NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

THE UNRESOURCED BURDEN ON UNITED STATES NAVY SAILORS AT SEA

by

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March 2018

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704–0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 2018	Master's Thesis

4. TITLE AND SUBTITLE

THE UNRESOURCED BURDEN ON UNITED STATES NAVY SAILORS AT SEA

5. FUNDING NUMBERS

6. AUTHOR(S)

Christine L. Fletcher

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Postgraduate School
Monterey, CA 93943

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

N/A

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

The views expressed in this document are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB Protocol Number: NPS.2017.0031-DD-N, NPS.2017.0050-IR-EM2-A.

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release. Distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(maximum 200 words)*

This thesis seeks to determine why U.S. Navy Sailors work longer hours than accounted for in Navy manpower models. The study focuses on at-sea tasks of enlisted Sailors aboard Guided Missile Destroyers. To address the question, we reviewed the full Navy Manpower Analysis Center model for Destroyer task requirements, interviewed Destroyer subject-matter experts knowledgeable about enlisted tasking, analyzed self-reported workload questionnaires administered to deployed Sailors, developed a comprehensive enlisted at-sea task model, and contrasted that model with Navy task models. The thesis finds that, over the past 25 years, Navy policy changes have resulted in decreased Destroyer manning, insufficient training due to revised methodologies, and deficient maintenance. Relying on technological advancements to reduce workload, the Navy cut manning levels. These manning shortfalls, combined with higher operational tempos, resulted in misalignment between actual at-sea tasks and manning models. The largest misalignment occurs in training, including on-the-job training and qualifications, warfare training, and underway drills. Additionally, the study finds that Navy-wide policy changes were not vetted through OPNAV N1 to determine their effect on at-sea Sailor workload. This thesis recommends instituting centralized policy analysis for new initiatives potentially affecting Sailor workload and periodic reassessment of the Navy Availability Factor (afloat wartime workweek).

14. SUBJECT TERMS

Navy manpower, fleet manning, Navy training, Navy maintenance, operational tempo, OPTEMPO, Navy Availability Factor, NAF, Navy Standard Workweek, NSWW, Navy Manpower Analysis Center, NAVMAC, working hours, Ship Manpower Document, SMD, Guided Missile Destroyer, DDG, fleet friction, readiness gap, command and control, sea/shore imbalance, maritime regulations, optimal manning, Revolution in Training, RIT, behavior analysis workload creep, workload imbalance, task shedding, fatigue, stress

15. NUMBER OF PAGES 243

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2–89)
Prescribed by ANSI Std. 239–18

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THE UNRESOURCED BURDEN ON UNITED STATES NAVY SAILORS AT SEA

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MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

This thesis seeks to determine why U.S. Navy Sailors work longer hours than accounted for in Navy manpower models. The study focuses on at-sea tasks of enlisted Sailors aboard Guided Missile Destroyers. To address the question, we reviewed the full Navy Manpower Analysis Center model for Destroyer task requirements, interviewed Destroyer subject-matter experts knowledgeable about enlisted tasking, analyzed self-reported workload questionnaires administered to deployed Sailors, developed a comprehensive enlisted at-sea task model, and contrasted that model with Navy task models. The thesis finds that, over the past 25 years, Navy policy changes have resulted in decreased Destroyer manning, insufficient training due to revised methodologies, and deficient maintenance. Relying on technological advancements to reduce workload, the Navy cut manning levels. These manning shortfalls, combined with higher operational tempos, resulted in misalignment between actual at-sea tasks and manning models. The largest misalignment occurs in training, including on-the-job training and qualifications, warfare training, and underway drills. Additionally, the study finds that Navy-wide policy changes were not vetted through OPNAV N1 to determine their effect on at-sea Sailor workload. This thesis recommends instituting centralized policy analysis for new initiatives potentially affecting Sailor workload and periodic reassessment of the Navy Availability Factor (afloat wartime workweek).

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List of Acronyms and Abbreviations

3M	Maintenance and Material Management
3MC	3M System Coordinator
AAA	American Automobile Association–Driving for Life
AC	Active Component
ADAMS	Alcohol and Drug Abuse Management Seminar
AMHAZ	Ammunition Hazard
AOR	Area of Responsibility
ATFP	Anti-Terrorism Force Protection
ATG	Afloat Training Group
BA	billets authorized
BSO	Budget Submitting Office
CAC	Common Access Card
CANES	Consolidated Afloat Networks and Enterprise
CASREP	Casualty Report
CBT	computer-based training
CFL	command fitness leader
CG	Guided Missile Cruiser
CM	corrective maintenance
CMC	Command Master Chief

CNA	Center for Naval Analyses
CNO	Chief of Naval Operations
CNP	Chief of Naval Personnel
CO	Commanding Officer
COB	current on board
CODEL	Congressional delegation
COMNAVSURFLANT	Commander, Naval Surface Force Atlantic
COMNAVSURFOR	Commander, Naval Surface Forces
COMNAVSURFPAC	Commander, Naval Surface Force, U.S. Pacific Fleet
CONREP	connected replenishment
COSO	Commanding Officer (CO)'s Standing Orders
COTS	Commercial-off-the-Shelf
CPO	Chief Petty Officer
CPPA	Command Pay/Personnel Administrator
CRUDES	Cruiser-Destroyer
CS	Culinary Specialist
CSG	Carrier Strike Group
CSMP	Current Ship's Maintenance Project
CSTT	Combat Systems Training Team
CVN	aircraft carrier
DAPA	Drug and Alcohol Program Advisor

DASN (M&B)	Deputy Assistant Secretary of the Navy for Management and Budget
DC	Damage Controlman
DCNO	Deputy Chief of Naval Operations
DCPO	Damage Control Petty Officer
DCTT	Damage Control Training Team
DDG	Guided Missile Destroyer
DFS	Departure From Specification
DH	department head
DITS	Department in the Spotlight
DIVO	division officer
DMDC	Defense Manpower Data Center
DoD	Department of Defense
DoN	Department of the Navy
DRB	Disciplinary Review Board
EOSS	Engineering Operational Sequencing System
ETT	Engineering Training Team
FEP	Fitness Enhancement Program
FFG	Guided Missile Frigate
FLTMPS	Fleet Training Management Planning System
FM	facility maintenance
FN	Fireman

FSA	Food Service Attendant
FY	Fiscal Year
FYDP	Future Years Defense Program
GAO	Government Accountability Office
GMT	General Military Training
GQ	General Quarters
HAZMAT	Hazardous Material
HQ	headquarters
HSR	human subject research
IA	Individual Augmentee
IG	Inspector General
ILC	International Labour Conference
ILO	International Labour Organization
IMO	International Maritime Organization
INDOC	Indoctrination
INSURV	Board of Inspection and Survey
IRB	Institutional Review Board
ISIC	Immediate Superior in Command
ITT	Integrated Training Team
JAG	Judge Advocate General
JQR	Job Qualification Requirements
KSA	knowledge, skills, and abilities

LHD	Amphibious Assault Ship
LIMDU	limited duty
LCPO	Leading Chief Petty Officer
LN	Legalman
LPD	Amphibious Transport Dock
LPO	Leading Petty Officer
LSD	Dock Landing Ship
MAA	Master at Arms
MCA	Manning Control Authority
MCAB	Manning Control Authority Bureau
MCPON	Master Chief Petty Officer of the Navy
MEB	Medical Evaluation Board
MFOM	Maintenance Figure of Merit
MIP	Maintenance Index Page
MLC	Maritime Labour Convention
MPT&E	Manpower, Personnel, Training and Education
MRC	Maintenance Requirement Card
MRPA	Make Ready/Put Away
MTT	Medical Training Team
MWR	Morale, Welfare, and Recreation
N96	Director of Surface Warfare
NAF	Navy Availability Factor

NAVMAC	Navy Manpower Analysis Center
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NEC	Navy Enlisted Classification
NETC	Naval Education and Training Command
NJP	Nonjudicial Punishment
NMCRS	Navy-Marine Corps Relief Society
NPC	Navy Personnel Command
NPRDC	Navy Personnel Research and Development Center
NSN	National Stock Number
NSWW	Navy Standard Work Week
OCCSTDs	Occupational Standards
OJT	on-the-job training
OM	operational manning
OMMS-NG	Organizational Maintenance Management System-Next Generation
OPNAV	Office of the Chief of Naval Operations
OPREP	Operational Report
OPNAV N12	Director, Total Force Manpower Requirements
OPNAV N122	Office of the Chief of Naval Operations (OPNAV) Force Manpower and Assessments
OPORD	Operations Order

OPTEMPO	Operations Tempo
ORM	Operational Risk Management
OS	Operations Specialist
OUS	own unit support
PA	productivity allowance
PAPA	Pay and Personnel Afloat
PB4T	Planning Board for Training
PB4M	Planning Board for Maintenance
PCS	Permanent Change of Station
PERA	Planning and Engineering for Repairs and Alterations
PFA	Physical Fitness Assessment
PF&D	personal needs, fatigue, and delay
PIN	Personal Identification Number
PM	planned maintenance
PMS	Planned Maintenance System
POM	Program Objective Memorandum
PQS	Personnel Qualification Standard
PREVENT	Personal Responsibility and Values: Education and Training
PS	Personnel Specialist
PSD	Personnel Support Detachment
PT	physical training
PVT	Psychomotor Vigilance Task

RADHAZ	Radiation Hazard
RADM	Relational Administration
RAND	Research and Development Corporation
RFI	requests for information
REM	rapid eye movement
RIT	Revolution in Training
RMC	Regional Maintenance Center
ROC	Required Operational Capabilities
ROC\POE	Required Operational Capabilities and Projected Operational Environment
RRL	Ready Relevant Learning
SAP	Special Access Program
SAPR	Sexual Assault Prevention and Response
SAR	Search and Rescue
SEA	Senior Enlisted Academy
SECDEF	Secretary of Defense
SECNAV	Secretary of the Navy
SIMA	Shore Intermediate Maintenance Activity
SMD	Ship Manpower Document
SME	subject-matter expert
SN	Seaman
SNTT	Seamanship and Navigation Training Team

SORM	Standard Organization and Regulations of the U.S. Navy
SRF-B	Security Reaction Force - Basic
SSLCM	Surface Ship Lifecycle Management
STAFFDEL	Staff delegation
STCW	Standards of Training, Certification, and Watchkeeping for Seafarers
SURFMEPP	Surface Maintenance Engineering Planning Program
TAD	temporary additional duty
TPO	training petty officer
TPPH	transients, prisoners, patients, and holdees
TSO	Temporary Standing Orders
TYCOM	Type Commander
UA	unauthorized absence
UN	United Nations
USD (P&R)	Under Secretary of Defense for Personnel and Readiness
USCG	U.S. Coast Guard
USFF	U.S. Fleet Forces
VBSS	visit, board, search and seizure
VCNO	Vice Chief of Naval Operations
VERTREP	vertical replenishment
VIP	Very Important Person
WCS	Work Center Supervisor

XO	Executive Officer
YN	Yeoman
ZIDL	Zone Inspection Discrepancy List

Executive Summary

The goal of this research is to determine what workload is placed upon U.S. Navy Sailors at sea that may not be included in Navy requirements documentation and manning models. This study focuses on U.S. Navy Arleigh Burke Class Destroyers (DDG 51) while on deployment. Although examining specific ship departments with the highest workload is important, this research concentrates on the workload of the entire crew of the Guided Missile Destroyer (DDG).

Five recent studies of USN crews conducted at the Naval Postgraduate School determined that Sailors work an average of 88.3 hours per week while underway – more than the average of 81 hours of work per week planned by the Navy for enlisted Sailors. By determining the levels and sources of the workload placed on enlisted Sailors, this thesis identifies the reasons for such long working hours to potentially ascertain ways to remediate the excessive burden. This thesis seeks to answer the following question. Why are Sailors working longer hours than planned for in Navy manpower models and resourcing?

In 2016, the research sponsor, Surface Forces Pacific, requested the Naval Postgraduate School conduct a study to determine fleet requirements creep due to the knowledge that Sailors were working longer hours than planned for in Navy manpower models. No specific event provided the impetus for this research. However, over the course of this study in 2017, the Navy had three surface ship collisions and one grounding within the span of only eight months. This study is the first phase of this effort and represents the first study of its kind.

This thesis began by extensively reviewing Navy manpower history and previous manning studies. Then, a gap analysis was conducted to examine the disparity between the expected working hours planned for by the Navy Availability Factor (Navy Standard Work Week) and actual Sailor working hours. Despite multiple reports examining why accidents occurred within the Navy surface force, no entity has yet looked at and assessed the excessive workload of Sailors to determine why they are working more hours than planned within Navy manpower models. To find the gap between planned and actual workload, we used a behavioral approach for Sailor job analysis, reviewing the actual tasks performed at sea by U.S. Navy Sailors.

We created a baseline model of Sailor shipboard workload, the Mark I model, based upon discussions with Surface Warfare Officers at Naval Postgraduate School. We then flew out to five different commands (four in port and one on deployment) to refine the Mark I model, including at-sea and in-port tasks Sailors must accomplish. This effort focused on those tasks considered to take a "disproportionate amount of time," i.e., greater than average, defined as the Navy Availability Factor (Navy Standard Work Week) by the Navy. From these interviews, we created the Mark II model. We then administered questionnaires to Sailors at sea on deployed DDGs to assess individual crew member perceptions of workload.

Using this information, we updated to the Mark III model prior to meeting with the Navy Manpower Analysis Center (NAVMAC), the entity responsible for determining minimum manpower requirements. The Mark III model was an attempt to determine which at-sea tasks were specified in Navy manpower models. We provided the Mark III model to the NAVMAC Afloat departmental personnel and NAVMAC leadership for review and comment. From those comments, we made changes and created the Mark IV, representing which tasks are included, partially included, or not included in Navy manpower models.

Interviews and questionnaires about sources of workload provided insight into areas of greater concern. We followed up on these areas of concern, to include the increased Sailor workload resulting from decreased manning from the minimal requirements listed in the Ship Manpower Document, inadequate Food Service Attendant manning, excessive Maintenance and Material Management spot checks, and annual / semi-annual maintenance requirements that are not included in Navy manpower models. We obtained data and reviewed instructions for these areas of concern and confirmed issues for further Navy assessment and review.

The readiness and risk gaps created by reduced manning alone increase as tasks, both warfare and non-warfare, are increasingly levied upon at-sea Sailors. Required tasks that are not warfare related must still be completed-even though they are not included in the NAVMAC models. Therefore, there will always be a workload disparity between Navy manpower models and actual DDG workload.

Simply adding more Sailors to ships is not always an appropriate or feasible resolution. We made several policy recommendations in order to improve at-sea safety and Sailor quality of life. These recommendations include the implementation of analysis for Navy-wide policy changes, instituting a policy of periodic assessment of the Navy Availability

Factor (Navy Standard Work Week) including departmental and divisional differences, conducting a fleet-by-fleet review of Operations Orders in order to improve efficiencies as Navy ships transit from fleet to fleet, initial training recommendations for new Sailors, and providing Surface Warfare Officers with in-depth training on shipboard manpower and manning processes.

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Acknowledgments

Dedicated to the Sailors who have been, who are, and who will be. For those who have given their lives, whether through ultimate sacrifice, or their sacrifice of time, big or small, you will always hold my respect and admiration.

I would like to thank my advisor, Dr. Nita Shattuck, for providing me stability as I worked through my frustrations and long days in order to achieve a product of which to be proud. Our mutual love for the Sailors with a goal of improving their lives at sea has brought us close, and I love that we can share in the amazing changes that are and will be. Captain Good, thank you so much for your guidance and realism. Your support and that of the Commander, Naval Surface Force Pacific is exactly what we need in our Navy. Thinking ahead and knowing what is wrong is the first step. Helping to move beyond that thought and allowing access to our amazing fleet to obtain the ground truth is a special experience that few get to have. The Navy Manpower Analysis Center team has been incredibly supportive. There are a lot of misconceptions in the fleet as to what really causes their angst. However, you bring an objective view to it all, and that is what we need in the military. My goal to identify the root issues through this research could not have been achieved without your help, guidance, and clarification. To the crew and leadership of USS *Kidd*, you are all amazing, and I greatly appreciate your support in my interviews, the surveys, and making me feel like I was a part of the crew; I felt at home with you! To the leadership of USS *Higgins*, USS *Lake Champlain*, USS *Mobile Bay*, and USS *Russell*, thank you for your time in holding invaluable interviews with me to help guide this important process.

Thank you, Mom and Dad, for your unending support, love, and understanding. You provided the foundation I needed to be confident and compassionate in the life I live. My precious daughter, Calliope, your unfailing love and happiness is an amazing thing. As you grow and blossom, I will be unwavering in my love. My wonderful husband, Chris, thank you for listening, caring, and helping me through every day. I make this journey with you and love every moment we share, whether together or far apart. Thank you for your love and support. You are truly appreciated!

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CHAPTER 1:
Introduction

> Pretending to be superhuman is very dangerous. In a well-led military, the self-maintenance of the commander, the interests of his or her country, and the good of the troops are incommensurable only when the enemy succeeds in making them so. It is time to critically reexamine our love affair with stoic self-denial. . . . If an adversary can turn our commanders into sleepwalking zombies, from a moral point of view the adversary has done nothing fundamentally different than destroying supplies of food, water, or ammunition. Such could be the outcome, despite our best efforts to counter it. But we must stop doing it to ourselves and handing the enemy a dangerous and unearned advantage.
>
> - Johnathan Shay, M.D., Ph.D., Veterans' Affairs Clinical Psychiatrist
> *Parameters*, Summer 1998

1.1 Introduction

On January 31, 2017, USS *Antietam* (CG 54) ran aground while anchoring in Tokyo Bay (U.S. Fleet Forces (USFF), 2017c). On May 9, 2017, USS *Lake Champlain* (CG 57) collided with a South Korean fishing vessel east of the Korean peninsula (USFF, 2017c). On June 17, 2017, USS *Fitzgerald* (DDG 62) collided with a cargo vessel off the coast of Japan, resulting in the deaths of seven Sailors and injury to three more (USFF, 2017c). On August 21, 2017, USS *John S. McCain* (DDG 56) collided with a tanker in the approach to the Singapore Strait, resulting in the deaths of ten Sailors and injury to five more (USFF, 2017c).

After all these events occurred within less than eight months, the country's leaders asked why. What was the root cause of these events? The Vice Chief of Naval Operations (VCNO) directed a comprehensive review of the 2017 incidents and concerns with U.S. Navy operations that may have led to these events.

The Commander, USFF (2017c) executed the review, which found Sailor workweeks and "shortcuts," due to a false sense of security, as the primary reasons. The report referenced Sailors' 100-plus hour workweeks cited by the Government Accountability Office (GAO)

(2017b), concluding that such long workweeks lead to reduced recovery from fatigue and limited crew endurance. It also noted that "shortcuts" had been rationalized by various echelons of the U.S. Navy, including ship commanders and ship crews, due to pressures associated with an increased Operations Tempo (OPTEMPO). Insufficient training time due to maintenance delays and a higher OPTEMPO from dynamic operational tasking also caused lapses in certifications (USFF, 2017c). USFF also found that rescheduled or waivered training and certifications became the "new normal." They continue, discussing the fact that risk mitigation plans for these waivers or extended timelines became more of an administrative notification of the existence of expired certifications, thereby becoming a shortcut within the intended process in order to meet Fleet mission requirements. "As a result of this increased demand and delays in maintenance execution[,] training opportunities were reduced and completed warfare area certifications across FDNF-J *declined from 93 percent in 2014 to 62 percent in 2016*" (USFF, 2017c, p. 67, emphasis added). The report concluded that Fleet leadership was lulled into a "false sense of safety and security" (p. 93) due to a decrease in mishaps prior to 2017. The leadership did not collect objective data to ensure risk mitigation plans were appropriate and effective due to this false sense of safety and security. Overall, the excessive OPTEMPO and long working hours resulted in crew fatigue and decreased training and maintenance standards (USFF, 2017c).

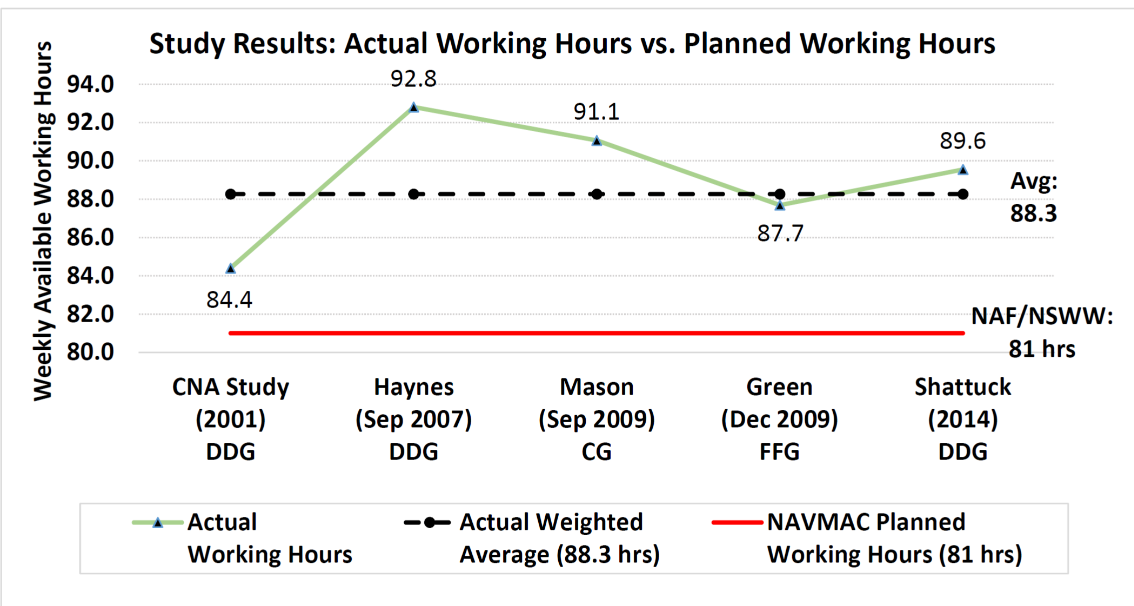
In addition to possible shortcuts taken by leadership, similar shortcuts may have been taken by individual Sailors faced with a much higher workload than expected. Since the 1990s, numerous changes have taken place within the Surface Force. Many of these changes have negatively impacted afloat manning and Sailor workload across the fleet. Contrary to expectations, decreased manning was not offset through technology and an allocation of work to shore commands. Because the improvements anticipated from technological advancements and shore support were not fully realized, Sailors experienced unexpected increases in workload. This thesis, therefore, analyzes Sailor workload in order to pinpoint issues and determine solutions to prevent further loss, injury, and death.

1.2 Scope

The goal of this research is to determine what workload is placed upon U.S. Sailors at sea that may not be included in Navy requirements documentation and manning models. This research focuses only on U.S. Navy Arleigh Burke Class Destroyers (DDG 51) while on deployment. During this portion of a Guided Missile Destroyer's (DDG's) three-year cycle, a ship's operational workload is at its highest, but the administrative workload is at its lowest, level. Furthermore, during this phase, manning is stable, and off-ship personnel are minimized. By focusing on the deployment phase, we present the "best case" scenario. Any shortcomings or issues identified during the deployment phase would almost surely be amplified during other phases of the ship's cycle. Although a detailed examination of specific ship departments with the highest workload demand is important, this research focuses on the DDG crew's workload as a whole. Of note, Guided Missile Cruiser (CG) data is also used throughout the study due to the similar nature of ship tasks to that of a DDG and because the pattern seen manifested in one surface ship will also manifest itself in another surface ship within the same organization.

1.3 Motivation

Multiple empirical studies show that U.S. Navy Sailors work long hours (see Figure 1.1).



This figure was created with data adapted from DCNO (MPT&E) (2016); Green (2009); Haynes (2007); Mason (2009); Moore, Gasch, et al. (2002); Shattuck and Matsangas (2014b).

Figure 1.1. Actual Sailor Working Hours Compared to the Hours Planned for in Navy Manpower Models.

We analyzed five recent studies and determined that Sailors work an average of 88.3 hours per week at a continuous Condition III or above level while underway. All five studies concluded that Sailors are working more than 81 hours per week, the planned level for Navy enlisted Sailor's average weekly working hours over the deployment period of approximately six months (24 weeks). By determining the levels and sources of the workload placed on enlisted Sailors, this thesis intends to identify the reasons for such long working hours and to potentially identify ways to remediate the excessive burden.

1.4 Research Question

Why are Sailors working longer hours than planned for in Navy manpower models and resourcing?

1.5 Thesis Outline

Chapter 1 provided an introduction to the study and its purpose. Chapter 2 presents an in-depth review of pertinent background information, history and methodology of fleet requirements, and literature. Chapter 3 details the thesis's methodology before Chapter 4 details the results. Chapter 5 concludes with a discussion, recommendations, and suggestions for future work.

CHAPTER 2: Background and Literature Review

A large individual workload that creates excessive working hours can, in turn, create corresponding fatigue factors that can damage unit readiness and the Sailors experiencing such conditions. Regardless of pay grade or position, excess workload places additional risk on the team as a whole. Excess workload can be imposed by the command or imposed by an external echelon, whether directly through additional tasking or indirectly through manning shortfalls. No matter the source, Sailors must adjust to excess workload. Manning shortfalls exacerbate excess workload as shortages mean a smaller team to handle the workload. The Guided Missile Destroyer (DDG) is a vessel where Sailors experience excess workload. DDGs are not the smallest ships in the U.S. fleet, but, with a high Operations Tempo (OPTEMPO) and with 65 ships in the DDG 51 class (Naval Sea Systems Command (NAVSEA), 2017a), the DDG comprises the largest class of any of the U.S. Navy surface forces.

This chapter details the step-by-step process by which the Navy determines authorized billets, from Navy end strength and congressionally authorized budget to actually manning the ship, identifying the origin of the readiness gap studied in the rest of the thesis. In order to provide an in-depth analysis of manpower issues, this chapter also reviews the history of changes and planning that affected workload for U.S. Navy Sailors, including the breakdown of work and factors that affect calculations, including accuracy, technology, sleep, and physiological effects of excessive workload. Last, through analysis of prior studies, the chapter examines workweek standards and how those standards compare to actual Sailor Available work time.

2.1 U.S. Navy Budget and End Strength

The ability to man a DDG begins with the Navy budget and congressionally authorized end strength. The process of determining Navy end strength, specifically the actual number of Sailors on active duty, begins with both the Congressional and Navy view of the nation's future along with Navy needs based on U.S. national security strategies. Together with national security goals, end strength is also determined by the Navy's budget. Every year, the Secretary of the Navy (SECNAV) provides a budget request to the Secretary of Defense (SECDEF), who, in turn, provides a budget request to the President. This request is vetted and validated through Navy processes to assure the appropriate demand signal for all portions of the Navy's budget. The planning process for any specific year's budget takes more than five years. Every year, the outlook provided as a part of the Program Objective Memorandum (POM) includes an update to the Future Years Defense Program (FYDP).

The complexity of the process, the need for procurement (along with appropriate adjustments of manpower and personnel), and innovation requires planning ahead. The FYDP, provided to the SECDEF each year, is the Navy's five year plan, including the next two years' budgets and the plan for the following three years in order to program the needs of the Navy. Internally, plans actually extend out 10, 15, and 20+ years in order to address national strategy objectives and to provide guidance to the budget process in the coming years. A simplistic budget timeline for Fiscal Year (FY) 19 and corresponding updates to the FYDP can help to understand the complexity and overlap (see Figure 2.1).

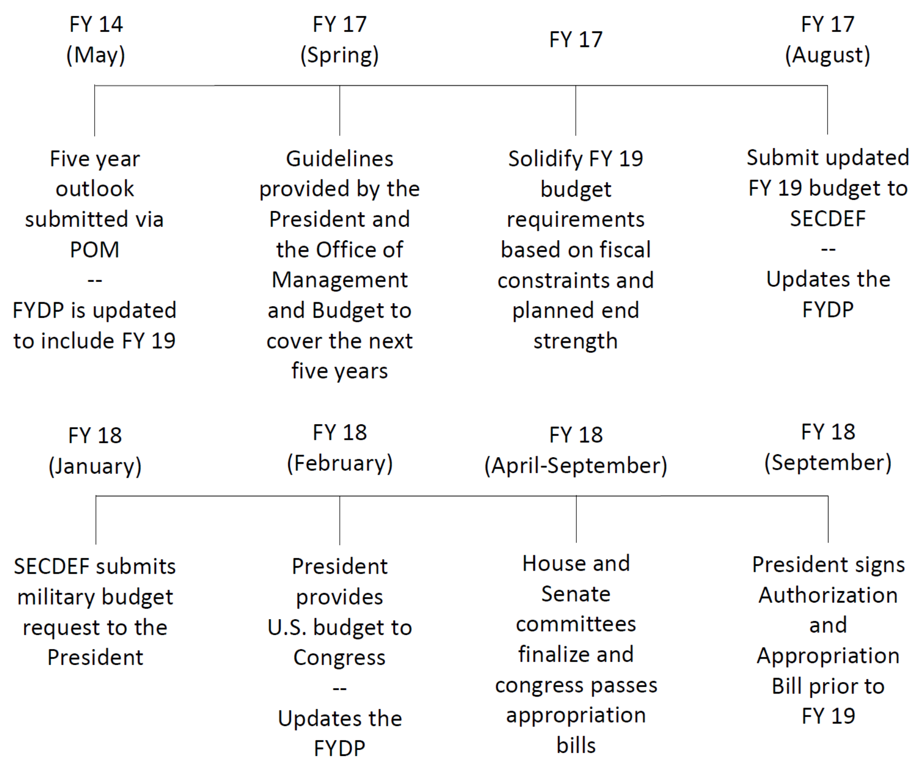


Figure 2.1. The Notional U.S. Budget Timeline for FY 19.

The Navy must set an appropriate manpower demand signal to meet the service mission. Naval personnel, especially leadership, must ensure their requirements are met, whether as a part of the procurement process, maintenance execution, or personnel management. As part of the budget process, *Personnel Strengths: Requirement for Annual Authorization,* 10 U.S.C. §115 (2006) states that "Congress shall authorize personnel strength levels for each fiscal year for ... The end strength for each of the armed forces ... for active duty personnel ... [and] The end strength for the Selected Reserve of each reserve component of the armed forces" (p. 79). Furthermore, *Permanent End Strength Levels to Support Two Major Regional Contingencies,* 10 U.S.C. §691 (2011) provides the minimum required end strength for each service in order to fight two regional wars simultaneously. Although end strength is congressionally mandated, the numbers approved are based on an end strength justification provided by the SECDEF within 45 days of the release of the President's budget (*Annual Defense Manpower Requirements Report,* 10 U.S.C. §115a, 2006), which is provided by the services within the anticipated budget constraints. Internally, the Navy budget must be balanced between Operations and Maintenance, Procurement, Military Personnel, Research and Development, and Infrastructure in order to meet all mission area needs, both now and in preparation for the future (for a breakdown of the Navy's FY 18 budget request, see Figure 2.2).

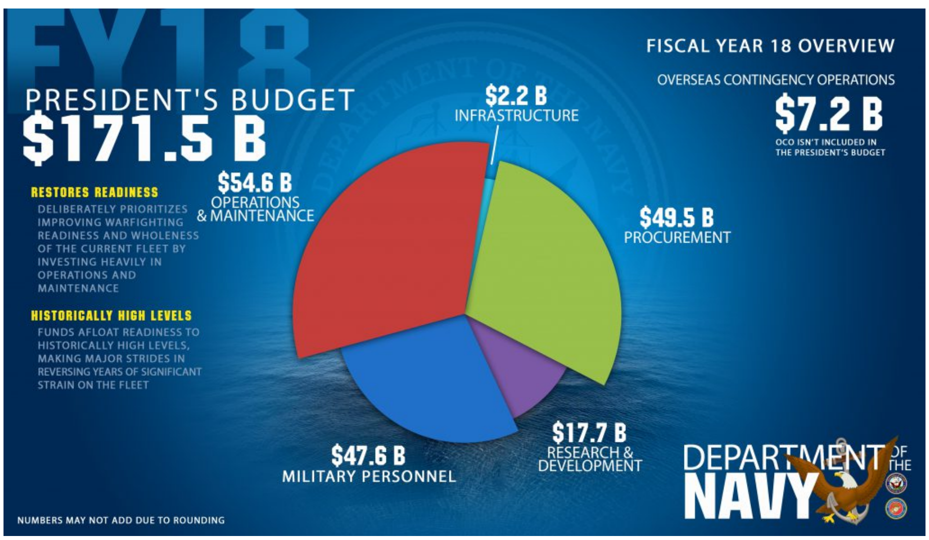


Figure 2.2. The Navy FY 18 Budget Request. Source: DASN (M&B) (2017).

The FY 18 budget request highlights an increase in maintenance costs to improve fleet readiness through the "funding [of] one hundred percent of projected ship depot maintenance" (DASN (M&B), 2017) and full funding for the procurement of eight new ships as the Navy prepares to increase from 278 "deployable battle force ships" (NAVSEA, 2017a) to the current Chief of Naval Operations (CNO) goal of 355.

Significantly, military personnel are expensive, making up approximately 28% of the FY 18 budget request (for a further breakdown, see Figure 2.3).

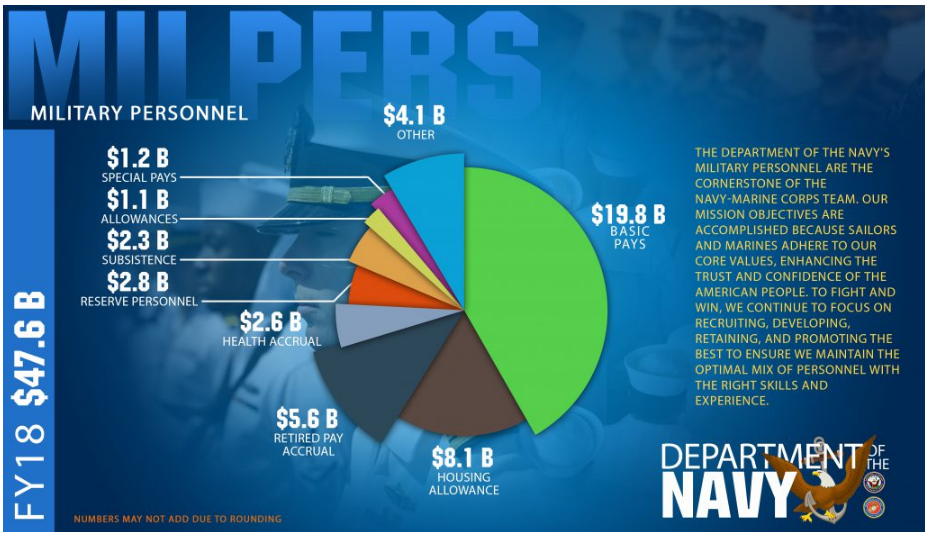


Figure 2.3. The Navy FY 18 Military Personnel Budget Request. Source: DASN (M&B) (2017).

That 28% then is made up of 41% for basic pay, meaning that basic pay accounts for over 11% of the total budget for the FY 18 request.

2.2 From Approved Navy End Strength to Navy-Funded Billets

Once end strength has been approved and budgeted,"manpower reconciliation" is the next step. The end strength request, submitted by the SECNAV, is built through the "manpower programming process ... [within the office of the] Deputy Chief of Naval Operation for Integration of Capabilities and Resources, CNO N8" (Deputy Chief of Naval Operations (DCNO) (Manpower, Personnel, Training and Education (MPT&E)), 2016, p. 1-4). This instruction, the *Navy Total Force Manpower Policies and Procedures*, continues with the process: any changes to end strength must be performed through the programming process. The reconciliation thus matches funded personnel billets, both active and reserve, to approved end strength. These funded billets form "the basis for military personnel end strength planning, recruiting, training, promotion, and personnel distribution" (DCNO (MPT&E), 2016, p. 1-5). Once a billet is funded, it is characterized as an "authorized billet."

There are several steps in reconciliation before a billet is authorized. First, the DCNO (MPT&E), Office of the Chief of Naval Operations (OPNAV) N1, oversees manpower requirements for all fleet, operational, and shore units. Within OPNAV N1, the requirements process is accomplished through the Director, Total Force MPT&E, (Director, Total Force Manpower Requirements (OPNAV N12)). OPNAV N12 oversees Navy Manpower Analysis Center (NAVMAC), the command directed to "develop and document manpower requirements for all fleet activities within the Navy" (DCNO (MPT&E), 2016, p. 1-6). Their command mission is to "define, translate, and classify the Navy's work into a workforce structure and position demand signal to sustain a combat ready force" (NAVMAC, 2016b, para. 1). Therefore, in order to meet the DCNO's goal of determining requirements, NAVMAC determines the minimum requirements (or "spaces") necessary to ensure mission accomplishment. The Budget Submitting Office (BSO) for the U.S. Navy fleet, U.S. Fleet Forces (USFF) command, "are authorized manpower resources" by the CNO in order to accomplish task and mission requirements (NAVMAC, 2017a, p. 28-2). Their coordination and approved Navy end strength determine what required billets within a manpower document to fund. The foundation of these billets is created through the process of determining fleet manpower needs so that appropriate funding decisions can be made.

2.2.1 Basis for Fleet Manpower Requirements

The primary guidance for NAVMAC and the BSO to determine authorized billets is based on U.S. Code of Law and Department of Defense (DoD) instruction. According to U.S. Code, "the Secretary of Defense shall establish a comprehensive readiness reporting system for the DoD. The readiness reporting system shall measure in an objective, accurate, and timely manner, the capability of ... units to conduct their assigned wartime missions" (*Readiness Reporting System: Establishment; Reporting to Congressional Committees,* 10 U.S.C. §117, 2003, p. 89). In addition, *United States Navy: Composition; Functions,* 10 U.S.C. §5062 (2006) directs that "the Navy shall be organized, trained and equipped primarily for *prompt and sustained combat incident to operations at sea*. It is responsible for the preparation of naval forces necessary for the effective prosecution of war except as otherwise assigned and ... for the expansion of the peacetime components of the Navy to meet the needs of war" (p. 1933, emphasis added). Moreover, Under Secretary of Defense for Personnel and Readiness (USD (P&R)) (2005) states, "it is DoD policy that national military objectives shall be accomplished with a *minimum of manpower* that is organized and employed to provide maximum effectiveness and combat power ... Manpower requirements are driven by *workload* and shall be established at the *minimum levels necessary to accomplish mission and performance objectives*" (p. 2, emphasis added). Therefore, under U.S. law, the Navy is responsible to authorize only the minimum billets, minimum being the ongoing challenge. Cut back too much and workloads, as well as risk to mission, escalate.

2.2.2 History of Manpower Requirements

After World War II, the Navy began to study manning issues. In 1963, "a sustained effort was implemented to define the work functions required in the Navy and to develop and promulgate staffing criteria as a means of improving the allocation of manpower resources" (Bright et al., 1969, p. v). Artis I. Plato was a project engineer in the Naval Ship Engineering Design Work Study Section within the offices of the Secretary of the Navy. In 1966, he worked on several manning projects to include the creation of the "Manpower Determination Model," developed to accurately predict the adequacy of crew size for U.S. Navy vessels (Plato, 1974). In his paper, he discussed the background and rationale for the development of a Navy Ship Manpower Document (SMD), attributing the manning issues for all U.S. military services to the extensive economic growth after World War II.

According to Plato (1974), rapid technological advancements after the second world war necessitated increasing numbers of technically skilled personnel, and it was in the late 1950s that the Navy began to take into account crew living conditions during the ship design process. The article notes that the Navy built ships to specifications created with poorly projected manning needs given the installation of more sophisticated technologies.

In addition, the only input to shipboard habitability up to this point was through past experience (Plato, 1974). Plato assessed that manning underestimates ranged from 6.7% to 30.5% of crew size, depending on ship class (see Table 2.1).

Table 2.1. Crew Underestimates for New Construction due to Technological Expectations. Adapted from Plato (1974).

POST WORLD WAR II EXAMPLES OF INITIAL CREW (SAILOR) UNDERESTIMATES FOR NEW CONSTRUCTION SHIPS

SHIP CLASS	INITIAL ESTIMATE	ACTUAL REQUIREMENTS	% INCREASE
CVA–59	3826	4582	19.8
CVA–63	4295	4582	6.7
CGN–9	857	1119	30.5
DLGN–25	459	524	14.1
DE–1040	195	245	25.5

Plato also noted that, as more personnel were added to compensate for underestimates, habitability decreased due to a lack of design margin to add berthing facilities. Plato (1974) states, "all of this led to a decision that in the future manning had to be determined accurately to avoid underestimating and to utilize better the available manpower resources" (p. 35). He continues by noting that standards for habitability were *first* directed in 1957 by the CNO, but, without the ability to accurately forecast manning, these standards proved difficult to achieve.

The Navy addressed the issue in the 1960s. In 1966, "an attempt was made ... to develop a special manning algorithm for the 'DD07' Program based on a study of DD 710 Class destroyers" (Plato, 1975, p. 52). Plato notes the fact that this original simplistic model was only applicable to the specific ship and was found to be inaccurate for any other destroyer or ship type. Without the ability to generalize, the algorithm was extremely limited. Soon thereafter, Plato determined that shipboard workload factors needed to be included and, due to the complicated nature of modeling fleet requirements, a computerized algorithm would be necessary in order to generate results.

By the late 1960s, the CNO mandated a study to determine unit configurations. The CNO also determined that the "Design Work Study" needed to develop a prototype "Ship Manning Document" (now known as the "Ship Manpower Document" in order to differentiate manpower requirements and manning) with the goal of accurately reflecting fleet manpower needs using analytic documentation (Bright et al., 1969; CNO, 1967; Plato, 1974). The study was undertaken by the Personnel Research and Development Laboratory, documented by Bright et al. (1969), to establish the fleet-wide SMDs in order to determine the requirements for each class of ship (e.g., CVA–59, DE–1040, etc.).

For this study, the DCNO for Manpower and Naval Reserve outlined the working hours for the baseline Sailor day, called the Navy Standard Work Week (NSWW), in a memorandum dated September 13, 1967. This memorandum set the workweek at 74 hours for watchstanders, including a breakdown of work, a six-day routine plus a day of watch, direction for an in-port routine, a productivity factor, utilities tasks (tasks other than work, maintenance, and service diversion), service diversion, personal needs, and messing (Bright et al., 1969; Vice Chief of Naval Operations (VCNO), 1967). This memorandum, obtained from Plato (1974), is provided in Appendix A. The hours for the NSWW could then be applied to the total workload hours in order to determine the required number of Sailors.

The study would prove invaluable, especially as the Navy transitioned away from conscription. "The primary objective of this study was accomplished in that it established a baseline for use in future analyses of the Navy's manpower planning system" (Wedding & Hutchins, 1974, p. vi). On July 1, 1973, the mandatory military draft expired, and the DoD became an all-volunteer force (Chambers, 2004). By that time, the U.S. Navy had finished their studies toward the minimization of shipboard manpower. The implementation of the SMD was prescient due to the increased costs associated with an all-volunteer force (Comptroller General of the United States, 1978; Plato, 1974). The Navy needed to ensure manpower requirements at sea were minimized, the goal being "a more precise measure of enlisted manpower requirements ... [in order to] improve the allocation of manpower resources" (Bright et al., 1969, pp. iii–v). By 1984, the Navy had implemented the Ship Manpower Document for 91 percent of their active surface ships (Government Accountability Office (GAO), 1986).

2.2.3 Manpower Requirements Methodology

Currently, the Required Operational Capabilities and Projected Operational Environment (ROC\POE) is generated by the DCNO for Warfare Systems, OPNAV N9 (specifically the Director of Surface Warfare (N96)) for the Arleigh Burke class DDG (DDG 51), the key document for determining Navy manpower needs. Navy surface ship requirements are based heavily on operational needs, technical publications for each individual platform, maintenance requirements, enlisted personnel specialties, positional requirements, and shipboard data. These items are consolidated by the NAVMAC staff. Sometime between 1969 and 1972, the CNO initiated the Required Operational Capabilities (ROC), providing the required shipboard mission, task, and readiness parameters to ship designers, which, in turn, helped with planning for manpower (Plato, 1974). This robust document is now the greatest driver for any change in a ship's manpower related to changes in operational requirements. If the ROC\POE does not accurately reflect the requirements of the ship class mission sets, including watch requirements for ship operations, then the ship could suffer from a lack of manpower in required mission areas and, potentially, expend too much manpower in areas that do not require it.

Based on the ROC\POE, NAVMAC determines the minimum authorized billets to meet Condition I and Condition III readiness, which does not necessarily account for in-port workload. NAVMAC defines "manpower requirements" as "the *minimum billets* required to accomplish 100% of the scenario based mission defined by the ROC\POE" (NAVMAC, 2016a, slide 2, emphasis added). In order to minimize manpower and meet the needs of the unit, specific positions must be filled to meet watch requirements for readiness Condition I and account for readiness Condition III wartime workload as defined in the ROC\POE (for a summarized view of "readiness" conditions for U.S. Navy ships, see Table 2.2).

Table 2.2. Navy Readiness Conditions as Defined by the Navy. Adapted from Cutler (1902/2002); N96 (2017).

CONDITION I	*Battle Readiness*. Also known as General Quarters. All battlestations are fully manned. This condition is set for combat situations or in cases of emergency. Expected continuous endurance is 24 hours.
CONDITION II	*Modified Battle Readiness*. A modified CONDITION I state of readiness necessary for an extended period of time. Expected continuous endurance is 10 days.
CONDITION III	*Wartime, Increased Tension and Forward-Deployed Cruising Readiness*. Systems are manned in order to ensure defense against pop-up threats. The expectation is for approximately one-third of the crew to be on watch. The manning of weapon stations is situation dependent. When deployed, a Naval vessel is considered to be in this condition. "To determine manpower requirements," expected sustainability is 60 days or less.
CONDITION IV	*Peacetime Training Cruising Readiness*. Normal peacetime cruising. Ready to change to CONDITION I, II, or III readiness as necessary.
CONDITION V	*In Port Readiness*. Capable of meeting any in-port requirement or emergency.

Inasmuch as ship Condition I and III are underway conditions, Navy ship manning models, by definition, do not account for in-port workload.

As for all Navy ships, NAVMAC measures the DDG workload based on the ROC\POE description of the operational work required to meet Condition I and III requirements. The breakdown of operational work for the DDG includes: operational manning, maintenance, support services, and other directed requirements necessary to meet the mission. Operational manning (OM), also known as watch stations, is defined as an operating station manned on a continuing basis for a specific amount of time in order to satisfy the ROC for the given condition of readiness. In other words, OM are positions that must be manned 24 hours per day (N96, 2017) in Condition III or positions (such as Condition I watches) that are infrequent in nature and, though less than 24 hours, undefined in length and necessary in a threat-imminent environment. Maintenance, both routine and non-routine, includes planned maintenance (PM), corrective maintenance (CM), and facility maintenance (FM). Support requirements, described as own unit support (OUS), includes supply support, clerical, disbursing, post office, food service, inventory, and custodial services (N96, 2017). N96 (2017) also notes that these requirements include the manning necessary for ship service facilities, messing facilities, living space maintenance, area command security, and fuels support. Directed requirements include manpower expected to meet specific manpower functions as directed by the CNO, including the Command Master Chief, 3M System Coordinator (3MC), or other specific positional need. The following shipboard workload information, unless otherwise noted, was attained through personal communications with NAVMAC as noted in NAVMAC Code 20 (2018); NAVMAC Code 40 (2017); NAVMAC, Codes 20 and 40 (2017); NAVMAC Commanding Officer (CO) (2018).

Personal Needs, Fatigue, and Delay (PF&D)

A fundamental understanding of workload breakdown first requires a detailed understanding of basic industrial engineering allowances that must be included in the analysis of workload. Konz (2001b) discusses these allowances, along with industry standards, including: personal needs, fatigue, and delays. Together, the allowances are known as the personal needs, fatigue, and delay (PF&D) allowance.

The first part of PF&D, personal needs, includes such things as drinking water, using the restroom, refilling a coffee mug, and taking a smoke break. Konz states that five percent is a typical standard value to account for personal needs (p. 1394).

Fatigue includes three areas: environmental, physical, and mental. Accounting for fatigue means there must be some sort of reason for it. According to Konz (2001b), if the position does not require a fatigue allowance (i.e., productivity or efficiency losses due to fatigue), then it should not be given, however, as noted by Konz, the International Maritime Organization (IMO) charts begin with a 10% fatigue allowance. The IMO (2001) provides ship-specific factors for fatigue affecting workload, physical stress, and sleep:

- Ship design
- Level of Automation
- Level of Redundancy
- Equipment reliability
- Inspection and Maintenance
- Age of vessel
- Physical comfort in work spaces
- Location of quarters
- Ship motion
- Physical comfort of accommodation spaces. (IMO, 2001, pp. 6–7)

The IMO notes that physical stress can also come from working long hours, common practice on board maritime vessels (p. 9). Fatigue likely affects every Sailor on board the ship. The amount of fatigue incorporated into the allowance needs to be dependent on the working environments for that Sailor. Charts are included in Kanawaty (1992) to determine an appropriate fatigue allowance based upon workload and work conditions.

Delay is the last allowance in PF&D. Konz (2001b) describes delay as an allowance that is task-dependent, not based on the Sailor. This is to account for delays from work-related conversations, maintenance or breakdowns on relative machinery, interrupted work flow, and other standard workplace happenings. The correct methodology for measurement would be to sample entire workdays. For example, if there was a six minute delay for every 100 minutes, then the delay allowance would be six percent (Konz, 2001b). Konz recommends reevaluation of fatigue allowances approximately every two years due to changing conditions (p. 1400).

Overall, with all three components, PF&D can quickly add up with a potential minimum as calculated: 5% + 1% + 4% = 10%. This would assume the 5% personal standard, 1% fatigue for only ship-specific factors (likely underestimated based on a quick review of the IMO tables as cited in Konz (2001b)), and 4% delay (this will be position dependent), a range minimum could easily start around 10%. More arduous shipboard work could easily reach closer to 20% once ship-specific factors are included. It is important that standard engineering allowances be taken into account in Navy manpower models.

As of 2002, ship manpower requirements changed to assume less than 20% PF&D allowance, meaning that on-paper requirements may not match actual work time requirements. When the SMD was created, a flat 20% productivity allowance (now referred to as personal needs, fatigue, and delay) was included as a part of the "other work, [consisting of] service diversions, productivity allowance, and training" (Bright et al., 1969, p. A-7). The 20% was a combination of "a 15-percent relaxation [personal and fatigue] allowance and a 5-percent contingency [delay] allowance ... based on studies of private industry as well as on activity sampling on several classes of ships" (GAO, 1986, pp. 32–33). In 2002, the PF&D/productivity allowance (PA) was decreased from 20% to a range of 2–8% for all ship classes to calculate manpower requirements (OPNAV N12, 2002). This allowance is only applied to FM, CM, and OUS to account for the inability of personnel to be 100% productive 100% of the time (watch stations are expected to be 100% productive at all times). A decrease in PF&D/PA directly affects the amount of time allotted for direct work requirements of FM, CM, and OUS. With a decrease in this allowance by just 10%, it amounts to about 10 minutes more time available for work. Therefore, ship manpower requirements decrease assuming a constant workload.

The allowance was changed to a new range of 2–20% in 2016 for the DDG, Guided Missile Cruiser (CG), Amphibious Assault Ship (LHD), Amphibious Transport Dock (LPD), and Dock Landing Ship (LSD) ship classes (OPNAV N12, 2016). The new PF&D/PA range is still being implemented using Industrial Engineering Standards as the ship classes are reviewed. A "range" is not provided in this revision in order to allow study and determination of actual conditions for each ship's division. The prior range of PF&D/PA will be utilized until officially assessed. The review for the listed ship classes was the first milestone in a multi-phased assessment by OPNAV N12 and NAVMAC. Phase Two will be completed for aircraft carriers (CVNs) in late 2018 or early 2019. Phase Three, the last phase, will target the remaining ship classes. Policy changes for the PF&D/PA have happened over time (see Table 2.3).

Table 2.3. NAVMAC Historical Guidelines for Personal Needs, Fatigue, and Delay (PF&D) / Productivity Allowance (PA).

1967–2002	2002–2016		2016–Present
20% (P, F: 15%, D: 5%)	2%	Administrative in nature, temperature controlled, minimal maintenance, and low noise levels	2–20% (Under revision)
	4%	Light to moderate maintenance, minimal exposure to weather, and situational awareness required	
	6%	Light industrial environment, partial exposure to weather, noise, and heat monitoring	
	8%	Heavy industrial environment, continued exposure to weather, and hazardous conditions	

Adapted from OPNAV N12 (2002, 2016); GAO (1986); Moore, Hattiangadi, et al. (2002); 2002–2016 descriptors summarized from NAVMAC Afloat Programs Department Director (2009b).

In sum, for 35 years until 2002, the Navy considered a 20% PF&D allowance, matching studies and engineering standards, when assessing manpower requirements. That 20% decreased to 2–8% from 2002–2016, and a new range, 2–20%, is now under revision and partial implementation.

Operational Manning (OM)

In the process of determining the number of personnel required for a Navy ship, of primary concern are the watch stations required for Condition I and III. As stated, the station must require the full attention of the personnel standing that watch with 24 hour manning (N96, 2017) in Condition III or positions (such as Condition I watches) that are infrequent in nature and, though less than 24 hours, undefined in length and necessary in a threat imminent environment. These operating stations, manned on a continuing basis for a specific amount of time, satisfy the ROC for the given condition of readiness and are a function of the ship design, ROCs, and operating procedures. Condition I watch stations are reflected directly in the SMD as a base manpower requirement. For Condition III watches, the planned manpower is determined by calculating 24 hours of watch among three people (i.e., three watch-sections) for each station, assuming the most intensive workload scenario in order to meet an at-sea, at-war scenario. The qualitative requirements for these positions ensure the right person with the necessary experience and specialty is at the right station in order to assure effective performance.

Planned Maintenance (PM)

Planned maintenance (PM) is the maintenance required by the Planned Maintenance System (PMS) component of the Navy's Maintenance and Material Management (3M) system and provides the necessary workload, or man-hours, expected for completing maintenance actions. This workload is based on the operating systems, equipment, and associated components on board the ship. Normally, only maintenance not in excess of quarterly and not in port is included in the workload calculations for Condition III. Due to the fact that the ROC\POE identifies the longest crew endurance of Condition III as 60 days, there is an assumption that most semi-annual and annual maintenance can be deferred until the ship is in-port or post Condition III operations (i.e., a reduced threat environment).

The man-hours that NAVMAC associates with PM include the three components of each action item: Make Ready, Maintenance, and Put Away. The fourth component is own unit support (OUS), which will be fully discussed later.

Make Ready includes the gathering of materials, including the Maintenance Requirement Card (MRC), manuals, tools, transiting requirements, Hazardous Material (HAZMAT), and any tag-outs that may be required.

The MRC provides the expected time for the maintenance itself and is itemized by the Maintenance Index Page (MIP). If no MIP is provided, then research is needed from manufacturer's directions or similar documentation in order to accurately identify the time required for maintenance. For new systems or equipment, PM requirements are accomplished through a Maintenance Engineering Analysis and documented appropriately. The maintenance times are then converted to the appropriate "weekly" equivalent for manpower hours.

The time provided is only the amount of time expected for the given MRC. Make Ready/Put Away (MRPA) allowances are not included and, therefore, must be calculated in order to adjust for actual workload. Prior to 2002, MRPA was set at 30% (Bright et al., 1969). In 2001, OPNAV N12 gave direction to change the standard to 15%, applied to all PM. In 2013, OPNAV N12 (2013) gave new direction to change the standard back to 30%, which is now the figure used for PM calculations.

PF&D/PA is not applied to this formulation. The GAO determined that including the PF&D/PA, which at the time was a blanket 20%, in addition to MRPA was double counting as such an allowance should only be used with raw productivity numbers, which would not include MRPA (GAO, 1986). They stated, "applying allowances to times based only on analysts' personal judgment and experience, workers' estimates of the time required to complete each task, or historical records is inappropriate because it is likely to result in a double counting of time ... [without] precise engineering methods" (p. 33). Therefore, PF&D/PA was removed from the PM calculation at that time and has remained that way since then. Of note, since the time of the report, NAVMAC has diligently conducted field activities to accurately time MRPA to account for all aspects of the required PM process.

Corrective Maintenance (CM)

Corrective maintenance (CM) is unscheduled maintenance due to system or component failure, malfunction, or deterioration, currently calculated by a general planning ratio. When collecting data, NAVMAC has found a lack of CM records within the system, ranging from none to very little, a problem that has plagued the Navy since they implemented official maintenance logging systems in 1964 (Bright et al., 1969; GAO, 1986). Without actual man-hour data, NAVMAC applies a general planning rule. Prior to 1968, a blanket 4:1 PM to CM ratio was used but then was changed to the ratios currently in use (GAO, 1986). NAVMAC now applies the post-1968 planning rules depending on the rating of the personnel maintaining the equipment, whether an electrical or mechanical specialty. Electronic and electrical systems receive a 1:1 PM to CM ratio while mechanical systems receive a 2:1 PM to CM ratio. The expectation is that the ratio accounts for troubleshooting and obtaining replacement parts from Supply. In addition, CM allowance provides for aging ships. In 2001, OPNAV N12 provided direction for these calculations. CM allowance must "increase by 40% (1.4 ratio) for ships less than 20 years old ...[and] 80% (1.8 ratio) for ships older than 20 years" (p. 1). Finally, NAVMAC utilizes PF&D/PA for this formulation as appropriate for the work environment.

Facility Maintenance (FM)

FM is the cleaning and preservation of the basic volume of the ship in order to maintain the ship's materiel condition. NAVMAC calculates the overall workload through actual space measurements and square footage of all ship areas. FM work ensures sanitation and cleanliness requirements are met as well as preservation from corrosion and deterioration. The development of this requirement includes an allowance for FM-specific MRPA including obtaining the required tools, transits to and from the work site, and necessary cleanup. The action includes sweeping, swabbing, overhead and compartment cleaning, touch-up painting, and polishing bright work. NAVMAC utilizes a PF&D/PA for this formulation as appropriate for the work environment.

Own Unit Support (OUS)

NAVMAC also calculates some manpower for OUS. OUS is defined as "The work actions required of personnel which are not within the categories of watch, maintenance, or service diversions, but which are *essential to the operation of the unit or activity*. Typical examples for ships ... are replenishment evolution, supervision, and working parties" (NAVMAC, n.d., p. 14, emphasis added). This category provides for the extra personnel needed to complete the administrative requirements for the ship and excess requirements due to special evolutions. Such OUS includes the Flight Deck Fire Fighting Team, Food Service Attendants, time for moderating the advancement exam, appropriate collateral duties, supply and medical support, and more.

Defining "appropriate" collateral duties is important for calculating workload because some collateral duties contribute to the work center or command mission while others do not. Therefore, collateral duties are considered either Productive or Nonproductive. NAVMAC (2000) defines Productive collateral duties as "duties that are useful and essential to the command's mission and directly support the work center or organizational mission ... [these duties] are considered productive and should be measured and captured" (p. 4-8). Furthermore, as discussed within the NAVMAC handbook, the productive hours determined for these collateral duties apply only to the work center of the primary representative. For example, productive collateral duties include the Damage Control Petty Officer (DCPO) and training petty officer (TPO). NAVMAC also defines Nonproductive collateral duties as those duties that do not contribute to the work center. The command may benefit from the Nonproductive collateral duty, but it "does not directly support the work center or the organizational mission" (p. 4-8). Therefore, nonproductive hours are not captured as a part of OUS. For example, a member of the Morale, Welfare, and Recreation (MWR) committee is considered a nonproductive collateral duty, and the time for such a duty is expected to be captured under service diversion.

The overall productive OUS workload determination is made through task analysis, interviews, and work sampling. A PF&D/PA is utilized for this formulation as appropriate for the work environment.

Directed Requirements

Directed Requirements include personnel who are mandatory by position to include the Command Master Chief, 3MC, or other positions that are directed via a written directive from an appropriate authority. Additional directed requirements are applied once direction is received.

Occupational Standards (OCCSTDs)

Also of note in NAVMAC's work breakdown are OCCSTDs. The OCCSTDs provide the details of exactly what a specific rate and pay grade does or can do (NAVMAC Code 40, 2017). NAVMAC utilizes the OCCSTDs to determine the minimum pay grade for work ability. For example, an E-5 in a given rate will be able to do some of the tasks listed for an E-6 if the tasks are listed for both the E-5 and E-6 within the OCCSTDs. However, the E-5 is considered to be unable to perform the work for the tasks listed for the E-6 that do not cross over into the E-5 OCCSTDs.

2.3 Navy Availability Factor (NAF) / Navy Standard Work Week (NSWW)

As stated in Section 2.2.3, NAVMAC utilizes the ROC\POE to determine the required Condition I positions, shipboard watch requirements, Condition III workload, and directed requirements. The NAF, previously (and still commonly) known as the NSWW (henceforth referred to as NAF/NSWW), provides the notional standard enlisted Sailor workday at sea. The "available" working hours within this workday are used in order to disperse the workload and minimize the manpower requirements for the ship. The required specialties and experience levels necessary to successfully accomplish the mission are also a part of this determination. NAVMAC then uses the minimum manpower requirements to build the SMD.

Definition of Navy Availability Factor (NAF) / Navy Standard Work Week (NSWW)
The Navy Availability Factor (NAF)/Navy Standard Work Week (NSWW) provides the number of hours the Navy plans for Sailors to be available for work at sea, broken down by the categories of watch, maintenance and/or OUS, training, and service diversion. Manpower requirements are built upon this expectation of working hours, based on the unit's mission and associated workload. Outlined by the *Navy Total Force Manpower Policies and Procedures* instruction, the "average weekly hours" for U.S. Navy at-sea enlisted Sailors are "guidelines for sustained personnel utilization" (DCNO (MPT&E), 2016, p. D-2). Although the instruction provides weekly hours, according to DCNO (MPT&E) (2016, pp. D-1, D-3), the expectation is for enlisted Sailors at sea to work a "long-term" average of 81 available (on-duty) hours with the belief that commands will ensure the management of the Sailor work schedules. Watchstander's 81 hours consists of 56 hours available for watch and 14 hours available for maintenance and OUS (or 70 hours available for maintenance and OUS for the non-watchstander) as discussed in Section 2.2.3, seven hours of training, and four hours of service diversion. Within the instruction, training is defined as "an activity of an instructional nature, which contributes directly to combat readiness ... factored to reflect those scheduled events (e.g., general drills, engineering casualty damage control) for all hands" (p. D-3). Furthermore, service diversion is defined as "actions required of military personnel by regulations or the nature of shipboard or staff routine" (p. D-3). The working hours set within the instruction reflect at-sea hours in readiness Condition III, "based upon operational requirements under projected wartime conditions ... and are not intended to reflect the limits of personnel endurance" (p. D-1).

The NAF/NSWW makes a few important assumptions. The goal is to minimize manpower requirements (USD (P&R), 2005). This is accomplished by complying with OCCSTDs, organizing workload at the appropriate level (i.e., departmental, divisional, and work center), and accurately defining the scope of the work (whether one or more ratings are required). Therefore, the baseline assumptions are optimal conditions for manning: (1) all requirements are funded and filled, (2) the Sailors: (a) are on board, (b) are fully trained, and (c) work at an "average" level of performance. "Average" is defined as the average ability "between experienced and inexperienced personnel as well as average physical and mental capacity, all across a spectrum of observations" (NAVMAC CO, 2018). As manning is reduced by deliberate action or by lack of distributable inventory, the workload is transferred to the remaining crew. Without being fully trained, the Sailor will not know how to, or may require more time to, complete their tasks. Though the reader may be surprised by these assumptions, it is nearly impossible to provide objective manpower requirements using anything other than those assumptions.

History of Navy Availability Factor (NAF)/Navy Standard Work Week (NSWW)

As discussed in Section 2.2.2, the NAF/NSWW gained traction in 1963 and was adopted by the VCNO in 1967 (Bright et al., 1969; VCNO, 1967). Since the adoption of the NAF/NSWW, several changes have been made (see Table 2.4).

Table 2.4. Navy Availability Factor, Formerly Known as the Navy Standard Work Week, Historical Changes (in Hours). Adapted from Bright et al. (1969); DCNO (MPT&E) (2002); VCNO (1967); as cited in Moore et al. (2001).

<table>
<tr><th></th><th>Available Time</th><th>Training and Service Diversion</th><th>Productive (Watch and Work)</th><th>Personal Time</th></tr>
<tr><td>September 1967 (DCNO (M&RA))</td><td>74</td><td>18 (including "Work")</td><td>56 (Watch only)</td><td>94</td></tr>
<tr><td>August 1970</td><td>74</td><td>4.5</td><td>69.5</td><td>94</td></tr>
<tr><td>Between 1970 to 1981</td><td colspan="4">Changed work week definition from "maximum" to "average"</td></tr>
<tr><td rowspan="2">August 1986</td><td>81</td><td>14</td><td>67</td><td>87</td></tr>
<tr><td colspan="4">Change from watchstanders only to all of ship's enlisted Sailors</td></tr>
<tr><td>June 2002</td><td>81</td><td>11</td><td>70</td><td>87</td></tr>
<tr><td>June 2015</td><td colspan="4">Change from "Navy Standard Work Week" to "Navy Availability Factor"</td></tr>
</table>

The changes include an update to the workweek definition to "average" from a "maximum" sometime between 1970 and 1981 and the dissolution of distinct watchstander and non-watchstander hours in the August 1986 revision of the NSWW (Moore et al., 2001). The study notes that one of the largest changes that took place also happened in the August 1986 revision: a decrease in personal time by 7 hours, moving that 7 hours to available working time for a total of 81 working hours.

Officer manpower requirements are not built through the NAF/NSWW. In a 1978 tasker from the DCNO(MPT&E), the Naval Manpower and Material Analysis Center, Atlantic, was directed to develop and submit an approach to determine officer requirements (Lull, 1981). Eight potential methodologies were submitted at the time. Today, officer requirements are considered "directed requirements" and are based solely on required numbers for shipboard operational manning billets, promotion opportunity, and community health.

2.4 Fleet Manning

It is not possible to man all funded requirements at once due to the availability and transfer process of personnel (for a snapshot of FY 17, see Table 2.5).

Table 2.5. Defense Report FY 17: U.S. Navy Enlisted Military Manpower Totals / Strength Estimates (in Thousands). Adapted from Total Force Planning and Requirements Directorate (2016).

Service	**Account**	**FY 15 Actual**	**FY 16 Estimate**	**FY 17 Estimate**
Navy	In Units [Fleet and Shore Commands]	231.9	232.2	232.0
	Individuals:			
	Transients	8.6	8.6	6.8
	Trainees/Students	27.2	26.1	24.1
	Midshipmen	0.0	0.0	0.0
	Patients/Prisoners/Holdees	1.5	1.5	1.5
	Undistributed Manning	0.0	0.0	0.0
	Total End Strength	269.2	268.5	264.4

This table is from the defense report explaining the DoD requirements request, built into the President's budget request for FY 17 (Total Force Planning and Requirements Directorate, 2016). The report was provided within 45 days from submission of the President's Budget as required in Section 115 of Title 10 (*Annual Defense Manpower Requirements Report,* 10 U.S.C. §115a, 2006), discussed in Section 2.1. The definitions for each category are provided by the USD (P&R) (2015).

Looking at actual FY 15 data, 8,600 Sailors were in transition. Transients include "all military personnel in a travel, proceed, leave en route, or temporary duty en route status on permanent change of station (PCS) orders to execute an accession, separation, training, operational, or rotational move ... [or] who are not available for duty during a no-cost move because of leave or temporary duty en route" (USD (P&R), 2015, p. 3). Combined with 1,500 who were either patients, prisoners, or holdees, at least 10,100 Sailors were not at a specific command conducting work.

2.4.1 Friction in the Fleet: Sea/Shore Imbalances

In addition to those Sailors not conducting work at a specific command, some surface ship personnel may be still working at a shore command due to lack of funding for the transients, prisoners, patients, and holdees (TPPH) and Student funding accounts. The imbalance of Naval personnel and the reasons for it are discussed by Belcher et al. (2014) and Belcher, Reese, and Lawler (2016). They state that personnel must be available to man the fleet when it is required, but, in reality, personnel may be waiting for their orders to conduct a Permanent Change of Station (PCS) or waiting to enter ("class up") into a required school. As further discussed by Belcher et al. (2014), this imbalance also includes those who may be augmenting another force, cannot deploy due to medical issues, or have a family situation prohibiting them from PCSing to a particular station. Such situations cause Sailor distribution friction to occur, which, in turn, leads to gapped, or unfilled, billets at sea.

In a perfect world, a Sailor conducting a PCS arrives to relieve another and has about two weeks to turn over the position before the second Sailor departs, transitioning to his or her next command. This transition takes a total of about 44 days if the member takes the 30 days of leave generally authorized prior to arrival at the new command. However, this process does not always occur, especially within U.S. Navy fleet commands. At times, positions are gapped prior to the arrival of a relief. The gap may be due to retirement with the retiring Sailor taking 30 to 60 days of terminal leave, a delay of the replacement's arrival, or unplanned losses due to medical, disciplinary, or other issues. Another reason for positions to be left gapped is a lack of specifically qualified personnel to fill the position (e.g., a student is unable to begin class instruction or sea/shore rotation issues within the specific enlisted rating). These problems result in fewer Sailors at a fleet command than billets funded.

According to OPNAV Force Manpower and Assessments (OPNAV N122), an average of 8.4 Sailors out of 100 were not available due to this friction in 2009. OPNAV N122 (2009) notes that, across the Navy, shore billets were reduced in parallel with decreases in Navy end strength, which reduced the ability to fill billet gaps at sea. Belcher et al. (2016) note that available personnel for sea and shore duty depends on the total number of U.S. Navy personnel. As seen in Table 2.5, the number of available personnel is the total end strength minus the transients, trainees, students, patients, prisoners, and holdees. There were imbalances of Navy fleet personnel distribution from FY 06 through FY 13 (Belcher et al., 2014) (see Figure 2.4).

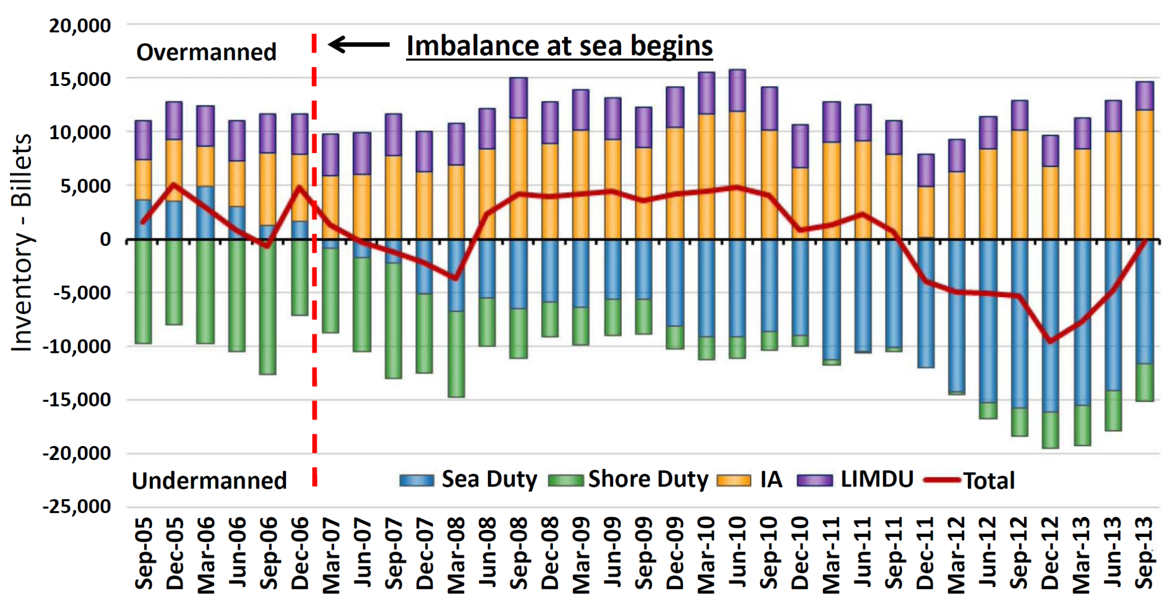


Figure 2.4. Fleet Imbalances from FY 06 through FY 13. Adapted from Belcher et al. (2014).

The horizontal red line represents total end strength. Shortfalls due to Individual Augmentees (IAs) and limited duty (LIMDU) personnel, seen in orange and purple, show excess overhead, reducing the availability of Sailors for sea and shore duty, seen in blue and green (Belcher et al., 2014). The imbalance at sea begins to grow between December 2006 and March 2007, indicated by the dotted red line, and continues to progressively increase.

With fewer Sailors aboard the surface ships, whether due to a mismatch between billet authorizations and the availability of Sailors, PCS gaps, or gaps due to rating rotations (sea/shore friction), the Manning Control Authority (MCA) Fleet (USFF Command for the Navy fleet and operational units) must manage ship manning to assure ship priorities are met (Manning Control Authority Bureau (MCAB), n.d.). To meet these priorities, the MCA may divert personnel from one command to another depending on required mission priority. The ability to divert personnel provides flexibility to ensure that the ships with the greatest priority get filled.

2.4.2 Personnel Attached but not on Board

Besides gapped billets, a Sailor currently attached to a command may not necessarily be available for work on board. There may be one of several reasons why that Sailor may not be on board or working on any specific day. Individuals in this situation are known as non-available personnel (USD (P&R), 2015). The reasons for their non-availability can vary from a few days of sickness to a long term medical or family issue causing their removal from the unit. Other reasons personnel may not be on the ship while deployed at sea are listed below. This list is not all-inclusive.

- Emergency Leave: Commanding officers may authorize up to 30 days of emergency leave, defined as "Leave granted for a personal or family emergency involving members of their household, immediate family, or a sole surviving relative which requires the Service member's presence whenever the circumstances warrant and the military situation permits" (Navy Personnel Command, PERS-91, 2013, p. 2).
- Individual Augmentee (IA): Temporarily assigned to a different unit due to the Sailor's specialty. This assignment is typically in support of a specific military campaign. The Sailor is still attached to the surface ship, also known as their "parent command," but are only performing work for the other command.

- Dwell Time: "The period of time between operational deployments" (CNO, 2014, p. 2). Due to PERSTEMPO [Personnel Tempo] thresholds and necessary dwell time, a Sailor who returns home from an IA deployment may not be able to fly out to the deployed parent command without a period of time to recover, reunite with family, and catch up on personal business.
- Short Term Hospitalization, Medical Diagnosis, or Injury: Not all medical issues and injuries can be resolved at sea on a DDG or another ship within the Strike Group. In such a case, the Sailor is sent ashore for treatment. The Sailor "will remain assigned to their units ... when they are projected to heal, recover, and return to full duty within ... 30 days for sea-based units" (USD (P&R), 2015, Enc. 2, p. 9). If longer than 30 days, then the member will be transferred out of the command.
- Billet Gap: Personnel who have transferred for reasons other than standard rotation. Examples include sexual assault expedited transfer, relief failed to screen for sea duty, pregnancy, and administrative separation due to misconduct.
- Desertion: A Sailor is not declared a deserter until 30 days after being in an unauthorized absence (UA) status, facts indicate a desertion, or the Sailor is UA with the intention or action of going to a foreign country (Navy Personnel Command (NPC), 2015b). Once declared a deserter, the Sailor remains attached to the command until 120 days thereafter when he or she is administratively transferred to the deserter command, Navy Absentee Collection and Information Center (NPC, 2015a). Therefore, it could take as much as 150 days before the command administratively removes the Sailor and can work to attain a new Sailor for the position. By the time a replacement arrives, the gap can easily be one year or more.

The first three items are temporary in nature. Emergency leave is approximately two to four weeks without the Sailor on board depending on the reason. The IA and Dwell Time combined can easily keep a Sailor away from the command anywhere from six months to a year and a half depending on the parent command's and augmented command's deployment schedule. Medical issues may or may not be permanent, lasting anywhere from two weeks to being permanently removed from the command due to LIMDU status. However, the need for LIMDU status may not be known until almost 30 days of the Sailor being off ship. Unplanned permanent departures cause a disruption in the billet due to a resulting billet gap (time between departure of one Sailor and the arrival of the relief). This disruption is due to administrative paperwork processing time to remove the Sailor from the billet, to identify a relief, and for the relief to arrive at the command. The resulting gap can easily be between six months to a year, if not more. For most of these issues, the end result is Type Commander (TYCOM) "unidentified" manning shortfalls (i.e., shortfalls that are not easily seen on the command's manning document). The resultant workload is passed on to the command's remaining personnel until a replacement arrives.

2.5 Manpower Historical Changes

> We need to figure out how to have the fewest number of people possible, and then build [ships] to make them as effective as they need to be.
>
> - Admiral J. M. Boorda, CNO, U.S. Navy
> (Winston et al., 1995, p. i)

With the DoD requirement to minimize military personnel, as previously discussed in Section 2.3, the assumption is made in manpower models that all personnel are on board, are fully trained, and work at an "average" level of performance. The minimal manpower for the DDG is built upon these assumptions. However, from 2002 through 2009, the DDG was the U.S. Navy surface platform with the greatest reduction in manpower. The DDG reduction was about 23% below what was thought to be minimal manning prior to 2002, mostly affecting lower pay grades (Rodney et al., 2009). The study found that, during this time frame, due to increased U.S. military efforts, IAs were increased, affecting as much as 1% of enlisted manning. For a crew of 280, that is a single source average decrease of 2.8 enlisted Sailors.

The Navy made numerous changes (mostly independently) from 2000 through 2009, causing such manpower decreases. As a result, the GAO report (2010) noted the fact that the Navy did not have a good analytic basis for reductions made to surface ship crew sizes. The GAO report noted that the lack of analysis for Cruisers and Destroyers resulted in the lack of assurance that the Navy "had appropriately sized its crews to maintain materiel readiness and accomplish necessary tasks aboard its ships" (GAO, 2011, p. 1).

2.5.1 Smart Ship Program, 1996–2000: A Test of Optimized Manning

From 1985 to 2000, the Navy budget was reduced by about 40% (Spindel et al., 2000). With such budgetary reductions, the Navy needed to revise the way it considered shipboard manpower. Because personnel are one of the most costly portions of the Navy budget, cutting back personnel made sense. Additionally, numerous publications in the 1990s discuss excessive U.S. Navy warship manning and associated personnel cost (whether direct or indirect) concerns, to include Bost, Mellis, and Dent (1995), Winston et al. (1995), along with seven more studies cited by Spindel et al. (2000, p. 13). These papers indicated concerns that manpower was not being calculated properly. Overall, the papers concluded that NAVMAC was overstating the minimal manpower requirements necessary to complete the Navy Strategic Plan and mission; they recommended review of watchstation consolidation and/or technology investment. "Military transformation" was the phrase being used throughout these 1990s manning discussions, which continued with President Bush's security strategy of 2001 and the Secretary of Defense 2002 Annual Report to the President and the Congress.

Papers in the early 2000s pointed to the need for better training and elimination of redundant staff, as well as misleading comparisons to foreign navies, as solutions to what they saw as excessive personnel. In a review of reduced manning initiatives, Hinkle and Glover (2004) noted in their paper that U.S. Navy leaders know "a smaller, *better-trained*, more stabilized crew could mean a more capable, more professional warfighting team" (p. 2, emphasis added). Bost et al. (1995) provide a historical illustration of unnecessary manning in the U.S. Army where five personnel were needed to fire weapons, but a sixth soldier just stood there. In the end, they determined that the sixth was previously used to hold the horses ("horse-holder") and, in fact, was no longer needed. The authors also point out that it took several more years before the U.S. Army removed the sixth person. They made the point that due to "resistance to change," the U.S. Navy does not actually minimize required manning. They stated that the U.S. Navy is overmanned compared to the practice of foreign navies. When comparing to other navies, however, they did not account for overall requirements above and beyond the base mission of the vessels for each country. On a dissenting note, Hinkle and Glover (2004), in their review, found that foreign navies had a need to *significantly* augment crews when forward deployed due to increased workload (p. 17).

In addition to the concern of potentially overstating the manpower requirement, between 1990 and 2000, Navy end strength steeply declined, with the Navy losing more than 200,000 Sailors (Defense Manpower Data Center (DMDC), 2017). Furthermore, Moore, Hattiangadi, Gasch, and Sicilia (2002) determined there were "concerns that the standard process may be overly affected by culture or hindered by outdated policies and business processes" (p. 8) as discussed in Bost et al.'s "horse-holder" article (1995).

The combination of suggested manpower reduction and technology increase had been suggested in 1995. Bost et al. (1995) reviewed the workload used in the creation of ship requirements using such terms as previously laid out in manpower methodology, Section 2.2.3 (i.e., operational manning, planned maintenance, corrective maintenance, own unit support, etc.). They also noted that certain portions of the NAF/NSWW could be pared down through automated systems. They end with a brief comment, "Reduced shipboard manning effectively will require this total organization effort" (p. 93).

Navy leadership heard the concerns and implemented a "smart ship" program. A 1997 Navy letter from Commander, Naval Surface Force, U.S. Atlantic Fleet stated that the report by the Winston et al. (1995), specifically, was the impetus for Navy leadership to begin a "smart ship" program on USS *Yorktown* (CG 48) in 1996 (Moore, Hattiangadi, et al., 2002). This program included cutting approximately 15% of ship's company and augmenting shipboard systems with greater automation (Spindel et al., 2000). The program meant to determine manpower reductions "without impacting mission readiness, ship integrity, or quality of service" (Hinkle & Glover, 2004, p. 9). This singular vessel program showed a reduction in personnel on board surface ships to be possible. It demonstrated "how technology insertion and changes in procedure can reduce manning, maintain capability and improve shipboard quality of life" (p. 3).

In 2000, the Naval Research Advisory Committee examined the "smart ship" program results and other worldwide sources of shipboard optimized manning and found potentials for cost reduction. Technological advances, both current and expected, along with highly educated Sailors, were expected to enhance the shipboard environment and allow for reduced manpower. This goal to optimize manning has an overarching construct to ensure warfighting capability with a minimum number of Sailors (see Figure 2.5).

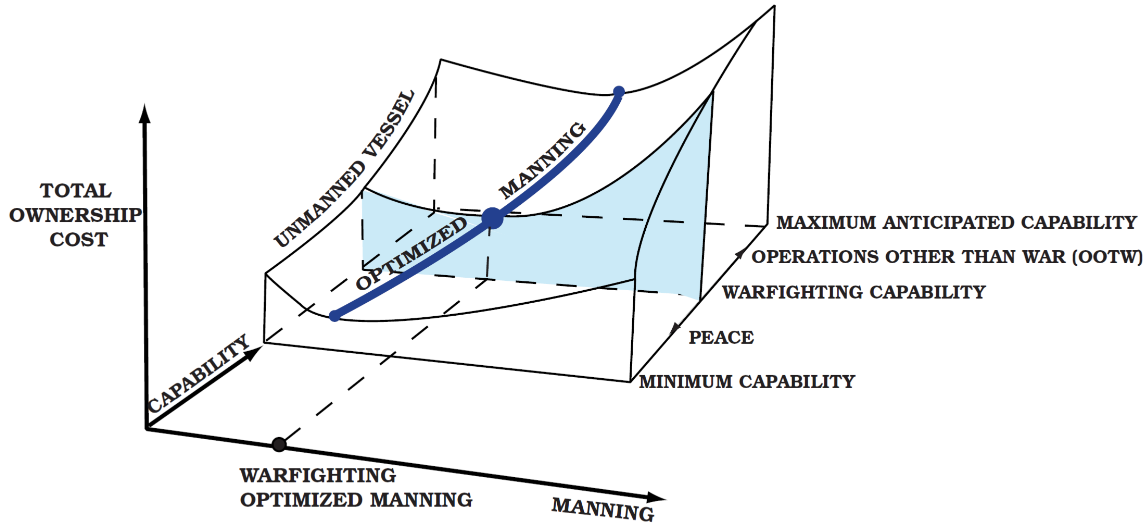


Figure 2.5. Graphical Description of Optimized Manning–Lowering Total Ownership Cost while Maintaining the Necessary Warfighting Capabilities. Source: Spindel et al. (2000).

Both the "smart ship" program results as well as research of foreign navy optimized manning provided considerable evidence that a reduction in manning held realistic potential. This evidence and validation of optimized manning along with budgetary concerns gave U.S. Navy leadership the foundation necessary to begin reducing shipboard manning. In order to achieve Optimized Manning as discussed by Spindel et al. (2000), multiple supporting requirements must be in place, to include *expected systems automation, 100% manning of billet requirements, more extensive support facilities ashore, consolidation of ratings, and other factors* (p. 27).

2.5.2 Optimal Manning Initiative: 2001–2006

Optimized manning discussions in the early 2000s indicate that not only was the Navy interested in improving technology in order to achieve smaller crew sizes, but they were also greatly interested in reducing the surface Navy operating costs by eliminating the "horseholders." In 2001, the Navy proceeded forward with an initiative called "Optimal Manning" that cut billets considered to be duplicative or unnecessary. The Commander, Naval Surface Forces (COMNAVSURFOR) (2004), directed the implementation of Optimal Manning via Naval message; called the "Optimal Manning Experiment," the Navy designated USS

Milius (DDG 69), USS *Mobile Bay* (CG 53), and USS *Boxer* (LHD 4) as the test platforms for optimal manning with USS *George Washington* (CVN 73) battlegroup testing the same efficiencies while on their 2002 deployment. The experiment continued throughout an entire operational cycle (COMNAVSURFOR, 2004). The message also discussed implemented changes in watchstation manning as well as lessons learned through the process. With a goal of meeting a specific number of allowed billets, OPNAV N1 and USFF identified certain billets as unnecessary and implemented cuts primarily through changing the ROC\POE (NAVMAC Code 20, personal communication, January 7, 2018). Other policies, including the Repair Party Manual (Naval Surface Forces, 2009), also saw changes. These changes directly affected the corresponding manpower requirements within the SMD.

2.5.3 Navy Standard Workweek Available Working Time: 2002

In June of 2002, NAVMAC increased the time available for work, including watch, maintenance and/or daily workload, for the NAF/NSWW from 67 to 70 hours (DCNO (MPT&E), 2002). Taken from the time allotted for service diversion, these three hours did not increase the total available time as shown in Table 2.4.

While annual savings seem to accrue quickly with even a small change in manpower, we must remember that one Sailor does not automatically equal another in terms of training and capability. Navy manpower requirements rely on the NAF/NSWW to optimize the personnel necessary to accomplish the ship's mission. Adding three hours per week of available working time for each position on board the ship makes a significant difference in enlisted manning. For example, say a DDG is manned with 280 personnel; using simplistic calculations and assuming constant workload billets, an increase of three hours available for work could reduce manning requirements by approximately 12 to 14 Sailors throughout the ship. Across the fleet, a cut of 12 to 13 Sailors would result in the reduction of approximately 815 Sailors. The 2018 E-5 burdened rate is $86,531.39 per year, which includes base pay, allowances (Cost of Living, CONUS/OCONUS Housing, Uniform, and Subsistence), retired pay accrual, Social Security, health care (Defense Health Care Accrual), special and/or incentive pay, and change of station costs (OPNAV N100B, personal communication, October 6, 2017). Based on the 2018 E-5 burdened rate, increasing work available time across the fleet could mean that one single simplistic change in manpower saves the Navy more than $70.5 Million USD annually. While this example demonstrates potential cost savings, it cannot be assumed that any one of the Sailors on board can complete any of the Ship's tasks, let alone account for gapped billets. .

2.5.4 Personal needs, Fatigue, and Delay (PF&D) / Productivity Allowance (PA) Reduction: 2002

As discussed in Section 2.2.3, leadership changed the PF&D/PA in 2002, reducing the allowance from 20% to a range of 2–8%. This reduction, though somewhat small in nature, effectively eliminates as many as 5 to 8 personnel due to the application of decreased PF&D/PA to OUS (NAVMAC Code 40, 2017). Along with the other changes made during this time frame, the PF&D/PA reduction appeared to create greater hardships for crew members by artificially raising productivity assumptions without any corresponding policy changes or technological improvements.

2.5.5 Make Ready / Put Away (MRPA) Reduction: 2002

Getting ready for and finishing up maintenance tasks can, at times, take longer than the maintenance itself, making MRPA an essential manpower calculation. In the same letter directing a revision to the PF&D/PA in 2002, leadership also directed a reduction in the MRPA, from 30% to 15%. Therefore, for all PM, the revision affected the time provided to take care of the collection of tools, tag-out requirements, and complete the evolution. Again, this artificial increase in productivity assumptions happened without any policy or technological improvements. As discussed in Section 2.2.3, leadership changed the MRPA back to 30% in 2013.

2.5.6 Pay and Personnel Afloat (PAPA) Detachments: 2003

Pay and Personnel Afloat (PAPA) Detachments were intended to consolidate the workload for surface ship pay and personnel support from each individual ship to a dedicated shore facility. The formation of detachments allowed a two-thirds cut of the Personnelman (PN) and Disbursing Clerk (DK) personnel (merged to form the Personnel Specialist (PS) rating in 2005) from surface ships. Additionally, the consolidation required fewer support personnel and, due to the locality, civilians could be utilized (Rodney et al., 2009). Therefore, the consolidation was seen as a win-win effort: cut manning, improve accuracy, and obtain efficiency all at the same time. According to Rodney et al., experiments were run in 2001 and implemented from 2003 to 2007 for all surface ships except CVNs, showing a nominal change for DDGs (see Table 2.6).

Table 2.6. DDG Manpower Reductions in the PS (DK / PN) Ratings due to PAPA Detachments, September 2003 through March 2009. Adapted from Rodney et al. (2009).

Ship class averages		Sep 2003	March 2009	Delta
DDG Flights I & II	BA	5	2	-3
	COB	6	2	-4

Previously having six personnel current on board (COB) for pay and personnel matters, the DDGs decreased to two.

2.5.7 Individual Augmentees (IAs): 2006–2010

Though the call for Navy IA support to the conflicts in Iraq and Afghanistan began in 2003, IAs increased dramatically between 2006 and 2010. According to Golfin et al. (2011), in 2006, the Navy had 424 enlisted personnel in an IA status. In 2010, that IA number had increased to 2,211 enlisted personnel. Billets authorized (BA) that were lost to IAs in FY 08 and FY 09 in select enlisted ratings reached as much as 5.8% (see Table 2.7).

Table 2.7. Percent of Sea-Duty Billets Authorized Lost to Active Component Individual Augmentees. Adapted from Golfin et al. (2011).

Enlisted Rating	FY 2008	FY 2009
Electronics Technician (ET)	2.1	2.0
Fire Controlman (FC)	3.2	4.7
Information System Technician (IT)	5.8	5.5
Operations Specialist (OS)	3.0	3.6
Aviation Electronics Technician (AT)	1.1	3.0
Aviation Structural Mechanic (AM)	1.1	1.9
Aviation Ordnanceman (AO)	1.0	1.7

As discussed in Section 2.4.2, because the IAs are still administratively attached to their command and are not replaced, Sailors left on board the DDG, which is already "optimally" manned, end up covering the workload of the absent Sailor.

2.5.8 Top Six Alignment: 2006

The 2000s also saw changes in the "Top Six," the Navy's E-4 through E-9 pay grades. According to OPNAV N1 (2009), starting in 2000, the Navy purposely increased seniority in order to improve technological knowledge and experience across the fleet due to the advanced systems on board vessels. Therefore, the Top Six pay grades saw an increase in authorized billets from FY 00 to FY 06 from 69% to 73.25% of the entire Navy enlisted force (OPNAV N1, 2009). Combined with force restructures, the Top Six increases caused the Navy to exceed the Top Six percentage for which they had budgeted (OPNAV N1, 2009). In 2006, the Navy began the "Top Six Alignment," also known as the "Top Six Rolldown," a manning initiative to reduce these costs by rolling down approximately 5,175 at-sea surface ship billets from the required pay grade to the next lower pay grade (Rodney et al., 2009). In addition, the alignment would have the benefit of improved sea/shore rotation (considered a critical factor in the alignment decision-making process) along with increased promotion opportunities (OPNAV N1, 2009).

The effects of such a reversal can be problematic, especially without review of the initial billet upgrades made in 2000. The Top Six Alignment focused more on improving sea/shore rotations than on "reversing" the effects of changes made in 2000. For a particular billet, the result of the alignment has the effect of decreased experience; take, for example, an E-8 billet which is rolled down to be an E-7 billet. With the Navy detailing standard of "one up - one down," an E-8 billet can be filled by an E-7, E-8, or E-9. However, once a billet is rolled down to E-7, the billet can now only be filled by an E-6, E-7, or E-8. The difference between an E-6 and an E-8 is a large gap in experience, as much as six or more years (Deputy Chief of Naval Personnel, 2014).

Though smaller crews require an overall more highly trained and experienced crew, with the Top Six Alignment in 2006, Navy ships saw a decrease in seniority, effecting an overall decrease in crew expertise (Readiness and Sustainment of the Navy's Surface Fleet, 2009b). With a decrease in experience comes a decrease in on-the-job training (OJT) quality for more junior Sailors, and an increase in expected time for task completion. Essentially, if indirectly, the Top Six Alignment increased the individual Sailor workload.

2.5.9 Afloat Training Group (ATG) Manning Reductions: 2007

The Afloat Training Group (ATG) provides training to the U.S. Navy Surface Fleet. They "serve as the TYCOM's executive agent for training and assessment" (Commander, Naval Surface Force, U.S. Pacific Fleet (COMNAVSURFPAC) & Commander, Naval Surface Force Atlantic (COMNAVSURFLANT), 2012, p. 1-2). From 2003 to 2009, there was a definite disparity between billets authorized (BA) and current on board (COB) of ATG manning (see Figure 2.6).

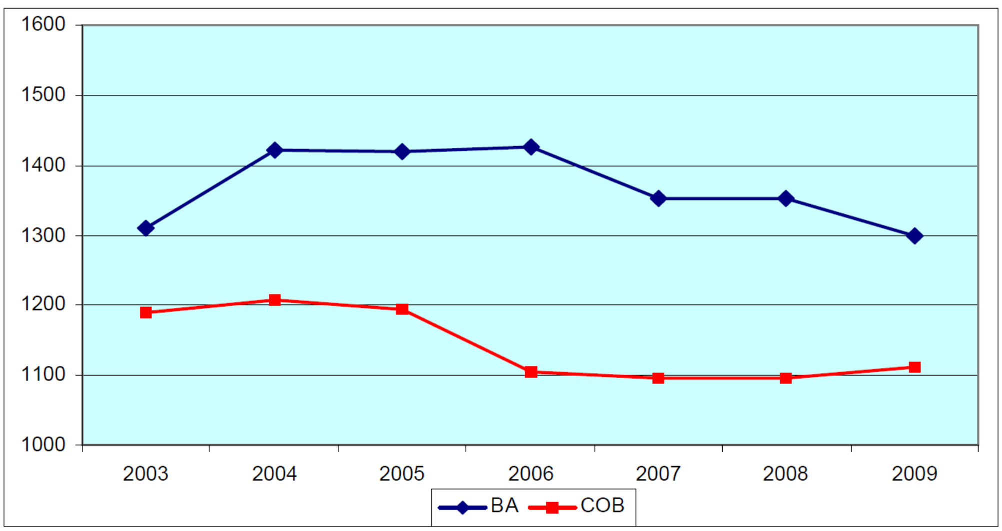


Figure 2.6. Afloat Training Group Enlisted Manning, 2003–2009. Source: Rodney et al. (2009).

COB, represented by the red line, is continually below the BA, represented by the blue line. FY 06 shows a difference of more than 300 Sailors. The difference affected ATG's ability to provide training and support to the fleet as a whole. Additionally, according to Rodney et al. (2009), this graph does not provide the entire gap. The authors note that the workload increase resulting from decreased manning was exacerbated by the increased workload resulting from the merging of commands, changes made to requirements for ship workups, and high OPTEMPOs (Rodney et al., 2009).

According to Rodney et al. (2009), ATG could still perform their certification mission but emergent events and unit-level training became low priority. Unit-level training is where surface Sailors need the most guidance due to high personnel turnover prior to the Basic Phase of the training cycle (Rodney et al., 2009). Due to ATG manning decreases, it became necessary to plan two to three months in advance in order to meet tasking requirements.

Furthermore, the 2009 CNA study points out an increase in certification extensions which, in their analysis, tends to indicate less ATG support due to the timeline to meet requirements. In testimony, the Director, Force Structure and Readiness Issues, Government Accountability Office (2017) stated, "as of June 2017, 37 percent of the warfare certifications for cruiser and destroyer crews homeported in Japan had expired – including mobility-seamanship and air warfare – had been expired for 5 months or more ... more than a fivefold increase ... since ... 2015" (p. 7). A reduction in manning in one area, such as training commands, can easily affect the surface fleet as a whole; add to this mix an intense OPTEMPO for Japan-based ships, and even what seem slight manpower reductions, if not strategically planned with an eye to the larger picture, can have far-reaching consequences.

2.5.10 Rating Mergers: 2000–2008

Another impact on manning in the 2000s came in the form of Sailor rating mergers, of which there were ten from 2000–2008. These mergers had minimal impact on SMD requirements but did serve to reduce some requirements through the optimization of workload (NAVMAC, 2008, Tab G). For details of what ratings were merged and when, see Table 2.8.

Table 2.8. History of Rating Mergers, 2000–2008. Adapted from CNO (2008); NAVMAC (2008).

Final Rating	Merged Ratings	Year	NAVADMIN
CTT	EW/CTT	2000	045/00
AM	AMS/AMH	2000	153/00
SK	SK/AK	2002	418/02
PS	PN/DK	2004	295/04
HM	HM/DT	2005	214/05
IT	IT/CTO	2005	338/05
MC	JO/PH/LI/DM	2005	339/05
GM	GM/TM	2007	049/07
YN	CTA/YN	2007	118/07
LS	SK/PC	2008	326/08

The optimization of workload through merged ratings (i.e., centralization of work) sounds good, but, in practice, an increased workload overhead (OJT) during the merger period, while the merging personnel learn the specialty of the other rating(s), means that the optimized workload is not realized right away and, in fact, creates a ship burden until personnel are fully trained.

2.5.11 Manning Effects on Maintenance

According to GAO (2017b), Navy officials have determined that smaller crews due to optimal manning initiatives are partly responsible for long-term increased maintenance costs due to deferred maintenance. Beland and Quester (1991) studied the duration of Navy ship downtime as a response variable against various explanatory variables that could possibly lead to maintenance issues. They found that "better material *[sic]* condition of ships was consistently associated with higher levels of manning relative to requirements and with smaller proportions of new crew" (p. 120). Rodney et al. (2009) also addressed what changes and what maintenance issues reduced manpower in surface ships from 2002 to 2009 created and how that affected reporting. These maintenance issues included an increase in the backlog of the Current Ship's Maintenance Project, 2008 Cruiser-Destroyer

(CRUDES) Board of Inspection and Survey (INSURV) failures and an increase in Casualty Reports (CASREPs). They also reported a high correlation between manning changes and an increase in CASREPs, the only highly correlated change. They specifically noted, however, that CASREP increases could be caused by more than just manning changes. For example, there was a concerted effort to have the ships report CASREPs due to prior low/inaccurate reporting. This was likely due to how the Commanding Officers felt about CASREPs as discussed by Ponce (2004). Ponce stated that until "recently," Commanding Officers felt a sense of failure if their ship was unable to get underway to complete a mission due to a materiel failure due to Navy culture that views the number of CASREPs "as [a] measure of how 'squared away' a ship was" (Ponce, 2004, p. 53).

Unsurprisingly, the Navy made many of its manpower changes since the turn of the century with an eye to cutting costs. A report by the GAO (2017b) attempted to assess if any correlation between maintenance costs to personnel costs exists by gathering data on the change in costs for personnel and maintenance over each ship class's optimal manning period (see Figure 2.7).

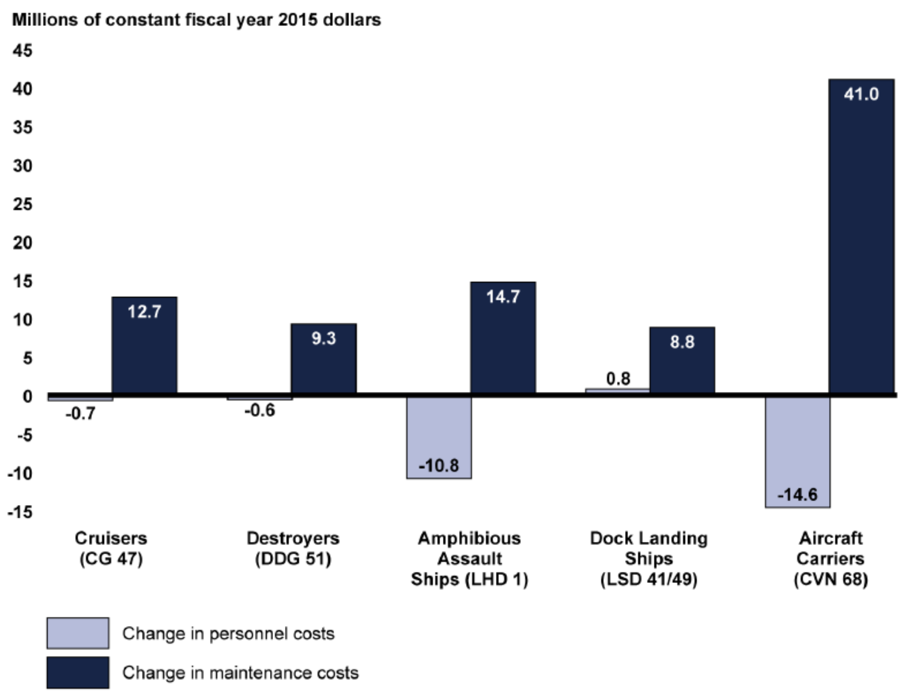


Figure 2.7. Average Annual Ship Personnel and Maintenance Cost Changes for the Indicated Surface Ship Class' Optimal Manning Period (2004–2010 for the DDG Ship Class). Source: GAO (2017b).

The DDG ship class includes costs from 2004 through 2010 (GAO, 2017b). The GAO study concluded that the lack of shipboard personnel due to Optimal Manning directly increased the maintenance costs. During the time frame of Optimal Manning, however, many other changes had the potential to drive up maintenance costs for the DDGs, to include: further changes to the manning structure, changes that lowered maintenance requirements, and an increased OPTEMPO which decreased maintenance availability (VCNO, 2017). Though there appears to be a direct correlation to Optimal Manning years, it is surprising that the GAO only briefly discussed other potential contributors to the increased maintenance costs since it is difficult to directly attribute the changes in maintenance costs only to Optimized Manning. Clearly, however, linkages exist between manning levels and maintenance performance. The maintenance changes during that time frame will be further reviewed in Section 2.8.

2.6 Risk to the Fleet

Gaps between true manning requirements, Condition I and III surface ship requirements known as "spaces," and actual manning cause risk to the fleet. The gap can be created during several processes, including funding/budget, personnel assignments, and actual Sailors currently on board, known as "faces." Those four processes are known as pillars of manpower (see Figure 2.8).

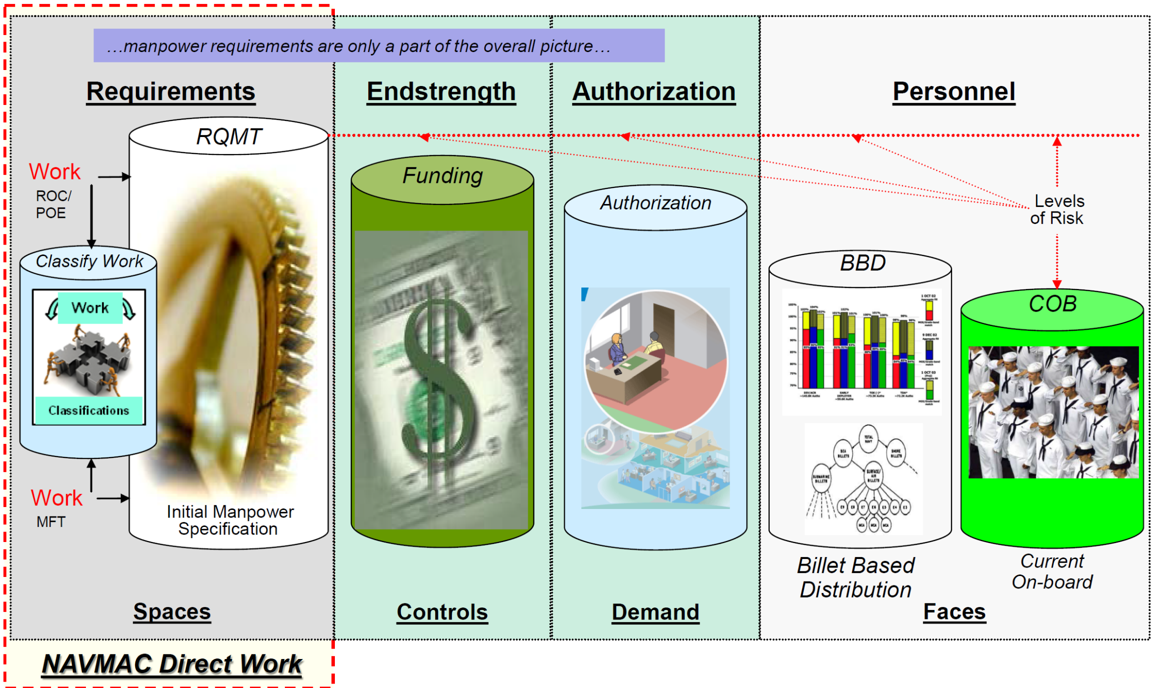


Figure 2.8. "Levels of Risk." Adapted from NAVMAC (2017b).

NAVMAC describes the disparities between the pillars as "Levels of Risk" (2017b). This divergence between a vessel's minimum manpower requirement and actual manning becomes a fleet risk. The direct changes to manpower requirements, discussed in Section 2.5, reduce the "spaces." The "spaces" reduction, in turn, decreases each of the other pillars. The ultimate decrease in personnel exacerbates workload for the remaining Sailors on board.

2.7 Navy Training Historical Changes

When Sailors think of Navy training, they tend to consider any of the following, likely dependent on the individual's particular command (not all-inclusive).

- Annual training requirements: General Military Training (GMT), Information Assurance, Bystander Intervention, etc.
- Emergent Navy-wide training
- Emergent command-focused training
- "A"- and "C"- Schools
- Warfare qualification (Personnel Qualification Standard [PQS])

- Ship-specific Job Qualification Requirements (JQR)
- On-the-job training for a given watchstation or position
- In-rate training, in general
- Surface ship workups: Basic, Intermediate, and Advanced Phases
- General Quarters (GQ)
- Shipboard departmental and team drills
- Shipboard departmental and divisional training

In essence, "training" is broadly defined, with different expectations depending on the Navy echelon and current command focus. The definition, as it applies to the NAF/NSWW, has also changed over time. Currently, the NAF/NSWW allots for seven training hours, which includes only ship-wide drills. The training allotment does not encompass all levels of training requirements.

2.7.1 Navy Standard Work Week (NSWW) Training Definition (1969)

Ideally, if we are to match time allotments to the real world, training time would adapt as training requirements adapted and would include all stages of training, giving Sailors adequate time to complete their requirements. When the Navy initially drafted and assessed the SMD, training included "three elements: Formal Training, Proficiency Training, and Drills and Practices" (Bright et al., 1969, p. 25). The report points out that training requirements are mandated for completion, so including such a category is necessary. Furthermore, Bright et al. separated out the training requirements for watchstanders and non-watchstanders, the (appropriate) assumption being that watchstanders are in continual training. Non-watchstanders were expected to train 1.0 hour per week for ship-wide training and 2.0 hours per week for practice and drills, while watchstanders were expected to train 0.67 and 1.33 hours per week respectively (Bright et al., 1969). Bright et al. concluded by defining "training allowance" to account for "proficiency training ... normal day-to-day on watch [training], on station [training], or on-the-job practice" (p. 26). The "training allowance" added up to 1.5 hours per week in 1970 (as cited in Moore et al., 2001).

2.7.2 Navy Availability Factor (NAF) / Navy Standard Work Week (NSWW) Training Definition (2018)

Currently, training time includes only the largest training, that required of all hands, and Sailors must adjust their schedules, sometimes sacrificing personal time or time for other work, to meet mandatory training requirements. The current Navy manpower policy describes the "training" portion of the NAF/NSWW as "factored to reflect those scheduled events (e.g., general drills, engineering casualty drills, damage control) for all hands" (DCNO (MPT&E), 2016, p. D-3). As the references have changed over the years, the guidelines have clearly departed from accounting for a training allowance beyond warfare ship-wide drills and practice drills. Because training time no longer includes anything beyond GQ, other aspects of training are now included in the service diversion and / or personal time allotments. This shift directly moves the burden of training workload to the Sailor who must take the time needed to meet training requirements through time management and prioritization. Depending on how well the Sailor can manage their time and prioritize efficiently, they may be forced to sacrifice in other areas, whether in their work performance or sleep.

2.7.3 Revolution in Training (RIT): 2001-2006

> The revolution is inevitable; it is underway outside the Navy; we must harness it, focus it, and bend it to the Navy's needs.
>
> - Revolution in Training Executive Review Team
> (CNO Staff, 2001, p. ix)

In October 2000, the CNO directed a panel to conduct a full review of Navy training with the goal of overall improvement. He directed the panel to review the alignment of Navy organizations, review new technology and its potential use, realize civilian sector collaboration opportunities, and take a look at how to best develop learning opportunities for Sailor professional and personal improvement (CNO Staff, 2001). The Future Years Defense Program (FYDP) had shown a shortfall for student billets from FY 02 to FY 07 that affected the ability to man the fleet. The review found that, by FY 07, the student shortfall would cause a gap of 9,366 billets at sea. By modernizing schoolhouse training programs and using technology where appropriate, the Navy would potentially be able to fill the gapped billets (CNO Staff, 2001).

Background

The review team found inefficiencies with funding flow to training requirements, meaning something did not quite add up (see Figure 2.9).

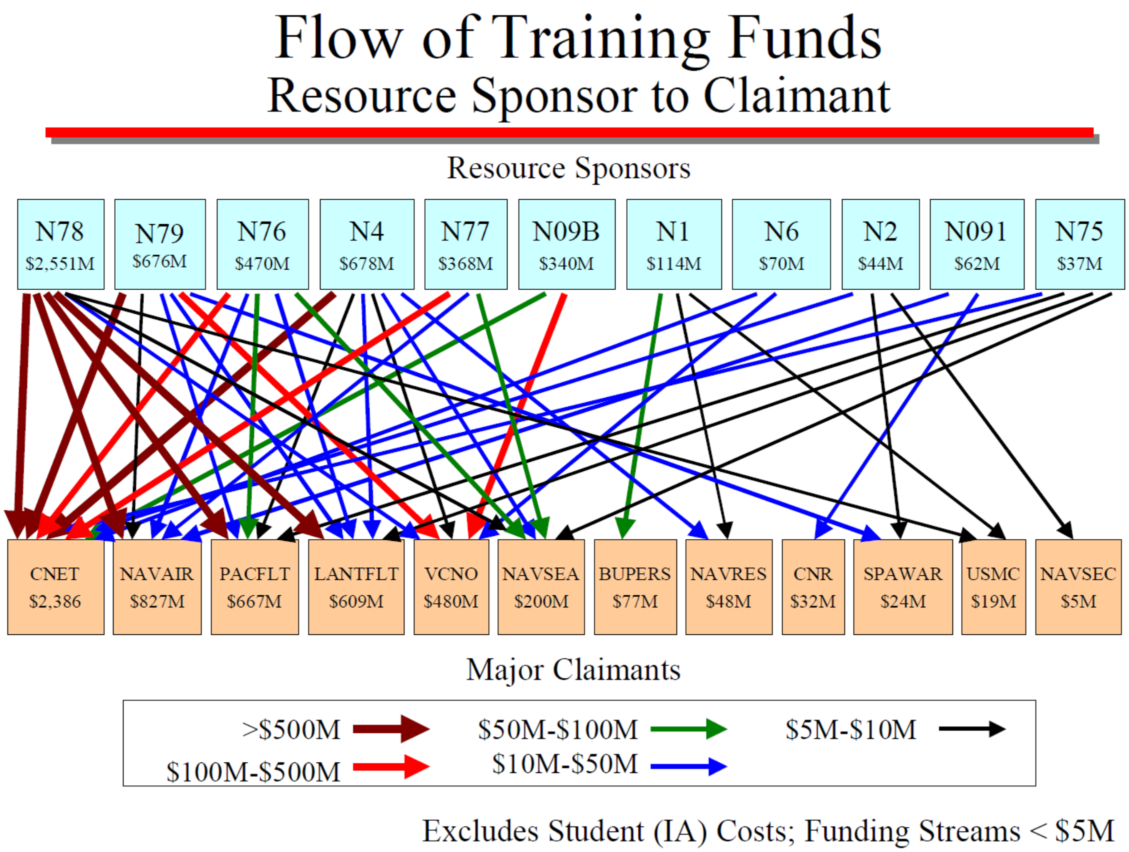


Figure 2.9. Flow of Training Funds, 2000–2001. Source: CNO Staff (2001).

Similarly, the training organizations showed fragmentation due to a lack of centralization (CNO Staff, 2001). The CNO Staff also found five training reorganizations since 1971 with numerous studies notating the need for a centralized training organization (p. 19). Due to these findings, the Navy determined alignment of training organizations as an appropriate next step, creating an "integrated training organization," also known as a Revolution in Training (RIT) (CNO Staff, 2001).

The review team found and suggested several other aspects prior to RIT implementation in 2001. Some of the solutions found were based upon experiences seen both in the U.S. Navy and the civilian industry (CNO Staff, 2001). Most Sailors interviewed by the CNO Staff expressed concerns about needing more time to train. The team found that industry leaders had shown that e-learning and distance learning could partially solve the training time issue (CNO Staff, 2001). In addition, they found that the private sector experienced "extraordinary leaps in effectiveness, efficiency, and performance" through technology (CNO Staff, 2001, p. 36). Sailors reported to the review team that OJT, specifically, was the most effective training. Considering the review team's findings, that RIT encompassed, in large part, a move to computer-based training (CBT) and OJT, makes a lot of sense as does the core of RIT: the science of learning. The CNO Staff (2001) stated that part of this process would require buy-in from khaki leadership to include their understanding that "Sailors must be able to learn while in their commands and on the job" (p. 36). The review team encompassed their findings and solutions (see Figure 2.10).

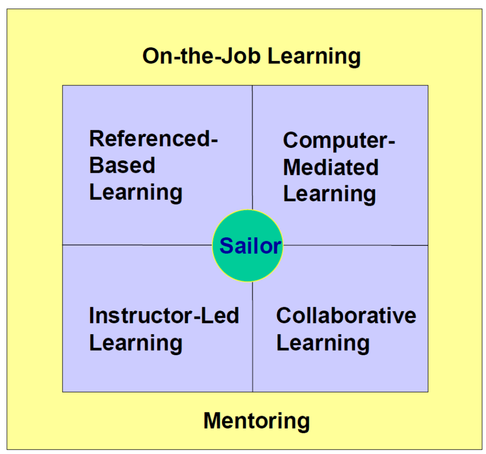


Figure 2.10. Navy Learning Model, 2001. Adapted from CNO Staff (2001).

This model illustrates how learning can be enhanced through multiple teaching sources, whether through a computer, peers, or an instructor. However, the learning model will likely fail when only one piece of the model is used without the comprehensive whole.

Results

The Inspector General received fleet concerns about Sailor knowledge levels when departing "A"-Schools and anecdotal reports about CBT (Navy Inspector General (IG), 2009). Due to this, they began a "Review and Assessment on 'Computer Based Training' in May 2008" (p.

ii). For their report, they defined CBT as "individual or group self-paced instruction using a computer as a primary training medium, to include web-delivered Navy E-Learning" (p. ii). The study found that by 2008, 34% of Navy "A"-School curriculum was CBT. They also note that RIT provided funding for planning and updating curriculum, decreasing timelines for curriculum updates. Even with this funding, the Navy IG found that course update timeframes did not decrease, and, in fact, increased for some curricula. Due to the need for contracting, developing, and delivering updated curricula, the process could easily take eighteen months (Navy IG, 2009).

The Navy IG noted numerous additional problems. Learning theory was not capitalized in the move to CBT curricula (i.e., blended instructor and technology training is better than relying only on technology), and a link was not being made from the learning material to Sailor work (Navy IG, 2009). The Navy IG also found that quality of Navy curricula varied widely. Some curricula were placed in a computer forum with no front-end analysis (as required by Navy instruction) while different government contractors developed others without a centralized standard, resulting in varying quality (Navy IG, 2009). In addition, the Navy IG found that no centralized agency existed to verify the validity of the CBT instituted.

The Navy IG's report cited several ways in which technology growth outpaced real-world training abilities and locations. The review found that the growth of technology outpaced funding (Navy IG, 2009). The schools fell behind in their ability to consistently meet the needs of the students while using CBT. Additionally, the Navy IG (2009) found that more than half of the training commands' 26,000 computer workstations were more than six years old and suffered from insufficient bandwidth. These issues contributed to course "time out" complications requiring frequent computer reloads and downtime.

The Navy IG's report also noted that RIT realized significant efficiencies in Sailor transition time from Basic Training to the fleet ("street to fleet") as well as resources, to include manpower and infrastructure. The Navy gained some cost savings through the replacement of the schoolhouse cadre of subject-matter experts (SMEs) with instructors who had less expertise (Navy IG, 2009). The Navy IG (2009) found that CBT reduced the time junior Sailors were being led by an instructor. Combined with a lack of expertise in those who were at the command, the Navy IG saw a decrease in Sailorization during the CBT review through reduced communication skills, military bearing, and wearing of the uniform (p. 16).

Inherent assumptions challenged RIT, further decreasing manning capacity and increasing pressure on Sailors. The first inherent assumption was that new Sailors would all be well-versed in computer technology (Navy IG, 2009). Second, the Navy IG found that the RIT assumed that the young Sailor would be able to competently learn from computers on their own. Third, RIT assumed that Sailors would prefer CBT over classroom instruction (Navy IG, 2009). However, the Inspector General found that most junior Sailors did not have any experience in learning from only a computer terminal all day for five days a week (p. 6). In the end, CBT resulted in sending "operators" instead of the high-need "maintainers" to the fleet (Navy IG, 2009). With an increased OPTEMPO along with fewer personnel, RIT's dependence on CBT decreased the time to train new personnel, pressurizing the OJT system.

Navy leadership noted decreases in Sailor ability while requirements increased, which also concerned Congress. In his congressional testimony, the Deputy Commander for Surface Warfare, Naval Sea Systems Command (SEA 21) stated:

> Blended Training Solution (combination of instructor lead training, lab training, computer-based training, simulation training, etc.) requires assessment if a Sailor's knowledge, skills, and abilities (KSAs) are not adequate to support the work assigned ... there is some concern that the pendulum has swung too far away from traditional schoolhouse based training and there needs to be a better balance between the two forms. (Readiness and Sustainment of the Navy's Surface Fleet, 2009a, p. 19)

The Navy IG (2009) discussed the need to assess KSAs within training programs to ensure Sailors arrive to the fleet ready to meet their work requirements. The Navy IG found that the necessary skill sets were not necessarily being completely provided due to a lack of specific learning objectives, finding that Sailors arrived at the fleet missing basic knowledge about their jobs, which, in turn, demonstrated that the pendulum had swung too far with CBT. Sailors now needed to arrive to the fleet with the ability to operate *and* maintain their equipment. Instead, the Navy IG noted, "fleet feedback indicates Sailors reporting from "A"-School have only a marginal ability to recognize equipment and operate its components" (p.

10) (specific ratings were not provided in the report). The Navy IG (2009) found that some Sailors required twice as much time to qualify for watches, placing greater strain on the ship's personnel. In the end, without hands-on training and discussion, RIT's dependence on CBT resulted in a long-term lack of critical thinking and ability to troubleshoot, whether with mechanical or electrical systems.

2.7.4 On-the-Job Training (OJT)

Training new Sailors while they fill their role on the ship, or OJT, is a way to provide effective training to an individual while reducing costs and to obtain efficiencies through sending personnel to their command earlier. In this situation, an informed and (preferably) proficient Sailor guides the new Sailor in their work, helping them learn their required skills through daily side-by-side instruction, which provides the structure of the training. If implemented correctly, OJT's hands-on approach provides a lot of benefits. As its definition requires, OJT is provided by a Sailor's more experienced peers. As noted by USFF (2017c), "The quality of that OJT is largely dependent upon the ship, its Commanding Officer, and the level of knowledge of the individuals assigned to that ship" (p. 48). However, for OJT to work properly, both the experienced and new Sailor need adequate materials. USFF noted that "no one interviewed could identify a resource available to them to learn how installed equipment was intended for use together in various operational scenarios. Not surprisingly, practices vary substantially" (pp. 82–83).

Missing the Basics

RIT was meant to enhance but, in some cases, replaced basics, over-burdening the ship as a whole. In 2003, as a part of RIT, untrained officers arrived at the fleet with a set of CDs to learn Surface Warfare Officer skills and initial knowledge in lieu of the traditional six month Division Officers' Course (USFF, 2017c, p. 162). Due to this change, the ship's Wardroom and Chief's Mess became burdened with training to the very basics every time a new Ensign arrived. The same happens when enlisted Sailors arrive to the fleet with less knowledge of the basics; they are forced to rely on their peers and resident leadership, increasing pressure and needed time for requirements all around, furthering the gap between manpower models and actual work time required.

Peers

In the case of the Navy, peers are not necessarily trained to provide training to another person nor eager to do so. The way the Navy resolves some of these issues is through advancement examinations to assure knowledge levels. A Sailor, however, learns only as much as their trainer provides at whatever quality is provided. Even though the training is through an MRC, JQR, or a PQS, the quality ranges since various individuals have differing capacities as well as available time to train others. The cost benefits are high, but, as Sisson (2001) states, "The cost of doing it properly in the first place may be obvious, but this is far outweighed by the even higher (but hidden) cost of workers who are poorly trained through unrealistic time limits" (p. 75). OJT is an excellent way to train personnel as they learn by doing. However, Sisson notes that OJT is not always successful if the leadership on board the ship does not remain engaged in the process by supporting the trainers (pp. 91–92).

2.7.5 Retention of Information

The Navy is aware of the importance of regular sleep, including for the retention of information. Research shows that rapid eye movement (REM) sleep is important for the retention of information (Fogel, Smith, & Cote, 2007; Karni, Tanne, Rubenstein, Askenasy, & Sagi, 1994). Sailors need the time to sleep in order to retain the information they learn, whether as a new Sailor or one who is in a leadership position. As discussed further in Section 2.11.3, direction has been provided and training has begun in order to transition the entire Surface Navy to circadian watchbills instead of rotating shift watchbills (COMNAVSURFPAC & COMNAVSURFLANT, 2017). As stated in the instruction, the expectation is a greater amount of sleep for Sailors.

2.7.6 Accuracy in Reporting

Increased fleet training requirements, whether due to OJT or a change in training methodologies, leads to longer hours, and, when those hours exceed available work time let alone actual available time in a day, Sailors may find themselves in a position where they face an ethical decision as to whether to falsely report training completion for which they simply did not have the available time. In the National Defense Authorization Act of 2017, the House of Representatives expressed concern about a recent report written by the Strategic Studies Institute and U.S. Army War College. In this report, Wong and Gerras (2015) discussed the extent of Army training requirements and how the number of required training hours exceeded available working hours. The House mandated that the military services review training requirements because “the committee is concerned that the ever-increasing training demand forces military leaders at multiple levels in the chain of command to make ethical decisions between actually training to standard or falsifying reporting, as well as choosing between training for mission essential tasks and those perceived to be of lesser value” (*National Defense Authorization Act for Fiscal Year 2017*, 2016, p. 121). When pressed for time as discussed in Section 2.7.2, U.S. Navy Sailors will potentially sacrifice their integrity through false documentation. This study asks a follow-up question. Is the Navy also fooling itself when it comes to training? Beyond concern over false reporting, lack of time for training creates numerous other concerns.

2.7.7 Warfare Qualifications: 1977, 2010

Personal time being used for voluntary training, to advance one’s own knowledge, would understandably fall under Personal Time; however, warfare qualification is no longer voluntary. After the 1969 advent of the SMD, the Navy introduced a Surface Warfare (officer) qualification in 1975 and an enlisted version followed in 1977. For the next 33 years, enlisted warfare qualification remained voluntary and considered “above and beyond” the normal requirements, hence presumed to be accounted for in Sailor personal (Non-Available) time. However, in 2010, warfare qualification became mandatory for enlisted personnel (CNO, 2010a) and continues to be mandatory (CNO, 2018). There has been no corresponding change made to the NAF/NSWW allowances.

2.8 Historical Changes to Surface Ship Maintenance

Undergoing several shifts over the years, currently, Navy ship maintenance falls into one of three levels of maintenance for the U.S. Navy surface fleet: Organizational, Intermediate, and Depot level maintenance. Organizational maintenance is completed by the Sailors on board the ship. Intermediate maintenance is currently completed by Regional Maintenance Centers (RMCs). Depot maintenance is completed by a shipyard, either public or private. Regular maintenance, whether by shipboard personnel or an intermediate maintenance facility, is crucial for keeping the Navy’s fleet viable throughout the projected service life of its ships. In an attempt to ensure the efficiency and flexibility of the fleet’s maintenance resources, the U.S. Navy has made several process changes over the years. The hope is that, by providing better shore support for ship's maintenance, the ship's company can have a greater focus on their daily work and the primary mission.

2.8.1 Ship Life Cyle Management: 1995–2009

From 1995 to 2009, no entity was responsible for ship life cycle management; the lack of ship life cycle management results in the opposite effect on Sailors: decreased time to focus on daily work and mission completion. The Navy abandoned ship life cycle management in 1995 with the disestablishment of Planning and Engineering for Repairs and Alterations (PERA), the entity responsible for the management (planning and execution) of life cycle maintenance for each class of ship in the U.S. Navy (Kern, 1969). The organization was disestablished during military Base Realignment and Closures (Balisle, 2010), resulting in a lack of centralized life cycle management. Therefore, the technical requirements necessary in order to meet expected ship service life were not being met 100% of the time (Readiness and Sustainment of the Navy's Surface Fleet, 2009b). The loss of life cycle maintenance planning to assure the ship makes it to the expected end of life "limits the ability to accurately forecast maintenance requirements and translate them into credible budget requests" (Readiness and Sustainment of the Navy's Surface Fleet, 2009b, p. 22). In addition, the lack of life cycle management causes the ships to deteriorate at a faster rate, resulting in an increased burden on the Sailors at sea.

In May 2009, 14 years after the disestablishment of PERA, the Navy stood up the Surface Ship Lifecycle Management (SSLCM) in order to meet the gap of tracking. Naval Sea Systems Command (NAVSEA) (2017b) shows that the SSLCM transitioned in 2010 to the Surface Maintenance Engineering Planning Program (SURFMEPP). As of 2017, SURFMEPP has nine detachments across the world with the mission of providing "centralized surface ship life cycle maintenance engineering, class maintenance and modernization planning, and management of maintenance strategies" (Bauer, 2016, Slide 3). This technical support enables better planning for maintenance funding requirements and helps extend the life of the surface ships.

2.8.2 A Change in Planned Maintenance: 1996

In 1996, leadership determined to reduce PMS in order to initiate Optimal Manning. Instead of shifting PMS requirements to shore as initially intended, the periodicity for maintenance requirements were extended or eliminated altogether beginning with the CG 47 class (Baseman, 2000). In 1996, as much as 50% of required PMS was reduced for ship's force (Button, Martin, Sollinger, & Tidwell, 2015), resulting in decreased PMS man hours across force revisions (see Figure 2.11).

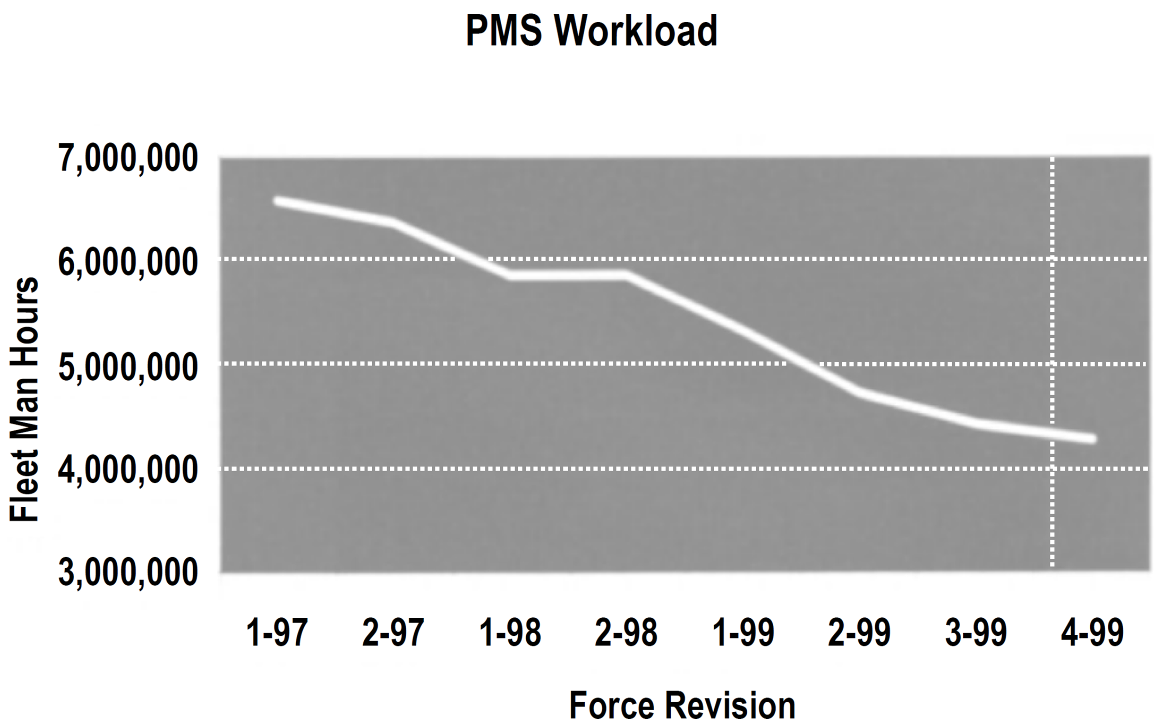


Figure 2.11. PMS Man-Hour Reductions across Force Revisions. Adapted from Baseman (2000).

Subsequently, the Navy saw evidence that a portion of materiel deficiencies resulted due to this reduced maintenance (Balisle, 2010). Thus, reductions in PM workload were at least partially offset by increases in CM workload.

2.8.3 Removal of External Command Materiel and Readiness Assessments: 1994–2009

A change in surface ship support took place between the years of 1994 and 2002, resulting in ship deterioration and increased Sailor burden. During this time frame, materiel and readiness assessments decreased from 73 in 1994 to 35 in 2002 (Fleet Review Panel, 2009). As of 2009, the requirement stood at 41. Most of these assessments were built into the ship's inter-deployment training cycle; only a handful were from 18 to 24 months in periodicity regardless of Inter-Deployment Training Cycle. Though tedious and taxing, external command materiel and readiness assessments, through the provision of training and system expert direction, can help the crew. A decrease in materiel readiness can easily result if an assist visit or assessment is removed without the assurance that the ship will, in fact, self-assess appropriately or a different entity already covers or has taken the task for that particular area of assessment. With a decrease in materiel readiness, the ships continue to deteriorate, and Sailor burden continues to increase.

2.8.4 Shore Intermediate Maintenance Activity (SIMA) / Regional Maintenance Center (RMC) Reorganization and Manning Reduction: 1997–2008

The closure of Shore Intermediate Maintenance Activities (SIMAs) began in the 1990s and continued at the turn of the century as bases closed or were integrated with the shipyards (GAO, 2017a). Leadership established seven RMCs in order to support intermediate maintenance in 2004 and 2005 while absorbing four of the SIMAs, standing up the RMCs integrated waterfront maintenance activity in order to reduce redundancies between multiple commands (Rodney et al., 2009). Of the commands absorbed at each RMC, the SIMAs had the largest number of military personnel assigned. Rodney et al. discuss that, over time, the RMCs decreased military personnel, replacing the work with contractor support. The RMCs now primarily contract out maintenance work instead of using Sailor labor as with the old maintenance model.

The changes to on-shore maintenance resulted in fewer onshore billets, which can, in turn, result in negative career progression, knowledge degradation, and maintenance backlogs (see Figure 2.12 and Table 2.9).

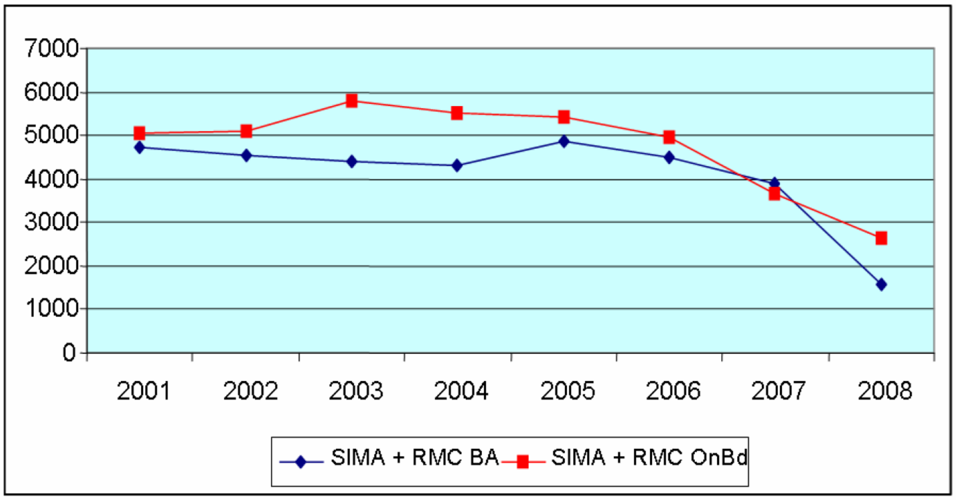


Figure 2.12. Combined Representation of BA and COB for Combined SIMA and RMC Personnel through the Transition. Source: Rodney et al. (2009).

Table 2.9. Changes in Sea and Shore Billets: SIMA and RMC Personnel, 2004–2008. Adapted from Rodney et al. (2009).

	SIMAs/RMCs Billets		ALNAV Shore Billets		Change in Shore Billets 2004 to 2008		ALNAV Sea Billets		2004 to 2008 Change %	
RATING	**2004**	**2008**	**2004**	**2008**	**SIMA/RMC**	**ALNAV**	**2004**	**2008**	**Shore**	**Sea**
HT	667	73	1856	846	**-594**	**-1010**	2147	1709	**-54%**	**-20%**
MM	660	338	6705	5399	**-322**	**-1306**	12212	9649	**-19%**	**-21%**
EN	473	149	2354	1521	**-324**	**-833**	4076	3709	**-35%**	**-9%**
EM	427	162	3576	2662	**-265**	**-914**	5230	4746	**-26%**	**-9%**
BM	364	49	3081	1630	**-315**	**-1451**	4113	3772	**-47%**	**-8%**
ET	291	199	7531	5525	**-92**	**-2006**	8196	7741	**-27%**	**-6%**
GSM	227	60	1046	689	**-167**	**-357**	2209	2097	**-34%**	**-5%**
MR	177	47	572	317	**-130**	**-255**	511	412	**-45%**	**-19%**
FC	113	40	3348	2101	**-73**	**-1247**	4398	4137	**-37%**	**-6%**
DC	105	9	1456	978	**-96**	**-478**	2655	2156	**-33%**	**-19%**
IC	102	38	1077	708	**-64**	**-369**	1728	1520	**-34%**	**-12%**
SK	96	17	5364	4272	**-79**	**-1092**	5486	5620	**-20%**	**2%**

As Rodney et al. (2009) point out, there is a lot of variation between the percent change of sea and shore billets for most of the ratings, causing a disparity between the billet types. This can potentially affect Sailor career progression (Rodney et al., 2009). As discussed by Rodney et al., this disparity (friction) causes a continued knowledge degradation for the personnel returning to sea duty. Also, since 2004, with high OPTEMPOs, a majority of CM was not completed on time. From 2011 to 2016 as discussed by the GAO (2016): "high deployment rates have led to shortened, eliminated, or deferred maintenance periods and a growth in maintenance backlogs" (p. 22). Such backlogs would have exacerbated the effects of manning cuts within the intermediate maintenance facilities.

2.8.5 Fleet Degradation: High Operations Tempo (OPTEMPO), Backlogs, and Maintenance Overruns

Combining with maintenance backlogs, maintenance overruns also combine with the current high OPTEMPOs to overburden Sailors. The VCNO (2017) discussed the struggle the U.S. Navy has experienced in regard to maintenance turmoil in the midst of a high OPTEMPO during his testimony to the House Armed Services Committee.

> The need to support the fight against ISIS in 2016 led us to extend the deployments of the *Harry S. Truman* and *Theodore Roosevelt* Carrier Strike Groups (CSGs) to eight and eight and a half months, respectively. Similar extensions apply to the Amphibious Ready Groups which support Marine Expeditionary Units. This collective pace of operations has increased wear and tear on ships, aircraft and crews and, adding to the downward readiness spiral, has decreased the time available for maintenance and modernization. Deferred maintenance has led to equipment failures, and to larger-than-projected work packages for our shipyards and aviation depots. This has forced us to remove ships and aircraft from service for extended periods, which in turn increases the tempo for the rest of the fleet, which causes the fleets to use their ships and airframes at higher-than-projected rates, which increases the maintenance work, which adds to the backlogs, and so on. (pp. 2–3)

The GAO, in their May 2017 report, also recognized an excessive maintenance backlog, due to a high OPTEMPO as cited by VCNO (2017). During congressional testimony, the Director, Force Structure and Readiness Issues, Government Accountability Office (2017) stated, "in 2011 through 2014 only 28 percent of scheduled maintenance for surface combatants was completed on time ... [furthermore,] in fiscal years 2011 through 2016, maintenance overruns on 107 of 169 (63 percent) surface combatants resulted in a total of 6,603 lost operational days—the equivalent of losing the use of 3.0 surface combatants each year" (pp. 13–14). The overruns are likely due to a combination of factors, but the increased maintenance requirements due to high OPTEMPOs are not only seen through more maintenance overruns, but increased Sailor-at-sea workload.

The numerous changes for U.S. Navy maintenance since the 1990s, compounded by a high OPTEMPO after the turn of the century, directly affected the fleet and the required Sailor workload. In addition to the notes made during the 2017 congressional testimony, the GAO (2015) reported the effect on casualty reports in the fleet. They analyzed CASREP data from January 2009 through July 2014 and found an increasing average number of CASREPs for both overseas- and U.S.-based ships, nearly doubling (see Figure 2.13).

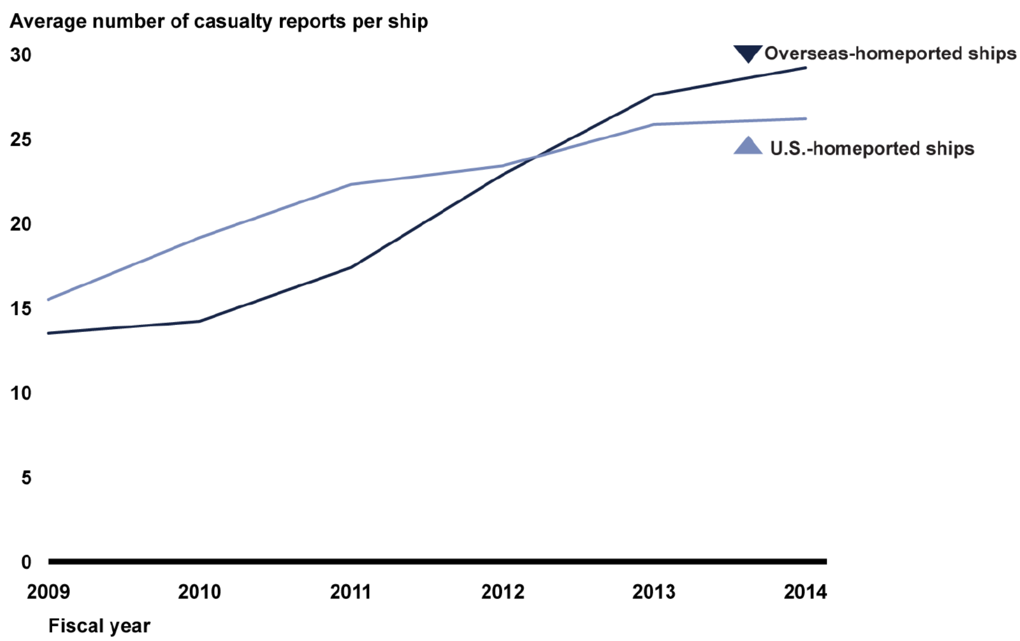


Figure 2.13. Average Number of Casualty Reports (CASREPs) per Ship for U.S.- and Overseas-Homeported Ships, January 2009–July 2014. Source: GAO (2015).

They also found statistical significance between the rates of increase, with ships based overseas increasing at a higher rate than those based in the U.S. Such increases in the number of CASREPs mean higher levels of CM, increased administrative tasks such as drafting and routing the reports, mandated periodic updates to the reports, as well as tracking each CASREP to completion.

2.9 Technology

The age of technology makes command and control even more difficult. Without improving communications and consolidating resources as technology develops, instead of technology alleviating work for the personnel, it can actually increase workload. McGuinness and Ebbage (2002) note that:

> experience in various domains shows that bringing new technology into an 'old system' can introduce unforeseen side-effects on workload and SA, such as a sense of being out-of-the-loop, which can have an underlying negative effect on performance. One conceivable risk, for instance, is the possibility that by dramatically increasing the sheer volume of low-level data available to HQs [headquarters] and their sub-units, this could actually confuse rather than enhance the SA of commanders as well as their subordinates. Additionally, if the rate of incoming data is high, the HQ staff could conceivably be over-burdened with the task of having to make sense of it all, thereby raising workload levels. (p. 3)

The possibility of data overwhelm happens aboard DDGs just as it can occur anywhere in the Navy. Data overwhelm can actually increase Sailor burden. Hart, Battiste, and Lester (1984) also note, "a potential consequence of adding automation could be a substantial increase in mental workload to replace the reduced physical workload, due, in part, to the added burden of supervising or monitoring the automation itself" (p. 432). The key point here is that workload does not necessarily decrease with an addition of technology.

Furthermore, the expectations for nascent or not yet developed technology may be unrealistically high, and decisions could be made using such expectations. Making decisions too soon based on technology that does not exist creates a risk (Koopman & Golding, 1999). Among the definitions of risk in a Center for Naval Analyses (CNA) report from 1997, high risk is where "technology does not exist or will involve high R&D and implementation costs" (as cited in Koopman & Golding, 1999, p. 18). As the report states, not only the existence of the technology but also high costs further increase the risk.

Since 1994, the Armed Forces has made an effort to increase Commercial-off-the-Shelf (COTS) purchases in hopes of reducing the costs while implementing improved technologies, which can work well but can also backfire in terms of actually increasing costs.

Technological advances are pushed within the commercial sector in order to remain successful (Gansler & Lucyshyn, 2008). It is to the military's advantage to take advantage of COTS when it makes sense, considering COTS can reduce procurement time, decrease development and logistic costs, and increase capabilities (Gansler & Lucyshyn, 2008). However, if care is not taken while creating contracts to purchase COTS technologies, the costs can outweigh the benefits.

Gansler and Lucyshyn (2008) discuss some of the issues the DoD may experience with COTS contracts, some of which may increase costs and add to Sailor burden. The issues Gansler and Lucyshyn mention include: a lack of knowledge of the underlying code requiring continued commercial support or even loss of that support if the company folds, concerns regarding what money can be used (e.g., if a company needs to make a military-related change to an existing system, procurement funds can not be used for the developmental testing), and unhelpful contract lock, meaning the military command could potentially lock themselves into technology that is owned by a particular company, making it costly to change to a different vendor.

If the Navy does not take such potential situations into account or spend the time to fully investigate their decisions to procure COTS technologies, COTS contract issues can affect the Sailors at sea. Assistant Secretary of the Navy (Research, Development and Acquisition) (2000) stated, "In another program, the end users found that the training, guidance, and help-desk support provided by the program office were not adequate to allow the end users to integrate the system into their site-unique environments" (p. 19). They go on to note that, because of the unique environments at each site, multiple contracts were made with the vendor in order to support what each site specifically needed. Though individual sites shouldered the cost, overall, the cost increased significantly, and the desired standardization did not take place (Assistant Secretary of the Navy (Research, Development and Acquisition), 2000). Such situations not only increase costs, but if it is a technology at sea, the Sailors may not have the ability to request such assistance. The Sailors must spend an increased amount of time beyond "normal" maintenance requirements without appropriate preparation. They must troubleshoot the systems on their own and, whether through lack of training support or the lack of vendor guidance at sea, may or may not be able to resolve any underlying technological problems.

2.10 Operations Tempo (OPTEMPO)

Over the span of the reductions in manpower and billet changes along with changes to training and maintenance Navy-wide, the Navy also experienced an increased OPTEMPO. For surface combatants, time spent at sea between 2001 and 2009 increased by 18% (Clark & Sloman, 2015). Furthermore, they state, "between 1998 and 2014, the number of ships deployed overseas remained roughly constant at 100. The fleet, however, shrank by about 20 percent. As a result, each ship is working harder to maintain the same level of presence" (p. 5). Yardley, Raman, Riposo, Chiesa, and Schank (2006) indicated that, post-9/11, the U.S. Navy saw the "largest deployment in recent history, with more than 70 percent of U.S. surface ships and 50 percent of U.S. submarines underway including seven CSGs, three amphibious readiness groups, two amphibious task forces, and more than 77,000 Sailors participating" (p. 3).

No matter the manning level or any degredation in capabilities, Sailors must complete their operations, maintaining a "can do" attitude throughout. The military is tasked with numerous operations, and the Navy must carry out its assigned missions. The DoD (2017) defines Operations as, "1. A sequence of tactical actions with a common purpose or unifying theme ... 2. A military action or the carrying out of a strategic, operational, tactical, service, training, or administrative military mission" (p. 172). With restricted funding, it is no surprise that leadership and Sailors both maintain a "do more with less" attitude, which combines badly with increased OPTEMPO, giving Sailors less time to maintain, train, and reset. This results in increased workload "crowding," less sleep, and increased fatigue.

High OPTEMPO has other associated risks. "Operations tempo has been linked to retention, family stability, and medical readiness" (Castro & Adler, 1999, p. 94). Castro and Adler demonstrated how high OPTEMPO can affect unit readiness (see Figure 2.14).

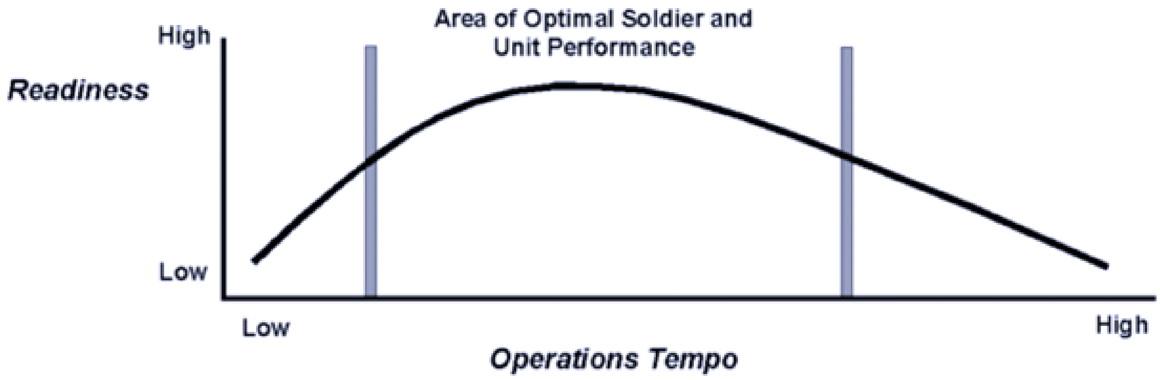


Figure 2.14. OPTEMPO Effects on Unit Readiness. Source: Castro and Adler (1999).

The authors also note unit readiness predictors, including retention, unit cohesion, health, and effects on the service member's family. Though contributors to a high OPTEMPO effectively increase unit readiness, leadership must balance readiness and the potentially detrimental effects due to an OPTEMPO that places undue burden on Sailors, increasing risk.

In response to the 2017 accidents, the CNO briefed the House and the Senate on the Navy's failings and resolution of potential influences, including increased OPTEMPO needs. The CNO (2017) stated,

> I have testified several times about the "triple whammy" - the corrosive confluence of high operational tempo, constrained funding levels, and budget uncertainty. Although warfighting capabilities of ships have dramatically increased in the last century, the size and scope of U.S. responsibilities around the world have also increased, and the Navy is feeling the strains of consistently high operational tempo. Added to this challenge, eight years of continuing resolutions and the 2011 Budget Control Act have impacted the ability to plan and schedule training, ship maintenance, and modernization. (p. 4)

As the CNO alludes to, in the review of the Seventh fleet accidents in 2017, demands for U.S. Navy Japan-based ships within the Western Pacific for operational support, both high-priority tasking as well as exercise and experimentation support, far exceeded availability within the given readiness cycle (USFF, 2017c). In an effort to meet demands, the CNO's report continues, the Navy reduced training time for ships based in Yokosuka, which, in turn, caused degraded materiel readiness and training standards of Japan-based ships. Training reductions made in an effort to meet the increased demands of an OPTEMPO environment "resulted in an increase to the operational risk to mission accomplishment" (p. 70).

2.11 Workload and Workload Creep

Coming back to basics, the thesis examines, in detail, Sailor workload. Workload is defined as "the amount of work or of working time expected or assigned" ("Workload," n.d.). In order to meet the planned average workload for a U.S. Navy Sailor, there must be some sort of measurement. NAVMAC utilizes the ship's ROC\POE in order to determine the ship's baseline requirements, assigning the minimum, or optimal manning to the SMD, as discussed in Section 2.2.3.

The difficulty in objectively observing workload furthers complexity in the workplace, especially on a surface ship with reduced manning. Anderson, Oberman, Malone, and Baker describe the inability to observe systemic workload (1997): "The greatest uncertainty lies in the area of defining workload in tasks which do not require much physical effort but, rather, load the operator in terms of perceptual, cognitive and decision making skills. One problem that exists is that workload is not directly observable" (pp. 68–69). In other words, it is impossible to, with accurate precision, observe the time necessary to complete each task.

In addition to basic tendencies for work to pile on, workload "creep" also factors in. Workload creep is defined as "to ... advance gradually so as to be almost unnoticed" ("Creep," n.d.). Like any aspect of workload and possibly more so, workload creep is not directly observable without a command and control authority directly vetting the requirements for surface ships, which exacerbates the uncertainty. The greatest amount of workload creep affecting surface ship Sailors originates from organizations other than their TYCOM. Whether meaning to or not, almost all administrative organizations within the U.S. Navy add to Sailor workload in some way. Examples include:

- Decisions made in Congress for Navy end strength
- Budgets or budget uncertainty, due to such things as Continuing Resolutions, not meeting the needs of the Sailors who must "make it work"

- Decisions made by the President of the United States, the Secretary of Defense, and the Joint Chiefs of Staff who must all make the hard military decisions with a focus on the needs of the country and foreign policy
- An external court system placing extra watchstanding requirements on shipboard personnel, such as the required citing of whales from January 2008 through January 2009 through a decision made at a U.S. District Court in California (Department of the Navy, 2008)
- The SECNAV and CNO who must ensure Navy functions across the world meet the intended missions as set forth by those for whom they work
- The combatant commanders who must meet the missions of the nation within their Area of Responsibility (AOR)
- The fleet commanders who must meet their missions and provide guidance for ships within their AOR
- OPNAV who must make the difficult funding decisions
- The Navy Supply Systems Command who make supply availability and distribution decisions, potentially affecting the ability for a ship to pass an inspection or conduct CM
- Naval Education and Training Command (NETC) who must assure the Sailors obtain the best training they can prior to arrival to the ship using what may or may not be the best technology and must update curriculum through an arduous process
- Fleet-wide training requirements due to policy changes
- Anti-Terrorism Force Protection (ATFP) requirements that increase the number of watchstanders and their training requirements while the ship is in port
- Organizations who evaluate the ships for certifications and assessments and desire to ensure their checklists are fully up to date, addressing current fleet administrative issues or concerns, potentially adding yet another requirement to a checklist
- Some of the personnel from the shipyard who work aboard the Navy's ships who may drop their trash or fail to clean up after they finish their work, who may require regular ship Sailor supervision to assure the hole that was required to be made in the hull of the ship for newly installed equipment is correctly patched up, or who may make a mistake that Sailors must fix while underway in order to meet the Navy's mission demands.

This list is only a sample of workload creep the Navy surface ships experience. Policies created at higher leadership levels must be implemented by USFF and the TYCOM. These policies put into place by the TYCOM do not necessarily come from that level but indirectly as a result of a decision made from a higher authority. The complex DoD and U.S. Navy network has numerous decision makers with different focuses in order to meet their goals. Each of those decisions affect the Sailors on board the ships, often creating extra work.

Ronen, Lechler, and Stohr (2012) call for greater awareness and mitigation of workload creep to lessen risk. In their discussion of workload creep and its effect on an organization, Ronen et al. note, "management should be aware that taking on too much work can adversely affect the organization's ability to execute - with a resulting, sometimes catastrophic, reduction in efficiency and profitability" (p. 4). They also discuss that workload creep can be mitigated at either end. Ronen et al. go on to say, "When the organization's workload is within its execution capacity, the adverse effects due to overloaded resources ... disappear and throughput, response times and quality of work improve" (p. 6). The management, or in the Navy's case, the leadership, must throttle back on the number of missions or "commitments" accepted until the Naval forces can be supplemented in order to carry out the mission set (CNO, 2017). Doing so results in better "output" for these Navy missions. The ship's Sailors can then focus on what is important: completing the mission safely and to the best of their ability. When workload is increased beyond capacity, the result is less focus with reduced efficiency and, as pointed out by Ronen et al. (2012), may eventually reach the point of catastrophe.

2.11.1 Overload (Task Saturation)

Like anyone, Sailors can experience work overload. Overload is defined as "to give too much of something to (someone or something): to supply with an excess of something" ("Overload," n.d.). Wickens and Tsang (2015) demonstrate what they see as happening with work overload in what they call the "Supply-Demand Function" (see Figure 2.15).

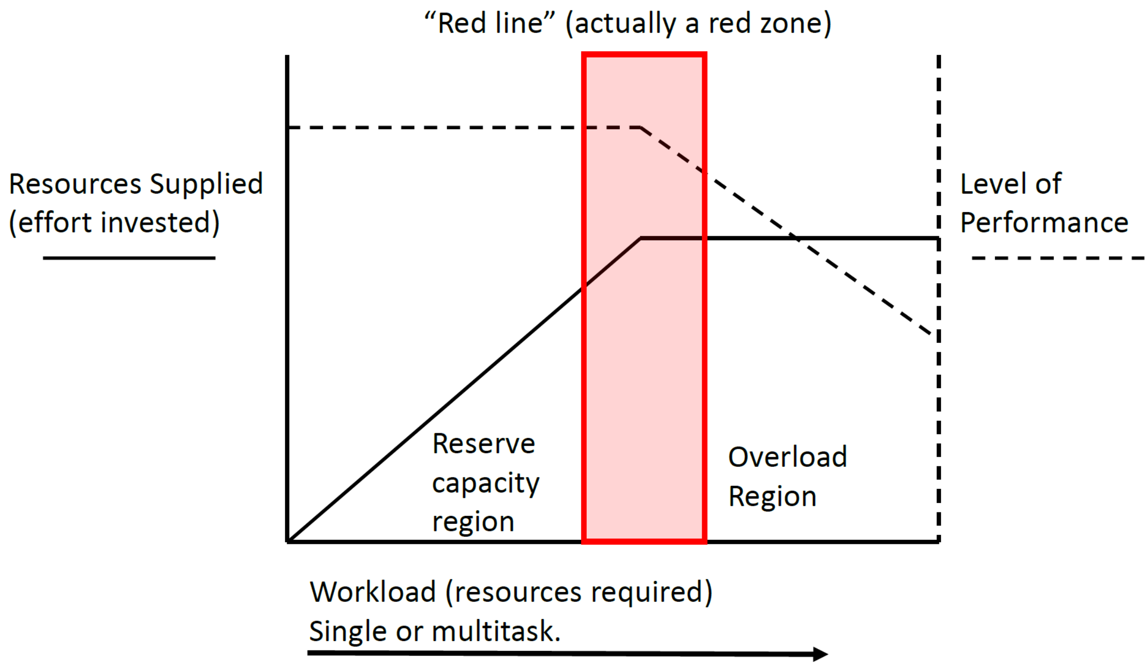


Figure 2.15. "Supply-Demand Function." Adapted from Wickens and Tsang (2015).

As workload increases or becomes excessive, too much of an increase enters a red zone where the level of performance starts to decrease and, eventually, with too much workload, dips down below the resources required to provide in order to accomplish their work.

It is important to note that a person's workload is primarily determined by how much time that person has. The required time to complete a task and the time available are in constant competition. When strain is placed on Sailors, they must determine what is most important for their focus (Parks & Boucek, 1989). Parks and Boucek further note that the breaking point for errors in pilots was at an 80% workload.

With excessive workload and lack of time, the temptation to cut corners and do just enough to meet the requirement arrives (Turner, Hershcovis, Reich, & Totterdell, 2014). Ideally, a Sailor will utilize a form of risk management in order to manage tasks and work with their chain of command. Operational Risk Management (ORM) is intended to reduce potential issues that could cause a failure and mitigate risk. It is designed as a way for all personnel to manage decisions "by identifying, assessing, and managing risks" (CNO, 2010b, Enc. 1, p. 1). Informed decisions can then be made by the personnel and the appropriate level of leadership. The instruction cites one of the primary tenants of ORM: "accept risks when benefits outweigh the costs" (Enc. 1, p. 1). Appropriately using ORM, however, does not always happen nor is it really always feasible. Sometimes, there is simply too much work, and something must be cut.

In maintenance, cutting corners can cause unexpected future issues and expenses. Cutting corners becomes a safety issue due to a lack of attention to procedures (including safety procedures) and trying to work too fast, increasing the chance of injury (Halbesleben, 2010). Halbesleben's research showed the results of cutting corners to be very similar to that seen with rule and safety violations (p. 8). Knowingly sending ships out to sea on missions with known problems will condition U.S. Navy personnel to accept greater risk, going out to sea when the ship is not ready to do so (USFF, 2017c) and, in turn, standing watch when they are not ready to do so.

2.11.2 Underload

Underload can affect Navy Sailors as much as overload and also has inherent risk. Underload is defined as "a load markedly below full capacity: an inadequate or insufficient load" ("Underload", n.d.). Boredom has been shown in numerous studies to relate to several negative effects to include distress and depression (Fisher, 1993; Game, 2007; Sommers & Vodanovich, 2000; Wiesner, Windle, & Freeman, 2005). It can also have negative effects on the company or organization as a whole (Spector & Fox, 2002; van Hooff & van Hooft, 2014). Discussing boredom in the military context, Ender (2012) notes, "boredom is both social and psychological and involves an absence of flow of human experience, no future, and unmet social expectations ... potential links with boredom and military training include mission success, morale, cohesion, loneliness, deprivation, discipline, and operational tempos" (pp. 313–314).

Low task demands may not only cause boredom but an associated fatigue as well. Research shows that, the lower the task demand, the greater the fatigue effect on a person's ability to respond (Desmond & Matthews, 1997). Desmond and Matthews go on to discuss how the lack of activity and the progressive fatigue can lead a driver to leave the road, causing an abrupt wake up or startle to the driver. Thus, we need balanced tasking as shown in what is now called the Yerkes-Dodson Law as presented by Hebb (1955, Figure 2) (see Figure 2.16).

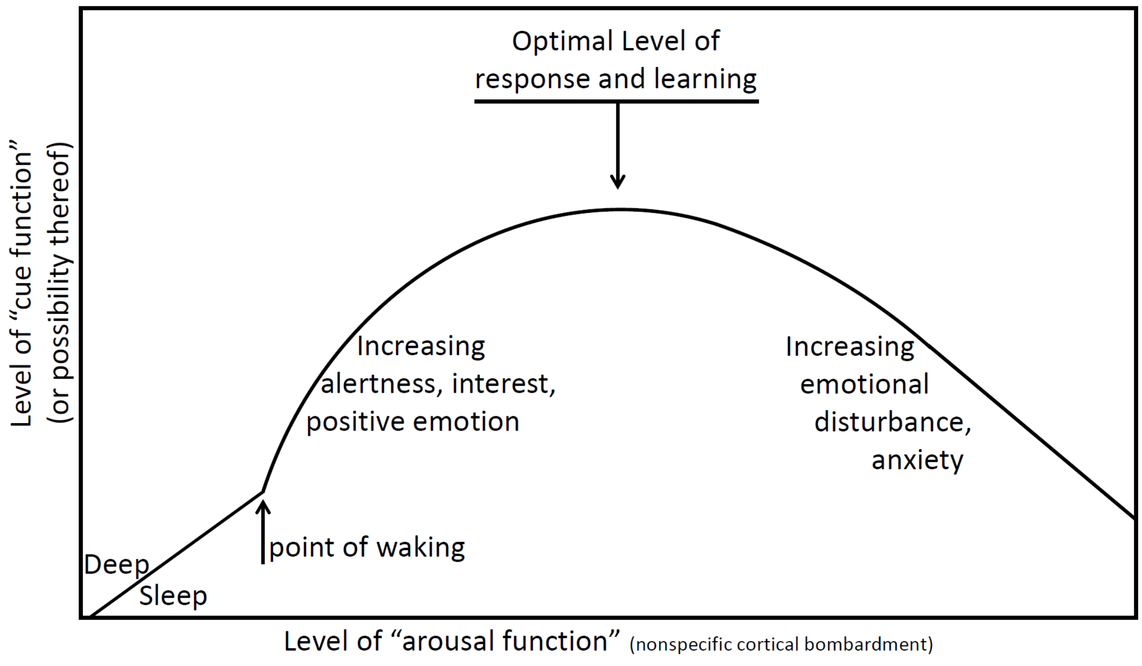


Figure 2.16. "Level of 'Arousal Function."' Adapted from Hebb (1955).

This illustration differs from Figure 2.15, which discusses an overload response in regard to singular visual, auditory, or tactile resources. The Yerkes-Dodson Law inverted-U shows effects of arousal, which can be related to workload, on performance.

2.11.3 Working Hours

As illustrated in Figure 2.8, "Levels of Risk," inadequate manning for shipboard requirements causes an increased workload for the remaining Sailors. When Sailors work longer hours to make up for inadequate manning, whether departmental or divisional, their workdays become excessively long as will be illustrated in Section 2.13, Case Studies. Inadequate manning causes a perpetual condition of Sailor overload.

As the U.S. Navy resolves to change watchstanding and shipboard schedule methodology, other agencies have laid out working standards to allow Sailors to get the "crew rest" they need. These civilian maritime regulations focus on maximum hours of work, instead of a long term average weekly expectation, in order to assure crew rest and, hopefully, reduce fatigue (International Labour Conference (ILC), 2014; IMO, 2010). The IMO (2001) states the reason for the concern about maritime fatigue.

> Human error resulting from fatigue is now widely perceived as the cause of numerous marine casualties ... The negative effects of fatigue present a disastrous risk to the safety of human life, damage to the environment, and property ... The seafarer is a captive of the work environment ... spends between three to six months working and living away from home ... subject to unpredictable environmental factors ... The most common causes of fatigue known to seafarers are lack of sleep, poor quality of rest, stress and excessive workload. (pp. 4–5)

This concern of fatigue from poor sleep, rest, stress, and workload at sea is a relevant concern not only the commercial vessels, but to U.S. Navy vessels as well.

Sailor work hours for commercial vessels are mandated by U.S. law. The summarized requirements (see Table 2.10) listed are minimal and do not account for emergency situations.

Table 2.10. Maritime Regulation Provisions.

Provision	NAF/NSWW	46 U.S.C. §8104 / 46 CFR §15.1111	MLC	STCW VIII/1
Agency	U.S. Navy	U.S. Law	ILO (UN)	IMO (UN)
Attributes	Manpower Planning	> 100 Gross Tons (incl. Oilers)	Int'l Water Vessels	Int'l Water Vessels
Working Hours	Planned for: 81 hrs/7 days	≤ 12 hrs/24 hrs; ≤ 36 hrs/3 days [ENG/DECK: ≤ 8 hrs/day]	≤ 14 hrs/24 hrs; ≤ 72 hrs/7 days	Same as MLC
			-or-	**-or-**
Rest Hours	Not regulated**	≥ 10 hrs/24 hrs in ≤ 2 periods w/ one ≥ 6 hrs [OIC/ENG/DECK]	≥ 10 hrs/24 hrs in ≤ 2 periods w/ one ≥ 6 hrs; ≥ 77 hrs/7 days	Same as MLC
Minimum Number of Watches	3-section watches	3-section watches	Defers to STCW	3-section watches [ENG/DECK]
Last Update	24 JUN 2015	1996 / 1997	Effective 20 AUG 2013	Align to MLC 3 AUG 2010

** The NSWW included a rest allotment but with the change to the NAF in 2016, this allotment was removed and left to the command / individual to figure out how to use their unavailable / off-work time or the regulation thereof (DCNO (MPT&E), 2007, 2016).

The Provisions of the NAF/NSWW and Civilian Maritime Regulations. Adapted from DCNO (MPT&E) (2016); ILC (2014); IMO (2010); *Shipping: Watches*, 46 U.S.C. §8104 (1996); *Shipping: Work hours and rest periods*, 46 CFR §15.1111 (1997); USCG (2013).

In addition, "Rest Hours" do not include short breaks during working hours. The Maritime Labour Convention (MLC) is a convention under the International Labour Organization (ILO), an agency of the United Nations (UN), that sets maritime requirements on international vessels adopted by those countries who have ratified it (USCG, 2013). According to the USCG (2013), the United States does not belong to this convention but has aligned with it as of 2013 (p. 2). The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) provides seafarer requirements under the IMO, also an agency of the UN to which the United States has belonged since 1950 (IMO, 2018).

U.S. Regulations mandate requirements for commercial shipping in order to mitigate fatigue, increasing overhead business costs. *Shipping: Work hours and rest periods,* 46 CFR §15.1111 (1997) notes, "The minimum period of rest required ... may not be devoted to watchkeeping or other duties" (p. 268). Understandably, U.S. Navy warships do not fall under these requirements. It is ironic, however, that the concern for fatigue and crew rest, which these regulations are based upon, is a requirement for merchant mariners but is not addressed for the most critically important vessels working in dangerous environments, Navy surface vessels.

2.12 Effects of Workload Imbalances

Workload imbalances, as discussed in Section 2.11, can cause potential physiological effects on personnel. Extensive research of underload and overload of tasks highlights causes for concern. The following information represents a small portion of the research available to provide some degree of the significant potential effects on a Sailor when the individual workload is not appropriately monitored or managed, whether because the Sailor is addressing command workload requirements or because of overarching U.S. Navy policy that affects Sailor workload requirements.

The Navy has been paying attention to fatigue and the need to ensure proper sleep for Sailors. Note, the TYCOMs for DDGs, COMNAVSURFPAC, and COMNAVSURFLANT, recently implemented a "Comprehensive Fatigue and Endurance Management Policy" (COMNAVSURFPAC & COMNAVSURFLANT, 2017). The TYCOMs had previously provided information on circadian routines via messages in 2013 and 2016 with encouragement for experimentation along with information on Sailor exercise, nutrition, and sleep (Naval Surface Forces, 2013, 2016). In May 2017, COMNAVSURFPAC and COMNAVSURFLANT issued a message to all fleet ships encouraging leadership to take a look at circadian watchbills and how they afford better sleep (Crew Endurance Team, 2017), followed up with a message in September, and finalized a policy in November (COMNAVSURFPAC & COMNAVSURFLANT, 2017). Up until that date, the Surface Navy had continued to operate on daily rotating watchbills, which have been shown to degrade sleep and effectiveness (Osborn, 2004; Roberts, 2012; Shattuck & Matsangas, 2014b).

The 2017 instruction implements a mandate for circadian watchbills with appropriate ship-wide schedule implementation in order to provide "protected sleep" to Sailors. In a Comprehensive Fatigue and Endurance Management Policy implementation brief, COMNAVSURFPAC and COMNAVSURFLANT Commander Action Groups and Detachment Monterey (2018) notes that such protected sleep should not be affected by internal ship requirements but cannot prevent externally imposed operational requirements in order to achieve the overall mission. No matter the mandate for protected sleep time, if workload is more than a Sailor can complete outside that time, it will creep into those protected hours and increase Sailor stress while lowering Sailor resiliency.

2.12.1 Stress

Stress can also have positive effects on Naval personnel. Positive effects include both professional and personal experience in solving a problem or achieving a goal. Personnel can gain confidence from the induced stress and the knowledge of an ability to cope, adapt, and learn from an experience to apply to future issues or problems. This confidence and knowledge can ease the induced stress experienced in the future (Glendon & Coles, 2001). The stressors in such cases help personnel to learn from experience, enabling the Sailor to grow in their area of expertise.

However, one negative side of stress, a decrease in desire to perform, can particularly affect a command. A study by Milgram, Orenstein, and Zafrir (1989) demonstrates a decline in perseverance, indicating that, with an increase in stressors, "soldiers reported a marked decline in their personal endorsement of the official goals of the military operation, in the endorsement of soldiers and officers in their unit, and in that of the nation as a whole" (p. 192). Such a lack of endorsement can lower morale and potentially affect others in the command. Several studies show that the primary negative stressor is a lack of time (Weaver, Bowers, & Salas, 2001), a significant point of concern for the U.S. Navy.

Studies have found that an increase in workplace stress–including emotional and cognitive demands, higher work demands as well as conflicts between work and goals–can negatively affect sleep and sleep behaviors (van Hooff, Geurts, Beckers, & Kompier, 2011). In a study by Loft and Cameron (2014), negative emotions related to work tended to increase the need for sleep potentially due to poor sleep quality, further exacerbating sleep issues caused by stress. With an increased individual workload, the Sailor will be unable to self-regulate and obtain more sleep, creating a negative cycle and building fatigue.

2.12.2 Sleep

Like stress, lack of sleep can affect the normal functions of the Sailors. Separate studies show that a lack of sleep can decrease vigilance or the ability to react; when a person "catches up" on sleep for a night, the individual's vigilance does increase, but does not return the individual to the initial levels of vigilance (Dinges et al., 1997; R. Wilkinson, Edwards, & Haines, 1966). When U.S. Sailors are standing watch, vigilance is a necessity; lack of sleep reduces their ability to remain vigilant.

The number of hours a Sailor is awake can affect their capabilities much like alcohol does. Dawson and Reid (1997) compared hours of wakefulness against relative blood alcohol concentration (see Figure 2.17).

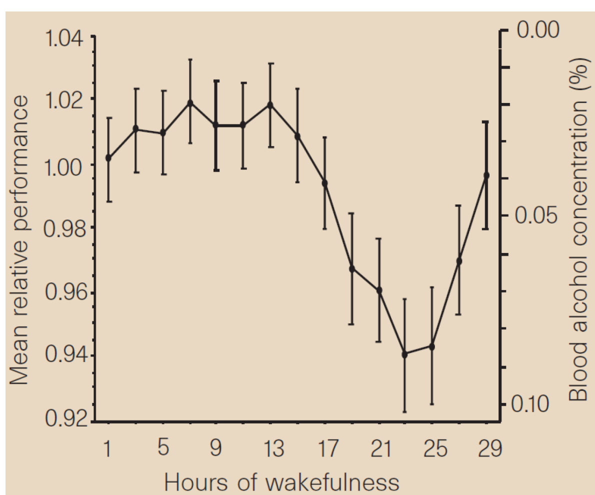


Figure 2.17. Performance in the Sustained Wakefulness Condition Expressed as Mean Relative Performance and the Percentage Blood Alcohol Concentration Equivalent. Error Bars ± s.e.m. Source: Dawson and Reid (1997).

They showed that a continued wakefulness causes impairment in reaction times similar to the effects of drinking alcohol.

Reaction times also decrease with lack of adequate sleep. Belenky et al. (2003) studied restricted sleep over a seven-day period (see Figure 2.18).

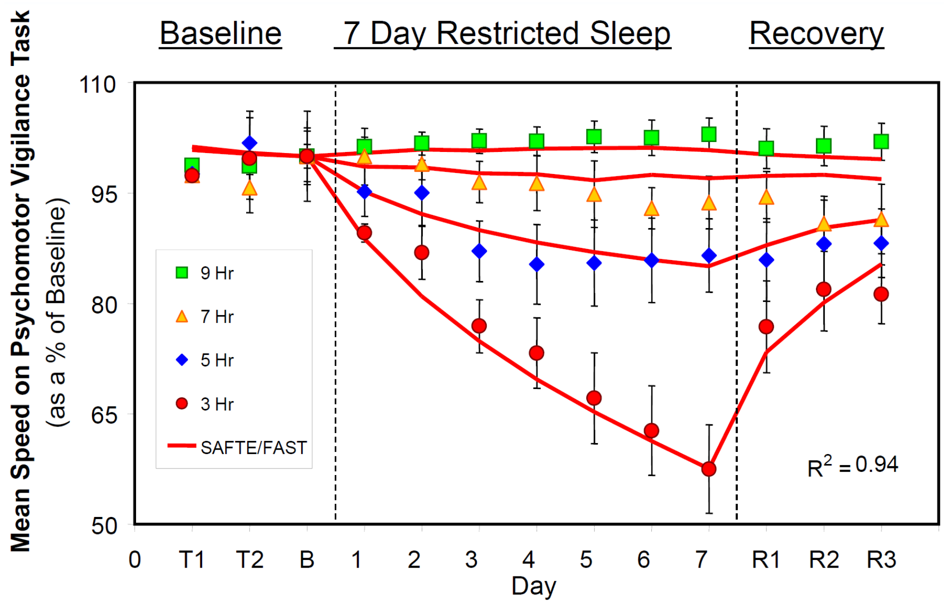


Figure 2.18. Mean Psychomotor Vigilance Task (PVT) Speed (and Standard Error) across Days as a Function of Time in Bed Group. Adapted from Belenky et al. (2003).

The reaction times of the subjects decreased dramatically with a reduction of sleep to three to five hours per night, never recovering to their initial reaction time after the study with three days of rest.

Concerns of Sailors managing to procure enough sleep have been exacerbated by many U.S. Navy traditional watch rotations that result in effective work days other than 24 hours in length. These watchbills rotate shifts each day, imposing shift lag and build-up of chronic sleep debt and disrupted circadian rhythms (Arendt, Middleton, Williams, Francis, & Luke, 2006; Folkard, 1992; Shattuck & Matsangas, 2015; R. T. Wilkinson, 1992).

As discussed at the beginning of the section, COMNAVSURFPAC and COMNAVSURFLANT finalized policy in November 2017 with the goal of providing protected sleep to at-sea Sailors (COMNAVSURFPAC & COMNAVSURFLANT, 2017). Since the finalized policy was issued, circadian watch rotations are starting to become the fleet standard. Sleep is a critical factor in vigilance and fatigue avoidance. Such reported effects due to the lack of sleep directly relate to the ability of a Sailor to stand a watch. The hope is that circadian watchbills can help alleviate such concerns.

2.12.3 Fatigue

The culmination of increased workload, and its association with reduced sleep, results in a fatigued Sailor. Konz divides fatigue into five factors.

> 1. Physical exertion (e.g., bicycle ergonometer work; descriptions such as "warm," "sweaty," "out of breath," "breathing heavily," "palpitations")
> 2. Physical discomfort (e.g., static load on small-muscle groups; descriptions such as "tense muscles," "aching," "numbness," "hurting," "stiff joints")
> 3. Lack of energy (mental plus physical; descriptions such as "exhausted," "spent," "overworked," "worn out," "drained")
> 4. Lack of motivation (mental; descriptions such as "lack of initiative," "listless," "passive," "indifferent," "uninterested")
> 5. Sleepiness (mental; descriptions such as "sleepy," "yawning," "drowsy," "falling asleep," "lazy"). (Konz, 2001a, p. 1365)

Frone and Tidwell (2015) also note the impact of fatigue on an individual's capacity to function: "Work fatigue represents extreme tiredness and reduced functional capacity that is experienced during and at the end of the workday" (p. 3). Desmond and Matthews (1997) found a decrease in task motivation due to complacency and showed that "increased subjective tiredness and physical and perceptual fatigue symptoms ... [resulted in] increased tension, annoyance and cognitive interference" (p. 521). Finally, numerous studies have found that long shipboard working hours and reduced personnel on board result in greater fatigue (Arendt et al., 2006; Houtman et al., 2005; Miller & Eddy, 2008; Murphy, 2002; Smith, Lane, & Bloor, 2002).

The Navy recognizes fatigue as a factor in collisions. Fatigue was found to be a "contributing factor in the USS *Fitzgerald* and USS *John S. McCain* collisions" (USFF, 2017c, p. 38).

Knowing how detrimental fatigue can be, it is important to understand the individual workload that may cause a lack of sleep. Murphy (2002) notes that, to prevent fatigue, Sailors need "sustained work limits and minimum sleep schedules ... The scheduling of work and sleep/rest periods is a key aspect of fatigue prevention" (p. 69). USFF (2017c) further discusses concern with fatigue in crew members. Though they tend to focus on safety awareness, Sailor self-assessment of fatigue is known to be poor. Sailors tend to believe they can "push through" with energy drinks or caffeine. Not surprisingly, in a survey of service members serving in Afghanistan, the Centers for Disease Control and Prevention (2012) found that, when three or more energy drinks were consumed, the service member was more likely to sleep less than four hours and more likely to fall asleep while on watch.

2.12.4 Burnout

Burnout is also a real concern for personnel at sea. Burnout is defined as "exhaustion of physical or emotional strength or motivation usually as a result of prolonged stress or frustration" ("Burnout", n.d.). Chung et al. (2017) cites that personnel at sea who are suffering from burnout are actually suffering from a disorder that rest does not easily resolve. He discusses the fact that, through a lack of energy or interest, such personnel are more likely to contribute to an accident at sea.

Demerouti, Bakker, Vardakou, and Kantas (2003) discuss burnout as the central element of exhaustion. The authors define exhaustion as "a consequence of intensive physical, affective, and cognitive strain, i.e., as a longterm consequence of prolonged exposure to certain job demands" (p. 14). The comparison of two studies included elements other than exhaustion. They found it more difficult to determine if those elements cause or are a result of burnout. The factors include disengagment, or depersonalization: an emotional distancing from work, general cynicism, dissatisfaction, and a desire to leave their current occupation (Demerouti et al., 2003). A high OPTEMPO for the Sailors in the Surface Navy without the dispersion of duties and responsibilities results in these factors, whether they are caused by or resulting from burnout.

Younger people are actually more likely to experience burnout. Alarcon also notes that turnover is strongly related to emotional exhaustion, a central component of burnout. Alarcon (2011) found, through a meta-analysis of numerous burnout studies, that consistent significant variables related to burnout include attitudes within the workplace, the demands placed upon the subject (also highly correlated to exhaustion), and the resources available to that individual. In a study on seafarers experiencing burnout and their relationships to incidents at sea, Chung et al. (2017) found direct effects of Work-Related Burnout and Sleepiness (if combined with the burnout disorder) to incidents at sea (see Figure 2.19).

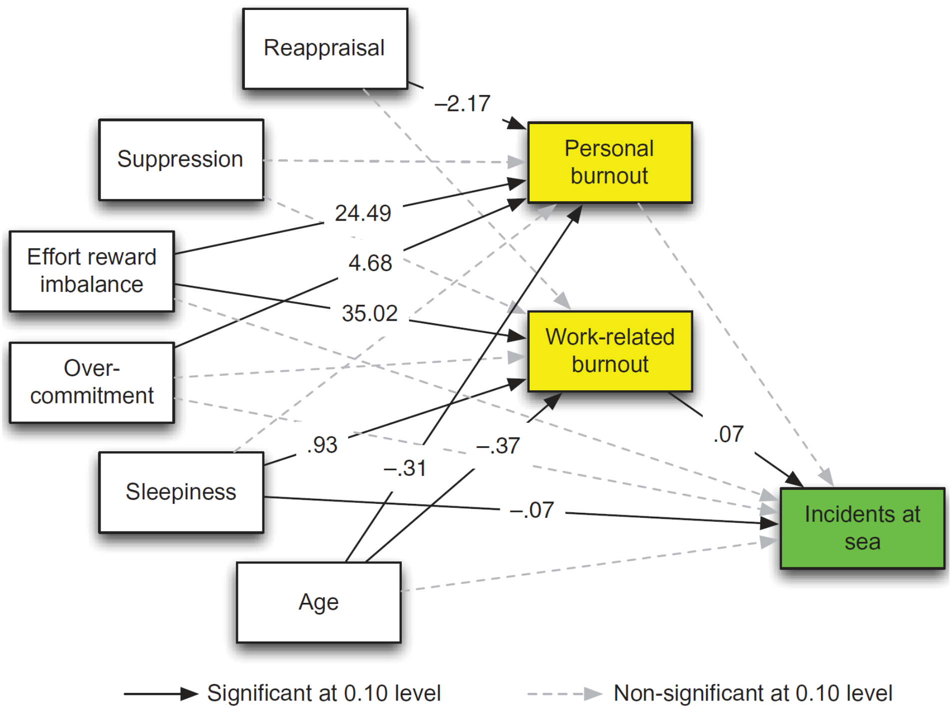


Figure 2.19. Simultaneous Equation Analysis Results of Incidents at Sea. Source: Chung et al. (2017).

Statistically significant results show that younger seafarers are more likely to experience burnout. With 64.6% of U.S. Navy Sailors being 30 years of age or less (Statistic Brain, 2017), the potential for a Navy Sailor to experience burnout is higher.

2.12.5 Potential Medical Concern

Discussing the relationship between burnout and illness, Melamed, Shirom, Toker, Berliner, and Shapira (2006) cite numerous studies through a meta-analytic study with evidence of illness due to burnout. Such illnesses, according to Melamed et al., include: depression, cardiovascular disease, stroke, the suppression of the immune system, and inflammatory reactions. They also found that heart-related diseases are shown in some studies to have a higher correlation to stress than what are considered the "normal" indicators: smoking, body mass index, age, lipids, and blood pressure (p. 331). Other potential concerns include "an unpleasant sensation of tension and restlessness at work, postwork irritability, sleep disturbances, and complaints of waking up exhausted" (Melamed et al., 2006, p. 335).

2.12.6 Decision Making, Error, and Results

The impacts of a high workload and resulting fatigue impact personnel in a negative way. A study completed by Joint Commission [for health care] (2011) discussed how long-term fatigue can lead to attention lapse, lower motivation, and difficulty with problem-solving. In addition, fatigue has been shown as one of the greatest contributors of accidents for all transportation modes (National Transportation and Safety Board, 2016). The report also notes that "mariners should recognize the effects of sleep loss on performance and should never take a watch while too fatigued to be fit for duty" (p. 60). Additionally, McCallum, Raby, and Rothblum (1996) from the U.S. Coast Guard Research and Development Center, conducted a study of incidents at sea. Reviewing 279 incidents that posed some sort of risk to the crew's safety or where the ship had significant damage, they determined "that fatigue was a contributing factor in 16% of critical vessel casualties and 33% of personnel injuries, making fatigue a significant causal factor in marine casualties" (p. iii).

In a study by Larsen (2001), Norwegian military academy students with at least two years of military experience trained on a course with "human-like targets," and, after being sleep-deprived, found frightening results. After five days of little sleep, Larsen had the students repeat the training evolution, except this time, the targets were replaced by actual humans. These human targets, upon the start of the attack, began moving normally, even standing up (Larsen, 2001). During this repeated evolution, the students were ordered to fire although the weapons provided to the students did not contain live ammunition. Larsen found that during the practice course, 59% of the sleep-deprived students fired at the human targets. Even though it could be clearly seen that there were actual humans on the course, and something unusual had occurred, 42% of those who fired continued to follow orders even when they realized something was different (p. 94). Following orders is not necessarily unusual for military personnel, however, with an expectation of targets and, instead, seeing real humans, it is notable that such a large percentage of the military academy students continued to fire. Even those who did not fire their weapon due to unusual circumstances failed to notify the others of what they saw happening, though they realized the potential repercussions of killing or severely injuring real humans. After the evolution, those personnel were concerned or even shocked by the fact that they did not warn the others (Larsen, 2001).

2.13 Case Studies

Numerous studies of surface ships within the past 20 years show an estimate of how many hours the U.S. Navy Sailor is working, many of which we found had valid methodology, and, therefore, used in Section 2.13. Of the prior nine studies conducted on CGs, DDGs, and Guided Missile Frigates (FFGs), one was conducted through the offices of the Secretary of the Navy in order to create the SMD, four were completed by entities outside of the Navy through interviews and surveys, and four were completed through the Naval Postgraduate School using daily activity logs. These methods are excellent ways to collect data (Anderson et al., 1997; Gilbreth & Gilbreth, 1919; Taylor, 1967). Anderson et al. (1997) discuss the various analytic methods that should be used to determine workload as well as the difficulty of doing so with Sailors. All of these studies use the components these authors review and recommend, whether through interviews, work logs, or reaction time tests (e.g., Psychomotor Vigilance Tests).

Other studies either had questionable methodology or the data was limited or unavailable and, thus, are not represented in Section 2.13. Navy Personnel Research and Development Center (NPRDC) conducted a study in 1975; however, the study was unobtainable. NPRDC data presented are a result of data provided through citations by Moore, Gasch, et al. (2002). Research and Development Corporation (RAND) completed a study in 1979. In a sample of 18,871 enlisted Naval personnel, Doering, Hutzler, Francisco, and Sanchez (1982) did not delineate working hours based on Sailor working location (i.e., sea, shore, overseas, et cetera). Therefore, the study does not meet the intent of this review or any other study of afloat working hours. However, it is important to note that, during the study, many participants believed that their working schedule did not affect their actual working hours: "From their perspective, the official work is complete 'when the work is completed'" (Doering, Perry, & Shishko, 1979, p. 23). The document refers to a study completed by the

Navy Manpower and Material Analysis Center in Norfolk, Virginia during February 1979 in order to review the Non-Availability Time (e.g., personal time, sleep, Sunday free time, etc.) for Sailors. Details for the results of this study are unavailable.

2.13.1 A Study for the Basis of the Ship Manpower Document (SMD)

As discussed in Section 2.2.2, the DCNO, in 1967, originally outlined the NSWW, setting the Sailor workday at 74 hours. The team, Bright et al. (1969), applied these hours to wartime cruising readiness (Condition III), as was discussed in more detail in Section 2.2.3, and assumed that the calculations collected for each portion of the NSWW represented the proportion of time each Sailor spent on that task type year round. The resulting recommendations were provided by industrial engineers, management analysts, and military personnel who had experience in the projection of manpower needs within the Navy (Bright et al., 1969). With the complete results from the NSWW, the CNO expanded the determination of manpower requirements to the other surface ship classes fleet-wide, implemented through the SMD (Plato, 1975).

2.13.2 Navy Personnel Research and Development Center (NPRDC): 1975

Seven years later, as cited in Moore, Gasch, et al. (2002), NPRDC conducted a study of the NAF/NSWW in 1975, which found disparities between the 74 hours planned for and the actual Sailor workweek. The results show an average available working hours for U.S. Navy personnel at sea of 91.8 hours. According to Sorenson (1982), the purpose of the report was to determine whether all afloat Sailors should have the same standard workweek, and, if so determined, whether actual observations within appropriate operating conditions should establish the workweek standard. Sorenson's summary of NPRDC's report recommended that a standard workweek for both air and surface enlisted personnel should be, "76 hours in length. Within that total, 7.5 hours should be allocated to drills and training; 5.5 hours, to service diversion activities; and 63 hours, to primary duties, watches, and other work activities" (p. 123). Due to a failure to report sample size within available documents, comparison of working hours to other studies and the current NAF/NSWW is not possible.

2.13.3 Center for Naval Analyses (CNA): 2001

In 2001, OPNAV N12, the Director for Total Force Programming Manpower, and Information Resource Management, asked the CNA to study afloat working hours and determine the average number of hours the Sailors work at sea (Moore, Gasch, et al., 2002). The study notes that it had been more than 20 years since the last study of the NSWW and, with considerable changes in technology, management and Sailor quality over that timeframe, the U.S. Navy determined that a study should be completed.

The methodology for the CNA study, conducted in 2001 and reported in 2002, used "one-on-one interviews with Sailors at sea" (p. 6). This methodology was recommended by Doering et al. (1979) within their discussion of how to study the Sailor's work week in order to obtain the most accuracy. They state that the personal interaction involved with interviews alleviates some of the issues with information recall and the concern of being asked personal or threatening questions.

The CNA team had specific methodology that focused on interviews. The CNA team conducted interviews with either 100% of a work group who stood the same watch throughout the day or through random selection within each department (Moore, Gasch, et al., 2002). Each interview only involved the Sailor's input as to what their activities had been over the past 24 hours (considered by the team as a period the Sailor could recall) and were later interpreted by the research team (Moore, Gasch, et al., 2002). The report noted that the DDG studied was conducting operations in the Indian Ocean, and manning was at 91%. The research team conducted 108 interviews with a total of 67 respondents (22% of the crew) (p. 9). By conducting interviews this way, the team gathered data on actual activities and determined the corresponding category within the NAF/NSWW. This approach helped to ensure the appropriate categorization of work.

The CNA team may have been the first to realize the gray area between "personal time" and "service diversion." CNA team noted that definitions of what activities were considered "personal time" and "service diversion" were major determinants in actual total work or personal time. The report noted that such scenarios included e-mail, education, and physical fitness. In the end, they determined that it was important to make an "apples to apples" comparison and use the definitions provided by NAVMAC (Moore, Gasch, et al., 2002).

The CNA study detailed some potential reasons that Sailors worked more hours than expected in the planned long term average. First, the CNA team hypothesized improper accounting for manpower requirements (e.g., differences in mission and shipboard activities such as messing and berthing inspections, identified as requiring 70 Sailors to complete on a U.S. Navy Cruiser) (p. 13). Second, the CNA team thought undermanning may be a reason for Sailors working more than the SMD planned. If ship manning is less than planned for in the SMD, whether due to funding or personnel not currently on board, it follows that the workday for the remaining Sailors increase.

The CNA study also found inconsistencies across departments. They found that "poorly manned departments (or ratings) did not work consistently more hours than Sailors working in well-manned departments (or ratings)" (p. 19) and found no correlation between manning and working hours. The study found no compelling explanation for this. It seems likely that poorly manned departments accomplish a smaller percentage of their work than well-manned departments. The lower task completion rates result in deferred, incomplete, or mediocre work. Digging deeper into department comparisons, the CNA team found that the two departments with the most working hours were Navigation and Medical. Overall, the CNA team found that the average work week consisted of 84.4 hours (see Table 2.11).

Table 2.11. Center for Naval Analyses Navy Standard Work Week Study: Average Weekly Available (Working) Hours Breakdown, 2002. Adapted from Moore, Gasch, et al. (2002).

DDG Findings n = 67	
Work and Watch	74.9 Hours
Other duty	6.4 Hours
Training	3.1 Hours
Average Available Working Hours	**84.4 Hours**

The average available working hours for the DDG was 84.4 hours consisting of 74.9 hours for work and watch, 6.4 hours for "other duty," and 3.1 hours for training.

2.13.4 USS *Chung-Hoon*: 2007

In 2007, the Haynes study found a higher average, 92.8 hours. Haynes conducted a study of USS *Chung-Hoon* (DDG 93) during their underway pre-deployment workups (training). Each participant filled out a daily Sleep and Activity Log broken down into 15 minute increments for each day the Sailor participated in the study, up to two weeks (Haynes, 2007). The report notes that they also wore wrist activity monitors to assess their movement and verify sleep time. Haynes detailed Sailor available working time across the ship (see Figure 2.20) and offered consolidated study results for enlisted participant working hours (see Table 2.12).

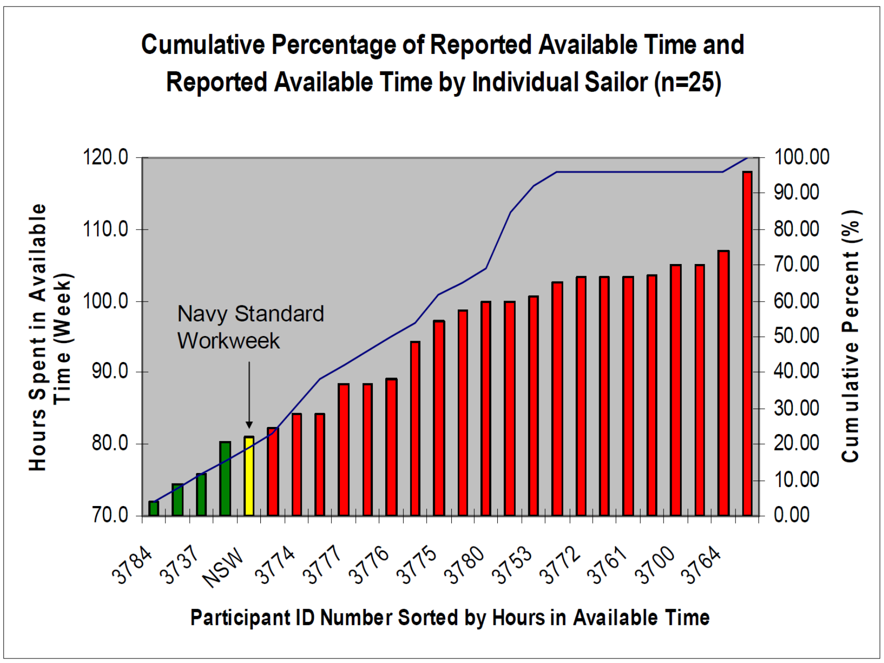


Figure 2.20. Weekly Average Available Time (Work), USS *Chung-Hoon*, Including Officers. Source: Haynes (2007).

Table 2.12. USS *Chung-Hoon* Study: Average Weekly Available (Working) Hours Breakdown, Enlisted only, 2007. Adapted from Haynes (2007).

USS *Chung-Hoon* Findings n = 21 enlisted	
Work and Watch	85.48 Hours
Service Diversion	2.75 Hours
Training	4.58 Hours
Average Available Working Hours	**92.8 Hours**

Based upon the activity logs, the average working hours or "available time" ranged from 71.85 hours to 117.97 hours with a standard deviation of 11.86 hours (p. 26). Eighty-six percent of the participants exceeded the 81 hours planned for in Navy manpower models. Haynes (2007) noted that Combat Systems had the greatest deviation (11 hours) from the standard workweek because of maintenance, suggesting a disparity between the maintenance included in the NSWW.

2.13.5 USS *Port Royal* and USS *Lake Erie*: 2009

In 2009, comparing a Cruiser workweek to the NSWW, Mason (2009) found the average workweek to be 90.90 hours. In a Cruiser-specific study during the Rim of the Pacific Exercise, Mason (2009) obtained data from 39 participants on USS *Port Royal* (CG 73) and USS *Lake Erie* (CG 70) over a period of three weeks. Each participant logged their day on a Sleep and Activity Log in 15-minute increments for each day they participated in the study, making the data able to be parsed by available working hours and non-available hours in order to correspond to the NSWW. The report notes that they also wore wrist activity monitors to assess their movement and verify sleep time.

Mason (2009) provided a detailed account of Sailor Available working time across the ship (see Figure 2.21) and the consolidated study results for enlisted participant Available working hours (see Table 2.13).

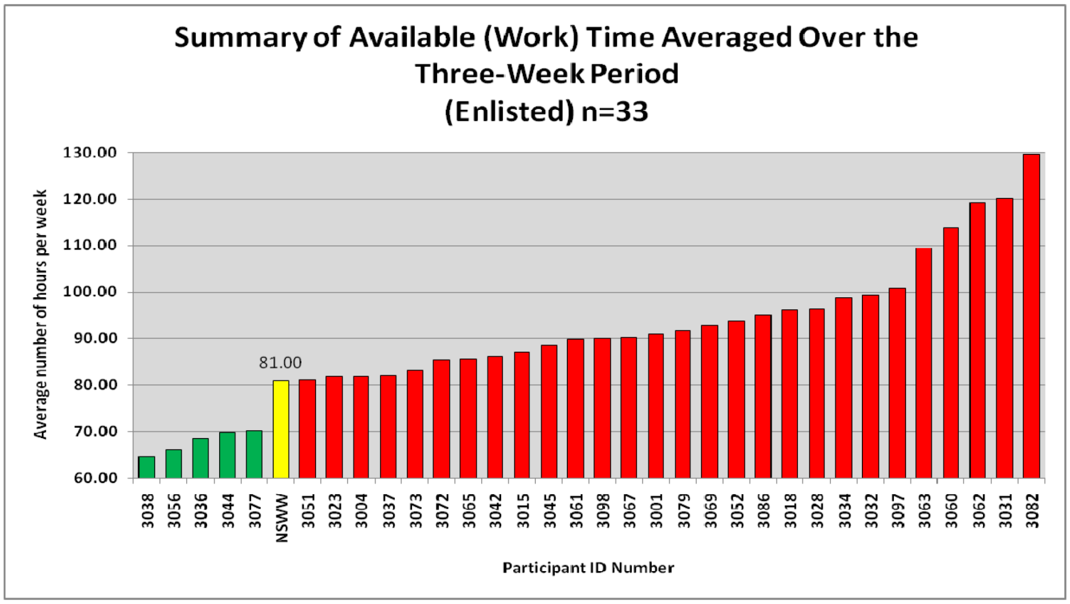


Figure 2.21. Weekly Average Available Time (Work), USS *Port Royal* and USS *Lake Erie*, Enlisted Only. Source: Mason (2009).

Table 2.13. USS *Port Royal* and USS *Lake Erie* Study: Average Weekly Available (Working) Hours Breakdown, Enlisted only, 2009. Adapted from Mason (2009).

USS *Port Royal* and USS *Lake Erie* Findings n = 33 enlisted	
Average Available Working Hours	**90.90 Hours**

Mason states that the enlisted working hours averaged 90.90 hours ranging from 64.58 hours to 129.63 hours with a standard deviation of 15.33 hours (p. 73). Eighty-five percent of the participants exceeded the average available working hours as planned for within the NSWW.

2.13.6 USS *Rentz*: 2009

Also in 2009, Green (2009) found an average of 87.12 hours in a study aboard the frigate, USS *Rentz* (FFG 46), during pre-deployment underway workups (training). Green (2009) compared actual daily activity, including sleep, to the NSWW average workweek standard.

This study involved detailing each subject's 24-hour day through a 15-minute increment daily activity log (Green, 2009). The report notes that they also wore wrist activity monitors to assess their movement and verify sleep time. Of the 24 participants, 21 were enlisted and completed the study (Green, 2009).

Green (2009) provided the detail across the ship for Sailor Available working time (see Figure 2.22) and the consolidated study results for enlisted participant working hours (see Table 2.14).

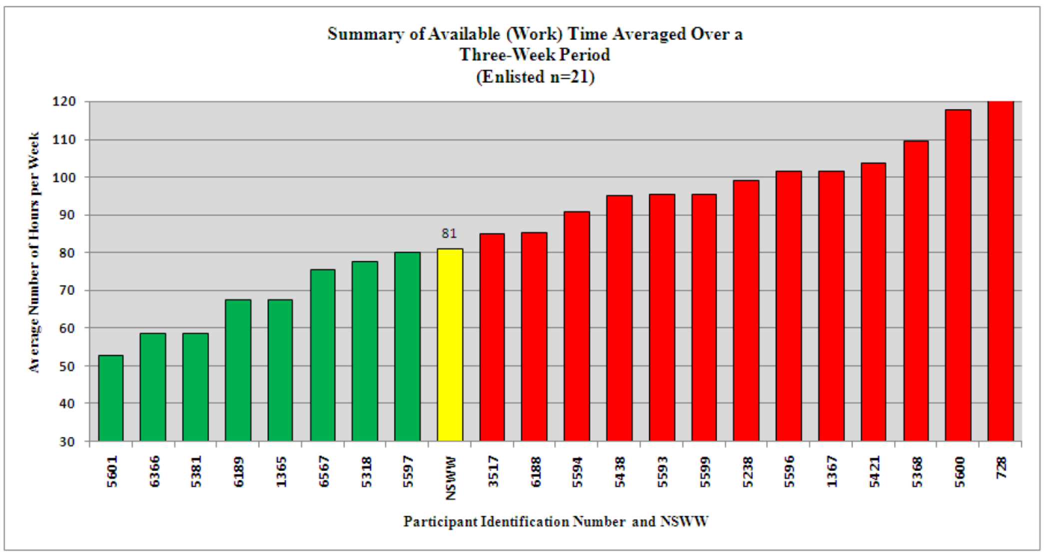


Figure 2.22. Weekly Average Available Time (Work), USS *Rentz*, Enlisted Only. Source: Green (2009).

Table 2.14. USS *Rentz* Study: Average Weekly Available (Working) Hours Breakdown, Enlisted only, 2009. Adapted from Green (2009).

USS *Rentz* Findings n = 21 enlisted	
Work and Watch	73.68 Hours
Service Diversion	11.93 Hours
Training	2.08 Hours
Average Available Working Hours	**87.69 Hours**

Enlisted participant available working hours averaged 87.12 hours ranging from 52.85 hours to 123.34 hours with a standard deviation of 19.89 hours (p. 78). Sixty-one percent of enlisted participants exceeded the NSWW model available working hours.

2.13.7 USS *Jason Dunham*: 2012

Conducting their study on board USS *Jason Dunham* (DDG 109) during independent steaming in the Arabian Gulf, Shattuck and Matsangas (2014b) compared various watchbills and their effects on the Sailors. They also compared actual daily activity, including sleep as it related to the NSWW. This process involved detailing each subject's 24-hour day using a 15-minute increment daily activity log. Some subjects wore wrist activity monitors in order to verify activity and sleep time. Of the 122 participants, 72 were enlisted and completed the study.

The data provided by Shattuck and Matsangas (2014a) provides the detail across the ship for Sailor Available working time (see Figure 2.23) and the consolidated study results for enlisted participant working hours (see Table 2.15).

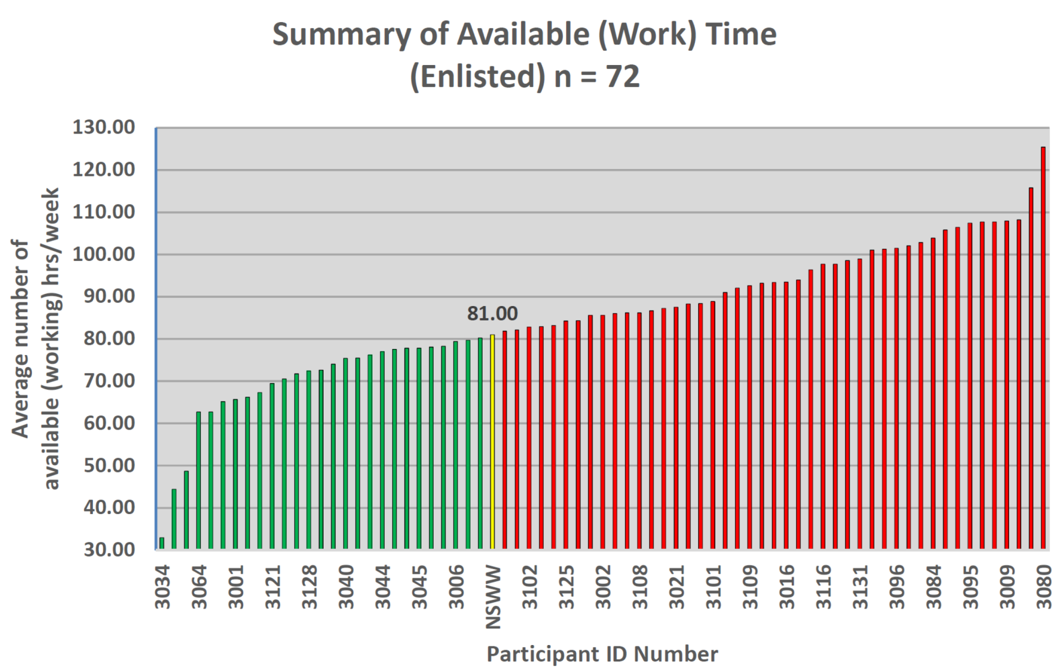


Figure 2.23. Weekly Average Available Time (Work), USS *Jason Dunham*, Enlisted Only. Adapted from Shattuck and Matsangas (2014a).

Table 2.15. USS *Jason Dunham* Study: Average Weekly Available (Working) Hours Breakdown, Enlisted only, 2012. Adapted from Shattuck and Matsangas (2014a).

USS *Jason Dunham* Findings n = 72 Enlisted	
Work and Watch	66.79 Hours
Service Diversion	14.25 Hours
Training	4.55 Hours
Average Available Working Hours	**85.59 Hours**

The average enlisted participant's available working hours was 85.58 hours, ranging from 32.96 hours to 125.42 hours, with a standard deviation of 16.35 hours. Of the enlisted participants, 62.5% exceeded the NSWW model for available working hours.

2.13.8 The Big Picture

Data have shown that Sailors are working longer days than is modeled by the NAF/NSWW. The Naval Postgraduate School studies provided enough detail to determine that, over four studies of five ships (two CGs, two DDGs, and one FFG), 107 (of 151) or 71% of Sailors worked a greater number of hours than that planned for in Navy manpower models. The maximum workweek values recorded from the four studies ranged from 36.97 to 48.63 hours *more* than 81 hours. Additionally, across the four studies, the Operations and Combat Systems departments consistently worked some of the longest days on board the ship, consistent with the key underlying assumption of the NAF/NSWW: a workload determination based upon at-sea Condition III readiness. These results may not be consistent with in-port workload, which is beyond the scope of both this thesis and the NAF as presently defined. Looking at the workload of the crew is vital in order to determine why the Sailors are working such long days. Personnel can experience detrimental effects with such long working hours, which, in turn, creates fleet-wide risks.

2.14 The Unresourced Burden

Each Sailor on U.S. Navy surface ships is affected in some way due to workload that is not included in Navy manpower models. Some departments may feel those effects more than others. This thesis, having extensively reviewed Navy manpower history and previous studies, conducts a gap analysis to determine the cause of the disparity between the expected working hours planned for by the NAF/NSWW and actual working hours. Despite multiple reports as to why incidents occurred with concern about surface force readiness for the U.S. Navy (Balisle, 2010; USFF, 2017c), no entity has yet looked at and assessed the gap between the Condition I and III workload planned for and the actual workload of the U.S. Navy Sailor at sea to determine why Sailors are working longer hours than planned within Navy manpower models. The rest of this thesis does exactly that.

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CHAPTER 3: Methodology

Chapter 2 offered an extensive review of U.S. Navy manpower history, planning, and factors that affect Sailor workload; it also partially demonstrated the complexity of assessing Sailor workload and how many ways the analysis of it can be approached. The Navy Manpower Analysis Center (NAVMAC) takes a task-based analysis approach to determine the time requirements for planned maintenance (PM) (which directly affects corrective maintenance (CM)) and own unit support (OUS). A task-based analysis breaks down the steps required for a task to determine the relative amount of time a Sailor spends on a given task (Mitchell & Driskill, 1996). During this process, NAVMAC analysts ask questions specific to the task (e.g., frequency, minimum time, average time, and maximum time for completion). In addition, they use industrial engineering methods in order to calculate the timing of the Make Ready/Put Away (MRPA) allowance (NAVMAC, Codes 20 and 40, 2017).

This thesis intends to account for all Guided Missile Destroyer (DDG) enlisted Sailor tasks that, when combined together, result in longer workdays than are modeled by the Navy. Therefore, the thesis attempted to identify all enlisted Sailor tasks, both warfare and non-warfare related, that are required of Sailors while at sea. To find the gap between planned and actual workload, we used a behavioral approach for Sailor job analysis, meaning identifying what the Sailors actually do while working at sea (Mitchell & Driskill, 1996). This chapter details our methodology.

3.1 Study Limitations

The thesis had limits in terms of duration and resources; therefore, we could not conduct a full job analysis for each person on board a deployed DDG. Ideally, Sailor at-sea workload would be compiled and departmental differences determined by using a combination of task- and behavioral-based analyses.

3.2 Phase I: The Shipboard Workload Model

The initial, or Mark I model, was a concept map or mind map (i.e., a visual representation) of the enlisted tasks accomplished at sea and in port (see Appendix B for the model and close-ups of two sections within the model). We constructed this mapping through personal knowledge and brainstorming with Naval Postgraduate School Surface Warfare Officer students who had previously served on either DDGs or Guided Missile Cruisers (CGs). The mapping reflects detailed Navy training requirements, department-specific tasks, and a preliminary breakdown of tasks using a broad stroke of Navy Availability Factor (NAF)/Navy Standard Work Week (NSWW) categories.

3.3 Institutional Review Board

Once we completed the base model, we created interview questions in order to guide discussions with subject-matter experts (SMEs) in the fleet. Appendix C contains these questions. We then submitted the questions to the Naval Postgraduate School's Institutional Review Board (IRB), in order to determine whether the interview questions constituted human subject research (HSR). The IRB subsequently determined that the research was not HSR.

We also created a questionnaire for underway DDG Sailors on deployment, included as Appendix D. We also submitted the questionnaire for IRB review, and, as they had with the interview questions, the IRB determined that the questionnaire was not HSR.

3.4 Phase II Data Collection: Subject-Matter Expert Interviews

We provided each interview participant with the interview questions as well as with a breakdown of the NAF/NSWW from Deputy Chief of Naval Operations (DCNO) (Manpower, Personnel, Training and Education (MPT&E)) (2016, p. D-3), included as Appendix E. The NAF/NSWW served to provide a definition of "average" work in order to provide a baseline across interview sessions.

We conducted interviews with shipboard leadership, both officer and senior enlisted, on board USS *Higgins* (DDG 76) and USS *Lake Champlain* (CG 57), the department heads of USS *Mobile Bay* (CG 53), the command triad (Commanding Officer, Executive Officer, and Command Master Chief) of USS *Russell* (DDG 59), and the leadership (E-6 and above) of USS *Kidd* (DDG 100) while deployed underway. We interviewed both CG and DDG leadership because the pattern seen manifested in one surface ship should also manifest itself in another surface ship within the same organization. Using the interview questions as a guide, a discussion of Sailor task requirements and sources of organizational frustration, both ashore and at sea, took place. Upon completion of the Phase I interviews, we updated the Mark I model to include enlisted tasks, both ashore and at sea, not previously identified. The updated model, the Mark II, is contained in Appendix F.

3.5 Phase III Data Collection: Sailor Surveys

We provided Sailors who volunteered to participate with an anonymous survey. Sailors completed surveys on USS *Kidd* and USS *Chafee* (DDG 90) during an underway deployment. The goal for the surveys was to assess Sailors' perceptions of workload. Once completed, we analyzed the data to assess at-sea perceptions. We identified task perceptions by analyzing the average hours for required tasks provided by the participants, and we made minor changes to the model from Phase III.

3.6 Phase IV: Navy Manpower Analysis Center

Understanding the processes of manpower determination and the Navy model was vital to this study. As discussed in Section 2.2.3, NAVMAC models Sailor workload and documents the minimum manpower requirements for each class of ship. Because NAVMAC does not make policy but, instead, follows it, the models and studies produced by NAVMAC include workload categories prescribed by the Department of Defense (DoD), the Department of the Navy (DoN), and U.S. Navy policy.

3.6.1 Communication and Correspondence

The first of two visits to NAVMAC was focused on understanding the entire Navy manpower and manning modeling process from the Required Operational Capabilities and Projected Operational Environment (ROC\POE) document to details and working papers of the final Ship Manpower Document (SMD). The meetings included a full review of NAVMAC methodologies for on site studies as well as the policies, directives, and other documentation that drive manpower requirements. We reviewed the output generated from Navy optimization models along with model inputs and calculations for crew workload dispersion.

The next step was to update the model, indicating which tasks were and were not included in the NAF/NSWW. We engaged in regular communication with NAVMAC staff as the model matured. To verify the model, we needed to categorize the tasks appropriately. First, we removed all ashore task requirements from the model because the focus of the study was Sailor workload at sea. We then separated the remaining tasks into the categories of operational manning (OM), OUS, PM, CM, facility maintenance (FM), service diversion, training, and personal time. We listed areas of concern not applicable to enlisted Sailor tasks separately, and we also notated shore-based requirements that creep into at-sea workload separately. The model used to prepare for the NAVMAC meeting, the Mark III, is included in Appendix G.

3.6.2 Feedback

We provided the Mark III to NAVMAC in preparation for the second visit. NAVMAC personnel methodically reviewed each task with us; we then further categorized and identified the tasks as inclusive or exclusive to the Navy model. Discussion ensued about what category each task belonged to and why. We then integrated findings from the second visit into the model. After concluding the visit, NAVMAC leadership, including all department heads, reviewed the updated model, the Mark IV, and provided feedback. The Mark IV, including details, is provided in Appendix H. We drew our conclusions from the interviews, surveys, and the final model.

CHAPTER 4:
Results

> Good leaders help prevent "gundecking" by ensuring that subordinates are qualified to do their jobs, have time to do their jobs, and do their jobs correctly.
>
> - Admiral Jonathan Greenert, Chief of Naval Operations
> *Proceedings*, September 2015

Chapter 3 provided a review of the methodologies used in the creation of the shipboard workload model, the Mark IV. Using this behavioral analysis approach, we created a shipboard workload model and accomplished an in depth look at the work completed by U.S. Navy Sailors. The model matured and changed, focusing on Sailor tasks completed at sea in order to have an equal comparison to what is included in Navy manpower models. The process provided insight into areas for further study.

The Shipboard Workload model went through several revisions in four phases. In Phase I, we created the Mark I prototype model at the Naval Postgraduate School. This model was meant to paint a broad brush of Guided Missile Destroyer (DDG) shipboard requirements, both in port and at sea, in an attempt to establish a baseline. We then filled out the model with tasks across the DDG.

In Phase II, we created the second edition of the model, the Mark II, advancing Mark I based upon interviews with numerous subject-matter experts (SMEs). This model took a deeper, more nuanced approach toward the administrative requirements, issues with personnel on and off board the ship, training cycle specifics, the various maintenance requirements, and additions to technology areas of concern.

Phase III consisted of a survey of Sailors' gauges of their workload in order to obtain fleet perceptions. This phase did not fundamentally change the model, instead deepening insights about Sailor tasks and concerns.

We then produced the Mark III model after a review of Navy Manpower Analysis Center (NAVMAC) documents and through relating the data to instructions. We removed data related to in-port requirements and added some requirements to the model in the interim, resulting in the Mark III model.

Phase IV produced the Mark IV, the final model. This phase required close coordination with NAVMAC personnel, including command leadership, in order to determine exactly which tasks within the Mark III are and are not included within Navy manpower models.

4.1 Limitations

An important caveat for Phases II and III is that they rely heavily on subjective data, therefore they were potentially biased by the "availability heuristic," i.e., a tendency to more readily recall recent and/or emotionally charged events. A likelihood of inaccuracies or incomplete information through Phases II and III exists. We attempted to determine the inaccuracies from Phase III during the analysis, but some may still be present. The goal of this phase was to report what Sailors stated, which may be the Sailor's perception, instead of the reality of the requirement. Meeting with a larger population of DDG and Guided Missile Cruiser (CG) Sailors would help resolve some potential inaccuracies.

Phase II and Phase III had natural limits based on the number of personnel interviewed and surveyed. The first of five ships examined were in port, either in the maintenance phase or conducting workups in preparation for the next deployment. The final ship was at sea, on deployment. The goal of ship diversity, a combination of DDGs and CGs, and varying phases of the ship's cycle was due not only to the limitations of the study as discussed in Section 3.1, but also in hopes of reducing the availability heuristic.

4.2 Phase I: The Shipboard Workload Model

Appendix B, Figure B.1, provides the study's Mark I model, the U.S. Navy Shipboard Workload Model. We developed the Mark I model in December 2016 based on discussions with Surface Warfare Officers at Naval Postgraduate School. The development of the Mark I model established a baseline of DDG task requirements. Appendix B, Figures B.2 and B.3 lend an up-close view of portions of the model.

We constructed the Mark I with the Navy Availability Factor (NAF)/Navy Standard Work Week (NSWW) in mind. The tasking sections included service diversion, divided into "extra workload," and "legal" deployment requirements; "personal," originally considered beyond the scope; "personnel," presenting basic Sailor manning concerns; "training," to include pre-deployment training, shipboard drills, Anti-Terrorism Force Protection (ATFP), and other forms of training. The model also included "engineering," both planned and unplanned, "technology," a known shipboard issue at sea, operational "watchstanding," and the sources of DDG tasking, both administrative and operational. The branches of the Mark I contained both at-sea and in-port requirements.

4.3 Phase II Data Collection: Subject-Matter Expert Interviews

To gain further insight into requirements, we interviewed DDG and CG SMEs. The SMEs provided more tasks required throughout the ship. Each ship SME had their own focus in the interviews depending upon their individual background and experiences. The goals of the interviews included identifying DDG tasks as well as those tasks taking a "disproportionate amount of time," defined as "more than average," and "causing organization frustration." We limited the interviews to one hour in order to minimize impact on the ship.

We provided interview questions (Appendix C) and the NAF/NSWW (Appendix E) to the SMEs. The NAF provided the baseline time allotment for the "average." Interviewees contributed areas of concern based on their own personal experiences in port and at sea. The interviews yielded the same or similar topics of concern, encompassing most areas of shipboard requirements.

The Mark II model reflected additional tasks identified by the interviewees (see Appendix F). Sample updated sections are provided in Figures F.2 and F.3.

4.3.1 Updating Mark I to Mark II

When creating the Mark II model, we removed some tasks from the Mark I model to create a more global ship-based perspective.

Changed or Removed

We changed or removed the following items.

1. We changed the model's mission focus from geographic to operational. The operational mission is driven by the ship's training cycle and falls into four phases.
   (a) Shipyard/Maintenance
   (b) Basic Phase
   (c) Intermediate Phase
   (d) Deployment/Sustainment Phase
2. We removed the emphasis on department-based technology and replaced it with ship-based technology.
3. We removed specific training cycle requirements and replaced them with generalized training team tasks.
4. We broke up task branches to specify in-port and at-sea requirements.

Added

We added the following items.

1. We added hours to NAF-specific task areas.
   (a) Service Diversion: 4 hours
   (b) Training: 7 hours
   (c) Watchstanding: 56 hours
   (d) Maintenance: 14 hours. (This was not technically correct as these hours also apply to own unit support (OUS). We corrected this discrepancy in the Mark III model.)
2. We added hours to NSWW-specific non-available (personal) time that are no longer included in the NAF.
   (a) Personal time: 14 hours
   (b) Messing: 14 hours
   (c) Sleep: 56 hours
   (d) Sunday free time: 3 hours
3. Computer-based Technology
   (a) We added technology concerns. These concerns primarily revolved around connectivity, access, and usability.
   (b) We added specific mandatory-use shipboard computer programs.
4. New and Old Technology

(a) We added the adverse effects of technologies.
    i. Duplicated reporting
    ii. At-sea usability
    iii. Decreased available hard drive space due to Consolidated Afloat Networks and Enterprise (CANES)
    iv. Manning changes that must be executed to accommodate new technologies
    v. New technology on-the-job training (OJT) requirements
    vi. New technology troubleshooting requirements
(b) Online tracking requirements
(c) Navy-provided iPads and Applications are not usable at sea
(d) Legacy Microsoft Software is not upgraded and no longer supported by Microsoft.
(e) Added "Special Access Program (SAP)"-labeled programs. Sailors are limited as to who can access the program information. The associated workload cannot be dispersed to more Sailors due to the nature of the program.

5. In-Port Watchstanding
   (a) ATFP: Base requirements
   (b) ATFP: Ship requirements
   (c) Tiger Teams
   (d) Fire Watches
   (e) Engineering
   (f) Combat Systems
6. At-Sea Watchstanding
   (a) Special Evolutions
   (b) Combat Systems
   (c) Operations (Combat Information Center)
   (d) Navigation / Bridge
   (e) Engineering
7. Maintenance
   (a) Planned
       i. Planned Maintenance System (PMS)
       ii. Corrosion Control

iii. Zone/Departmental Assessment preparation. (This task should have been placed under Administration. We corrected this discrepancy in the Mark III model.)
iv. Zone/Departmental Assessment. (This item was duplicated under Administration. The correct location would be Administration. We corrected this discrepancy in the Mark III model.)
v. Spot Checks
vi. Corrections for the Zone Inspection Discrepancy List (ZIDL) and Department in the Spotlight (DITS). (This item was placed in the incorrect location. It belongs with unplanned maintenance as it is corrective in nature. We corrected this discrepancy in the Mark III model.)

(b) Unplanned
i. Corrective Maintenance
ii. Casualty Control

(c) Administration
i. Force Revisions
ii. Cold and Hot Work chits
iii. Current Ship's Maintenance Project (CSMP) management
iv. TAGOUTs
v. Temporary Standing Orders (TSO)/Departure From Specification (DFS)
vi. Personnel Qualification Standard (PQS) training reports
vii. Hazardous Material (HAZMAT) Pickup and Return
viii. Zone Inspection
ix. Availability Planning
x. Maintenance and Material Management (3M) Spot Checks

8. Training
(a) Navy-wide training
i. Absorbed the General Military Training (GMT) requirement
ii. Chart the Course / Full Speed Ahead (Bystander Training)
iii. Sexual Assault Prevention and Response (SAPR)
iv. Emergent Navy training (e.g., Transgender, Blended Retirement, et cetera)
v. Personal Responsibility and Values: Education and Training (PREVENT)
vi. Alcohol and Drug Abuse Management Seminar (ADAMS)

vii. American Automobile Association–Driving for Life (AAA)

(b) Initial reporting requirements

i. Indoctrination (INDOC)

ii. Fire Fighting

iii. Damage Control

iv. Maintenance

v. ATFP

(c) Warfare Training

i. PQS

ii. Drills

iii. Knowledge exams are required for specific rated / watch qualified personnel.

iv. We added Ship Training Teams to include the Integrated Training Team (ITT) (absorbed the General Quarters (GQ) task), Damage Control Training Team (DCTT), Combat Systems Training Team (CSTT), Engineering Training Team (ETT), Medical Training Team (MTT), and Seamanship and Navigation Training Team (SNTT).

(d) Detail of ATFP training

i. Weapons

ii. Tactics

iii. Gun shoots

iv. Security Reaction Force - Basic (SRF-B)

(e) Petty Officer Leadership Course

(f) Chief Petty Officer (CPO) 365

9. Personnel

(a) Manning

i. Food Service Attendants (FSAs)

ii. Flight Deck Fire Fighting Team

iii. Search and Rescue (SAR) swimmer

(b) Off Ship

i. Detachment for cause

ii. Limited duty (LIMDU)

iii. Ready Relevant Learning

iv. Medical Evaluation Board (MEB). (This was marked as MEDBOARD on Mark II.)

10. Service Diversion
    (a) Admin/legal off ship
        i. Morale Events
        ii. Finances
        iii. Medical/Dental
        iv. Personnel Support Detachment (PSD)
        v. Leave
        vi. Emergency Leave
        vii. The following items were added but actually belong in personal. We corrected this discrepancy in the Mark III model.
            A. Navy-Marine Corps Relief Society (NMCRS)
            B. Fleet and Family Service Center
            C. Housing
            D. Family issues
            E. Personal Property
    (b) Admin/legal on board
        i. Waiting "Do-Nothing" Allocation
        ii. Email
        iii. Very Important Person (VIP) visits
        iv. Eight O'clock reports
        v. Required reading
        vi. Working party
        vii. Physical Fitness Assessment (PFA)
        viii. Fitness Enhancement Program (FEP)
        ix. Professional Development Boards
        x. Personnel inspections (We changed this from "inspection.")
        xi. Advocacy
        xii. Security clearance
        xiii. Awards

xiv. Congressional delegation (CODEL)/Staff delegation (STAFFDEL). (This item primarily applies to aircraft carriers (CVNs) and was removed in the Mark III model.)

xv. Preparation/Practice for Boards, etc. (This item actually belonged in personal. We corrected this discrepancy in the Mark III model.)

xvi. The following items were added but actually belong in maintenance. We corrected this discrepancy in the Mark III model.

A. Cleaning Stations

B. Compartment Cleaning

11. "Quality of Life" (Personal)

(a) Relaxing

(b) Letter writing

(c) Study for advancement

(d) Needs. Three hours for exercise were added due to the instructional requirement for commands to allow for three hours of exercise per week for every Sailor (Chief of Naval Operations (CNO), 2011).

4.3.2 Interviews: Concerns Expressed

Sailors expressed concerns within the interviews that were not added to the Mark II model. These are summarized below.

1. Personnel

(a) The "Personnel" pillar of the Defense Readiness Reporting System - Navy (DRRS-N), indicates green (a computed capability of 80–100%) as a function of the funded billets, billets authorized (BA), instead of the total requirements as provided in the Ship Manpower Document (SMD).

(b) A 106% fill with a 92% fit still results in increased Sailor workload for the division or department without the correct fit.

(c) Sailors are being pulled from their ships while in port for ratings that are hard to fill due to sea/shore rotational friction or Navy Enlisted Classifications (NECs) that are difficult to pass (e.g., Search and Rescue Swimmer). Pulling from the ships in port discourages ship leadership from sending personnel to special NEC schools, which works to the disadvantage of Sailors. The Sailor with the high-need NEC has an increased likelihood of being temporarily transferred, resulting in increased in-port workload for the remaining Sailors.

2. Training
   (a) ATFP
      i. ATFP training is, at minimum, three weeks for non-engineering Sailors who have prior ATFP qualifications. The basic qualification requirements for a Sentry are expected to take nine weeks (Naval Education and Training Command (NETC), 2014) for a Sailor without prior training. Increased ATFP requirements have created a greater in-port burden.
      ii. New Sailors arrive to the ship unqualified (or with lapsed qualifications) to stand an ATFP watch. New Sailors may also have had minimal weapons training prior to arrival.
      iii. In San Diego, the shooting ranges are booked long in advance with local ships vying for the four days of required range training. Both ranges offer low-light training, however, the outdoor range only provides this condition in the evening.
      iv. Some Sailors fail to qualify their first time at the range (some have had as many as three failures according to one leader) due to little firearms training prior to range qualification. Extra training is not possible due to range access wait times.
      v. Requirements include annual re-certification and semi-annual refresher training in addition to those qualifying the first time. The ship can expect approximately one-sixth of the crew to be qualifying at one time.
      vi. There is no standardization for tracking required ATFP training. Tracking the requirements becomes an in-port and end-of-deployment collateral duty for a designated chief.
   (b) The Navy's surface Sailors are not provided the basic "Sailor" tools prior to arrival in order to be a contributing member of the ship and workcenter. Unlike the Navy, the U.S. Marine Corps declares and requires every Marine to have the "Marine" basics: considered a "rifleman." The Sailor must be provided a training time line to qualify "basic" knowledge of requirements once on board the ship. These basic requirements include Damage Controlman (DC) and 3M.

As a result, the Sailor must be scheduled for further course work in order to become the functioning “Sailor” the ship needs.

(c) Sailors do not arrive fully trained, having attended neither an “A”- or “C”-School (i.e., they arrive missing needed schools). The ship will need to schedule a course in order to meet the needs of the ship if a school is required. As a result, a Sailor might miss significant portions of deployment as a result.

(d) A Sailor must be PQS qualified in order to be a “valid” member of the crew. OJT creates a larger burden on the experienced Sailors above and beyond the basic PQS requirements.

(e) Navy leadership has an expectation for ships to have “homegrown” NECs across departments. Homegrown NECs require four to six months of OJT.

(f) Bystander intervention training must be logged on-line for each individual along with deployment training requirements.

(g) A ship transfer requires a full PQS re-qualification, even when the Sailor is transferring from one DDG to another with the same technologies. (Of note, failure to conduct a proper re-qualification was noted as a concern in the *Comprehensive Review of Recent Surface Force Incidents*, U.S. Fleet Forces (USFF) (2017c)).

(h) The Petty Officer Leadership Course must be completed prior to being frocked or promoted to Petty Officer Third Class, Second Class, or First Class. The responsibility of providing the courses falls to the command due to the lack of externally provided courses.

(i) Master Chief Petty Officer of the Navy (MCPON) guidance requires CPO 365 training requirements for First Class Petty Officers. MCPON guidance is not an instruction, but a recommendation. Some in the fleet see this as a requirement but not officially mandatory. Phase I of CPO 365 training occurs from September through August with Phase II commencing once CPO selection results are released.

(j) The Navy’s Senior Enlisted Academy (SEA) is mandatory in order to promote to Master Chief Petty Officer. This requirement applies to FY 17 Senior Chief selectees who will have their first look for promotion in 2020. The course is eleven consecutive weeks long, consisting of seven weeks online (with 12 to 15 hours of academic work per week), a one week break, and three weeks in residence in Newport, RI. The three weeks in-residence requirement can not be completed during a Permanent Change of Station (PCS) due to conflicting funding entities (temporary additional duty (TAD) vs. PCS orders). The one exception is new Command Master Chiefs and Command Senior Chiefs who have not already attended the course. They can complete the last three weeks of training during PCS en route to their new command.

3. Maintenance
   (a) A large portion of the ship is engaged during zone inspections, with a minimum of three people per inspection team: one inspector (usually E-7 or above), a divisional escort (usually an E-6 who is also the discrepancy recorder), and a Sailor standing by who has ownership of the space. The Sailor standing by waits within the space until the inspection team gets there. Assuming 150 personnel involved in weekly zone inspections, the inspection adds up to a minimum of 150 man-hours per week.
   (b) Sailors must follow up on zone inspection discrepancies with the CSMP and a separate paperwork trail (ZIDLs). This results in a duplication of effort.
   (c) Smaller workcenters tend to have a disproportionate number of quarterly 3M spot checks to PMS requirements, further discussed in Section 4.7.3.
   (d) Maintenance availability planning begins as soon as the ship is underway for deployment (see Figure 4.1).

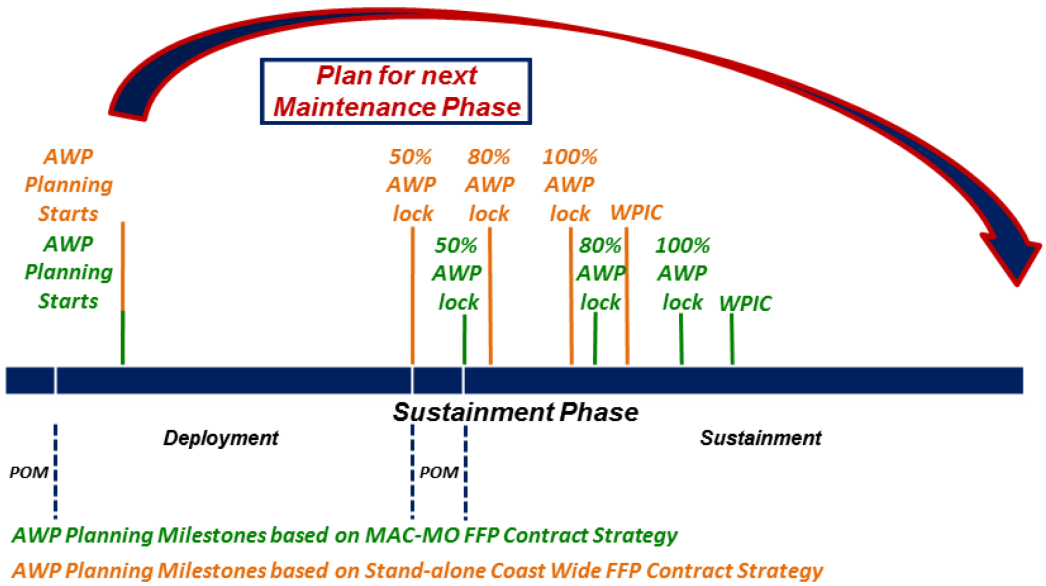

Figure 4.1. Maintenance Phase Planning. Source: COMNAVSURFPAC and COMNAVSURFLANT (2016).

Preparing for the availability includes weekly meetings as well as entry of all expected hours of availability work into the CSMP.

4. Technology
   (a) Accessibility
      i. There are not enough computer drops to maintain one station per person. Most senior personnel have an assigned computer, but most junior personnel have a 5:1 or 6:1 ratio of personnel to a single computer.
      ii. CANES has restricted the availability of computers to less than the previous numbers of "drops" for a given ship class. This has decreased computer accessibility.
   (b) Bandwidth
      i. Numerous programs become slow (or even unusable) with a low bandwidth. Various Navy leadership entities mandate their use, resulting in delays in processing time while using the computer. In some cases, low bandwidth causes applications to "time out" or reset, requiring rework.
      ii. A recommendation was made to create an "afloat" version to reduce problems of sites with bandwidth issues.
   (c) Usability

i. Relational Administration (RADM)
   A. All watchbills are required to be created, managed and maintained in RADM. All individual level PQS, training, qualifications, and certifications are required to be managed through RADM as well (Commander, Naval Surface Force, U.S. Pacific Fleet (COMNAVSURFPAC) & Commander, Naval Surface Force Atlantic (COMNAVSURFLANT), 2016).
   B. To build a watchbill in RADM, each individual Sailor must be entered one at a time. It can take up to five minutes for a single watch station entry due to poor usability and processing delays.
   C. Sailors do not receive official RADM training. Sailors either learn through OJT, self-training, or by reviewing .pdf documents.

ii. The software used to link parts information to the maintenance system, Organizational Maintenance Management System-Next Generation (OMMS-NG), is a slow process to use. One chief stated it takes eleven clicks to approve one single part. The junior Sailor must do even more than that to complete a single entry for review and approval.

iii. Maintenance documentation requires a Personal Identification Number (PIN) entry when documenting maintenance. Each time a Sailor conducts maintenance, the Sailor must then wait until a computer seat is available, log on, and then log the maintenance. The Work Center Supervisor must also log on and review the maintenance once a computer is available. This becomes an onerous and cumbersome process.

5. Duplicated Processes
   (a) Casualty Reports (CASREPs)
      i. Sailors must enter every CASREP into a Maintenance Figure of Merit (MFOM) Fleet CASREP Program.
      ii. Though the program creates the required Naval message, the message must then be routed through eight to nine people prior to release. Leadership expected the MFOM Fleet CASREP program to streamline the process by alleviating the routing requirement, but, in fact, it did not.
   (b) Operational Report (OPREP)-5

    i. The Immediate Superior in Command (ISIC) requires daily operational reports; it takes one enlisted Sailor approximately three hours each day to complete the report, resulting in a total of 21 hours per week.
    ii. Ship personnel may also receive a message or email requesting the same information received within the report.
  (c) Online vs. Paper Tracking
    i. The DDG must log all training online via either the shipboard RADM program or Fleet Training Management Planning System (FLTMPS).
    ii. Inspections require paper-based training jackets containing much of the same information even though the Sailors have been reported as qualified within the mandatory reporting system.

6. Own Unit Support (OUS)
  (a) Explosive Safety Warfare Programs (collateral duty)
    i. Each ship must have and keep a viable up-to-date Explosives Safety Management Program.
    ii. The responsible Sailor must continue to assess and manage the Ammunition Hazard (AMHAZ), Radiation Hazard (RADHAZ), and Afloat Magazine Safety programs.
  (b) Legal
    i. The legal officer is the person responsible for keeping the Commanding Officer (CO) and Executive Officer (XO) out of "hot water."
    ii. The enlisted support for the legal officer (only in regard to paperwork) is a Yeoman (YN) instead of a Legalman (LN).
    iii. There is no direct Judge Advocate General (JAG) support from the ISIC. Therefore, the ship must use Type Commander (TYCOM) support, unless actively attached to the Carrier Strike Group (CSG), in which case they may use the support of the JAGs on board the CVN.

7. In-Port Inspections
  (a) Checklists
    i. Inspection and certification checklists tend to change every 18 to 24 months, if not more often.
    ii. Checklist changes are not pushed out to the ship via official message.

iii. Ships do not directly receive checklists; instead the ship must pull the checklists instead of the checklists being pushed to the ship. Additionally, checklists found online may not be the most recent version.

(b) Confusion. Differences in entity assessments exist and cause confusion. Examples follow.

i. A ship with too few Sailors with a specific NEC requirement must get the TYCOM and ISIC on the same page as their certifying agent. The TYCOM and ISIC know about the NEC discrepancy, but the agency conducting the inspection does not, resulting in confusion.

ii. The Board of Inspection and Survey (INSURV) and Afloat Training Group (ATG) inspection criteria differ from each other. For example, INSURV inspects to the Maintenance Requirement Card (MRC) while ATG inspects to the Engineering Operational Sequencing System (EOSS).

(c) Often, certifications and assessments typically begin on a Monday. Sailors must come in for a full day of work on Sunday for final pre-inspections, cleanliness inspections, and set-up. Better scheduling and assessment time lines could potentially alleviate the additional workday for personnel off duty.

8. Fleet Nuances: Different fleets have different training requirements, reporting requirements, and reporting procedures. The document that must be reviewed (Fleet Operations Order (OPORD)) is greater than 1000 pages. The OPORD must be read and understood by multiple personnel prior to transit into a different fleet.

9. Whiplash

(a) Tasks or changes in requirements usually come from outside entities.

(b) DDG leadership must make a plan to complete the new requirement. The plan is then passed to the divisional leadership who must likely make their own plan. By the time the Sailors must complete the requirement(s), deadlines loom close creating the "whiplash" effect.

(c) Due to an inability to plan, this whiplash creates a culture of reactive Sailors instead of proactive Sailors.

10. Exercise Equipment

(a) The DDG class has limited gym space. Some DDGs have two gyms; however, as the previously lacking towed arrays are placed into their intended location, only one gym remains. Sailors must wait if they want to work out, either extending workout time, or diminishing their workout prior to standing watch

(b) Of note, according to Naval Sea Systems Command (NAVSEA) (2016), two facilities for a DDG are mandated based on the number of personnel for new ship construction and ship modifications

4.4 Phase III Data Collection: Sailor Surveys

Sailors from two DDGs volunteered to take the surveys (see Appendix D). Fifty-three Sailors volunteered, consisting of 14 officers, 22 senior enlisted, and 17 junior enlisted Sailors. The feeling of being "stuck on ship" or "always at work" is prevalent throughout survey responses. Therefore, there may be a tendency to keep working longer hours because the Sailors cannot go anywhere while at sea.

4.4.1 Workload (Question 1)

The workload questions determined what tasks require a "disproportionate amount of time," what tasks are shed as a result of excess workload, and what Sailors believe can be removed from the ship tasking requirements. The meaning of "disproportionate amount of time" was the same as with the leadership interviews, relying upon the standards of the NAF/NSWW.

1. Workload Requiring a "Disproportionate Amount of Time"
   - (a) Wait times / white space
     - i. Waiting in line
     - ii. Waiting for a computer
     - iii. Waiting to meet with the CO / chop messages and documents
     - iv. Waiting for HAZMAT
   - (b) Attempting to find the single person with access for a specific requirement (single point of failure)
   - (c) Maintenance preparations
   - (d) Facility maintenance
   - (e) Planned maintenance
   - (f) Duplicated inspection requirements

i. Example: Due to the requirement to demonstrate a fuel safety valve multiple times for inspections to include the TYCOM Material Inspection (TMI), the TYCOM Mid-Cycle Inspection (MCI), Engineering Readiness Assist Team (ERAT), and INSURV Readiness Assist Team (IRAT), the fuel safety valve now leaks. Sailors were not only required to demonstrate the same requirement four times for inspections, but there was a resulting corrective maintenance (CM) burden.

ii. An excess amount of time is used preparing and executing multiple inspections that review the same things such as those mentioned above as well as the Damage Control Material Assessment (DCMA) and the Light Off Assessment (LOA).

(g) Navy training requirements

i. Emergent Navy training (e.g., Transgender, Blended Retirement, et cetera)

ii. Bystander intervention training

iii. Safety training

iv. New technology training

v. Medical training

(h) Emergent tasking and requests for information (RFI) which are likely a compilation of data that is available through different sources

(i) "We are overtasked, undertrained, under cared for, and expected to complete everything proficiently."

(j) Sources (not all inclusive) of tasks discussed.

i. Secretary of the Navy (SECNAV)

ii. Office of the Chief of Naval Operations (OPNAV)

iii. Numbered fleet commanders

iv. USFF

v. TYCOM

vi. ISIC

vii. Navy Personnel Command (NPC)

4.4.2 Task Shedding (Question 2)

1. Personal tasks

(a) Religious ceremonies

   (b) Banking and finance
   (c) Cleanliness
   (d) Uniform standards
   (e) Coping mechanisms
      i. Exercise
      ii. Sleep
      iii. Medical needs
      iv. Eating nutritiously
      v. Personal development
2. Professional/Training tasks
   (a) “Anything that won’t result in [Non-Judicial Punishment]”
   (b) Mentoring (either giving or receiving)
   (c) Studying
   (d) Training
   (e) Painting and preservation of the ship
   (f) Cleaning
   (g) Routine tasks
   (h) Career Development Boards
   (i) Training reports (3M and PMS)
   (j) Muster
   (k) PMS
   (l) Warfare qualification
   (m) PQS
   (n) In-rate training
   (o) Required Reading (such as CO’s Standing Orders (COSO), Rules of the Road review, or for the Tomahawk–over 200 pages)
   (p) Reviewing (or pulling) updated instructions – Instructions are not typically pushed out to the ship as they change
   (q) Poor or incomplete Navy-wide training
3. Safety tasks
   (a) Following safety rules
   (b) Ensuring appropriate safety checks are completed
4. Shedding personal, professional, training, and safety tasks can potentially result in:

(a) An increase in LIMDU-status personnel
(b) Watchstanding errors
(c) PFA failures, and, therefore, a greater number of Sailors on FEP
(d) The outstanding Sailor who is working the hardest does not obtain the training he or she needs
(e) Poor Sailor evaluations
(f) Decreased levels of knowledge
(g) Individual or training team remediation
(h) Failure to meet Navy standards
(i) Injury or death

Removal of Tasks (Question 3)

We asked Sailors what tasks they thought could be removed from their requirements. They follow:

1. Mandatory physical training (PT), as many as three organizations require it at once to include division, FEP, and the First Class Association
2. Reduce Force Revisions to twice per year
3. Drills (surprisingly, four people made this comment)
4. Khaki call every day
5. Mustering multiple times a day
6. Computer-based training
7. Waiting for supervisory personnel to begin quarters
8. Summer safety training while deployed
9. Using SKED 3.2 for PMS tracking but still printing everything
10. Visual Information requirements: one slide easily takes three to six people to generate and about 36 hours to ensure it is a perfect submission

4.4.3 Technological Barriers to Work Accomplishment at Sea

There are multiple areas of concern in regard to technology. For computer technology, the potential barriers reviewed included the number of computers available, the ship's connectivity, and Navy web-based programs (see Table 4.1).

Table 4.1. Responses to Technological Barriers to Work Accomplishment at Sea.

Barrier	Believe this is a Barrier (%)
Number of computers available	79%
Computer connectivity	92%
Navy-designed websites	45%
Navy-designed programs	19%
Online tracking requirements	19%
Network drive space	55%
Unsupported software	26%
Other Concerns	26%

There were several highly notated barriers in regard to technology. The barriers seen by a greater percentage of Sailors included computer connectivity, number of computers available, network drive space, and Navy-designed websites.

1. Computer Availability: Forty-two participants (79%) believe the number of computers available is a barrier to work completion. The departments with the largest percentages were Engineering (31%) and Weapons (17%).
2. Computer Connectivity: Forty-nine participants (92%) indicated connectivity as a barrier for work completion.
3. Navy-designed Websites, Programs, and Online tracking requirements
    (a) Twenty-four personnel believe Navy-designed websites are a barrier:
        i. Sixteen (67%) of those personnel mention some attribute of My Navy Portal (http://my.navy.mil/).
            A. Logging into Navy e-Learning required “Hours upon hours of loading and crashing”
            B. The amount of logins required
            C. Navy e-Learning accessed through My Navy Portal takes as many as three Common Access Card (CAC) logins. Low connectivity speeds cause CAC time outs.
        ii. BUPERS Online (BOL)

iii. Career Waypoints (C-WAY)
iv. Career Management System - Interactive Detailing (CMS-ID)
v. Navy Enlisted Advancement System (NEAS)
vi. Fleet Management & Planning System (FLTMPS)
vii. Defense Travel System (DTS)
viii. Training and Operational Readiness Information Services (TORIS)
ix. OneTouch (for Supply)

(b) Ten (18%) of the participants indicated issues with programs and online tracking requirements. Specific programs noted include:
i. Haystack supply tracking site
ii. electronic Departure From Specification system (eDFS)

(c) Afloat programs appear to be highly regarded, and Sailors seem to believe that more local databases with daily uploads would help with website interactions. For example, as a result of being retooled for shipboard use, a Sailor noted that "the Marine Gas Turbine Information System/Web-based Logbook (WEBLOG) has improved 100% in regard to speed and use."

4. Unsupported Software, and Other Concerns

(a) "CANES does not support FEDLOG." FEDLOG Online allows the user to look up National Stock Numbers (NSNs) and access the available data.

(b) The following programs have slowed considerably.
i. HAZWIN (the HAZMAT tracking program)
ii. OMMS-NG
iii. RADM

4.4.4 Perception of Task Requirements

The time it takes to accomplish a task (and be accurate about it) requires diligence in tracking time for tasks from start to finish (task analysis). The survey asked Sailors how long specific service diversion, training, and personal tasks take and how often they are required to complete them. The responses are the perceptions of the participants. We asked them to provide data on the following:

- Inspections
- Boards (giving or receiving)
- Quarters and muster
- Mentorship (giving or receiving)

- Evaluations
- Awards
- Working party
- Cleaning stations
- Sweepers
- Training team drills (preparing, briefing, and debriefing)
- Watch stander required reading
- Study for advancement
- Warfare qualifications
- Job Qualification Requirements (JQR) and/or PQS training
- CPO 365
- Petty Officer Leadership Training
- Navy-wide training requirements
- Higher education (classroom education and studying)

From the responses, we assessed the perceptions of what takes the most time throughout their workdays. The perceptions were reviewed for junior enlisted Sailors (E-1 thorough E-6), senior enlisted Sailors (E-7 through E-9), and officers in order to (mostly) group among peers and similar duties.

Junior enlisted (E-1 through E-6) tasks focus on their individual requirements (see Figure 4.2).

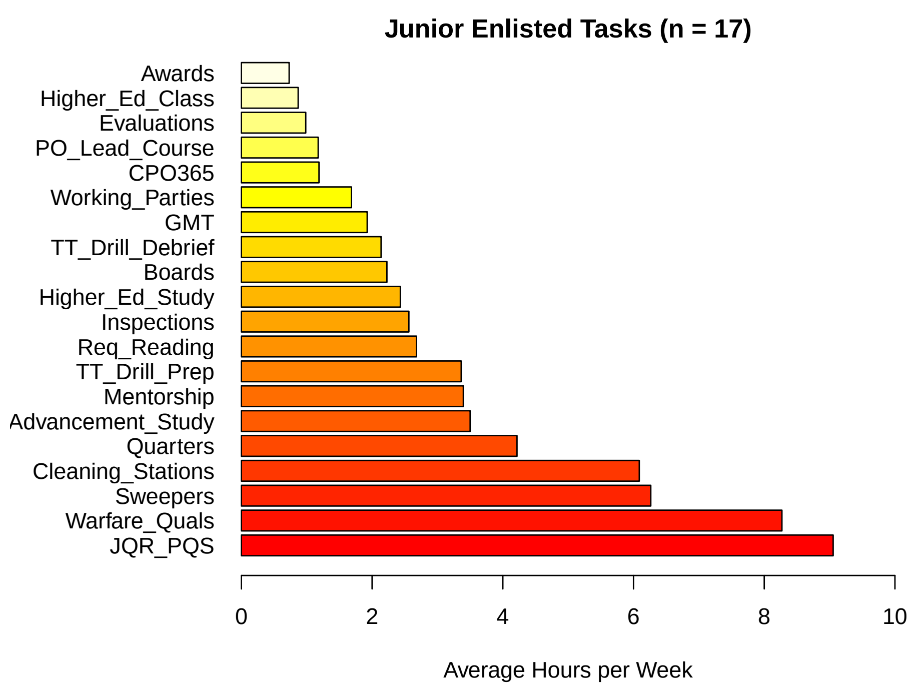

Figure 4.2. E-1 through E-6 Task Perception.

The junior enlisted task perceptions show the continued focus on training and keeping the ship clean. The top five tasks (hours per week) were:

1. JQR and/or PQS (9.0 hours)
2. Warfare qualifications (8.2 hours)
3. Cleaning stations (6.2 hours)
4. Sweepers (6.3 hours)
5. Quarters (4.2 hours)

Senior enlisted (E-7 through E-9) tasks range across the ship from taking care of others to ensuring personnel are trained appropriately (see Figure 4.3).

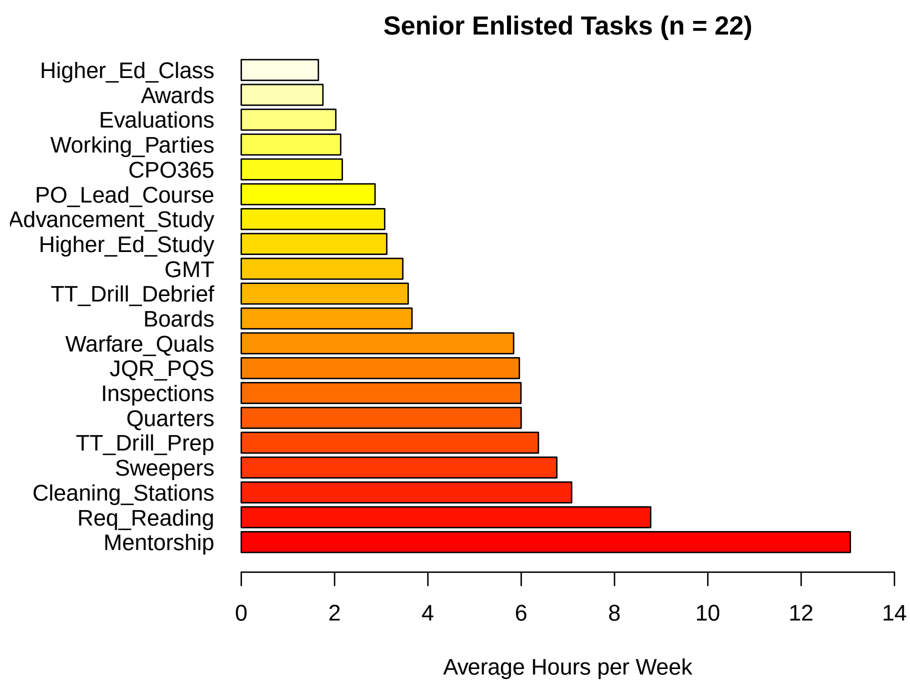

Figure 4.3. E-7 through E-8 Task Perception.

The senior enlisted task perceptions show the focus on mentoring both junior officers and junior enlisted as well as maintenance of knowledge. The top five tasks (hours per week) were:

1. Mentorship (13.1 hours)

2. Required reading (8.8 hours)
3. Cleaning stations (7.1 hours)
4. Sweepers (6.8 hours)
5. Training team drill preparations (6.4 hours)

Officer (O-1 through O-5) tasks focused primarily on their own training and then on leadership requirements (see Figure 4.4).

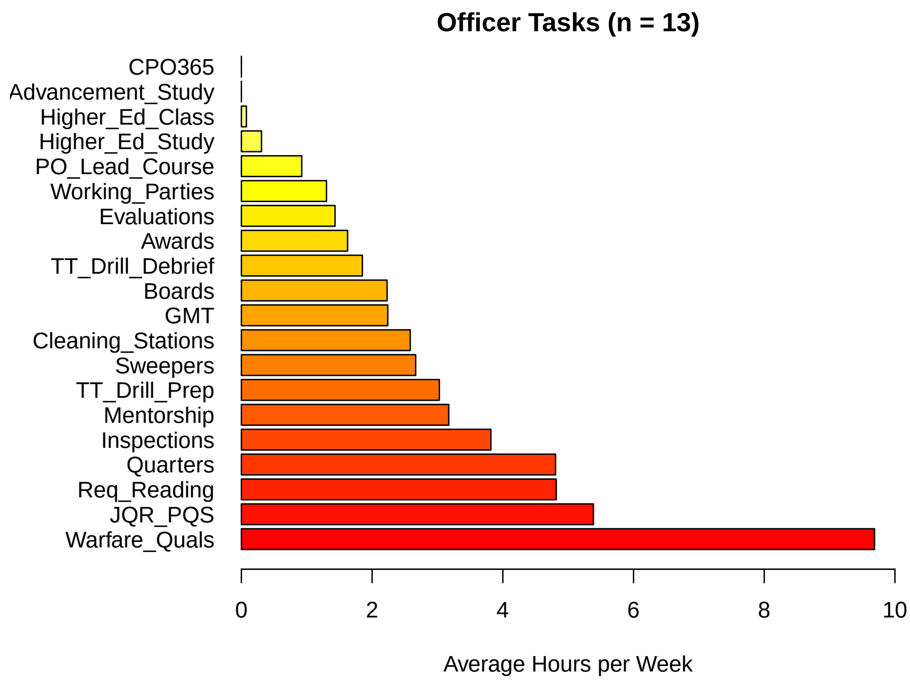

Figure 4.4. Officer Task Perception.

The focus on training is not surprising due to the top priority of junior officers to qualify. The top five tasks (hours per week) were:

1. Warfare qualifications (9.7 hours)
2. JQR and/or PQS (5.4 hours)
3. Required reading (4.8 hours)
4. Quarters (4.8 hours)
5. Inspections (3.8 hours)

4.4.5 Adequacy of Time

We asked five questions to assess the Sailor's perception of time availability, on the following topics:

1. Sailors have adequate personal time
2. Sailors have adequate time to exercise
3. Sailors have adequate time to study for advancement
4. Sailors get adequate sleep
5. In regard to maintenance, "good enough" is a typical Sailor attitude

The responses varied, but there were answers with high frequency rates.

Personal Time

For the question, "Do Sailors have adequate personal time?," we used a scale of one through five. The answer of greatest frequency was "2, Disagree" (see Table 4.2).

Table 4.2. "Sailors Have Adequate Personal Time" Frequency Table.

Personal Time		
1 Strongly Disagree	9	(16%)
2 Disagree	24	(45%)
3 Neutral	9	(16%)
4 Agree	8	(15%)
5 Strongly Agree	3	(5%)

Overall, this shows a general consensus that Sailors do not have adequate personal time. Some of the comments included:

1. If you want personal time, you have to give up one of the below (exercise, studying, sleep)
2. Less than 30 minutes per day
3. You have to sacrifice other needs
4. Not enough time

5. It is the Sailors choice (n = 2)
6. To workout means less sleep and less qualification time
7. Depends on watch schedule/drills/inspection
8. Rate dependent (n = 2)
9. It varies between department
10. Could be better if schedules/events were better planned throughout the day

Exercise

For the question, "Do Sailors have adequate time to exercise?," we used a scale of one through five. The answer of greatest frequency was "2, Disagree" (see Table 4.3).

Table 4.3. "Sailors Have Adequate Time to Exercise" Frequency Table.

Time to Exercise		
1 Strongly Disagree	4	(7%)
2 Disagree	17	(32%)
3 Neutral	16	(30%)
4 Agree	15	(28%)
5 Strongly Agree	1	(1%)

Overall, this shows a general consensus that Sailors do not have adequate time to exercise. Some of the comments included:

1. This is typically my personal time even though it is a requirement
2. They have to use their free time
3. You have to sacrifice other needs
4. Exercise or sleep
5. Depends on watch station
6. They fit it in when they can
7. PT is highly encouraged but reduces personal study time/qualification time
8. Sometimes but not always
9. Depends on the workcenter; Some have a lot, some have none

10. My department emphasizes it
11. Engineering and Deck have the least
12. Officers have less than enlisted
13. Lack of facilities and demanding watch schedules often prevent this.

Study for Advancement

For the question, “Do Sailors have adequate time to study for advancement?,” we used a scale of one through five. The answer of greatest frequency was “4, Agree” (see Table 4.4).

Table 4.4. “Sailors Have Adequate Time to Study for Advancement” Frequency Table.

Time to Study		
1 Strongly Disagree	2	(3%)
2 Disagree	13	(25%)
3 Neutral	11	(21%)
4 Agree	22	(42%)
5 Strongly Agree	4	(7%)

Overall, this shows a general consensus that Sailors do have enough time to study for advancement. Some of the comments included:

1. I don’t study; all my knowledge is from OJT
2. They have to use their free time
3. Usually done on watch (if permitted)
4. Too many distractions
5. Study or sleep
6. Always time
7. I build study time into my Sailors’ daily schedule
8. Watch standing on rate-related equipment aids this
9. Divisional training can be used
10. If working their rate, yes
11. Especially on deployment; they just need initiative

12. It is dependent on the Sailor to use their time wisely
13. Training is emphasized throughout the command

Sleep

For the question, "Do Sailors get adequate sleep?," we used a scale of one through five. The answer of greatest frequency was "2, Disagree" (see Table 4.5).

Table 4.5. "Sailors Get Adequate Sleep" Frequency Table.

Time to Sleep		
1 Strongly Disagree	16	(30%)
2 Disagree	18	(33%)
3 Neutral	10	(18%)
4 Agree	7	(13%)
5 Strongly Agree	2	(3%)

Overall, this shows a general consensus that Sailors do not get adequate sleep. Some of the comments included:

1. Four to five hours average; If I get six, I feel like I missed something
2. Depends on your rate
3. Too many distractions
4. Some do; I personally have not
5. Just depends on how Sailors utilize that time
6. Everyone is always tired
7. This is getting better but we still need changes to the POD [Plan of the Day]
8. Engineers definitely don't
9. Sailors in circadian rotations can work this
10. Depends on watch schedule and ship events
11. If no flight quarters or other special evolutions
12. Some rates more than others, but typically no
13. Even when time is given, noise, training, etc. impacts sleep

14. In OPS (OD and OI), sleep is hard to come by due to watch schedule
15. Sleep and personal time are often considered the same thing

Maintenance–Is "good enough" typical?

For the question, "In regards to maintenance, is 'good enough' a typical Sailor attitude?," we used a scale of one through five. The answer of greatest frequency was "4, Agree" (see Table 4.6).

Table 4.6. "In Regard to Maintenance, 'Good Enough' Is a Typical Sailor Attitude" Frequency Table.

Maintenance is typically "Good Enough"		
1 Strongly Disagree	0	(0%)
2 Disagree	14	(26%)
3 Neutral	12	(22%)
4 Agree	19	(35%)
5 Strongly Agree	8	(15%)

Overall, this shows a general consensus that Sailors, in regard to maintenance, have a "good enough" attitude. Of note, all enlisted personnel who provided a written response to this question (n = 9) noted that "yes, 'good enough' is typical." The primary reasons provided by the Sailors as to why it is typical are provided below.

1. If there is no time (n = 2)
2. Depends on how rushed it is
3. Maybe for some equipment but usually not
4. Sailors must complete all tasks; quality gets degraded with each task added
5. A lot of things are a "temporary fix" because of the supply system hassle
6. Manning driven
7. Only if you allow it
8. People need to care more about equipment

9. Unless motivated by leadership/peers, Sailors will sometimes do the minimum that's expected because either they can get away with it or they just don't have the time and energy

4.5 Mark III Model: Preparation for the Navy Manpower Analysis Center Review

Once interviews and surveys were complete, we updated the model and designed it specifically for discussion with NAVMAC. We removed all in-port tasks, highlighted each task block based on the best guess as to whether it was included or not in the planned workload for the Sailors, and divided the blocks into specific NAF/NSWW terminology in order to discuss tasks equivalent to planning practices. Due to further research necessary to place requirements in the appropriate section in preparation for the visit, we also made some additional changes (changes made at this point that were previously discussed in Section 4.3 are not included).

1. Changed or Removed
   (a) We removed all in-port tasks.
   (b) We separated training into Warfighter and Non-warfighter training.
      i. Warfighter training included drills conducted while deployed.
      ii. Non-warfighter training included all other training requirements.
      iii. We removed duplicate training tasks to include advancement studying and PQS qualification.
   (c) We separated maintenance into Preventive Maintenance, Corrective Maintenance, and Facility Maintenance.
      i. Preventive maintenance included assessments, spot checks, and Combat Systems "use" maintenance.
      ii. Corrective maintenance included TSO/DFS, troubleshooting, casualty control, and ZIDL / DITS corrections.
      iii. Facility maintenance included corrosion control, compartment cleaning, and cleaning stations.
   (d) OUS included low-visibility lookout, a consolidation of special evolutions, collateral duties, FSAs, CSMP management, PQS training reports, MRC force

revisions, availability planning, data recording for maintenance, medical / dental, flight deck fire fighting team, SAR swimmer, and working party.

   (e) Service diversion. We split up collateral duties between OUS for productive collateral duties and left nonproductive collateral duties in service diversion. As discussed in Section 2.2.3, productive collateral duties support the workcenter and/or command mission directly, and, though the command may benefit from the collateral duty, nonproductive does not support the workcenter or command mission directly (NAVMAC, 2000).

2. Added
   (a) Training
      i. We added training team training and experience to warfighter training.
      ii. We added higher education to non-warfighter training.
   (b) Maintenance
      i. We added spot Check preparation, Semi-annual and Annual PMS, and make ready and put away to preventive maintenance.
      ii. We added make ready and put away to corrective maintenance.
      iii. We added make ready and put away, polishing bright work, and hull, deck, and superstructure preservation to facility maintenance.
   (c) We added Culinary Specialists (CSs) to OUS.
   (d) We added haircuts, hangar bay integrity watch, business at the post office, ship's store, ship's services, and exercise requirements to service diversion.

Once we updated the model to the Mark III model, we added space for NAVMAC discussion points (see Appendix G). Figures G.2, G.3, and G.4 provide close-ups of the changes made to Figures F.2 and F.3.

4.6 Phase IV: Additional Input from the Navy Manpower Analysis Center

We provided the Mark III model to NAVMAC personnel for review in order to verify what is or is not included within Navy manpower models, methodically reviewing each task listed on the Mark III model with NAVMAC Code 40, Afloat. We crated the Mark IV model once the Mark III model was completely revised and appropriately color-coded upon completion of discussions with NAVMAC Code 40 and NAVMAC command leadership (see Appendix H). Figures H.2, H.3, H.4, H.5, H.6, and H.7 are included to provide detail of the final Mark IV shipboard workload model for DDG tasking.

The Mark IV provides color codes for what is included (green), what is partially included (yellow), or what is not included (red) within Navy manpower models. The question to justify inclusion within Navy manpower models follows. Would the task be executed if the ship was actively at war?

4.6.1 Mark IV: Service Diversion Allowance

NAVMAC does not measure service diversion in workload reviews. NAVMAC provided insight as to what would be included if they did measure service diversion workload (see Figure 4.5).

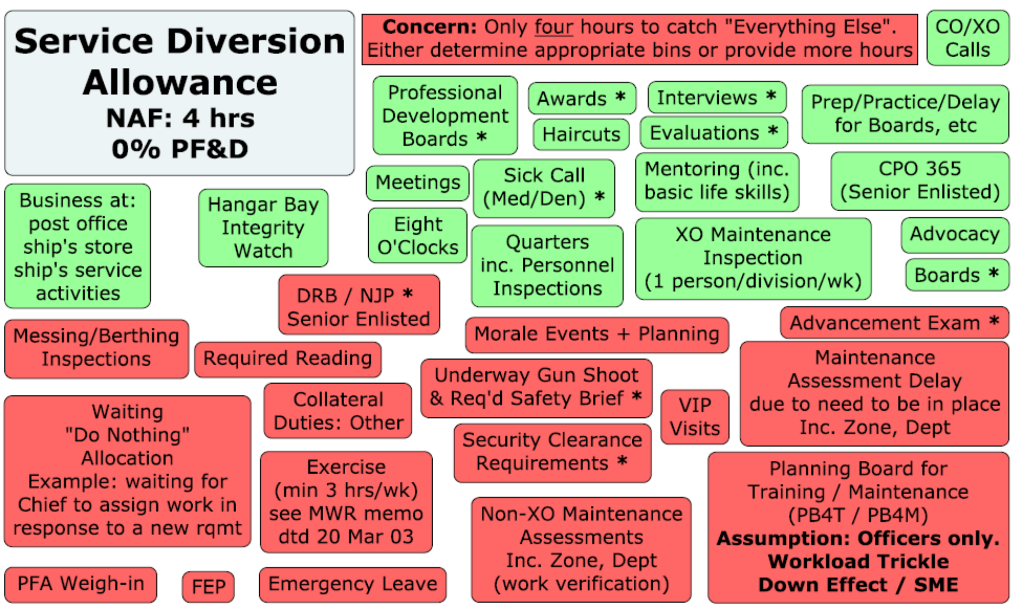

Figure 4.5. Mark IV: Service Diversion, February 2018.

Service diversion is applied as a singular value of four hours and is only measured when the NAF/NSWW is studied for accuracy. A personal needs, fatigue, and delay (PF&D) allowance is not applied to service diversion for this reason. The following administrative changes were made to the service diversion section of the Mark IV model.

Changed or Removed

We either changed or removed the following tasks from service diversion.

1. We moved personal property to personal.
2. We moved email to OUS.

Added

We added the following tasks to service diversion.

1. Disciplinary Review Board (DRB)
2. Messing and Berthing Inspections
3. We changed “PFA only” to “PFA weigh-in,” the portion that would be completed on deployment.
4. CPO 365 (Senior Enlisted)
5. Underway gun shoot and required safety briefing
6. XO Maintenance Inspection (one person per division per week)
7. Maintenance assessment delay due to Sailor in place
8. Non-XO maintenance assessments
9. Planning Board for Training (PB4T) and Planning Board for Maintenance (PB4M)

Inclusion in Manpower Models

If service diversion was workload measured by NAVMAC, the following tasks would be included in their task analysis.

1. CO and XO calls
2. Professional Development Boards (with senior enlisted for OUS)
3. Awards (with senior enlisted for OUS)
4. Interviews (with senior enlisted for OUS)
5. Boards (with senior enlisted for OUS)
6. Preparation, Practice, and Delay for Boards
7. CPO 365
8. Sailor advocacy
9. Meetings (in general)
10. Eight O’clock reports (Daily departmental updates)

11. Sick call, medical and dental (medical personnel for OUS)
12. Mentoring, including basic life skills
13. Business at the post office, ship's store, and ship's service activities
14. Hangar bay integrity watch
15. Quarters, including personnel inspections
16. ZIDL: XO maintenance inspection (one person per division per week)

The following service diversion tasks would not be included in a task analysis but must still be accomplished while at sea.

1. Waiting or "do nothing" allocation
2. Messing and berthing inspections
3. Required reading
4. DRB and Nonjudicial Punishment (NJP) (senior enlisted is provided OUS)
5. Morale events and planning requirements
6. Underway gun shoots and required safety briefs (range master and line coach are included under OUS)
7. VIP visits
8. Maintenance assessment delays (personnel in compartment waiting for the assessor)
9. Emergency leave
10. Security clearance requirements (YN, NEC 9190, Special Security Assistant, is provided under OUS)
11. Non-XO maintenance assessments, including zone and departmental (Master at Arms (MAA) is provided OUS for assessments)
12. PB4T (Only officers are listed in the Standard Organization and Regulations of the U.S. Navy (SORM) for attendance at PB4T (CNO, 2012))
13. PB4M (The "core maintenance team" must attend PB4M (USFF, 2017b, p. VI-41-23))
14. FEP
15. Collateral duties not listed within NAVMAC Afloat Programs Department Director (2009a)

4.6.2 Mark IV: Own Unit Support (OUS)

OUS depends on the type of work being accomplished. NAVMAC provided insight as to what model tasks would is included in OUS task analysis (see Figure 4.6).

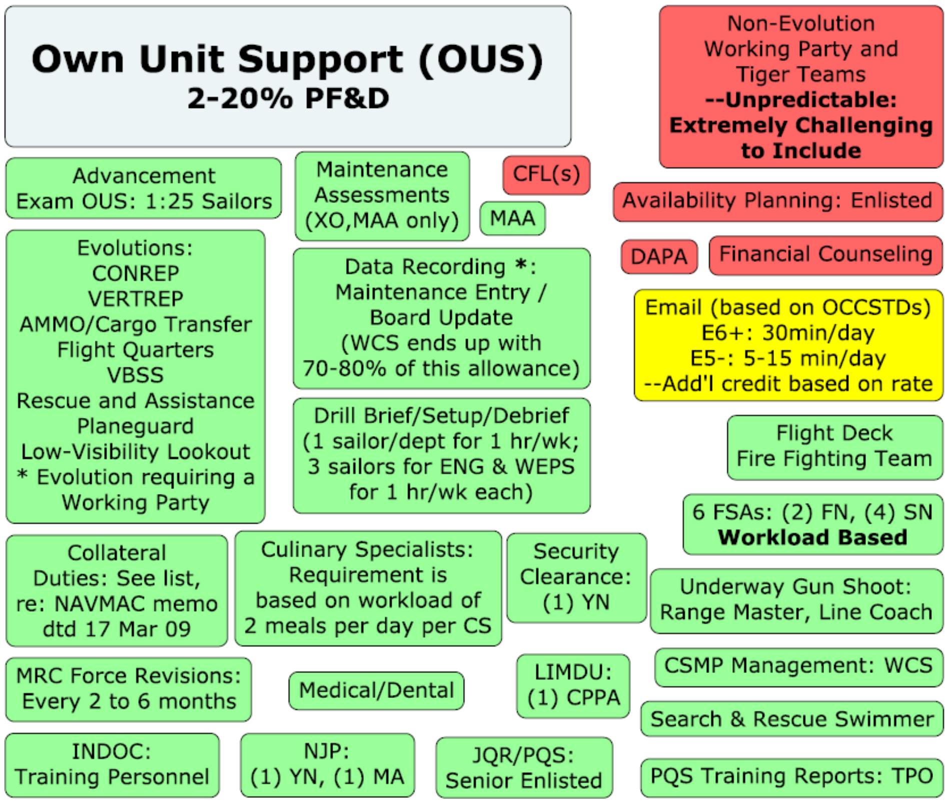

Figure 4.6. Mark IV: Own Unit Support, February 2018.

OUS is applied based on ship workload that is productive (i.e., directly supports of the ship's mission). A PF&D allowance is applied to OUS. The following administrative changes were made to the OUS section of the Mark IV model.

Changed or Removed

We either changed or removed the following tasks from OUS.

1. We split data recording for maintenance activities. The Work Center Supervisor (WCS) is credited for OUS and maintenance data entry is credited as part of Make Ready/Put Away (MRPA).
2. Special evolutions were combined into a single descriptive block.

Added

We added the following tasks to OUS.

1. Advancement exam proctoring. There is an allocation of one proctor to 25 exams with a minimum of two proctors.
2. Maintenance assessments (XO and MAA)
3. MAA
4. Underway gun shoot. There is an allocation for a range master and line coach.
5. Security Clearance support (YN, NEC 9190, Special Security Assistant)
6. LIMDU support (Command Pay/Personnel Administrator (CPPA))
7. Drill brief, setup, and debrief (one Sailor per department for one hour per week; Engineering and Weapons departments are allotted three Sailors each for one hour per week)
8. Email, based on Occupational Standards (OCCSTDs) (30 minutes per day for E-6 and above; 15 minutes per day for E-5 and below). Some rates are allotted more time per day
9. Command fitness leaders (CFLs)
10. Drug and Alcohol Program Advisor (DAPA)
11. Command Financial Specialist
12. Non-evolution working parties and tiger teams
13. NJP support (one YN and MAA)
14. INDOC (training personnel)
15. CS requirement (workload based–each CS is expected to work only two meals per day)
16. JQR/PQS senior enlisted support
17. FSAs (Workload based. Six for DDG – two Fireman (FN) and four Seaman (SN); proportion of FN and SN to the ratings on board)

Inclusion in Manpower Models

Workload measured by NAVMAC for OUS includes the following tasks.

1. Advancement exam proctoring. There is an allocation of one proctor to 25 exams with a minimum of two proctors.
2. Maintenance assessments (XO and MAA)
3. MAA
4. Underway gun shoot for a range master and line coach
5. Security Clearance support (YN, NEC 9190, Special Security Assistant)
6. NJP support (one YN and MAA)
7. LIMDU support (CPPA)
8. Drill Brief, setup, and debrief (one Sailor per department for one hour per week; Engineering and Weapons departments are allotted three Sailors each for one hour per week)
9. Evolutions requiring a working party (connected replenishment (CONREP), vertical replenishment (VERTREP), AMMO/Cargo Transfer, Flight Quarters, visit, board, search and seizure (VBSS), Rescue and Assistance Planeguard, Low-visibility Lookout).
10. Email (this is only partially captured in Navy manpower models: 30 minutes/day for E-6 and above; 5-15 minutes/day for E-5 and below)
11. Collateral duties as notated in NAVMAC Afloat Programs Department Director (2009a):
    (a) Communications Security Material Custodian
    (b) Ship's 3M System Coordinator (3MC)
    (c) Naval Warfare Publications Custodian (Part of Operations Specialist (OS) rating; used when appropriate for other rates)
    (d) Supply/Repair Parts Petty Officer (RPPO)
    (e) Departmental Yeoman
    (f) Division Mail Petty Officer
    (g) Division training petty officer (TPO) (preparation only)
    (h) Damage Control Petty Officer (maintenance data by workcenter)
    (i) Surface Rescue Swimmer (directed requirement for NEC)
    (j) Workcenter Supervisor (maintenance related)

12. MRC Force Revisions
13. INDOC training personnel
14. CS requirement
15. JQR/PQS senior enlisted support
16. PQS training reports (TPO)
17. Search and Rescue Swimmer
18. CSMP Management (WCS)
19. FSAs
20. Flight Deck Fire Fighting team
21. Data recording for maintenance (WCS)

The following OUS tasks are not included in NAVMAC task analysis but must be accomplished at sea.

1. CFLs
2. DAPA
3. Command Financial Specialist
4. Availability planning
5. Non-evolution working parties and tiger teams (note that this requirement is unpredictable and challenging to include)

4.6.3 Mark IV: Maintenance

Maintenance tasks are completed by the entire ship, whether facility maintenance (FM), planned maintenance (PM), or CM. NAVMAC provided insight as to what model tasks would be included in maintenance task analysis (see Figure 4.7).

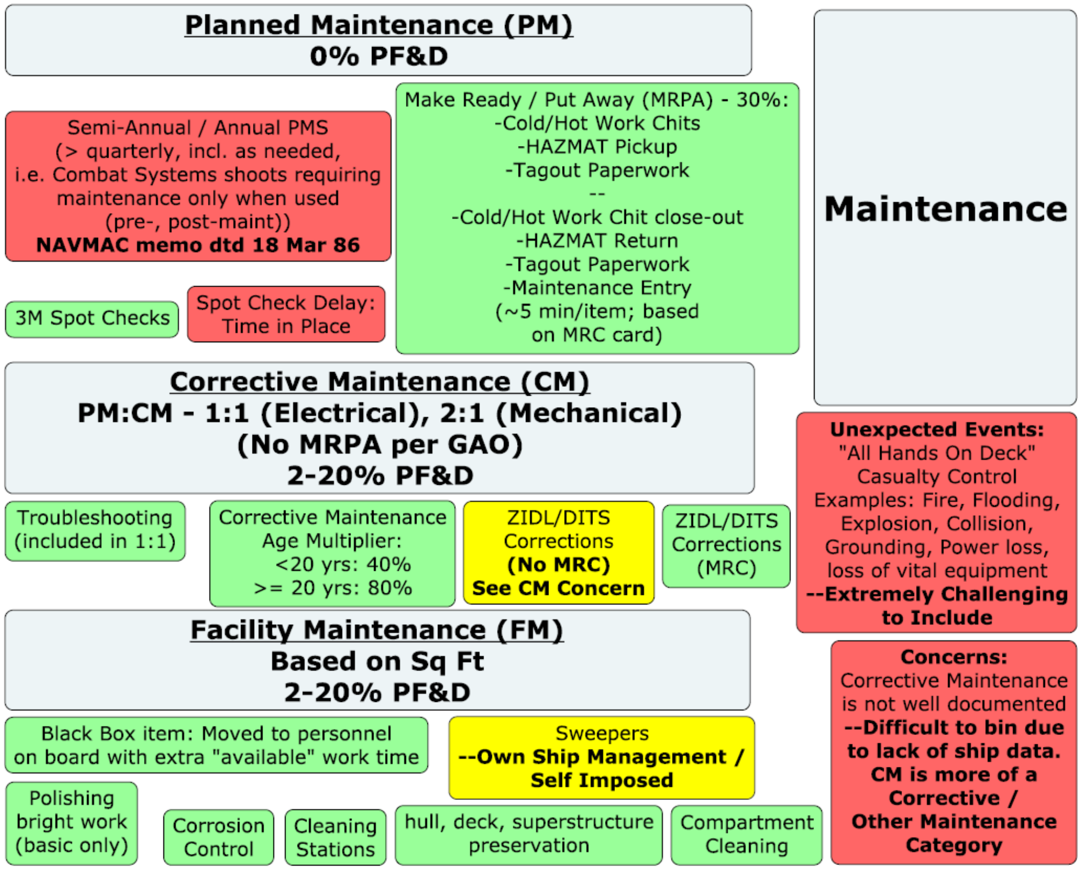

Figure 4.7. Mark IV: Maintenance, February 2018.

Most maintenance tasks are included in the projected plan for work hours, but not all of them. In some cases, NAVMAC makes a judgment call as to how much time might be spent on an activity due to a lack of data. A PF&D allowance is applied to CM and FM. A MRPA allowance is applied to PM. Thus, we made the following administrative changes to the maintenance section of the Mark IV model.

Changed or Removed

We either changed or removed the following tasks from maintenance.

1. We removed Spot Check preparation. NAVMAC noted that preparation should not be necessary for a spot check, a historical review to assure the maintenance was completed.

2. We removed assessment (e.g., ZIDL, etc.) preparation. Preparation should not be necessary for assessments.
3. We moved assessments to service diversion.
4. A Combat System shoot was noted as requiring maintenance only when the system was used. We absorbed this requirement into Semi-Annual and Annual PMS.
5. Casualty control was changed to "Unexpected events." We added more unanticipated events to the list.
6. We removed MRPA tasks from both Facility Maintenance and Corrective Maintenance and only applied them to Planned Maintenance tasks.

Added

We added the following tasks to maintenance.

1. Spot Check Delay. A Sailor waits in place for the assessor(s) to arrive.
2. Corrective maintenance age multiplier, less than 20 years is a 1.4 ratio (40%), and greater than or equal to 20 years is a 1.8 ratio (80%)

Inclusion in Manpower Models

Workload measured by NAVMAC for maintenance includes the following tasks.

1. Planned Maintenance
   (a) 3M Spot Checks
   (b) MRPA
2. Corrective Maintenance
   (a) Troubleshooting (Electrical is 1:1 PM to CM; Mechanical is 2:1 PM to CM)
   (b) Corrective maintenance age multiplier
   (c) ZIDL/DITS Corrections (MRC only)
   (d) ZIDL/DITS Corrections (Non-MRC)–partial inclusion. NAVMAC believes these are captured due to the lack of Corrective Maintenance data.
3. Facility Maintenance
   (a) Basic polishing of bright work
   (b) Corrosion control
   (c) Cleaning stations

(d) Hull, deck, superstructure preservation

(e) Compartment cleaning

(f) Sweepers–partially captured. NAVMAC believes time for sweepers is partially captured in existing sweeper activities.

The following are not included in NAVMAC task analyses of Maintenance but must still be accomplished while at sea.

1. ZIDL/DITS Corrections (Non-MRC). Corrective Maintenance is based on a ratio from PM, i.e., MRC-related maintenance only.
2. Sweepers. Cleaning time exceeding that provided by the square footage of cleaning surface would be a self-imposed burden.
3. Unexpected events and casualties
4. Corrective maintenance cannot be determined unless Sailors accurately record and update system data for hours spent on CM.

4.6.4 Mark IV: Training

NAVMAC does not measure training tasks during workload reviews. NAVMAC provided insight as to what would be included in training workload if they measured it (see Figure 4.8).

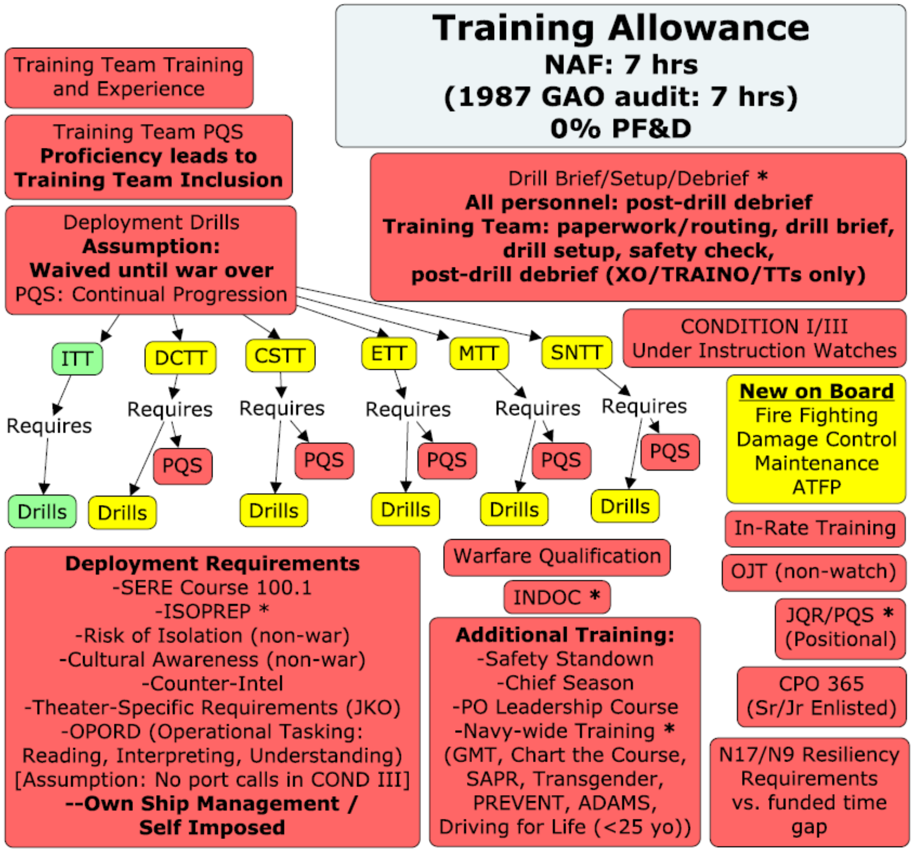

Figure 4.8. Mark IV: Training, February 2018.

Training is applied as a singular value of four hours and is only measured when the NAF/NSWW is studied for accuracy. A PF&D allowance is not applied to training for this reason. Thus, we made the following administrative changes to the training section of the Mark IV Model.

Changed or Removed

We either changed or removed the following tasks from training.

1. We split INDOC between OUS and training. OUS is provided for trainers. Attendees would be receiving training.
2. We moved higher education to personal time.
3. We moved advancement training to personal time.

Added

We added the following tasks to training.

1. Deployment training requirements were moved to training.
2. Warfare qualification
3. N17/N9 Resiliency requirements
4. Training team PQS
5. Drills for readiness sustainment
6. Drill brief, setup (including safety checks), and debrief
7. Condition I and III readiness level Under Instruction watches

Inclusion in Manpower Models

If training was workload measured by NAVMAC, the following tasks would be included in their task analysis.

1. General Quarters (ITT)
2. Related training team drills accomplished during a ship-wide drill

The following training tasks would not be included in a task analysis, but must still be accomplished while at sea.

1. Deployment training requirements. These are expected to be completed in port prior to departing for deployment.
2. Warfare qualification
3. N17 and N9 Resiliency requirements
4. Training team PQS
5. Other than ship-wide drills, including Condition III drills (assumed by NAVMAC to be waived during a war)
6. Drill brief, setup (including safety checks), and debrief
7. Condition I and III readiness level Under Instruction watches
8. Navy training requirements to include: Safety briefs and stand-downs (two briefs per month and one stand-down per year are mandated (CNO, 2007)), CPO 365 Phases I and II, Petty Officer leadership course, GMT, Chart the Course / Bystander

intervention, SAPR, emergent Navy training (e.g., Transgender, Blended Retirement, et cetera), PREVENT, ADAMS, and AAA

9. INDOC
10. JQR and/or PQS training that cannot be completed while on watch
11. On-the-job training (non-watch)
12. New Sailor training requirements: Fire fighting, Damage Control, 3M, and ATFP
13. PQS for drill positions

With the final Mark IV model, a red, yellow, and green color coding was used to identify the inclusion or exclusion of tasks. The large amount of red, though not all warfare tasks, provides a visual of the amount of risk placed on over-tasked Sailors.

4.7 Additional Findings

We investigated a few SME concerns in depth to see what might be causing the described "excessive" workload. This includes the effect on Sailor working hours when not all personnel are on board the ship, the FSA disparity between NAVMAC's workload analysis and the actual number of FSAs assigned by COs, 3M spot check concerns, and NAVMAC's assumption about semi-annual and annual maintenance requirements.

4.7.1 Manning Effects on Sailor Working Hours

Navy manpower models use the NAF/NSWW to determine the minimal number of personnel needed to accomplish a ship's workload (see Table 4.7).

Table 4.7. Navy Availability Factor / Navy Standard Work Week Summary. Adapted from DCNO (MPT&E) (2016).

Navy Availability Factor		
Standard Workweek (On-Duty Hours)		**81 hours (12 hrs Mon-Sat and 9 hrs Sun)**
	Productive Workweek	70 hours
	Training	7 hours
	Service Diversion	4 hours
Non-Available Time (Off-Duty Hours)		**87 hours**

We used the NAF/NSWW hours to illustrate the impact on working hours when Sailors are not on board to help meet task requirements. The following current on board (COB) manning configurations were used: 95%, 90%, 86%, and 81% of BA (see Table 4.8).

Table 4.8. Manning Effects on U.S. Navy Destroyer Sailor Working Hours.

DDG 1	
Enlisted BA	280
Enlisted COB (96% of BA)	270
Muster (95% of BA)	267
Difference	13
Total Hours Overload (Difference * 70 Hours)	910 Hrs
Additional "productive" hours per enlisted Sailor per week	3.4 Hrs
Total working hours per enlisted Sailor per day	12.1 Hrs **(+ 0.5 Hrs)**

DDG 2	
Enlisted BA	280
Enlisted COB (91% of BA)	255
Muster (90% of BA)	252
Difference	28
Total Hours Overload (Difference * 70 Hours)	1,960 Hrs
Additional "productive" hours per enlisted Sailor per week	7.8 Hrs
Total working hours per enlisted Sailor per day	12.7 Hrs **(+ 1.1 Hrs)**

DDG 3	
Enlisted BA	280
Enlisted COB (88% of BA)	245
Muster (86% of BA)	242
Difference	38
Total Hours Overload (Difference * 70 Hours)	2,660 Hrs
Additional "productive" hours per enlisted Sailor per week	11.0 Hrs
Total working hours per enlisted Sailor per day	13.1 Hrs **(+ 1.5 Hrs)**

DDG 4	
Enlisted BA	280
Enlisted COB (82% of BA)	230
Muster (81% of BA)	227
Difference	53
Total Hours Overload (Difference * 70 Hours)	3,710 Hrs
Additional "productive" hours per enlisted Sailor per week	16.3 Hrs
Total working hours per enlisted Sailor per day	13.9 Hrs **(+ 2.3 Hrs)**

To simplify calculations, we used an average of 81 hours of work, equal to 11.6 hours per day, seven days per week for the calculations, assuming all billets to be funded. Therefore, the difference between manpower requirements as determined by NAVMAC and billets authorized are not included in these calculations.

USFF Command enforces surface ship manning levels according to “fit” and “fill.” Fit is the personnel’s ability to meet the skill set and pay band for the billets authorized. When a ship has a lack of fit, it is due to the inability of a Navy community to provide enough Sailors with the required NEC and pay band. Fill is the aggregate manning of the ship without accounting for skill and pay band requirements. The target levels for the DDG-51 are 90% Fit and 90% Fill until about 15 months prior to deployment when the unit must assure 92% Fit and 95% Fill prior to the start of the Basic Phase (USFF, 2015). The fill goal is minimally 95% to assure most Sailors who will deploy receive the appropriate training prior to the ship’s deployment. From the calculations, the effects of 92% fill on the Sailors remaining on board can be seen, as well as the divisional corollary for fit, if not all required ratings and trained personnel are on board.

4.7.2 Disparity in Food Service Attendants (FSAs)

Leadership noted that they primarily refer to the Naval Supply Systems Command (NAVSUP) Food Service Management Manual or the source document, the SORM, for the required number of FSAs. The goal being the improvement of Sailor quality of life. The SORM (CNO, 2012) states,

> All departments ... shall transfer personnel to the Supply Department for temporary duty as food service attendants ... *Absent an approved SMD/FMD*, it is recommended that FSAs be provided at a ratio of 1 to 25 from ship’s enlisted company ... the number of CPO mess attendants furnished will be on a 1 to 15 ratio, and that the number of wardroom rotational pool members assigned will equal 12 percent of its officer population. (pp. 6-23–6-24, emphasis added)

If the DDGs are using these numbers to supply FSAs, then it is in excess of those provided via the approved SMD (See Table 4.9).

Table 4.9. Food Service Attendant Requirements NAVSUP vs. NAVMAC. Crew Totals Adapted from U.S. Navy Chief of Information (2018).

<table>
<tr><th>Mess</th><th>Total</th><th>NAVSUP
Required FSAs</th><th>NAVMAC
Required FSAs</th></tr>
<tr><td>Officer</td><td>32</td><td>3 (12%)</td><td rowspan="3">(2) FN
(4) SN</td></tr>
<tr><td>CPO</td><td>27</td><td>2 (1:15)</td></tr>
<tr><td>Junior Enlisted</td><td>270</td><td>8 (Remaining)</td></tr>
<tr><td>Total</td><td>270 Enlisted</td><td>13 (1:25)</td><td>6</td></tr>
</table>

There is a disparity of *seven* FSAs between NAVSUP recommendations and workload measured by NAVMAC. NAVMAC's FSA requirement of six listed in the SMD is expected to cover the FSA workload for all DDG messes.

4.7.3 Maintenance and Material Management (3M) Spot Checks

Leadership expressed concern about 3M spot checks, stating that smaller workcenters tend to have a disproportionate number of quarterly 3M spot checks to PMS requirements. A spot check is "the tool that supervisory personnel utilize to determine the accomplishment status of an MRC [Maintenance Requirement Card] that has been previously reported as accomplished" (NAVSEA, 2015, p. 2-40). This means that, each time a spot check is completed, it is in addition to normal planned maintenance.

There are differing requirements for spot checks depending on the entity's instruction. As an echelon creates its own instruction, the requirements can either be the same or more restrictive than the parent instruction. NAVSEA (2015) indicates that "each Work Center shall receive an audit once per quarter by a supervisory individual, (E-7 or above)" (p. 2-40). Alternatively, USFF (2017a) takes the requirement one step further, identifying a minimal percentage of 2% of "recent" randomly selected MRCs (p. VI-19A-10). The TYCOM, provides the minimum, most restrictive, requirement for the surface ship. COMNAVSURFPAC & COMNAVSURFLANT (2013) discuss the submission of quarterly spot checks to the ISIC. The instruction does not mention a minimal percentage. Instead, a table is provided with required periodicity checks for each management level. The established minimum periodicity for each level is weekly (see Table 4.10).

Table 4.10. Mandatory Leadership 3M Spot Checks and Periodicities. Adapted from COMNAVSURFPAC and COMNAVSURFLANT (2013).

Management Level	**Number of PMS Rqmts Spot Checked**	**Interval**
CO	One	Weekly
XO	One	Weekly
3MC	Two (One will be ER09)	Weekly
Command Master Chief (CMC)	One	Weekly
Department Head (DH)	One	Weekly
Division Officer (DIVO)	One	Weekly
Leading Chief Petty Officer (LCPO)	One	Weekly
Leading Petty Officer (LPO)	One	Weekly

When a division has only 12 quarterly maintenance requirements, the number of spot checks becomes pretty large in comparison. The quarterly (every 13 weeks) spot checks required, accounting for only the DIVO, LCPO, and LPO, would be 39. In total, there would be 51 overall maintenance requirements (PMS and spot checks). This is 4.2 times the actual required quarterly maintenance.

A sample of the PMS checks compared to the required spot checks for a DDG's departments and corresponding divisions shows the disparity for smaller divisions (see Table 4.11).

Table 4.11. Representative Sample of DDG Quarterly Planned Maintenance System Checks to Spot Checks. Adapted from Sample DDG 3MC (2018).

Department (Division)	Quarterly PMS Checks	Quarterly Spot Checks	Ratio
COMBAT SYSTEMS (CA)	300	26	8.6%
COMBAT SYSTEMS (CC)	2976	52	1.7%
COMBAT SYSTEMS (CE)	1585.25	130	8.2%
COMBAT SYSTEMS (CF)	977.75	78	7.9%
COMBAT SYSTEMS (CG)	2281.5	104	4.5%
COMBAT SYSTEMS (CM)	514	52	10.1%
ENGINEERING (EA)	1399.75	52	3.7%
ENGINEERING (EE)	670	52	7.7%
ENGINEERING (EM)	1839.75	130	7.0%
ENGINEERING (ER)	5145.5	104	2.0%
HEALTH SERVICES (HM)	51	26	50.9%
NAVIGATION (N)	58	26	44.8%
EXEC (NN)	11.5	26	226.0%
OPERATIONS (OD)	2881	26	0.9%
OPERATIONS (OI)	119	26	21.8%
OPERATIONS (OT)	468	52	11.1%
SUPPLY (S-1)	23.5	52	221.2%
SUPPLY (S-2)	843	26	3.0%
SUPPLY (S-3)	212	26	12.2%

These numbers are derived from twelve months of data and averaged across the quarters. The calculated ratio is:

$$\frac{Quarterly\ Spot\ Checks}{Quarterly\ PMS\ Checks}$$

Anything over 20% of quarterly maintenance checks being verified with spot checks are highlighted. The Fleet Forces instruction requires spot checks for at least 2% of ship's maintenance requirements. The expectation of the TYCOM meets (and exceeds) that requirement. The data show an overall 21.0% quarterly spot check rate across the ship with five divisions having a range of 21.8% to an astounding 226.0% quarterly spot check to quarterly PMS check ratio. The disparities described by DDG leadership can easily be seen through these calculations.

4.7.4 Annual and Semi-Annual Planned Maintenance System (PMS)

As discussed in Section 2.2.3, NAVMAC does not include annual and semi-annual PMS within the calculations for ship manpower requirements due to the assumption that most semi-annual and annual maintenance can be deferred until the ship is in-port or post Condition III operations (i.e., a reduced threat environment).

COMNAVSURFPAC N43 provided the annual and semi-annual PMS data for 24 months for all DDGs in service. After we reviewed the data, we removed any ships with less than 18 months of data due to a lack of records, 15 ships. We labeled the hours recorded as either "at sea," "in port," or "none" within the official maintenance records. Ideally, all maintenance recorded would have indicated either "at sea" or "in port," but when SKED is not transitioned from "none" to a different condition, recorded maintenance will be notated as "none."

We averaged the hours of semi-annual and annual maintenance hours per week by department for DDG 51 Flights I, II, and IIA. We also calculated the number of personnel required to complete at-sea annual and semi-annual PMS using the NAF/NSWW available working hours of 70 hours per week (see Tables 4.12, 4.13, and 4.14).

Table 4.12. DDG 51 Flight I 3M Annual and Semi-annual Requirements.

Flight I (DDG 51–71)	Hours per Week	30% of Total	Additional Sailors Required
Combat Systems	815.01	244.50	3.49
Engineering	1568.93	470.67	6.72
Nav/Exec/Med	95.60	28.68	0.41
Ops/Planning and Tactics	405.65	121.69	1.73
Supply	326.99	98.09	1.40
Weapons	479.54	143.86	2.05
Total			**15.8**

Table 4.13. DDG 51 Flight II 3M Annual and Semi-annual Requirements.

Flight II (DDG 72–78)	Hours per Week	30% of Total	Additional Sailors Required
Combat Systems	636.65	190.99	2.72
Engineering	915.04	274.51	3.92
Nav/Exec/Med	63.43	19.03	0.27
Ops/Planning and Tactics	362.07	108.62	1.55
Supply	247.91	74.37	1.06
Weapons	140.50	42.15	0.60
Total			**10.1**

Table 4.14. DDG 51 Flight IIA 3M Annual and Semi-annual Requirements.

Flight IIA (DDG 79 +)	Hours per Week	30% of Total	Additional Sailors Required
Combat Systems	895.68	268.70	3.83
Engineering	1842.61	552.78	7.89
Nav/Exec/Med	48.73	14.61	0.21
Ops/Planning and Tactics	857.46	257.24	3.67
Supply	309.28	92.78	1.32
Weapons	118.61	35.58	0.51
Total			**17.4**

We totaled the hours per week of annual and semi-annual maintenance requirements due to the lack of complete at-sea and in-port requirement data. COMNAVSURFPAC N43, in personal correspondence on March 2, 2018, provided a swag for at-sea required annual and semi-annual planned maintenance. He indicated at-sea maintenance requirements would be about 30% of the total annual and semi-annual maintenance. We then calculated thirty percent of the hours per week, providing the average weekly hours of annual and semi-annual maintenance at sea. Using 70 hours of available working time (i.e., dividing by 70 hours), we then recorded the total manpower required to conduct the annual and semi-annual at-sea maintenance. The additional Sailors required to accomplish the annual and semi-annual maintenance workload range from approximately 10 to 17 personnel. These Sailors are not currently provided due to the assumptions made within Navy manpower models.

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CHAPTER 5:
Discussion and Recommendations

> To change something in the Navy is like punching a feather bed, you punch it with your right and your left until you are finally exhausted and then you find the damn bed just as it was before you started.
>
> - Franklin D. Roosevelt
> (Eccles, 1951, p. 336)

5.1 Discussion

Policy and leadership decisions made throughout the past 25 years have greatly affected U.S. Navy Sailors at sea. Decreased manning and increased tasking have placed the Sailors at risk. The workload is increased, and, therefore, the risk put upon the Sailors at sea is increased. The Navy is mandated to minimize manpower for the purpose of war. At sea, the readiness condition that applies is Condition III, which is expected to be maintained by the crew for, at most, 60 days. When tasks are being accounted for, there is a single question that is always asked. Would the Sailors be doing the task if the Navy was at war?

Sailors have to do many tasks that are unaccounted for in Navy manpower models. Tasking comes from multiple sources. They come from the chain of command as well as external sources, such as Naval Sea Systems Command (NAVSEA), Naval Supply Systems Command (NAVSUP), and Chief of Naval Personnel (CNP). They can also come through indirect means, such as policy change that impacts ship workload in the future.

The critical issue of concern is whether Sailors at sea have the means to complete their actual requirements without feeling overwhelmed or feeling the need to finish their tasks only to the point of "good enough." The Navy does a great disservice to its Sailors when there is no centralized control for all surface ship requirements.

Initially, one would think that providing more personnel would ease the workload burden. However, because sea/shore friction exists, the Navy needs more than just an increase in recruits. The Navy would be wise to undertake a review and analysis to determine how to alleviate the sources of the friction discussed in Section 2.4.1.

The Navy uses fit and fill to determine manning levels for the surface ships, but a fill above 100% is not necessarily helpful if some of the departments with the greatest workload are undermanned. In addition, funding is required in order to increase Navy end strength to expand ship manning, requiring a higher level of congressional buy-in. Furthermore, the Navy will need to plan appropriately while the fleet expands to 355 ships. The Navy must rely on others to accomplish such changes due to the nature of military funding. The one vital factor the Navy has the power to control is its own internal policies.

5.1.1 Pillars of Risk

Workload issues will not fully resolve through additional manning or Navy manpower model adjustments. Ship leadership must know the actual risk undertaken because of this. Also known as the "Readiness Gap," Navy Manpower Analysis Center (NAVMAC)'s "Levels of Risk" from Figure 2.8 is just the start of the real gap (see Figure 5.1).

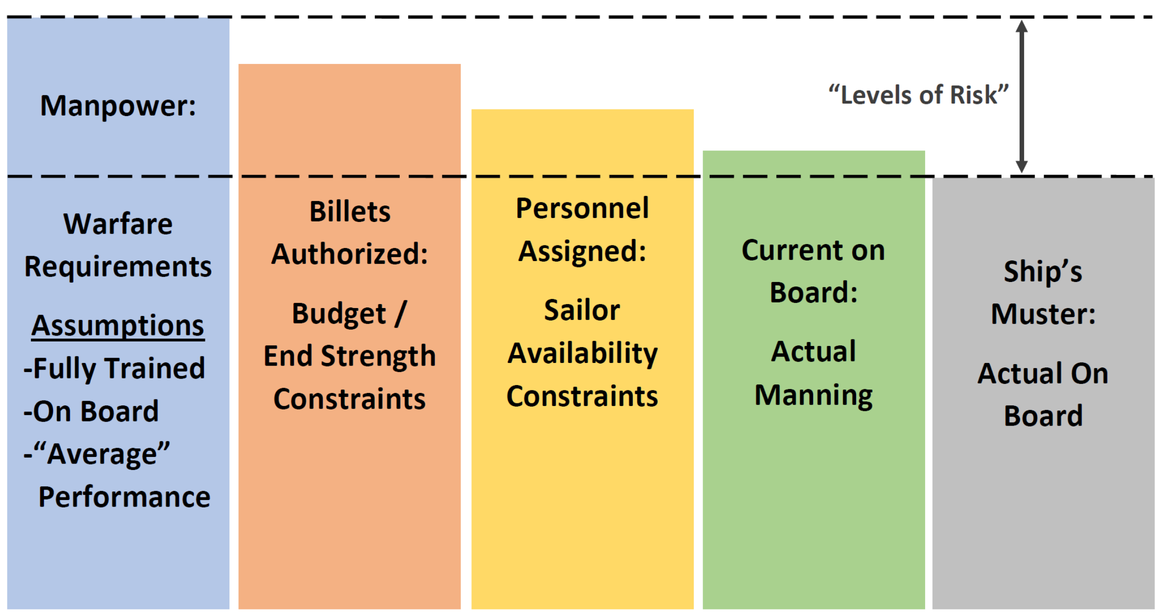

Figure 5.1. "Levels of Risk," Also Known as a "Readiness Gap." Adapted from NAVMAC (2017b).

This is a revised version of NAVMAC's illustration. This figure is the most common representation of what happens to the minimal requirements for ship manpower as billets are funded and personnel are assigned.

Difference Between Ship Manpower Document (SMD) and Actual Mission Needs

This thesis finds that the "Readiness Gap" is truly larger that what has been stated within the Navy. This increase of the gap is two-fold. First, as discussed in Section 4.6, there are at-sea Condition I or III requirements that are not included. Second, when the U.S. Navy began shaving actual billets from the Required Operational Capabilities and Projected Operational Environment (ROC\POE) as described in Section 2.5.2, Optimal Manning Initiative: 2001–2006, the gap grew larger (see Figure 5.2).

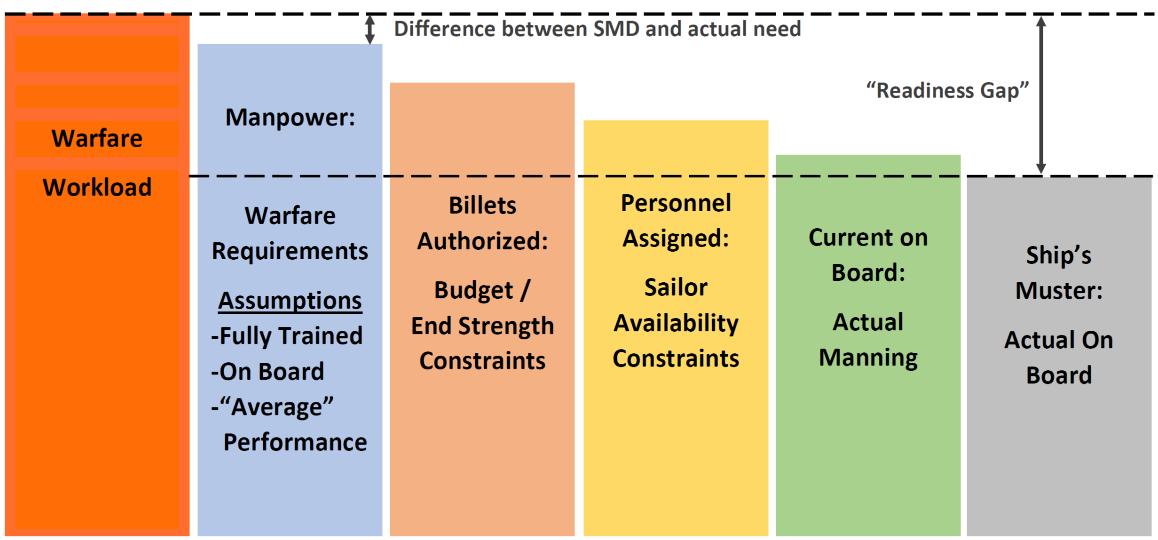

Figure 5.2. The Actual "Readiness Gap": Adding the Difference between the SMD and Actual Warfare Workload. Adapted from NAVMAC (2017b).

This figure shows an increased readiness gap through wartime tasks not included in Navy manpower models as well as the billet changes over the past 25 years. Though the gap created due to tasks not planned for can be reduced or eliminated, once billet changes were made, the gap was not noted or filed away. Therefore, the gap will not close without reversal of billet decisions made in the past. The Navy undermines itself when cutting billets through the removal of billet requirements. When manpower billets are "just removed," the Navy cannot include the billets as unfunded requirements when asking Congress for funding.

The True Level of Risk

Once non-warfare workload is added, the true level of risk becomes even more obvious (see Figure 5.3).

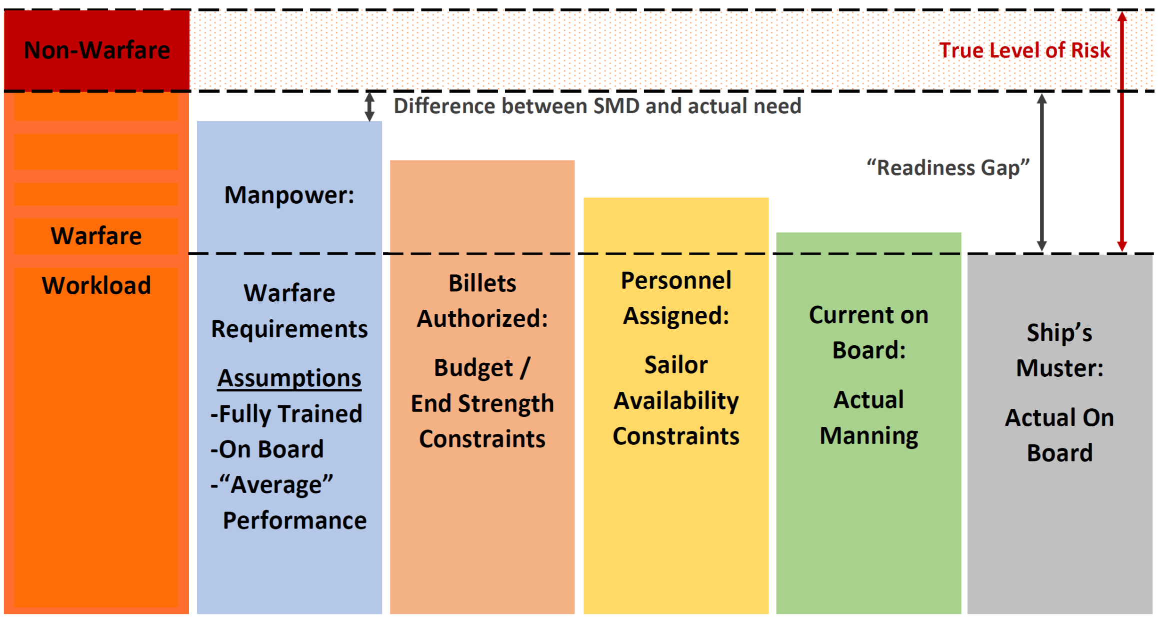

Figure 5.3. The Readiness Gap: True Level of Risk.

The additional unidentified gap includes non-warfare workload. This gap is not acknowledged by the Navy due to the need to "minimize for war." This readiness gap is the "True Level of Risk."

5.2 Recommendations

Recommendations are made based upon the findings of this thesis and review of DDG 51 at-sea tasks.

- Review analysis processes of overarching Navy policy changes and their effect on Navy Sailors at sea. The Under Secretary of Defense for Personnel and Readiness

(USD (P&R)) (2005) states, “New policy, including fiscal policy, shall be evaluated before implementing to decide its effect on manpower and personnel performance. Existing policies, procedures, and structures shall be periodically evaluated to ensure efficient and effective use of manpower resources” (p. 2). Though changes to CONDITION I and III requirements are expected to be completed, in part, through the update of the ROC\POE for each ship class, such an update only accounts for mission requirements. The Navy does not conduct these evaluations in accordance with the directive (Government Accountability Office (GAO), 2017b).

- Update the Office of the Chief of Naval Operations (OPNAV) Instruction 1000.16, Navy Total Force Manpower Policies and Procedures, to include a requirement to reassess the Navy Availability Factor (NAF)/Navy Standard Work Week (NSWW) every ten years.
- Review fleet by fleet Operations Orders (OPORDs) with the goal of removing inefficiencies for transiting Navy vessels.
- Add departmental, divisional, and/or rate working hour differences using appropriate statistical methodology as a part of NAF/NSWW reassessments.
- Review the disparity of Food Service Attendant (FSA) manpower NAVSUP recommendations and NAVMAC manpower requirements, based upon workload analysis, to determine the most appropriate manning for FSA workload and quality of life.
- Review funding processes to potentially allow non-Navy Personnel Command (NPC) funding in the midst of a Permanent Change of Station (PCS) in order to allow for school funding concerns for such school programs as Senior Enlisted Academy (SEA).
- Provide training to new Sailors prior to arrival to their first command to include Shipboard Firefighting, Damage Controlman (DC) wet training, basic Maintenance and Material Management (3M) training, and Anti-Terrorism Force Protection (ATFP) certification. Though not all may be able to be accomplished, as many as possible would alleviate the workload once a new Sailor arrives.
- Train Surface Warfare Officers at the beginning of their career along with each leadership training milestone as to how their ship is manned, from workload and requirements to personnel on board.
- Review the Surface Force Exercise Manual to verify the required CONDITION III drill time requirement over the course of a six month deployment. These drills are not currently fully included in Navy manpower models.

- Update the Surface Force 3M instruction (Commander, Naval Surface Force, U.S. Pacific Fleet (COMNAVSURFPAC) & Commander, Naval Surface Force Atlantic (COMNAVSURFLANT), 2013), to account for divisional spot check to Planned Maintenance System (PMS) ratios. This is not to necessarily decrease requirements for other departments or divisions, but to create a more appropriate spot check loading for each division.
- Provide a Type Commander (TYCOM) "pre-workup package" with the current checklists and standards expected to be used during the workup cycle. This will alleviate the responsibility of the ship to pull workup requirements without knowledge of changes or, in some cases, where to obtain them. This package should not change throughout the workup process once it has begun in order to reduce "whiplash" to the ship through changing requirements.
- Review TYCOM and Immediate Superior in Command (ISIC) requests for informations (RFIs) and ensure existing systems adequately provide necessary information to prevent duplication of administrative work.

5.3 Future Work

Further studies on the following topics could enhance this thesis. We suggest:

- The final Mark IV model should be validated with a larger sample size due to the lack of time and available resources for this research.
- The sources of at-sea requirements should be traced in order to help the TYCOM and ISIC maintain command and control over their fleet vessels.
- Tiers one, two, and three phase inspections, certifications, and assessments need to be reviewed for duplication and inconsistencies, to include a comparison to Board of Inspection and Survey (INSURV).
- Review ATFP requirements and determine potential unrealized efficiencies. This is an in port function and was struck in order to focus on the at-sea model, however, it is clear from surveys and data that this is a large workload growth area.
- As a part of the resiliency goals of the Navy, recommend statistical tracking of stress score by command type.
- As current training changes take effect due to Ready Relevant Learning (RRL), we recommend a review of the effects on the fleet.

- Officer workload needs to be objectively reviewed. Alleviating officer workload and long working days may result in improved attrition rates.

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APPENDIX A: VCNO Memorandum: NSWW for Enlisted Personnel Afloat, Dated September 13, 1967

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, D.C. 20350

IN REPLY REFER TO
Op-100/1mc
Ser 13401P10
13 SEP 1967

MEMORANDUM FOR THE DEPUTY CHIEF OF NAVAL OPERATIONS
(MANPOWER AND NAVAL RESERVE)

Subj: Navy Standard Work Week For Enlisted Personnel Afloat

Ref: (a) Op-01 memo ser 13400P10 of 3 Aug 1967

Encl: (1) Data pertaining to subject work week

1. The Navy standard work week for enlisted personnel afloat as proposed in reference (a) and presented to the CNO Advisory Board on 17 July 1967 is hereby approved for use as a manpower planning objective in the development of manning authorizations for ships and embarked squadrons. The following total weekly work hours are specifically approved.

<u>At Sea</u>

Watchstander	74 hours
Non-watchstander	66 hours

<u>In Port</u>

Watchstander	45 hours
Non-watchstander	41 hours

2. Clerical and support personnel shall be cross-trained to stand watches as practical in order to reduce the total workload of normal watchstanders and to reduce the number of non-watchstanders on board.

3. While it is recognized that accommodation limitations and other constraints may not permit full attainment of the standard work week objective in all instances, development of manpower authorizations shall incorporate the objective work week to the maximum extent practicable.

4. For purposes of uniformity, the standard work week objectives will be reflected in manning proposals of all activities involved in the development and validation of manpower requirements. This includes contractors working under Navy contracts.

HORACIO RIVERO
Vice Chief of Naval Operations

Copy to:
Op-03, 04, 05, 06, 07, 008, 96, 602D
OPA

TERMINOLOGY AND DEFINITIONS

1. Work Week

Total time, expressed in hours, to accomplish ship's work, including watches.

2. Work

The activity of a body or mind which can be measured against standards in time, quantity or quality. This includes:

a. watches/operation of equipment
b. maintenance
c. utilities tasks
d. administration
e. support
f. training and schooling
g. supervision/job related conversations, etc.

3. At-Sea Routine

a. Six working days (plus Sunday watches)

b. Normal off-watch working hours

0745 - 1130

1300 - 1630

4. In-Port Routine

a. Five working days (½ day off Wednesday, ½ working day Saturday)

b. Normal off-watch working hours

0800 - 1200

1300 - 1615

c. Includes 1-in-4 duty section

(Continued)

Enclosure (1)

5. Productivity Factor

A percentage allowance applied to standards of work performance to provide for delays stemming from:

a. fatigue
b. adverse environmental factors
c. unavoidable interruptions, etc.

An 80% per capita effectiveness factor, derived from work sampling analyses, is currently being used in manning analyses connected with development of Ship Manning Documents.

6. Utilities Tasks

Work which:

a. does not fall within the major categories of maintenance, watches, support or administration
b. is not amenable to expression in work standards, i.e., it is not regularly repetitive and is of varying duration
c. but which is essential to the operation of a ship.

Typical examples are; rigging/unrigging and transfer evolutions.

7. Service Diversions

Diversions from work which occur during normal off watch working hours. Includes sick call, conducting business at ship's office and disbursing office, paycall, ship's store, post office, barber shop and cobbler shop; etc., includes those awaiting service.

8. Personal Needs

This includes health and comfort needs, mail, leisure, relaxation, uniform changes, etc.

9. Messing

This includes everything that encompasses the act of drawing utensils, being served, eating, etc., including standing in the mess line until departure from the scullery.

Enclosure (1)

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APPENDIX B: Mark I: At-Sea/In-port Shipboard Workload Model

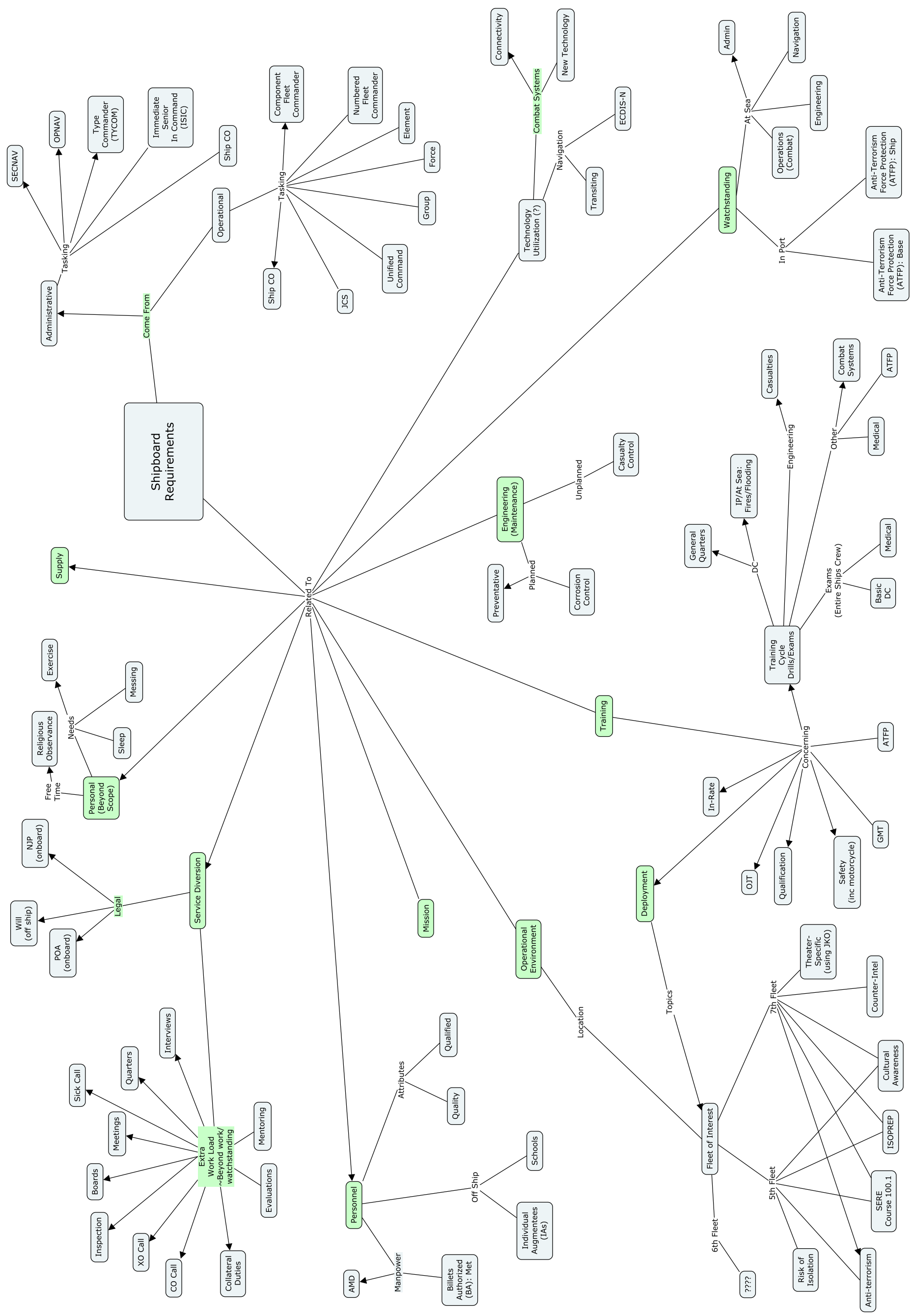

Figure B.1. Mark I, Shipboard Workload Model, December 2016.

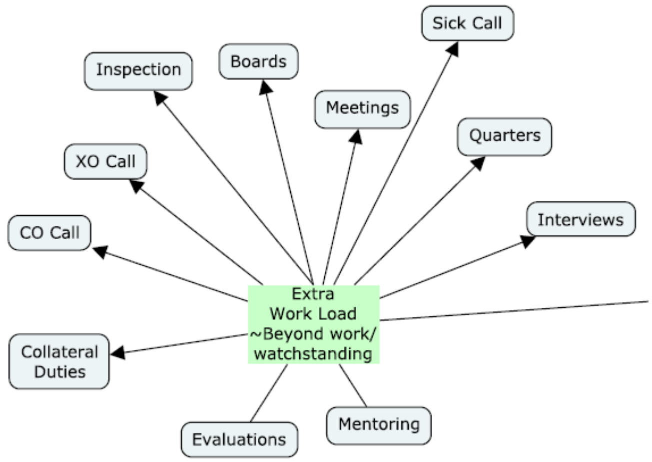

Figure B.2. Example 1: Mark I Close-up of Service Diversion, December 2016.

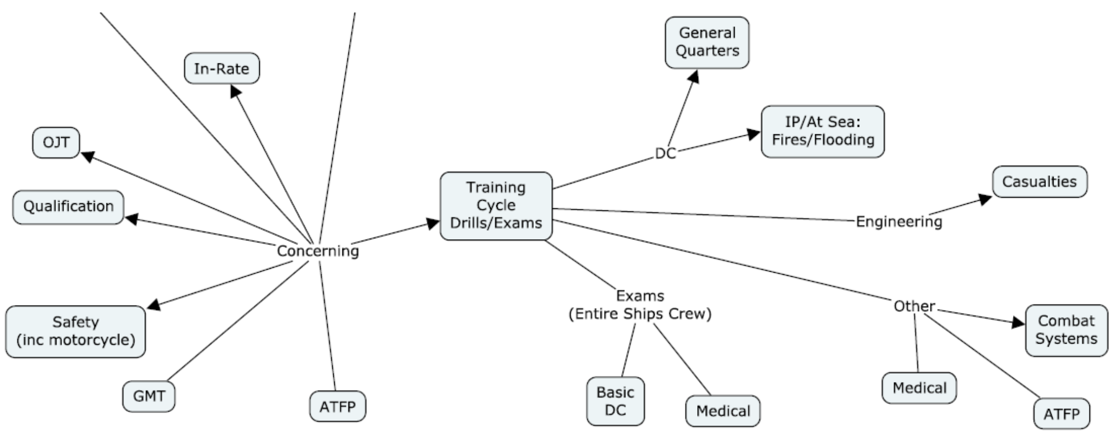

Figure B.3. Example 2: Mark I Close-up of Training, December 2016.

APPENDIX C: U.S. Navy Leadership / Subject-Matter Expert Interview Questionnaire

Subject-Matter Expert Survey/Interview Questions

For these questions:

1. Think "disproportionate amount of time" defined as more than the average and "causes of organizational frustration"

2. The focus is on the Junior Enlisted Sailors. If there is anything to add in regard to Senior Enlisted Sailors or Officers, please describe it.

A. Broad Scope Sources of Requirements

1. On what requirements do most personnel work longer than the average number of hours to meet?

2. Is there a procedure that Sailors follow to prioritize requirements? If yes, what are those procedures?

3. Do some departments spend a disproportionate amount of time meeting requirements?

a. At Sea?

b. In Port?

4. Are there extra requirements placed on the ship that are not required by regulation?

a. Are there any requirements that specifically take a disproportionate amount of time for the Sailors?

b. What are they?

c. What are the source(s) of the workload increase?

d. Do the source(s) of workload increase go through a central point of contact at the ISIC, i.e. is the ISIC aware when extra requirements are placed on the ship?

e. Sources of consideration for requirements include: Commanding Officer, ISIC, TYCOM, SURFOR, Big Navy, etc. Please expand this list to include other sources for consideration.

B. Mission and Operational Requirements

1. Are there any regular or intermittent changes to the ship's overall mission?

a. If so, what effect does it have on the ship's Junior Enlisted Sailors?

b. What effect does it have on the Senior Enlisted Sailors or Officers?

2. Do changes in the operational environment change the number of requirements placed on the Sailors? How often does this happen?

C. Technology

1. Are there any issues with connectivity either in port or at sea for Junior Enlisted Sailors?

a. What is the effect on their day to day work?

b. What is the effect on their ability to train?

2. How are connectivity issues resolved to allow requirements to be met?

3. What new technology have Navy ships seen within the past 10 years?

4. What effect has this new technology had on Sailor workload?

a. Was the purpose of the technology to reduce Sailor workload?

b. Did the new technology reduce Sailor workload?

c. Are there any specific new technologies that reduced Sailor workload?

d. Are there any specific new technologies that did not reduce Sailor workload, i.e. they either increased workload or maintained the status quo?

D. Sailor Qualification and Availability

1. Do Navy ships receive Sailors who are untrained?

a. Please provide examples of why they are untrained?

b. Do untrained sailors receiving training?

c. What ratings in particular tend to arrive untrained?

d. What causes the Sailors to arrive untrained?

2. Sailor Availability

a. What situations prevent Sailors from being on board the ship in port?

b. What situations prevent Sailors from being on board the ship at sea?

E. Personal Requirements

1. Are Sailors receiving the required personal time, workout time or sleep while at sea?

a. If no, why not? If so, what are the causes; what is the source of these issues?

b. Are there repercussions for the ships when Sailors are not able to meet their personal needs?

2. How do ships resolve issues with personal time?

F. Watchstanding

1. In Port

a. What effect do ATFP requirements have on the ships crew?

b. What effect do ATFP requirements have on Port watchstanding duties?

c. What other in port watchstanding requirements have an effect on a ship's Sailors?

2. At Sea

a. Do Sailors work a disproportionate amount of time in their watchstanding duties at sea?

1. If so, how are they overworked?

2. Why are they overworked?

b. Do specific departments have a larger percentage of overworked Sailors than others?

1. If so, what departments experience this the most?

2. How do the departments deal with this overwork?

G. Maintenance

1. What situations cause the ship to fail to meet maintenance requirements?

a. What are the effects when a ship is unable to meet maintenance requirements?

b. Are requirements waived? If yes, why?

c. Are maintenance needs considered when extra requirements are placed on Sailors?

2. What changes made over the past 10 years that affect a Navy ship's ability to meet maintenance requirements?

a. Have there been any changes in maintenance systems?

b. Have there been any changes in maintenance requirements?

H. Supply

1. What Supply issues affect ship requirements or Sailor workload?

a. In Port?

b. At Sea?

2. What effect does the ability to receive supplies have on a ship's Sailor's workload?

a. In Port?

b. At Sea?

I. Legal

1. Are Sailors able obtain legal services? What services, specifically, might a sailor not be able to obtain?

2. What is the affect of a Sailors ability to obtain legal services on that Sailor's available time on the ship prior to deployment?

3. NJP

a. On average, how much time does NJP take out of the Sailor's day?

b. What effects can NJP results have on the Sailor's ability to continue to meet shipboard requirements?

J. Extra Workload. Do any of the following take a disproportionate amount of time for Junior Enlisted Sailors? If so, in what way?

1. Collateral Duties

2. Inspections

3. Boards

4. Sick Call

5. Quarters

6. Interviews

7. Mentorship (either giving or receiving)

8. Evaluations

K. Training (Note: "Warfighter" training includes Damage Control, General Quarters and Engineering Casualty training)

1. Of the different types of training, what takes a greater percentage of a Sailor's day? Why? Examples: Deployment, ATFP, GMT, Safety (inc motorcycle), Qualification, OJT, In-Rate, cycle-related training (DC/GQ/Eng Casualties)

2. Are there any extra non-warfighter training requirements placed upon the Junior Sailors? If so, what administrative authority do they come from?

3. What effect does the regular and (if any) extra non-warfighter training requirements have on the Sailors?

4. How does connectivity affect the Sailors?

5. In regard to non-warfighting deployment training, when are the Sailors notified of the requirements placed on the ship?

    a. Are the Sailors notified while deployed or prior to departure on deployment?

    b. If prior to departure for deployment, how soon prior?

L. Conclusion

1. Of everything asked, are there effects on shipboard performance due to any of the issues or requirements?

2. Where are the effects on shipboard performance found?

3. Are there any other requirements placed on Navy ships that have not been discussed or asked about? Please provide specifics.

APPENDIX D: U.S. Navy Sailor Survey

Shipboard Requirements Survey

This survey will be used to find out how Sailors spend their time while at sea. Please ask your researcher if you have any questions.

1. Do personnel spend a "disproportionate amount of time" on certain requirements?
   - ☐ No (Skip to question 2)
   - ☐ Yes

   a. On what requirements do personnel spend a "disproportionate amount of time"?

   b. What are the source(s) of the increased workload? (Example: SURFPAC, Fleet Forces, etc)

2. When there isn't enough time to do everything, what tasks or needs does a Sailor shed at sea?

3. What at sea requirements could be removed without mission degradation in order to reduce the number of hours Sailors work?

What are some barriers to Sailor ability to accomplish work using a computer at sea? (Check all that apply)

☐ Number of computers available

☐ Connectivity speeds

☐ Navy-designed websites, specifically ____________________

☐ Navy-designed programs, specifically ____________________

☐ Online tracking requirements, specifically ____________________

☐ Network drive space

☐ Unsupported software (Example: Microsoft, Adobe, etc.)

☐ Other: ____

____

The answers below refer to the ________________________ Department (Example: Engineering)

Approximately how many hours does a Sailor spend on a <u>single instance</u> of the following evolutions <u>at sea</u>? How many times per month does the evolution occur? State N/A if unknown.

(**Example:** Inspection __3__ hours, __2__ times per month)

<u>Tasks:</u>	**<u>Enlisted personnel spend:</u>**	**<u>Officers spend:</u>**
Inspection	_____ hours, _____ times per month	_____ hours, _____ times per month
Board (giving or receiving)	_____ hours, _____ times per month	_____ hours, _____ times per month
Quarters/Muster	_____ hours, _____ times per month	_____ hours, _____ times per month
Mentorship (giving or receiving)	_____ hours, _____ times per month	_____ hours, _____ times per month
Evaluations	_____ hours, _____ times per month	_____ hours, _____ times per month
Awards	_____ hours, _____ times per month	_____ hours, _____ times per month
Working Party	_____ hours, _____ times per month	_____ hours, _____ times per month
Cleaning Stations	_____ hours, _____ times per month	_____ hours, _____ times per month
Sweepers	_____ hours, _____ times per month	_____ hours, _____ times per month
Preparing for / Briefing Training Team Drills	_____ hours, _____ times per month	_____ hours, _____ times per month
Debriefing Training Team Drills	_____ hours, _____ times per month	_____ hours, _____ times per month
Required Reading for Watchstanding	_____ hours, _____ times per month	_____ hours, _____ times per month
Study for Advancement	_____ hours, _____ times per month	_____ hours, _____ times per month
Warfare Qualifications	_____ hours, _____ times per month	_____ hours, _____ times per month
JQR/PQS Training (any)	_____ hours, _____ times per month	_____ hours, _____ times per month
CPO 365	_____ hours, _____ times per month	_____ hours, _____ times per month
PO Leadership Training	_____ hours, _____ times per month	_____ hours, _____ times per month
Navy-wide Training Requirements	_____ hours, _____ times per month	_____ hours, _____ times per month

Tasks (cont):	**Enlisted personnel spend:**	**Officers spend:**
Higher Education - Classroom	_____ hours, _____ times per month	_____ hours, _____ times per month
Higher Education - Studying	_____ hours, _____ times per month	_____ hours, _____ times per month

For each of the questions below, circle the response that best characterizes the typical Sailor experience while at sea:
1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree, 6 = Don't Know

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Don't Know
1. Sailors have adequate personal time	1	2	3	4	5	6
Comment:						
2. Sailors have adequate time to exercise	1	2	3	4	5	6
Comment:						
3. Sailors have adequate time to study for advancement	1	2	3	4	5	6
Comment:						
4. Sailors get adequate sleep	1	2	3	4	5	6
Comment:						
5. In regard to maintenance, "good enough" is a typical Sailor attitude.	1	2	3	4	5	6
Comment:						

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APPENDIX E: Afloat (Wartime) Navy Availability Factor

a. Afloat (Wartime) - Military Personnel

NAF		81.00
Productive Availability Factor (NOTE 1)		70.00
Analysis of Duty Hours		
Non-Productive Availability Factor:		81.00
Training (NOTE 2)	(7.00)	(11.00)
Service diversion (NOTE 3)	(4.00)	
Total Hours Available for Productive Availability Factor (NOTE 1)		70.00

NOTE 1. For watch standers, 56 hours is allocated to watch stations (8 hours in 7 days) (14 hours available for work in addition to 56 hours watch standing equals 70 hours).

NOTE 2. Training is an activity of an instructional nature, which contributes directly to combat readiness and deducts from the individual's capability to do WAF. Training hours are factored to reflect those scheduled events (e.g., general drills, engineering casualty damage control) for all hands. Hours indicated have been standardized for condition III in SMDs.

NOTE 3. Service diversion consists of actions required of military personnel by regulations or the nature of shipboard or staff routine. Service diversion includes, but is not limited to, the types of activities as per subnotes 1) through 3).

1) Quarters, inspections, and sick call.

2) Other administrative requirements including: commanding officers non-judicial punishment, participation on boards and committees, interviews, and non-training-related assemblies.

3) Flight and hangar-deck integrity watches.

Figure E.1. Afloat (Wartime) Navy Availability Factor (NAF). Source: DCNO (MPT&E) (2016).

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APPENDIX F:
Mark II: Post-interview Workload Model

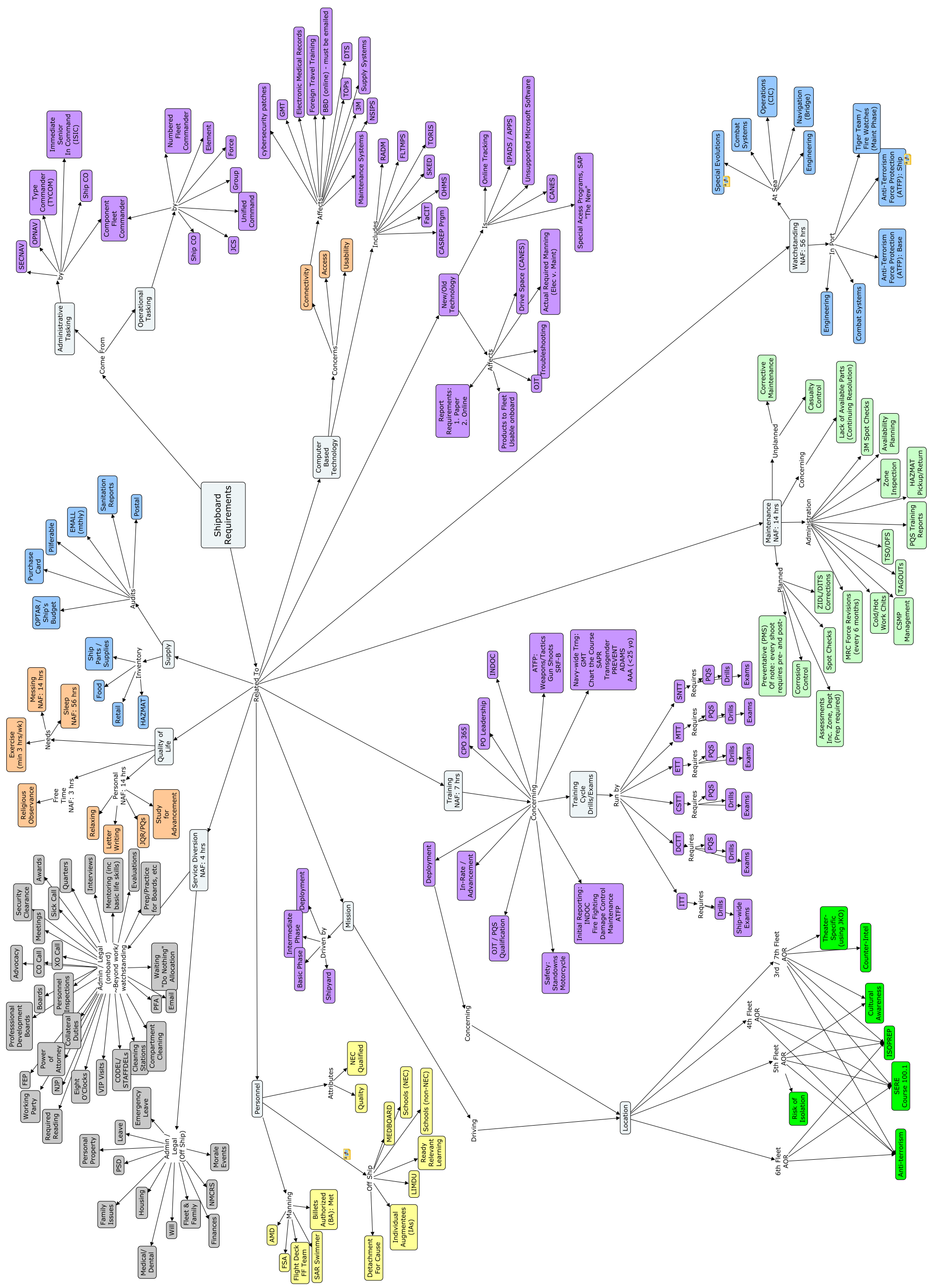

Figure F.1. Mark II, Post-interview Shipboard Workload Model, May 2017.

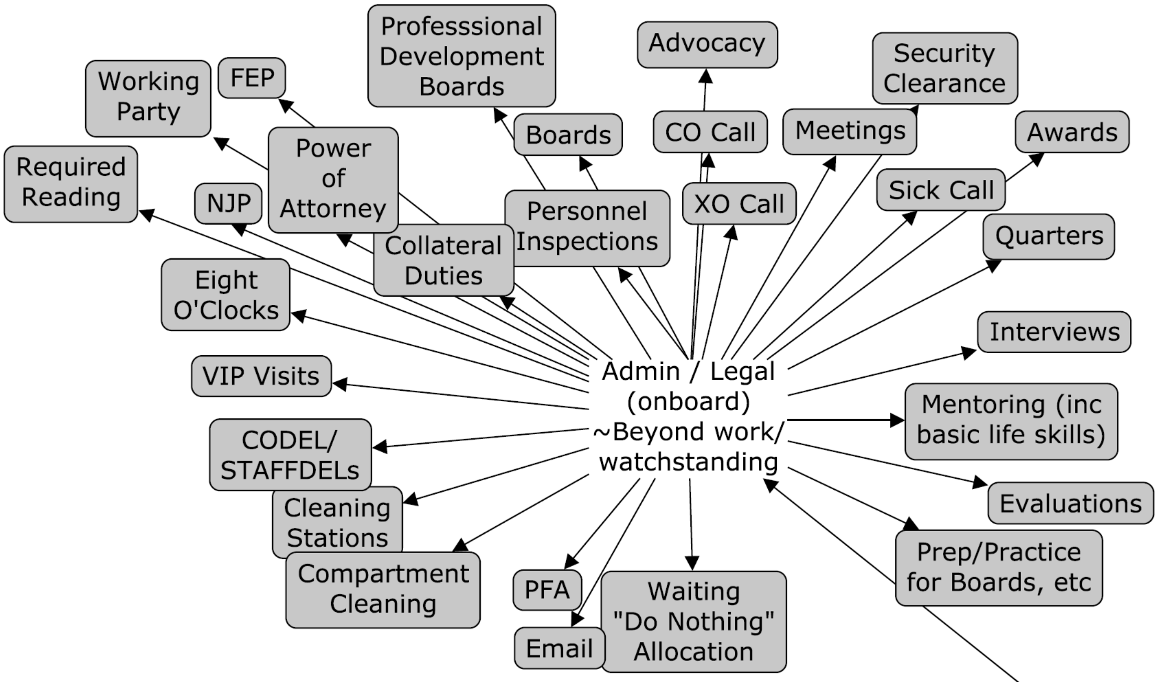

Figure F.2. Example 1: Mark II Close-up of Service Diversion, May 2017.

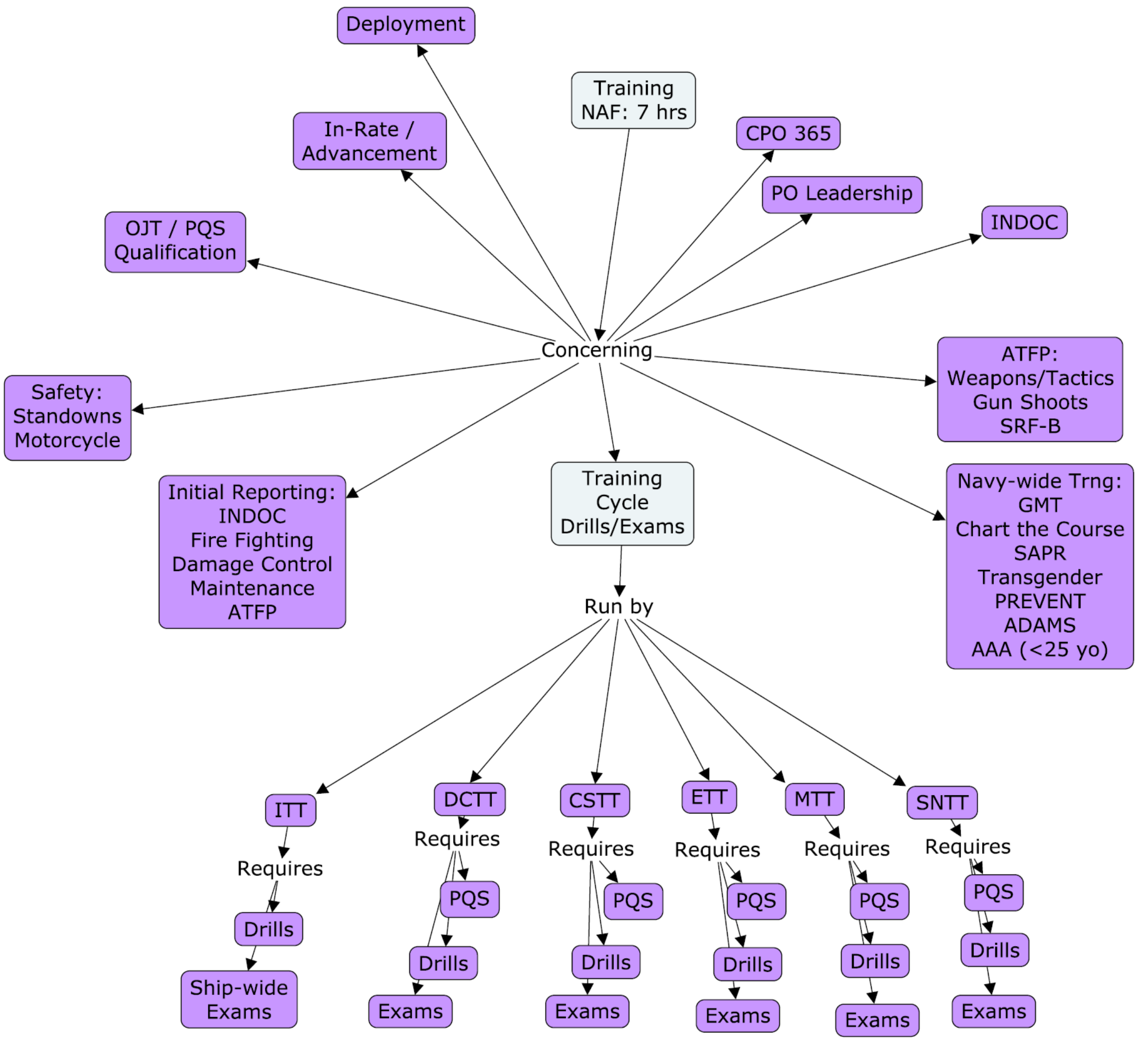

Figure F.3. Example 2: Mark II Close-up of Training, May 2017.

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APPENDIX G:
Mark III: At-Sea Model Provided to NAVMAC

Figure G.1. Mark III, At-Sea Shipboard Workload Model, September 2017.

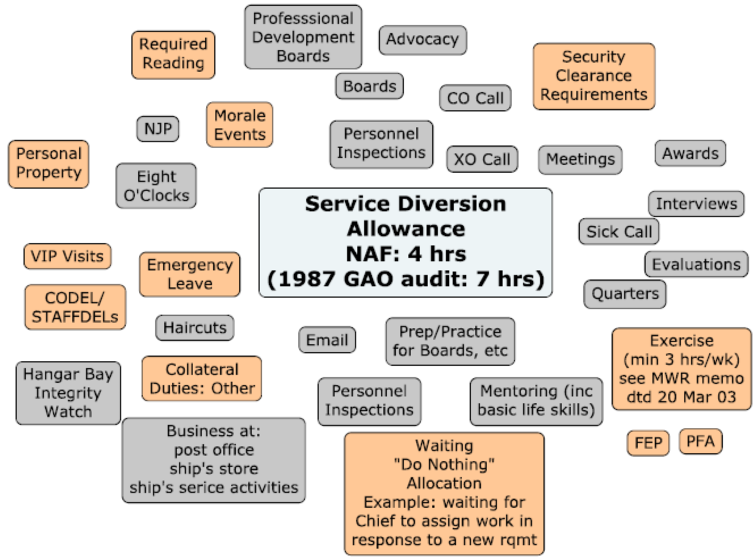

Figure G.2. Example 1: Mark III, Close-up of Service Diversion, September 2017.

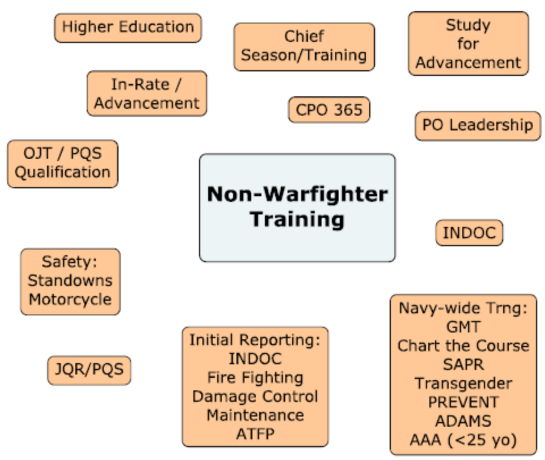

Figure G.3. Example 2: Mark III, Close-up of Non-warfighter Training, September 2017.

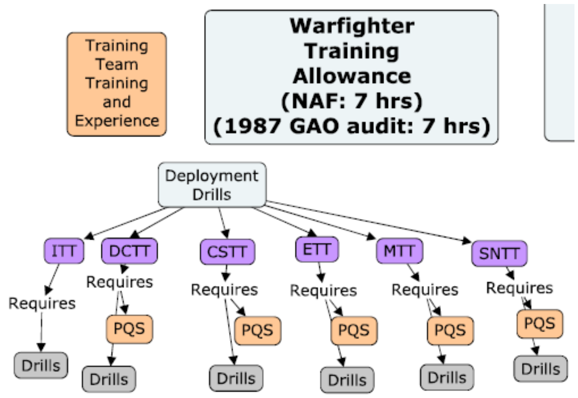

Figure G.4. Example 2: Mark III, Close-up of Warfighter Training, September 2017.

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APPENDIX H:
Mark IV: Final At-Sea Shipboard Workload Model

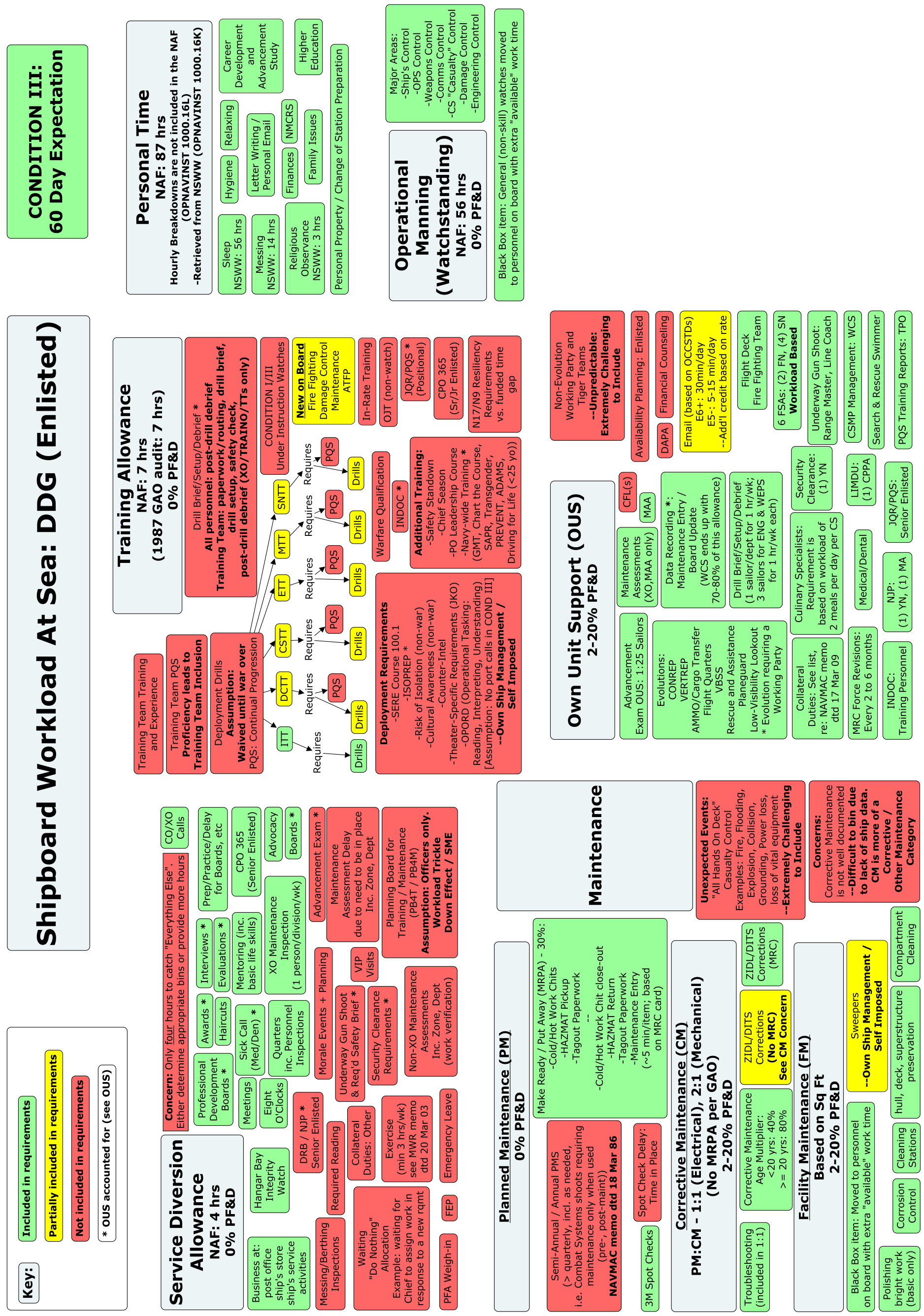


Figure H.1. Mark IV, At-Sea Shipboard Workload Model, February 2018.

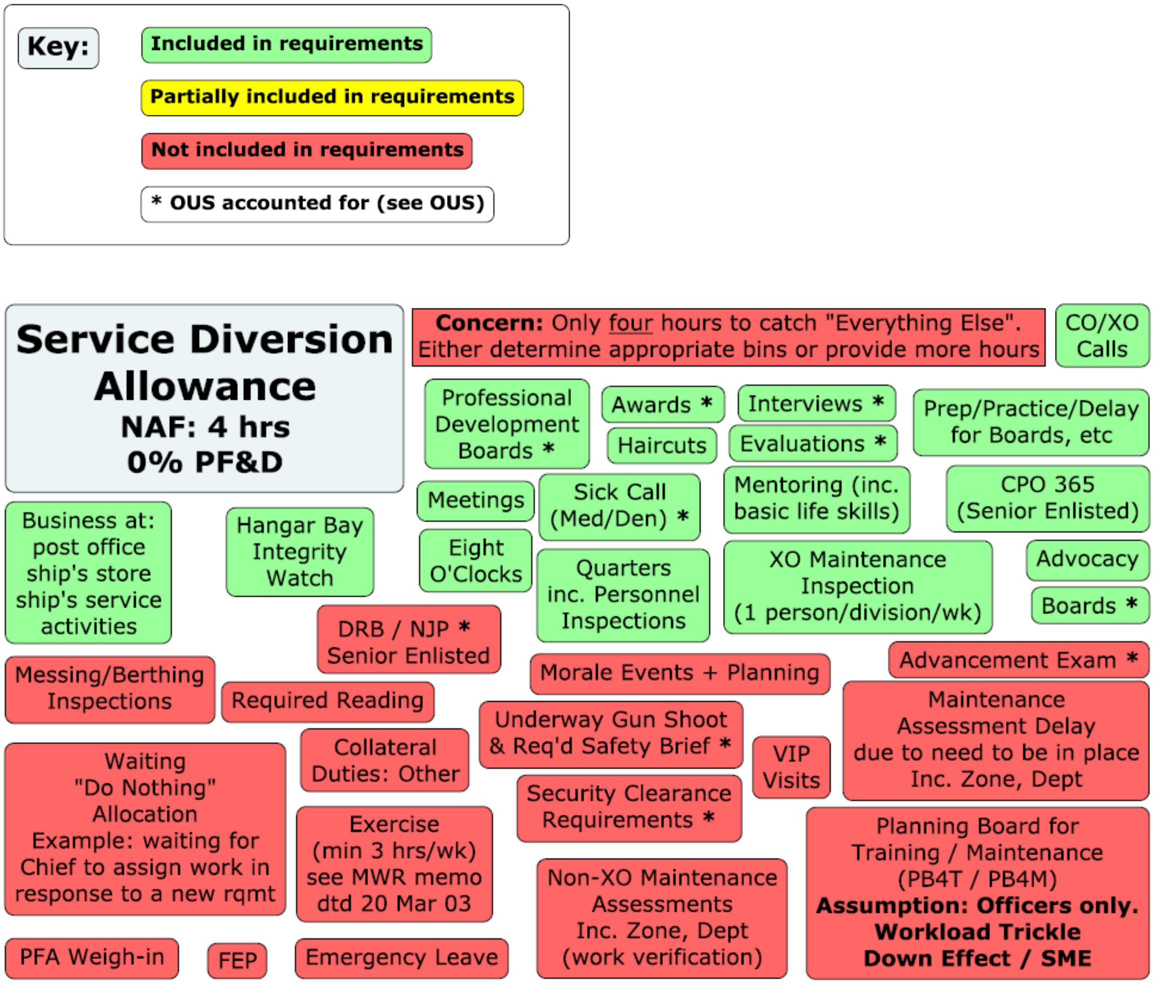


Figure H.2. Mark IV: Service Diversion, February 2018.

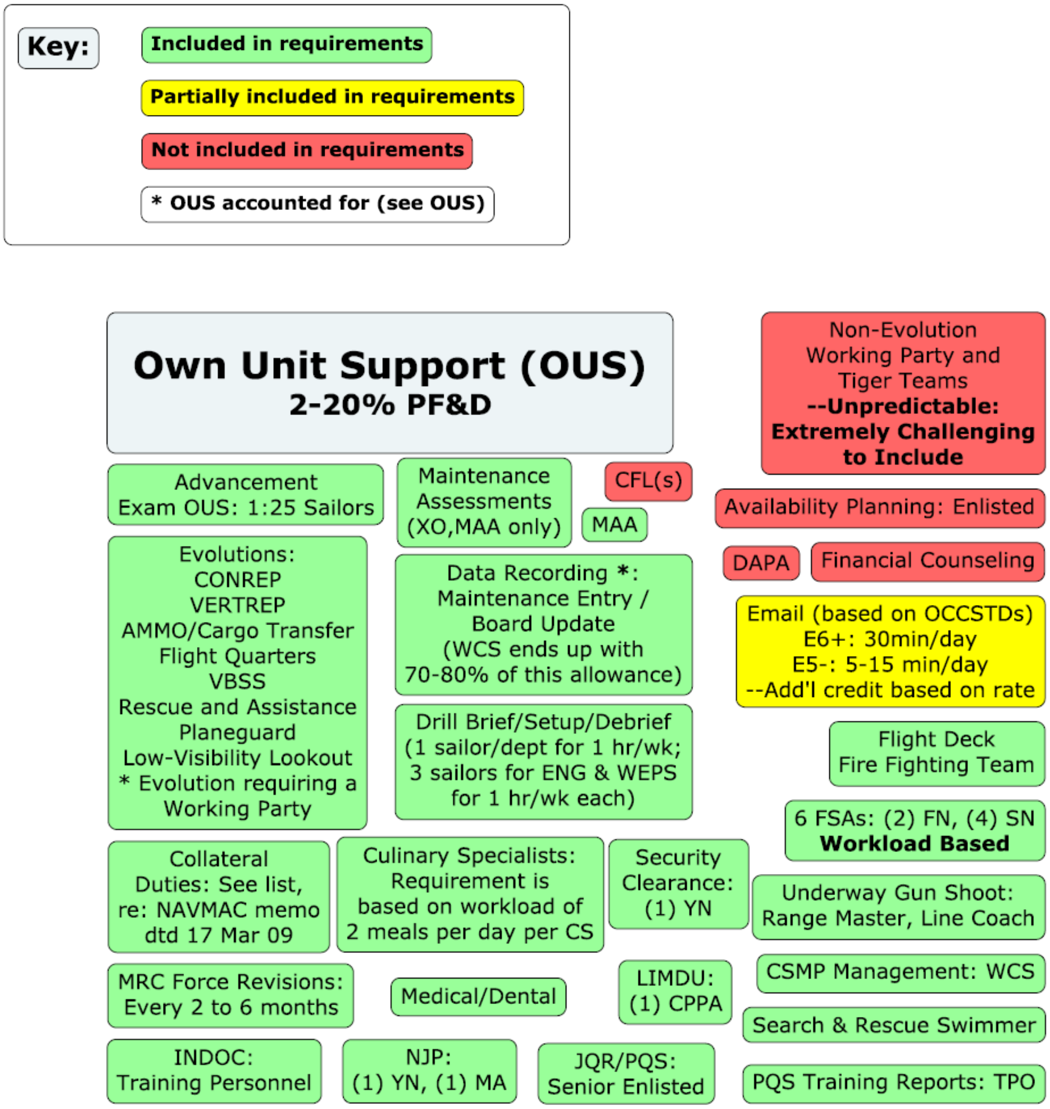


Figure H.3. Mark IV: Own Unit Support (OUS), February 2018.

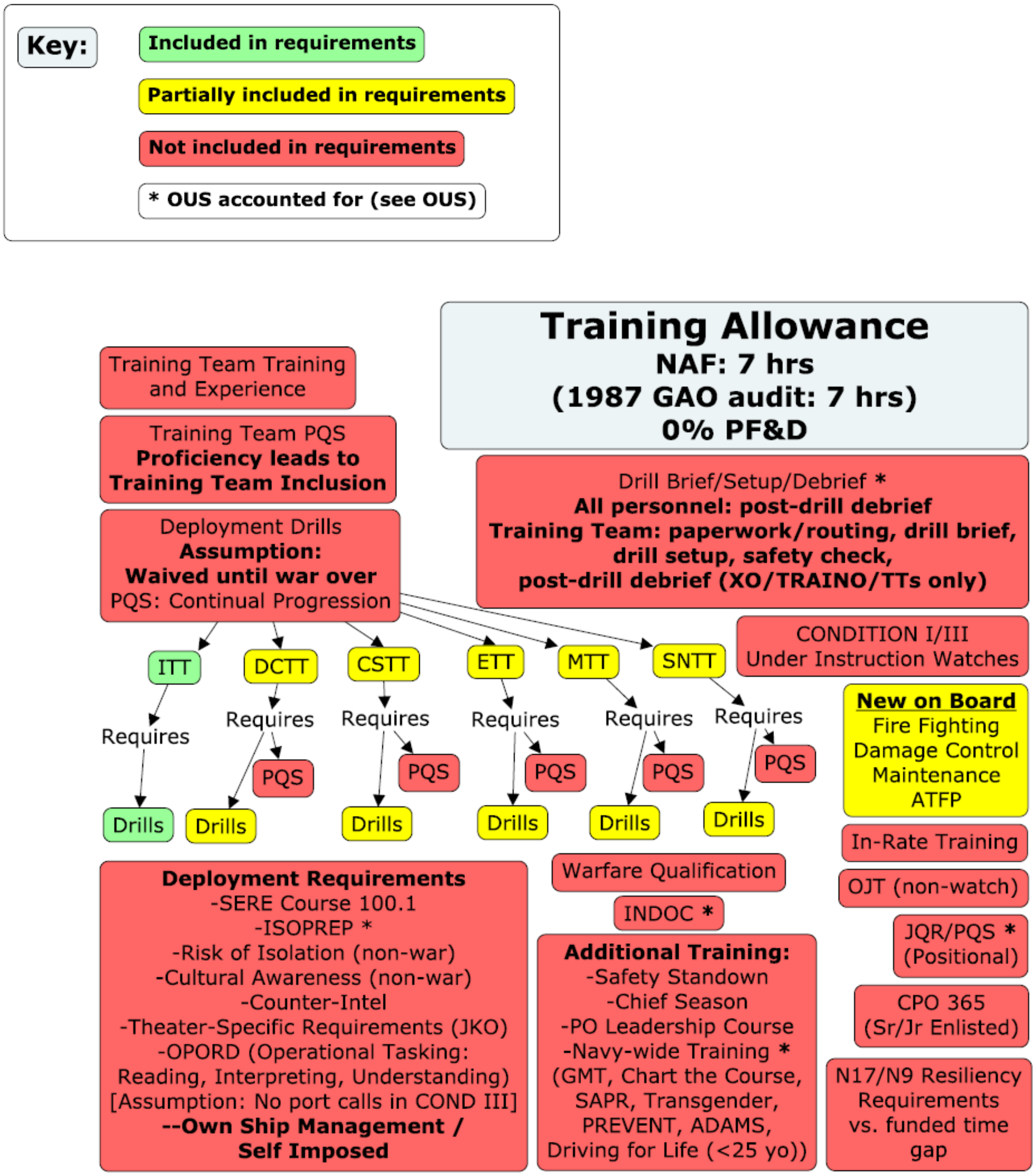


Figure H.4. Mark IV: Training, February 2018.

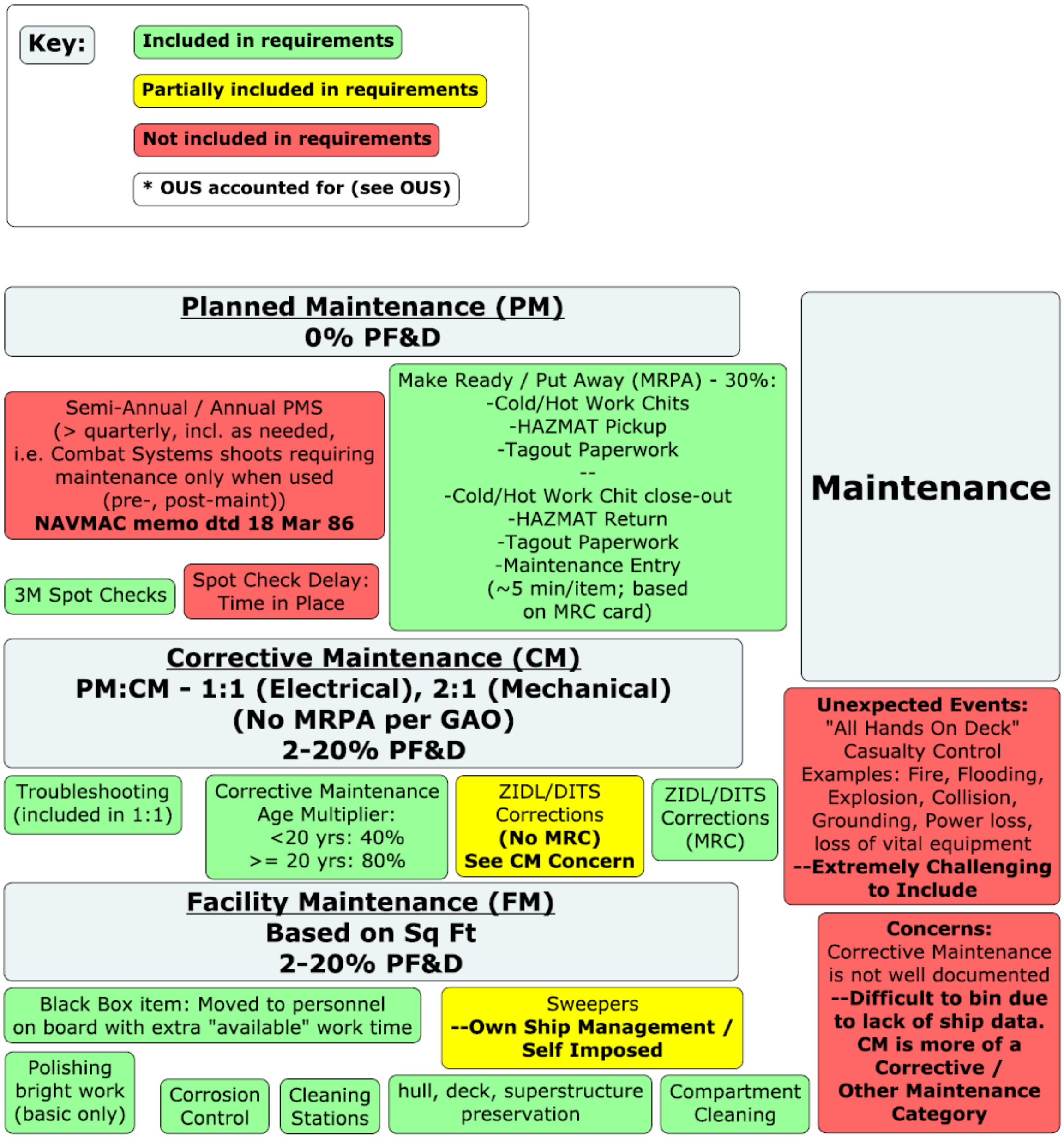
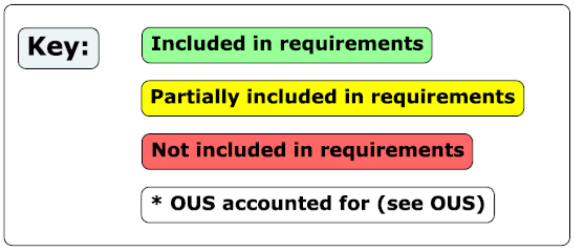


Figure H.5. Mark IV: Maintenance, February 2018.



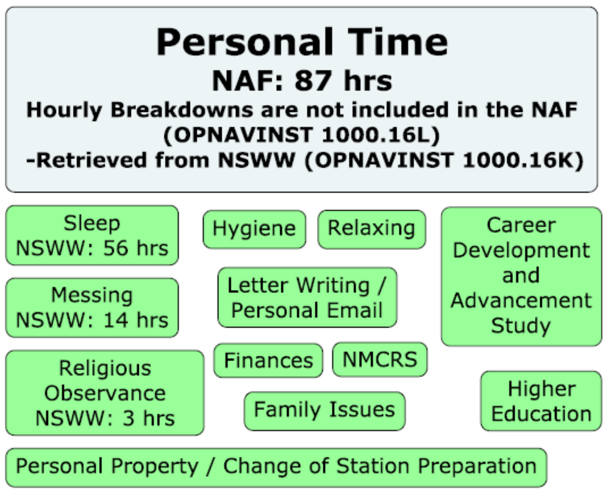


Figure H.6. Mark IV: Personal Time, February 2018.

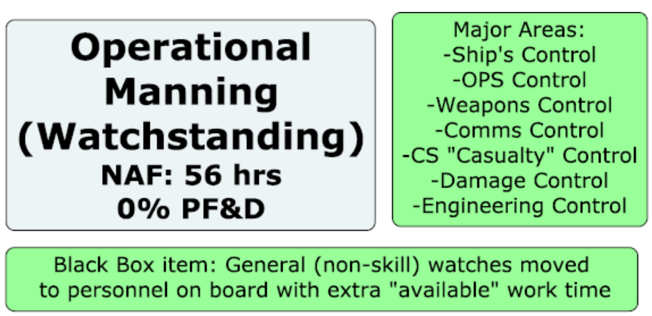


Figure H.7. Mark IV: Operational Manning, February 2018.

List of References

Alarcon, G. M. (2011). A meta-analysis of burnout with job demands, resources, and attitudes. *Journal of Vocational Behavior*, *79*(2), 549–562. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0001879111000315

Anderson, D., Oberman, F., Malone, T. B., & Baker, C. C. (1997, September). Influence of human engineering on manning levels and human performance on ships. *Naval Engineers Journal*, *109*(5), 67–76. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1559-3584.1997.tb02373.x

Annual defense manpower requirements report, 10 U.S.C. §115a. (2006).

Arendt, J., Middleton, B., Williams, P., Francis, G., & Luke, C. (2006, June). Sleep and circadian phase in a ship's crew. *Journal of Biological Rhythms*, *21*(3), 214–221. Retrieved from http://journals.sagepub.com/doi/pdf/10.1177/0748730405285278

Assistant Secretary of the Navy (Research, Development and Acquisition). (2000, June). *Commercial item acquisition: Considerations and lessons learned.* Retrieved from http://www.secnav.navy.mil/rda/OneSource/Documents/Program\%20Assistance\%20and\%20Tools/Handbooks,\%20Guides\%20and\%20Reports/Page\%202/ciacll.doc

Balisle, P. M. (2010, February 26). *Fleet review panel of surface force readiness.* Unpublished manuscript.

Baseman, A. (2000, March). The U.S. Navy – Reducing shipboard planned maintenance. *Maritime Reporter and Engineering News: Ship Repair and Conversion*, *62*(3), 20.

Bauer, D. E. (2016, January). Surface maintenance engineering planning program (SURFMEPP). Powerpoint presented at *28th Annual Surface Navy Association Symposium*, Crystal City, Virginia. Retrieved from http://www.navsea.navy.mil/Portals/103/Documents/Exhibits/SNA-SURFMEPP.pdf?ver=2017-01-11-152858-837]]

Beland, R. W., & Quester, A. O. (1991). The effects of manning and crew stability on the material condition of ships. *Interfaces*, *21*(4), 111–120. Retrieved from https://pubsonline.informs.org/doi/pdf/10.1287/inte.21.4.111

Belcher, S. W., Reese, D. L., & Lawler, K. S. (2016, February). *Improving NEC fit* (DRM-2015-U-011116-1REV). Alexandria, VA: Center for Naval Analyses.

Belcher, S. W., Rodney, D. M., McIntosh, M. F., Golfin, P. A., Sutton, W. T., Griffis, H. S., . . . Lawler, K. S. (2014, July). *Improving enlisted fleet manning* (DRM-2014-U-007586). Alexandria, VA: Center for Naval Analyses.

Belenky, G., Wesensten, N. J., Thorne, D. R., Thomas, M. L., Sing, H. C., Redmond, D. P., . . . Balkin, T. J. (2003). Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: A sleep dose-response study. *Journal of Sleep Research*, *12*(1), 1–12. Retrieved from https://onlinelibrary.wiley.com/doi/full/10.1046/j.1365-2869.2003.00337.x

Bost, J. R., Mellis, J. G., & Dent, P. A. (1995). Losing the horse-holders. *U.S. Naval Institute Proceedings*, *121*(10), 89–93.

Bright, A. W., Witham, K. E., Wedding, D. A., & Bell, W. R. (1969, September). *Proposed procedures for the development of ship manning documents* (No. WRR 70-1). Washington, DC: Naval Personnel Research and Development Laboratory.

Burnout. (n.d.). In *Merriam Webster Online*. Retrieved January 9, 2018, from https://www.merriam-webster.com/dictionary/burnout

Button, R. W., Martin, B., Sollinger, J. M., & Tidwell, A. (2015). *Assessment of surface ship maintenance requirements* (No. RR1155). Santa Monica, CA: Research and Development.

Castro, C., & Adler, A. (1999). OPTEMPO: Effects on soldier and unit readiness. *Parameters*, *Autumn 1999*, 86–95. Retrieved from https://search.proquest.com/docview/1306227284?pq-origsite=gscholar

Centers for Disease Control and Prevention. (2012, November 9). Energy drink consumption and its association with sleep problems among U.S. Service Members on a combat deployment — Afghanistan, 2010. *Morbidity and Mortality Weekly Report*, *61*(44), 895–898. Retrieved from https://www.cdc.gov/mmwr/pdf/wk/mm6144.pdf

Chambers, J. W. (Ed.). (2004). *The Oxford companion to American military history.* Retrieved from http://www.encyclopedia.com/history/encyclopedias-almanacs-transcripts-and-maps

Chief of Naval Operations. (1967, August 2). *Development and review of enlisted manpower requirements in naval ships* (OPNAV Instruction 5300.3). Washington, DC: Author.

Chief of Naval Operations. (2001, August 8). *Revolution in Training: Executive review of Navy training*. Washington, DC: Author. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a419988.pdf

Chief of Naval Operations. (2007, May 30). *Navy safety and occupational health (SOH) program manual for forces afloat: SOH and major hazard-specific programs* (OPNAV Instruction 5100.19E Vol. I). Washington, DC: Author.

Chief of Naval Operations. (2008, November 17). *Merger of the Storekeeper (SK) and Postal Clerk (PC) ratings* (NAVADMIN 326/08). Washington, DC: Author.

Chief of Naval Operations. (2010a, August 10). *Navy enlisted warfare qualification programs* (OPNAV Instruction 1414.9). Washington, DC: Author.

Chief of Naval Operations. (2010b, July 2). *Operational risk management* (OPNAV Instruction 3500.39C). Washington, DC: Author.

Chief of Naval Operations. (2011, July 11). *Physical readiness program* (OPNAV Instruction 6110.1J). Washington, DC: Author.

Chief of Naval Operations. (2012, July 16). *Standard organization and regulations of the U.S. Navy: Standard organization and regulations manual (SORM)* (OPNAV Instruction 3120.32D, Encl. 1). Washington, DC: Author.

Chief of Naval Operations. (2014, March 14). *Navy personnel tempo and operating tempo program* (OPNAV Instruction 3000.13D). Washington, DC: Author.

Chief of Naval Operations. (2017, September 19). *Testimony to the Senate Committee on Armed Services on the recent U.S. Navy incidents at sea.* Washington, DC: United States Senate. Retrieved from https://www.armed-services.senate.gov/hearings/17-09-19-recent-united-states-navy-incidents-at-sea

Chief of Naval Operations. (2018, January 8). *Navy enlisted warfare qualification programs* (OPNAV Instruction 1414.9A). Washington, DC: Author.

Chung, Y., Lee, P. T., & Lee, J. (2017). Burnout in seafarers: Its antecedents and effects on incidents at sea, maritime policy & management. *Maritime Policy & Management*, *44*(7), 916–931. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/03088839.2017.1366672

Clark, B., & Sloman, J. (2015). *Deploying beyond their means: America's Navy and Marine Corps at a tipping point.* Retrieved from http://nationalinterest.org/feature/deploying-beyond-their-means-the-us-navy-marine-corps-14378

Commander, Naval Surface Force, U.S. Pacific Fleet and Commander, Naval Surface Force Atlantic. (2012, June 29). *Readiness evaluation instruction* (COMNAVSURFPAC/COMNAVSURFLANTINST 3500.10). San Diego, CA: Author.

Commander, Naval Surface Force, U.S. Pacific Fleet and Commander, Naval Surface Force Atlantic. (2013, July 17). *Surface force maintenance and material management program* (COMNAVSURFPAC/COMNAVSURFLANTINST 4790.1H). San Diego, CA: Author.

Commander, Naval Surface Force, U.S. Pacific Fleet and Commander, Naval Surface Force Atlantic. (2016, November 8). *Surface force readiness manual* (COMNAVSURFPAC/COMNAVSURFLANTINST 3502.3A). San Diego, CA: Author.

Commander, Naval Surface Force, U.S. Pacific Fleet and Commander, Naval Surface Force Atlantic. (2017, November 30). *Comprehensive fatigue and endurance management policy* (COMNAVSURFPAC/COMNAVSURFLANTINST 3120.2). San Diego, CA: Author.

Commander, Naval Surface Force, U.S. Pacific Fleet and Commander, Naval Surface Force Atlantic Commander Action Groups and Detachment Monterey. (2018, February 12). *Circadian rhythm watchbills & shipboard routines: Implementing the TYCOM comprehensive fatigue and endurance management policy (CFEMP).* San Diego, CA: Author.

Commander, Naval Surface Forces. (2004, March 9). *Optimal manning implementation best practices (number one)* (Message Identifier PSN 959468S41). San Diego, CA: Author.

Commander, U.S. Fleet Forces. (2015). *Manning target levels* (Manning Control Authority Fleet (MCAF) Directive 15-1). Norfolk, VA: U.S. Fleet Forces Command.

Commander, U.S. Fleet Forces. (2017c, October 26). *Comprehensive review of recent surface force incidents.* Norfolk, VA: U.S. Fleet Forces Command.

Comptroller General of the United States. (1978, February 6). *Report to the Congress: Additional cost of the All-Volunteer Force* (FPCD-78-11). Washington, DC: Author.

Creep. (n.d.). In *Merriam Webster Online.* Retrieved January 23, 2018, from https://www.merriam-webster.com/dictionary/creep

Crew Endurance Team. (2017). *Crew endurance.* Retrieved from Naval Postgraduate School Crew Endurance website: https://my.nps.edu/web/crewendurance

Cutler, T. J. (Ed.). (2002). *The bluejacket's manual* (23rd ed.). Annapolis, MD: Naval Institute Press. (Original work published 1902)

Dawson, D., & Reid, K. (1997, July 17). Fatigue, alcohol and performance impairment. *Nature*, *388*(6639), 235.

Defense Manpower Data Center (Ed.). (2017). *DoD personnel, workforce reports & publications.* Washington, DC: Office of the Secretary of Defense. Retrieved from https://www.dmdc.osd.mil/appj/dwp/dwp_reports.jsp

Demerouti, E., Bakker, A. B., Vardakou, I., & Kantas, A. (2003). The convergent validity of two burnout instruments: A multitrait-multimethod analysis. *European Journal of Psychological Assessment*, *19*(1), 12–23. Retrieved from https://search.proquest.com/docview/614446163

Department of Defense. (2017, August). *Defense manpower requirements report.* Washington, DC: Author.

Department of the Navy. (2008, January 24). *Decision memorandum accepting alternative arrangements for the U.S. Navy's southern California operating area Composite Training Unit Exercises (COMPTUEXs) and Joint Task Force Exercises (JTFEXs) scheduled to occur between today and January 2009* (Federal Register Notice 73 FR 4189). Washington, DC: Federal Register. Retrieved from https://www.federalregister.gov/d/E8-1175

Deputy Assistant Secretary of the Navy for Budget. (2017, May). *Department of Navy Fiscal Year 18 budget: Restore, innovate, compete.* Retrieved from http://navylive.dodlive.mil/category/readiness/budget-readiness/

Deputy Chief of Naval Operations (Manpower, Personnel, Training, and Education), N1. (2002, June 17). *Manual of Navy total force manpower policies and procedures* (OPNAV Instruction 1000.16J CH-1). Washington, DC: Author.

Deputy Chief of Naval Operations (Manpower, Personnel, Training, and Education), N1. (2007, August 22). *Navy total force manpower policies procedures* (OPNAV Instruction 1000.16K). Washington, DC: Author.

Deputy Chief of Naval Operations (Manpower, Personnel, Training, and Education), N1. (2016, April 28). *Navy total force manpower policies and procedures* (OPNAV Instruction 1000.16L CH-1). Washington, DC: Author.

Deputy Chief of Naval Personnel. (2014, May 6). *Advancement manual for enlisted personnel of the U.S. Navy and U.S. Navy Reserve* (BUPERS Instruction 1430.16F CH-1). Millington, TN: Bureau of Naval Personnel.

Desmond, P., & Matthews, G. (1997). Implications of task-induced fatigue effects for in-vehicle countermeasures to driver fatigue. *Accident Analysis and Prevention*, *29*(4), 515–523. Retrieved from https://torpedo.nrl.navy.mil/tu/ps/doc.html?vol=29&dsn=1229691&ssn=710&iss=4&st=JRNAL

Dinges, D. F., Pack, F., Williams, K., Gillen, K. A., Powell, J. W., Ott, G. E., . . . Pack, A. I. (1997, April 1). Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4–5 hours per night. *Sleep*, *20*(4), 267–277. Retrieved from https://doi.org/10.1093/sleep/20.4.267

Director, Force Structure and Readiness Issues, Government Accountability Office. (2017, September 7). *Testimony before the subcommittees on readiness and seapower and projection forces, committee on armed services, House of Representatives; Navy readiness: Actions needed to address persistent maintenance, training, and other challenges facing the fleet* (GAO Publication 17-798T). Washington, DC: U.S. Government Printing Office.

Director, Total Force Manpower Requirements, N12. (2001, October 17). *PM/CM ratio* (Email dtd October 17, 2001). Washington DC: Author.

Director, Total Force Manpower Requirements, N12. (2002, August 16). *Revised Make Ready/Put Away (MRPA) and Productivity Allowance (PA) standards* (Ser N12/2U0240). Washington DC: Author.

Director, Total Force Manpower Requirements, N12. (2013, February 13). *Revised Make Ready/Put Away Allowance for Ship Manpower Document (SMD) and Fleet Manpower Document (FMD) studies* (Ser N12/012). Washington DC: Author.

Director, Total Force Manpower Requirements, N12. (2016, April 6). *Revised variable productivity allowance* (OPNAV Ser N12/042). Washington, DC: Author.

Doering, Z. D., Hutzler, W. P., Francisco, C. M., & Sanchez, M. J. (1982, March). *Description of officers and enlisted personnel in the U.S. Armed Forces: A reference for military manpower analysis* (No. R-2851-MRAL). Santa Monica, CA: Research and Development. Retrieved from https://files.eric.ed.gov/fulltext/ED223896.pdf

Doering, Z. D., Perry, W. D., & Shishko, R. (1979, October). *Non-availability of military manpower* (No. RAND Note N-1313-MRA). Santa Monica, CA: Research and Development. Retrieved from https://www.rand.org/pubs/notes/N1313.html

Eccles, M. S. (1951). *Beckoning frontiers: Public and personal recollections* (S. Hyman, Ed.). New York: Alfred A. Knopf.

Ender, M. G. (2012). Boredom: Groundhog Day as metaphor for Iraq. In J. H. Laurence & M. D. Matthews (Eds.), *Military psychology* (pp. 311–324). New York: Oxford University Press.

Fisher, C. D. (1993). Boredom at work: A neglected concept. *Human Relations*, *46*(3), 395–417. Retrieved from http://journals.sagepub.com/doi/pdf/10.1177/001872679304600305

Fleet Review Panel. (2009, September). Readiness and assist visits: 15 years ago, 7 years ago, and today (Unclassified PowerPoint). In P. M. Balisle (Ed.), *Balisle report*, Appendix 019.

Fogel, S. M., Smith, C. T., & Cote, K. A. (2007, June 4). Dissociable learning-dependent changes in REM and non-REM sleep in declarative and procedural memory systems. *Behavioural Brain Research*, *180*(1), 48–61. Retrieved from https://brocku.ca/sleeplab/articles/The\%20effects\%20of\%20learning\%20on\%20sleep.pdf

Folkard, S. (1992). Is there a 'best compromise' shift system? *Ergonomics*, *35*(12), 1453–1463. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/00140139208967414

Frone, M. R., & Tidwell, M. O. (2015). The meaning and measurement of work fatigue: Development and evaluation of the three-dimensional work fatigue inventory (3D-WFI). *Journal of Occupational Health Psychology*, *20*(3), 273–288. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4505929/

Game, A. M. (2007). Workplace boredom coping: Health, safety, and HR implications. *Personnel Review*, *36*(5), 701–721. Retrieved from https://search.proquest.com/docview/214797291?accountid=12702

Gansler, J. S., & Lucyshyn, W. (2008, September). *Commercial-off-the-shelf (COTS): Doing it right.* College Park, MD: University of Maryland, School of Public Policy, Center for Public Policy and Private Enterprise. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a494143.pdf

Gilbreth, F. B., & Gilbreth, L. M. (1919). *Fatigue study: The elimination of humanity's greatest unnecessary waste, a first step in motion study* (2nd ed.). New York: MacMillan.

Glendon, I., & Coles, F. (2001). Stress in ambulance staff. In P. A. Hancock & P. A. Desmond (Eds.), *Stress, workload, and fatigue* (pp. 167–199). Mahwah, NJ: Lawrence Erlbaum Associates.

Golfin, P. A., Belcher, S. W., & Reese, D. L. (2011, August). *Impact of individual augmentees (IAs) on personnel readiness levels* (CRM D0025374.A2). Alexandria, VA: Center for Naval Analyses.

Government Accountability Office. (1986, March). *Navy manpower: Improved ship manpower document program could reduce requirements.* Washington, DC: U.S. Government Printing Office.

Government Accountability Office. (2010, June). *Military readiness: Navy needs to reassess its metrics and assumptions for ship crewing requirements and training* (GAO-10-592). Washington, DC: U.S. Government Printing Office.

Government Accountability Office. (2011, July 7). *Military readiness: Navy's report to Congress on the impact of training and crew size on surface force material readiness* (GAO-11-746R). Washington, DC: U.S. Government Printing Office.

Government Accountability Office. (2015, May). *Navy force structure: Sustainable plan and comprehensive assessment needed to mitigate long-term risks to ships assigned to overseas homeports* (GAO Publication 15-329). Washington, DC: U.S. Government Printing Office.

Government Accountability Office. (2016, September). *Military readiness: DoD's readiness rebuilding efforts may be at risk without a comprehensive plan* (GAO Publication 16-841). Washington, DC: U.S. Government Printing Office.

Government Accountability Office. (2017a, September). *Naval shipyards: Actions needed to improve poor conditions that affect operations* (GAO Publication 17-548). Washington, DC: U.S. Government Printing Office.

Government Accountability Office. (2017b, May). *Navy force structure: Actions needed to ensure proper size and composition of ship crews* (GAO Publication 17-413). Washington, DC: U.S. Government Printing Office.

Green, K. Y. (2009). *A comparative analysis between the Navy Standard Work Week and the actual work/rest patterns of sailors aboard U.S. Navy frigates* (Master's thesis). Naval Postgraduate School, Monterey, California.

Greenert, J. (2015, September). The moral component of leadership. *U.S. Naval Institute Proceedings*, *141*(9), 1351. Retrieved from https://www.usni.org/magazines/proceedings/2015-09/moral-component-leadership

Guided Missile Destroyer 3M System Coordinator (3MC). (2018). *Sample DDG 3M PMS and Spot Checks, Twelve Months* [Data File]. San Diego, CA: Sample DDG.

Halbesleben, J. R. B. (2010, January). The role of exhaustion and workarounds in predicting occupational injuries: A cross-lagged panel study of health care professionals. *Journal of Occupational Health Psychology*, *15*(1), 1–16. Retrieved from https://search.proquest.com/docview/614512019

Hart, S. G., Battiste, V., & Lester, P. T. (1984, September 1). *Popcorn: A supervisory control simulation for workload and performance research* (Conference Paper). 20th Annual Conference on Manual Control, Vol. 1. Moffett Field, CA: NASA Ames Research Center. Retrieved from https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19850006206.pdf

Haynes, L. E. (2007). *A comparison between the Navy Standard Workweek and the actual work and rest patterns of U.S. Navy sailors* (Master's thesis). Naval Postgraduate School, Monterey, California.

Hebb, D. O. (1955). Drives and the C.N.S. (conceptual nervous system). *Psychological Review*, *62*, 243–254. Retrieved from https://search.proquest.com/docview/614251374

Hinkle, J. B., & Glover, T. L. (2004, March 18). *Reduced manning in DDG 51 class warships: Challenges, opportunities and the way ahead for reduced manning on all US Navy ships.* Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA422116

Houtman, I., Miedema, M., Jettinghoff, K., Starren, A., Heinrich, J., Gort, J., . . . Wubbolts, S. (2005, December 28). *Fatigue in the shipping industry* (No. TNO-Report 20834/11353). Hoofddorp, Netherlands: TNO Quality of Life: Work and Employment. Retrieved from http://www.he-alert.org/filemanager/root/site_assets/standalone_article_pdfs_0605-/HE00605.pdf

International Labour Conference. (2014). *Maritime Labour Convention, 2006, as amended.* Retrieved from http://www.ilo.org/wcmsp5/groups/public/---ed_norm/---normes/documents/normativeinstrument/wcms_554767.pdf

International Maritime Organization. (2001, June 12). *Guidance on fatigue mitigation and management* (MSC/Circ.1014). Retrieved from http://www.imo.org/ourwork/humanelement/visionprinciplesgoals/documents/1014.pdf

International Maritime Organization. (2010, August 3). *Adoption of the final act and any instruments, regulations and recommendations resulting from the work of the conference* (STCW/CONF.2/34, Agenda Item 10). Retrieved from http://www.gc.noaa.gov/documents/afs-convention.pdf

International Maritime Organization. (2018). *Member states.* Retrieved from http://www.imo.org/en/About/Membership/Pages/MemberStates.aspx

Joint Commission [for health care]. (2011, December 14). Sentinel event alert: Health care worker fatigue and patient safety. *The Joint Commission Sentinel Event Alert*(48). Retrieved from https://www.jointcommission.org/assets/1/18/SEA_48.pdf

Kanawaty, G. (Ed.). (1992). *Introduction to work study* (4th ed.). Geneva, Switzerland: International Labour Office.

Karni, A., Tanne, D., Rubenstein, B. S., Askenasy, J. J. M., & Sagi, D. (1994, July 29). Dependence on REM sleep of overnight improvement of a perceptual skill. *Science*, *265*(5172), 679–682. Retrieved from http://www.jstor.org/stable/2884281

Kern, D. H. (1969, December). Planning and engineering for repairs and alterations (PERA). *Naval Engineers Journal*, *81*(6), 28–32. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1559-3584.1969.tb05172.x

Konz, S. (2001a, December). Manpower resource planning: Methods engineering. In G. Salvendy (Ed.), *Handbook of Industrial Engineering* (3rd ed., pp. 1353–1390). New York: Wiley-Interscience. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1002/9780470172339

Konz, S. (2001b, December). Manpower resource planning: Time standards. In G. Salvendy (Ed.), *Handbook of Industrial Engineering* (3rd ed., pp. 1391–1408). New York: Wiley-Interscience. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1002/9780470172339

Koopman, M. E., & Golding, H. L. W. (1999, July). *Optimal manning and technological change* (CRM 99-59). Alexandria, VA: Center for Naval Analyses.

Larsen, R. (2001). Decision-making by military students under extreme stress. *Military Psychology*, *13*(2), 89–98. Retrieved from https://search.proquest.com/docview/1288301801

Loft, M., & Cameron, L. (2014). The importance of sleep: Relationships between sleep quality and work demands, the prioritization of sleep and pre-sleep arousal in day-time employees. *Work & Stress*, *28*(3), 289–304. Retrieved from http://dx.doi.org/10.1080/02678373.2014.935523

Lull, E. W. (1981, June). *Development of officer requirements study* (No. N00014-81-C-0125). McLean, VA: Resource Consultants, Inc.: Resource Consultants, Inc. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA108206

Manning Control Authority Bureau. (n.d.). *MCA BUREAU (PERS-453).* Millington, TN: Navy Personnel Command. Retrieved January 7, 2018, from http://www.public.navy.mil/bupers-npc/support/distribution/Pages/Pers_453.aspx

Mason, D. R. (2009). *A comparative analysis between the Navy Standard Work Week and the work/rest patterns of sailors aboard U.S. Navy Cruisers* (Master's thesis). Naval Postgraduate School, Monterey, California.

McCallum, M. C., Raby, M., & Rothblum, A. M. (1996, September). *Procedures for investigating and reporting human factors and fatigue contributions to marine casualties* (Tech. Rep. No. CG-D-09-97). Seattle, WA: Battelle Seattle Research Center and U.S. Coast Guard Research and Development Center.

McGuinness, B., & Ebbage, L. (2002, May). *Assessing human factors in command and control: Workload and situational awareness metrics.* Bristol, England: BAE Systems Advanced Technology Centre. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA467497

Melamed, S., Shirom, A., Toker, S., Berliner, S., & Shapira, I. (2006). Burnout and risk of cardiovascular disease: Evidence, possible causal paths, and promising research directions. *Psychological Bulletin*, *132*(3), 327–353. Retrieved from https://search.proquest.com/docview/614443813

Milgram, N. A., Orenstein, R., & Zafrir, E. (1989). Stressors, personal resources, and social supports in military performance during wartime. *Military Psychology*, *1*(4). Retrieved from https://search.proquest.com/docview/1288301838?accountid=12702

Miller, J. C., & Eddy, D. R. (2008, August). *Operational risk management of fatigue effects II* (No. AFRL-RH-BR-TR-2009-0030). Fairborn, OH: NTI Inc. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA501985

Mitchell, J. L., & Driskill, W. E. (1996). Military job analysis: A historical perspective. *Military Psychology*, *8*(3). Retrieved from https://search.proquest.com/docview/1288301780?accountid=12702

Moore, C. S., Gasch, J. L., Hattiangadi, A. U., Quinton, J., & Schriver, K. (2002). *Hours of work at sea: An empirical analysis* (CAB D0005118.A2). Alexandria, VA: Center for Naval Analyses.

Moore, C. S., Griffis, H. S., & Keenan, J. D. (2001, January). *The Navy standard workweek: A preliminary assessment* (CAB D0003113.A1). Alexandria, VA: Center for Naval Analyses.

Moore, C. S., Hattiangadi, A. U., Gasch, J. L., & Sicilia, G. T. (2002, March). *Inside the black box: Assessing the Navy's manpower requirements process* (CRM D0005206.A2). Alexandria, VA: Center for Naval Analyses.

Murphy, P. (Ed.). (2002). *Fatigue management during operations: A commander's guide.* Puckapunyal, Vic: Doctrine Wing Land Warfare Development Centre. Retrieved from http://www.defence.gov.au/Health/About/Docs/FatigueManagementHandbook.pdf

National Transportation and Safety Board. (2016). Lessons learned from marine accident investigations. *NTSB Safer Seas Digest*. Retrieved from https://www.ntsb.gov/investigations/AccidentReports/Pages/SPC1701.aspx

National Defense Authorization Act for Fiscal Year 2017, H.R. 4909, 114th Cong. (2016, May 4).

Naval Education and Training Command. (2014, March). *Personnel qualification standard for antiterrorism common core* (NAVEDTRA 43387-2F). Norfolk, VA: Naval Personnel Development Command.

Naval Sea Systems Command. (2015, November 30). *Ships' Maintenance and Material Management (3-M) manual* (NAVSEAINST 4790.8C CH-1). Washington Navy Yard, DC: Author.

Naval Sea Systems Command. (2016, December 21). *Shipboard habitability design criteria and practices manual (surface ships) for new ship designs and modernization* (T9640-AC-DSP-010/HAB, Rev. 1). Washington Navy Yard, DC: Author.

Naval Sea Systems Command. (2017a, September 19). Chapter 19: Maintenance and material management. In *Joint Fleet Maintenance Manual, Volume VI* (COMUSFLTFORCOMINST 4790.3 REV C CH-6) (pp. VI-19-1–VI-19F-2). Norfolk, VA: U.S. Fleet Forces Command.

Naval Sea Systems Command. (2017b, September 19). Chapter 41: Maintenance and project team. In *Joint Fleet Maintenance Manual, Volume VI* (COMUSFLTFORCOMINST 4790.3 REV C CH-6) (pp. VI-41-1–VI-41-24). Norfolk, VA: U.S. Fleet Forces Command.

Naval Sea Systems Command. (2017a, October 30). *Naval vessel register: Ship battle forces.* Retrieved from http://www.nvr.navy.mil/NVRSHIPS/SHIPBATTLEFORCE.HTML

Naval Sea Systems Command. (2017b, January). *Surface maintenance engineering planning program (SURFMEPP) program summary.* Retrieved from http://www.navsea.navy.mil/Home/Team-Ships/NAVSEA-21/SURFMEPP/

Naval Surface Forces. (2009, October). Manpower changes FY02-FY09 for Surface Forces (Unclassified PowerPoint). In P. M. Balisle (Ed.), *Balisle report*, Appendix 008.

Naval Surface Forces. (2013, May 3). *Circadian watchbill* (Message Identifier RHMFIUU0950 1232157). San Diego, CA: Author.

Naval Surface Forces. (2016, February 2). *Warfighting serial ten: Individual readiness* (Message Identifier RAAUZYUW RULYFOO0140 0332001). San Diego, CA: Author.

Navy Inspector General. (2009, March). *Naval Inspector General report to the Secretary of the Navy: Computer based training.*

Navy Manpower Analysis Center. (n.d.). *Glossary: Manpower definitions.* Retrieved January 25, 2018, from http://www.public.navy.mil/bupers-npc/organization/navmac/Documents/MANPOWERGLOSSARY.doc

Navy Manpower Analysis Center. (2000, April). *Navy Total Force Manpower Requirements Handbook*. Millington, TN: Navy Personnel Command. Retrieved from http://www.public.navy.mil/bupers-npc/organization/navmac/Documents/ReqHdBk.pdf

Navy Manpower Analysis Center. (2008, July 11). Where we are and how we got here – surface force manpower (Unclassified Memorandum). In P. M. Balisle (Ed.), *Balisle report*, Appendix 008. Millington, TN: Author.

Navy Manpower Analysis Center. (2016a, April). *Fleet manpower requirements: Introduction to Code 40*. Millington, TN: Navy Personnel Command. Retrieved from http://www.public.navy.mil/bupers-npc/organization/navmac/Documents/Code_40_APR_16_ver_2.ppt

Navy Manpower Analysis Center. (2016b, February). *Navy Manpower Analysis Center*. Millington, TN: Navy Personnel Command. Retrieved from http://www.public.navy.mil/bupers-npc/organization/navmac/Pages/default3.aspx

Navy Manpower Analysis Center. (2017a, September 18). *Activity manpower management guide*. Millington, TN: Navy Personnel Command. Retrieved from http://www.public.navy.mil/bupers-npc/organization/navmac/Documents/AMMG_SEP2017.pdf

Navy Manpower Analysis Center. (2017b, April). *NAVMAC at a glance brief: Command overview*. Millington, TN: Author. Retrieved from http://www.public.navy.mil/bupers-npc/organization/navmac/Documents/NAVMAC_AT_A_GLANCE_Apr17.pptx

Navy Manpower Analysis Center Afloat Programs Department Director. (2009a, March 17). *Collateral duty data collection for SMD/FMD development* (Memorandum, Afloat Programs Department, Ser 002). Millington, TN: Author.

Navy Manpower Analysis Center Afloat Programs Department Director. (2009b, March 16). *Productivity allowance application criteria* (Memorandum, Afloat Programs Department, Ser 001). Millington, TN: Author.

Navy Manpower Analysis Center Code 20. (2018, January 18). Personal Communication.

Navy Manpower Analysis Center Code 40. (2017, September 14). Personal Communication. Millington, TN: Navy Manpower Analysis Center.

Navy Manpower Analysis Center, Codes 20 and 40. (2017, April 21). Personal Communication. Millington, TN: Navy Manpower Analysis Center.

Navy Manpower Analysis Center Commanding Officer. (2018, January 9). Personal Communication. Monterey, CA: Naval Postgraduate School.

Navy Personnel Command (PERS-00D). (2015a, February 22). *Acceptance and disposition of returned deserters* (MILPERSMAN 1600-030). Millington, TN: Author. Retrieved from http://www.public.navy.mil/bupers-npc/reference/milpersman/1000/1600Performance/Documents/1600-030.pdf

Navy Personnel Command (PERS-00D1). (2015b, April 16). *Deserters* (MILPERSMAN 1600-010). Millington, TN: Author. Retrieved from http://www.public.navy.mil/bupers-npc/reference/milpersman/1000/1600Performance/Documents/1600-010.pdf

Navy Personnel Command, PERS-91. (2013, March 29). *Leave policy* (MILPERSMAN 1050-010). Millington, TN: Author. Retrieved from http://www.public.navy.mil/bupers-npc/reference/milpersman/1000/1000General/Documents/1050-010.pdf

Office of the Chief of Naval Operations, Force Manpower and Assessments (OPNAV N122). (2009, November 3). Navy ship manning levels (Unclassified Document). In P. M. Balisle (Ed.), *Balisle report*, Appendix 020.

Office of the Chief of Naval Operations (OPNAV N1). (2009). Top six alignment deck plate explanation CNP priority, (Unclassified Document). In P. M. Balisle (Ed.), *Balisle report*, Appendix 035.

Osborn, C. M. (2004). *An analysis of the effectiveness of a new watchstanding schedule for U.S. submariners* (Master's thesis). Naval Postgraduate School, Monterey, California.

Overload. (n.d.). In *Merriam Webster Online.* Retrieved January 5, 2018, from https://www.merriam-webster.com/dictionary/overload

Parks, D. L., & Boucek, G.P., Jr. (1989). Workload prediction, diagnosis, and continuing challenges. In G. R. McMillan, D. Beevis, E. Salas, M. H. Strub, R. Sutton, & L. van Breda (Eds.), *Applications of human performance models to system design* (pp. 47–63). Berlin, Germany: Springer Science & Business Media.

Permanent end strength levels to support two major regional contingencies, 10 U.S.C. §691. (2011).

Personnel strengths: Requirement for annual authorization, 10 U.S.C. §115. (2006).

Plato, A. I. (1974). The naval engineer and shipboard manpower utilization. *Naval Engineers Journal*, *86*(1), 33–38. Retrieved from https://onlinelibrary.wiley.com/doi/full/10.1111/j.1559-3584.1974.tb03565.x

Plato, A. I. (1975). Manpower determination model–a tool for the naval engineer. *Naval Engineers Journal*, *87*(4), 51-57. Retrieved from https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1559-3584.1975.tb03756.x

Ponce, B. P. (2004). *Hollow promises: The problem of culture and the integration of new technology into the Navy* (Monograph). School of Advanced Military Studies, United States Army Command and General Staff College, Fort Leavenworth, Kansas.

Readiness and Sustainment of the Navy's Surface Fleet, House, 111th Cong. 31. (2009a). (Testimony of Deputy Commander for Surface Warfare, Naval Sea Systems Command (SEA 21)). Retrieved from https://www.gpo.gov/fdsys/pkg/CHRG-111hhrg49866/html/CHRG-111hhrg49866.htm

Readiness and Sustainment of the Navy's Surface Fleet, House, 111th Cong. 31. (2009b). (Testimony of Director, Fleet Readiness Division (OPNAV N43), Director of Staff, Fleet Maintenance Officer (USFF N43), Deputy Commander for Surface Warfare, Naval Sea Systems Command (SEA 21), and Deputy Commander Naval Systems Engineering, Naval Sea Systems Command (SEA 05)). Retrieved from https://www.gpo.gov/fdsys/pkg/CHRG-111hhrg49866/html/CHRG-111hhrg49866.htm

Readiness reporting system: Establishment; reporting to congressional committees, 10 U.S.C. §117. (2003).

Roberts, D. A. (2012). *Analysis of alternative watch schedules for shipboard operations: A guide for commanders* (Master's thesis). Naval Postgraduate School, Monterey, California.

Rodney, D. M., Bowes, M. D., Duquette, C. M., Russell, S. M., Lawler, K. S., & Oi, J. S. (2009, November). *Impact of manning and infrastructure initiatives on the surface Navy* (CRM D0021247.A2). Alexandria, VA: Center for Naval Analyses.

Ronen, B., Lechler, T. G., & Stohr, E. A. (2012, January 12). The 25/25 rule: Achieving more by doing less. *International Journal of Production Research*, *50*(24), 7126–7133. Retrieved from https://en-coller.tau.ac.il/sites/nihul_en.tau.ac.il/files/RP_228_Ronen.pdf

Shattuck, N., & Matsangas, P. (2014a). *Jason Dunham Navy Standard Work Week* (Data File). Monterey, CA: Naval Postgraduate School.

Shattuck, N., & Matsangas, P. (2014b, September). *Work and rest patterns and psychomotor vigilance performance of crewmembers of the USS Jason Dunham: A comparison of the 3/9 and 6/6 watchstanding schedules.* Retrieved from http://hdl.handle.net/10945/44348

Shattuck, N., & Matsangas, P. (2015). Operational assessment of the 5-h on/10-h off watchstanding schedule on a US Navy ship: Sleep patterns, mood and psychomotor vigilance performance of crewmembers in the nuclear reactor department. *Ergonomics*, *59*(5). Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/26360772

Shay, J. (1998). Ethical standing for commander self-care: The need for sleep. *Parameters*, *28*(2), 93–105. Retrieved from http://ssi.armywarcollege.edu/pubs/parameters/articles/98summer/shay.htm

Shipping: Watches, 46 U.S.C. §8104. (1996).

Shipping: Work hours and rest periods, 46 CFR §15.1111. (1997).

Sisson, G. R. (2001). *Hands-on training : A simple and effective method for on-the-job training*. Oakland, CA: Berrett-Koehler Publishers, Incorporated. Retrieved from https://ebookcentral.proquest.com/lib/ebook-nps/detail.action?docID=479235

Smith, A., Lane, T., & Bloor, M. (2002). An overview of fatigue in support shipping in the offshore oil industry. In P. T. McCabe (Ed.), *Contemporary ergonomics 2003* (pp. 113–118). Boca Raton, FL: CRC Press.

Sommers, J., & Vodanovich, S. J. (2000, January). Boredom proneness: Its relationship to psychological and physical health symptoms. *Journal of Clinical Psychology*, *56*(1), 149–155. Retrieved from https://doi.org/10.1002/(SICI)1097-4679(200001)56:1<149::AID-JCLP14>3.0.CO;2-Y

Sorenson, R. C. (Ed.). (1982, February). *Consolidated bibliography: Unclassified technical reports, special reports, and technical notes: FY 1974 through FY 1981* (No. NPRDC TR 82-34F). San Diego, CA: Navy Personnel Research and Development Center.

Spector, P. E., & Fox, S. (2002). An emotion-centered model of voluntary work behavior: Some parallels between counterproductive work behavior and organizational citizenship behavior. *Human Resource Management Review*, *12*(2), 269–292. Retrieved from https://torpedo.nrl.navy.mil/tu/ps/doc.html?vol=12&dsn=1035772&ssn=304&iss=2&st=JRNAL

Spindel, R. C., Laska, S., Cannon-Bowers, J. A., Cooper, D. L., Hegmann, K. C., Hogan, R. J., . . . Smith, J. A. (2000, April). *Optimized surface ship manning* (No. NRAC-00-1). Arlington, VA: Naval Research Advisory Committee.

Statistic Brain. (2017, August 12). *Demographics of Active Duty U.S. Military.* Retrieved from https://www.statisticbrain.com/demographics-of-active-duty-u-s-military/

Surface Warfare Directorate, N96. (2017, July 28). *Required operational capabilities and projected operational environment for (Arleigh Burke) Class Guided Missile Destroyers* (OPNAV Instruction F3501.311C). Washington, DC: Chief of Naval Operations.

Taylor, F. W. (1967). *The principles of scientific management*. New York, NY: Norton & Company.

Total Force Planning and Requirements Directorate. (2016, April). *Defense manpower requirements report.* Washington, DC: Office of the Assistant Secretary of Defense for Manpower and Reserve Affairs. Retrieved from http://prhome.defense.gov/Portals/52/Documents/RFM/TFPRQ/docs/FY16DMRR.PDF

Turner, N., Hershcovis, M., Reich, T. C., & Totterdell, P. (2014). Work-family interference, psychological distress, and workplace injuries. *Journal of Occupational and Organizational Psychology*, *87*(4), 715–732. Retrieved from http://eprints.whiterose.ac.uk/94557/3/WRRO_94557.pdf

Under Secretary of Defense for Personnel and Readiness. (2005, February 12). *Guidance for manpower management* (DOD Directive 1100.4). Washington, DC: Department of Defense.

Under Secretary of Defense for Personnel and Readiness. (2015, March 17). *Programming and accounting for active component military manpower* (DOD Instruction 1120.11). Washington, DC: Department of Defense.

Underload. (n.d.). In *Merriam Webster Online.* Retrieved December 13, 2017, from https://www.merriam-webster.com/dictionary/underload

United States Coast Guard. (2013, July 30). *Guidance implementing the Maritime Labour Convention, 2006* (NVIC 02-13). Retrieved from http://www.dco.uscg.mil/Portals/9/DCO\%20Documents/5p/5ps/NVIC/2013/NVIC-02-13(Ch1).pdf

United States Navy: Composition; functions, 10 U.S.C. §5062. (2006).

U.S. Navy Chief of Information. (2018, February 28). *United States Navy fact file: Destroyers - DDG.* Retrieved from http://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=900&ct=4

van Hooff, M. L. M., Geurts, S. A. E., Beckers, D. G. J., & Kompier, M. A. J. (2011). Daily recovery from work: The role of activities, effort and pleasure. *Work & Stress*, *25*, 55–74. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/02678373.2011.570941

van Hooff, M. L. M., & van Hooft, E. A. J. (2014). Boredom at work: Proximal and distal consequences of affective work-related boredom. *Journal of Occupational Health Psychology*, *19*(3), 348–359. Retrieved from https://search.proquest.com/docview/1533053182

Vice Chief of Naval Operations. (1967, September 13). *Navy Standard Work Week for enlisted personnel afloat* (Memorandum). Washington, DC: Author.

Vice Chief of Naval Operations. (2017, February 7). *Testimony to the House Armed Services Committee on state of the military.* Retrieved from http://docs.house.gov/meetings/AS/AS00/20170207/105530/HHRG-115-AS00-Wstate-MoranW-20170207.pdf

Weaver, J. L., Bowers, C. A., & Salas, E. (2001). Stress and teams: Performance effects and interventions. In P. A. Hancock & P. A. Desmond (Eds.), *Stress, workload, and fatigue* (pp. 83–106). Mahwah, NJ: Lawrence Erlbaum Associates.

Wedding, D. A., & Hutchins, E.S., Jr. (1974, October). *Navy manpower planning and programming: Basis for systems examination* (Tech. Rep. No. 75-19). Naval Personnel Research and Development Center. Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a015325.pdf

Wickens, C., & Tsang, P. S. (2015). Workload. In D. A. Boehm-Davis, F. T. Durso, & J. D. Lee (Eds.), *Handbook of Human Systems Integration* (pp. 277–292). Washington, DC: American Psychological Association.

Wiesner, M., Windle, M., & Freeman, A. (2005, April). Work stress, substance use, and depression in young adults: An examination of main and moderator effect models. *Journal of Occupational Health Psychology*, *10*(2), 83–96. Retrieved from https://search.proquest.com/docview/614455289

Wilkinson, R., Edwards, R., & Haines, E. (1966). Performance following a night of reduced sleep. *Psychonomic Science*, *5*(12), 471–472. Retrieved from https://link.springer.com/content/pdf/10.3758/BF03328474.pdf

Wilkinson, R. T. (1992). How fast should the night shift rotate? *Ergonomics*, *35*(12), 1425–1446. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/00140139208967412

Winston, P. H., Low, R. D., Etter, D., Held, D. N., Hieb, L. D., Kauderer, B. M., . . . Peden, I. C. (1995, October). *Reduced ship manning* (No. NRAC-95-2). Arlington, VA: Naval Research Advisory Committee.

Wong, L., & Gerras, S. J. (2015, February). *Lying to ourselves: Dishonesty in the Army profession.* Carlisle Barracks, PA: United States Army War College Press.

Workload. (n.d.). In *Merriam Webster Online.* Retrieved January 5, 2018, from https://www.merriam-webster.com/dictionary/workload

Yardley, R. J., Raman, R., Riposo, J., Chiesa, J., & Schank, J. F. (2006). *Impacts of the fleet response plan on surface combatant maintenance* (No. TR358). Santa Monica, CA: Research and Development.

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