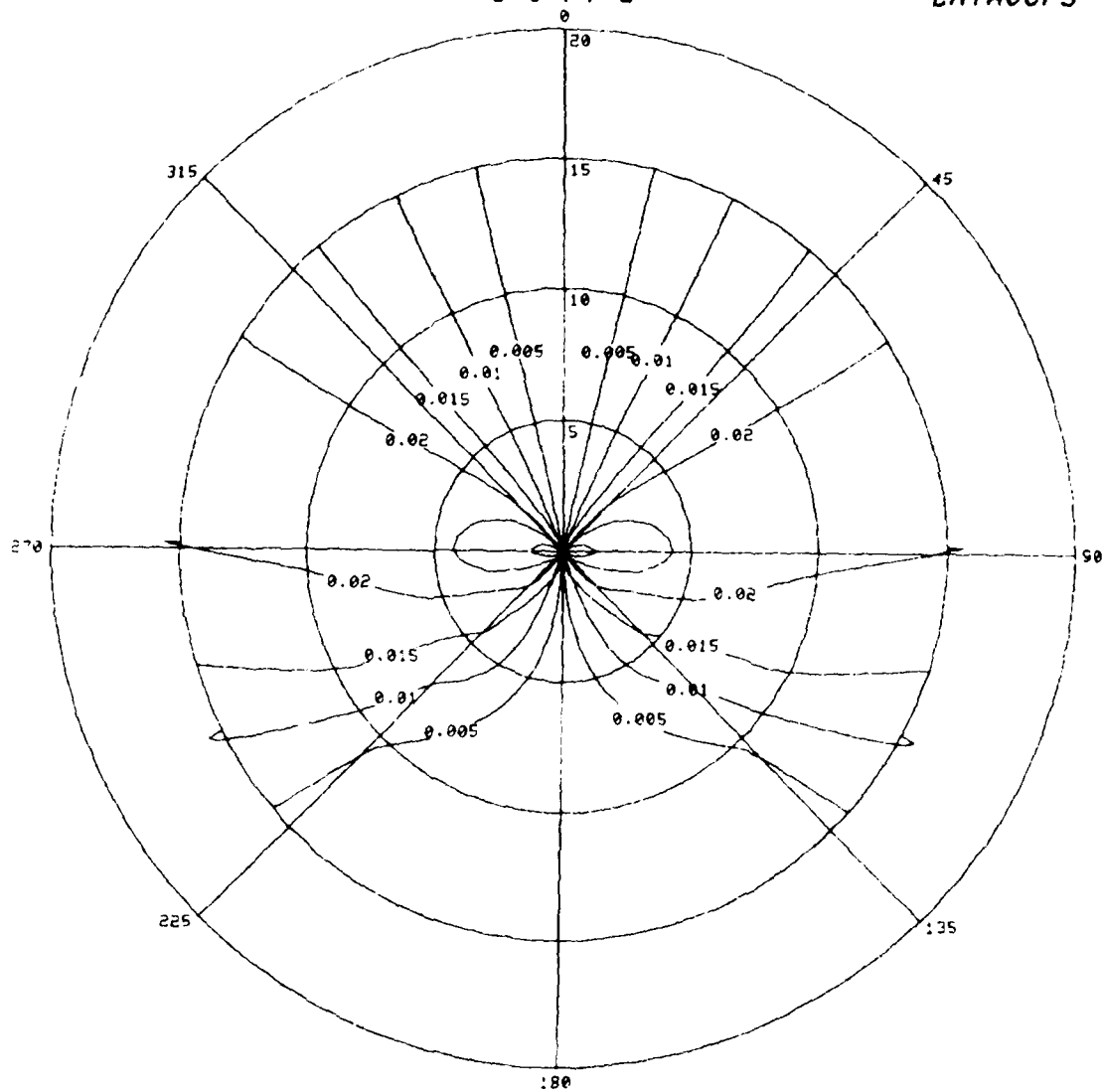
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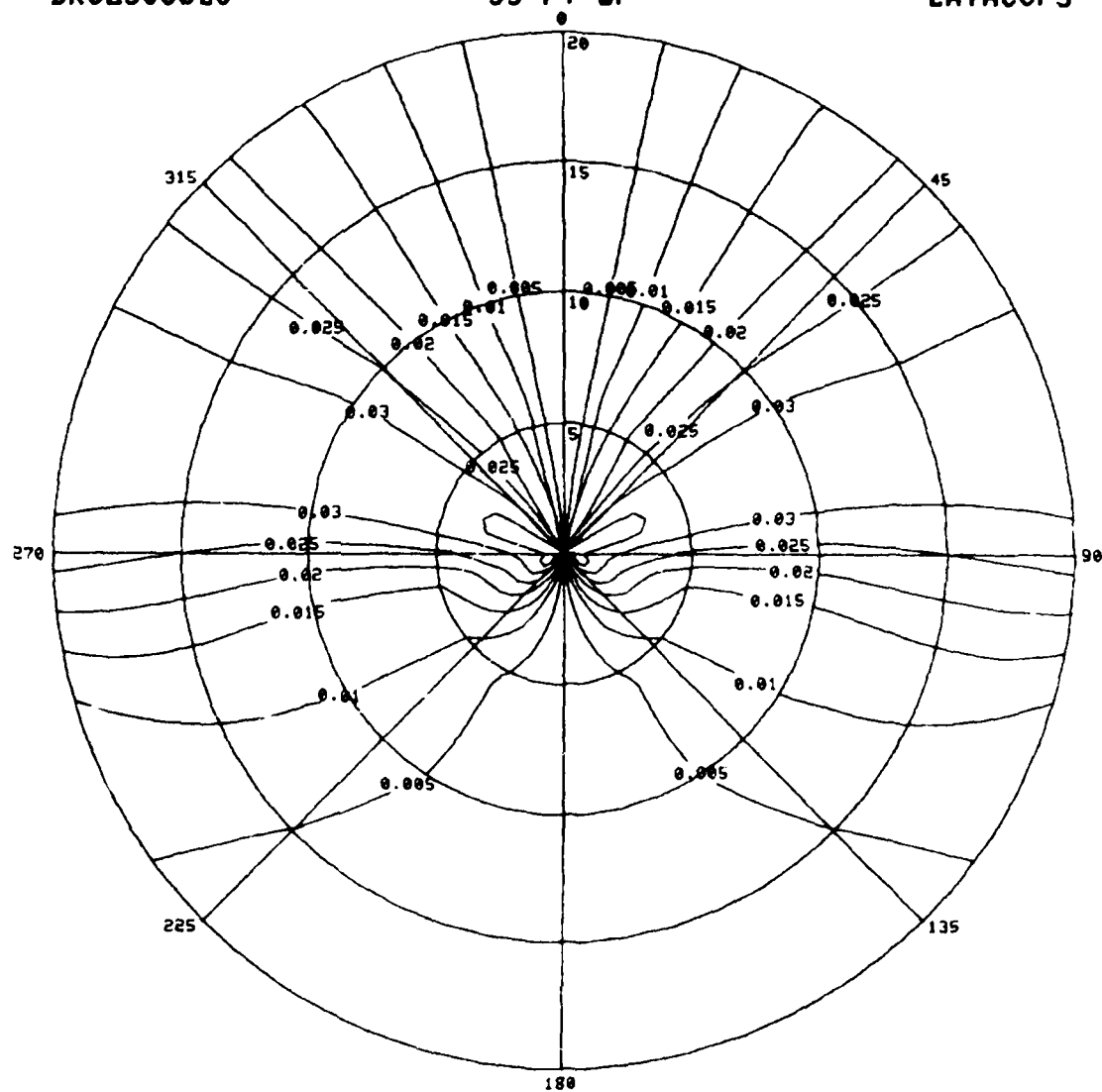
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95-FT WP

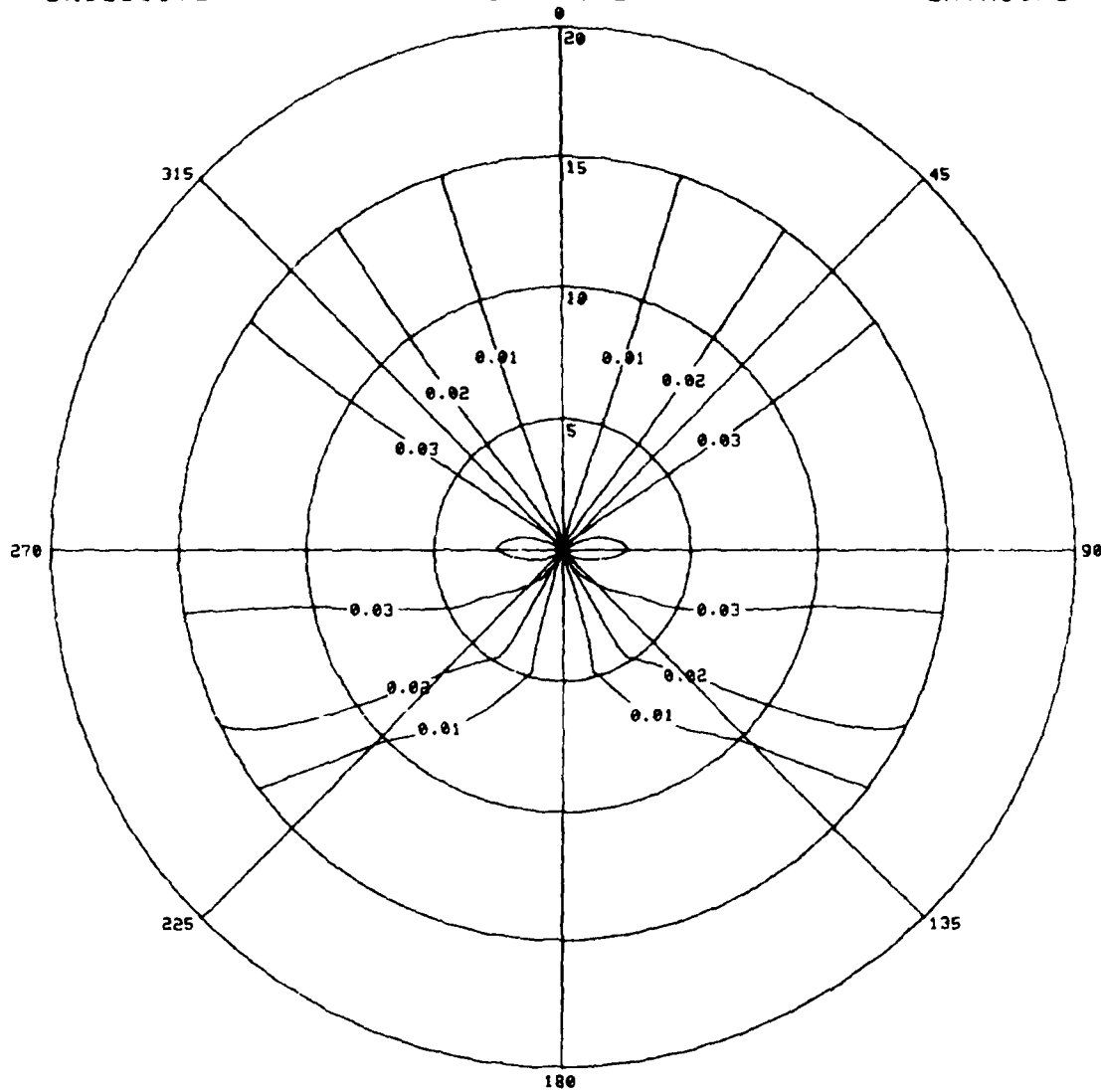
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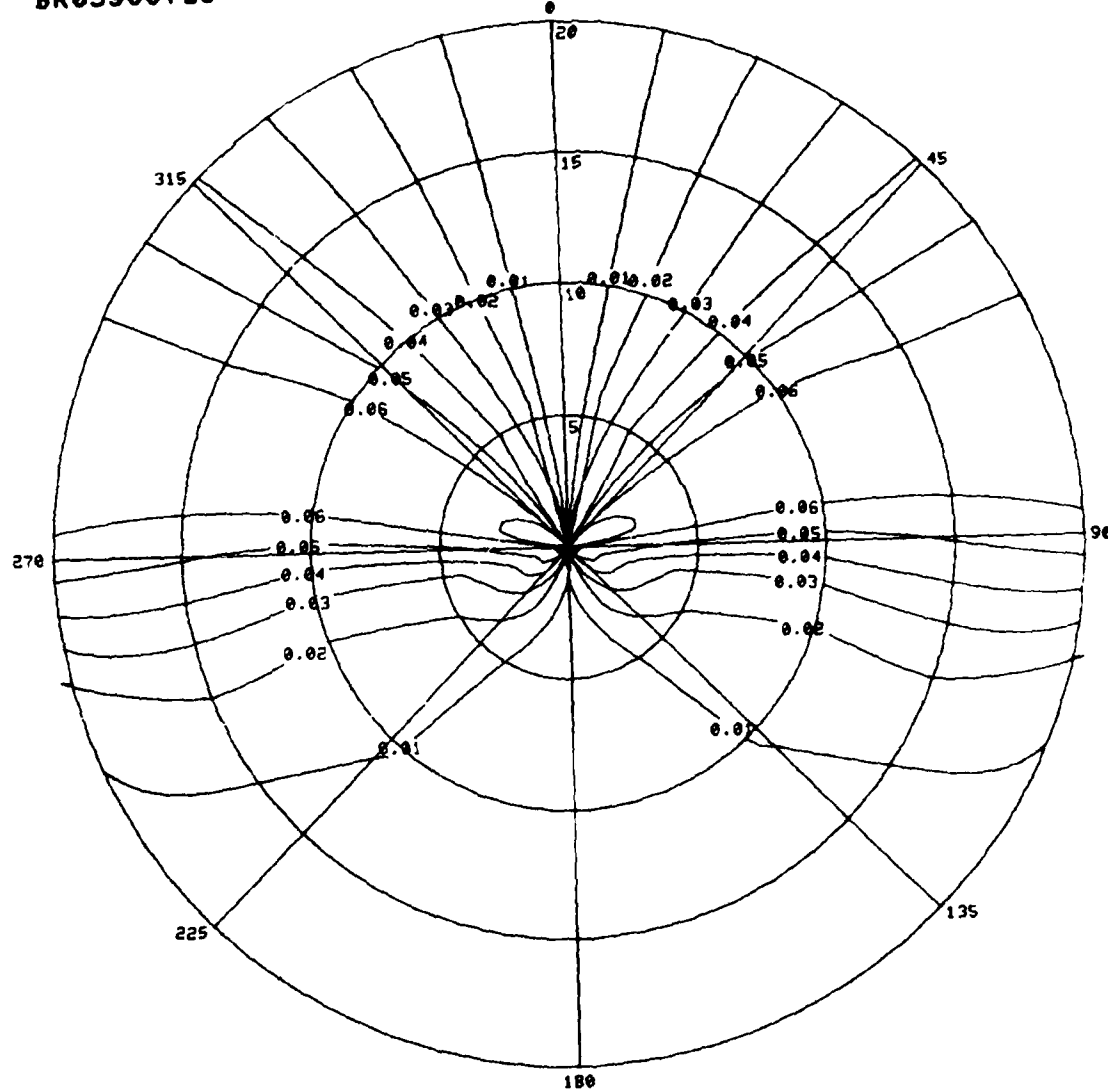
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95-FT WP

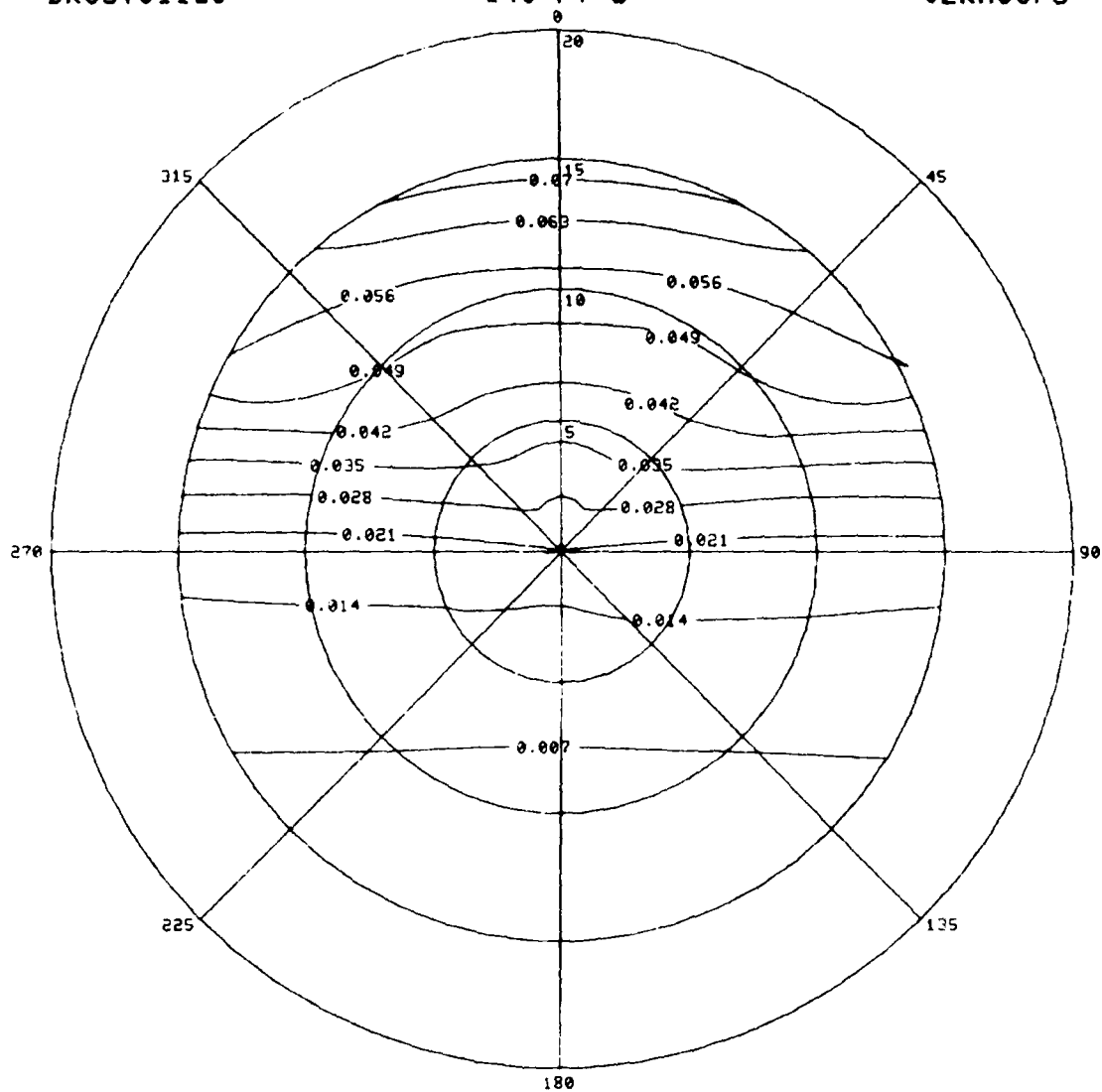
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140-FT W

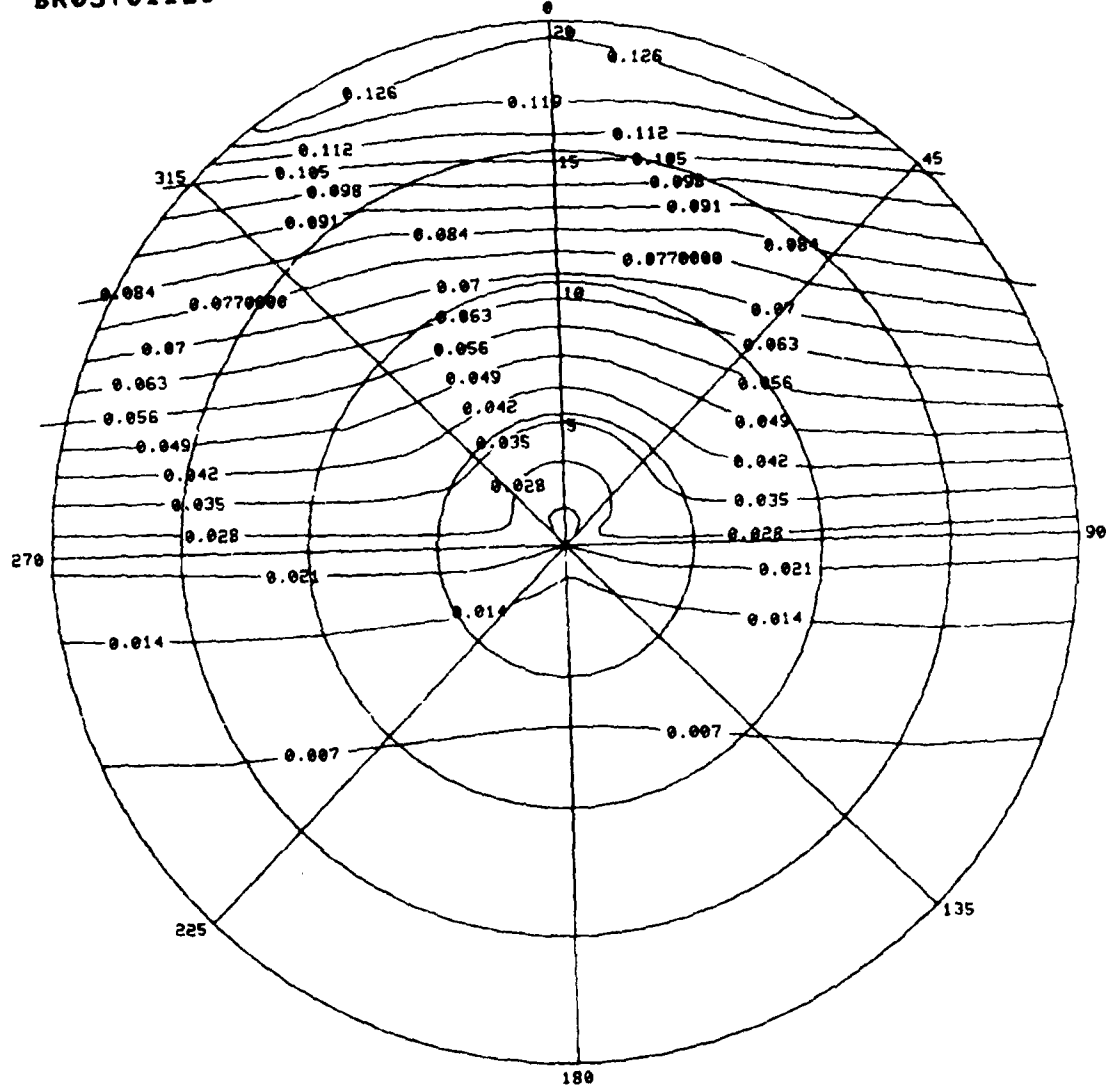
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95-FT UP

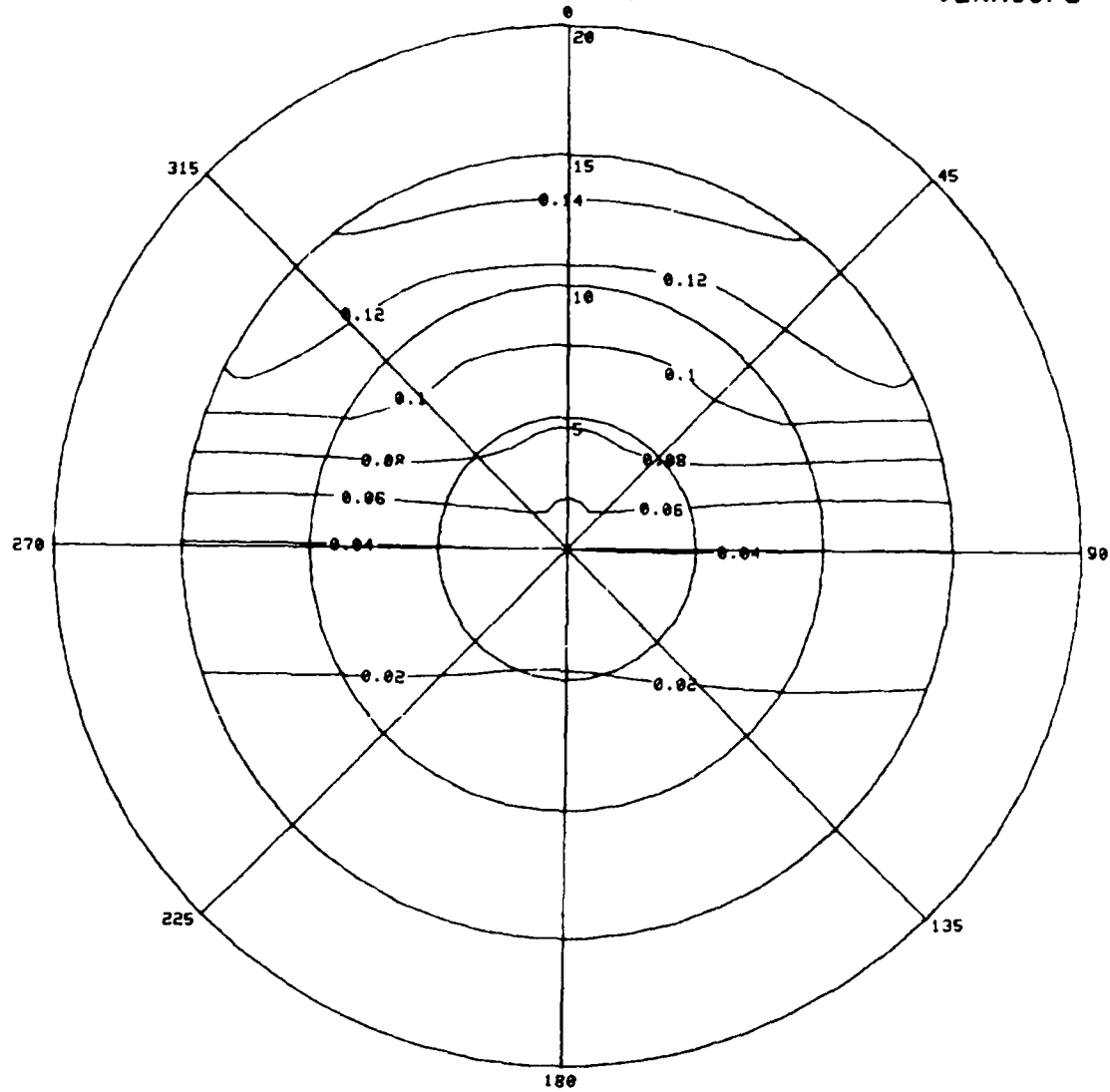
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140-FT W

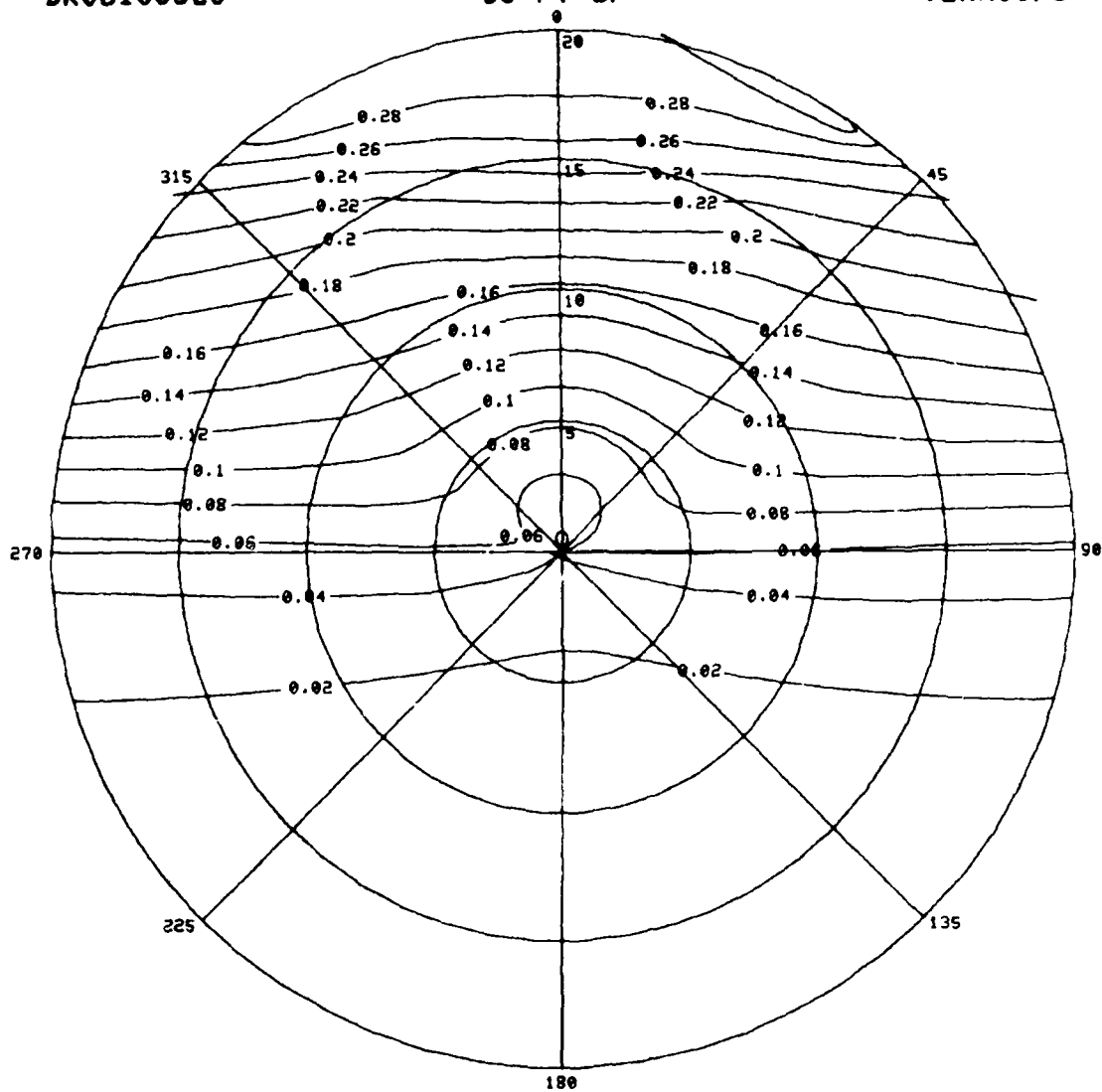
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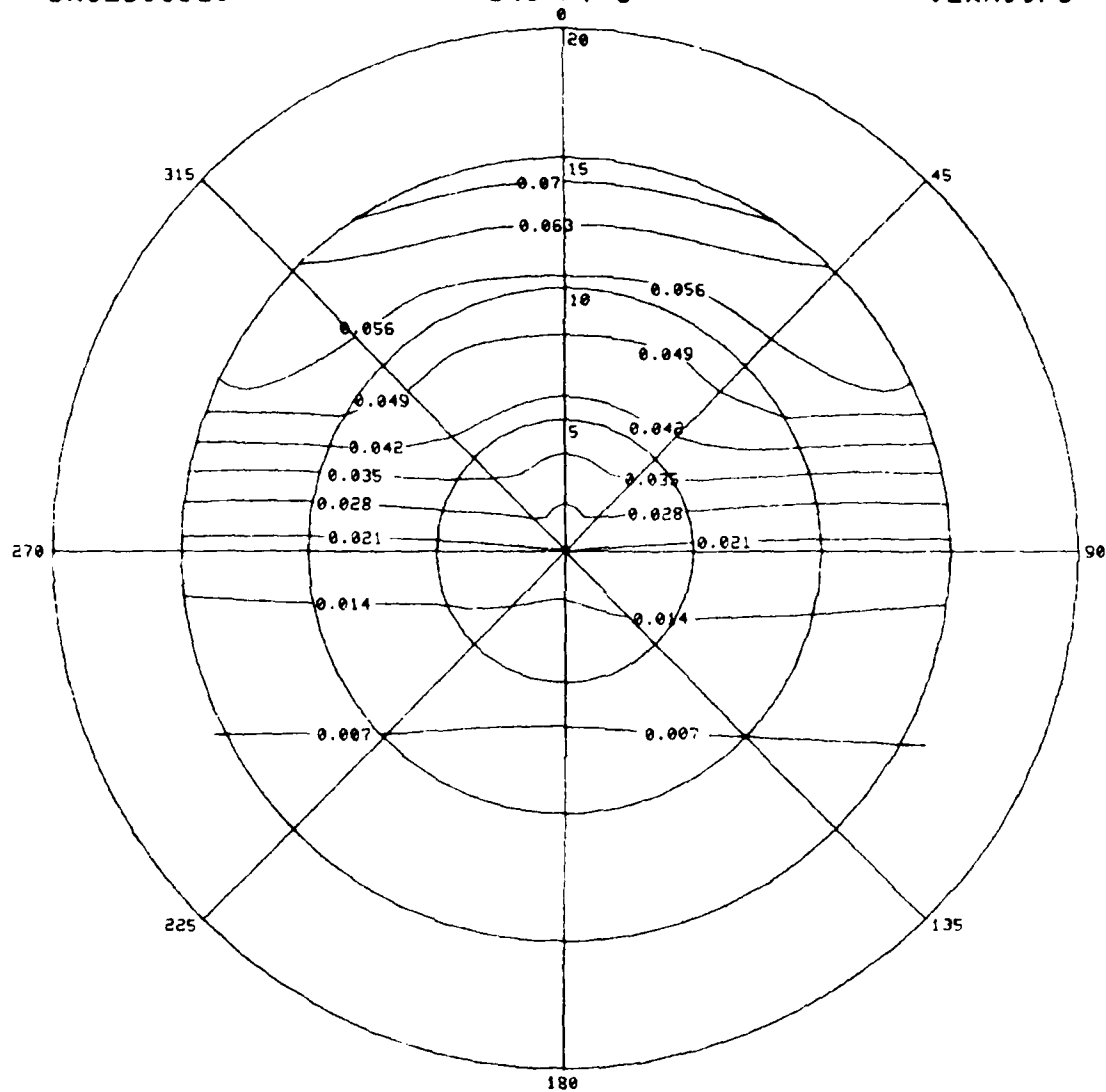
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BR029009LC

140-FT U

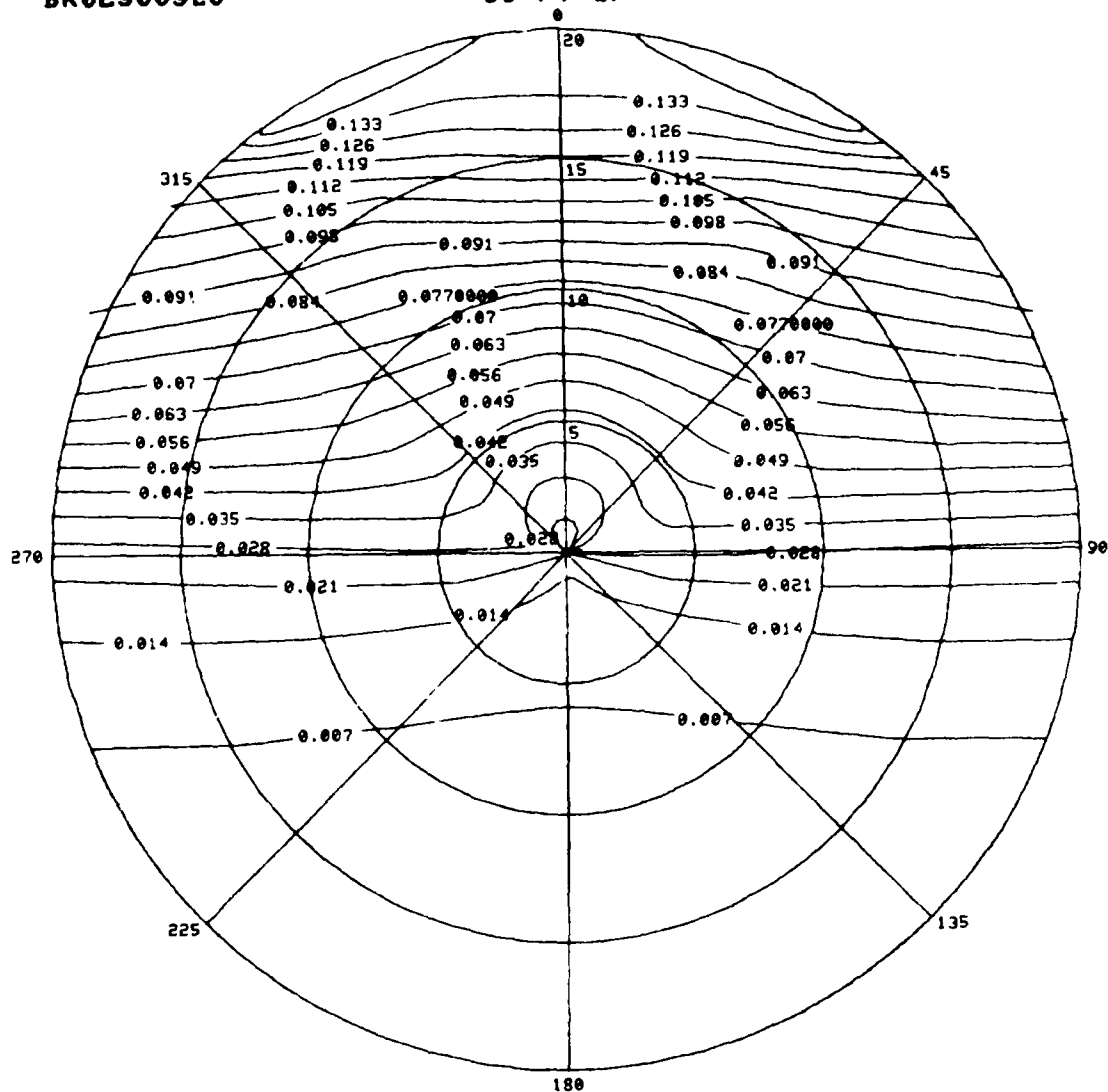
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95-FT WP

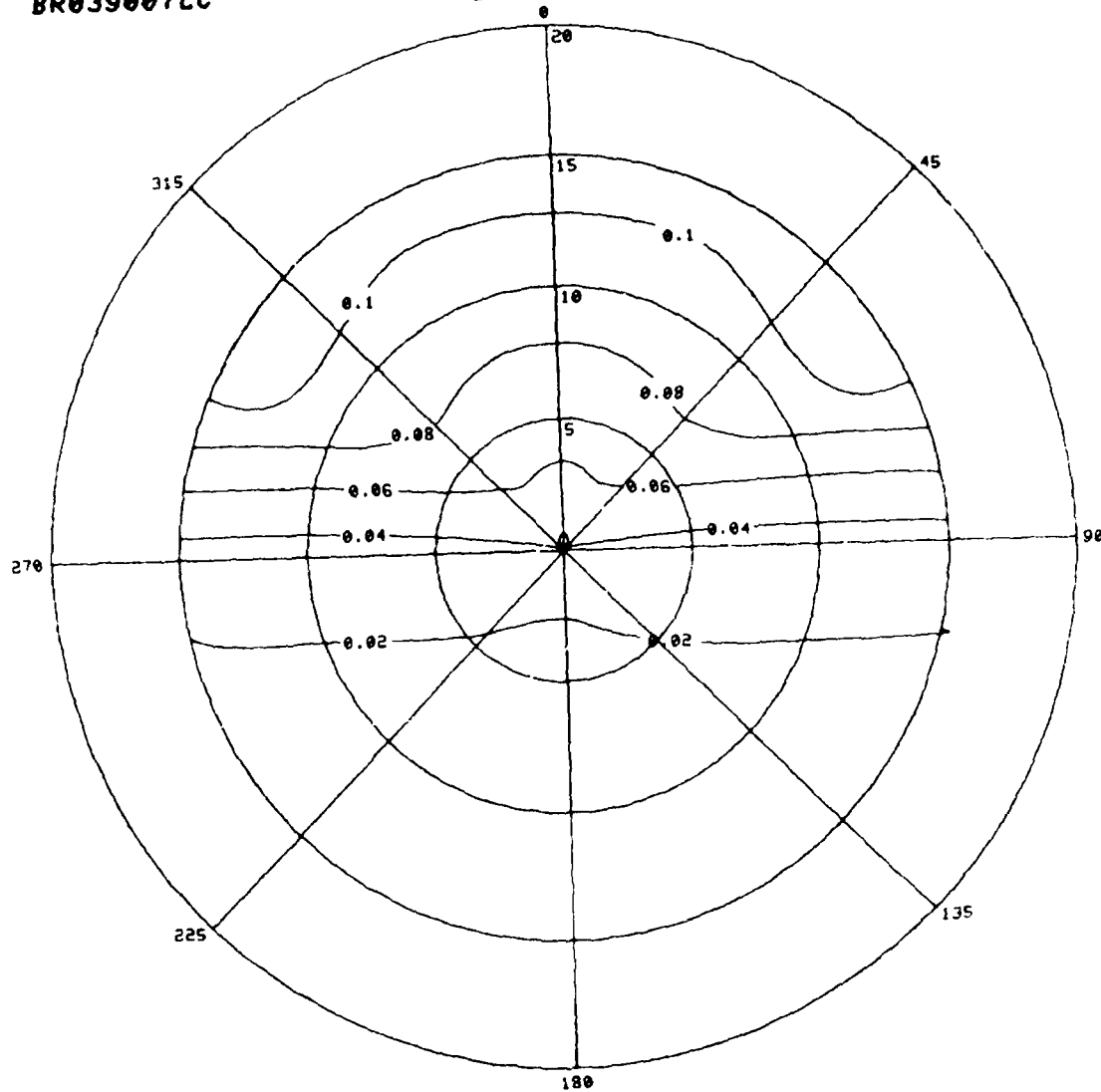
VERACCP3



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140-FT U

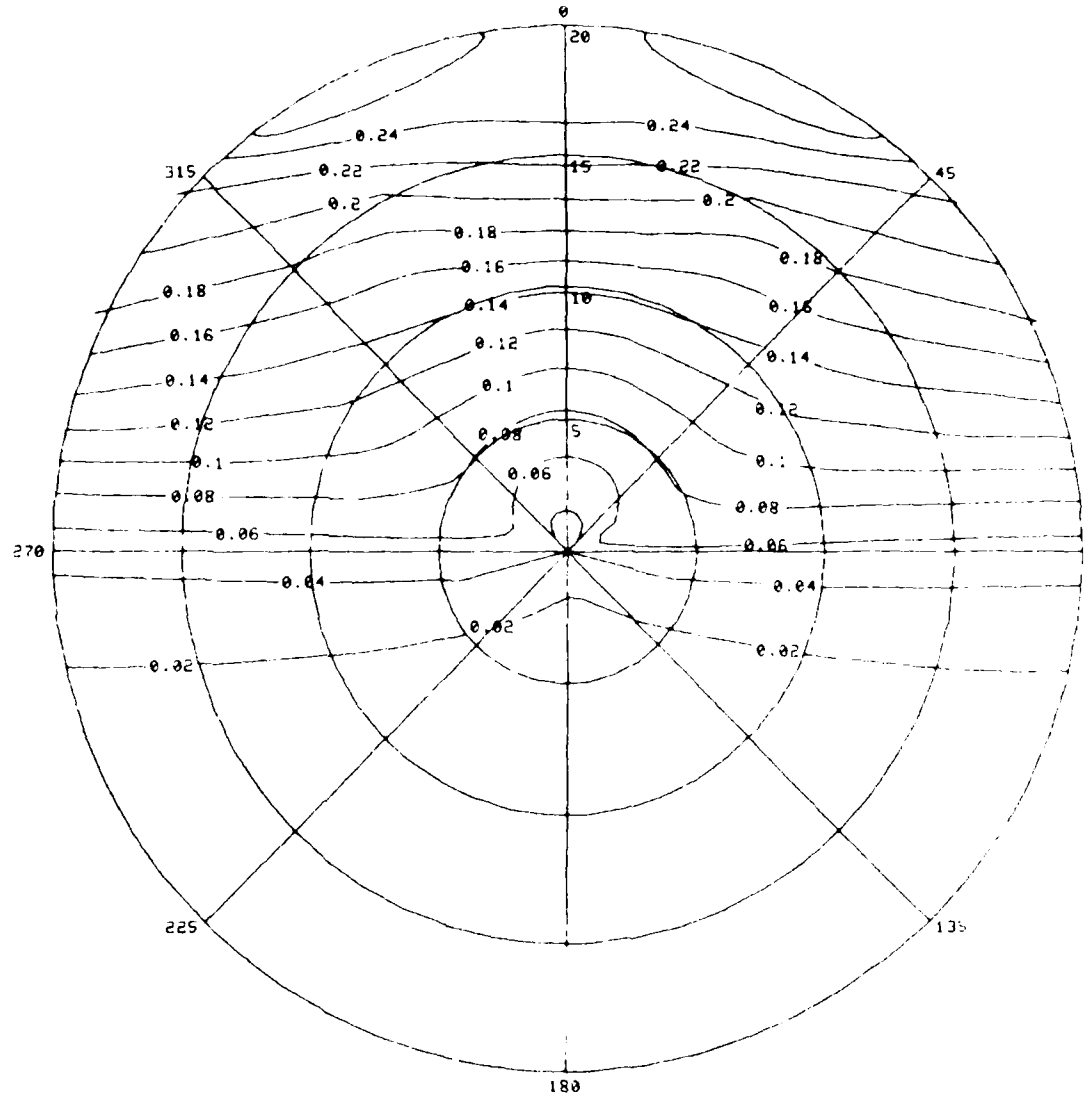
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APPENDIX D
THE REVISED PERFORMANCE ASSESSMENT QUESTIONNAIRE

SHIP: _____

OCTAGON #: _____

to be filled out by DENSEDC

PERFORMANCE ASSESSMENT QUESTIONNAIRE II

SECTION 1: BACKGROUND

Name or Number and Rank: _____

Length of Service: _____

Average time at sea per year (%): _____

Previous sea duty: Date- _____

Type of Ship- _____

- 1.) From your past experience, how susceptible do you honestly feel you are to seasickness?
☐ very susceptible
☐ moderately
☐ slightly
☐ not susceptible
☐ no past experience
- 2.) Do you usually take medication for seasickness?
☐ yes
☐ no
- 3.) Are you currently suffering from an ear infection, cold, hay fever, or other ailment?
☐ yes
☐ no Specify: _____
- 4.) Do you suffer from dizziness, lack of balance, or nausea?
☐ yes
☐ no
- 5.) Are you currently taking any medication?
☐ yes
☐ no Specify: _____
- 6.) Indicate your mental and physical condition before the start of this octagon.
Specify: _____

OCTAGON # _____

LEG # _____

to be filled out by
DTNSRDC

SECTION 2: INDIVIDUAL ASSESSMENT

7.) What were you doing during this leg?
Briefly describe: _____

8.) Did you experience any difficulty in doing this because of:

- ☐ your mental and/or physical condition(s)
- ☐ an equipment malfunction
- ☐ other: _____
- ☐ NO DIFFICULTY

(a) If it was mental and/or physical, was it due to

- ☐ seasickness alone
- ☐ excessive ship motions alone
- ☐ seasickness and excessive motions
- ☐ ship-motion-related injury

(b) To what degree were you impaired?

- ☐ Incapacitated
- ☐ Significant
- ☐ Moderate
- ☐ Slight
- ☐ NO IMPAIRMENT

(c) How would you rate your level of concentration?

- ☐ Poor
- ☐ Fair
- ☐ Good

9.) What area of the ship were you in? _____

10.) How would you rate this area's

(a) temperature?

- ☐ too hot
- ☐ comfortable
- ☐ too cold

(b) ventilation?

- ☐ poor
- ☐ fair
- ☐ good

(c) noise?

- ☐ loud
- ☐ moderate
- ☐ quiet

(d) fuel odor/ exhaust

- ☐ yes
- ☐ no

11.) Did you have a view of the sea and/or horizon?

- ☐ yes
- ☐ no

OCTAGON # _____

LEG # _____

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SECTION 3: DEPARTMENT ASSESSMENT

12.) How much difficulty did your department's crew members have in performing their duties?

- ☐ Extreme
- ☐ Moderate
- ☐ Slight
- ☐ None

13.) Was the major cause of this difficulty due to

- ☐ seasickness?
- ☐ ship motions?
- ☐ equipment failure?
- ☐ other? _____
- ☐ NO DIFFICULTY

14.) Assess your department's performance:

(a) There was a ____% degradation in performance having to do primarily with

- ☐ the speed at which duties were accomplished.
- ☐ the quality and accuracy with which duties were performed.

(b) Out of _____ (# of crew in your department) there were _____ (# of crew) too sick to function, and _____ (# of crew) sick but continued to function.

15.) What functions of your department, if any, were affected by poor crew performance?

- (a) _____
- (b) _____
- (c) _____
- (d) _____

16.) In your opinion, what would be the long-range forecast on the performance of your department, if this course and speed were to be maintained for a longer period of time?

OCTAGON # _____

LEG # _____

to be filled out by DTNSRDC

SECTION 4: COMMANDING OFFICER'S ASSESSMENT

17.) What were the reasons that ship speed was limited at this heading?
List them in order of importance.

- (a) _____
- (b) _____
- (c) _____
- (d) _____

18.) If the speed has been limited on this leg, are there circumstances under which you would not reduce speed, and, if so, what are they?

19.) If speed was not limited on this leg, would you maintain this course and speed for an extended period of time? If so, for how long and with what effects?

20.) Comments:

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