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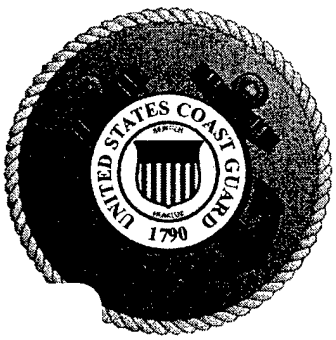
# DEVELOPING PERFORMANCE-BASED ASSESSMENTS OF MARINER PROFICIENCY


**FINAL REPORT**

**February 2001**



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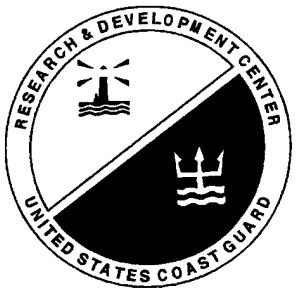


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16. Abstract (MAXIMUM 200 WORDS)

The present study explored the requirements for developing and documenting performance-based assessments that would conform to the amended *Seafarers' Training, Certification and Watchkeeping (STCW) Code.* The study had two major objectives: (1) specify and refine a method for developing performance-based assessments of mariner proficiency; and (2) develop an assessment for Automatic Radar Plotting Aid (ARPA) operator proficiency. A five-step method for developing performance-based assessments of mariner proficiency was created on the basis of a review of STCW requirements and the Instructional Systems Development literature, then applied in the development of an ARPA operator proficiency assessment. Overall, the proposed assessment development method was found to be useful in guiding the development of an objective and valid set of performance-based assessment procedures. It was recommended that future efforts be directed toward refinement of the method, development of additional assessment examples, and development of practical guidance and training for the maritime community.

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# EXECUTIVE SUMMARY

## A research project to examine mariner assessment

The assessment of mariner proficiencies by practical demonstration is mandated by the International Maritime Organization (IMO) in its 1995 amendments to the *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention)* and the accompanying *Seafarer's Training, Certification and Watchkeeping Code (STCW Code)*. This requirement is a substantial departure from earlier practice, and methods for developing, conducting, and documenting such assessments must be established. The United States Coast Guard's (USCG) National Maritime Center (NMC) sponsored a research project through the USCG Research and Development Center (R&DC) to examine the implications of the mandate and to ensure that the best practices are available to the industry. The major objective of the project was to provide a systematic, step-by-step process for developing reliable and valid assessments and to investigate its feasibility for implementation.

## Project efforts in this and subsequent phases

The efforts described in the present report were the first phase of the project. A team, consisting of researchers with expertise in training and assessment and marine educators, reviewed the requirements of the *STCW Code,* relevant USCG Navigation and Vessel Inspection Circulars (NVICs), Instructional Systems Development (ISD) literature, and the best practices of industry. From these sources, they distilled a systematic, step-by-step method for developing assessments. To test and refine the method and to provide a sample assessment, they applied it to a skill that is emphasized in the *STCW Code*, proficiency in the operational use of Automatic Radar Plotting Aids (ARPA). Their ARPA assessment procedure was designed for use on the United States Merchant Marine Academy's (USMMA) high-fidelity, real-equipment-based ARPA laboratory. The development methodology was successful, as documented herein.

This report first describes five steps to developing an assessment procedure: identify assessment objectives, determine assessment methods, specify the assessment conditions, define proficiency criteria, and prepare assessment objectives. This process is illustrated by following the research team members during their development of their ARPA procedure. Appendices contain the ARPA assessment objectives, the needed simulator exercises, instructions to the assessor and the candidate, and worksheets. Sufficient detail is provided to allow others to reproduce their procedures.

During this first phase of the project, the team identified several critical aspects of mariner assessment that merited further examination in subsequent phases. These additional aspects were examined in further investigations. The second phase involved the design of a systematic method to assist an instructor/assessor in evaluating the bewildering variety of available simulators, including personal computer (PC) based simulators, in their capability to support mariner assessments. This method is described in another project report titled "Evaluating Simulators for Assessments of Mariner Proficiency." Step-by-step support materials for a marine

instructor in *developing* valid and reliable assessments without the assistance of training consultants were prepared with the participation of faculty from two state academies. The resulting workshop materials, a developer's manual, and illustrative assessment procedures for deck and engine room are presented in a third report titled "A Method for Developing Mariner Assessments." Lastly, researchers worked with a major shipping company to identify the special requirements of *conducting* over-the-shoulder assessments during commercial operations. The shipboard trials are described in a fourth report titled "Conducting Mariner Assessments," which includes an assessor's manual for the shipboard officer and sample assessments adapted for shipboard use.

## Recommendations for Implementation of Project Findings and Products

For the most effective implementation of the project's findings on performance-based assessment and its supporting products, the following USCG and industry actions are recommended:

- The USCG should encourage the maritime industry to use the performance-based assessment method, as described in the project reports and materials. As a first step, the materials in this report should be made widely available, on the USCG STCW website (http://www.uscg.mil/stcw) and through the National Technical Information Service (NTIS). When the industry becomes more familiar with the method, it can serve as the basis for a new NVIC. In addition, the USCG should submit the supporting materials to the IMO subcommittee on Standards for Training and Watchkeeping and recommend their further distribution.
- The USCG should encourage further familiarity with the performance-based assessment approach by USCG staff, as a tool for discussions of assessment with the industry and for the review of procedures submitted for approval.
- The USCG should encourage the review and use of the performance-based assessment method and materials by those groups who are dealing with the important technical issues of assessment. These groups include the Maritime Academy Simulator Committee (MASC), the Merchant Marine Personnel Advisory Committee (MERPAC), and academy committees appointed by the Maritime Administration (MARAD) to address STCW issues. The materials can provide a common approach and a common basis for discussion.
- Those in the industry who are responsible for training and assessment of mariner proficiency in academies, training schools, and shipping companies should make use of the performance-based assessment method and the materials presented here as a guide for their own development of assessment procedures. All the project materials are especially appropriate for inclusion in train-the-trainer courses. The developer's manual and the assessor's manual are also appropriate for those who do not take such courses.

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ARPA | Automatic Radar Plotting Aid |
| CMA | California Maritime Academy |
| COLREGS | International Rules for the Prevention of Collisions at Sea |
| CPA | Closest point of approach |
| CFR | Code of Federal Regulations |
| DIW | Dead in the water |
| ECDIS | Electronic Chart Display and Information System |
| IMO | International Maritime Organization |
| ISD | Instructional Systems Development |
| kt | Knot |
| MARAD | Maritime Administration |
| MASC | Maritime Academy Simulator Committee |
| MERPAC | Merchant Marine Personnel Advisory Committee |
| min | Minute |
| MMA | Massachusetts Maritime Academy |
| nm | Nautical mile |
| NMC | National Maritime Center |
| NVIC | Navigation and Vessel Inspection Circular |
| SART | Search and rescue transponder |
| STCW Code | Seafarers' Training, Certification and Watchkeeping Code |
| STCW Convention | International Convention on Standards of Training, Certification and Watchkeeping for Seafarers |
| TCPA | Time to closest point of approach |
| USCG | United States Coast Guard |
| USDOD | United States Department of Defense |
| USMMA | United States Merchant Marine Academy |

# INTRODUCTION

In recent years, larger ships, multinational crews, and more complex automation have increased the demand for well-trained, competent mariners. The 1995 amendments to the International Maritime Organization (IMO) *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention)* (IMO, 1996A) and its annexed *Seafarers' Training, Certification and Watchkeeping Code (STCW Code)* (IMO, 1996B) recognized these challenges and redefined the requirements for mariner assessment. The *STCW Code* guidance regarding assessment practices and standards emphasizes the need for an assessment of mariner skills and knowledge that incorporates a *practical demonstration.* In defining this term, the United States Coast Guard (USCG) provided the following guidance in regulations 46 CFR 10.103 and 46 CFR 12.01-6:

> Practical demonstration means the performance of an activity under the direct observation of a designated examiner for the purpose of establishing that the performer is sufficiently proficient in a practical skill to meet a specified standard of competence or other objective criterion.

Thus, the USCG established policy in support of a shift in assessment toward greater use of practical demonstrations (46 CFR 10.103, 1997; 46 CFR 12.01-6, 1997; USCG, 1997A; USCG 1997B; USCG 1997C). The shift toward a wider application of performance-based assessment in the maritime industry requires the development of a broad spectrum of assessment procedures that specify how assessments are to be conducted and what objective criteria will be used to determine mariner proficiency. In order to meet this requirement, methods for developing, conducting, and documenting such assessments are needed. The USCG National Maritime Center (NMC) sponsored a research project through the USCG Research and Development Center (R&DC) to examine the implications of these requirements and to ensure that the best practices of assessment are available to the maritime industry.

On this project, research staff worked with representatives of the U.S. maritime industry over several years, examining the *STCW Code* requirements, training and assessment methods in the literature, and the best existing assessment practices. Together, they developed STCW- and USCG-compliant methods, tested them in practical settings, and revised them to better support the industry in assessing mariner performance. The present report describes the technical basis of the project's approach to performance-based assessment, which was prepared by a team of researchers working with faculty from the U.S. Merchant Marine Academy (USMMA). As they prepared a general approach, they exercised and refined it with a specific application to assessment of mariner proficiency in the use of Automatic Radar Plotting Aids (ARPA). They designed the approach using the USMMA's high-fidelity radar simulator laboratory as a testbed.

During the first phase of the project, which is reported here, the team identified several critical aspects of mariner assessment that merited further examination. These other aspects were examined in further investigations. A systematic method to assist an instructor/assessor in evaluating the bewildering variety of available simulators in their capability to support mariner assessments is described in another project report (Raby, Forsythe, McCallum, & Smith, 2000). Step-by-step support material for a marine instructor in *developing* valid and reliable assessments without the assistance of training consultants was prepared with the participation of faculty from the Massachusetts Maritime Academy (MMA) and the California Maritime Academy (CMA). The resulting workshop materials, a developer's manual, and illustrative assessment procedures for deck and engine room are presented in a third report (McCallum, Forsythe, Barnes, Smith, Macaulay, Sandberg, Murphy, & Jackson, 2000). Lastly, researchers worked with SeaRiver Maritime, Inc. (SRM) to identify the special requirements of *conducting* over-the-shoulder assessments during commercial operations. The shipboard trials are described in a fourth report (McCallum, Barnes, Forsythe, Smith, Maynard, Blanchard, Hempstead, Martinez, Murphy, & Jackson, 2000), which includes an assessor's manual for the shipboard officer and sample assessments adapted for shipboard use.

## Objectives and Approach of the Present Study Phase

The purpose of the present study phase was to explore the requirements for developing and documenting performance-based assessments that would conform to the *STCW Code* guidance regarding assessments based on practical demonstrations. This exploration began with a review of the Instructional Systems Development (ISD) literature and past work in mariner assessment. Based on this review, a general method for developing performance-based assessments was prepared. Then, a trial application of the method was conducted for the purposes of evaluating and refining the method, as well as to develop an illustrative assessment procedure.

The trial application had the explicit purpose of meeting the *STCW Code* guidance regarding assessment through mariner demonstration. Because the requirements for conducting an assessment of Automatic Radar Plotting Aid (ARPA) operations are well defined in the *STCW Code*, it was selected as the proficiency for this first practical application of the assessment development method. In addition, the study team began by applying the method in the more controlled environment of a maritime training institution before addressing the more diverse requirements of the commercial maritime industry.

In exploring the requirements for developing performance-based assessments, two study objectives were established:

- Specify and refine a method for developing performance-based assessments of mariner skills and knowledge that is responsive to IMO and USCG guidance.
- Develop a performance-based assessment for ARPA operation that can serve as one example of an assessment procedure that conforms to the standards of competence in the *STCW Code*.

## *Report Organization*

The remainder of the main body of this report is divided into three sections. First, a general method, derived from a review of the ISD literature, is presented for developing performance-based assessments of mariner proficiency. Next, the trial application of this method to the development of an ARPA operator assessment procedure is described. Finally, conclusions regarding this STCW-compliant assessment development method and recommendations regarding its implementation are presented.

Following the main body of this report is a list of referenced documents and a glossary of the proficiency assessment terms used in this report. Lastly, a series of appendices document the ARPA operator assessment procedure and its development. Appendix A provides the assessment objectives, conditions, and performance measures. Appendix B documents the ARPA simulator assessment exercises. Appendix C documents the assessment candidate instructions and worksheets. Appendix D documents the assessor's instructions.

## A GENERAL METHOD FOR DEVELOPING PERFORMANCE-BASED ASSESSMENTS OF MARINER PROFICIENCY

Structured approaches for developing assessment procedures based on practical demonstration have been available for several decades as part of broader methods aimed at the development of performance-based training programs. The precursor to many of the performance-based training methods used in the United States is commonly referred to as the *Instructional Systems Development* (ISD) method. This method was originally developed for application within the U.S. Department of Defense (USDOD) and has been adopted and implemented throughout the U.S. military services (Meister, 1985). The ISD method has been highly successful in providing a common structure for developing training and assessment programs for a wide range of military skills and duties. However, due to the complex and specialized nature of the techniques involved, it has had limited application outside of the USDOD environment.

The method for developing performance-based assessments of mariner proficiencies presented in this report has been distilled from the original ISD method (TRADOC, 1977), as well as a number of more recent developments in instructional development (Gagné, Briggs, & Wagner, 1992; Goldstein, 1993; Jonassen, Hannum, & Tessmer, 1989; Krieger, 1994; Mager, 1997; Rothwell & Kazanas, 1998; Sanquist, Lee, & Rothblum, 1994; Smith et al., 1996; and Sullivan & Elenburg, 1988). The method proposed here intends to preserve the ISD objectives of establishing valid and reliable performance objectives, measures, and standards. However, the present method also represents a significantly streamlined version of ISD that is intended to better serve the operational constraints within the U.S. maritime industry. The current method is targeted at users in a broad range of maritime organizations, including maritime academies that provide four-year degrees, maritime colleges with two-year programs, commercial maritime training institutions that provide integrated curricula or individual courses, and shipping companies that develop in-house training and certification programs.

The step-by-step method is described in this section and illustrated in the next section by its application to an assessment of ARPA proficiency developed by the researchers and the USMMA faculty. Note that another treatment of these steps is presented in a "developer's manual" for the instructor/assessor in another project report (McCallum, Forsythe, Barnes, Smith, Macaulay, Sandberg, Murphy, & Jackson, 2000). The method is consistent with the guidance in a Circular on assessment published by the International Maritime Organization (1998).

## Method Overview

Figure 1 depicts the proposed five-step method for developing performance-based assessments of mariner proficiency. The method consists of a series of four analytic steps, followed by a final step for the preparation of the assessment package. The first step in the method is to identify the assessment objectives, which are the various aspects of mariner proficiency that are to be assessed. The second step is to determine the assessment method (or methods) to be used in conducting the assessments. The third step calls for specifying the assessment conditions, which are the conditions necessary for eliciting the mariner's performance. The fourth step is to define the criteria that are to serve as objective indicators of mariner proficiency. Finally, in the fifth step, the results of the preceding analyses are compiled into a documented assessment procedure. The remainder of this section provides a general description of each step in the performance-based assessment development method, along with a discussion of some issues that should be addressed in conducting each step.

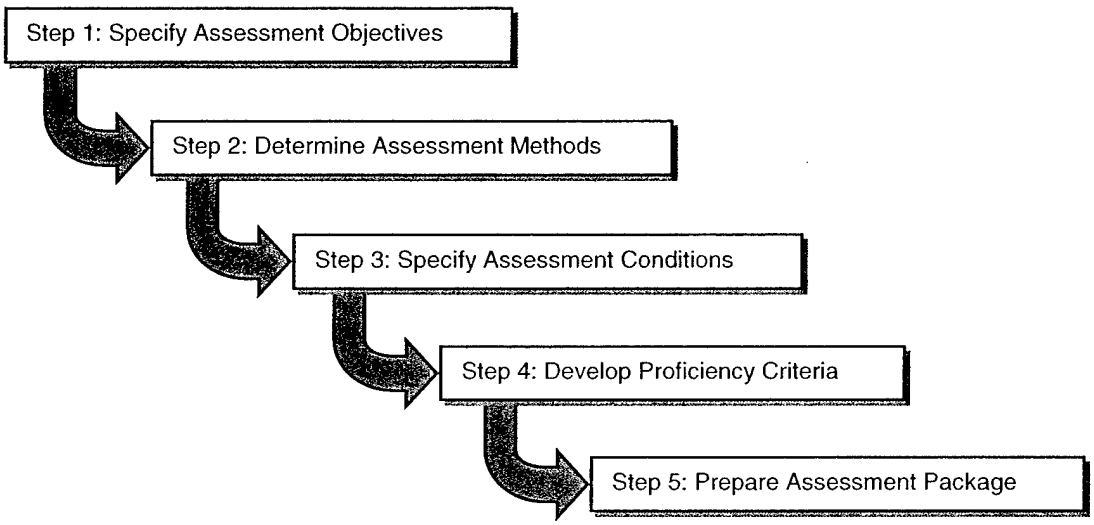


**Figure 1. Five-step method for developing mariner performance-based assessments.**

## Step 1: Specify Assessment Objectives

The first step in developing a performance-based assessment is to identify the assessment objectives. The fundamental goal in identifying assessment objectives is to specify the critical requirements of job performance that can be measured and assessed in a performance-based assessment. These requirements take two general forms. First, there are *skills*, which refer to learned behaviors that must be applied in successful job performance. Second, there is *knowledge*, which refers to the learned concepts, cues, and procedures that allow the mariner to determine when and how to apply his or her skills. A comprehensive set of performance-based assessment objectives addresses both the skill and knowledge requirements of the job. This results in objectives that require the demonstration of: (1) prerequisite knowledge; (2)

fundamental job skills; and (3) ability to select and execute skilled performance, based on the mariner's reference to his or her knowledge.

Assessment objectives should be based on a detailed understanding of the job requirements corresponding to the proficiency of interest. For assessments that are to be developed in accordance with proficiencies identified in the *STCW Code*, that document should serve as the starting point for this review. The "Standard of Competence" tables in the *STCW Code* specify, in general terms, four sets of information intended to guide the assessment development process:

- The *competence*, or broadly defined job requirements.
- The *knowledge, understanding and proficiency* requirements associated with the competence.
- *Methods* for demonstrating competence.
- *Criteria* for assessing competence.

To ensure compliance with these requirements, the assessment developer must carefully review the information in the *STCW Code* tables that correspond to the area of assessment. However, a review of these tables reveals that the mariner skill and knowledge requirements corresponding to the proficiency must be further analyzed to specify the associated assessment objectives. Following an initial review and analysis of the appropriate portions of the *STCW Code*, an assessment developer should next review any additional requirements pertinent to the proficiency area under analysis. In the United States., the primary source for regulatory requirements is found in the *Code of Federal Regulations* (CFR), *Title 46 – Shipping*. Other requirements for a given job may also be found in union agreements and company operating procedures. Following review of the regulatory requirements, assessment developers may need to refer to technical manuals, job instructions, textbooks, and task analyses to aid in the identification of job requirements.

In most cases, an individual proficiency is analyzed to identify a set of several related assessment objectives that should be addressed separately during mariner proficiency assessment. Each of these objectives should represent a critical job requirement corresponding to the proficiency being analyzed. There are numerous job analysis methods that can be used in defining assessment objectives. At this point, broad areas of knowledge, skill, and ability that are critical to successful job performance should be identified. Later, during development of the proficiency criteria, a more detailed task analysis should be conducted. Further guidance on the conduct of job and task analyses can be found in texts that address these topics in detail (Janassen, Hannum, & Tessmer, 1989; Mager, 1997; Rothwell & Kazanas, 1998).

An individual assessment procedure should address either a single proficiency, or an integrated set of proficiencies defined in the *STCW Code*. In addition, the time and resource requirements for assessment should be within a practical level. An assessment is too broad in scope if it addresses unrelated proficiencies or if its conduct requires an unnecessarily extensive amount of time and resources.

To ensure consistency and completeness when specifying assessment objectives, a standard format should be applied. Each assessment objective should include a general description of the mariner actions to be demonstrated and the conditions under which they are to be demonstrated. The conditions should identify any special characteristics of the assessment setting, such as day or night conditions and major types of equipment or equipment settings required for proficiency assessment.

Following specification of the assessment objectives, it is often appropriate to ensure that they are *valid.* A valid assessment objective is one that accurately reflects the skill, knowledge, and performance requirements of the job. A commonly accepted means of establishing the validity of a set of assessment objectives is to reach consensus on the objectives among a group of subject matter experts. An open and frank discussion of the knowledge, skill, and performance requirements corresponding to a proficiency provides a solid basis for establishing valid assessment objectives.

## *Step 2: Determine Assessment Methods*

The intent of the *STCW Code* is to foster assessment through practical demonstration. Thus, it is important that assessment developers carefully consider the alternative assessment methods available to them and select the method that best meets the intent of the *STCW Code*, while also considering the practical limitations of mariner assessment. There are three basic methods of assessment:

- Written or oral questions.
- Exercises in a simulated job setting.
- Exercises in an actual shipboard job setting.

At the most general level, there are two basic categories of *what* is being assessed by an assessment procedure. First, an assessment can assess the candidate's demonstration of his or her knowledge of concepts, constructs, rules, and procedures. Often, specific areas of knowledge can be identified as a prerequisite to proficiency in job performance. In such cases, assessment of a candidate's knowledge is appropriate. Second, an assessment can assess the candidate's demonstration of his or her ability to apply knowledge and skills in an operational setting. This type of assessment is the primary focus of the present method. Demonstration of ability in operational settings provides a much more valid basis for assessment. However, due to economic, efficiency, or safety concerns, sometimes the assessment of knowledge demonstration in a non-operational setting is appropriate.

General guidance in the selection of assessment methods can be provided, as summarized in Table 1. As presented here, written or oral questions are used to assess the mariner's demonstration of knowledge. On the other hand, simulated or actual shipboard job settings are used to assess the mariner's demonstration of the ability to apply knowledge and skills in an operational setting.

**Table 1. General guidance on the selection of assessment methods.**

| What is Being Assessed | Method of Mariner Assessment |
|---|---|
| **Knowledge of concepts, constructs, rules, and procedures** | **Oral and written questions** |
| **Demonstration of the ability to apply knowledge and skills in an operational setting** | **Exercises in real or simulated operations** |

Once the alternative assessment methods have been identified, the assessment developer should consider the advantages and disadvantages of each alternative. Factors to consider are assessment validity, assessment reliability, ease of assessment development, and ease of assessment administration. In the context of assessment, *validity* can be defined as the degree to which knowledge, skill, and performance requirements of the job are accurately reflected by assessment requirements. *Reliability* can be defined as the consistency of the assessment outcome following administration under comparable conditions. Table 2 summarizes some of the common advantages and disadvantages associated with each of the three general assessment methods.

**Table 2. Assessment method advantages and disadvantages.**

| Method | Advantage | Disadvantage |
|---|---|---|
| Written/Oral Question | Easy to standardize | May not adequately represent actual requirements in work setting (validity) |
| | Easy to assess many candidates | |
| | Good measure of knowledge | |
| Simulator Practical Demonstration | High reliability | May not adequately represent actual requirements in work setting (validity) |
| | Safe | May be expensive |
| | May have high validity | Usually need one assessor per candidate |
| Shipboard Practical Demonstration | High validity | Usually need one assessor per candidate |
| | | More difficult to control conditions (reliability) |
| | | Task may be infrequent or dangerous |

The assessment developer should consider each assessment objective and define an assessment method corresponding to each objective. The definition of the selected assessment method should include a preliminary description of the assessment method type and assessment conditions for each objective. Assessment methods and conditions should provide a reasonable level of operational fidelity. That is, they should be as faithful as possible to conditions present in an actual shipboard environment. Assessment methods should also provide a means of maintaining sufficient control over events so that mariner safety is optimized and operational risks are minimized.

## *Step 3: Specify Assessment Conditions*

Following the determination of assessment methods, the assessment developer should begin a more detailed description of *how* the assessment will be conducted. The assessment conditions provide a good point of departure for this detailed specification. The primary concern in specifying assessment conditions is to ensure that comparable conditions can be repeated from one application to the next. The following should be included in a detailed description of the assessment conditions:

- Assessor instructions.
- Candidate instructions.
- Tools and apparatus used by candidate.
- Written and oral questions.
- Simulator exercise requirements.
- Shipboard operations requirements.

The assessor instructions should address the general procedures and requirements for conducting an assessment. In addition, special assessment requirements that the assessor needs to prepare in advance should be identified in the assessor instructions. In the case of simulator-based assessments, these requirements will include familiarization with the controls, displays, and outputs of the simulator. In the case of shipboard assessments, these requirements will include specific operational conditions required to ensure a valid, reliable, and safe assessment.

Candidates should be provided with the appropriate information to allow adequate preparation for assessment. However, these instructions should not be a self-contained training resource. The instructions should identify training courses or resources that address the performance requirements corresponding to the assessment objectives under consideration. If simulators are being employed, a detailed description of the initial conditions of the operational scenario should be provided in the candidate's instructions, specifying both the initial settings of equipment, as well as any control of equipment that is exercised by the candidate during the course of the assessment. If shipboard assessment is being used, the operations under which the assessment is conducted should be described and the initial settings of operational equipment should be specified. This description requires comparable detail to that of the simulator assessment, although control of these conditions may be more difficult.

Tools and apparatus used by the candidate typically vary between simulator and shipboard assessments. If assessment is being conducted aboard ship, a subset of the tools and equipment available in the workplace are usually specified. If assessment is being conducted in a simulated setting, facsimile tools and equipment are often developed for the purposes of training and assessment.

Written and oral questions should be adequately specified to ensure comprehensive and consistent assessment. The specific topics to be addressed by the set of questions should be adequately defined so that the administration of any assessment addresses a common set of concepts, constructs, rules, and problem solving skills. In the best case, a library of test items is

provided, along with procedures for sampling from this library for any assessment. At a minimum, the number of questions should be identified, and the topics and subtopics for subsets of questions should be identified. In addition, the type of question (e.g., open-ended, multiple-choice, fill-in, and essay/discussion) also should be specified.

Finally, the simulator exercise or shipboard operations requirements must be specified. The use of simulators typically allows a high level of control in defining the sequence of events presented to the candidate during assessment. This high degree of control can often be used to advantage in establishing valid and reliable assessments that consistently present the operational conditions of interest. Shipboard operations can vary substantially in the level of control that is available, depending on the area of assessment and phase of shipboard operations. A great deal of consideration is necessary in specifying shipboard assessment conditions to ensure that they consistently reflect those job requirements that correspond to the assessment objectives under consideration.

## Step 4: Develop Proficiency Criteria

Up to this point in the assessment development method, assessment objectives are defined that correspond to specific proficiencies included in the *STCW Code*, other regulatory requirements, or major job requirements. However, for the purpose of defining performance that can be objectively assessed, the performance required by an assessment objective may need to be broken into smaller, more discrete components. The separate components of an objective consist of knowledge and/or application of: (1) concepts or constructs; (2) rules of operation; or (3) steps or procedures for operation. Textbooks, course materials, training experts, regulations, organizational policies, technical manuals, ship manuals, and operational experts should be referred to, as necessary, to ensure the definition of valid assessment objective components. As noted in the earlier discussion of assessment objective validity, review and discussion among a panel of subject matter experts is advisable.

Reliable and valid assessment requires the consistent measurement of mariner performance, and the consistent application of relevant *proficiency criteria. Proficiency criteria* are the scoring procedures applied in determining the proficiency of a candidate on the basis of *performance measures* and *performance standards. A performance measure* identifies how a candidate's performance is observed and recorded. A common distinction between types of measures contrasts objective measures and subjective measures. An *objective measure* can be defined as one that relies upon measurement apparatus that can be calibrated to yield highly consistent and accurate measurement results. Examples of apparatus used in objective measurement are stopwatches, compasses, rudder angle indicators, oil pressure gauges, and voltmeters. An example of an objective performance measure is the time required to launch a lifeboat. This measure would include specification of: (1) how to signal the start of the launching assessment; (2) when to start the timer; (3) which timer to use and its calibration; and (4) when to stop and record the launch time. Whenever practical and meaningful, objective measures should be used in assessment because they provide the most reliable means of measurement.

A *subjective measure* can be defined as one that relies primarily on the assessor's observation and interpretation of mariner performance to determine the assessment outcome. Two types of subjective measures that are commonly used in assessments are checklists and ratings. A *checklist* requires the assessor to observe the mariner's performance, or the outcome of performance, and choose one of two performance levels, typically labeled "pass" and "fail." A *rating* requires that the assessor observe the mariner's performance, or the outcome of performance, and choose one of three or more performance levels. For example, a three-level rating could assign scores of 0, 1, and 2 to the observed performance. A subjective measure is comprised of the recording form and the instructions for how to categorize the observed performance. Although not as inherently consistent and accurate as objective measures, the consistency and accuracy of subjective measures can be greatly enhanced by carefully defining what performance or outcome is being observed and how it should be categorized and recorded by the assessor.

A *performance standard* is the value of a performance measure that is established as an acceptable, or target, value. In the case of objective measures, the performance standard is typically established independently of the measurement procedures. For example, the time required for an activity to be performed can be recorded, then compared to the established standard of performance. However, in the case of subjective measures, the performance standard is established as part of the measurement procedure. For oral and written questions, this means the inclusion of acceptable answers. When the subjective measure requires the assessor's observation of procedural steps or their outcomes, guidance on the performance that is to be considered proficient must be included with the assessor's recording form. In developing standards for STCW certification, the criterion for proficiency specified in that document is an important first source for establishing standards. Other sources are the same ones used for establishing the assessment objectives and breaking them into components. These include government regulations, technical manuals, job instructions, textbooks, task analyses, and finally appropriate experts.

Table 3 provides a basic set of guidelines for selecting a measure type and developing performance standards. The guidance provided in the second and third columns of this table assumes prior consideration of the basis of performance measurement, identified in the first column. In the first case, if performance is best measured on the basis of a calibrated apparatus, then the appropriate measure type is objective and the performance standard should be established by determining an acceptable level of the measure. Second, if performance is best classified into two pre-defined levels, then the appropriate measure type is a subjective checklist and the performance standard should be established by defining the two levels of performance (typically "pass" and "fail"). Finally, if performance is best classified into three or more pre-defined levels, then the appropriate measure type is a subjective rating and the performance standard should be established by defining each of the levels of performance (e.g., 0, 1, and 2).

**Table 3. Selecting measure types and establishing performance standards.**

| IF performance is best measured on the basis of... | THEN the measure type is... | AND the performance standard should be established by... |
|---|---|---|
| a calibrated apparatus | objective | determining an acceptable level of the measure |
| classification into two pre-defined levels | subjective checklist | defining the two levels of performance |
| classification into three or more pre-defined levels | subjective rating | defining each level of performance |

When the assessment objectives have been broken down into individual components and performance measures and standards, it is typically necessary to combine these separate measures and standards into a more integrated metric of proficiency. The separate measures and standards should be reviewed with respect to the broader assessment objectives and requirements for mariner proficiency. Based on this review, scoring procedures should be developed that combine individual measures to establish a proficiency criterion for each larger assessment objective.

The proficiency criteria corresponding to each assessment objective must be validated in a manner that ensures that assessment will represent the requirements of the job. Proficiency is, in the end, a judgment that takes into account the risks associated with sub-optimal performance and the costs of requiring optimal performance of all mariners. A final, formal review of the proficiency criteria by a panel of experts typically provides justification of the validity of an assessment.

## *Step 5: Prepare the Assessment Package*

Following the completion of the analytic steps that define the content of an assessment, the assessment procedures should be documented to ensure consistent application during assessment. The assessment package should be prepared as a stand-alone procedure. That is, an assessor not familiar with the history of its development should be able to administer it. The goal should be the preparation of clear and concise instructions that can be used by multiple assessors in obtaining valid and reliable assessment results over multiple applications. The resulting assessment package should include six major components:

- Assessment worksheets.
- Assessor instructions.
- Candidate instructions.
- Written and oral items.
- Simulator and/or shipboard procedures.
- References, source materials, and validation documentation.

The central products of the assessment package are the written procedures or worksheets that will be used by the assessor while conducting the assessment. It might be most efficient to prepare these worksheets first, since they likely will be referred to in all of the other assessment package materials. An assessment worksheet should provide sufficient information to guide the assessor through the assessment procedure and provide a means of recording the outcome corresponding to the individual assessment objectives, measures, and standards. It should be noted that detailed assessor instructions could take the place of highly elaborate assessment worksheets. That is, much of the information required for conducting an assessment could be included in the assessor instructions, with only the minimum necessary for recording the results of the assessment included in the worksheet. On the other hand, assessor instructions could be limited to the necessary information, with more detailed guidance provided directly on the worksheet. Factors to consider in selecting the detail included in the worksheet and instructions include the amount of assessment training available to assessors and the amount of information that can be reasonably included in these two documents.

Every assessment package should include a set of assessor instructions. In many cases, detailed step-by-step instructions will help to ensure the reliability and validity of the resulting assessment. Although proficient mariners should be conducting the assessment, there can be many interpretations of how an assessment is to be conducted, especially with regard to briefing and instruction of the candidate, equipment set-up, and timing and pace of assessment activities. Assessor instructions could include the following topics:

- Assessment preparation.
- Candidate pre-briefing.
- Performance observations and recording.
- Determination of assessment outcome.
- Assessment debriefing.

The assessment package should also include separate, self-contained candidate instructions that can be provided to the candidate well in advance of the time that the assessment is conducted. The candidate instructions should include, at a minimum:

- Assessment objective source (*STCW Code* chapter, table, function, competence, and proficiency).
- Assessment objective.
- Assessment method.
- Conditions under which the assessment will be conducted (equipment status, underway versus in port, etc.).
- Assessment procedures (who will be administering the assessment and how long it will take).
- A summary of the measures and standards that will be used to determine the outcome of the assessment.

Written items should be documented either by defining detailed question objectives or by developing a library of questions. The assessment developer must be aware of the dangers of inadequate specification of written or oral questions. Without a detailed set of questions, the performance measures are not defined and any performance standards are arbitrary. At a minimum, the specific knowledge areas to be assessed should be defined, along with the format of the assessment items (i.e., true/false, multiple-choice, short answer, and essay/discussion), and the number of items that should be included for each knowledge area. The developer should consider providing a detailed listing of specific questions, along with the correct answers for each question.

Just as it is necessary to detail written and oral questions, the detailed procedures for simulator and/or shipboard assessment procedures should also be finalized in the assessment package. When simulators are used, specific assessment exercises or scripts should be developed and documented. Fully documented simulator scripts or scenarios might include the following specifications:

- Simulated time of day and weather conditions.
- Own vessel status at the start of the scenario.
- Other vessel locations at the start of the scenario.
- Sequence and timing of own ship malfunctions, if any.
- Course, speed, and maneuvers of other vessels, if any.

Specifying shipboard procedures for assessment must take numerous factors into consideration, as noted in the earlier discussion of assessment conditions. Such procedures must provide adequate guidance to ensure safe, valid, and reliable assessment, while recognizing the practical constraints of commercial operations. It is anticipated that selected mariner proficiencies will be identified as amenable to shipboard assessment. These proficiencies should correspond to job activities and settings that can be conducted with relatively high levels of safety and control over operational conditions. Further research and development work is required in this area to determine the appropriate issues that must be addressed to ensure valid and reliable shipboard assessment.

The final step in preparing the assessment package is to document references, source materials, and the validation process. This last step serves two purposes. First, it provides the necessary references and documentation to allow the assessment developer, or his/her successor, to maintain and update the assessment procedure. Second, this documentation provides reference material that can be used by an external reviewer who may evaluate the assessment procedure.

# DEVELOPMENT OF AUTOMATIC RADAR PLOTTING AID OPERATOR ASSESSMENT PROCEDURE

The basic assessment development method described in the preceding section was applied in an exploratory effort to ARPA operator proficiencies. This trial application was conducted during the fall and winter of 1996 and 1997 by a team consisting of USCG R&D Center technical staff, Battelle technical staff, and faculty from the USMMA. The academy's ARPA simulator laboratory facilities were used as the developmental testbed. The following discussion is organized around the five steps of the proposed assessment development method. For each assessment development step, identified issues, findings, and assessment products are discussed.

## *Assessment Objectives*

The specification of assessment objectives began with an initial review of several source documents. The summary of competencies for ARPA assessment provided in the *STCW Code* (IMO, 1996B, Section B-I/12) served as the starting point for this review. Further detail was obtained from a review of two additional IMO documents, *Model Course 3.12 – Examination and Certification of Seafarers* (IMO, 1992) and *Model Training Record Book for Candidates for Certification as Officers in Charge of a Navigational Watch* (IMO, 1996C). In addition, a formal analysis of ARPA operation skill and knowledge requirements conducted earlier under the direction of the USCG R&D Center provided a useful functional analysis of ARPA operational requirements (Sanquist, Lee, & Rothblum, 1994). Finally, basic issues and concepts were reviewed in selected ARPA instructional texts (Bole & Dineley, 1990; Van Wyck & Carpenter, 1984).

Following this initial review of available source documents, a series of meetings was convened to discuss and refine the set of assessment objectives. Meeting attendees included experts in navigation and ARPA operation, regulatory requirements, and assessment development. In these meetings, lists of assessment objectives were reviewed and refined until a final set of objectives was specified. In developing the set of ARPA assessment objectives, a more general set of functions that could be used to categorize assessment objectives for the operation of a range of marine electronic equipment emerged. Six general categories, representing separate aspects of knowledge and skill requirements were identified. It was postulated that these categories would apply to the assessment of other electronic equipment operation, such as Electronic Chart Display and Information Systems (ECDIS) and large-scale sensor and alarm systems, as well as ARPA. These six general categories are:

- Equipment initialization.
- Basic understanding of equipment output.
- Technical limitations of the equipment.
- Advanced technical operations.
- Broad application of knowledge and skill to the job.

- Operational warnings and system tests.

For the present ARPA application, 27 separate assessment objectives were organized under the six assessment objective areas presented in Table 4. Appendix A provides a detailed listing of the assessment objectives identified in the present ARPA application, along with the citation from the *STCW Code* used as the reference in developing each objective.

**Table 4. ARPA assessment objective areas.**

| | |
|---|---|
| 1. | Setting up and maintaining displays. |
| 2. | Situation assessment. |
| 3. | Knowledge of factors affecting ARPA performance and accuracy. |
| 4. | Parallel indexing. |
| 5. | Applications of COLREGS* and operation of trial maneuvers. |
| 6. | Use of operational warnings and system tests. |

* Collision Regulations (USCG, 1999)

The mariner performance specified for assessment was determined on the basis of a detailed review of each assessment objective, the conditions necessary for eliciting that performance, and a preliminary determination of the specific measures of performance that would be obtained and assessed. For example, one of the ARPA assessment objectives presented in Appendix A is 3.1 – *Knowledge of effects of limitations of radar range and bearing on the accuracy of ARPA data.* One such limitation is that when two or more vessels have different ranges, but are on the same bearing, an ARPA system will often take longer to calculate valid target data than if the targets are on different bearings. When this is the case, a mariner must wait a sufficient period of time until the vessel data become stable and valid.

In general, application of the proposed method to ARPA operation resulted in a comprehensive set of assessment objectives. The development of these objectives required substantial resources and time. Even in this trial application, for which the *STCW Code* provides detail regarding mariner proficiencies, a substantial amount of analysis was required to define a complete set of assessment objectives. In the present case, it was found that the presence of assessment development experts was critical in defining the general objectives and requirements for assessment. In the future, the need for having assessment developer experts present throughout development could be replaced with clear guidance that can be applied by mariner training experts.

## Assessment Method

The *STCW Code* specifies the use of an ARPA simulator as the preferred method for assessing operator proficiency. In the present application, the assessment was developed using the high fidelity, part-task ARPA simulator at the USMMA in Kings Point, New York. At the Academy's facility, a total of 18 separate operator consoles are controlled by a Norcontrol simulator system. Each operator console has an operational ARPA console that displays real-time target data fed by the Norcontrol system, a vessel control unit, a communications unit, and a chart table for reviewing charts and plotting traffic situations.

It is important to note that our results here should not be interpreted as a mandate for using the specific type of simulator employed in this study, or for the use of high-fidelity simulators in assessing ARPA operation. Various other simulators are available for assessing ARPA operation, including PC-based simulators. For the purposes of assessment, the capability of any simulator to support assessment and training can be evaluated on the basis of the degree to which the specified training and assessment conditions can be provided by the simulator.

For 21 of the 27 ARPA assessment objectives, it was determined that the USMMA simulator provided the best assessment method. In these cases, it was determined that real-time ARPA operation and interpretation would provide the most valid method of assessment. However, for three objectives it was determined that basic ARPA knowledge was being assessed. For these objectives, it was decided that a series of written test questions would serve as the most valid and practical method of assessment. Additionally, for three other objectives it was determined that performance was highly dependent upon the type of equipment being operated. In these cases, no assessment procedures were developed. Appendix A indicates the selected assessment method for each of the present ARPA assessment objectives.

The finding regarding the use of written questions for the assessment of basic knowledge can probably be generalized to a wide range of mariner proficiencies. Most maritime jobs require the application of theoretical or procedural knowledge. Often, one can expect that mariner recall or recognition of the corresponding information is a prerequisite to successful job performance. When a written or oral question legitimately reflects the requirements of the job, incorporating this assessment method into the complete assessment procedure should increase the overall validity and reliability of the assessment. However, it is also important to recognize that written and oral questions typically represent limited aspects of job conditions and requirements. Demonstrating the application of the theoretical and procedural knowledge under conditions that reflect normal job requirements reflects a more demanding, realistic, and valid method of assessment.

## *Assessment Conditions*

In the current application of the proposed assessment development method, the conditions required for each assessment objective were identified and grouped into six separate simulator exercises. The grouping of objectives resulted from several cycles of revision and refinement, with the basic objective of establishing a realistic series of events that represented vessel traffic conditions that could be expected under normal operating conditions.

An earlier bridge watchkeeping assessment development effort (Smith et al., 1996) demonstrated the value of dividing watchkeeping exercises into two segments. In the first segment, the vessel traffic situation evolves without allowing the candidate to maneuver own ship. This segment provides a basis for assessing the candidate's ability to initialize, set-up, and operate equipment, as well as understand and interpret equipment displays. In the second segment, the candidate is allowed to maneuver the vessel. This latter segment allows for confirmation of situation assessment and application of the International Rules for the Prevention of Collisions at Sea (COLREGS) (USCG, 1999). This basic approach was also found to be useful in the present application.

Each of the six ARPA simulator exercises begins with own ship and several other vessels displayed on the screen after the system has been initialized and set up. Assessment candidates are given specific set-up instructions in some exercises and left to select their preferred operating mode in others. Specific instructions are provided regarding the intended course of own ship and allowable closest point of approach (CPA) to other vessels. Candidates are asked to record accurate vessel data for all ships while standing the watch. Candidates are also given control of ship course and speed at predetermined times. Exercises vary on the basis of traffic conditions, system alarms, and unexpected system malfunctions that occur.

Figure 2 provides an example of the situation for an exercise, showing the plot of all vessels following successful navigation during exercise C. This exercise involves an open waters situation with six other vessels traveling and three anchored buoys. During this exercise, a pre-programmed own ship maneuver occurs automatically prior to the assessment candidate assuming control of the vessel, but no other vessel maneuvers occur until own ship returns to its original course. This exercise was designed to assess seven individual objectives. Appendix B provides assessment exercise general descriptions, assessment objectives, and event timelines.

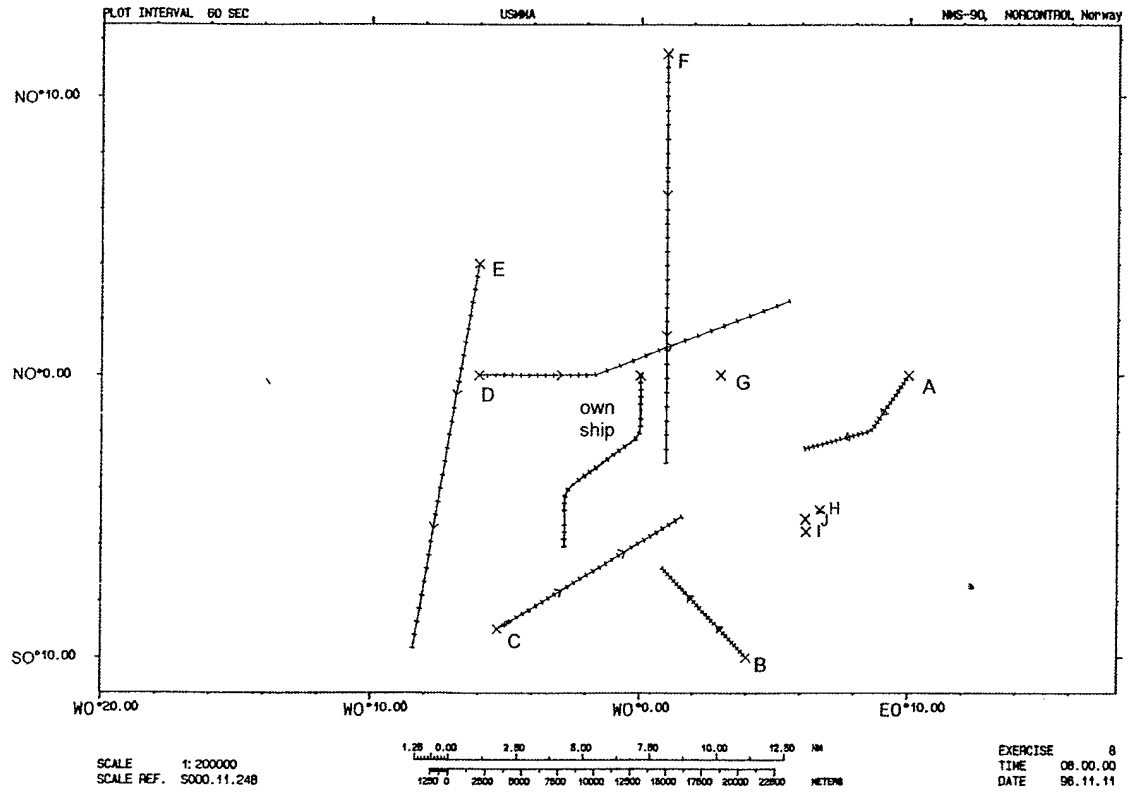


**Figure 2. Plot of an example simulator exercise.**

The development of the simulator exercises went through several cycles before the final set of six exercises was completed. During this process, several shorter, more discrete exercises that focused on individual assessment objectives were defined. As the simulator exercises evolved, some of these smaller exercises were incorporated into longer and more complex exercises. At the completion of exercise development, a basic trade-off between the complexity of the exercise and the ease of performance measurement and the application of performance standards was identified. Those involved in this application of the assessment development method noted the inherent advantage of less complex simulator exercises that focus on a limited set of assessment objectives. The main advantages of this type of exercise are that assessment conditions can be more tightly controlled, and performance standards can be more precisely defined and applied.

## *Proficiency Criteria*

For the current application, performance standards were established through consultation between assessment development and ARPA experts. Individual assessment objectives were reviewed and performance measures were defined in the context of the particular simulator exercise that was used. Table 5 provides an example of the performance measures and standards corresponding to assessment objective 2.6 – *The speed and direction of target's relative movement, and the identification of critical echoes (in both relative and true motion modes of display.* For this assessment objective, there are four separate performance measures to be obtained for each vessel up to three times during the course of an exercise. However, a single set of standards can be applied to the measures throughout the exercises. As long as the reported vessel data are within the standards presented in Table 5, a candidate would "pass" this assessment objective. Appendix B provides a complete list of measures and standards for the present ARPA application.

**Table 5. Example of performance measures and standards for assessment objective 2.6 – *Identification of critical echoes: Target course, speed, CPA, and TCPA.***

| | Vessel Data Measures and Standards | | | |
|---|---|---|---|---|
| | **Course** | **Speed** | **CPA** | **TCPA** |
| Standard for "Pass" Performance | ± 4° | ± 1 kn | ± 0.5 nm | ± 3 min |
| Standard for "Fail" Performance | *Outside performance standards for "pass"* | | | |

Although the current application yielded a comprehensive set of individual performance measures and standards, a more integrated set of proficiency criteria and scoring procedures was not developed as part of this effort. A more comprehensive proficiency criterion is needed at two levels: first, to judge if performance corresponding to an individual assessment objective with multiple performance measures is acceptable; and second, to judge if performance across the full range of assessment objectives in the assessment procedure is proficient. At the time of development, the lead ARPA expert for this study considered the development of such proficiency criteria as premature. A comprehensive pre-test of the individual measures and

standards with a representative sample of academy cadets was considered necessary prior to establishing proficiency criteria.

In certain cases, the ARPA assessment procedure represents a unique set of requirements. Preliminary performance standards can be set for the individual measures in the ARPA assessment. However, more familiarity with how candidates perform may be required prior to developing proficiency criteria and scoring procedures. In general, it is likely that complex watchstanding job requirements, such as ARPA operation, will require substantial trial application before setting proficiency criteria and scoring procedures. In addition, the available guidance regarding development of more integrated scoring procedures was very limited at the time of trial application. Thus, it appears that additional research and development are required to provide a more comprehensive assessment development method and corresponding practical guidance that addresses establishing proficiency criteria and scoring procedures.

## Assessment Package

In the present ARPA application, development of assessment materials was a time-consuming process that required several iterations of review and refinement. The final products of this effort were a programmed set of six exercises on the USMMA ARPA simulator and the final assessment materials. For the most part, assessment documentation served as a tool to track the assessment development process and was not, in itself, an undue burden. The results of this documentation effort are presented in the appendices to this report:

- **Appendix A:** ARPA assessment objectives, conditions, and performance measures.
- **Appendix B:** ARPA assessment simulator exercise specification (including performance measures and correct operator responses).
- **Appendix C:** Candidate instructions and worksheets for ARPA assessment (including all written questions).
- **Appendix D:** Assessor instructions for ARPA assessment.

The following documentation *is not provided* in the appendices of this report; however, it would be required for a complete assessment package:

- Reference materials for candidate review.
- Self-contained candidate pre-briefing materials.
- Proficiency scoring procedures and record forms.

## Summary of Application Findings

Overall, this trial application of the general method of developing assessment procedures found it to be useful in guiding the development of an objective and valid set of performance-based assessment procedures. The availability of researchers expert in training and assessment proved a valuable and even critical resource in guiding the marine educators through the development process. The high-fidelity ARPA simulator available at the USMMA was an excellent testbed,

providing the capabilities needed to support the assessment of this very complex mariner proficiency. During the trial, several aspects of the assessment method that required further consideration were identified. These included approaches to integrating individual performance measures and standards into proficiency criteria for larger units of performance. Also needed was more specific guidance on the useful content and format of the final assessment package to be handed over to the over-the-shoulder assessor and the candidate. In addition, this trial had centered on the use of a simulator in an academy setting and little consideration had been given to the requirements of shipboard assessment.

# CONCLUSIONS AND RECOMMENDATIONS

## *Conclusions*

This report describes a major effort to examine the *STCW Code* and the USCG requirements for performance-based assessments and to ensure that the best practices are available to the maritime industry in fulfilling those requirements. The effort addressed two principal objectives:

- Specify and refine a method for developing performance-based assessments of mariner skills and knowledge that is responsive to IMO and USCG guidance.
- Develop a performance-based assessment for ARPA operation that can serve as one example of an assessment procedure that conforms to the standards of competence in the *STCW Code*.

To fulfill the first objective, a team of researchers with expertise in training and assessment worked with marine educators from the USMMA to prepare a step-by-step method of developing assessments that was especially tailored for the current needs of the industry. To test and refine the method, the team applied it to the assessment of proficiency in a skill emphasized in the *STCW Code*, the operational use of ARPA. The team's success in fulfilling these objectives is documented here. Section 2 presents their systematic five-step method for the development of an assessment procedure; Section 3 describes their experience in applying it to ARPA. The appendices provide their ARPA assessment objectives, the needed simulator exercises, instructions for the assessor and the candidate, and worksheets to allow others to recreate their assessment procedures.

While substantial progress was made on these ambitious objectives, the trial application identified several aspects of the assessment process that merited additional examination. The team had available the USMMA ARPA laboratory, a high-fidelity, real-equipment-based simulator, and did not need to concern themselves with the capabilities of the setting to support their assessments. The team included expertise in the variety of disciplines that contribute to assessment development and had dedicated time for the project. Others in the industry are not likely to have these ample resources available and will need guidance on developing and conducting assessments with fewer resources. In addition, the trial ARPA assessment identified limitations to the guidance provided in the five-step method. While the method was effective in guiding the development of performance measures and standards for specific mariner actions, it did not provide scoring techniques for integrating these measures into proficiency criteria for larger units of mariner performance. Also, the team found that further guidance was needed on the content of the instructions to be provided to the over-the-shoulder assessor. (Since the method is limited in guiding these specific aspects of assessment development, the ARPA illustration is limited there as well. Future users of these ARPA materials should consider augmenting these features.) Later phases of the research project focused on all these additional needs. The resulting project reports provide the additional guidance for the use of the industry, as described below.

The second phase of the research project provided a method to evaluate simulators in their capability to support the mariner in realistically demonstrating the performance to be assessed, and to support the instructor/assessor in preparing, controlling, monitoring, and recording assessment exercises. The general simulator evaluation method is presented in a second project report, along with example exercises and worksheets for evaluating PC-based ARPA simulators (Raby, Forsythe, McCallum, & Smith, 2000). The third project phase focused on the guidance that maritime instructors/assessors would need to apply the step-by-step method of assessment development without the assistance of assessment experts. The researchers worked with maritime instructors to prepare and refine the guidance that they needed for developing valid and reliable assessments. Workshop materials, a developer's manual, and sample assessments for both deck and engine room proficiencies are provided in a third project report (McCallum, Forsythe, Barnes, Smith, Macaulay, Sandberg, Murphy, & Jackson, 2000). During this additional refinement of the step-by-step method, techniques for combining individual performance measures and standards into proficiency criteria for larger units of performance were perfected and are included in the developer's manual.

The fourth and final phase of the project was an intense examination of the process of conducting over-the-shoulder assessments, especially in the demanding setting of a commercial ship. The training officers of a major shipping company worked with the research team to adapt previously developed assessments to the operations and equipment of their own ships and to prepare assessment packages for use by their regular ship officers in conducting trial shipboard assessments. A discussion of what was learned during the shipboard trials is presented in the final report of the project (McCallum, Barnes, Forsythe, Smith, Maynard, Blanchard, Hempstead, Martinez, Murphy, and Jackson, 2000). Also included are an assessor's manual and sample assessment materials for deck and engine proficiencies. The trials provided a detailed understanding of what is needed in the assessment package to support the activities of the assessor and the candidate.

## *Recommendations for Implementation of the Findings and Products*

For the most effective implementation of the project's findings on performance-based assessment and its supporting products, the following USCG and industry actions are recommended.

- The USCG should encourage the maritime industry to use the performance-based assessment method, as described in the project reports and materials. As a first step, the materials in this report should be made widely available, on the USCG STCW website (http://www.uscg.mil/stcw) and through the National Technical Information Service (NTIS). When the industry becomes more familiar with the method, it can serve as the basis for a new NVIC. In addition, the USCG should submit the supporting materials to the IMO subcommittee on Standards for Training and Watchkeeping and recommend their further distribution.
- The USCG should encourage further familiarity with the performance-based assessment approach by USCG staff, as a tool for discussions of assessment with the industry and for the review of procedures submitted for approval.

- The USCG should encourage the review and use of the performance-based assessment method and materials by those groups who are dealing with the important technical issues of assessment. These groups include the Maritime Academy Simulator Committee (MASC), the Merchant Marine Personnel Advisory Committee (MERPAC), and academy committees appointed by the Maritime Administration (MARAD) to address STCW issues. The materials can provide a common approach and a common basis for discussion.
- Those in the industry who are responsible for training and assessment of mariner proficiency in academies, training schools, and shipping companies should make use of the performance-based assessment method and the materials presented here as a guide for their own development of assessment procedures. All the project materials are especially appropriate for inclusion in train-the-trainer courses. The developer's manual and the assessor's manual are also appropriate for those who do not take such courses.

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## GLOSSARY

**Assessor.** Anyone who conducts an assessment or evaluation of an individual's proficiency. Although the use of the term *assessor* is retained in some discussions of STCW requirements, including NVIC 4-97 on company roles and responsibilities, the term *designated examiner* is used for *assessor* in the U.S. implementing regulations.

**Assessment.** The process of evaluating whether an individual's performance meets established *proficiency criteria*. The terminology used for this process in the U.S. implementing regulations includes both an *examination* for knowledge and an *assessment* based on a *practical demonstration* as witnessed by a *designated examiner*.

**Assessment conditions.** The *assessment conditions* define the setting, tools, references, aids, and safety precautions that are in place at the time that a candidate's proficiency is assessed.

**Assessment objective.** A critical requirement of job performance that can be measured and assessed. Assessment objectives include skills and knowledge required by the job. A complete *assessment objective* description includes the required mariner performance, the conditions of assessment, and the standards of performance for successful accomplishment of the objective.

**Assessment procedures.** The activities that are conducted in administering the assessment of a candidate's proficiency. The term *assessment procedure* can be used to describe either the actions taken or the written instructions and activity descriptions that are carried out in conducting an assessment.

**Checklist.** A type of subjective measure that requires the assessor to observe the candidate's performance, or outcome of performance, and choose one of two performance levels, typically labeled "pass" and "fail."

**Competence.** Broadly defined job requirements that are described on the basis of training, experience, and job skills. The *standards of competence* as defined in the *STCW Code*, are the "levels of proficiency to be achieved for the proper performance of functions on board ship."

**Designated examiner.** A person who has been trained or instructed in techniques of training or *assessment* and is otherwise qualified to administer performance assessment procedures. In practice, the *designated examiner* evaluates whether the candidate's performance meets an established *proficiency criterion* to earn credit toward the license, document, or endorsement. Further details on the qualifications of *designated examiner* can be found in NVIC 6-97.

**Duty.** An ongoing responsibility within a job. It usually requires the performance of multiple tasks (e.g., officer in charge of the engineering watch, lookout, helmsman).

**Evaluation criteria.** The *evaluation criteria* comprise the general *standards of competence*. In practice, the *evaluation criteria* are further defined on the basis of *performance measures*, *performance standards*, and *proficiency criteria*. This term is defined in the *STCW Code* as the "entries appearing in column 4 of the *Specification of Minimum Standard of Competence* tables in part A."

**Job.** A post of employment consisting of a cluster of related work responsibilities and duties (e.g., chief engineer, third mate, able-bodied seaman). In the *STCW Code*, a job is further defined on the basis of licensure level (e.g., officer in charge of a navigational watch on ships of 500 gross tonnage or more).

**Knowledge.** The learned concepts, cues, facts, rules, and procedures that are necessary for proficient performance of a task (e.g., knowledge of algebra, knowledge of the Navigation Rules, knowledge of procedures for starting the main engine).

**Objective measure.** A measure that relies primarily upon measurement apparatus that can be calibrated to yield highly consistent and accurate measurement results.

**Performance measure.** The procedures used for observing and recording mariner actions, or the outcome of those actions. Performance measures record either the process of performance or the product of performance.

**Performance standard.** The acceptable or target level established for individual *performance measures. Performance measures* and *performance standards* are combined on the basis of *scoring procedures* to establish *proficiency criteria* for a proficiency.

**Proficiency.** An individual's demonstrated ability to meet job performance requirements, as established on the basis of *performance measures*, *performance standards*, and *proficiency criteria.*

**Proficiency criteria.** The scoring procedures applied in determining the proficiency level of a candidate on the basis of *performance measures* and *performance standards.*

**Qualified instructor.** According to the United States implementing regulations, "the person who has been trained or instructed in instructional techniques and is otherwise qualified to provide required training to candidates for licenses, documents, or endorsements." Further details on the qualifications of *qualified instructors* can be found in NVIC 6-97.

**Rating.** A type of subjective measure that requires the assessor to observe the candidate's performance, or outcome of performance, and choose one of three or more performance levels.

**Reliability.** The *consistency* of a measurement procedure. In the context of assessment, reliability generally can be defined as the consistency of the assessment outcome when applied under comparable conditions. The reliability of an assessment establishes the maximum level of possible assessment *validity*. That is, an assessment cannot be any more valid than it is reliable.

**Scoring procedure.** The defined procedures for combining individual *performance measures* and *performance standards* in the application of *proficiency criteria.*

**Skills and abilities.** The behaviors that must be applied in successful performance (e.g., typing skills, equipment fault-finding skills, navigation skills, shiphandling skills). Measurable and observable skills are those of interest in proficiency assessment.

**Subjective measure.** A measure that relies primarily upon an *assessor's* observation and interpretation of mariner performance to determine the assessment outcome.

**Task.** A single, observable work assignment that is independent of other actions and results in a valuable outcome. A task must be observable, be a complete work assignment, have a specific beginning and end, and be able to be measured by its intended product or outcome.

**Validity.** In the context of assessment, validity can be defined as the degree to which an assessment accurately reflects the skill, knowledge, and performance requirements of the job. The maximum validity of an assessment is established on the basis of its *reliability.* That is, an assessment cannot be any more valid than it is reliable.

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# APPENDIX A—ARPA Assessment Objectives, Conditions and Performance Measures

Appendix A provides a detailed description of the 27 ARPA assessment objectives derived from the amended STCW requirements (IMO, 1996). The appendix is divided into six tables, corresponding to the following assessment objectives:

1. Setting up and maintaining displays.
2. Situation assessment.
3. Knowledge of factors affecting ARPA performance and accuracy.
4. Parallel indexing.
5. Application of the International Rules for the Prevention of Collisions at Sea (COLREGS) and operation of trial maneuver.
6. Use of operational warnings and system tests.

Each table is divided into four columns. In the first column each assessment objective is described in detail. Each objective was derived from the amended *STCW Code* from either Table A-II/1 or Section B-I/12, the sections in which ARPA proficiency standards are described. The *STCW Code* reference for each objective is provided in the second column (IMO, 1996).

In the third column the simulated conditions necessary to measure each assessment objective are described, and the simulation exercises developed to correspond to the assessment conditions are cited. For example, objective 1.6, *Display characteristics and an understanding of when to use ground- or sea-stabilized modes*, requires a scenario which includes navigation down a narrow channel with a cross current and at least one threat vessel. In the present application, the exercise that was developed to meet these conditions was exercise E.

The fourth column describes the performance measures for each test objective. These performance measures should be applicable to the corresponding assessment objectives as long as the general, requisite assessment conditions are met.

Twenty-one of the 27 assessment objectives are measured using simulator-based exercises described in Appendix B. However, three objectives are measured using written test questions because they were determined to be the most logistically feasible assessment method: (1) 2.5 - *Knowledge and recognition of historic data as a means of indicating recent maneuvering of targets*; (2) 3.4 - *An appreciation of the IMO performance standards for ARPA,* in particular the standards relating to accuracy; and (3) 6.3 - *Precautions to be taken after a malfunction occurs.* The questions for each of these objectives follow a simulation exercise in which a related objective is assessed.

For three additional objectives it was determined that mariner performance depended highly on the type of ARPA equipment used, therefore the assessment conditions and performance measures for these objectives are to be determined by the individual assessor: (1) 2.4 – *The use of graphic representation of danger areas*; (2) 6.2 - *Methods of testing for malfunctions of*

*ARPA systems including functional self-testing*; and (3) 6.4 - *Ability to perform system checks and determine data accuracy of ARPA, including the trial maneuver facility, by checking against the basic radar plot.*

**Table A-1. ARPA assessment objectives that address *setting up and maintaining displays*.**

| Assessment Objective | STCW Reference | Assessment Conditions | Performance Measure |
|---|---|---|---|
| 1.1 The selection of display presentation; stabilized relative motion displays and true motion displays | 32.2<br>Sect. B-I/12 | **Exercise A**<br>Initial ARPA set-up<br>• Instructions for set-up of display mode and presentation | 1.1.1 Display mode and presentation |
| 1.2 The selection, as appropriate, of required speed and compass input to ARPA | 32.4<br>24.2<br>24.1<br>Sect. B-I/12 | **Exercise A**<br>Initial ARPA set-up<br>• Instructions for set-up of speed and compass input | 1.2.1 Speed log input<br>1.2.2 Compass input |
| 1.3 The selection of ARPA plotting controls, manual/automatic acquisition, vector/graphic display of data | 32.5<br>Sect. B-I/12 | **Exercise A**<br>Initial ARPA set-up<br>• Instructions for set-up of acquisition rings and manual target acquisition | 1.3.1 Acquisition ring (guard zone) settings<br>1.3.2 Targets manually acquired |
| 1.4 The selection of the vector time scale | 32.6<br>Sect. B-I/12 | **Exercise B**<br>Initial ARPA set-up<br>• Instructions for setting vector time scale | 1.4.1 Vector time scale |
| 1.5 The use of exclusion areas when automatic acquisition is employed by ARPA | 32.7<br>Sect. B-I/12 | **Exercise B**<br>Initial ARPA set-up<br>• Instructions for setting exclusion area | 1.5.1 Exclusion zone settings |
| 1.6 Display characteristics and an understanding of when to use ground- or sea-stabilized modes | 21.0<br>Sect. B-I/12 | **Exercise E**<br>Own ship navigating down narrow channel with cross wind/current and other vessel | 1.6.1 Maintenance of ship position and course<br>1.6.2 Determination of aspect of other vessels |

**Table A-2. ARPA assessment objectives that address *situation assessment*.**

| Assessment Objective | STCW Reference | Assessment Conditions | Performance Measure |
|---|---|---|---|
| 2.1 Understanding the criteria for the selection of targets by automatic acquisition | 25.1<br>Sect. B-I/12 | **Exercises A and B**<br>ARPA set-up<br>• Instructions for setting of guard zones | 2.1.1 Guard zone settings (same as performance measure 1.3.1) |
| 2.2 Appreciation of the uses, benefits and limitations of ARPA operational warnings | 27.0<br>Sect. B-I/12 | **Exercise B**<br>ARPA set-up<br>• Instructions for setting safe limit | Safe limit settings<br>Safe limit warning<br>Guard zone warning |

**Table A-2. ARPA assessment objectives that address *situation assessment.* (Continued)**

| Assessment Objective | STCW Reference | Assessment Conditions | Performance Measure |
|---|---|---|---|
| 2.3 Detection and identification of false echoes, sea return, racons, and Search and Rescue Transponders (SARTs) | Table A | **Exercise B**<br>Racon included in exercise<br>*SARTs are not currently available at USMMA ARPA simulator* | 2.3.1 Identification of racon code |
| 2.4 The use of graphic representation of danger areas | 30.1<br>Sect. B-I/12 | Due to variations in equipment characteristics, assessor-determined | *Assessor-determined* |
| 2.5 Knowledge and recognition of historic data as a means of indicating recent maneuvering of targets | 31.0<br>Sect. B-I/12 | **Exercise A**<br>Instruction to demonstrate vessel history display<br>**Written questions:**<br>Display of vessel history patterns (administered at the end of exercise A) | 2.5.1 Demonstration of vessel history display<br>2.5.2 Identification of vessel history patterns on paper facsimile of an ARPA display |
| 2.6 The speed and direction of target's relative movement, and the identification of critical echoes (in both relative and true motion modes of display) | 26.0, 34.1, 34.2, 34.3, 34.4<br>Sect. B-I/12 | **Exercise A**<br>Dead in the water target<br>**Exercise C**<br>True motion<br>**Exercise D**<br>Relative motion<br>Instruction to report accurate speed and direction of target relative movement as soon as possible | 2.6.1 Time of reporting speed and direction of target relative movement<br>2.6.2 Reported speed and direction of target relative movement<br>2.6.3 Reported speed and direction of dead in the water (DIW) target |
| 2.7 Detecting course and speed changes of targets and the limitations of such information (in both relative and true motion modes of display) | 26.0<br>34.5<br>Sect. B-I/12 | **Exercise C**<br>True motion<br>**Exercise A and Exercise D**<br>Relative motion<br>Other vessel course and speed changes<br>Instruction to update vessel data as required | 2.7.1 Time of reporting other vessel data following other vessel course/ speed change<br>2.7.2 Reported vessel data following course/speed change |
| 2.8 The effect of changes in own ship's course or speed or both (in both relative and true motion modes of display) | 26.0<br>34.6<br>Sect. B-I/12 | **Exercise C**<br>True motion<br>**Exercise A**<br>Relative motion<br>Own vessel course or speed change<br>Instruction to update vessel data as required | 6.3.1 Time of reporting other vessel data following own ship course/speed change<br>2.8.2 Reported vessel data following own ship course/speed change |

## Table A-3. ARPA assessment objectives that address *knowledge of factors affecting performance and accuracy.*

| Assessment Objective | STCW Reference | Assessment Conditions | Performance Measure |
|---|---|---|---|
| 3.1 Knowledge of effects of limitations of radar range and bearing on the accuracy of ARPA data | 24.1<br>Sect. B-I/12 | **Exercise F**<br>Three vessels on same initial bearing, with two on collision course and fourth vessel on a different bearing<br>Instructions to report valid target data as soon as possible | 3.1.1 Reported vessel data |
| 3.2 The circumstances causing "target swap" and their effects on display data | 25.4<br>Sect. B-I/12 | **Exercise C**<br>Vessels in open water passing one another and buoys | 3.2.1 Identification of pairs of targets where swap is likely to occur |
| 3.3 The effects on tracking of "lost" targets and target fading | 25.3<br>Sect. B-I/12 | **Exercise A**<br>Loss of target track and sounding of "target lost" alarm | 6.3.1 Identification of lost target alarm<br>3.3.2 Reacquisition of lost target |
| 3.4 An appreciation of the IMO performance standards for ARPA, in particular the standards relating to accuracy | 22.0<br>Sect. B-I/12 | **Written questions**<br>(administered at the end of exercise F) | 3.4.1 Correct responses to written questions |

## Table A-4. ARPA assessment objectives that address *parallel indexing.*

| Assessment Objective | STCW Reference | Assessment Conditions | Performance Measure |
|---|---|---|---|
| 4.1 Plotting parallel index lines to maintain position on planned course | Use of Radar and ARPA<br>Table A-II/1 | **Exercise B**<br>Instruction to draw parallel index lines to maintain three miles from land | 4.1.1 Location and bearing of parallel index lines |
| 4.2 Using parallel index lines to identify time of maneuver | Use of Radar and ARPA<br>Table A-II/1 | **Exercise B**<br>Instruction to change own vessel course in accordance with parallel index lines | 6.3.1 Ship heading at predetermined time in exercise<br>4.2.2 Ship distance from parallel index lines at predetermined time in exercise |

**Table A-5. ARPA assessment objectives that address *application of COLREGS and operation of trial maneuver.***

| Assessment Objective | STCW Reference | Assessment Conditions | Performance Measure |
|---|---|---|---|
| 5.1 The benefit of switching between true and relative vectors | 30.4<br>Sect. B-I/12 | **Exercise D**<br>Relatively complex and varied traffic conditions, including other vessel maneuvers<br>Request to identify lights that would be seen for each vessel | 5.1.1 Identification of other vessels' lights based on ARPA display |
| 5.2 Analysis of potential collision situations from displayed information, determination and execution of action to avoid close-quarters situations in accordance with COLREGS | 35.0<br>Sect. B-I/12 | **Exercise D**<br>Relatively complex and varied traffic conditions, including other vessel maneuvers<br>Request to identify whether or not there is a risk of collision with each of the other vessels<br>Request to identify applicable COLREGS for each of the other vessels | 6.3.1 Identification of whether or not there is a risk of collision with other vessels<br>5.2.2 Identification of applicable COLREGS for other vessels |
| 5.3 The operation of the trial maneuver facility | 34.7<br>Sect. B-I/12 | Exercise C **(true motion)**<br>Exercise D (relative motion)<br>Relatively complex and varied traffic conditions, including other vessel maneuvers<br>Instruction (at specific time) to calculate required new course when vessel bearing ___ is at ___ distance, to maintain a minimum CPA of ___. | 6.3.1 Calculated new course<br>6.3.1 Maintenance of minimum CPA between own ship and all other vessels<br>5.3.3 Resumption of base course after completion of trial maneuver |

**Table A-6. ARPA assessment objectives that address *use of operational warnings and system tests.***

| Assessment Objective | STCW Reference | Assessment Conditions | Performance Measure |
|---|---|---|---|
| 6.1 Performance checks of radar, compass, speed input sensors and ARPA | 32.8<br>Sect. B-I/12 | **Exercise C**<br>Speed log error during open waters operations | 6.1.1 Identification of and response to speed log error |
| 6.2 Methods of testing for malfunctions of ARPA systems including functional self-testing | 28.1<br>Sect. B-I/12 | *Assessor-determined* | *Assessor-determined* |
| 6.3 Precautions to be taken after a malfunction occurs | 28.2, 30.3<br>Sect. B-I/12 | **Written questions**<br>Questions concerning the validity of specific types of vessel data, given certain types of malfunction<br>(Administered at the end of exercise C) | 6.3.1 Recognition of which display data are valid after an equipment malfunction occurs |

**Table A-6. ARPA assessment objectives that address *use of operational warnings and system tests.* (Continued)**

| Assessment Objective | STCW Reference | Assessment Conditions | Performance Measure |
|---|---|---|---|
| 6.4 Ability to perform system checks and determine data accuracy of ARPA, including the trial maneuver facility, by checking against basic radar plot | 33.0<br>Sect. B-I/12 | *Assessor-determined* | *Assessor-determined* |

# APPENDIX B—ARPA Assessment Simulator Exercise Specification

Appendix B describes in detail the six ARPA simulation exercises developed using the present methodology to measure 21 of the objectives detailed in Appendix A.

Exercises A, B, C, D, E and F each are divided into five sections:

- **General Description**, including type of waters, weather considerations, complexity of the traffic situation, and details about which targets maneuver.
- **Assessment Objectives**, including the number and description of each test objective.
- **Vessel Data at the Beginning of the Exercise**, including own ship initial course and speed, and initial bearing, range, course speed, CPA, and TCPA for all targets.
- **Detailed Description** of the events that occur during the exercise, including the time and phase when they occur, as well as the assessment objective and performance measured in each event, and the correct operator response (the performance standard) for each performance measure.
- **Mechanical Plot of the Scenario**, with a plan view graphical depiction of the ships, buoys, racons, and land present in each exercise.

## *Exercise A*

### General Description

- Open waters scenario with mix of other vessels
- Own ship and target E maneuver
- Target D reduces speed
- Target C is lost (due to instructor moving target), resulting in lost target alarm actuation

### Assessment Objectives

1.1 Selection of display presentation

1.2 Set-up of speed and compass input

1.3 Selection of plotting controls and of vector/graphic display of data

2.1 Set-up of guard zone

2.5 Recognition of historic data as a means of indicating recent maneuvering (ARPA demonstration and written test)

2.6 Dead in water (DIW) vessel course readout variations and identification of critical echoes

2.7 Detecting course and speed changes of targets and the limitations of such information in relative motion

2.8 The effect of changes in own ship's course or speed or both in relative motion

3.3 Effect on tracking of "lost" targets

**Table B-1. Exercise A vessel data at 0100:00 (approximate).**

| Vessel | Bearing | Range | Course | Speed | CPA | TCPA |
|---|---|---|---|---|---|---|
| Own Ship | not applicable | not applicable | 090 | 20 | not applicable | not applicable |
| *A* | 073 | 10.4 | DIW | DIW | 3.0 | 01:30:00 |
| *B* | 090 | 10.0 | 090 | 7 | 0.0 | 01:47:00 |
| *C* | 131 | 10.6 | 000 | 23 | 1.4 | 01:21:00 |
| *D* | 285 | 8.2 | 090 | 25 | 2.0 | 01:47:00 |
| *E* | 050 | 10 | 200 | 13 | 2.3 | 01:21:00 |

## Table B-2. Detailed description of exercise A.

| Time | Phase | Event | Assessment Objective | Performance Measure | Correct Operator Response |
|---|---|---|---|---|---|
| NA | Pre-test | Instructor sets speed log and compass to incorrect settings and sets display to unstabilized mode | NA | NA | NA |
| 0100:00 | Set-up | Operator sets speed log to 20.0 | 1.2 | 1.2.1 Speed log input | Manual input of 20.0 knots exactly |
| 0100:00 | Set-up | Operator sets compass to course 090 | 1.2 | 1.2.2 Compass input | 090° exactly on digital readout |
| 0100:00 | Set-up | Operator sets display presentation to a stabilized mode and is instructed to set vectors and presentation to relative motion; and set exclusion line 3 nm north of own ship | 1.1 | 1.1.1 Demonstration of course-up, North-up, and head-up display presentations and true and relative motion vector modes | Demonstration of course-up, North-up, and head-up display presentations; and true and relative motion vector modes |
| 0100:00 | Set-up | Operator demonstrates acquisition ring (guard zone) settings appropriate for equipment | 1.3 & 2.1 | 1.3.1 Acquisition ring settings<br>2.1.1 same as above | Raypath guard ring set to 6.0 nm; Raycas V guard rings set to 5 nm & 9 nm |
| 0101:00 | Simulation | Operator is instructed to manually acquire all targets | 1.3 | 1.3.2 Targets manually acquired | Targets manually acquired in accordance with instructions |
| 0101:00 | Simulation | Operator is instructed to record vessel data when appropriate | 2.6 | 2.6.1 Time of reporting vessel data | Vessel data reported 0103:00 to 0106:00 |
| 0103:00 to 0105:00 | Simulation | Operator records vessel data | 2.6 | 2.6.2 Reported vessel data<br>2.6.3 Reported speed & direction of DIW target | Acceptable ranges for vessel data:<br>*A*: DIW, CPA +/- .5 nm, TCPA +/-3 min.<br>*B*, *C*, *D*, *E*: Speed +/- 1 knot; Course +/- 4°; CPA +/- .5nm, TCPA[1] +/- 3 min. |
| 0106:00 | Simulation | Own ship changes course to 120° and operator is instructed to record vessel data when appropriate | 2.8 | 2.8.1 Time of reporting vessel data after own ship course or speed change | Vessel data reported 0109:00 to 0112:00 |
| 0109:00 to 0112:00 | Simulation | Operator records vessel data | 2.8 | 2.8.2 Reported vessel data after own ship course or speed change | Acceptable ranges for vessel data are same as for 2.6.2 above |
| 0112:00 | Simulation | Target *E* changes course to 180° | NA | NA | NA |

[1] For targets on parallel course and same speed, TCPA is not applicable

## Table B-2. Detailed Description of Exercise A (Continued)

| Time | Phase | Event | Assessment Objective | Performance Measure | Correct Operator Response |
|---|---|---|---|---|---|
| 0113:00 | Simulation | Target *C* is lost; warning sounds; operator is instructed to reacquire lost target | 3.3 | 3.3.1 Identification of lost target alarm<br>3.3.2 Reacquisition of lost target | Identification of lost target alarm<br>Reacquisition of lost target, *C* |
| 0114:00 | Simulation | Target *D* reduces speed to 15 knots | NA | NA | NA |
| 0115:00 | Simulation | Operator demonstrates display of vessel history and is instructed to record accurate vessel data when appropriate | 2.5 | 2.5.1 Demonstration of vessel history display | Vessel history actuated |
| 0115:00 to 0120:00 | Simulation | Operator records vessel data | 2.7 | 2.7.1 Time of reporting vessel data following course/speed change<br>2.7.2 Recorded vessel data following target course/speed change | Vessel data recorded 0115:00 to 0120:00<br>Acceptable ranges for vessel data are same as for 2.6.2 above |
| Post-simulation | Written test | Operator identifies vessel history patterns on paper facsimile of an ARPA display | 2.5 | 2.5.2 Identification of vessel history patterns on written test | Answers: (14a) A, (14b) E, (14c) B, (14d) F, (14e) D |

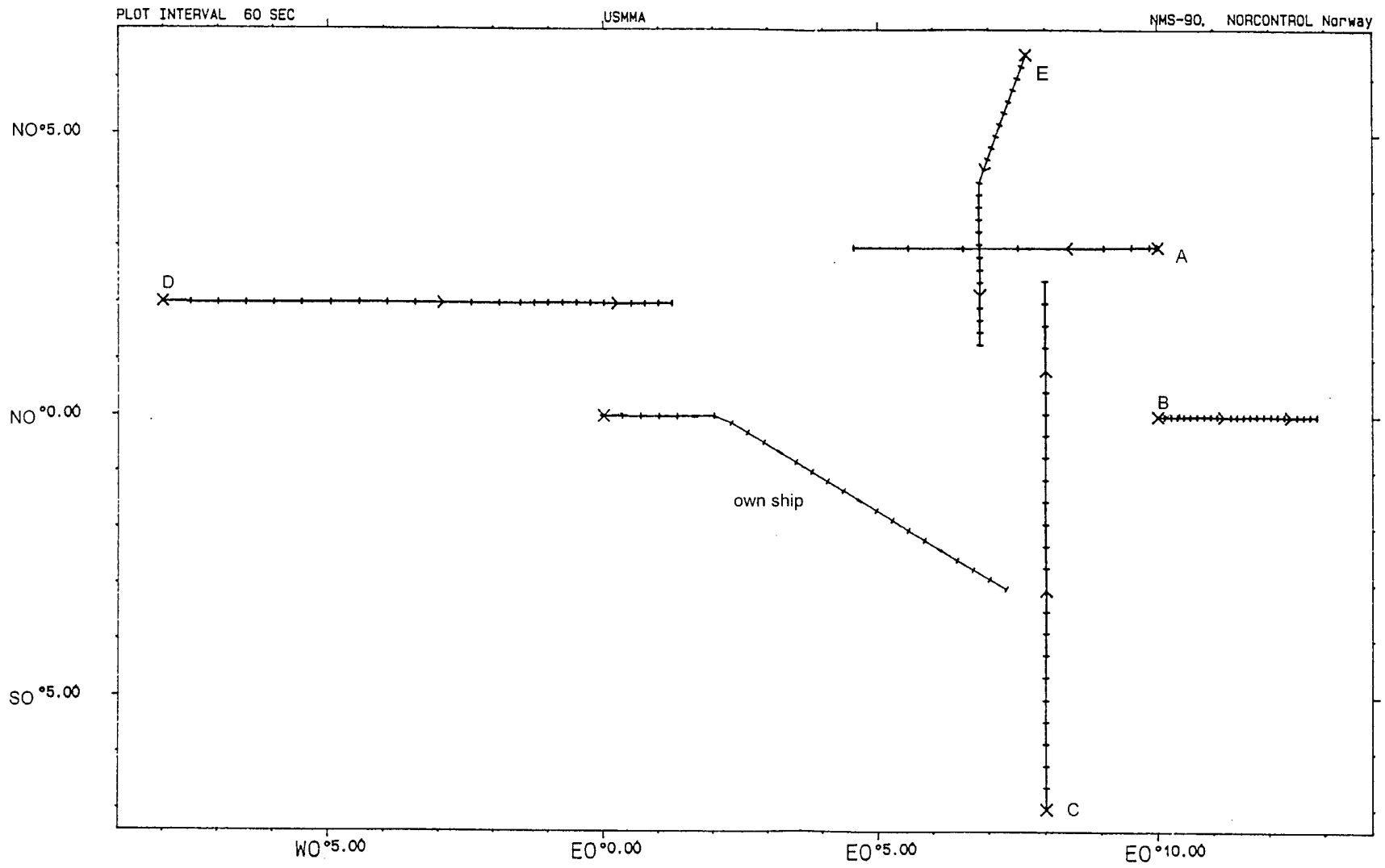



**Figure B-1. Plot of ARPA assessment exercise A.**

## *Exercise B*

### General Description

- Relatively complex traffic situation with coastline and rounding point
- Numerous DIW fishing vessels on same and different bearings
- Target *D* is a racon on coastline at Isla Tarifa
- Targets *B* & *E* maneuver
- Own ship maneuvers to 270° according to parallel index lines pre-drawn by student operator on reflection plotter to stay three miles from Isla Tarifa

### Assessment Objectives

1.4 Selection of time scale vectors in accordance with instructions

1.5 Use of exclusion areas when automatic acquisition is employed

2.2 Appreciation of the uses, benefits and limitations of operational warnings

2.3 Detection and identification of racon

4.1 Plotting parallel indexing lines to maintain position on planned course

4.2 Using parallel index lines to identify time of maneuver



**Table B-3. Exercise B vessel data at 1000:00 (approximate).**

| Vessel | Bearing | Range | Course | Speed | CPA | TCPA |
|---|---|---|---|---|---|---|
| Own Ship | NA | NA | 255 | 20 | NA | NA |
| A | 230 | 4.8 | 075 | 15 | 2.0 | 10:08 |
| B | 255 | 11.7 | 090 | 16 | 1.4 | 10:20 |
| C | 255 | 6.0 | 165 | 10 | 2.7 | 10:15 |
| D | 281 | 6.7 | DIW | DIW | 3.0 | 10:18 |
| E | 069 | 5.8 | 255 | 30 | 0.6 | 10:34 |
| F | 207 | 5.8 | DIW | DIW | 4.3 | 10:12 |
| G | 207 | 6.7 | DIW | DIW | 4.9 | 10:14 |

| Vessel | Bearing | Range | Course | Speed | CPA | TCPA |
|---|---|---|---|---|---|---|
| H | 214 | 6.3 | DIW | DIW | 4.2 | 10:14 |
| I | 207 | 4.3 | DIW | DIW | 3.2 | 10:09 |
| J | 296 | 4.0 | DIW | DIW | 2.6 | 10:09 |
| K | 296 | 3.0 | DIW | DIW | 2.0 | 10:07 |
| L | 311 | 4.0 | DIW | DIW | 3.3 | 10:07 |
| M | 312 | 3.0 | DIW | DIW | 2.5 | 10:05 |
| N | 300 | 3.0 | DIW | DIW | 2.6 | 10:09 |

## Table B-4. Detailed description of exercise B.

| Time | Phase | Event | Assessment Objective | Performance Measure | Correct Operator Response |
|---|---|---|---|---|---|
| NA | Pre-test | Instructor sets vectors to 3 minutes | NA | NA | NA |
| 1000:00 | Set-up | Operator instructed to select display presentation he or she prefers | 1.1 | measured in Exercise A | see Exercise A |
| 1000:00 | Set-up | Operator sets safe limits to 2 nm & 24 min | 2.2 | 2.2.1 Safe limit settings | Safe limits set in accordance with instructions |
| 1000:00 | Set-up | Operator sets vectors to 6 minutes | 1.4 | 1.4.1 Vector time scale | Vector scale set at exactly 6.0 |
| 1000:00 | Set-up | Operator instructed to draw parallel index lines to maintain 3 mile distance from land at bearing 180° from Isla Tarifa | 4.1 | 4.1.1 Location and bearing of parallel index lines | Lines drawn in accordance with instructions |
| 1000:00 | Set-up | Operator sets guard zone at 3 miles | 1.3 & 2.1 | measured in Exercise A | see Exercise A |
| 1000:00 | Set-up | Operator instructed to set exclusion area to exclude southerly fishing vessels (*E*, *F*, *G*, *H*, & *I*) and land | 1.5 | 1.5.1 Exclusion zone settings | Exclusion zone should cover some portion of guard zone near fishing vessels, exclude land and southerly fishing vessels, and include non-fishing vessels |
| 1000:00 | Set-up | Instructor checks safe limits, guard zone, exclusion zone, vector settings and parallel index lines | 1.3, 1.4, 1.5, 2.1, 2.2, 4.1 | see above | see above |
| 1001:00 | Simulation | Own ship gets underway; operator asked to identify the code for any and all racon(s) present | 2.3 | 2.3.1 Identification of racon code(s) | Racon code for *D*: Isla Tarifa |
| 1001:00 | Simulation | Operator instructed to manually acquire all targets except fishing vessels to the north & to record vessel data when appropriate | 1.3 | measured in Exercises A and D | see Exercises A and D |
| 1001:00 | Simulation | Operator instructed to identify warning | 2.2 | 2.2.2 Safe limit warning | Safe limit warning identified |
| 1001:00 to 1005:00 | Simulation | Operator instructed to identify any other warning(s) | 2.2 | 2.2.3 Guard zone warning | Guard zone warning identified |
| 1003:00 to 1006:00 | Simulation | Operator records vessel data | 2.6 | measured in Exercises A and D | see Exercises A and D |
| 1018:00 | Simulation | Operator instructed to change own vessel course to 270°, keeping the point of land at 3 nm, in accordance with parallel index lines | 4.2 | 4.2.1 Ship heading at predetermined time in exercise<br>4.2.2 Ship distance from parallel index lines at predetermined time in exercise | Own ship heading at 1018:00 is 270°<br>Ship distance from parallel index lines at 1018:00 is .5 nm on either side of the lines |

## Table B-4. Detailed description of exercise B. (Continued)

| Time | Phase | Event | Assessment Objective | Performance Measure | Correct Operator Response |
|---|---|---|---|---|---|
| 1018:00 | Simulation | Vessel *E* changes course to 285° | NA | NA | NA |
| 1019:00 | Simulation | Vessel *B* changes course to 020° | NA | NA | NA |
| 10:0:00 | Simulation | Operator instructed to identify any vessels that changed course or speed and record new vessel data | 2.7 | measured in Exercises A, C & D | see Exercises A, C & D |

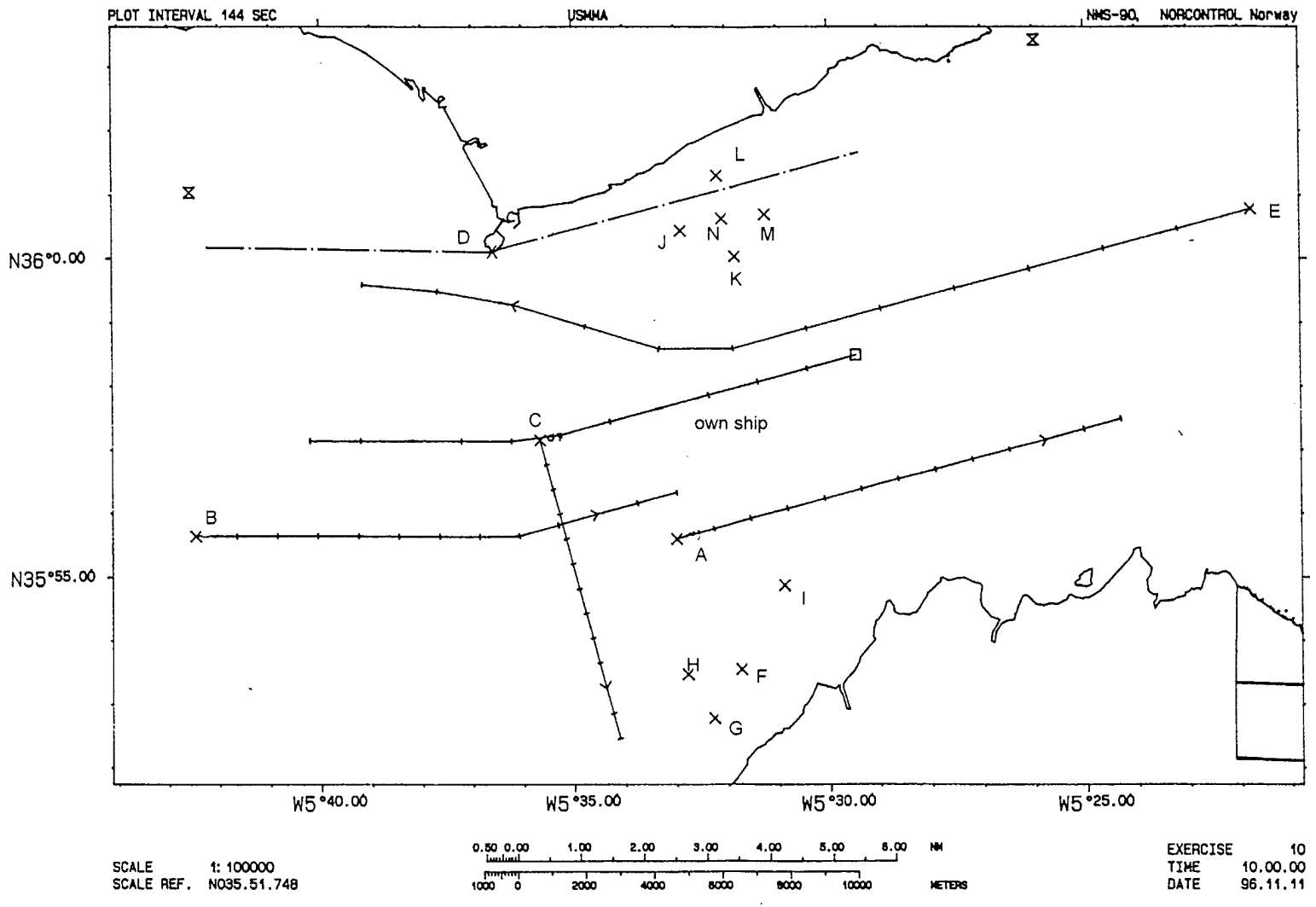



**Figure B-2. Plot of ARPA assessment exercise B.**

## *Exercise C*

### General Description

- Open waters with mix of other vessels and buoys
- True motion display and vectors
- Trial maneuver is calculated and executed
- Target *D* changes course and speed; Target *A* changes course
- Speed log is disabled by instructor

### Assessment Objectives

2.6 The speed and direction of target's relative movement and the identification of critical echoes

2.7 Detecting course and speed changes of targets, and the limitations of such information

2.8 The effect of changes in own ship's course or speed or both

3.2 The circumstances causing "target swap" and its effects on display data

5.3 The operation of the trial maneuver facility in true motion

6.1 Use of digital readout when speed log fails

6.3 Precautions to be taken after an ARPA equipment malfunction occurs (measured using written test)



**Table B-5. Exercise C vessel data at 0800:00 (approximate).**

| Vessel | Bearing | Range | Course | Speed | CPA | TCPA |
|---|---|---|---|---|---|---|
| Own ship | NA | NA | 180 | 15 | NA | NA |
| A | 090 | 10.0 | 215 | 16 | 2.0 | 09:30:00 |
| B | 158 | 10.8 | 315 | 9 | 1.0 | 08:29:00 |
| C | 210.5 | 11.7 | 060 | 16 | 0.1 | 08:23:00 |
| D | 270 | 6.0 | 090 | 18 | 3.8 | 08:10:00 |
| E | 304 | 7.1 | 190 | 28 | 7.2 | 08:07:00 |

| Vessel | Bearing | Range | Course | Speed | CPA | TCPA |
|---|---|---|---|---|---|---|
| F | 005 | 11.5 | 180 | 29.5 | 1.0 | 08:48:00 |
| G | 090 | 3.0 | DIW | DIW | 3.0 | 08:00:00 |
| H | | | DIW | DIW | | |
| I | | | DIW | DIW | | |
| J | | | DIW | DIW | | |

## Table B-6. Detailed description of exercise C.

| Time | Phase | Event | Assessment Objective | Performance Measure | Correct Operator Response |
|---|---|---|---|---|---|
| 0800:00 | Set-up | Operator selects true motion display | 1.1 | measured in Exercise A | see Exercise A |
| 0800:00 | Set-up | Operator sets safe limits to 3 nm and 20 min | 2.2 | measured in Exercise B | see Exercise B |
| 0801:00 | Simulation | Operator initializes speed log | 1.2 | measured in Exercise A | see Exercise A |
| 0801:00 | Simulation | Operator acquires all targets except three buoys with initial bearing 125, 130, and 132 | 1.3 | measured in Exercise A | see Exercise A |
| 0802:00 | Simulation | Operator instructed to record accurate vessel data | 2.6 | 2.6.1 Time of reporting vessel data | Vessel data reported 0802 to 0806 |
| 0802:00 to 08:06:00 | Simulation | Operator records accurate vessel data | 2.6 | 2.6.2 Reported vessel data | Acceptable ranges for vessel data:<br>*A*: DIW, CPA +/- .5 nm, TCPA +/-3 min.<br>*B, C, D, E*: Speed +/- 1 knot; Course +/- 4°; CPA +/- .5nm, TCPA[2] +/- 3 min. |
| 0804:00 | Simulation | Operator identifies vessels with potential for target swap | 3.2 | 3.2.1 Identification of target(s) with potential for swap | Target bearing 090° at 9 nm |
| 0806:00 to 0808:00 | Simulation | Operator instructed to calculate and record trial maneuver, and execute the maneuver by 0808:00 so that CPA is 3.0 or greater | 5.3 | 5.3.1 Calculated course change | Acceptable range for calculated course change: 240° +/- 5° |
| 08:08:00 | Simulation | Operator instructed to record vessel data after own ship maneuver | 2.8 | 2.8.1 Time of reporting other vessel data following own ship course or speed change<br>2.8.2 Reported vessel data | Vessel data reported 0811:00 to 0814:00<br>Acceptable ranges same as for 2.6.2 |
| 0811:00 to 0820:00 | Simulation | At console, instructor checks that CPA is 3+ miles for all targets | 5.3 | 5.3.2 Maintenance of minimum CPA between own ship & other vessels | CPA is 3.0 nm or greater for all targets |
| 0812:00 | Simulation | Instructor tells operator not to change course until after 0818:00 or later | NA | NA | NA |
| 0814:00 | Simulation | Target *D* changes speed to 30 kn. and changes course to 070° | NA | NA | NA |
| 0814:00 | Simulation | Target *A* changes course to 255° | NA | NA | NA |

[2] For targets on parallel course and same speed, TCPA is not applicable

## Table B-6. Detailed description of exercise C. (Continued)

| Time | Phase | Event | Assessment Objective | Performance Measure | Correct Operator Response |
|---|---|---|---|---|---|
| 0814:00 | Simulation | Instructor disables speed log | 6.1 | see below | see below |
| 0815:00 | Simulation | Instructor checks that manual speed log has been reset correctly | 6.1 | 6.1.1 Identification and response to speed log error | Speed log error identified and speed manually reset to 20 knots |
| 0817:00 to 0820:00 | Simulation | Operator instructed to identify targets that have changed course or speed or both and record new vessel data | 2.7 | 2.7.1 Time of reporting vessel data following course/speed change<br>2.7.2 Reported vessel data | Vessel data reported 0817:00 to 0820:00<br>Acceptable ranges same as for 2.6.2 |
| 0821:00 to 0824:00 | Simulation | Operator instructed to resume base course ASAP | 5.3 | 5.3.3 Resumption of base course after completion of trial maneuver | Base course of 180° resumed by 0824:00 |
| Post-simulation | Written test | Operator responds to questions regarding precautions to be taken when an ARPA equipment malfunction occurs | 6.3 | 6.3.1 Recognition of which display data are valid after an equipment malfunction occurs | Answers: (13a) B, C, D (13b) A, B, C, D (13c) G |

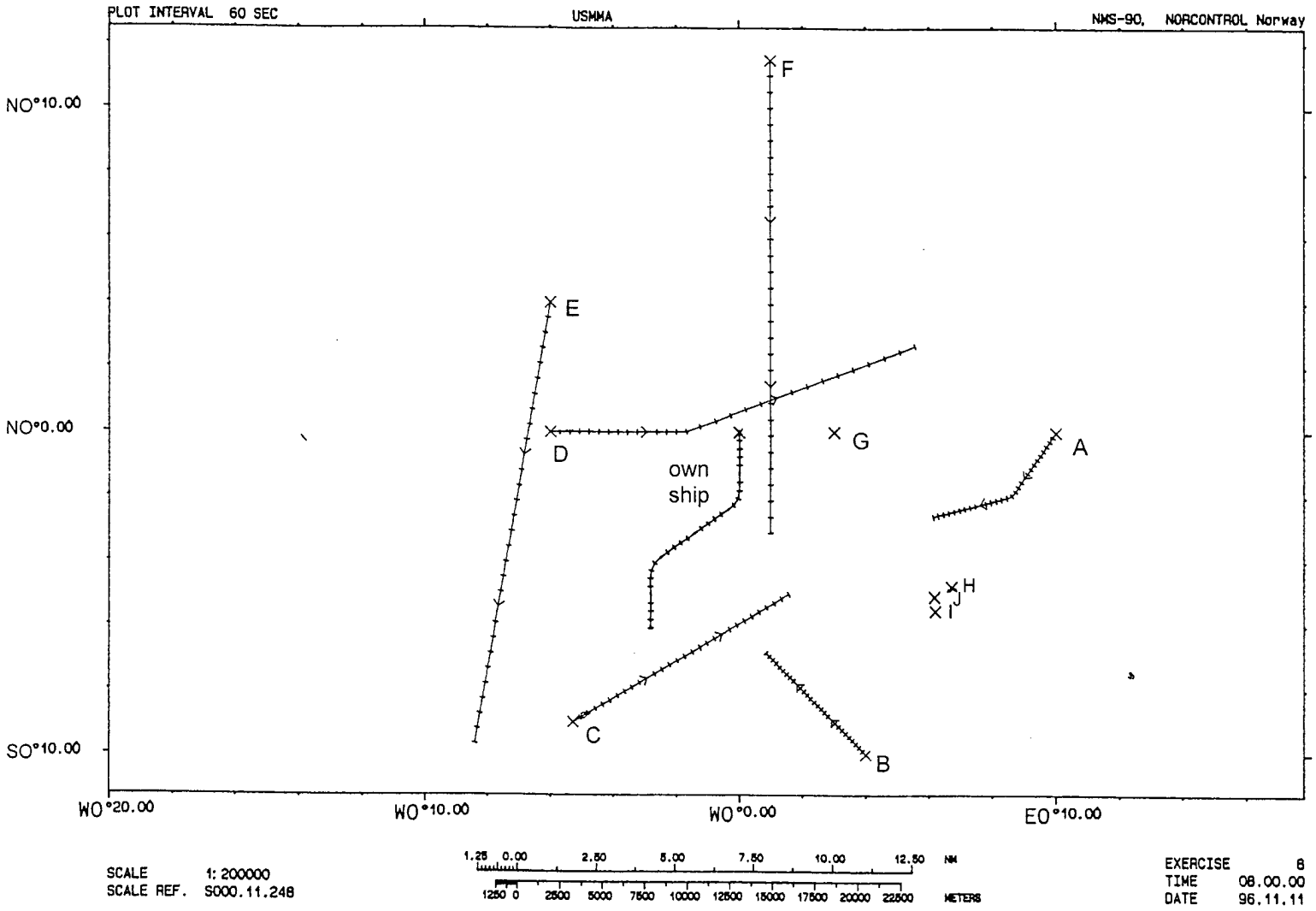



**Figure B-3. Plot of ARPA assessment exercise C.**

## *Exercise D*

### General Description

- Open waters situation with mix of other vessels
- Relative motion display and vectors
- Targets *A* & *G* maneuver; target *F* reduces speed
- Requires own ship maneuver, but involves ambiguous situation where most obvious own ship maneuver will result in a close quarters situation
- Also requires operator to resume base course 180° as soon as possible ensuring at least a three- mile minimum CPA on all targets

### Assessment Objectives

2.6 Speed and direction of target's relative movement and identification of critical echoes

2.7 Detection of course and speed changes of targets

5.1 Identification of probable lights on all targets

5.2 Recognition of COLREGS: overtaking, head-on, crossing, action of stand-on vessel; action of give-way vessel

5.3 Operation of the trial maneuver facility in relative motion

**Table B-7. Exercise D vessel data at 0600:00 (approximate).**

| Vessel | Bearing | Range | Course | Speed | CPA | TCPA | COLREGS Comments |
|---|---|---|---|---|---|---|---|
| Own Ship | NA | NA | 180 | 15.0 | NA | NA | NA |
| *A* | 090 | 10.0 | 270 | 27.0 | 4.9 | 17:00 | changes course to 300° at minute 12 (give-way) |
| *B* | 158 | 10.8 | 000 | 24.0 | 4.0 | 15:00 | no risk of collision |
| *C* | 298 | 11.5 | 080 | 9.0 | 0.4 | 37:00 | C is stand-on vessel; own ship gives way (crossing) |
| *D* | 270 | 6.0 | 195 | 11.0 | 5.3 | 38:00 | no risk of collision |
| *E* | 304 | 7.2 | 140 | 12.0 | 6.8 | 15:00 | no risk of collision |
| *F* | 040 | 10.0 | 180 | 30.0 | 6.4 | 31:00 | reduces speed to 15 knots (overtaking) |
| *G* | 180 | 11.5 | 000 | 5.0 | 0 | 35:00 | changes course to 040° (meeting) |

## Table B-8. Detailed description of exercise D.

| Time | Phase | Event | Assessment Objective | Performance Measure | Correct Operator Response |
|---|---|---|---|---|---|
| 0600:00 | Set-up | Operator sets display to relative motion | 1.1 | measured in Exercise A | see Exercise A |
| 0601:00 | Simulation | Operator acquires all targets | 1.3 | measured in Exercise A | see Exercise A |
| 0601:00 | Simulation | Operator instructed to assess targets using COLREGS | 5.2 | 5.2.1 Identification of risk of collision<br>5.2.2 Identification of applicable COLREGS | *A*: crossing (5 nm CPA)<br>*B*, *D*, *E*: no risk of collision<br>*C*: crossing (stand-on)<br>*F*: overtaking<br>*G*: meeting (both give way) |
| 0602:00 | Simulation | Operator instructed to record vessel data | 2.6 | 2.6.1 Time of reporting vessel data | Data reported during 0603:00 to 0612:00 |
| 0603:00 to 0612:00 | Simulation | Operator records vessel data | 2.6 | 2.6.2 Reported vessel data | Acceptable ranges for data:<br>Course +/-4°, Speed +/- 1 knot, CPA +/- .5 nm, TCPA +/- 3 min for all vessels |
| 0605:00 | Simulation | Operator instructed to report what lights are seen on each target on or before 0610:00 | 5.1 | 5.1.1 Identification of other vessels' lights based on ARPA display | *A*, *B*, *C*, *D*, & *E*: red<br>*F*: green; *G*: red and green |
| 0612:00 | Simulation | Target *A* changes course to 300° (give-way) | NA | NA | NA |
| 0612:00 | Simulation | Target *F* reduces speed from 30 to 15 knots | NA | NA | NA |
| 0613:00 | Simulation | Operator instructed to identify targets that have changed course or speed and record vessel data | 2.7 | Time of reporting vessel data following course/speed change<br>2.7.2 Reported vessel data following course or speed change(s) | Vessel data reported 0615:00 to 0617:00<br>Same as 2.6.2 above |
| 0617:00 | Simulation | Target *G* changes course to starboard to 040° | NA | NA | NA |
| 0617:00 | Simulation | Operator instructed to calculate and report course change ASAP for change when Target *C* is at 6 miles for a 3-mile CPA | 5.3 | 5.3.1 Calculated new course | Acceptable range: 225° - 245°<br>(232° is calculated) |
| 0618:00 | Simulation | At console, instructor checks that CPA is 3 + miles for all targets | 5.3 | 5.3.2 Maintenance of minimum CPA between own ship & other vessels | CPA is 3.0 nm or greater for all targets |
| 0633:00 | Simulation | Operator should resume base course of 180° | 5.3 | 5.3.3 Resumption of base course after completion of trial maneuver | Base course of 180° resumed by 0638:00 |

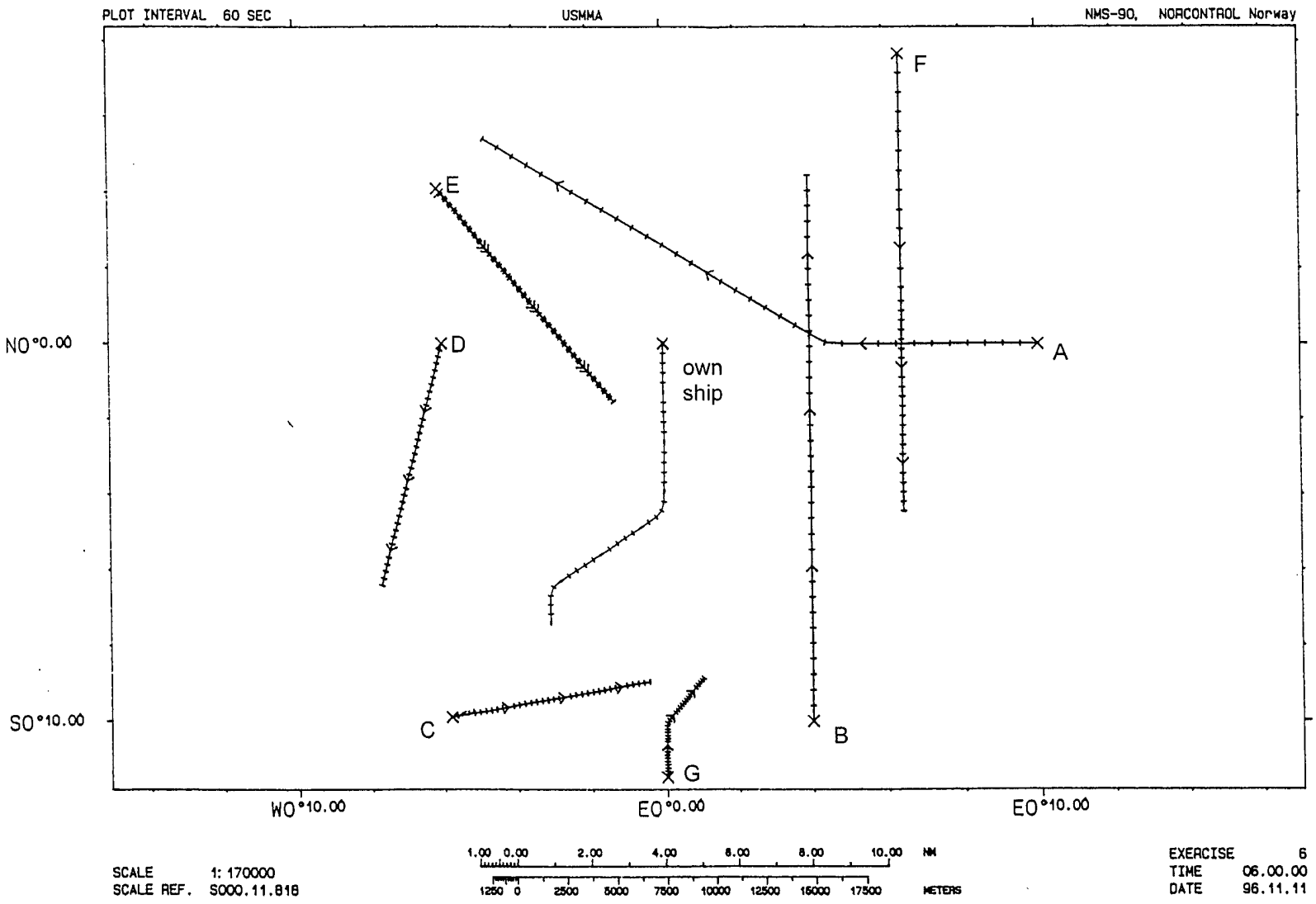



**Figure B-4. Plot of ARPA assessment exercise D.**

## *Exercise E*

### General Description

- Narrow channel navigation
- Cross current and/or wind requiring "crabbing" of ship down the channel; crabbing is facilitated by ground stabilized presentation mode
- Own ship is outbound
- One threat vessel is inbound

### Assessment Objective

1.6 Understanding of when to use ground- or sea-stabilized modes, and when to use north-up, course-up, and head-up presentations

**Table B-9. Exercise E vessel data at 1100:00 (approximate).**

| Target | Bearing | Range | Course | Speed | CPA | TCPA |
|---|---|---|---|---|---|---|
| Own ship | NA | NA | 180 | 15[3] | NA | NA |
| *A* | 167 | 7.0 | 347 | 11 | 0.2 | 17.5 |
| *B* | 172 | 4.0 | DIW | DIW | | |

[3] Full-ahead; varies based on depth of water under keel

## Table B-10. Detailed description of exercise E.

| Time | Phase | Event | Assessment Objective | Performance Measure | Correct Operator Response |
|---|---|---|---|---|---|
| 1100:00 | Set-up | Operator is given a chartlet for this exercise | NA | NA | NA |
| 1100:00 | Set-up | Operator is instructed to use ground-stabilized presentation mode | 1.1 | measured in Exercise A | see Exercise A |
| 1101:00 | Simulation | Operator instructed to set autodrift (groundlock) to target bearing 172° at 4 nm and manually acquire any northbound target(s) | 1.3 | measured in Exercise A | see Exercise A |
| 1101:00 | Simulation | Operator navigates own ship through channel avoiding buoys, land, and other target | 1.6 | 1.6.1 Maintenance of ship position and course | Bearing of 180° maintained with no groundings |
| 1102:00 | Simulation | Operator instructed to record vessel data for any inbound target(s) | 2.6 | measured in Exercises A, C, and D | see Exercises A, C, and D |
| 1113:00 | Simulation | After passing under bridge, operator reports lights that would be seen on Target *A* from 1113:00 to 1115:00 | 1.6 | 1.6.2 Determination of aspect of other vessel | Green lights |

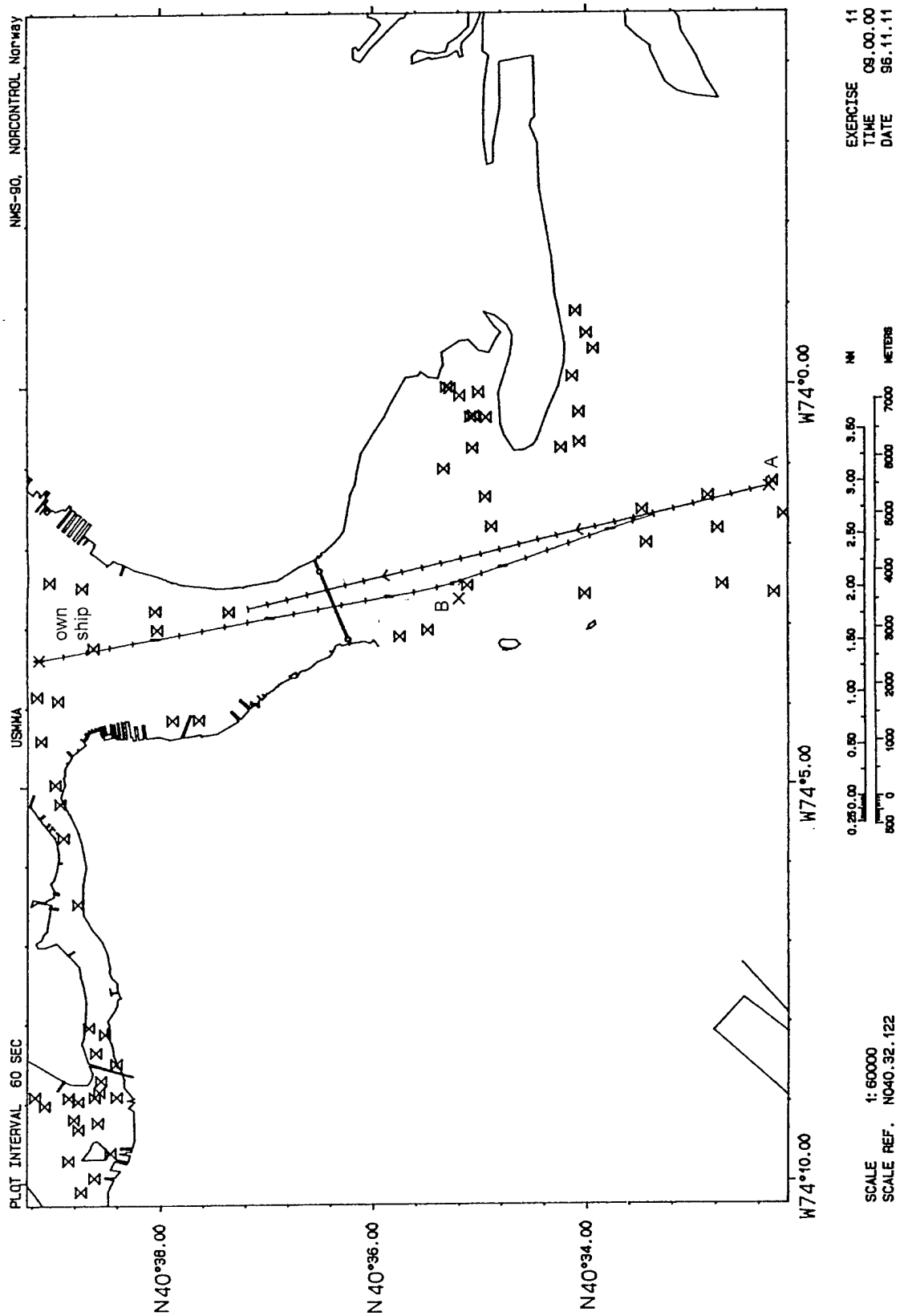



Figure B-5. Plot of ARPA assessment exercise E.

## *Exercise F*

### General Description

- Open waters situation with three targets, *A*, *B*, and *C*, starting at the same bearing
- Targets *A* and *C* on a collision course
- Operator required to assess danger and maneuver to starboard soon after recording vessel data to keep outside established CPA of 1 nm

### Assessment Objective

3.1 Knowledge of selected ARPA processing limitations and their effects on accuracy of ARPA data

**Table B-11. Exercise F vessel data at 0500:00 (approximate).**

| Vessel | Bearing | Range | Course | Speed | CPA | TCPA |
|---|---|---|---|---|---|---|
| Own Ship | NA | NA | 270 | 20.0 | NA | NA |
| A | 220 | 11.5 | 005 | 26.5 | 0 | 20 |
| B | 220 | 9.5 | 295 | 29.0 | 7.4 | 16 |
| C | 220 | 7.5 | 335 | 16.8 | 0 | 22.5 |
| D | 048 | 6.0 | 270 | 20.0 | 6.0 | NA |

## Table B-12. Detailed description of exercise F.

| Time | Phase | Event | Assessment Objective | Performance Measure | Correct Operator Response |
|---|---|---|---|---|---|
| 0500:00 | Set-up | Operator initializes ARPA in the display presentation and mode of his or her choice | 1.1 | measured in Exercise A | see Exercise A |
| 0500:00 | Set-up | Operator sets safe limits to 1 nm | 2.2 | measured in Exercise B | see Exercise B |
| 0501:00 | Simulation | Operator acquires all targets in the order that will give best information about potential collision | 1.3 | measured in Exercise A | see Exercise A |
| 0501:00 | Simulation | Operator instructed to record accurate vessel data on targets which have highest likelihood of collision | 3.1 | 3.1.1 Reported vessel data | Acceptable ranges for *C*: Course +/-4°; Speed +/-2 knots; CPA +/-.5nm; TCPA +/-3 min<br>Acceptable ranges for *D*:<br>Course +/-4°; Speed +/-3 knots;<br>CPA +/-.5nm; TCPA +/-3 min |
| 0506:00 | Simulation | Operator instructed to record accurate vessel data for rest of targets | 3.1 | 3.1.1 Reported vessel data | Acceptable ranges for *A* and *B*:<br>same as for *D* above |
| 0507:00 | Simulation | Operator instructed to calculate own ship course change for 1nm minimum CPA | 5.3 | measured in Exercise D | see Exercise D |
| 0507:00 to 0510:00 | Simulation | Operator must execute course change by 0510:00 for 1 nm CPA | 5.3 | measured in Exercise D | see Exercise D |
| Post-simulation | Written test | Instructor administers written test regarding IMO performance standards for ARPA, in particular those relating to accuracy | 3.4 | 3.4.1 Correct responses to written test | see below for answers to test |

### Answers to Written Test for Objective 3.4

| | | | | |
|---|---|---|---|---|
| 1) B | 6) A | 10) B | 14) B | 18) B |
| 2) D | 7) C | 11) A | 15) B | 19) B |
| 3) B | 8) A | 12) C | 16) B | 20) B |
| 4) A | 9) A | 13) B | 17) D | 21) B |
| 5) B | | | | |

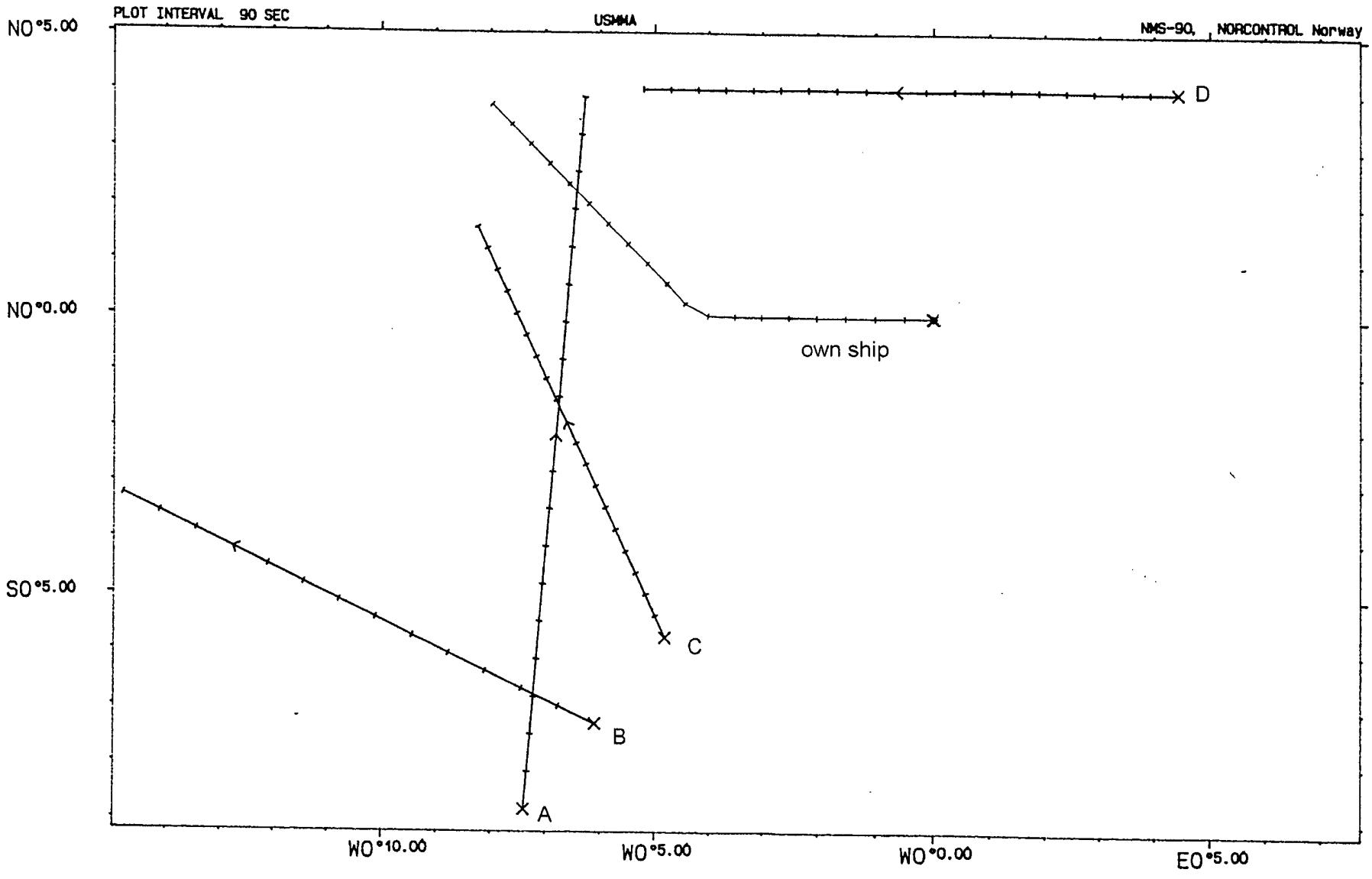



**Figure B-6. Plot of ARPA assessment exercise F.**

# APPENDIX C—Candidate Instructions and Worksheets for ARPA Assessment

Appendix C provides the vessel cards, instructions and worksheets for the candidates whose ARPA proficiency is assessed using the present exercises. There are two vessel cards: one for exercise E and another for exercises A, B, C, D and F. Exercises A, B, C, D, E, and F each have a candidate worksheet with instructions that correspond to exercise events involving the candidate. Instructions include the exercise time of day, the settings for own ship course and speed, and the settings for other pertinent display information, such as safe limits CPA and TCPA, guard zone, exclusion area, and vector time scale. The candidate worksheets also include tables in which vessel data can be recorded at various times during an exercise. Instructions for own ship maneuvers, parallel indexing and other candidate actions are also included on these worksheets.

Candidates respond to simulator-based questions directly on the worksheet for each exercise. For exercises A, C, and F a second, separate worksheet with multiple-choice, true/false or short answer test questions was designed. After the simulations end in exercises A, C, and F, the assessor collects the worksheets for the simulations and administers the test questions on the second worksheet.

| | |
|---|---|
| Vessel Name | Noel Mariner |
| Vessel Make | Cargo 9 |
| Built at: | |

**Vessel Dimensions**

| | Overall | Between Perpendiculars |
|---|---|---|
| Length | 194.6 | 182.9 |

| | Net | Gross |
|---|---|---|
| Tonnage | 15,000 DWT | |

| | Bridge to Bow | Bridge to Manifold | Bridge to Poop |
|---|---|---|---|
| Distance | 97.3 | 24.4 | |

| | | | |
|---|---|---|---|
| Keel to Top of Mast | | | |
| Height | 27.8 | Breadth | 24.4 |

**Maneuvering Speeds (Knots)**

| Engine Order | RPM | | LOADED | | LIGHT | |
|---|---|---|---|---|---|---|
| | Ahead | Astern | Ahead | Astern | Ahead | Astern |
| Full | 80 | -80 | 19.9 | -16.6 | N/A | N/A |
| Half | 65 | -65 | 16.1 | -13.4 | N/A | N/A |
| Slow | 40 | -40 | 9.95 | -8.4 | N/A | N/A |
| Dead Slow | 25 | -25 | 6.22 | -5.19 | N/A | N/A |

| | | |
|---|---|---|
| Time Full Ahead to Full Astern | 720 | SECS |

**Engine Information**

| Type of Plant | Bridge Control | Bow Thruster |
|---|---|---|
| Diesel | Yes | None |

| Astern Power | | Max Time Astern | | Critical RPM |
|---|---|---|---|---|
| 80 | % of ahead | N/A | MIN | |

**Maneuvering Data**

| Ships Speed (Knots) | Advance (yards) Loaded | Advance (yards) Light | Transfer (yards) Loaded | Transfer (yards) Light | Rudder (degrees) |
|---|---|---|---|---|---|
| Full 30° | 963 | N/A | 1225 | N/A | |
| Half 30° | 750 | | 1218 | | |
| Slow | | | | | |
| Dead Slow | | | | | |
| Full 20° | 1094 | N/A | 1410 | N/A | |
| Half 20° | 1019 | N/A | 855 | N/A | |
| Slow | | | | | |
| Dead Slow | | | | | |
| Full | | | | | |
| Half | | | | | |
| Slow | | | | | |
| Dead Slow | | | | | |
| Full | | | | | |
| Half | | | | | |
| Slow | | | | | |
| Dead Slow | | | | | |

**Loss of Speed in a Turn (Knots)**

| Rudder (DEG) | Full Loaded/Light | | Half Loaded/Light | | Slow Loaded/Light | | Dead Slow Loaded/Slow | |
|---|---|---|---|---|---|---|---|---|
| 20° | -3.3 | N/A | -2.3 | N/A | | N/A | | N/A |
| 30° | -4.6 | N/A | -3.3 | N/A | | N/A | | N/A |
| | | N/A | | N/A | | N/A | | N/A |
| | | N/A | | N/A | | N/A | | N/A |

| | | | |
|---|---|---|---|
| Drafts | FWD 9.8 | AFT | 9.8 |



**Figure C-1. Vessel card for exercises A, B, C, D, and F.**

| | |
|---|---|
| Vessel Name | Ove Skou |
| Vessel Make | Cargo |
| Built at: | Gdansk, Poland |

**Vessel Dimensions**

| | Overall | Between Perpendiculars |
|---|---|---|
| Length | 523.55 ft | 492.15 ft |

| | Net | Gross |
|---|---|---|
| Tonnage | 15,000 DWT | 40,000 DWT |

| | Bridge to Bow | Bridge to Manifold | Bridge to Poop |
|---|---|---|---|
| Distance | 413 ft. | N/A | 111 ft. |

| | | | |
|---|---|---|---|
| Keel to Top of Mast Height | 124.6 ft | Breadth | 81.7 ft. |

**Maneuvering Speeds (Knots)**

| Engine Order | RPM Ahead | RPM Astern | LOADED Ahead | LOADED Astern | LIGHT Ahead | LIGHT Astern |
|---|---|---|---|---|---|---|
| Full | 110 | -100 | 15.8 | -6.0 | N/A | N/A |
| Half | 90 | -82 | 13.0 | -3.8 | N/A | N/A |
| Slow | 60 | -60 | 8.4 | -2.7 | N/A | N/A |
| Dead Slow | 40 | -40 | 5.6 | -1.8 | N/A | N/A |

Time Full Ahead to Full Astern: 240 SECS

**Engine Information**

| Type of Plant | Bridge Control | Bow Thruster |
|---|---|---|
| Diesel | Yes | Yes/1 |

| Astern Power | | Max Time Astern | | Critical RPM |
|---|---|---|---|---|
| 100 | % of ahead | N/A | MIN | 25 |

**Maneuvering Data**

| Ships Speed (Knots) | Advance (yards) Loaded | Advance (yards) Light | Transfer (yards) Loaded | Transfer (yards) Light | Rudder (degrees) |
|---|---|---|---|---|---|
| Full | 1003 yds | N/A | 994 yds | N/A | 5 |
| Half | 1005 yds | N/A | 989 yds | N/A | 5 |
| Slow | 991 yds | N/A | 982 yds | N/A | 5 |
| Dead Slow | 985 yds | N/A | 979 yds | N/A | 5 |
| Full | 801 yds | N/A | 799 yds | N/A | 10 |
| Half | 800 yds | N/A | 794 yds | N/A | 10 |
| Slow | 786 yds | N/A | 786 yds | N/A | 10 |
| Dead Slow | 770 yds | N/A | 782 yds | N/A | 10 |
| Full | 645 yds | N/A | 612 yds | N/A | 20 |
| Half | 643 yds | N/A | 607 yds | N/A | 20 |
| Slow | 624 yds | N/A | 599 yds | N/A | 20 |
| Dead Slow | 616 yds | N/A | 595 yds | N/A | 20 |
| Full | 585 yds | N/A | 528 yds | N/A | 30 |
| Half | 579 yds | N/A | 523 yds | N/A | 30 |
| Slow | 560 yds | N/A | 515 yds | N/A | 30 |
| Dead Slow | 549 yds | N/A | 512 yds | N/A | 30 |

**Loss of Speed in a Turn (Knots)**

| Rudder (DEG) | Full Loaded | Full Light | Half Loaded | Half Light | Slow Loaded | Slow Light | Dead Slow Loaded | Dead Slow Slow |
|---|---|---|---|---|---|---|---|---|
| 30 | 10.4 | N/A | 7.6 | N/A | 4.8 | N/A | 3.2 | N/A |
| 20 | 9.5 | N/A | 6.9 | N/A | 4.4 | N/A | 2.9 | N/A |
| 10 | 7.7 | N/A | 5.6 | N/A | 3.5 | N/A | 2.3 | N/A |
| 5 | 6.2 | N/A | 4.5 | N/A | 2.8 | N/A | 1.9 | N/A |

Drafts FWD: 29.9 ft. AFT: 29.9 ft

**Figure C-2. Vessel card for exercise E.**

## *ARPA Assessment Exercise A*

**Name** _____ **ARPA Unit** _____

Exercise Time: 0100:00 Own Ship Course: 090° Own Ship Speed: 20.0 knots

*Section A*

1. Initialize ARPA to North-up, stabilized, relative motion mode and be prepared to demonstrate all types of display presentations and modes available on your ARPA unit.
2. Set guard ring (Raypath) to 6 nm.
3. Set guard rings (Raycas V) to 5 nm & 9 nm.
4. Set exclusion line(s) 3 nm north of you.
5. Set automatic acquisition rings.
6. As soon as your initial ARPA settings have been checked by the instructor, turn off automatic acquisition.
7. Manually acquire all targets on your display.
8. As soon as you are underway, record vessel data, and include the time you recorded the data for each target (e.g. 0105:00).

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 073 | A | | | | | |
| 090 | B | | | | | |
| 131 | C | | | | | |
| 285 | D | | | | | |
| 050 | E | | | | | |

9. Your ship is in a pre-programmed mode, and it changes course during the exercise. After the own ship course change, record new vessel data, and include the time you recorded the data for each target (e.g. 0101:00):

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 073 | A | | | | | |
| 090 | B | | | | | |
| 131 | C | | | | | |
| 285 | D | | | | | |
| 050 | E | | | | | |

10. When asked by the assessor, demonstrate the target history capability of your ARPA unit.

11. Identify any vessels that change course or speed and record new vessel data, and include the time you recorded the data for each target:

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 073 | A | | | | | |
| 090 | B | | | | | |
| 131 | C | | | | | |
| 285 | D | | | | | |
| 050 | E | | | | | |

## *ARPA Assessment Exercise A*

**Name** _____ **ARPA Unit** _____

*Section B*

12. Using the attached facsimile of an ARPA display, respond to the following questions regarding vessel history trails. Assume true vectors are displayed with vector length as 12 minutes and a 12-mile range scale, and two-minute history intervals.

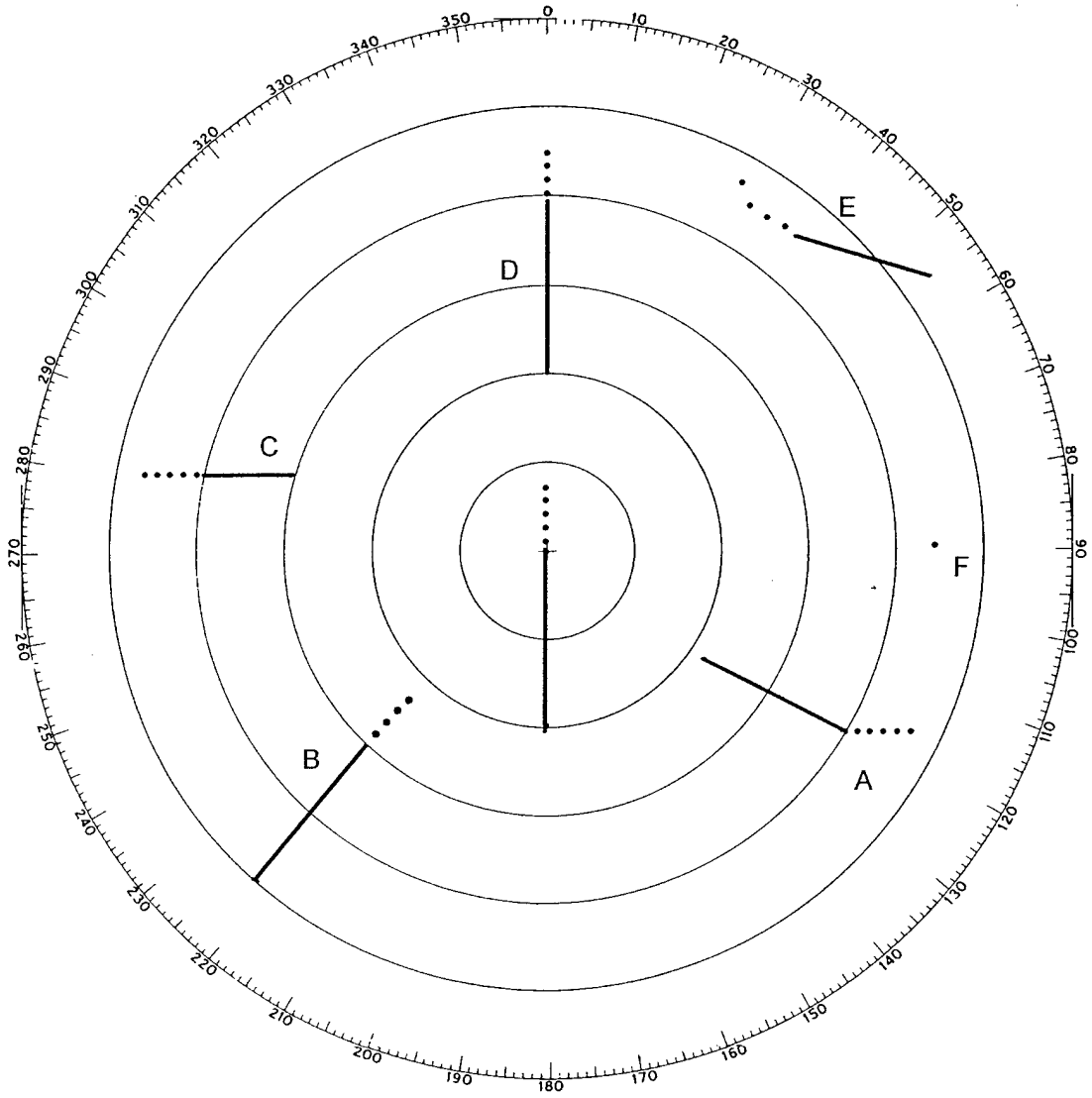
    a. What target, if any, changed course in the last two minutes? _____

    b. What target(s), if any, changed course several minutes ago? _____

    c. What target, if any, is increasing speed? _____

    d. What target is either dead in the water or recently acquired? _____

    e. What target has been tracked for at least three minutes but less than seven minutes? _____




True vector display
Vector length: 12 minutes
Range scale: 12 nm

Own ship initial course: 180 degrees
Own ship initial speed: 20 knots

**Figure C-3. Facsimile of an ARPA display for use in exercise A.**

## *ARPA Assessment Exercise B*

**Name** _____ **ARPA Unit** _____

Exercise Time: 1000:00 Own Ship Course: 255° Own Ship Speed: 20 knots

1. Initialize your ARPA unit with the display presentation and mode of your choice.
2. Set safe limits to 2 nm CPA and 24 minutes TCPA.
3. Set vector time scale to 6 minutes.
4. Set guard zone to 3 nm.
5. Draw parallel index lines to maintain 3-mile distance from land north of you.
6. Set exclusion line(s) 2.5nm south of own ship.
7. As soon as you are underway, identify the code(s) for any racon(s) present:

   _____

8. Manually acquire all pertinent targets on your display.
9. Record vessel data, and include the time you recorded the data for each target (e.g. 1005:00):

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 230 | A | | | | | |
| 255 @ 11.7 nm | B | | | | | |
| 255 @ 6.0 nm | C | | | | | |
| 069 | E | | | | | |
| 296 @ 3.0 nm | K | | | | | |

10. Record warnings that sound, if any, and the time they occurred:

| Warning | Time |
|---|---|
| | |
| | |
| | |

11. If one or more warnings sound, take the appropriate action for each warning.
12. At approximately 1018:00, maneuver to course 270° keeping the point of land at 3nm, in accordance with parallel index lines.

13. Identify any vessels that change course or speed and record new vessel data, and include the time you recorded the data for each target:

| **Initial Bearing** | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 230 | A | | | | | |
| 255 @ 11.7 nm | B | | | | | |
| 255 @ 6.0 nm | C | | | | | |
| 069 | E | | | | | |
| 296 @ 3.0 nm | K | | | | | |

## *ARPA Assessment Exercise C*

**Name** _____ **ARPA Unit** _____

Exercise Time: 0800:00 Own Ship Course: 180° Own Ship Speed: 15.0 knots

*Section A*

1. Initialize ARPA in true motion mode.
2. Set CPA safe limit to 3 nm and TCPA safe limit to 20 minutes.
3. As soon as you are underway, initialize speed log.
4. Acquire all targets except three buoys bearing 125°, 130°, 132° true.
5. Record data for all targets, and include the time you recorded the data for each target (e.g., 0810:00):

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 090° | A | | | | | |
| 158° | B | | | | | |
| 210° | C | | | | | |
| 270° | D | | | | | |
| 304° | E | | | | | |
| 005° | F | | | | | |
| 090° | G | | | | | |

6. At time 08:04, identify all targets, if any, that have target swap potential:

   _____

7. Calculate and execute course change at or before 0808:00 for a min. CPA of 3 nm. Calculated course change: _____. Resume base course as soon as possible.
8. After executing the course change, record accurate vessel data, and include the time you recorded the data for each target:

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 090° | A | | | | | |
| 158° | B | | | | | |
| 210° | C | | | | | |
| 270° | D | | | | | |
| 304° | E | | | | | |
| 005° | F | | | | | |
| 090° | G | | | | | |

9. Do not adjust your vessel's course or speed between 0812:00 and 0818:00; however, return to base course as soon as possible after 0818:00, and maintain at least a minimum CPA of 3nm.

10. Record warnings that sound, if any, and the time they occurred:

| Warning | Time of occurrence |
|---|---|
| | |
| | |
| | |

11. If one or more warnings sound, take the appropriate action for each warning.

12. Identify target(s), if any, that changed course or speed during the exercise, and include the time you recorded the data for each target:

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 090° | A | | | | | |
| 158° | B | | | | | |
| 210° | C | | | | | |
| 270° | D | | | | | |
| 304° | E | | | | | |
| 005° | F | | | | | |
| 090° | G | | | | | |

## *ARPA Assessment Exercise C*

**Name** _____ **ARPA Unit** _____

*Section B*

13. After the simulation, respond to the following questions regarding the accuracy of ARPA information during equipment malfunction. Assume that the vessel data in question are: (A) bearing, (B) CPA, (C) TCPA, (D) range, (E) course, (F) speed or (G) none of these. Your response may include more than one type of data.

    a. Assume the compass/heading input is incorrect. Which, if any, of the above vessel data would be correct?

    _____

    b. Assume the speed log input is incorrect. Which, if any, of the above vessel data would be correct?

    _____

    c. Assume you're relying solely on ARPA, and the ARPA target tracking capability fails. What, if any, automatic ARPA information is still available?

    _____

## *ARPA Assessment Exercise D*

**Name** _____ **ARPA Unit** _____

Exercise Time: 0600:00 Own Ship Course: 180° Own Ship Speed: 15.0 knots

1. Initialize ARPA in relative motion mode.
2. Acquire all targets.
3. Assess the COLREGS situation for each target:

| Initial Bearing | Target | Risk of Collision? (Y/N) | COLREGS |
|---|---|---|---|
| 090 | A | | |
| 158 | B | | |
| 210 | C | | |
| 270 | D | | |
| 304 | E | | |
| 040 | F | | |
| 180 | G | | |

4. Record vessel data before own ship course change, and include the time you recorded the data for each target:

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 090 | A | | | | | |
| 158 | B | | | | | |
| 210 | C | | | | | |
| 270 | D | | | | | |
| 304 | E | | | | | |
| 040 | F | | | | | |
| 180 | G | | | | | |

5. Record what lights are seen on each vessel on or before 06:10:00:

| Initial Bearing | Target | Lights |
|---|---|---|
| 090 | A | |
| 158 | B | |
| 210 | C | |
| 270 | D | |
| 304 | E | |
| 040 | F | |
| 180 | G | |

6. Identify any vessels that change course or speed and record new vessel data, and include the time you recorded the data for each target:

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 090 | A | | | | | |
| 158 | B | | | | | |
| 210 | C | | | | | |
| 270 | D | | | | | |
| 304 | E | | | | | |
| 040 | F | | | | | |
| 180 | G | | | | | |

7. Calculate and execute course change when target C is at 6 nm for at least a 3 nm CPA. Calculated course change: _____

8. Does the action to avoid target C bring another vessel into an unacceptable situation? If so, what will you do?

_____

9. Resume base course as soon as possible while maintaining at least the minimum CPA on all targets. If this is not possible, indicate "impossible" below:

_____

## *ARPA Assessment Exercise E*

**Name** _____ **ARPA Unit** _____

Exercise Time: 1100:00 Own Ship Course: 180° Own Speed: 15.7 knots

No VHF radio or pilot is available during this exercise; a chartlet (figure C-4) is attached.

1. Initialize your ARPA unit with a ground-stabilized presentation mode.
2. As soon as you are underway, set autodrift (groundlock) to target bearing 172° at 4 nm, and manually acquire any northbound target(s).
3. Avoid collisions or groundings.
4. Record vessel data for any inbound target(s), and include the time you recorded the data for each target:

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| | A | | | | | |
| | B | | | | | |

5. Your vessel is under your control: what color lights should you see on the inbound target when you emerge from under the Verrazano Bridge, at about 1113:00?

_____

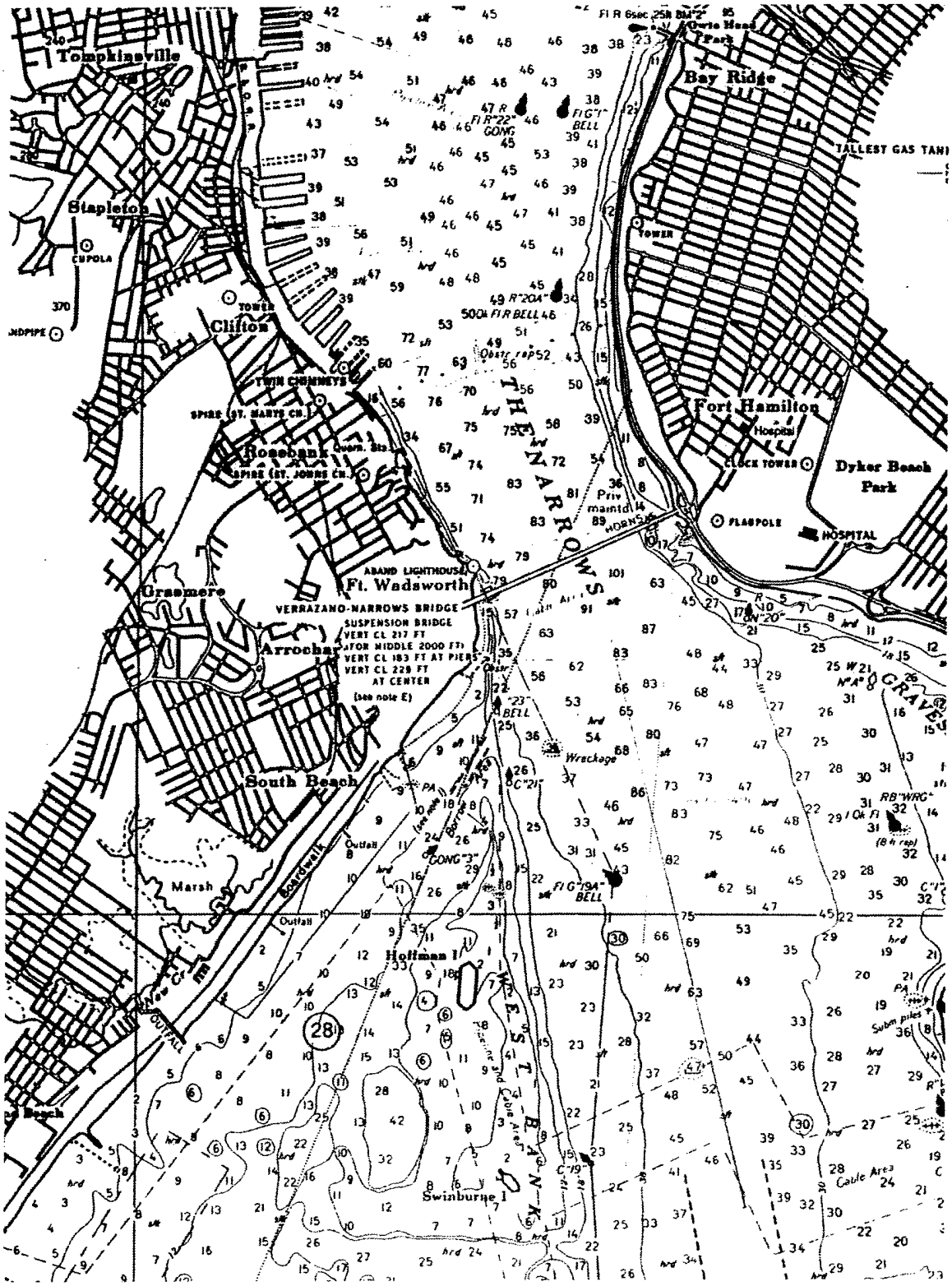



**Figure C-4. Chartlet of a portion of New York Harbor upper bay for use in ARPA exercise E.**

## *ARPA Assessment Exercise F*

**Name** _____ **ARPA Unit** _____

Exercise Time: 0500:00 Own Ship Course: 270° Own Ship Speed: 20.0 knots

*Section A*

1. Initialize ARPA in the display presentation and mode of your choice.
2. Set safe limits CPA to 1 nm.
3. Acquire all targets in the order that will give you the best information about a potential collision.
4. Record vessel data, and include the time you recorded the data for each target (be sure to record this data before executing any course change). Record data for targets that have highest likelihood of collision first.

| Initial Bearing | Target | Course | Speed | CPA | TCPA | Time |
|---|---|---|---|---|---|---|
| 220 | A | | | | | |
| 220 | B | | | | | |
| 220 | C | | | | | |
| 048 | D | | | | | |

5. What, if any, problems did you encounter while recording the above data?

   _____

6. Assess threat and maneuver to starboard as required. Calculate and execute course change at or before 0510:00 for the maximum CPA allowable given the circumstances. Calculated course change: _____

   (Course change may not be more than 70° to starboard.)

## *ARPA Assessment Exercise F*

**Name** _____ **ARPA Unit** _____

*Section B*

After the simulation ends, respond to the following multiple-choice and true/false questions regarding IMO performance standards for ARPA, in particular, the standards relating to ARPA accuracy:

1. ARPAs with auto-acquisition capability:
   I. Must be able to track only 10 targets.
   II. Must have a means to cancel targets.
      A. I only
      B. II only
      C. Both I & II
      D. Neither I nor II
2. (A) typical source(s) of error(s) is/are:
      A. Speed log
      B. Gyrocompass
      C. Glint
      D. All of the above
      E. None of the above
3. The primary purpose of ARPA is to:
      A. Give more accurate CPAs
      B. Reduce the workload of the operator
      C. Eliminate the requirement to plot
      D. All of the above
      E. None of the above
4. ARPA with auto-acquisition should have a facility to suppress acquisition in certain areas.
      A. True
      B. False
5. The ARPA should be capable of operating with a true motion display with North-up and either course-up azimuth stabilization or head-up.
      A. True
      B. False

6. One minute after target acquisition:
   I. The targets' motion trend must be presented by the ARPA.
   II. The targets' predicted motion must be presented.
      A. I only
      B. II only
      C. Both I & II
      D. Neither I nor II
7. ARPAs should have visual and/or audible signals for:
   I. Targets crossing guard zones
   II. Lost targets
      A. I only
      B. II only
      C. Both I & II
      D. Neither I nor II
8. All ARPAs must present course, speed, CPA, TCPA, range and bearing of at least 20 tracked targets.
      A. True
      B. False
9. Target swap may occur when two or more targets get into one tracking gate.
      A. True
      B. False
10. Exclusion zones/areas are required of all IMO-approved ARPA units.
      A. True
      B. False
11. ARPAs should give the operator the ability to activate and deactivate operational warnings.
      A. True
      B. False
12. All ARPAs are required to display:
   I. At least four equally spaced past positions
   II. Target history for at least eight minutes
      A. I only
      B. II only
      C. Both I and II
      D. Neither I nor II

13. All IMO-approved ARPAs are required to have "nav-lines"

    A. True

    B. False

14. When using an ARPA in the course-up mode:

    I. Targets smear when you change course.

    II. The heading flasher moves in accordance with the amount you change course.

    A. I only

    B. II only

    C. Both I and II

    D. Neither I nor II

15. At least eight minutes of target history is available to the operator as soon as the target is acquired.

    A. True

    B. False

16. When all tracking gates are full the computer in an ARPA must determine which targets to continue to track and what target(s) to drop when a new target appears. The process the computer goes through is called:

    A. Due process

    B. Prioritization

    C. Rate-aiding

    D. Glinting

    E. Danger assessment

    F. All of the above

    G. None of these

17. The center of the ship moves over the full length of the ship causing:

    A. Seasickness

    B. Spoking

    C. Rate-aiding

    D. Glinting

18. Setting the CPA and TCPA safe limits to zero will eliminate close quarters situations from developing.

    A. True

    B. False

19. If your heading flasher is not running through a collision point, there is no risk of collision.

    A. True

    B. False

20. Which of the following are optional?

    I. Vectors

    II. Graphic representations

    A. I only

    B. II only

    C. Both I and II

    D. Neither I nor II

21. All guard zones have the capability of auto-acquiring targets.

    A. True

    B. False

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# APPENDIX D—Assessor Instructions for ARPA Assessment

Appendix D provides instructions for the assessor administrating the present ARPA assessment. For each of the six exercises, instructions are included for actions that the assessor is required to perform before, during, and after each simulation. For example, to assess the candidate's knowledge of how to set the speed and compass heading in exercise A, the assessor has to de-initialize the ARPA units before candidates arrive so that the speed and compass settings are *incorrect.*

Instructions are also provided for the assessor to perform specific activities during the simulation, such as disable the automatic speed log in exercise C, or remove a target from the candidates' displays in exercise A to set off the lost target alarm. The assessor is also required to watch the instructor console to monitor, for example, that candidates maintain at least the minimum CPA on all targets; or to make sure that candidates have manually reset the speed log following the automatic speed log error. Cueing instructions are provided for activities such as these.

The instructions for administering the written test questions in exercises A, C, and F are at the end of the assessor instructions for those exercises.

## *Assessor Instructions for ARPA Assessment Exercise A*

| | |
|---|---|
| **IMPORTANT:** | Instruct candidates to read all instructions before each exercise begins. |

1. Before the candidates arrive, de-initialize ARPA units such that speed and compass settings are incorrect.
2. Before getting underway, verify that each candidate has correctly initialized his or her ARPA unit:
   - Speed log manually set to 20.0 knots.
   - Compass set to 090°.
   - Guard zone set in accordance with instructions.
   - Exclusion line set to 3 nm north of own ship.
3. Ask each candidate to demonstrate the various display presentations and display modes that are available:
   - North-up, course-up and head-up presentations.
   - Relative motion and true motion vector modes.
4. After demonstration, verify that each ARPA unit is set to a relative motion, stabilized mode, and that automatic acquisition rings have been turned off.

5. During first minute of simulation, instruct the candidates to manually acquire all targets and to record vessel data at the appropriate time.
6. Verify that each candidate has correctly manually acquired all targets.
7. At approximately 0106:00, instruct candidates to record vessel data at the appropriate time after the own ship maneuver.
8. At 0113:00, remove target *C* from each candidate's display to actuate the lost target alarm.
9. Verify that each candidate correctly responds to the lost target alarm by reacquiring target *C*.
10. Beginning approximately 0115:00, ask candidates to demonstrate the ARPA's vessel history capability.
11. After simulation ends, administer written test questions on vessel history patterns. Distribute section B after the simulation ends and allow candidates five minutes to complete the written exam questions.

## *Assessor Instructions for ARPA Assessment Exercise B*

1. Before the assessment begins, set vector scale on ARPA units to 3 minutes.
2. During set-up, tell candidates to set safe limits CPA to 2 miles, safe limits TCPA to 24 minutes, and vector scale to 6 minutes.
3. Ask candidates to set exclusion area to exclude southerly fishing vessels (*E, F, G, H, & I*) and land.
4. Before getting underway, instruct candidates to draw parallel index lines to maintain a 3-mile distance from land at bearing 180°.
5. Verify that each candidate has correctly initialized his or her ARPA unit:
   - Speed log manually set to 20 knots.
   - Compass set to 255°.
   - Vectors set to 6 minutes.
   - Guard zone set to 3 nm.
   - Exclusion line set 2.5 nm to south.
   - Parallel index lines drawn in accordance with instructions.
6. After getting underway, tell candidates to identify and record the code for any racon(s) that are present in the exercise.
7. At approximately 1001:00, ask candidates to manually acquire all targets except fishing vessels to the north, and to record vessel data when appropriate.

8. Instruct candidates to identify, record and respond to any warnings that occur during the exercise.

9. Throughout the exercise, verify that each candidate maintains ship's position with respect to parallel index lines.

10. At 1018:00, tell candidates to change course to 270°, keeping the point of land at 3 nm, in accordance with parallel index lines.

11. After own ship maneuver, verify that each candidate's ship is no more than 0.5 nm on either side of parallel index lines.

## *Assessor Instructions for ARPA Assessment Exercise C*

1. Verify that each candidate has correctly initialized his or her ARPA unit:
   - Speed log manually set to 15.0 knots.
   - Compass set to 180°..
   - Vectors set to true motion.
   - CPA safe limit set to 3 nm and TCPA safe limit set to 20 minutes.
2. After getting underway, instruct candidates to initialize automatic speed log.
3. Tell candidates to respond to any operational warnings that occur during the exercise.
4. Instruct candidates to acquire all targets except three buoys bearing 125°, 130°, 132° true, and to record vessel data when appropriate.
5. Tell candidates to record which vessels have potential for target swap at 0804:00.
6. Instruct candidates to calculate and record trial maneuver, and to execute the maneuver by 0808:00 so that resulting CPA is 3.0 or greater.
7. Ask candidates to record vessel data when appropriate after own ship changes course.
8. At console, check that each candidate has executed a large enough course change to maintain a minimum CPA of 3.0 nm for all targets.
9. At approximately 0812:00, tell candidates not to change course again until after 0818:00 or later.
10. At 0814:00, disable speed log, and then verify that each candidate correctly manually resets his or her speed log.
11. At approximately 0824:00, verify that each candidate has resumed the base course of 180°.
12. At the end of the exercise, ask candidates to identify any targets that changed course or speed during the exercise, and to record the nature and direction of the change on their answer sheet.

13. Administer the written test questions regarding precautions to be taken after an ARPA equipment malfunction occurs. Distribute section B after the simulation ends and allow candidates five minutes to complete the written test questions.

## *Assessor Instructions for ARPA Assessment Exercise D*

1. Verify that each candidate has correctly initialized his or her ARPA unit:
   - Speed log manually set to 15.0 knots.
   - Compass set to 180°.
   - Vectors set to relative motion.
2. Tell candidates to acquire all targets.
3. Instruct candidates to assess and record the COLREGS situation for each target.
4. Tell candidates to record vessel data as soon as appropriate.
5. At approximately 0605:00, instruct candidates to report what lights they see on each target at or before 0610:00.
6. At approximately 0613:00, ask candidates to identify targets that have changed course or speed, and record the nature and direction of the change on their answer sheet.
7. At 0617:00, tell candidates to calculate, report, and execute a course change as soon as possible for change when target C is at 6 miles for a 3-mile CPA.
8. Verify that each candidate resumes the base course of 180° by 0638:00.

## *Assessor Instructions for ARPA Assessment Exercise E*

1. Provide candidates with chartlet of New York Harbor Upper Bay, and remind them that no VHF radio or pilot is available during the exercise.
2. Verify that each candidate has correctly initialized his or her ARPA unit:
   - Speed log manually set to 15.0 knots.
   - Compass set to 180° true.
3. After getting underway, verify that each candidate is using true vectors, and that candidates do not run aground (failure is automatic for collision or grounding).
4. Instruct candidates to set autodrift (groundlock) to target bearing 172° at 4 nm and to manually acquire all northbound target(s).
5. Tell candidates to report what lights are seen on inbound target from approximately 1113:00 to 1115:00.

## *Assessor Instructions for ARPA Assessment Exercise F*

1. Verify that each candidate has correctly initialized his or her ARPA unit:
   - Speed log manually set to 20.0 knots.
   - Compass set to 270°.
   - CPA safe limits set to 1 nm.
   - Display presentation and vector mode settings are at discretion of candidate.
2. Tell candidates to respond to any operational warnings that occur during the exercise.
3. Instruct candidates to acquire all targets and record vessel data as soon as appropriate.
4. Ask candidates to record any problems they encountered in reporting vessel data.
5. Instruct candidates to assess threat and maneuver to starboard as required, and to calculate, record and execute a course change at or before 0510:00 for the maximum CPA allowable given the circumstances.
6. After simulation ends, administer section B, the written test questions regarding IMO performance standards for ARPA, in particular the standards relating to ARPA accuracy. Distribute section B after the simulation ends, and allow candidates 30 minutes to complete the written questions.

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