

U.S. Coast Guard Research and Development Center
1082 Shennecossett Road, Groton, CT 06340-6096

Report No. CG-D-13-00

Simplified Crew Size Evaluation Method



FINAL REPORT
JANUARY 2000



This document is available to the U.S. public through the
National Technical Information Service, Springfield, VA 22161

Prepared for:

U.S. Department of Transportation
United States Coast Guard
Marine Safety and Environmental Protection (G-M)
Washington, DC 20593-0001

20000515 069

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

This report does not constitute a standard, specification, or regulation.



Marc B. Mandler, Ph.D.
Technical Director
United States Coast Guard
Research & Development Center
1082 Shennecossett Road
Groton, CT 06340-6096



1. Report No. CG-D-13-00		2. Government Accession Number		3. Recipient's Catalog No.	
4. Title and Subtitle Simplified Crew Size Evaluation Method				5. Report Date January 2000	
				6. Performing Organization Code Project No. 3302.2.2	
7. Author(s) John D. Lee, PhD., Alice M. Forsythe; Anita M. Rothblum, Ph.D.				8. Performing Organization Report No. UDI 16(2)	
9. Performing Organization Name and Address Battelle Seattle Research Center 4000 N.E. 41 st Street Seattle, WA 98105-5428		U.S. Coast Guard Research and Development Center 1082 Shennecossett Road Groton, CT 06340-6096		10. Work Unit No. (TRAVIS) SHRD Report No. 125	
				11. Contract or Grant No. Contract No. DTCG39-94-D-E00777	
12. Sponsoring Organization Name and Address U.S. Department of Transportation United States Coast Guard Office of Marine Safety and Environmental Protection (G-M) Washington, DC 20593-0001				13. Type of Report & Period Covered Final Report	
				14. Sponsoring Agency Code Commandant (G-MSO-1) U.S. Coast Guard Headquarters Washington, DC 20593-0001	
15. Supplementary Notes The R&D Center's technical point of contact is Dr. Anita Rothblum, 860-441-2847.					
16. Abstract (MAXIMUM 200 WORDS) This report identifies a simplified method of crew size evaluation that can complement the relatively complex crew size evaluation method (CSEM). The simplified crew size evaluation method (S-CSEM) uses lookup tables that were generated via CSEM analyses and a task-based description of operating conditions to eliminate complex calculations, provide flexibility, and link operating conditions to the number of crew needed for vessel operation. Thus, S-CSEM is a simple and practical tool for crew size evaluation. This report is one of two reports on the use of CSEM to evaluate crew needs under different operational scenarios. The lookup tables in this report were generated by an in-depth analysis reported in, "The Use of the Crew Size Evaluation Method to Examine the Effect of Operational Factors on Crew Needs," CG-D-12-00. That report contains a detailed description of the analyses, the data sets used to perform the analyses, and criteria which can be applied in the evaluation of sufficient crew.					
17. Key Words crew size, manning, model, port calls, maintenance, work hours			18. Distribution Statement This document is available to the U.S. public through the National Technical Information Service, Springfield, VA 22161.		
19. Security Class (This Report) UNCLASSIFIED		20. Security Class (This Page) UNCLASSIFIED		21. No of Pages 62	22. Price

Form DOT F 1700.7 (8/72) Reproduction of form and completed page is authorized.

Acknowledgments

The authors would like to thank the three shipping companies who participated in this study for providing us with information about their U.S. tanker fleets.

Executive Summary

This report describes a concept demonstration of a simplified method of crew size evaluation that can complement the relatively complex Crew Size Evaluation Method (CSEM). The Simplified Crew Size Evaluation Method (S-CSEM) uses lookup tables that were generated via CSEM analyses and a task-based description of operating conditions to eliminate complex calculations, provide flexibility, and link operating conditions to the crew complement. Combining lookup tables with shipboard tasks makes S-CSEM a simple and practical tool for crew size evaluation.

S-CSEM matches operating conditions to the crew complement using lookup tables. Lookup tables use rows and columns to show how two variables, such as the port call frequency and the level of shore-based maintenance, affect a third variable, the crew needed to operate the vessel. These tables provide a consistent and understandable estimate of crew needs.

S-CSEM uses a three-step process to identify the crew complement. Step 1 summarizes the relevant operating conditions. Step 2 uses lookup tables to identify combinations of operating conditions that are relevant to estimating crew needs. Work Distribution Summary tables (developed via CSEM simulation analyses) are provided to show the influence of the ship's operating conditions on shipboard tasks and crew work hours. These tables make explicit how changes in operating conditions (compared to a baseline condition) affect crew task activity and, thus, crew needs. Step 3 uses a lookup table to link the combinations of crew-relevant operating conditions to the different crew complements. Based on these three steps, S-CSEM provides a simple procedure that can extend guidelines from the *Marine Safety Manual* with results of task-based analyses from CSEM to develop practical estimates of the crew complement needed to operate a vessel.

As technology and economic pressures change the nature of shipboard operations, a task-based approach to estimating the needed crew will become more prevalent. With S-CSEM, each change in operating conditions can be traced to shipboard functions and then to a recommended crew complement. By linking crewing to shipboard functions, S-CSEM provides a simple, yet powerful, task-based approach for crew size evaluation. For this concept demonstration, S-CSEM lookup tables were developed for two operating variables: port call frequency, and

shoreside maintenance support. As additional analyses are done with CSEM, S-CSEM can support a wider range of operating conditions. This provides the flexibility that is required to meet the needs of a changing industry.

This report is one of two reports on the use of CSEM to evaluate crew needs under different operational scenarios. The lookup tables in this report were generated by an in-depth analysis reported in, "The Use Of the Crew Size Evaluation Method to Examine the Effect of Operational Factors on Crew Needs," CG-D-12-00. That report contains a detailed description of the analyses, the data sets used to perform the analyses, and criteria which can be applied in the evaluation of sufficient crew.

Table of Contents

Executive Summary	v
1. Purpose and Overview	1
1.1 Purpose	1
1.2 Overview of the Simplified Method.....	2
1.3 Work Distributions	4
2. Concept Demonstration of the Simplified Crew Size Evaluation Method	8
2.1 S-CSEM Step 1: Summarize Operation Conditions	8
2.2 S-CSEM Step 2: Identify Crew-Relevant Combinations of Operating Conditions	11
2.3 S-CSEM Step 3: Identify Crew Complement Based on Crew-Relevant Combination of Operating Conditions	15
2.4 Limits and Capabilities of CSEM and S-CSEM.....	16
3. Conclusions	17
4. References	19
Appendices:	
A Shipboard Functions and Principles of Safe Manning	A-1
B Complete Worksheets for the Simple Model	B-1
C Tasks Allocated to Shore Based Maintenance	C-1

List of Figures

Figure 1. The simplified, task-based method for analyzing crew needs.	3
Figure 2. The <i>Baseline Work Distribution and Crew Needs</i> summary, showing fractions of persons for each crew type assigned to the functions for the baseline voyage.	6
Figure 3. The <i>Operating Conditions Summary</i> with the baseline conditions shaded and the example vessel characteristics checked.....	11
Figure 4. The <i>Operating Conditions Lookup Table</i> , which identifies crew-relevant combinations of operating conditions.....	12
Figure 5. <i>Work Distribution Summary</i> for the effect of port call frequency.	14
Figure 6. The <i>Crew Complement Lookup Table</i> for five combinations of port call frequency and shore-based maintenance.....	15

List of Tables

Table 1. The shipboard functions that summarize crew activities for S-CSEM.....	5
Table 2. Operating conditions, their definitions, and levels.....	9

1 Purpose and Overview

1.1 Purpose

The purpose of this report is to identify a simplified method of crew size evaluation that can complement the relatively complex Crew Size Evaluation Method (CSEM). CSEM is a comprehensive and complex tool that can evaluate a wide range of crew size issues with great precision (Lee, McCallum, Maloney, & Jamieson, 1997; Lee, Forsythe, & Rothblum, 1999). The complexity of CSEM is evident in the volume of task data that must be reviewed before each analysis, the time taken to run the simulation, and the time required to interpret its output. Without a computer, it would be impossible to conduct a comprehensive analysis using CSEM. Although a computer makes a wide range of analyses possible, the use of CSEM requires familiarity with the computer and training with the software.

CSEM's complexity is necessary in order to provide a capable, accurate, and flexible tool for crew size modeling. At the same time, it was recognized that CSEM was too complex to be practical for day-to-day use. The Simplified Crew Size Evaluation Method (S-CSEM) represents a bridge that makes the analytical power of CSEM available in a simple-to-use format. The results of detailed analyses generated via CSEM have been captured in S-CSEM lookup tables, making them readily accessible for day-to-day application.

We adopted several principles to guide the development of a simplified method and assure it would have practical utility. First, the Simplified Crew Size Evaluation Method (S-CSEM) should be capable of addressing many crew size issues, particularly those that are relatively routine. Second, S-CSEM should evaluate a crew without the need for a computer. Third, it should be a task-based method; a crew size evaluation with S-CSEM must be traceable to underlying task demands. Fourth, S-CSEM should provide a framework for compiling and disseminating findings generated by CSEM, other analyses, and existing Coast Guard policy. Fifth, S-CSEM should generate the crew complement for a set of operating conditions rather than just evaluate a candidate crew.

This report describes S-CSEM, including:

- An overview of the method, showing its inputs and a procedure for identifying the crew complement
- A concept demonstration of how the simple method can be used
- The limits and assumptions of S-CSEM

The report concludes with a brief description of the potential roles of CSEM and S-CSEM. The operational scenarios and lookup tables discussed in this report are treated in more detail in Lee, Forsythe, & Rothblum (1999).

1.2 Overview of the Simplified Method

Like CSEM, S-CSEM identifies the crew needed for a set of operating conditions, which include the type and size of the vessel, the frequency of port calls, and the level of shoreside maintenance. S-CSEM uses a series of lookup tables to link operating conditions to the crew complement. The lookup tables use rows and columns to show how two variables, such as port call frequency and the level of shore based maintenance, affect a third variable, the needed crew complement. To explain the effect of operating conditions on the needed crew, S-CSEM includes a summary of the work associated with shipboard tasks. This summary shows why the workload of particular crew members, such as mates, increases with particular operating conditions, such as port calls. This general process is shown in detail in Figure 1.

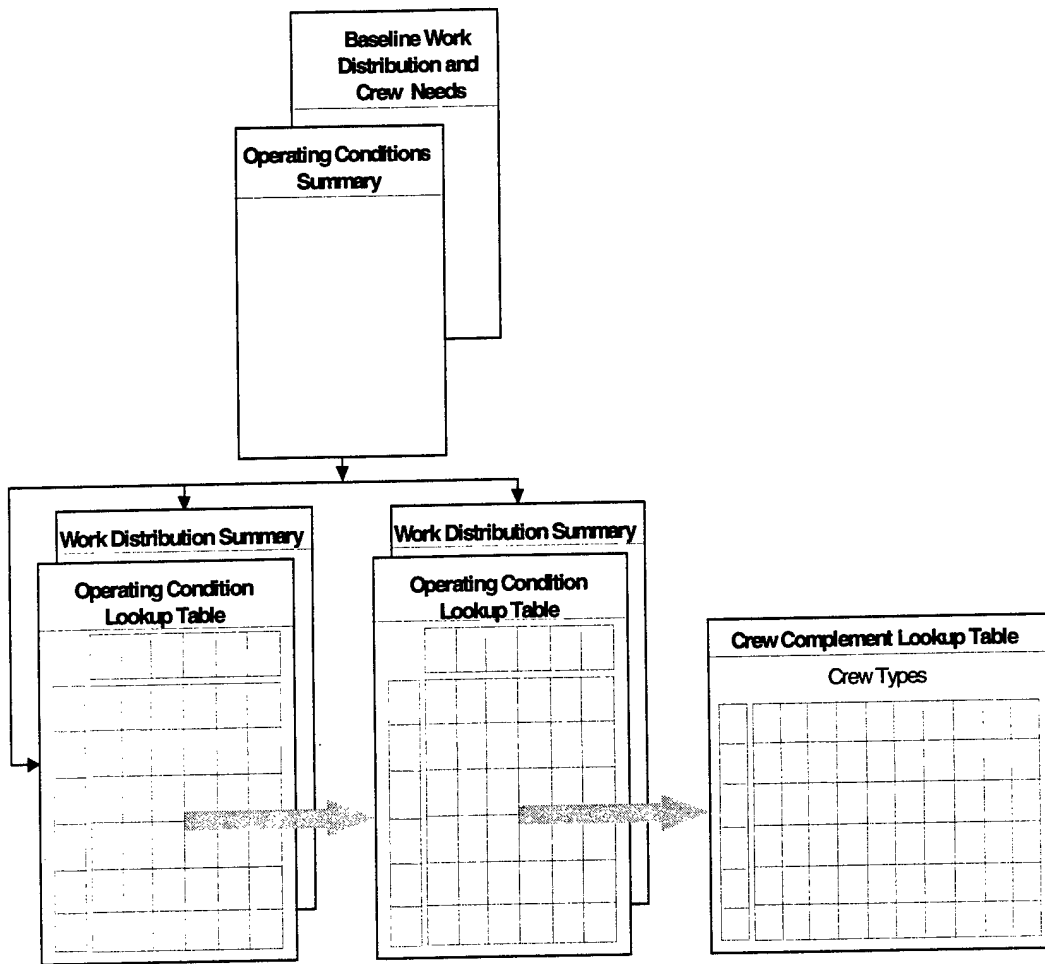


Figure 1. The simplified, task-based method for analyzing crew needs.

Figure 1 shows how S-CSEM begins with a summary of operating conditions. The particular operating conditions identify where to enter the lookup tables. Each lookup table identifies combinations of operating conditions that affect crew needs. These crew-relevant combinations can be further combined with additional operating conditions in another lookup table. In this way, the sequence of lookup tables identifies the crew needs of a complex array of operating conditions. The final lookup table matches the crew-relevant combinations of operating conditions to the recommended crew complement. This method provides a consistent and understandable way to estimate crew needs for a wide variety of conditions.

1.3 Work Distributions

Figure 1 also shows another key element of S-CSEM: the work distribution associated with shipboard tasks. Work distribution tables (such as that shown in Figure 2) are generated via simulation analyses in CSEM. They show the number of person-days of work for each crew type for each of the fifteen shipboard functions listed in Table 1. The fifteen shipboard functions represent the tasks needed to operate a container ship or oil tanker. Each shipboard function is a composite of the work demands of many individual tasks. For example, the function “Navigation” includes tasks such as bridge watchkeeping, lookout, steering, voyage passage planning, and weather monitoring (see Appendix A for a list of the tasks within each shipboard function). The numbers in the *Baseline Work Distribution and Crew Needs* table for “2.0 Navigation” (Figure 2) represent the average daily work of each crew type for all the navigation tasks (averaged over the entire voyage; see below). Together, the shipboard functions form a comprehensive description of shipboard activity, and provide a natural link between operating conditions and crew needs.

S-CSEM uses the *Baseline Work Distribution and Crew Needs* to summarize the work demands associated with each shipboard function. The work demands of each shipboard function are averaged over the baseline voyage, which includes three port calls in 14 days (see Section 2.1). Figure 2 shows the work summary, with crew types across the top of the worksheet and the shipboard functions down the left side. Gray cells in this table indicate that there are no work demands associated with that particular combination of crew type and shipboard function. The work demands are shown as a fraction of a person-day of effort, assuming a 12-hour workday. For example, Figure 2 shows that Command and Control consumes 0.58 of a Master’s effort each day. This means that the Master spends approximately 6.96 hours each day ($0.58 \text{ person/day} \times 12 \text{ hrs/person}$) on Command and Control activities. The work demands are also reflected in the watchkeeping responsibilities of the Mates. Each Mate (assuming a four-hour on/eight-hour off watch schedule) spends eight hours per day on watch, a 0.67 person per day demand. Figure 2 shows that for three port calls in 14 days (the baseline condition),

Table 1. The shipboard functions that summarize crew activities for S-CSEM.

Ship Function	Definition
Command and Control	Command, control, and coordination of the vessel, bridge resource management, and crew performance management.
Navigation	Bridge watchkeeping, lookout, steering, voyage passage planning, and weather monitoring.
Communications	Long-range radio operations, communication record keeping, and sound and visual signaling.
Engineering System Monitoring, Control, and Operations	Engineering rounds and record keeping, and monitoring, control, and operation of all engine room components.
Scheduled Maintenance and Testing	Preventive maintenance and testing of all bridge and deck equipment, as well as all engine room and pump room components.
Unscheduled Maintenance and Repair	Repair of all bridge and deck equipment, as well as all engine room and pump room components.
Emergency Response	Response to crew incapacitation, fires, steering gear failures, man overboard emergencies, oil spills, and abandon ship alarms.
Training and Drills	All shipboard training and drills.
Management and Administration	Management of deck and engine work, chart corrections, financial and payroll transactions, deck and engine stores, drill and main engine record keeping, shipyard planning, and medical care and record keeping.
Internal Ship Communication and Meetings	Labor relations, shipboard management meetings, and safety meetings.
Regulatory Compliance	Deck and engine room pollution prevention compliance, and inspections.
Cargo Responsibilities	Cargo and ballast planning, loading, discharge, maintenance, and record keeping; stability monitoring and tank cleaning.
Hotel Services	Food preparation and service; galley, mess room, bridge, accommodation, and space cleaning; provisioning, galley stores and hotel services administration.
Arrival, Departure, & Port Watchkeeping	Arrival and departure preparation, docking, undocking, mooring, unmooring, anchoring, weighing anchor, port watchkeeping.
Special Operating Requirements	Underway lightering planning, loading, discharge, and underway and replenishment operations.

BASELINE WORK DISTRIBUTION AND CREW NEEDS

1.0 Command & Control

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.58	0.02					0.17								

2.0 Navigation

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.03	0.55	0.55	0.55		3.14	0.02								

3.0 Communications

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.02	0.02													

4.0 Engineering System Monitoring, Control, and Operations

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
				0.02	0.02	0.36	0.88	0.88	0.88	2.0	0.02			

5.0 Scheduled Maintenance & Testing

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
			0.04	0.16	0.18		0.09	0.08	0.08	0.29	0.29	0.14		

6.0 Unscheduled Maintenance & Repair

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
	0.02			0.03	0.02	0.06	0.06	0.06	0.06	0.23	0.01	0.15		

7.0 Emergency Response

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

8.0 Training Drills

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.02	0.03	0.03	0.03	0.02	0.02	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02

9.0 Management & Administration

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.12	0.11	0.02		0.18		0.04	0.02							

10.0 Internal Ship Communications & Meetings

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.01														

11.0 Regulatory Compliance

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.03	0.02			0.03	0.03					0.02	0.03			

12.0 Cargo Responsibilities & Passenger Care

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.02	0.51	0.16	0.16	0.07	0.05		0.05	0.05	0.05	0.08	0.19			

13.0 Hotel Services

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
												0.56	0.94	0.71

14.0 Arrival, Departure & Port Watchkeeping

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.06	0.09	0.12	0.12	0.10	0.94		0.03	0.03	0.03					

Figure 2. The *Baseline Work Distribution and Crew Needs* summary, showing fractions of persons for each crew type assigned to the functions for the baseline voyage.

this demand is split between Navigation (0.55) and Arrival, Departure, and Port Watchkeeping (0.12)¹. Together these responsibilities add to a 0.67 person per day demand, or eight hours per day.

The *Baseline Work Distribution and Crew Needs* does not directly specify the crew complement beyond those of the baseline condition. Instead, it provides a reference point for considering how changes in operational conditions might affect crewing. For example, as the frequency of port calls increases, more time will be spent on Arrival, Departure & Port Watchkeeping tasks. As Figure 2 shows, the Mates and ABs would be the crew members primarily affected by this operational factor, whereas the Cooks would not be affected.

¹ The voyage consists of 14 days overall with three port calls. This translates into roughly 11.55 days spent in transit and 2.5 days spent in port. To determine the average time/day (out of the entire 14 days) spent on Navigation by each Mate, multiply the 11.55 days in transit by 0.67 (= eight hours on watch/twelve-hour work day), which gives 7.74 person-days spent on the Navigation watch by each Mate over the 14-day voyage. Dividing by 14 gives 0.55 person days per day.

2 Concept Demonstration of the Simplified Crew Size Evaluation Method

S-CSEM uses a three-step process to estimate a crew complement. Step 1 summarizes the relevant operating conditions using an *Operating Conditions Summary*. Step 2 uses *Operating Condition Lookup Tables* to identify combinations of operating conditions that are relevant to estimating crew needs. How these combinations affect the distribution of work across shipboard functions and crew members is examined using a *Work Distribution Summary*. These summary tables show how changes in operating conditions affect crew activities through a task-based description of work demands. Step 3 uses a lookup table to link the combinations of crew-relevant operating conditions to the different crew complements using a *Crew Complement Lookup Table*. Appendix B contains a complete set of the worksheets used in each step of S-CSEM. The three steps of S-CSEM support a flexible and easy-to-use crew size evaluation procedure.

The ability to combine the results of CSEM simulation analyses with existing Coast Guard crew size policies is a major benefit of S-CSEM. Currently, S-CSEM contains information on two operating factors: shore-based maintenance, and port call frequency. As additional analyses are done with CSEM, S-CSEM could support many other operating conditions. In this way, S-CSEM can be used to extend Coast Guard policies regarding crew size, such as those in the *Marine Safety Manual*. S-CSEM provides a practical solution to many crew size evaluation issues by combining current policies with the results of task-based analyses.

An example analysis provides a concept demonstration to show how S-CSEM can be used to estimate crewing. The following sections explain each step of the simplified method and then demonstrate the steps with the example.

2.1 S-CSEM Step 1: Summarize Operating Conditions

Identifying the operating conditions of a vessel is the first step in any crew size evaluation. Operating conditions include characteristics of the vessel, such as its size and the type of cargo it carries. Operating conditions also include the voyage profile and operating policies, such as the frequency of port calls and the amount of shore-side maintenance. The goal of identifying the operating conditions is to summarize the factors that affect crew needs.

We have compiled a list of six operating conditions that capture many of the factors affecting crewing. These operating conditions describe only tankers and container ships; adding other operating conditions, such as those needed to describe towing or other vessels, might be desirable in the future. The crew needs have not been defined for all these conditions, but this list shows the range of issues that S-CSEM can address once their effects on crew tasking have been defined (via additional CSEM simulation analyses). The flexibility to address the operating conditions in Table 2, and others not yet identified, is a key benefit of S-CSEM.

Table 2. Operating conditions, their definitions, and levels.

Operating Factor	Definition	Levels
Route	Critical characteristics of trade route	Ocean-going or coastwise Lakes, bays, and sounds Great Lakes Rivers
Port Call Frequency	How often vessel typically visits a port	1 port in 14 days 3 ports in 14 days 7 ports in 14 days
Cargo Type	Typical cargo carried aboard vessel	Crude oil Refined oil products Other tank products
Shore-side Cargo Support	Typical use of shore-based cargo personnel when loading/unloading vessel	Shoreside cargo mate available No shoreside support
Power Plant and Engine Room Automation	Engine room characteristics which affect maintenance requirements and enable unattended operations	Attended Unattended
Shore-side Maintenance Support ²	Typical use of shore-based maintenance personnel for preventive maintenance and/or repair	Minimal to high shoreside support of maintenance and repair tasks

² The specific maintenance tasks assigned to shore-based crew are shown in Appendix C.

Figure 3 shows the *Operating Conditions Summary*, which is used to describe the operating conditions of a particular ship. The shaded boxes identify the baseline conditions. The baseline condition is a 150,000 gross ton (GT) crude oil tanker. The vessel is a steamship and its engine room is manned (attended). On its typical route from Valdez, Alaska, to Bellingham, Washington, the ship visits a port about once every four days (three ports in 14 days). When it is in port, the vessel utilizes a shore-based loading mate to support cargo operations; it also receives a low level of shoreside maintenance support. The detailed crew tasking by shipboard function is shown in Figure 2. If a vessel matches these baseline conditions (including having a crew-function work distribution similar to that shown in Figure 2), then the recommended crew is simply the baseline crew and no further analysis is required.

The baseline crew complement consists of 24 members of the ship's crew plus a shore-based loading mate. The ship's crew includes:

- Master (MA)
- 3 Mates (CM, 2M, 3M)
- Boatswain (B)
- 6 Able Seamen (AB)
- Utility (U)
- Chief Engineer (CE)
- 3 Assistant Engineers (1E, 2E, 3E)
- 3 Qualified Members of the Engineering Department (Q)
- 2 Pumpmen (PM)
- Chief Steward (CS)
- 2 Cooks (CK)

With this baseline condition as a reference point, the *Operating Conditions Summary* (Figure 3) defines the vessel used in this example. The checked boxes in Figure 3 show the characteristics of this vessel. Specifically, this vessel differs from the baseline in the number of port calls (seven ports in 14 days). Beyond this operating factor, the vessel is the same as the baseline condition. The *Operating Conditions Summary* sheet provides a reference for the next step in the analysis: identifying those operating conditions which affect crew size.

OPERATING CONDITIONS SUMMARY SHEET

Port Call Frequency							
<input type="checkbox"/>	1 port in 14 days (14 days between ports)	<input checked="" type="checkbox"/>	3 ports in 14 days (4.5 days between ports)	<input checked="" type="checkbox"/>	7 ports in 14 days (2 days between ports)		
Shoreside Cargo Support							
<input checked="" type="checkbox"/>	Yes	<input type="checkbox"/>	No				
Engine Room Automation							
<input checked="" type="checkbox"/>	attended	<input type="checkbox"/>	unattended				
Shoreside Maintenance Support							
<input checked="" type="checkbox"/>	Low	<input type="checkbox"/>	Medium (Maint.)	<input type="checkbox"/>	High (Maint.)	<input type="checkbox"/>	Very High (Maint.)
	<input type="checkbox"/>	Medium (Maint.) & Repair	<input type="checkbox"/>	High (Maint.) & Repair	<input type="checkbox"/>	Very High (Maint.) & Repair	

Figure 3. The *Operating Conditions Summary* with the baseline conditions shaded and the example vessel characteristics checked.

2.2 S-CSEM Step 2: Identify Crew-Relevant Combinations of Operating Conditions

The second step of S-CSEM uses a series of lookup tables to identify crew-relevant combinations of operating conditions. Crew-relevant combinations are those sets of operating conditions that affect the number of crew members needed to operate the ship. The goal of this

step is to identify the set of operating conditions for a vessel and to understand how they will affect crewing.

Figure 4 shows an *Operating Conditions Lookup Table*. This table draws upon the information in the *Operating Conditions Summary*, which was completed in Step 1, and combines two important operating conditions: frequency of port calls and shore-based maintenance support. The cells in this table represent combinations of port call frequency and shore-based maintenance that need different crew complements; the numbers signify different crew complements associated with the port call-maintenance combinations as shown in the *Crew Complement Lookup Table* in Figure 6. The baseline condition (low maintenance and three ports in 14 days) is highlighted as a reference point; its combination of shoreside maintenance and port call frequency uses a crew complement identified as “2” in the *Crew Complement Lookup Table*. Continuing with the example introduced earlier, the operating conditions for the example ship are different than the baseline condition. With a port call frequency of seven port calls in 14 days and a low level of shore-based maintenance, the lookup table (Figure 4) labels the crew-relevant combination of conditions as “3.”

OPERATING CONDITIONS LOOKUP TABLE

Shore-based Maintenance and Repair	<i>Port Call Frequency</i>		
	1 in 14	3 in 14	7 in 14
Low (Maintenance)	1	2	3
Medium (Maintenance)	1	2	3
High (Maintenance)	4	5	3
Very High (Maintenance)	4	5	3
Medium (Maintenance & Repair)	4	5	3
High (Maintenance & Repair)	4	5	3
Very High (Maintenance & Repair)	4	5	3

Figure 4. The *Operating Conditions Lookup Table*, which identifies crew-relevant combinations of operating conditions.

In order to understand how the operating conditions represented in the lookup table (Figure 4) influence the resulting crew work demands, S-CSEM uses *Work Distribution Summary Tables*. As discussed in Section 1.3, the purpose of examining the *Work Distribution Summary* is not to identify a specific crew complement, but to better understand the influence of the operating conditions contained in the lookup tables.

The *Work Distribution Summary* shows how the work demands on each crew position change with increasing levels of the operating factor (see Figure 5). The numbers in the cells are the person-days of effort in the baseline condition. If the operating condition results in work demands which increase over the baseline condition, that is noted by a "+"; decreased work demands are shown by a "-". A "+ +" reflects large increases and "- -" reflects large decreases. If a cell is shaded, then the operating factor has little or no influence on those work demands. This notation provides a simple description of how changing operating conditions affect the workload of different crew positions.

Continuing with the example, Figure 5 shows a *Work Distribution Summary* for port call frequency (generated via a CSEM simulation analysis). In the example, the frequency of port calls was greater than the baseline condition and so Figure 5 suggests that we should expect greater demands on the Mates and ABs. This information leads us to expect an increase in crew needs, with additions to the Mates or ABs as the most likely.

In addition to its use in determining the crew complement, the *Work Distribution Summary* can be a valuable aid in "check rides" on ships which have been granted temporary approval to operate with reduced crews. Since the *Work Distribution Summary* shows which crew members and which tasks will be affected by the ship's operational changes (e.g., changes in port call frequency or shoreside maintenance and repair), it can be used as a checklist during crewing discussions. Or, the crew could be asked to keep records of work hours associated with specific shipboard functions (such as Cargo Responsibilities), and those could be compared with the *Work Distribution Summary* to determine precisely how crew work hours have changed, yielding an objective measure of whether additional crew may be needed.

WORK DISTRIBUTION SUMMARY INCREASING PORT CALL FREQUENCY

1.0 Command & Control

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.58+						0.17+								

2.0 Navigation

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.03+	0.55+	0.55+	0.55+		3.14++	0.02+								

3.0 Communication

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

4.0 Engineering System Monitoring, Control, and Operations

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
						0.36+								

5.0 Scheduled Maintenance & Testing

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

6.0 Unscheduled Maintenance & Repair

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

7.0 Emergency Response

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

8.0 Training & Drills

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

9.0 Management & Administration

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

10.0 Internal Ship Communications & Meetings

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

11.0 Regulatory Compliance

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

12.0 Cargo Responsibilities & Passenger Care

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
	0.51++	0.16+	0.16+	0.07+	0.05+						0.19++			

13.0 Hotel Services

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

14.0 Arrival, Departure & Port Watchkeeping

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
		0.12++	0.12++	0.10++	0.94++									

Figure 5. Work Distribution Summary for the effect of port call frequency.

2.3 S-CSEM Step 3: Identify Crew Complement Based on Crew-Relevant Combinations of Operating Conditions

The final step of the analysis is to use another lookup table to identify the crew complement associated with the combination of operating conditions identified in Step 2. In Step 2 (Figure 4) the baseline condition of Low Maintenance and three port calls in 14 days is highlighted. The combined operating condition is shown as “2”. The *Crew Complement Lookup Table* (Figure 6) highlights the crew for the baseline condition.

How does our example differ from the baseline? In Step 2, we selected an operating condition of Low Maintenance and seven port calls in 14 days, which is coded as a “3” in Figure 4. This set of operating conditions is labeled “Op Cond 3”, and can be found in Figure 6 just below the baseline condition. The crew complement associated with the operating conditions in our example is arrayed to the right. Notice that the complement suggests two Chief Mates. This signals the need for an additional Mate (or an additional Shoreside Loading Mate) to offload some of the CM’s port call tasks and responsibilities. “Op Cond 3” also uses one additional AB, due (as shown in Figure 5) to the increased work in Navigation and in Arrival, Departure, and Port Watchkeeping as a result of the increased frequency of port calls.

Crew Complement Lookup Table

Op Cond*	MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
1	1	1**	1	1	1	6	1	1	1	1	3	2	1	1	2
2	1	1	1	1	1	6	1	1	1	1	3	2	1	1	2
3	1	2	1	1	1	7	1	1	1	1	3	2	1	1	2
4	1	1**	1	1	0	6	1	1	1	1	3	1	1	1	2
5	1	1	1	1	1	6	1	1	1	1	3	1	1	1	2

* Operating conditions from Figure 4.

** No shoreside loading mate needed.

Figure 6. The Crew Complement Lookup Table for five combinations of port call frequency and shore-based maintenance.

2.4 Limits and Capabilities of CSEM and S-CSEM

CSEM simulation analysis provides a very flexible means of evaluating crew complements, but requires a computer to complete its calculations. In addition, its data entry and output interpretation requirements are substantial. S-CSEM eliminates the analytic burden, and still retains much of the power of CSEM, by making the results of CSEM analyses available via simple lookup tables. Thus, S-CSEM provides estimates of crew size without calculations.

The benefits of S-CSEM's simplicity are balanced by several limits. S-CSEM has less flexibility because only a predefined range of operating conditions can be considered. For example, S-CSEM addresses the effect of port call frequency, but considers only three levels. Other levels cannot be examined with S-CSEM until additional analyses have been completed using CSEM. In addition, other operating factors, such as different crew configurations, cannot be considered until analyses have been completed using CSEM. S-CSEM provides a framework to include many other operating factors, but will always have less flexibility than CSEM. Simplicity comes at the cost of flexibility.

Simplifying the crew size evaluation process can also undermine its accuracy. Simplified methods, such as S-CSEM, rely on information that has been distilled from analyses with CSEM. Simpler methods that extrapolate beyond these analyses provide results that tend to be less accurate. S-CSEM makes more assumptions about how work is distributed and does not provide the detailed information about crew activities that is available with CSEM.

While S-CSEM has less flexibility and possibly less accuracy, it is simpler and can be applied much more quickly. S-CSEM strikes a balance between the benefits of a comprehensive and complex approach and an overly simplified and limited approach. It retains many of the benefits of CSEM, in particular, it is a task-based approach. S-CSEM benefits from being a task-based approach because it links operating conditions to the activities of, and need for, particular crew members. The need for a particular crew complement can be traced to shipboard tasks and functions, which in turn can be traced to operating conditions. Linking the crew to shipboard tasks provides a relatively flexible basis for crew size evaluation that explains the influence of operating conditions on crew size.

3 Conclusions

This report has discussed the need for a simple yet flexible framework for task-based analysis of commercial vessel crew size. The Crew Size Evaluation Method (CSEM) provides an adaptable and comprehensive approach via task-based simulation. However, to perform a CSEM analysis requires much time and expertise on the part of the analyst and extensive, detailed information about the ship being analyzed. What is needed is a framework that can take the results of CSEM simulation analyses and make them readily available for application to day-to-day crew complement evaluations (such as those for Certificates of Inspection).

Such a framework, Simplified CSEM (S-CSEM), was described. In S-CSEM, the results of CSEM simulation analyses have been summarized in simple lookup tables and worksheets. Thus, the power of CSEM has been captured in a quick and easy-to-use format. A concept demonstration was provided that considered two operating factors, port call frequency and shoreside maintenance support. Neither of these factors is currently covered in the *Marine Safety Manual*. The concept demonstration showed how S-CSEM can easily and quickly establish a task-based crew complement. S-CSEM can be expanded to consider other common operating factors by running additional CSEM simulation analyses and summarizing those results in additional worksheets and lookup tables. In this way, S-CSEM can make task-based crew size analyses readily accessible, effectively supplementing the guidance provided in the *Marine Safety Manual*.

With the many benefits of S-CSEM come limits. The benefit of S-CSEM depends on how well its lookup tables match the demands of a particular crew size evaluation issue. Complex issues that require very precise results will best be addressed by a full CSEM analysis, while those that are relatively routine and well understood can be addressed with S-CSEM. Even if the lookup tables do not address an issue exactly (as, for example, a ship which makes five port calls in 14 days), the associated *Work Distribution Summary* table provides a clear indication of the crew types and ship tasks which are affected by the issue in question. This allows an educated guess to be made as to the crew complement which is likely to be needed (and supplies the Coast Guard with a checklist of tasks against which the crew complement could be validated on the

vessel in question). Thus, even considering its limitations, S-CSEM can provide a time-efficient and task-based supplement to the *Marine Safety Manual*.

As technology and economic pressures change the nature of shipboard operations, a task-based approach to determining crew size will become more prevalent. By linking crew size to shipboard functions and operating conditions, S-CSEM is a practical tool for crew size evaluation. S-CSEM provides the flexibility that is required to meet the needs of a changing industry.

4 References

Lee, J.D., McCallum, M.C., Maloney, A.L., & Jamieson, G.A. (1997). *Validation and sensitivity analysis of a crew size evaluation method*. U.S. Coast Guard Report No. CG-D-25-97 (AD-A331589). Washington, DC: U.S. Coast Guard.

Lee, J.D., Forsythe, A.M., & Rothblum, A.M. (1999). *"The use of the crew size evaluation method to examine the effect of operational factors on crew needs,"* U.S. Coast Guard Research and Development Center Report No. R&DC 01/99. Groton, CT 06340.

[This page left blank intentionally.]

Appendix A: Shipboard Functions and Principles of Safe Manning

This appendix lists the shipboard functions and the associated tasks. For each function the principles of safe manning are shown for the relevant crew positions. Likewise, the tasks associated with each function are linked to the crew types who typically perform the function. The purpose of this description of shipboard operations and responsibilities is to specify clearly each shipboard function and its effect on the crew needed to manage a ship.

1. *Command and Control*

Principles of safe manning

Master

- Continuously exercises command over ship.
- Has management level of responsibility for navigation function.

Chief Mate

- Assumes command in the event of the incapacitation of the captain.

Task list

1.1 Command, Control and Coordination

Master

- The process of directing and managing the safety of the crew, vessel, passengers, cargo, and basic mission of the ship.
- Overall administration and organization of the vessel.
- Management support and supervision of safe watchkeeping procedures and vessel operations.
- Voyage planning.
- Route planning and review.
- Cargo planning and review.
- Resource budgeting guidance and review.
- Watchkeeping coordination and scheduling.
- Propulsion systems planning and review.
- Monitoring and control compliance with legislative bodies.
- All tasks required because of crew incapacitation or acts of God.

Chief Mate

- Management support and supervision of safe watchkeeping procedures and vessel operations.
- Watchkeeping coordination and scheduling.
- Voyage planning.
- Route planning and review.
- Cargo planning and review.
- Resource budgeting guidance and review.
- Monitoring and control compliance with legislative bodies.
- All tasks required because of crew incapacitation or acts of God.

Chief Engineer

- Management support and supervision of safe watchkeeping procedures and vessel operations.
- Propulsion systems planning and review.
- Resource budgeting guidance and review.
- Monitoring and control compliance with legislative bodies.
- All tasks required because of crew incapacitation or acts of God.

1.2 Bridge Resource Management

Master

- Insuring that bridge resources are utilized in the safest and most effective fashion to facilitate efficient information and resource sharing on the bridge.
- Establishing and clarifying the master-pilot relationship.
- Acting as pilot.
- Communication and operational activities required by effective use of bridge watch team, including acts required by incapacitation of crew or acts of God.

1.3 Crew Performance Management and Maintenance

Master

- Insuring that crew performance is adequate for the requirements of the vessel and its voyage.
- Crew work hours management.
- Management and prevention of fatigue and impairment of crew members.

Chief Mate

- Insuring that crew performance is adequate for the requirements of the vessel and its voyage.
- Crew work hours management.
- Management and prevention of fatigue and impairment of crew members.

Chief Engineer

- Insuring that crew performance is adequate for the requirements of the vessel and its voyage.
- Crew work hours management.
- Management and prevention of fatigue and impairment of crew members.

First Assistant Engineer

- Crew work hours management.
- Management and prevention of fatigue and impairment of crew members.

2. Navigation

Principles of safe manning

Master

- Management level of responsibility for navigation function.
- Does not keep watch on ship >3000 gross tons.

Chief Mate

- Management level of responsibility for navigation function.
- Directly control the ship and supervise watchkeeping.
- Ensure safe watch is maintained.

Second Mate

- Directly control the ship and supervise watchkeeping.
- Ensure safe watch is maintained.

Third Mate

- Directly control the ship and supervise watchkeeping.
- Ensure safe watch is maintained.

Able-Bodied Seaman

- Perform duties associated with support level of responsibility for navigational watch under supervision of officer in charge of the navigational watch.

Task List

2.1 Bridge Watchkeeping

Chief Mate, Second Mate, Third Mate

- Process of monitoring and controlling the vessel during the navigational duty period.
- Establishing the vessel's position.
- Planning the ship's route.
- Navigating the ship and performing tasks required by the practice of good seamanship.
- Performing safety, maneuvering, and anti-collision tasks.
- Performing administrative and management tasks.
- Monitoring tows, integrated tug barges, and other vessels as necessary.
- Ensuring that navigation equipment is in proper working order.
- Monitoring vessel and system performance to insure that both are performing as required.
- Maintaining an efficient internal and external communication system in order to insure a safe navigational passage.

2.1 Lookout

Able-Bodied Seaman, Chief Mate, Second Mate, Third Mate, Ordinary Seaman

- Vigilant watching, hearing and reporting of navigation objects and obstacles under both favorable and adverse (e.g., fog, rain, etc.) conditions to ensure safe passage through navigated routes.

2.2 Steering

Able-Bodied Seaman, Chief Mate, Second Mate, Third Mate

- Governing the course of a ship by controlling, directly or indirectly, the helm or the rudder.
- On vessels operating under automatic pilot, this may include monitoring the vessel's course and the steering system's execution of the automatically ordered course.
- On vessels operating "by hand", this includes directing the steering system so as to execute the ordered course, comparing the ordered course with the executed course, and notification to the pilot, master or watch officer of the vessel's performance.

2.4 Voyage Passage Planning

Master, Chief Mate, Second Mate, Third Mate

- Planning and preparing for a voyage in all phases: at dock, in restricted waters, and at sea.
- Reviewing the voyage schedule, preparing the orders and voyage plans, and monitoring the weather and route.

2.5 Weather Monitoring, Planning and Reporting

Master, Chief Mate, Second Mate, Third Mate, Radio Officer

- Checking weather development and patterns, including using automated equipment in order to make sound forecasts.

3. Communications

Principles of Safe Manning

Radio Officer, Master, Chief Mate, Second Mate, Third Mate

- Operational level of responsibility for radio communications duties assigned to crew
- Emergency radio communications

Radio Officer

- Performing radio watch
- Maintaining radio communications equipment
- Emergency radio communications

Task List

3.1 Long Range Radio Operations

Radio Officer, Master, Chief Mate, Second Mate, Third Mate,

- Effecting long distance radio or satellite communications with shoreside management, regulatory agencies, vessel traffic control services, other shoreside parties, or other vessels.
- Maintaining an effective radio watch.

3.2 Communication Record Keeping

Radio Officer, Master, Chief Mate, Second Mate, Third Mate

- Recording all communication systems receipts and transmissions, including required radio watches and transmissions.

3.3 Sound and Visual Signaling

Chief Mate, Second Mate, Third Mate, Able-Bodied Seaman

- Using sound and visual signals to communicate, including whistles, bells, gongs, flags, sound-powered telephones, flashing lights, semaphore, Aladaids, and signals from the International Code of Signals and the Rules of the Road.

4. Engineering System Monitoring, Control, and Operations (MC&O)

Principles of Safe Manning

Chief Engineer

- Manage marine engineering function.
- Does not perform a watch on ship > 3000 gross tons.
- Supervise watchkeeping arrangements.

First Engineer, Second Engineer, Third Engineer

- Maintain safe engineering watches in accordance with Reg. VIII/2 of 1978 STCW Convention.
- Operate the main propulsion and auxiliary machinery to enable ship to "overcome the foreseeable perils of the voyage."
- Operate alternators, generators, control systems.

Task List

4.1 Main Engine MC&O

Chief Engineer, First Engineer, Second Engineer, Third Engineer

- Ensuring main engines are functional and operational.
- Establishing performance objectives, planning and scheduling, preparation and coordination, start up and shut down, and sustaining operations.
- Monitoring and evaluating performance.
- Adjusting equipment and services to meet operating requirements.
- Controlling malfunctions.
- Testing vital systems on arrival/departure.

Qualified Member of the Engineering Department (QMED)

- Adjusting equipment and services to meet operating requirements.
- Controlling malfunctions.
- Testing vital systems on arrival/departure.

4.2 Engineering Rounds and Record Keeping

Chief Engineer, First Engineer, Second Engineer, Third Engineer

- Compiling and maintaining records on the main propulsion system equipment.
- Gathering data about main engine and auxiliary systems status, performance, and response.
- Checking for leaks and other malfunctions while moving through the machinery spaces.

QMED

- Gathering data about main engine and auxiliary systems status, performance, and response.
- Checking for leaks and other malfunctions while moving through the machinery spaces.

4.3 Boiler MC&O

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Monitoring, controlling and operating the ship's boilers.
- Monitoring water levels and steam pressure, salinity and oxygen testing, and cleaning.
- Preparing to light off, operating the boilers during maneuvering and at sea.
- Securing the boilers in port or during yard periods.
- Producing steam for whistles, sirens, deck equipment, heating, cooking, ventilation, refrigeration, and air conditioning.

4.4 Fuel Oil Systems MC&O

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Operating, monitoring, and controlling the ship's fuel oil systems.
- Monitoring fuel levels.
- Operating fuel pumps.
- Performing fuel oil transfer operations and fuel oil service activities associated with the main propulsion system.
- Pumping and cleaning the settling tank.

4.5 Transfer Fuel Oil, Diesel Oil, and Lube Oil

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Transferring fuel oil, diesel oil, and lube oil in support of ship activities.
- Planning transfers, calculating and recalculating stability, and effecting the transfer.
- Monitoring the fluid levels once transfer is achieved.

4.6 Bunkering

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Preparing for and taking on fuel used for the ship's propulsion and auxiliary machinery
- Notifying and communicating with bunkering facility or barge and vessel
- Transferring the fuel

4.7 Evaporator MC&O

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Operating and controlling the ship's evaporators
- Testing water for salinity

4.8 Generator Systems MC&O

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED, Electrician

- Controlling and operating the primary, secondary, and emergency shipboard generators

4.9 Electrical System MC&O

Electrician, Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Insuring that the electrical system is functional and operational
- Controlling and operating ship's primary and auxiliary electrical systems, power distribution systems, circuit breakers, junction boxes, and auxiliary electrical systems.

4.10 Inert Gas Systems MC&O

Pumpman, Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Controlling and operating the ship's inert gas generating systems
- Testing, monitoring, and controlling inert gas output, production, and generation.
- Recording and maintaining inert gas and gas free levels.
- Reporting inert gas and gas levels as required, and keeping the oil record book.

4.11 Heating, Ventilation and Air Conditioning MC&O

Electrician, Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Operating and controlling the ship's heating, ventilation, and air conditioning systems, including associated air, steam, electrical, and mechanical ducting components of the system

4.12 Sewage System MC&O

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Operating and controlling the ship's sewage system, including pumping, monitoring, and controlling fresh and salt water for sanitary flushing requirements.

5 *Scheduled Maintenance and Testing (M&T)*

Principles of Safe Manning

Chief Engineer

- Manage marine engineering function

First Engineer, Second Engineer, Third Engineer

- Maintain marine engineering systems, including control systems
- Maintain main propulsion and auxiliary machinery
- Maintain radio communications equipment
- Maintain fire and life-saving equipment
- Test and maintain mechanical and electrical installations of the ship

QMED, Pumpman

- Support above engineering functions

Task List

5.1 Navigation Equipment M&T

Chief Mate, Second Mate, Third Mate

- Keeping navigation equipment in good operating condition
- Performing periodic and required testing and preventive maintenance on ship's electronic positioning equipment (e.g., SATNAV, LORAN-C, and GPS), radars, ARPA, collision avoidance systems, weather systems, facsimile machines, sextants, bearing circles, gyros, repeaters, magnetic compasses, and depth sounding equipment.

5.2 Communication Equipment M&T

Radio Officer, Chief Mate, Second Mate, Third Mate, First Engineer

- Keeping communication systems in good operating condition.

5.3 Vessel Fabric Maintenance

Able-Bodied Seaman, Ordinary Seaman, Utility

- Maintaining the deck systems, bulkheads, structures and fabric in good operational order by scraping, chipping, painting, applying coverings, and monitoring the vessel fabric.

5.4 Cargo, Deck, and Hull Equipment M&T

Able-Bodied Seaman, Pumpman, Reefer, Electrician, Chief Mate, Second Mate, Third Mate

- Maintaining the ship's cargo equipment in operational condition.
- Preventive maintenance activities and periodic testing of ship's cranes, hoists, lashing, security equipment, cargo lines, pumps, valves, electrical systems, container systems, refrigerated cargo systems, lights, pneumatic systems, crude oil washing systems equipment, closed gauging equipment, gauging indicators, and any other ancillary cargo, deck, and hull equipment carried on board.

5.5 Fire Fighting Equipment M&T

Third Mate, Able-Bodied Seaman, Chief Mate, Second Mate

- Periodically maintaining and testing all fire fighting equipment aboard ship

5.6 Lifesaving Equipment M&T

Third Mate, Able-Bodied Seaman, Chief Mate, Second Mate

- Periodically maintaining and testing all lifesaving equipment aboard ship

5.7 Tools and Test Equipment M&T

Able-Bodied Seaman, Pumpman, First Engineer, Second Engineer, Third Engineer, QMED

- Periodically maintaining and testing shipboard tools and test equipment

5.8 Plumbing M&T

First Engineer, Second Engineer, Third Engineer, QMED

- Maintaining the sewage, potable water, and other elements of the plumbing system.

5.9 Galley M&T

First Engineer, Second Engineer, Third Engineer

- Maintaining and testing the galley electrical and mechanical equipment.

QMED, Messman

- Disinfecting and cleaning the galley electrical and mechanical equipment.

5.10 Main Engine M&T

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Planning, scheduling, preparing, and coordinating the routine and preventive maintenance of the main propulsion engine
- Maintaining and testing the main propulsion engine

5.11 Boiler M&T

First Engineer, Second Engineer, Third Engineer, QMED

- Keeping the main or auxiliary waste heat boilers in good operating condition.

5.12 Fuel Oil System M&T

First Engineer, Second Engineer, Third Engineer, QMED

- Keeping the fuel oil systems in good operational condition.
- Maintaining fuel levels
- Checking and maintaining fuel pumps
- Maintaining the fuel oil transfer system and fuel oil service activities associated with the main propulsion system.

5.13 Evaporator M&T

First Engineer, Second Engineer, Third Engineer, QMED

- Keeping the evaporators in good operating condition.
- Maintaining evaporated sea water levels, amounts, and quality for feed water, drinking, cooking, and washing.

5.14 Generator M&T

First Engineer, Second Engineer, Third Engineer, QMED

- Maintaining and testing the generators at periodic intervals.

5.15 Electrical System M&T

Electrician, First Engineer, Second Engineer, Third Engineer, QMED

- Maintaining and testing the ship's primary and auxiliary electrical system.

5.16 Pump M&T

Pumpman, First Engineer, Second Engineer, Third Engineer, QMED

- Maintaining the pump system in support of the vessel's main propulsion, fuel oil, fresh water, lube oil, diesel oil, fire main, and cargo systems.

5.17 Piping M&T

Pumpman, First Engineer, Second Engineer, Third Engineer, QMED

- Maintaining the piping system in support of the vessel's main propulsion, fuel oil, fresh water, lube oil, diesel oil, fire main, and cargo systems.

5.18 Steering Gear M&T

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Maintaining and testing steering gear systems.

5.19 Inert Gas System M&T

Pumpman, First Engineer, Second Engineer, Third Engineer, QMED

- Maintaining the inert gas system, including testing, monitoring, and maintaining inert gas output, production, and generation
- Recording inert gas levels and maintaining gas free equipment.

5.20 Engine Systems Fabric Maintenance

QMED, First Engineer, Second Engineer, Third Engineer

- Maintaining the engine systems fabric, bulkheads, and structures
- Painting, chipping, coating, covering, supporting, and care.

5.21 Heating, Ventilation, and Air Conditioning M&T

Electrician, First Engineer, Second Engineer, Third Engineer, QMED

- Maintaining the heating, ventilation, and air conditioning systems.

5.22 Sewage System M&T

First Engineer, Second Engineer, Third Engineer, QMED

- Keeping the sewage system in good operational condition.

5.23 Engine Room Cleaning

QMED

- Cleaning the engine room spaces.

6. *Unscheduled Maintenance and Repair*

Principles of Safe Manning

Chief Engineer

- Manage marine engineering function

First Engineer, Second Engineer, Third Engineer

- Repair marine engineering systems, including control systems
- Repair main propulsion and auxiliary machinery
- Repair radio communications equipment
- Repair fire and life-saving equipment
- Repair mechanical and electrical installations of the ship

QMED, Pumpman

- Support unscheduled maintenance and repair functions

Task List

6.1 Navigation Equipment Repair

Chief Mate, Second Mate, Third Mate

- Repairing the ship's navigation equipment, including the ship's electronic positioning equipment (e.g., SATNAV, LORAN-C, and GPS), radars, ARPA, collision avoidance systems, weather systems, facsimile machines, sextants, bearing circles, gyros, repeaters, magnetic compasses, and depth sounding equipment.

6.2 Communication Equipment Repair

Radio Officer, Chief Mate, Second Mate, Third Mate, First Engineer

- Repairing communication equipment, including bridge radios, satellite communications systems, lifeboat radios and communications systems, cellular phones, VHF radios, telexes, facsimile machines and associated computing equipment.

6.3 Vessel Fabric Maintenance

Able-Bodied Seaman, Ordinary Seaman, Utility

- Repairing the deck systems, bulkheads, structures and fabric.

6.4 Cargo, Deck, and Hull Equipment Repair

Able-Bodied Seaman, Pumpman, Reefer, Electrician, Chief Mate, Second Mate, Third Mate

- Repairing the ship's cargo equipment, including the ship's cranes, hoists, lashing, security equipment, cargo lines, pumps, valves, electrical systems, container systems, refrigerated cargo systems, lights, pneumatic systems, crude oil washing systems equipment, closed gauging equipment, gauging indicators, and any other ancillary cargo, deck, and hull equipment carried on board.

6.5 Fire Fighting Equipment Repair

Third Mate, Able-Bodied Seaman, Chief Mate, Second Mate

- Repairing damaged fire-fighting equipment.

6.6 Lifesaving Equipment Repair

Third Mate, Able-Bodied Seaman, Chief Mate, Second Mate

- Repairing damaged lifesaving equipment.

6.7 Tools and Test Equipment Repair

Able-Bodied Seaman, Pumpman, First Engineer, Second Engineer, Third Engineer, QMED

- Repairing shipboard tools and test equipment

6.8 Plumbing Repair

First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the sewage, potable water, and other elements of the plumbing system.

6.9 Galley Repair

First Engineer, Second Engineer, Third Engineer

- Repairing the galley electrical and mechanical equipment.

6.10 Main Engine Repair

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the main propulsion engine.

6.11 Boiler Repair

First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the main or auxiliary waste heat boilers.

6.12 Fuel Oil System Repair

First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the fuel oil systems.

6.13 Evaporator Repair

First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the evaporators to insure that evaporated sea water levels, amounts, and quality are adequate for feed water, drinking, cooking, and washing.

6.14 Generator Repair

First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the generators.

6.15 Electrical System Repair

Electrician, First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the ship's primary and auxiliary electrical system.

6.16 Pump Repair

Pumpman, First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the pump system in support of the vessel's main propulsion, fuel oil, fresh water, lube oil, diesel oil, fire main, and cargo systems.

6.17 Piping Repair

Pumpman, First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the piping system in support of the vessel's main propulsion, fuel oil, fresh water, lube oil, diesel oil, fire main, and cargo systems.

6.18 Steering Gear Repair

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Repairing steering gear systems.

6.19 Inert Gas System Repair

Pumpman, First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the inert gas system.

6.20 Engine Systems Fabric Maintenance

QMED, First Engineer, Second Engineer, Third Engineer

- Repairing the engine systems fabric, bulkheads, and structures.

6.21 Heating, Ventilation, and Air Conditioning Repair

Electrician, First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the heating, ventilation, and air conditioning systems.

6.22 Sewage System Repair

First Engineer, Second Engineer, Third Engineer, QMED

- Repairing the sewage system.

7. *Emergency Response*

Principles of Safe Manning

- Prevent, control and fight fires on board
- Launch and operate life-saving appliances
- Apply medical first aid
- Render assistance to passengers in an emergency

8. *Training and Drills*

Principles of Safe Manning

- On-going training for all personnel including familiarization and basic training in fire-fighting, medical first aid, personal survival, safety and social responsibility.
- Specialized training for particular types of ships.

- Organization of efficient fire and life saving drills, including organizing damage control parties to operate watertight arrangements.

Task List

8.1 Navigation Training

Master, Chief Mate, Second Mate, Third Mate, Able-bodied Seaman

- Training crew members in navigation practices and with navigation equipment.

8.2 Engine Systems Training

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Training crew members in main and auxiliary propulsion equipment operations and maintenance, and electrical equipment operations and maintenance.

8.3 Navigation Emergency Drills

Master, Chief Mate, Second Mate, Third Mate, Able-bodied Seaman

- Conducting emergency drills for navigation emergencies, such as steering gear or other equipment failure or malfunction.

8.4 Communication Systems Emergency Drills

Master, Chief Mate, Second Mate, Third Mate, Able-bodied Seaman

- Conducting drills to train the crew to use radio services in the event of an emergency.

8.5 Engine Room Emergency Drill

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Conducting emergency drills for engine room emergencies, such as equipment failure and malfunction or crew incapacitation.

8.6 Fire and Lifeboat Drill

All Crew

- Conducting drills to train crew members for fire emergencies.

8.7 Man Overboard Drill

All Crew

- Conducting drills to train crew members to deal with man overboard emergencies.

8.8 Oil Spill Response Drill

All Crew

- Conducting drill to train crew members to deal with an oil spill.

9. Management and Administration

Principles of Safe Manning

- Apply medical first aid on board ship

Master

- Manage navigation function

Chief Mate

- Manage navigation functions in the event of the incapacitation of the master.

Chief Engineer

- Manage marine engineering functions

First Engineer

- Manage marine engineering functions in the event of the incapacitation of the chief engineer

Task List

9.1 Deck Work Schedule Management

Chief Mate, Boatswain

- Identifying tasks and assigning work to members of the deck department.
- Coordinating concurrent tasks.
- Verifying that tasks have been completed.

9.2 Chart Records and Corrections

Second Mate, Third Mate, Chief Mate

- Maintaining and correcting nautical charts, including electronic charts.
- Inventorying and ordering new charts.

9.3 Sign-On/Sign-Off Crew Members

Master, Chief Mate, Radio Officer

- Adding and deleting crew members to official crew lists.

9.4 Financial and Payroll Transactions

Master, Chief Mate

- Paying crew members and accounting for payments.

9.5 Deck Stores and Supplies

Chief Mate, Boatswain, Able-bodied Seaman

- Storing, ordering, receiving, and handling deck materials for the voyage.

9.6 Drill Record Keeping and Reporting

Chief Mate, Second Mate, Third Mate

- Maintaining detailed information about drill results, lessons learned, and areas for improvement.

9.7 Ship Yard Planning

Master, Chief Engineer, Chief Mate, First Engineer

- Preparing the vessel, its personnel, and its facilities for shipyard periods.

9.8 Main Engine Record Keeping – Historical

Chief Engineer, First Engineer

- Compiling and maintaining records on the main propulsion system equipment, including machinery history, consumable stores inventory, personnel, and the planning of shipyard work.

9.9 Engine Room Work Schedule Management

Chief Engineer, First Engineer

- Identifying tasks and assigning work to members of the engineering department.
- Coordinating concurrent activities.
- Verifying that tasks have been completed.

9.10 Engine Room Stores and Supplies

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Storing, ordering, receiving, and handling materials for the voyage.

9.11 Medical Record Keeping, Logging, and Inventory

Second Mate, Master, Chief Mate

- Maintaining medical records and organizing and managing medical care for crew members.

9.12 Medical Care

Second Mate, Master, Chief Mate

- Providing medical care to crew members.

10. Internal Ship Communications and Meetings

Principles of Safe Manning

Task List

10.1 Labor Relations

Master

- Dealing with labor concerns and handling disputes.

10.2 Shipboard Management Meetings

Master, Chief Mate, Chief Engineer, First Engineer

- Conducting meetings to discuss personnel, labor, safety and management issues.

10.3 Safety Meetings

All Crew

- Conducting meetings during which safety observations practices, drills, and experiences are discussed, including identifying problem areas and developing recommendations for improvement.

10.4 Quality of Work Life Meetings

All Crew

- Conducting meetings to discuss shipboard life, conditions practices, and changes to enhance shipboard life.

10.5 Continuing Education and Professional Development

- Providing continuing education and professional development services for crew members.

10.6 Promotion, Retention and Career Planning

Master, Chief Engineer

- Providing personnel promotion and career planning services aboard ship.

11. Regulatory Compliance

Principles of Safe Manning

- Comply with anti-pollution procedures and pollution prevention requirements.

Task List

11.1 Deck Pollution Prevention Compliance

All Deck Crew

- Effecting deck pollution regulatory compliance activities.

11.2 Engine Room Pollution Prevention Compliance

All Engine Crew

- Effecting pollution prevention activities associated with the main propulsion system.

11.3 Documentation and Certification

- Maintaining current required shipboard certification and documentation.

11.4 Regulatory Publications and Management Policy Manuals

- Maintaining a library of government publications and policy manuals.

11.5 Pre-Sail Testing/Fitness for Duty Testing

Master

- Checking and verifying that crew members are physically prepared for the impending voyage.

11.6 Communication Equipment, GMDSS Testing

Radio Officer, Chief Mate, Second Mate, Third Mate

- Verifying and checking that communication equipment and GMDSS are functional.

11.7 Fire and Safety Inspections

- Organizing and conducting workplace safety inspections and fire hazard inspections.

11.8 Sanitary Inspections

Master, Chief Engineer, Chief Mate, Chief Steward

- Conducting reviews and visual examinations of shipboard spaces so as to ensure their cleanliness.

11.9 Inspection Planning

Master, Chief Engineer, Chief Mate, Chief Steward

- Planning reviews and visual examinations of shipboard spaces so as to ensure their cleanliness.

11.10 Oversight Inspection Planning

Master, Chief Engineer, Chief Mate, Chief Steward

- Preparing the vessel, its personnel and facilities for periodic oversight inspection required by safety regulations.

12. Cargo Responsibilities and Passenger Care

Principles of Safe Manning

Able-Bodied Seaman, Pumpman

- Assume operational level of cargo handling and stowage tasks assigned to crew

“Cargo Officer” – could be Chief Mate, Second Mate, or Third Mate

- Plan and monitor loading, stowage, securing and unloading of cargo
- Care for cargo during voyage
- Keep cargo records
- Control ballast
- Calculate stability
- Monitor refrigeration
- Oversee special stowage requirements for hazardous substances

Task List

12.1 Cargo Planning

Chief Mate, Master

- Preparing the plan detailing the quantities and description of the ship's cargo so that ship officers and shoreside agents can make arrangements for cargo discharge and loading.

12.2 Cargo Load/Discharge Preparation

Chief Mate, Second Mate, Third Mate, Pumpman, Boatswain, Able-Bodied Seaman

- Preparing cargo spaces for cargo loading and discharge.

12.3 Cargo Equipment Test

Chief Mate, Second Mate, Third Mate, Pumpman Boatswain, Able-Bodied Seaman

- Checking and verifying that cargo equipment is ready for transfer.

12.4 Cargo Loading

Chief Mate, Second Mate, Third Mate, Pumpman Boatswain, Able-Bodied Seaman

- Loading cargo onto the ship, including taking soundings and topping off.

12.5 Cargo Unloading

Chief Mate, Second Mate, Third Mate, Pumpman Boatswain, Able-Bodied Seaman

- Discharging cargo from the ship.

12.6 Cargo Maintenance

Chief Mate, Second Mate, Third Mate, Pumpman, Boatswain, Able-Bodied Seaman, Reefer, Electrician

- Monitoring and maintaining cargo during transit.

12.7 Cargo Monitoring and Record Keeping

Chief Mate, Second Mate, Third Mate

- Producing and updating cargo records.

12.8 Refrigerated Cargo Monitoring and Record Keeping

Reefer, Chief Mate

- Ensuring and documenting that refrigerated cargo is secured, properly chilled or cooled, and properly handled.

12.9 Hazardous Cargo Monitoring and Record Keeping

Chief Mate

- Ensuring that hazardous cargo is safely stored and monitored.

12.10 Tank Cleaning

Chief Mate, Second Mate, Third Mate, Pumpman, Boatswain, Able-Bodied Seaman, Utility

- Cleaning cargo tanks.

12.11 Ballast Loading

Chief Mate, Second Mate, Third Mate, Pumpman, Boatswain, Able-Bodied Seaman, Utility

- Taking on water in order to maintain the stability of the vessel and trim.
- Conducting stability calculations.

12.12 Ballast Discharge or Transfer

Chief Mate, Second Mate, Third Mate, Pumpman, Boatswain, Able-Bodied Seaman, Utility

- Discharging or transferring water in order to maintain the stability of the vessel and trim.

12.13 Ballast Maintenance and Soundings

Chief Mate, Second Mate, Third Mate, Pumpman, Boatswain, Able-Bodied Seaman, Utility

- Monitoring and controlling the water taken on board to maintain the stability of the vessel and trim.
- Making daily rounds to determine ballast levels, recording and comparing ballast levels.

12.14 Stability Monitoring and Calculations

Chief Mate, Second Mate, Third Mate

- Maintaining and calculating the vessel's stability.

12.15 Passenger Assistance

Master, Chief Mate, Chief Steward

- Helping passengers on board the vessel with hotel services and communications requirements.

12.16 Passenger Monitoring and Record Keeping

Master, Chief Mate, Chief Steward

- Producing, maintaining and updating records of passenger information.

13. Hotel Services

Principles of Safe Manning

- Provide food
- Maintain cleanliness of all accessible spaces

Task List

13.1 Hotel Services Administration

Chief Steward

- Supervising the activities of the steward department.

13.2 Food Preparation

Chief Steward, Cook

- Preparing the food for the crew.

13.3 Food Service

Messman, Cook, Chief Steward

- Serving prepared meals to the crew.

13.4 Galley and Mess Room Cleaning

Messman, Cook, Chief Steward

- Maintaining a sanitary environment for the preparation and consumption of meals.

13.5 Bridge, Accommodation and Space Cleaning

Able-bodied Seaman, Utility, QMED

- Ensuring that accommodations are kept clean and orderly.

13.6 Provisioning and Provisioning Management

Chief Steward

- Ordering, inventorying, and planning galley, cleaning, and shipboard food and supplies to ensure adequate and contingency stores for the vessel's voyage.

13.7 Galley Stores and Supplies

Chief Steward, Cook, Messman, Boatswain, Able-Bodied Seaman

- Receiving, handling, and storing galley stores for the voyage.

13.8 Recreation

14. Arrival, Departure and Port Watchkeeping

Principles of Safe Manning

- Moor and unmoor the ship effectively and safely
- Manage the safety functions of the ship when employed in a stationary or near-stationary mode at sea

Task List

14.1 Departure Preparation and Testing

Chief Mate, Second Mate, Third Mate

- Checking navigation equipment.
- Checking steering gear.
- Gauging tanks.

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Checking main and auxiliary propulsion equipment.

Boatswain, Able-Bodied Seaman, Pumpman

- Checking lines.
- Securing bulk cargoes.
- Testing safety of cargo systems.

14.2 Arrival Preparation and Testing

Chief Mate, Second Mate, Third Mate

- Checking navigation equipment.
- Checking steering gear.
- Gauging tanks.

Chief Engineer, First Engineer, Second Engineer, Third Engineer, QMED

- Checking main and auxiliary propulsion equipment.

Boatswain, Able-Bodied Seaman, Pumpman

- Breaking out lines.
- Securing bulk cargoes.
- Testing safety of cargo systems.
- Warming winches and anchor windlass
- Cleaning anchor.

14.3 Escort Vessel Interaction/Coordination

Boatswain, Able-Bodied Seaman

- Tethering and untethering escort vessels.
- Coordinating and conferring with escort vessels.
- Standing by escort vessel lines.
- Monitoring escort vessel operations and interactions.

Master, Chief Mate, Second Mate, Third Mate

- Coordinating and conferring with escort vessels.
- Monitoring escort vessel operations and interactions.

14.4 Docking

Master, Chief Mate

- Navigating a vessel into a dock.
- Reading vessel's draft at appropriate intervals.

Chief Mate, Second Mate, Third Mate, Pumpman, Boatswain, Able-Bodied Seaman, Utility

- Putting down the gangway.
- Breaking out lines.
- Warming winches and anchor windlasses.
- Cleaning anchor.
- Securing the vessel to the shore with adequate lines, ropes, and wires.

- Checking the vessel's security.
- Ensuring that the vessel is adequately lighted.

14.5 Undocking

Master, Chief Mate

- Guiding the vessel off the pier.

Chief Mate, Second Mate, Third Mate, Boatswain, Able-Bodied Seaman, Pumpman, Utility

- Securing the gangway.
- Taking aboard and stowing the vessel's lines, ropes, and wires.
- Checking the vessel's security.
- Gauging tanks.
- Making cargo calculations.
- Securing bulk cargo.
- Reading the vessel's draft, if possible.
- Ensuring that the vessel is properly lighted once underway.

14.6 Mooring to Buoy

Master, Chief Mate

- Guiding the vessel to a wharf, pier, another ship, the shore, or to anchored mooring buoys.

Chief Mate, Second Mate, Third Mate, Boatswain, Able-Bodied Seaman, Pumpman, Utility

- Putting out a brow, gangway or ladder for external access.
- Breaking out lines.
- Warming winches and anchor windlasses.
- Clearing the anchor.
- Securing the vessel with adequate lines, ropes, wires, etc.
- Checking the vessel's security.
- Reading the vessel's draft, if possible.
- Establishing a mooring watch.
- Taking mooring bearings to ascertain the ship's position.

14.7 Unmooring from Buoy

Chief Mate, Second Mate, Third Mate, Boatswain, Able-Bodied Seaman, Pumpman, Utility

- Pulling in one anchor and casting off mooring lines from a wharf, pier, another ship, the shore, or from anchored mooring buoys.
- Securing the gangway, brow, or ladder used for external access.
- Taking aboard and stowing the vessel's lines, ropes, and wires.
- Checking the vessel's security.
- Reading the vessel's draft.
- Insuring that the vessel is properly lighted once away.

14.8 Anchoring

Chief Mate, Second Mate, Third Mate, Boatswain, Able-Bodied Seaman, Pumpman, Utility

- Preparing for anchor let-go.
- Clearing the hawse and chocks.
- Checking the anchor brake.
- Insuring that appropriate lights and day shapes are available to indicate that the vessel is lighted.
- Making anchor security fast once anchored.
- Establishing an anchor watch to ensure that the vessel maintains its anchorage.

14.9 Weighing Anchor

Chief Mate, Second Mate, Third Mate, Boatswain, Able-Bodied Seaman, Pumpman, Utility

- Preparing for heaving in the anchor.
- Clearing the hawse and chocks.
- Checking the anchor brake.
- Insuring that appropriate lights and day shapes are available to indicate that the vessel is lighted.
- Insuring that there is adequate power for heaving in.
- Making anchor fast once it is home.

14.10 Crane and Tug Operation

- Directing and controlling the use of tug boats and floating cranes in support of shipboard work.

14.11 Monitor Vessel's Lines and Security

Boatswain, Able-Bodied Seaman

- Making frequent rounds throughout the vessel to determine her security, and logging the results of the rounds.

Chief Mate, Second Mate, Third Mate

- Planning, preparing and insuring that the vessel is secure to its moorings, the pier, a wharf, or another ship.
- Periodically checking the vessel's draft.
- Watchkeeping in port.

14.12 Intrusion Security Watch Operations

- Ensuring that the vessel is secure from the intrusion of harmful outsiders.

14.13 Stowaway Security Watch Operations

- Ensuring that the vessel is secure from stowaways.

15. Special Operational Requirements

Principles of Safe Manning

Task List

15.1 Underway Lightering Planning

- Preparing the cargo plan to enable shipboard officers and shoreside agents to make the necessary arrangements for cargo loading and discharge.

15.2 Underway Lightering Loading

- Loading cargo onto the ship.
- Breaking out wires, ropes, shackles, and tackle.
- Communicating with the terminal.
- Cargo safety preparations.

15.3 Underway Lightering Discharge

- Preparing for and discharging cargo.
- Breaking out wires, ropes, shackles, and tackle.
- Communicating with the terminal.
- Cargo safety preparations.

15.4 Underway and Vertical Replenishment Operations

- Taking in cargo while the ship is underway, from either shipboard or airborne sources.
- Planning for replenishment operations.
- Securing transfer hoses, and security lines.
- Disestablishing shipboard or airborne connection.

[This page left blank intentionally.]

Appendix B: Complete Worksheets for the Simple Model

This Appendix contains the following:

- *Operating Conditions Summary Sheet*
- *Baseline Work Distribution and Crew Needs*
- *Operating Conditions Lookup Table* (for Port Call Frequency and Shore-based Maintenance and Repair)
- *Work Distribution Summary* (for Increasing Port Call Frequency)
- *Crew Complement Lookup Table.*

OPERATING CONDITIONS SUMMARY SHEET

Port Call Frequency

- 1 port in 14 days (14 days between ports) 3 ports in 14 days (4.5 days between parts) 7 ports in 14 days (2 days between parts)

Shoreside Cargo Support

- Yes No

Engine Room Automation

- attended unattended

Shoreside Maintenance Support

- Low *Medium (Maint.)* *High (Maint.)* Very high (Maint.)
 Medium (Maint. & Repair) High (Maint. & Repair) Very high (Maint. & Repair)

Baseline operating conditions are shaded.

BASELINE WORK DISTRIBUTION AND CREW NEEDS

1.0 Command & Control

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.58	0.02					0.17								

2.0 Navigation

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.03	0.55	0.55	0.55		3.14	0.02								

3.0 Communications

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.02	0.02													

4.0 Engineering System Monitoring, Control, and Operations

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
				0.02	0.02	0.36	0.88	0.88	0.88	2.0	0.02			

5.0 Scheduled Maintenance & Testing

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
			0.04	0.16	0.18		0.09	0.08	0.08	0.29	0.29	0.14		

6.0 Unscheduled Maintenance & Repair

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
	0.02			0.03	0.02	0.06	0.06	0.06	0.06	0.23	0.01	0.15		

7.0 Emergency Response

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

8.0 Training & Drills

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.02	0.03	0.03	0.03	0.02	0.02	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02

9.0 Management & Administration

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.12	0.11	0.02		0.18		0.04	0.02							

10.0 Internal Ship Communications & Meetings

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.01														

11.0 Regulatory Compliance

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.03	0.02			0.03	0.03					0.02	0.03			

12.0 Cargo Responsibilities & Passenger Care

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.02	0.51	0.16	0.16	0.07	0.05		0.05	0.05	0.05	0.08	0.19			

13.0 Hotel Services

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
												0.56	0.94	.71

14.0 Arrival, Departure & Port Watchkeeping

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.06	0.09	0.12	0.12	0.10	0.94		0.03	0.03	0.03					

OPERATING CONDITIONS LOOKUP TABLE

Shore-based Maintenance and Repair	Port Call Frequency		
	1 in 14	3 in 14	7 in 14
Low (Maintenance)	1	2	3
Medium (Maintenance)	1	2	3
High (Maintenance)	4	5	3
Very High (Maintenance)	4	5	3
Medium (Maintenance & Repair)	4	5	3
High (Maintenance & Repair)	4	5	3
Very High (Maintenance & Repair)	4	5	3

WORK DISTRIBUTION SUMMARY FOR INCREASING PORT CALL FREQUENCY

1.0 Command & Control

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.58+						0.17+								

2.0 Navigation

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
0.03+	0.55+	0.55+	0.55+		3.14++	0.02+								

3.0 Communications

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

4.0 Engineering System Monitoring, Control, and Operations

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
						0.36+								

5.0 Scheduled Maintenance & Testing

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

6.0 Unscheduled Maintenance & Repair

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

7.0 Emergency Response

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

8.0 Training & Drills

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

9.0 Management & Administration

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

10.0 Internal Ship Communications & Meetings

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

11.0 Regulatory Compliance

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

12.0 Cargo Responsibilities & Passenger Care

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
	0.51++	0.16+	0.16+	0.07+	0.05+						0.19++			

13.0 Hotel Services

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK

14.0 Arrival, Departure & Port Watchkeeping

MA	CM	2M	3M	B	AB	CE	1E	2E	3E	Q	PM	U	CS	CK
		0.12++	0.12++	0.10++	0.94++									

CREW COMPLEMENT LOOKUP TABLE

	MA	CM	2M	3M	B	AB	CE	1E	2E	3E	JE	PM	U	CS	CK
1	1	1*	1	1	1	6	1	1	1	1	3	2	1	1	2
2	1	1	1	1	1	6	1	1	1	1	3	2	1	1	2
3	1	2	1	1	1	7	1	1	1	1	3	2	1	1	2
4	1	1*	1	1	0	6	1	1	1	1	3	1	1	1	2
5	1	1	1	1	1	6	1	1	1	1	3	1	1	1	2

*No shore-based loading mate needed.

Appendix C: Tasks Allocated to Shore Based Maintenance

This appendix shows the maintenance tasks delegated to shore-based crew. The analyses of each level of maintenance assumes that shore-side support can complete maintenance tasks as efficiently as shore-based crew.

Type of Maintenance	Four Levels of Maintenance Activities Performed by Shore-based Crew			
	Very High	High	Medium	Low
5.1 Navigation equipment	X	X	X	Partial
5.2 Communication equipment	X	X	X	Partial
5.3 Vessel fabric (painting & chipping)	X			
5.4 Cargo, deck, and hull equipment	X	X	X	
5.5 Fire fighting equipment	X	X		
5.6 Lifesaving equipment	X	X		
5.7 Tools and test equipment	X	X		
5.8 Plumbing	X	X		
5.9 Galley	X	X		
5.10 Main engine	X	X	X	
5.11 Boiler	X	X		
5.12 Fuel oil system	X	X		
5.13 Evaporator system	X	X	X	
5.14 Generator	X	X	X	
5.15 Electrical system	X	X		
5.16 Pump	X	X	X	
5.17 Piping	X	X	X	
5.18 Steering gear	X	X	X	
5.19 Inert gas system	X	X		
5.20 Engine system fabric	X			
5.21 Heating, A/C, and ventilation	X	X	X	Partial
5.22 Sewage system	X	X		
5.23 Engine room cleaning				

[This page left blank intentionally.]