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THESIS

**SUITABILITY OF ROYAL AUSTRALIAN NAVY
STANDARD WORK WEEK IN RELATION TO
FATIGUE LEVELS FOR OPERATIONAL TASKINGS**

by

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December 2020

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**SUITABILITY OF ROYAL AUSTRALIAN NAVY STANDARD WORK WEEK
IN RELATION TO FATIGUE LEVELS FOR OPERATIONAL TASKINGS**

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ABSTRACT

This thesis assessed the manning structure of HMAS Warramunga in at-sea conditions against Navy Standard Work Week (NSWW) criteria such that a Scheme of Complement (SoC) is “sufficient” to meet the workload and sustainment requirements. IMPRINT Pro Forces Module was used to model planned activities and unplanned events of sailors to include the Marine Engineering Department to assess workload, daily sleep duration (DSD), training, service diversion activities, and task completion rates.

Results showed that the crew slept less and worked more than the NSWW criteria. Also, completion rates for all but the highest priority events were low. These findings indicate crew had little surge capacity available without sacrificing administrative and maintenance tasks. With clearer understanding of the limitations on the ship imposed by crew size, decision-makers will be able to assign operational tasking based on knowledge of expected endurance of a ship to maintain such an operational tempo.

Findings indicate that the NSWW in its current state should not be used solely to define ships’ SoC. However, using modeling and simulation (M&S) combined with SMEs’ knowledge will provide insight on crew workload, lead to improved SoC, and fulfill the ship’s Statement of Operating Intent (SOI). Another potential application of IMPRINT could be to assess the ship’s pre-sailing risk state based off the ship’s current manning levels and maintenance requirements.

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LIST OF ACRONYMS AND ABBREVIATIONS

AB	Able Seaman
ACPB	Armidale Class Patrol Boat
AFS	Average Funded Strength
AMEO	Assistant Marine Engineering Officer
AMPS	RAN Maintenance Management Tool
ANP	Australian Navy Publication
BAL	Blood Alcohol Level
CM	Corrective Maintenance
CMDR	Commander
CN	Chief of Navy
CPO	Chief Petty Officer
DCN	Deputy Chief of Navy
DGFNW	Director General of Future Navy Workforce
DMEO	Deputy Marine Engineering Officer
DNEPP	Directorate of Navy Engineering Publication and Policy
DSD	Daily Sleep Duration
DSTG	Defence Science Technology Group (formerly DSTO)
DSTO	Defence Science and Technology Organization (See DSTG)
ECCD	Engineering Casualty Control Drill
ET	Electronics Technician
FFH	Guided Missile Frigate
FTE	Full-Time Equivalent
GM	General Maintenance
HADR	Humanitarian Aid and Disaster Relief
HMAS	Her Majesty's Australian Ship
IMPRINT	Improved Performance and Research Integration Tool
JOUT	Junior Officer Under Training
LCDR	Lieutenant Commander
LCS	Littoral Combat Ship
LEUT	Lieutenant

LS	Leading Seaman
MAPS	Manpower Analysis and Planning System
ME	Marine Engineering
ME01	Marine Engineering Sub-department 01
ME02	Marine Engineering Sub-department 02
ME03	Marine Engineering Sub-department 03
ME04	Marine Engineering Sub-department 04
MEO	Marine Engineering Officer
MT	Marine Technician
NAF	Navy Availability Factor
NFW	Navy Future Workforce
NGN	New Generation Navy
NMD	Navy Management Diary
NPS	Naval Postgraduate School
NREM	Non-Rapid Eye Movement
NSWW	Navy Standard Working Week
OJT	On the Job Training
PAF	Productive Availability Factor
PM	Planned Maintenance
PO	Petty Officer
PQ	Primary Qualification
PT	Productive Time
Pty	Priority
Qty	Quantity
RAN	Royal Australian Navy
REM	Rapid Eye Movement
Rqd	Required
SAD	Ship's Army Detachment
SBLT	Sub-Lieutenant
SCN	Suprachiasmatic Nuclei
SE	Standard Error
SMD	Ship Manpower Document

SME	Subject Matter Expert
SMN	Seaman
SoC	Scheme of Complement
SOI	Statement of Operating Intent
TIB	Time in Bed
TST	Total Sleep Time
TWT	Total Work Time
UDW	Unspecified Departmental work
U/T	Under Training
URE	Unit Readiness Evaluation
USN	United States Navy
WE	Weapons Electrical Engineering
WO	Warrant Officer
WSB	Watch and Station Bill
WS-G	Whole Ship - General

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I. INTRODUCTION

The manning of Royal Australian Navy (RAN) Ships is critical for successful mission completion as directed by the Australian Government. Since the introduction of *Australian Navy Publication 2101* (Royal Australian Navy [RAN], 2017), the RAN has used the Navy Standard Work Week (NSWW) to guide initial and subsequent crew sizing. To allocate manning levels, the RAN uses the NSWW as a means to identify a scheme of complement (SoC) for each class of ship. Specifically, the SoC identifies what type and how many personnel are required to operate at full capacity and is broken into rank, category, and sub-specialization, with each unique position identified by its billet number.

However, there appears to be a disparity between work hours, as defined by the NSWW, and what is actually needed to operate a ship during both war and peacetime situations. Naval ships are required to operate 24 hours a day 7 days a week, at varying readiness levels, with a myriad of potential taskings and under a variety of environmental conditions. To achieve the ship's mission, the crew is broken into a combination of watchkeeping teams and daylight-hour working hands. Daylight tasks are typically completed by personnel identified as "day hands." Day hands perform preventative and corrective maintenance, training, communal, and administrative tasks; however, day hands are expected to work outside of daylight hours when required. Watchkeepers maintain 24-hour manning via rotational shift-based crewing determined by department function as well as the ship's readiness or alert level. Typical watchkeeper roles include navigation/bridge staff, operations room, and engineering staff. Watchkeepers generally execute the ship's program and undertake monitoring and exigent tasks.

Due to the diverse range of potential requirements for each individual crew member, accurately capturing individual workloads is challenging. The introduction of the NSWW by the RAN has tried to bridge this gap, but there appears to be a significant disparity between crewmember specializations that is not accounted for by the NSWW, as it only provides guidance on a generic enlisted member (RAN, 2017). Insufficient manning requires personnel to consistently operate at surge levels to achieve standard mission goals with no/limited ability to work at higher capacities if/when unplanned events occur.

Sustained high levels of workload can ultimately burn out individuals causing injury (physical or mental), reluctance for personnel to post to ships, or separation from the Navy, all of which have far-reaching affects throughout the RAN in the near and long term (Deputy Chief of Navy [DCN], 2018).

Ships are rarely manned at 100% crew levels unless on operational tasking due to higher manning priorities being assigned to operational ships (Chief of Navy [CN], 2019). Reasons that lead to understaffing can be short-notice injury, insufficient pool of suitably qualified personnel, required shore time respite, external training, leave, and unforeseen personal circumstances. These reasons are not factored into SoC design and are beyond the control of ship's management to counter. To compound this discrepancy, as technology in modern ship design has increased, the expectation of ship designers and policy makers is that ships can be manned with even fewer personnel while achieving the same if not better performance than aging or obsolete platforms (RAN, 2019).

An operating cycle for a ship is described as “ships’ sailing schedule,” which is broken up into periods at sea and periods alongside for the conduct of maintenance and crew respite. The disparity between actual operating cycles and predicted operating cycles causes a number of critical problems. The dangers of operating a ship in both benign and hostile environments make it critical for the crew to remain alert and vigilant; maintaining alertness and vigilance is not possible when crews are undermanned and/or excessive weekly work routines exist resulting in fatigued crewmembers (RAN, 2019). Moreover, disparity between actual operating cycles and predicted operating cycles leads to a requirement to conduct SoC reviews. SoC reviews are conducted at various timepoints: for a future class of ship, within the first 24 months of introduction for a new class of ship, following a change of operating intent or significant equipment change, and at least every five years. Another trigger for a SoC review can be due to suspected deficiency of a ship's SoC, which can be identified by accumulative incomplete administrative and maintenance tasks (RAN, 2020). Low crew levels—in addition to deferred maintenance—can ultimately affect a ship's ability to operate through to its end of life (Maurer, 2019). Ships operating while undermanned could lead to ships not meeting life expectancy, excessive external maintenance costs, and premature personnel separation due to excessive workloads,

causing hollowness in the workforce at key ranks for enlisted and officers (Maurer, 2019; Miranda, 2019). Hollowness in the workforce could result in further exacerbated work routines, due to an inability to train replacement personnel in sufficient time, resulting in even fewer personnel being posted to a ship and spreading an even greater workload through those who remain.

Therefore, this thesis investigates if the RAN's use of NSWV guidelines for defining a ship's SoC provides sufficient personnel to achieve a ship's operational objective during deployment, without detriment to its maintenance, collective crew training, individual advancement training, and ship administration requirements. In particular, this thesis will focus on the HMAS *Warramunga* trial to identify if the ship was insufficiently manned to a point where their operation, maintenance, and administration requirements became unachievable due to excessive fatigue levels.

A. ROYAL AUSTRALIAN NAVY POLICY

The introduction of NSWV into the RAN was born from a culture that encouraged looking for ways to implement improvements to look after its people. The RAN program New Generation Navy (NGN) commenced in 2009 and was based on three pillars: People, Performance, and Professionalism. The three pillars were designed to provide guidance to RAN personnel on maximizing job performance and engaging in socially and personally healthy behaviors. The first pillar's fundamental values were an agreement to respect everyone's contribution whilst encouraging individuals to consider how to help each other fully contribute to the RAN. The second pillar, Performance, was directed at empowering individuals to take action to improve individual workplaces. The third pillar, Professionalism, related directly to the RAN's vision statement, "An Australian Navy renowned for excellence in service to the nation," and its motto: "Navy—Serving Australia with Pride" (Groot, 2015; Kemp, 2008).

In 2013, the RAN's NGN strategy was updated by the Chief of the Navy (CN) to reflect cultural improvements that had occurred over the previous four years. The RAN's new strategy was described by the CN as:

1. Trusted to defend Australia and its interests by being ready to fight and win at sea,
2. Proven to deliver seaworthy and mission ready forces, and
3. Diverse and respectful always, where we live our Signature Behaviors and Values every day. (Naval Today, 2013)

The three statements are designed to encapsulate what the RAN is striving to become and are intrinsically linked to RAN culture and its way forward. The first statement emphasizes the importance of individuals understanding what their Navy is about and how each and every person could be called upon to serve their country. The second statement promotes a culture that embraces a high standard of seaworthiness while improving and encouraging accountability at all levels. The third statement focuses on leadership across the Navy with its people and their values at the core (Naval Today, 2013). These guiding principles have shaped the Royal Australian Navy into what it is today. An extension to the New generation Navy program that was reviewed and re-released in 2018 was Plan Pelorus—Navy Strategy 2022 (RAN, 2018b). Plan Pelorus was introduced to provide clarity and alignment of day-to-day actions that will effectively achieve the following Headmarks by 2022:

Workforce—that will be fully crewed at sea and ashore with the ability to train for future demand and be prepared for continued growth,

Lethal—The RAN will be able to deny, deter, and defeat our adversaries and despite evolving threats and challenges,

Integrated—The RAN will be integrated into the Joint force (with Australian Army and Air Force) to operate effectively with our like-minded partners and allies,

Battleworthy—The RAN will provide sea, cyber, and air worthy platforms to the Chief of Joint Operations for government directed tasks,

Sustained—The RANs resources are optimized to enable conduct of all of our activities and future commitments,

Persistent—RAN will ensure ability to maintain long-term presence away from home ports, and

Near Region—The navy will meet all domestic requirements while being engaged throughout the Indo-Pacific and working closely with our partners in the near-region and with our friends.

Workforce analysis is crucial for providing the RAN with the cornerstones to achieve the vision of both NGN and Plan Pelorus. A correctly identified workforce will provide understanding for training throughput requirements, people that are ready, willing, and able to serve when and where required (RAN, 2018b).

B. SCOPE

This thesis is focused on the operation of a Guided Missile Frigate (FFH) in at-sea conditions to analyze its manning structure versus NSWV methodology such that a SoC is “sufficient” to meet the workload and sustainment requirements. The FFH data was collected by Defence Science and Technology Organisation (DSTO) during a trial on HMAS *Warramunga* in 2012. A “sufficient” SoC is described as the correct number of sailors in the correct categories to operate a ship in war and peace time operations.

From this analysis, I will discuss whether NSWV methodology provides Navy Future Workforce (NFW) personnel with the ability to correctly identify sufficient crewmembers to operate at sea sustainably. My research questions are:

1. Assess the difference between workload as observed during DSTO trial on HMAS *Warramunga* and the provisions of the NSWV.
2. Assess the results of the ME departments modelled data in IMPRINT to allow further investigation of the identified problems beyond conditions observed during the trial.

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II. LITERATURE REVIEW

A. IMPORTANCE OF MANNING

Manpower requirements of a ship are a critical element of how successful a ship (in our case a warship) can complete its task; however, this term is not to be confused with the manning of a ship. Australian Navy Publication (ANP) 2101—Navy Workforce Requirements Planning, details the policy for determining the manpower requirements for individual classes of ships for the RAN (2017). Manning levels of a ship can be described as the level of crewmembers physically onboard that are operating and maintaining the ship either as part of the “Trained Force” or posted onboard for endorsement, up-skilling, and consolidation (RAN, 2017). As such, there is a difference between manpower requirements and the “as manned” manning level of a ship.

A study conducted by a previous NPS student assessed the effects of manning levels on two U.S. Navy Destroyers and how different levels of a ship’s manning relate to fatigue, mood, and sleep patterns (Murph, 2019). The study determined that an increase of 30 personnel (8.7% of total crew size) to one of the destroyers resulted in improvements in length of sleep by an average of 43 minutes per night. Not only did crewmember length of sleep time improve but, the study revealed a positive trend in their moods, too. Further benefits included smoother operation of essential services such as laundry, food service and ship’s store, which was shown to increase morale to a higher level still. Benefits of increased morale are known to lead to increased production, increased sleep and decreased fatigue that resulted in higher certification results (Murph, 2019).

Another NPS student recently conducted a study on the how the increase in manning of U.S. Warships, both underway and in port, affects crewmembers’ workloads (Garbacz, 2019). The study was conducted onboard two destroyers during the Basic Phase, as a consequence of recommendations from a Comprehensive Review following three collisions and one grounding occurring from ships in the SEVENTH Fleet during 2017. The study was based around two destroyers operating with different crew manning levels. The first ship’s manning levels were left as “standard” and the second ship’s manning level

was augmented with an additional 30 sailors to increase their manning to 100% of the Ship Manpower Document (SMD). Results of the study found that increasing manning for one of the ships resulted in sailors working on average 0.8 hours less per day (Garbacz, 2019).

Research conducted by the University of Turku into the impact of ship crews on maritime safety focused on a wide range of topics relating from cultural diversity of the crew through to crew size and how technology affects maritime safety. Interestingly, even with advances in technology, some 80% of maritime accidents are caused by human error. Fatigue was identified as a contributing factor in human error incidents. Tight schedules, under-manning of ships, and bad management have all been labelled as causal factors contributing to fatigue in a maritime environment (Berg et al., 2013).

The RAN has an approved number of people it can legally employ, identified as the Average Funded Strength (AFS) for military and Full-Time Equivalent (FTE) for civilians (RAN 2017). For the RAN, AFS and FTE strengths are mandated and any change in these approved numbers requires a submission and subsequent approval from the Australian government (Watt, 2018). Navy workforce requirements are capability driven and they must have the ability to produce a functional output that contributes to operational outcomes/government objectives (RAN 2017). The composition of AFS is determined by the positions identified, both ashore and at sea, for the RAN to complete mandated government directions (Australian Department of Defence, 2016). Due to workforce hollowness and ongoing training burdens, RAN ships are rarely manned at 100%, meaning that our ships are not operating at their determined manpower requirements for the bulk of their in-service life (Chief of Navy, 2019). Reduced/Insufficient manning of a ship therefore results in less than optimal number of personnel operating the ship and ultimately could lead to increased occurrence of accidents.

B. IMPORTANCE OF SLEEP

1. Function of Sleep

Sleep is an essential element for maintaining optimal health, playing a critical role in systemic physiology and brain function. According to the American Academy of Sleep Medicine, “normal” sleep is comprised of four stages and shown in Figure 1. Stages one to

three of sleep are categorized as Non-Rapid Eye Movement (NREM), relating to depth of sleep while the remaining stage is Rapid Eye Movement (REM). Stage one is classified as light sleep and increases in depth up to stage 3, which is classified as deeper sleep. The most restorative stage of sleep is believed to occur in the deepest stage of NREM (Stage N3), known as slow-wave sleep. It typically occurs during the first one-third of a sleep episode (Medic et al., 2017). REM sleep typically occurs in the last two-thirds of a sleep episode and progressively increases in length, and usually is longest during the last one-third of a sleep episode. When compared with wakeful periods, blood pressure, heart rate, respiration, and blood flow to the brain decrease during all of the NREM stages (Medic et al., 2017).

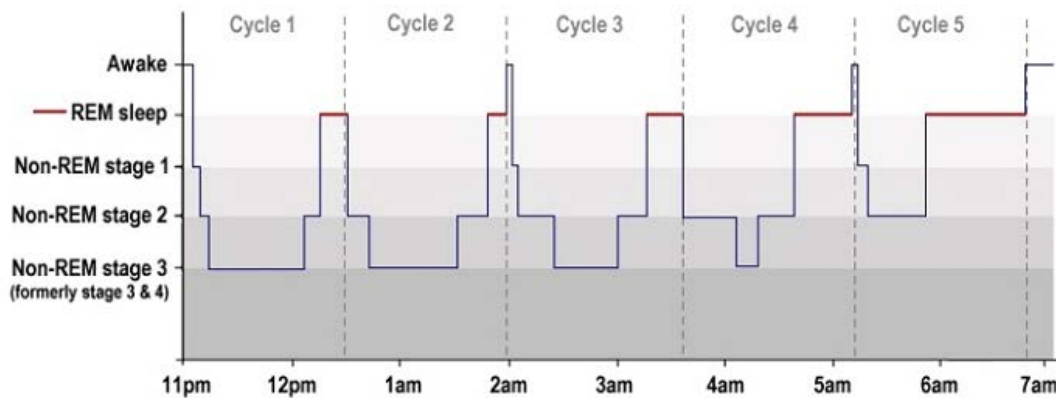


Figure 1. Sleep Cycles throughout Sleep Period. Source: Mastin (2013).

The aforementioned processes, along with motor and sensory areas, are increased during REM sleep, but not to the same level as during awake periods (Medic et al., 2017). From Mastin's Figure 1 above we can see a typical sleep cycle and how an individual cycles repeatedly between the four stages. Sleep provides the ability for the body to recover from the buildup of fatigue; the type of fatigue determines how much and how often sleep needs to occur for the body to recover (Miller, 2006).

2. Fatigue and Factors That Are Influenced by Sleep in a Maritime Environment

Fatigue in the general sense, as defined by the Oxford dictionary, is “a feeling of being extremely tired, usually because of hard work or exercise” (Oxford, 2020). Miller (2006), however, further defines human fatigue’s primary hallmark as the variability of performance. Fatigue can result in a variability of performance in attentiveness, which can be caused by large fluctuations happening on a moment-to-moment basis. Fluctuations for individuals can on average be acceptable, but throughout the day brief periods of “lapses” (absent or delayed responses) can occur. These lapses are referred to as distractibility and can often be seen more readily from system operators that are fatigued versus non-fatigued system operators (Miller, 2006). Fatigue affects everybody (each individually), in everything they do (pervasively) and unknowingly (insidiously). The misperception about the effects of fatigue to one’s self may cause ill-informed intentions that could lead to poor decisions (Miller, 2006).

Miller further defines fatigue into five categories, Circadian Effect, Physical, Acute fatigue, Cumulative fatigue, and Chronic fatigue. Acute fatigue occurs daily during a person’s awake period, is unavoidable and recovery from acute fatigue occurs with a good-quality nocturnal sleep (Miller, 2006). Cumulative fatigue occurs due to a buildup across multiple waking/duty periods with insufficient recovery between these periods. The delineating difference between cumulative and acute fatigue is that the body cannot recover from cumulative fatigue with a single good-quality nocturnal period of sleep. Chronic fatigue may result as a buildup of cumulative fatigue continues unabated for one to two weeks. The symptoms of chronic fatigue can be similar to those of Chronic Fatigue Syndrome; a common term used to identify chronic fatigue is apathy, which also accurately describes the observed effects of a person suffering from chronic fatigue (Miller, 2006).

Cumulative fatigue can occur in a maritime environment; with an increase in the use of technology on ships, there is an expectation that a decrease in crewing is possible. As a result, a pervasiveness of fatigue and sleep deprivation for members of the crew can lead to performance degradation for both the unit and individuals (Groot, 2015). Increase in fatigue levels can also be attributed to working in a combined military and maritime

environment. This environment includes factors such as extreme external temperatures (hot or cold), noise, ship's vibrations, ship's motion, lighting in sleep quarters, authoritative leadership, taxing physical work, lack of exercise, unhealthy diets, and being away from family and loved ones (Comperatore et al., 2005).

In Figure 2, Shattuck et al. (2018) define many factors that cause sleep to be disrupted; these factors have been broken into four separate categories: organizational, psychological/pharmacological, environmental, and berthing compartment habitability. This thesis will consider the organizational impacts as related to SoC and whether NSWW potentially increases the effects of extended work hours, rotating watch schedules, irregular bedtimes, and operational commitments.

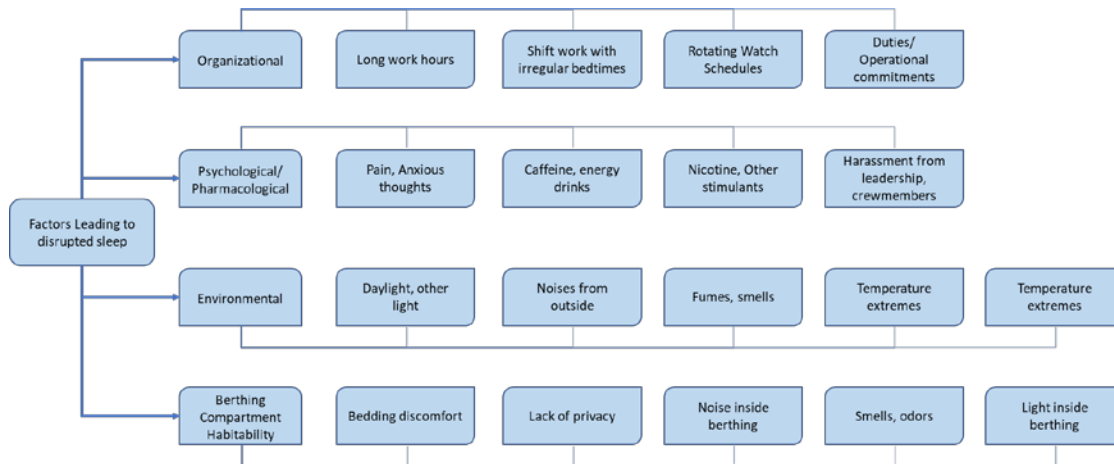


Figure 2. Factors Leading to Disrupted Sleep. Adapted from Shattuck et al. (2018).

3. Chronic Sleep Restriction

Chronic sleep restriction is considered to be ubiquitous in modern society; studies have shown that Americans are sleeping less, and a large portion of the population are reporting less than the recommended 8 hours per night (Belenky et al., 2003). The study by Belenky et al. (2003) shown in Figure 3 examined performance changes during chronic sleep restriction for 66 volunteers that were assigned a varying range of time in bed (TIB), measured in hours per day, from 3, 5, 7, or 9 h TIB. The subjects slept for their assigned periods for 7 days followed by 3 days with 8 h TIB per day.

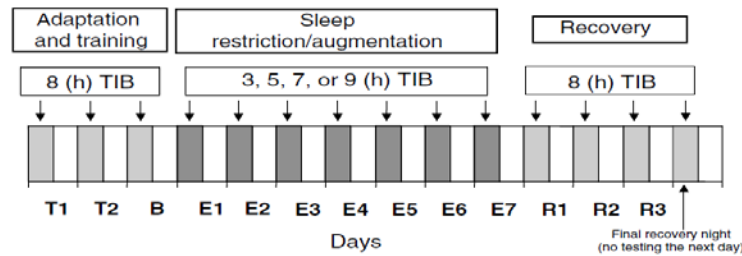


Figure 3. Design for Sleep Experiment Displaying TIB.
Source: Belenky et al. (2003).

The study found that subjects in the 3 h TIB group had a steady decline in their response time and psychomotor vigilance tests as the 7-day trial progressed. TIB groups with 5 h and 7 h TIB per day were found to initially have a decline in both response time and psychomotor vigilance but stabilized at a reduced level with an increased number of lapses occurring for the 5 h TIB group. The group allocated to 9 h TIB did not show any change from their baseline measurements for psychomotor vigilance or response times. During the 3-day recovery phase, the 9 h TIB group also remained unchanged at their baseline measurements; the 5 h and 7 h TIB groups remained stable as did the quantity of lapses for the 5 h TIB group.

Figure 4 shows that after the first night of recovery sleep for the 3 h TIB group, their response time recovered quickly and improved up to the same levels as TIB groups 5 h and 7 h during their recovery period. Interestingly, the 3 h TIB group remained the same as the 5 h and 7 h TIB groups after the initial quick recovery. The psychomotor vigilance test for the 3 h TIB group shows higher initial recovery to nearly the same level as the other TIB groups and then dipped again during the 3-day recovery period. Belenky et al. hypothesized that the brain adapts to chronic sleep restriction, and during mild to moderate sleep restrictions, an individual's performance decreases. Although the decrease in performance stabilizes throughout the period of restricted sleep, the restricted operational capacity of the brain persists for several days after the body returns to normal levels of sleep duration (Belenky et al., 2003).

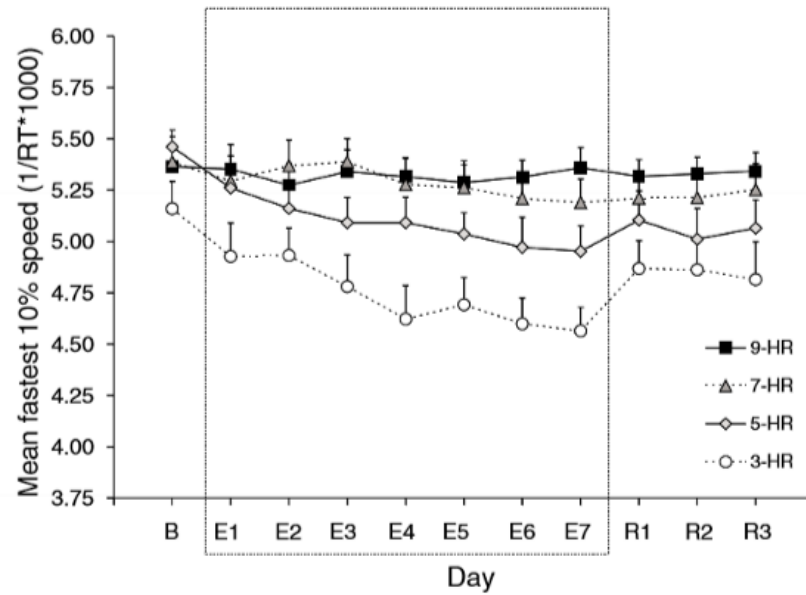


Figure 4. Mean Psychomotor Vigilance Task Speed for the Fastest 10% of Responses Across Days as a Function of TIB.
Source: Belenky et al. (2003).

Knowing the effects of sleep deprivation on an individual's response time and psychomotor vigilance tests highlights the need to understand how a ship's SoC can affect crew performance in the short and long term.

C. CIRCADIAN RHYTHM

1. Definition

A person's circadian rhythm is an internal body clock that operates on an approximately 24-hour period. It affects one's alertness and sleepiness; these effects are normal, inherent, and unavoidable. The circadian rhythm cycles between alertness and sleepiness in a routine pattern, a diurnal process. Most people's circadian rhythm swings from a high point late in the day to a low point in the hours before dawn (Miller, 2015, p. 56). Of note, certain cultures still factor in an afternoon siesta, which aligns with a mild dip of performance in the early afternoon prior to the cycle's highest point (Comperatore et al., 2005, p 4–5). In Figure 5, it can be seen that a person's mental and physical performance cycles in line with their circadian rhythm that culminates in a low point at approximately

0200–0400 local time for individuals who work days and sleep nights. Sleep/wake cycles are affected by external factors including external light levels, as such local day and night cycles effect an individual’s circadian rhythm.

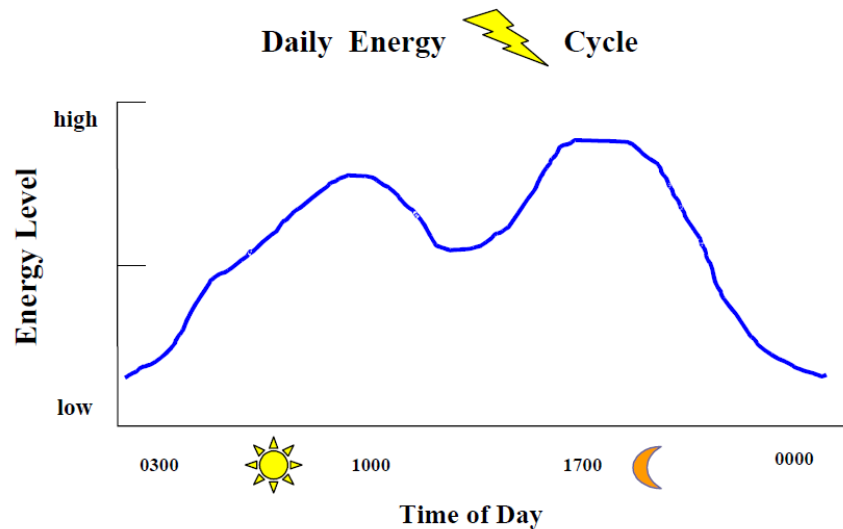


Figure 5. Daily Energy Cycle as a Function of Time of Day.
Source: Comperatore et al. (2005).

2. Central Timekeeper

The hypothalamus contains a paired set of suprachiasmatic nuclei (SCN) that regulates the circadian rhythms of mammals. The SCN has been demonstrated in multiple experiments to be the central timekeeper (body clock) of an individual’s circadian rhythm. The SCN also receives information that relates to an individual’s environmental and behavioral states to help confirm correct settings of the body clock (Gillette & Abbott, 2009).

3. Organ Systems Involved

Various organ systems also have their own internal mechanisms of control but are still synchronized to the central timekeeper and are affected by mealtimes and external cues in the same manner as the central timekeeper. These internal mechanisms are secondary (or peripheral) oscillators and occur in the following organs: kidneys, liver, heart, lungs,

skin, intestines, spleen, esophagus, thymus, prostate, adrenal gland, olfactory bulb, and lymphocytes (Reddy et al., 2020).

4. Zeitgebers, Especially Light

Exogenous influences called *zeitgebers*, meaning “time givers” in German, are time cues that set the circadian rhythm to one cycle per day, with the main cue relating to our 24 h daylight-darkness cycle. The body clock is also affected by minor cues that include meals and social activities; however, these cues are so minor though that they are hard to measure (Miller, 2015). The daylight-darkness cycle, SCN, and the brain’s ability to produce sleep all interact together. Night work impairs daytime sleep duration, the resulting circadian effects cause a feeling of fatigue during the body clock’s midnight to dawn period. During this period, the body’s sleepiness and sleep drive are highest while body temperature and alertness are at their lowest (Miller, 2015).

5. Entrainment and Ability to Shift

Circadian rhythms can be adjusted; in fact, entrainment occurs all the time, from light cues associated with seasonal changes and changes in daylight-darkness cycles. Behavioral patterns, daytime sounds and mealtimes can also be used to adjust a person’s circadian rhythm, but are less effective than light cues (Shattuck et al., 2019). Circadian cycles are slow to adjust and only change at approximately one time zone (or hour) per day. If a person changes more than one time zone in a day, the circadian rhythm will re-synchronize based off new local cues. This inability to adjust quicker than one time zone per day is termed “jet lag,” which leaves the individual with a feeling of malaise and fatigue, until synchronization is complete for the local time zone (Miller, 2015). Miller also noted that any more than three time zone shifts occurring over a rapid period (i.e., flying) results in a detectable mood change.

6. Effect of Night-Shift Work

When operations require work to be scheduled 24 hours a day, 7 days a week, shiftwork is required. However, “good” shiftwork schedules become continually sought to minimize the negative impacts to workers and improve their effectiveness (Miller, 2006).

Miller describes shiftwork as a “crime against nature,” primarily due to a slowing of metabolism overnight usually hitting the lowest point during pre-dawn hours. Another effect that darkness has on our bodies is the production of melatonin from the pineal gland, a hormone that makes the body drowsy. In short, our bodies and brains are designed to operate during the day and to sleep at night (Miller, 2006).

A plethora of studies have been conducted on the effects of productivity and safety for 24/7 operations. A National Sleep Foundation study found an overall increased risk to health, lower productivity and increased risk of workplace accidents is likely to occur during the hours of darkness (SleepFoundation, 2018).

The military and first response communities have an abundance of shiftwork requirements and these requirements are known to be a major source of acute and chronic fatigue levels. Long term changes to the brain, affecting baseline alertness levels and performance, occur as a result of chronic sleep restrictions imposed by shiftwork (Belenky et al., 2003). After sleep durations have returned to baseline levels, shift workers have been known to experience the effects of sleepiness and sleep disturbance after conducting years or even only months of shiftwork. “Circadian scarring” is the term coined to describe these effects brought about increasingly often in individuals affected by sleep deprivation and shiftwork (Shattuck et al., 2019).

One such case investigated by Mysliwiec et al. (2016) speaks to the circadian scarring observed from a 29-year-old active duty sailor from the U.S. Navy diagnosed with mild obstructive sleep apnea. The sailor’s sleepiness symptoms were not fully explained by the sleep apnea resulting in further investigation. The sailor operated under a 5 h on and 10 h off watch-standing schedule on deployments that typically lasted for up to 6 months. The routine of the 5/10 is a shiftwork schedule that conducts watches in three sections, made up of 5 h on-watch, followed by 10 h off watch. Watches conducted utilizing the 5/10 schedule start at 0200, 0700, 1200, and 1700 for the first 4 watches and the final watch’s duration is 4 h to align with starting time for the 0200 watch the next day (Mysliwiec et al., 2016). The analysis of the sailor revealed a suspected case of self-sustaining circadian rhythm that aligned with his sea-going 5/10 working schedule. After two weeks of a prescribed sleep schedule and doses of melatonin and bright light therapy,

his circadian rhythm was entrained back to “normal” circadian rhythm. This case combined with a previous case of a submariner that displayed similar symptoms of a 6/12 on-off watch cycle employed by submariners suggests “chronic non-circadian military-shift schedules may result in circadian arrhythmia” (Mysliwiec et al., 2016).

7. Shiftwork/Watch Schedules as Used in the Military

Even though numerous studies have assessed civilian work schedules and their biological effects, studies focusing on military personnel whilst deployed are sparse. Reasons for lack of data can be related back to priorities for always being assigned to mission first and foremost that do not allow for routine interruptions for data collection (Good et al., 2020). The U.S Navy and other navies around the world have to respond to threats while maintaining productivity during 24/7 operations. As a result, multiple watch standing routines have been developed to cater for ship manning and threat levels to achieve operational requirements. In more recent years, multiple studies by numerous navies have been conducted in an attempt to align operational requirements with better sleep hygiene (Ryan, 2014).

Miller classified shiftwork schedules as regular-fixed, and regular-rotating within a 24/7 domain (Miller, 2013). These fixed or rotating shifts are the types of shiftwork that are utilized within the military environment and known as “watchkeeping” in the RAN. Regular-fixed watchkeeping, as an example, would be a one in three watch system with the workforce broken into three watches, where each watch consists of 4 h on-watch and 8 h off-watch. Two other regular-fixed schedules employed by the RAN are a one in two and a one in four schedule, that are comprised of 6 h on 6 h off and 4 h on and 12 h off, respectively (Ryan, 2014).

Regular-rotating watchkeeping in the RAN, when utilized, typically employs the above, one in three or one in four, routines but modified to include a “splitting of the dogs” and is shown in Figure 6. A dogs’ watch occurs between 1600–2000, the 1st dogs (1600-1800) is conducted by 1st watch and the 2nd watch conducts the 2nd part of the dogs (1800-2000). The split introduces a rotation so that the subsequent watches conducted by the 1st watch are the “guts” watch (0001-0400) and the 2nd watch’s subsequent watch is the

“morning” watch. A drawback to this schedule is that off watch-time is inconsistent with not always 8 h between watches and it is continually adjusting the body-clock due to the backwards rotation (Ryan, 2014).

The reason for employing a rotating watchkeeping model was to provide watchkeepers with broader working knowledge for all of the ship operating cycles. Another “popular” regular rotating watch system in the RAN is based off the one in three. The watch times are maintained at 4 hours but to provide the rotation a “celebrity” watch, made up of day hands, is used to keep a standing watch (same time every day) that provides an extra 4 hours of off watch time to each watch. A rotation results for the watches that still provides broader knowledge of all tasks conducted throughout a 24 h period (RAN, 2018a); however, this schedule does not consider the effects on the body clock.

Time	Day 1	Day 2	Day 3
0001-0100	Red	White	Blue
0100-0200	Red	White	Blue
0200-0300	Red	White	Blue
0300-0400	Red	White	Blue
0400-0500	White	Blue	Red
0500-0600	White	Blue	Red
0600-0700	White	Blue	Red
0700-0800	White	Blue	Red
0800-0900	Blue	Red	White
0900-1000	Blue	Red	White
1000-1100	Blue	Red	White
1100-1200	Blue	Red	White
1200-1300	Red	White	Blue
1300-1400	Red	White	Blue
1400-1500	Red	White	Blue
1500-1600	Red	White	Blue
1600-1700	White	Blue	Red
1700-1800	White	Blue	Red
1800-1900	Blue	Red	White
1900-2000	Blue	Red	White
2000-2100	Red	White	Blue
2100-2200	Red	White	Blue
2200-2300	Red	White	Blue
2300-2359	Red	White	Blue
	Red White Blue	Team One Team Two Team Three	

Figure 6. Three-Watch Shift Regular-Rotating via a “Dogged” Watch.
Source: Ryan (2014).

A presentation from Shattuck and Matsangas (2015) articulating regular shiftwork schedules, as used by the U.S. Navy, show which of the watchkeeping schedules align with circadian rhythms and which do not. Of note, Figure 7 only includes watchkeeping duties/work, but additional duties could be implemented by the Commanding Officer.

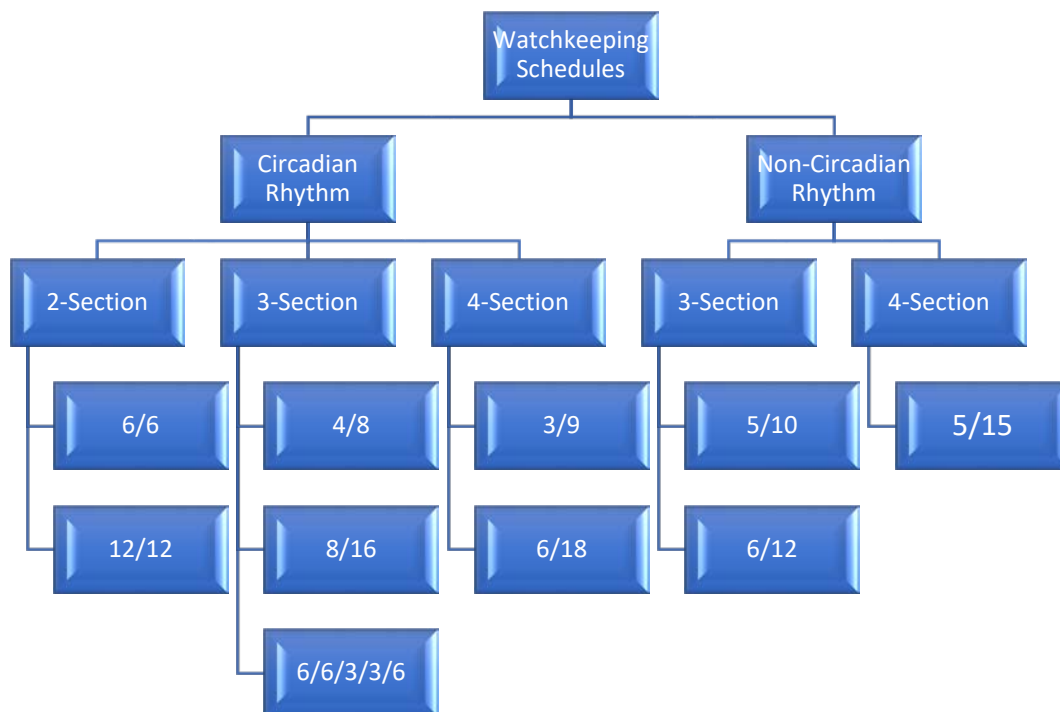


Figure 7. Adaptation of Watchkeeping Schedules (in hours) and How They Align to Circadian Rhythms. Source: Shattuck et al. (2018).

D. NAVY STANDARD WORK WEEK AS USED IN THE U.S. NAVY

The U.S. Navy policy and procedures on personnel manpower requirements is stipulated in *Navy Total Force Manpower Policies and Procedures*, OPERATIONS NAVAL INSTRUCTION 1000.16L. Naval Operations—Manpower, Personnel, Training and Education department produces and is the sponsor of OPNAVINST 1000.16L (2019). The Naval Manpower Analysis Center (NAVMAC) in conjunction with type commanders and Warfighting enterprises, use OPNAVINST 1000.16L as the primary document to produce, authorize, employ, and revise Ship Manpower Documents (SMD). SMDs are produced within the bounds of the Naval Availability Factor (NAF), which is the result of

the revision of the NSWW in 2015, in conjunction with other criteria laid out in the instruction. The NAF expresses total average times per person expected to complete required work hours for all naval units ashore, at sea and in the air (Chief of Naval Operations, 2019).

Table 1 depicts a version of the NSWW as used by the U.S. Navy between 2002 (OPNAVINST 1000.16J CH-1, Appendix C) through 2015 (OPNAVINST 1000.16L CH-2 N12, Appendix D), describes the breakdown of the NSWW for afloat units under projected wartime conditions. Basic workweek considerations employed in formulating the NSWW acknowledge that the nature of the Navy work, watch, and duty requirements make it difficult to determine all circumstances to predict work periods on a weekly basis. As such, averaging techniques were utilized to determine all the elements of various workweeks on a monthly annual basis. At-sea assumptions for the NSWW assume that the unit is steaming in Condition III (Wartime Deployed Cruising readiness) utilizing a 3-watch rotation (Chief of Naval Operations, 2002).

Of particular note from the NSWW is the total number of productive work (PW) hours identified as 70 h, and their sub-categories allocating 56 h to watchkeeping, and 14 h of availability for activities other than training and service diversion. The definition of training has been defined as, training that further contributes directly to combat readiness and factored into scheduled events, including general drills, engineering casualty control drills (ECCD) and damage control exercises. What this implies is that individual training requirements for “On the Job Training” (OJT), professional advancement, operator qualification training has not been factored into the 7 h allocated to training. Similarly, Service Diversion refers specifically to quarters/clear lower deck, inspections, sick parade, participation on boards/committees, non-training related assemblies, flight/hangar deck integrity watches (Chief of Naval Operations, 2002). The 14 h per person per week of production time is allocated for any/all tasks outside of those noted above and include tasks such as preventative maintenance (PM) and corrective maintenance (CM) and departmental duties.

Table 1. Navy Standard Work Week for Afloat (Wartime) Military Personnel.
Adapted from OPNAVINST 1000.16J CH-1, Appendix C (2002).

Navy Standard Workweek (OPNAVINST 1000.16J CH-1)		
Ship Standard Workweek		81 hrs
Productive Workweek (Note 1)		70 hrs
Analysis of Duty Hours		
Total Hours Available Weekly		168 hrs
Less Non-available Time per week:		
Sleeping (8hrs per day)	56 hrs	
Messing	14 hrs	
Personal Time	14 hrs	
Sunday Free Time	3 hrs	87 hrs
Scheduled on Duty Hours Per Week		81 hrs
Less:		
Training (Note 2)	7 hrs	
Service Diversion (Note 3)	4 hrs	11 hrs
Therefore: Total Hours Available for:		
Productive Work (Note 1)		70 hrs
Note 1: For watchstanders, 56 hours is allocated to watch stations (8 hours X 7 days) (14 hours available for work in addition to 56 hours watchstanding = 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 productive work. 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 ship's manning documents (SMDs).		
Note 3: Service diversion consists of actions required of military personnel regulations or the nature of shipboard/staff routine. Service diversion includes, but is not limited to, the following types of activities:		
1) Quarters, inspections, and sick call.		
2) Other administrative requirements including: Commanding Officers Non-Judicial Punishment (NJP), participation on boards and committees, interviews, and non-training-related assemblies.		
3) Flight and hangar deck integrity watches.		

In 2015, the U.S. Navy NSWW was updated and renamed "Navy Availability Factor" (NAF) and is shown in Table 2. The changes between the NSWW and the NAF are minor in appearance but noteworthy of mentioning with the most recent change occurring in January 2019 (Chief of Naval Operations, 2019).

The latest revision of the NAF (2019) describes the time in hours per week allotted to training as 8 hours, which is an increase of 1 hour from the NSWW. The other change in allocated hours relates to service diversion, which has an increase of 3 hours per week. Training requirements under the 8 hours allocated in the NAF now include 3 hours of individual training and a reduction to 5 hours for scheduled training events. The individual training is detailed as under instruction watches, rating, skills training, warfare qualifications, personnel qualifications standards and job qualification requirements. There has been no change to the definitions to service diversions despite the increase of 1 additional hour per week (Chief of Naval Operations, 2019).

E. NAVY STANDARD WORKING WEEK AS USED IN THE RAN

The RAN adopted a version of the U.S. Navy Standard Work Week (NSWW) in 2015 following trials onboard HMAS *Choules* to determine its suitability for RAN use (Groot, 2015). The trial conducted on *Choules* considered of an operational scenario that included a 90-day Humanitarian Aid and Disaster Relief (HADR) utilizing the below NSWW criteria is shown in Table 3.

The RAN NSWW amounts to 70 hours of productive time (PT) per week, divided into 10 hours per day per crewmember and is the primary figure used to determine workload and hence SoC. During the *Choules* trial the maintenance component of the NSWW was allocated to sailors with the rank of Able Seaman (AB) and comprised of weekly averaged PM and as well as expected CM. Only when the allocated average maintenance time is exceeded for all ABs, within each category, are Leading Seaman (LS) or senior enlisted sailors allocated the residual maintenance until all of the maintenance allocation is completely filled. The NSWW considers watchkeeping (56 h), service diversion (4 h) Training (7 h) and maintenance (11 h for watchkeepers). The model, however, does not consider logistics support, medical duties, personnel administration, or day-to-day catering (Groot, 2015).

Table 2. Navy Availability Factor for Afloat (Operational) Military Personnel.
Adapted from OPNAVINST 1000.16L CH-2 Appendix D (2019).

Navy Availability Factor (OPNAVINST 1000.16L CH-2 N12, 2019)		
NAF (NOTE 4)		81.00
Productive Availability Factor (Note 1)		67.00
Analysis of Duty Hours		
Non-Productive Availability Factor:		
Training (NOTE 2)	(8.00)	
Service Diversion (NOTE 3)	(6.00)	(14.00)
Total Hours Available for Productive Availability Factor (NOTE 1)		67.00
NOTE 1: For watch standers, 56 hours is allocated to watch stations (8 hours a day for 7 days) (11 hours available for work in addition to 56 hours watch standing equals 67 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 work. This includes unit training and mission centric individual training. The 8 hours of training include 5 hours per week of training to reflect those scheduled events (e.g., general drill, engineering casualty damage control,) for all hands, and 3 hours factored to reflect individual sailor training (e.g., under instruction watches, rating, skills training, warfare qualifications, personnel qualifications standards and job qualification requirements). Hours indicated have been standardized for Condition III in SMDs.		
NOTE 3: Service diversion consists of actions required of military personnel regulations or the nature of shipboard/staff routine. Service diversion includes, but is not limited to, the following types of activities:		
1) Quarters, inspections, and sick call.		
2) Other administrative requirements including: Commanding Officers Non-Judicial Punishment (NJP), participation on boards and committees, interviews, and non-training-related assemblies.		
3) Flight and hangar deck integrity watches.		
NOTE 4: A week contains 168 hours. Non-Available time represents the delta between 168 hours in a week and the NAF.		

Table 3. Navy Standard Work Week—RAN. Adapted from Groot (2015).

Navy Standard Work Week (NSWW)—RAN		
Hours in a Week		168.00
Non-Available Time	Sleep (8 hours x 7 days)	-56.00
	Messing (2 hours x 7 days)	-14.00
	Personal Time/Hygiene (2 hours x 7 days)	-14.00
	Sunday Sea (3 hours x 1 day)	-3.00
Available Time (AT)		81.00
Additional Service Allowance	Training—Individual and Collective Training Allowance	-7.00
	Service Diversion—Actions required by regulations or standard routine. Includes department musters, round, sick parade.	-4.00
Productive Time (PT)		70.00

Several assumptions that allowed the analysis of the NSWW conducted on *Choules* to work included (Groot, 2015):

3. Ship manning is at 100% for all positions, both RAN and Ship's Army Detachment (SAD).
4. Watches are one in three, and watchkeepers are not required for other tasks in the scenario-based simulation.
5. Time is allocated for personnel as specified in the RAN NSWW (see above table).
6. The minimum number of personnel required to carry out each evolution or activity is available from the Watch and Station Bill (WSB) or provided in supplementary information from the ship.

Heat maps were generated from average workload in hours per day and used to determine which positions were operating at or close to capacity. Aggregated results for each rank and category/primary qualification (PQ) were averaged to provide specific hours each working group is required to complete. Each working group's hours were then divided by the 70 h PT per week to identify the quantity of personnel required to complete the designated activities (Groot, 2015). The results of the trial on *Choules* found that despite

excessive workloads on particular PQs/MOS, the averaged results indicated sufficient SoC to complete the 90-day HADR activities (Groot, 2015).

When used to determine SoC, the RAN NSWV did not consider periods less than 7 days at sea or time alongside required for the conduct of maintenance, leave, or respite. This proposed operating cycle is often in contradiction to RAN ship's operating cycles. RAN ships' operating cycles often include weekly running routines that occur on completion of maintenance activities and workups to confirm equipment and crew are at an acceptable standard for upcoming missions. When deployed, RAN ships conduct port visits that not only disrupt the continuous 7-day NSWV cycle but, incur specific activity criteria that are excluded from the NSWV activity guides (RAN 2017).

Throughout the remainder of this thesis, I will delineate between the two Navy's policies by referring to the RAN's policy as NSWV and the USN's policy as NAF.

F. PRIOR LITERATURE FROM ROYAL AUSTRALIAN NAVY AND U.S. NAVY

Numerous workload studies have been conducted over the last decade by the RAN and the USN in an attempt to understand optimal ship manning figures and improve routines to maintain warfighter effectiveness while reducing crew fatigue levels. Manning levels have become increasingly important with the advent of newer technologies resulting in an expectation by government and warfighters of reduced manning requirements while still achieving the "mission." These studies have provided insight into operating routines and spurred amendments to ship operating policies that have improved crew efficiency and reduced fatigue (Grech et al., 2013).

The RAN and USN studies not only analyze sleep levels for volunteer crew members but also assess the use of the Navy Management Diary (NMD). NMD is a software package designed to aggregate data from multiple sources such as daily orders/routines, training, conducted maintenance summaries, and defects to be entered by the crew either manually or via import wizards, while tracking individual sleep hours, which gives an estimate of fatigue. This software replaced an information communications

technology (ICT) software package titled MONICAR; the decision to replace MONICAR was made due to the software's inability to track fatigue and to improve data aggregation.

NMD is typically managed by the Operations Officer (or delegate) and provides a level of access to select individuals with varying level of authority to change/input data. Since DSTO's trialing of NMD in HMAS *Warramunga* (Grech et al., 2013), the software has been introduced across all RAN surface ships and is slowly being introduced throughout the submarine fleet. As each ship has been introduced, it has taken time to train and promote the use of NMD. As the familiarity of the software increases, so too will the Navy's ability to collect accurate data.

Due to the large range of ages and origin of RAN ships, each ship (even from the same class) can have different administration/management systems in use. This variety of systems has made it hard for some of the import wizards to work quickly and correctly, leading crew responsible for entering data to be reluctant to shift some of the ship's record keeping into NMD. The aforementioned issue is particularly true for sleep data entry and maintenance importation. As a result of portions of the crew continually forgetting/being unable to add their own sleep data, ships sometimes revert to their previous methods of sleep data collection (Excel spreadsheet) that they are familiar with and can easily report back to command and ashore. It is expected that as systems are progressively aligned across platforms, NMD knowledge will increase across the fleet. Also, as more widespread use occurs, NMD will become a great source for data analysis. Communication with CMDR Hamilton indicates, it is anticipated that in the future, data collected via NMD will provide the ability to better understand the complexity of ships routines, particularly how impacts to manning affect crew fatigue, operations, and maintenance.

- 1. A Validation of the Proposed Royal Australian Navy Standard Work Week and Naval Management Diary Using a Simulated Crew of an Armidale Class Patrol Boat (Groot, 2015)**

Groot's thesis investigated the validity of the NSWV and NMD by simulating an Armidale Class Patrol Boat (ACPB) operating conditions using the Fatigue Avoidance Measuring Tool (FAST) (Groot, 2015). FAST is based on the Sleep, Activity, and Fatigue Task Effectiveness (SAFTE™ © 2000–2008 Fatigue Science) model, which was initially

developed for the Department of Defense (DoD). The NMD's built-in fatigue measurement tool was compared to the SAFTE/FAST model to estimate high risk periods for activities on an ACPB over a three-week period.

Groot found that of the categories modelled from the NSW, the maintenance category was the category that most often exceeded allocated hours, leading to a recommendation that further research should be conducted on the NSW. The recommendation put forward relates to determining whether the NSW needs to be customized specifically for PQs and/or ship class type. Groot further goes on to recommend that a similar study be conducted with a larger data sample and to include empirical observations of performance during actual operations before comparing predicted levels of effectiveness generated by the FAST model (Groot, 2015). Of note, the data originally intended for use by Groot for her research was from a trial conducted by DSTO, the second in a series of three trials between 2011–2014, to determine crew endurance for different operating units (ships, boats, and submarines).

The second trial was conducted onboard an ACPB, a ship class introduced into service in 2005, that has an approximate crew of 21 and conducts boarding operations along the Australian coastline and in the waters north of Australia, and is a small vessel with a length of 168 feet and a beam of 32 feet. Limitations to the data were identified, however, with the sample size being small; of the potential 21 crewmembers, only 13 had meaningful data obtainable from their Actiwatchs. Another limitation was that the data were further diluted due to non-compliance of the participants, with several participants dropping out from data collection and others inconsistently wearing their Actiwatchs. These factors combined with insufficient supplemental data available to create a realistic model supported a conclusion that the dataset was too flawed and simulated data was to be created and used for the research instead (Groot, 2015).

The simulated data consisted of work and rest schedules for an ACPB crew underway during a three-week “best case” scenario and compared between two sleep allowance levels (6 h and 8 h), respectively. The benefit of a simulated data set removes all of the above-mentioned limitations. It also requires, however, a thorough understanding of assumptions made during the creation of the simulated data. The broad categories of the

NSWW required “interpretation” for some activities that do not fit nicely within the NSWW definitions; one such example is that of the chefs and their allocation as watchkeepers (Groot, 2015).

2. Fatigue Mitigation and Crew Endurance Management in the Royal Australian Navy and the U.S. Navy: A Review of Recent Efforts and a Collaborative Path Forward (Ryan, 2014)

Ryan’s research centered around a review of simulated and field topics from a variety of sources, the USN, the Royal Canadian Navy, the civilian maritime sector, and the RAN (Ryan, 2014). Ryan identified that major gaps in research exist in the areas of “sleep quality onboard ships, the formal design and conduct of evaluative research rather than descriptive efforts, and organizational level fatigue management policy and education.” Ryan further identified that sleep management systems are not matured to the point that guarantees crewmembers on ships are able to routinely receive adequate, acceptable quality levels of sleep at sea.

In summation of the studies reviewed by Ryan (2014), the identified gaps in crew endurance and fatigue management studies are Environment, Sleep Quality, Individual Factors, Individual Tolerance Factors, Isolated Studies, Manpower Policies, and Education. Despite these gaps, to expand the body of knowledge, Navies should continue to expend efforts on best practices, not only during sleep studies, but after the trial data has been assessed and recommendations have been implemented. Ryan (2014) goes on to discuss NMD and its use to improve crew fatigue monitoring and suggests that ultimately ship’s crews should be able to operate under the same rest standards that naval aircrew currently operate under.

3. The Effect of Shipboard Manning Levels on Operational Effectiveness—An LCS Case Study (Meredith, 2016)

A recent case study was conducted to see how Freedom variant LCS manning levels affected its operational effectiveness. The study was conducted using the Improved Performance and Research Integration Tool (IMPRINT) software (Meredith, 2016).

The method employed included the creation of a baseline model for the ship that explored the impact of planned activities such as Watchkeeping, Sleep, and Maintenance on shipboard departments and personnel rates (categories). Next, a second more involved model included unplanned events injected into the baseline model to compare the effects of corrective maintenance, drills, etc., on shipboard departments and personnel rates. The results of the comparison between the two models showed an increase (from baseline) in watchkeeper workloads as well as identification of critical crewmembers, as identified by least amount of sleep and high workload levels. Finally, a third model was created to show the operational effect of “extreme” unplanned events, such as a major fire, on the crewmembers. Results from the third model predicted sustained wakefulness (approximately 30 crewmembers not sleeping for close to 40 hours) during an occurrence of an “extreme” unplanned event (Meredith, 2016).

Results for the baseline model showed that watchkeepers were experiencing 14-hour workloads without the occurrence of any unplanned events. This amount is far higher than the workload conditions factored into the USN NAF of an average 10 hours per day. The inclusion of unplanned events in the second model indicates an increase of workload/duty time and a decrease to sleep time; this increase was more noticeable for the Engineering and Combat Systems departments (Shattuck et al., 2016). When unplanned events were introduced, two other causes for concern were introduced. First, two thirds of the divisions responsible for preventive maintenance (PM) were unable to accomplish all of their PM tasks. Of the four divisions unable to complete PM tasks, three were from the engineering department. Approximately 25% of PMs from the engineering divisions were not completed. Second, three quarters of the divisions that failed to complete their PMs were shown to have the least amount of sleep as well. Another concern noted from the second model was the inability of the same divisions that failed to complete all PM to complete corrective maintenance (CM) within a timely manner. Delays in completing CM ranged from 24% to 51% for critical systems such as Ships Service Diesel Generators and Gas Turbine repairs that ultimately could reduce the operational effectiveness of the ship (Shattuck et al., 2016). Overall conclusions from the research noted that the USN Freedom variant LCS manning levels place a demanding workload upon its small crew, and

especially the watchkeepers with little to no capacity to surge for extended periods of time (Meredith, 2016).

III. METHODOLOGY

A. METHODOLOGY OVERVIEW

This thesis first focused on an analytical analysis of data from a DSTO trial conducted onboard HMAS *Warramunga*, a Guided Missile Frigate (FFH), to describe sailor work/rest patterns from all departments and rank groups during underway operations. Next, we used insight from the *Warramunga* data in combination with FFH SMEs' assessments to develop a model in IMPRINT using the Pro Forces module to identify how the addition of unplanned events affect fatigue and the capacity of the Marine Engineering (ME) department to successfully complete routine activities and unplanned events.

B. APPARATUS

1. IMPRINT PRO Forces Module

Improved Performance and Research Integration Tool (IMPRINT) Pro is a software package developed by the Army Research Laboratory by Alion, Inc. IMPRINT Pro uses discrete event simulation to predict the cognitive workload of personnel when conducting both scheduled and unplanned events to determine manpower requirements and human performance (Data and Analysis Center [DAC], 2019). This thesis used IMPRINT Forces Module (version 4.6.54.0) to predict the effects of increased workload and whether the outputs relate to the NSW criteria.

2. Computer Equipment

Spreadsheet manipulation and management was conducted in Microsoft Excel (version 13.0.13328.20262) using a personal Asus GU501G laptop. Analysis of data was conducted using JMP Pro 15 on the same personal laptop. The IMPRINT Pro Forces Modelling was conducted on an NPS-supplied Dell Latitude 5480 laptop. This laptop consistently completed a single scenario run in approximately 1.0–1.3 seconds. An IMPRINT Pro batch launcher was used to conduct multiple runs of the same model with different seed numbers.

To manage the large volumes of files created from a batch run, a software data extractor tool (Upton, 2020) was used to extract all files and merge them in five separate comma separated values (.csv) files. JMP Pro 15 was used to import and conduct the final analysis.

3. Pre-collected Data from HMAS *Warramunga*

A summarized version of the data collected during the *Warramunga* trial by DSTO was investigated to determine the viability of using the NSW criteria to assist in SoC creation in its current form or identify areas for improvement, recommending alternative solutions where possible. The DSTO study was focused on crew endurance over a period of three months between 01 Aug–30 Nov 2011, totaling 122 days of data collection. The trial consisted of volunteer members from the ship’s company wearing Actiwatches (loaned from NPS), ship’s schedules (through NMD), and individual logs to provide context to sleep, watchkeeping routines and work conducted on a ship. Figure 8 shows how the three-month trial was broken into four stages to allow downloading from the Actiwatches: 1—At Home Workup, 2—At Home Workup, 3—O/S Deployment, and 4—O/S Deployment.

All stages had periods of data collection occur during “at sea” (red) and “alongside” (blue) phases. The periods alongside consisted of deployment preparation, crew respite, maintenance, and international relations. Periods at sea consisted of pre-workup training, workup assessment, steady steaming and “at sea” exercises with foreign navies. The pre-workup, workup assessment and “at sea” exercises were conducted with the majority of the ship’s watchkeeping crew undertaking defense watches, the steady steaming period was conducted in cruising watches.

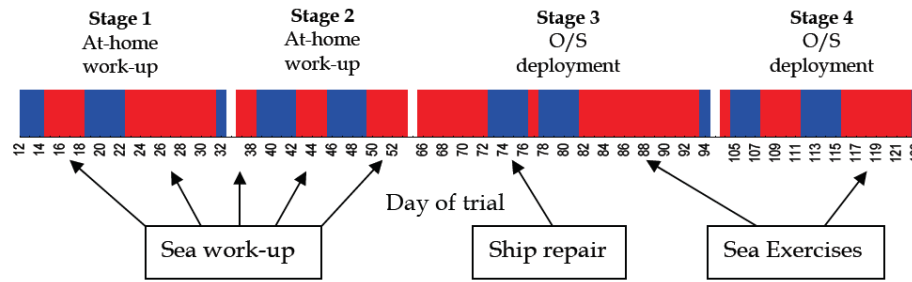


Figure 8. Daily Timeline of Stages 1–4 with “At Sea” Designated in Red and “Alongside” Designated as Blue. Source: Grech et al. (2013).

Due to the quality of the dataset and this thesis’ topic relating to the NSW, which is based off a ship operating at sea, only the sea days were analyzed. *Warramunga* completed 60 sea days during the trial; as such, a maximum of 60 days of data per person from the possible 122 days of data collection was used in this analysis.

Defense watches are utilized when the ship is in a heightened response state and are a one in two watch rotation typically consisting of shift durations 6hr per watch, 12hr per watch or 5hr and 7hr watches. Cruising state is utilized when the ship is transiting and conducting non-heightened state evolutions. Departments/sections that employ defense watches include the operations room and communications room. The other departments/sections that watchkeep, are engineering and bridge watchkeepers regardless of the ship’s state (cruising or defense watches). The study was observational in nature and no change occurred to the ship’s schedule accommodate the trial.

Of a possible designed SoC (depending on current operational configuration) of 174 personnel, this trial consisted of 162 crew members. The sampled crew consisted of 135 (83.3%) males with an average age of 28.7 years (SD=7.9, ranging from 19 to 53 years). Due to anomalies/discrepancies during the collection of data, a total of 149 individuals were included in the final dataset for analysis. Table 4 shows the breakdown of the specific activities data were collected on using a combination of Actiwatches, NMD and individual activity logs. To ensure anonymity for ranks with low numbers, ranks were grouped as shown in Table 5.

Table 4. Data Activities Collected for Duration of Trial

Activity	Measurement
Routine	CW, Daily Sea, Daily Sea Mod, Sun Sea, Sun Sea Mod, Daily Hbr, Sat Hbr, Sun Harbour, and Def Watches
Workday	Yes, No
Inc. Sleep Data	Yes, No
Day	Individual day identification ranging 1–122
Stage	1,2,3, and 4
Total Hours Slept	hours (between day Actiwatch started and stopped recording a sleep episode)
Work Hours	hours (between day work commenced up to when work ceased)
Maintenance- Corrective Hours	hours (between day CM commenced up to when work ceased)
Maintenance- Planned Hours	hours (between day PM commenced up to when work ceased)
Maintenance- Maintenance General Hours	Hours (between day general maintenance commenced up to when work ceased)
Hours Worked Non-core	Hours/day
Training- Collective Hours	Hours/day
Training- Individual Hours	Hours/day
Training- Training General Hours	Hours/day
Watchkeeping	Hours/day
Whole Ship- Messing Hours	Hours/day
Reporting	Hours/day
Whole Ship- Whole Ship General Hours	Hours/day
Whole Ship Activity	Hours/day
Unspecified Departmental	Hours/day
Watches (First, Dogs etc.)	Hours/day
Core Hours (Day Worker)	Hours/day
FF and DC Hours	Hours/day
Actiwatch Quality	Bad, Poor, Good, Download, Watch off

Table 5. Ranks by Rank Groups

Rank	Number in group
SMN, AB, CPL, LS	97
PO, CPO, WO	28
ASLT, SBLT	6
LEUT	13
LCDR, CMDR	5

Figure 9 shows the makeup of the crew. From the 149 sailors included in the analysis, 35 were in the ME department, 64 in Operations, 26 in Supply, and 25 sailors in the WE department.

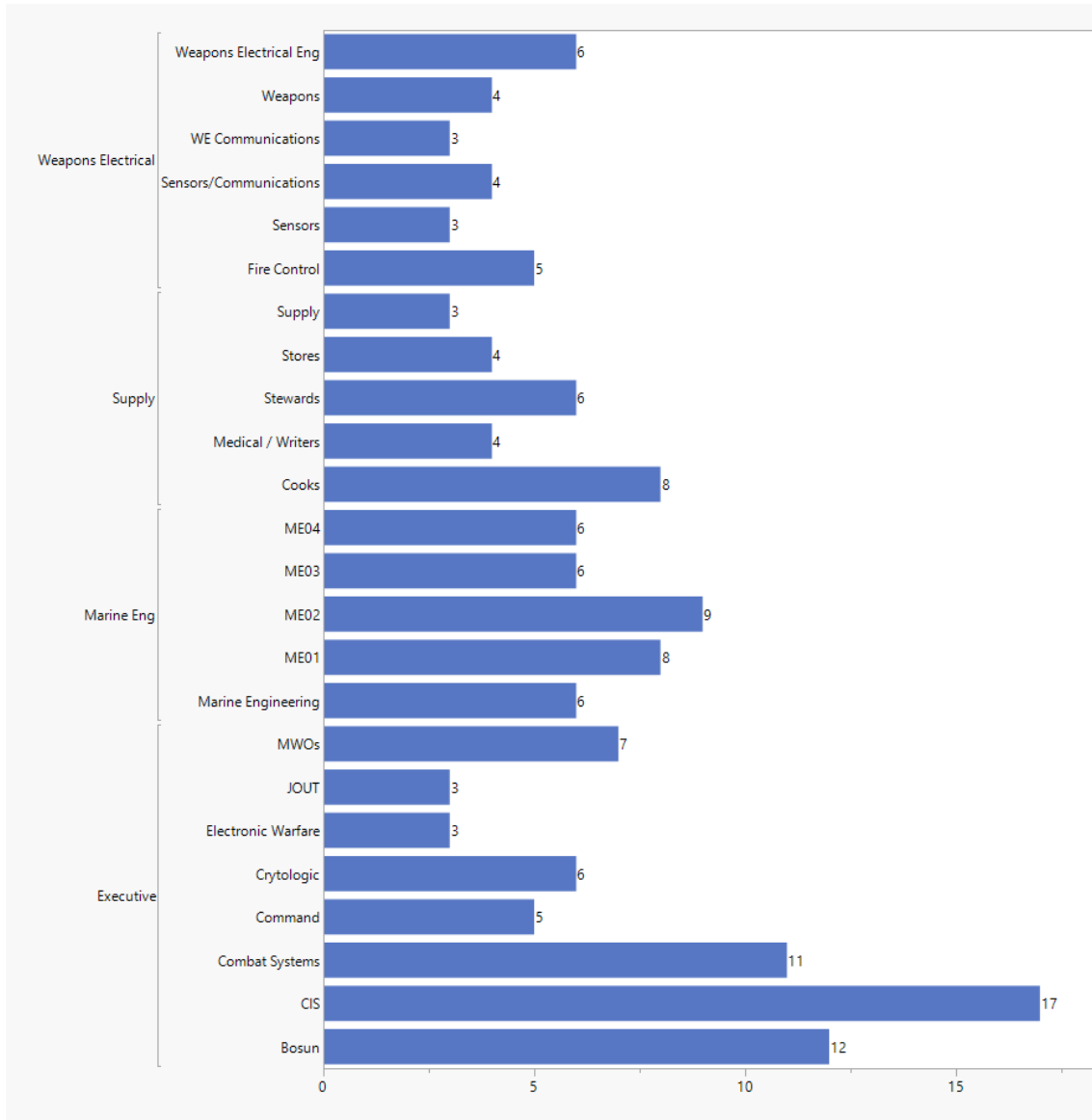


Figure 9. Number of Personnel by Department and Sub-department

The data used for the assessment of the NSW criteria are from all four stages of the trial, but only from the “at sea” days. Consideration was given to the ship’s routine during the sea days, which are broken into Cruising Watches, Sunday Sea, Modified

Sunday Sea, and Defence Watches. Of note, when a ship is conducting a Sunday Sea or a Modified Sunday Sea routine, the ship was in cruising watches and watchkeeping was still required in a one in three rotation or a one in four rotation for the ME department.

a. *Sleep Assessment*

Wrist-worn actigraphy was used to assess sleep duration. The Actiware V3 software (Respironics USA) was used to capture the sleep episodes of individuals. For each individual, the duration of sleep from multiple sleep episodes in a single day was summed and is identified throughout the thesis as the daily sleep duration.

b. *Data Preparation*

The data from HMAS *Warramunga* were inspected for accuracy and validity. During this analysis, all port days, including working days, Sunday and Saturday harbor routines, were removed. This removal reduced the number of recorded days from 18422 down to 9060, leaving a total of 60 days of records per person remaining.

Also, days without manually recorded or actigraphic sleep were deleted leaving 6303 days of data for further assessment. Next, rows were cross-checked for correct addition of hours. Specifically, in the DSTO study, the sleep data were organized from 1800–1800 each day to account for a full sleep episode when analyzing fatigue. Given that our analysis focus is on sleep and work averages, summary data for each day's sleep were used. The exception to the aforementioned approach was the recording of sleep overnight that started before midnight and ended after midnight (into the next day). These periods of sleep were counted on the day that sleep commenced, not when it ceased. Recorded data for work were similarly calculated to provide consistency between the data. For each person, there was up to a maximum of four sleep episodes in a single day and a maximum of three work periods in a day. This decision led to a few situations where either daily sleep duration (DSD) or total work time in a day was far greater than possible but coincided with either the day before or the day after having a reduced period of sleep. To ensure that no data were missed, each person's data was analyzed row by row to confirm validity. Often any days that read as zero hours sleep typically had a sleep episode start at a period prior to midnight with the following night's sleep episode starting after midnight the next night.

Where the data showed zero recorded sleep on a day immediately prior or after a sea day, the port days (either day 64 or 73) were analyzed to confirm that sleep data did exist (and no sleep occurred rather than no sleep data being available from that day. From the line-by-line analysis of the 6303 rows of data, a total of 67 rows were removed from 49 individuals.

Oftentimes sailors go out to socialize and unwind on the days when the ship pulled alongside but these days were still categorized as “at sea” days in the data set and thus included in the analysis. The result of this unwinding meant that some crew members did not have a sleep period until after midnight, which typically displayed a binge-like sleep behavior to catch up on sleep the following day. These data from the next day (categorized as “alongside”) were excluded from analysis.

The next step in preparing the data for analysis was to assess the number of days with sleep per sailor. two crewmembers only had 9 days of data available for analysis. Anyone with less than 10 rows of data was deemed too low a figure to accurately rely on their average sleep and work hours, as such they were removed from the analysis leaving a total of 6218 rows of data. Of the 149 personnel taking part in the trial data collection on average was 41.73 days (SD 12.76 ranging from 12 to 58 days), and a total of 1200 individual sleep episodes occurred throughout the 60 days at sea.

To allow meaningful analysis of smaller sub-departments, the fire control—weapons sub-department was amalgamated with the fire control sub-department. Because there were only 2 medical staff and 2 writers, they too, were combined to allow robustness to the statistical analysis.

C. MODEL DEVELOPMENT IN IMPRINT

1. Overview of the Model

As a result of the findings in the data analysis and due to the unavailability of detailed day to day schedules of activities for each crewmember aboard *Warramunga*, only crewmembers in the ME department were included in the IMRINT model. A secondary consideration for focusing on the ME department was the researcher’s in-depth knowledge of the ME department and the access to SME’s that are members of ME departments on

FFH ships in the RAN. Figure 10 identifies the organizational structure of the ME department and explains what each section is responsible for. The organizational layout of the ME department on an FFH changed to three subsections (ME01, ME02 and ME03) subsequent to when this trial was conducted. In order to align with the data attained from *Warramunga* trial the original four sub-department organization has been kept. The ME department is made up of both watchkeepers and day hands and operates in a similar routine regardless of the ship's assigned State or Condition, meaning that the watchkeeping routine will not change when the rest of the ship's operating routine changes.

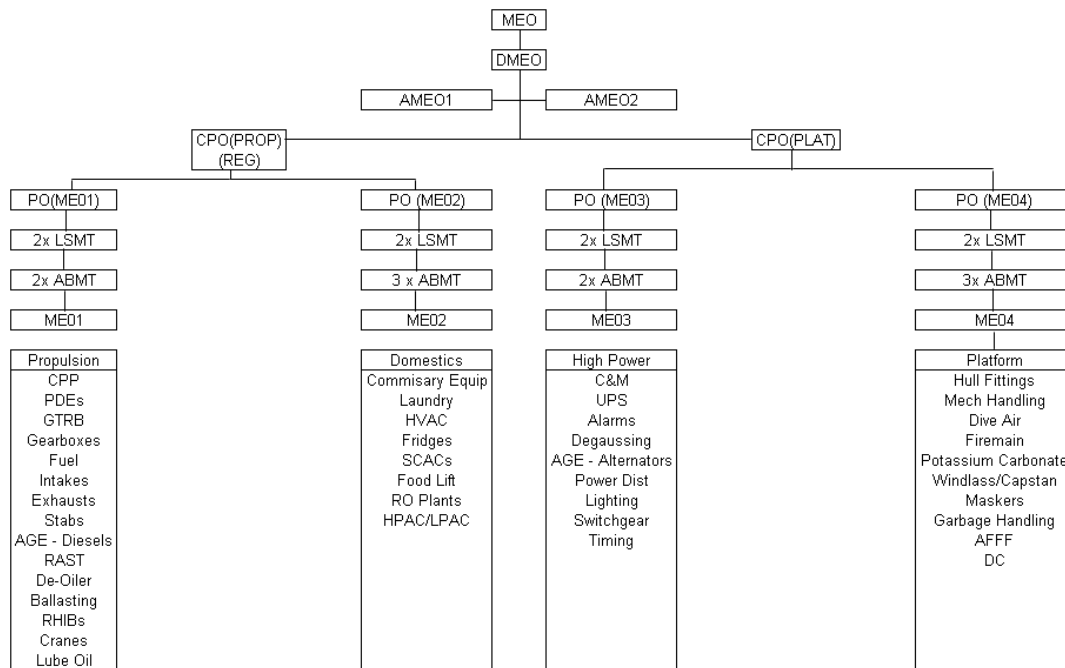


Figure 10. Marine Engineering Department Organizational Chart During Trial Period (RAN, 2013)

IMPRINT requires creation of “Activity” schedules for each role and a Trump matrix to determine the order of priority that tasks are conducted or excluded. The consistency of the ME department's routines allowed an accurate interpretation of collected *Warramunga* data for formulating the activities schedule in IMPRINT Pro Forces Module. The trump matrix is how the program “selects” which task to apply resources to, for how long, and which tasks to “pause” until appropriate resources become available to continue

or restart the task. Selectable options in IMPRINT allow selection of interrupted tasks to be either continued from where they left off or restarted from the beginning of task to attempt to complete when resources are available. IMPRINT also provides an option to allow a task to “fail” to be completed if the task was unable to be achieved within a specific timeframe (Data and Analysis Center, 2019).

2. Model Design and Inputs

We used a modified version of Meredith’s (2016) process to develop the model in IMPRINT. Specifically, the steps used are the following: (1) define the unit topic, (2) develop job lists, (3) assign roles to identified jobs, (4) develop planned activities, (5) identify, develop and define unplanned events, (6) prioritize events and activities in the trump matrix, and (7) define schedules of planned activities for identified jobs.

a. Define the Unit Topic

The collected *Warramunga* data had start/stop times for each sleep episode and start/stop times per person for each work period, which allowed identification of who was not watchkeeping and who was working as a day hand. Each crewmember manually recorded their work times, whereas actigraphic data were used for the identification of sleep episodes. Each crewmember’s assigned hours against sub-categories did not stipulate start/stop times for individual activities. The sub-categories are described below:

- Maintenance CM
- Maintenance PM
- Maintenance Gen
- Training Collective
- Training Individual
- Training General
- Whole Ship Messing / Eat
- Whole Ship Reporting
- Whole Ship General
- Unspecified Departmental Work
- Fire Fighting and Damage Control

The period selected for creation into the IMPRINT model was an “at sea” period where *Warramunga* transited from her home port to an overseas port. This period at sea was chosen because the transit was conducted utilizing cruising watches (thus minimizing

unobserved influences during the data collection) and guarantees MTs were operating in a one in three watchkeeping routine. As seen in Table 6, the modelled period at sea commenced on day 66 and completed on day 72, equating to a total of 8 days of transit time. The benefit of selecting a transit period during cruising watches for MTs is the reduction of whole ship exercises and non-routine interactions occurring. By selecting a routine period at sea, greater accuracy in the creation of the model is predicted, which will aid in removing vagaries when unplanned events are introduced.

Table 6. IMPRINT Model Data Days

Sea/Port	Loc.	Employ.	Routine	Workday	Day
<i>Port</i>	<i>FBW</i>	<i>Deploy Prep</i>	<i>Daily Hbr</i>	<i>Yes</i>	<i>64</i>
Sea	Sea	Passage	CW	Yes	65
Sea	Sea	Passage	CW	Yes	66
Sea	Sea	Passage	CW	Yes	67
Sea	Sea	Passage	CW	Yes	68
Sea	Sea	Passage	CW	Yes	69
Sea	Sea	Passage	CW	Yes	70
Sea	Sea	Passage	Sun Sea	Yes	71
Sea	Sea	Passage	CW	Yes	72
<i>Other Port</i>	<i>Penang</i>	<i>Alongside</i>	<i>Daily Hbr</i>	<i>Yes</i>	<i>73</i>

b. Develop Job Lists

Analysis of the recorded data sub-categories determined that the best way to ensure errors were minimized during the creation of the schedules, due to no minute-by-minute data collection, was to create an activities schedule for each rank by sub-department (identified in IMPRINT as a job). Consideration for which watches were kept, number of day hands, quality of individual data and similarity with other crewmembers' routines of the same rank and sub-department was analyzed to select an accurate representation of each sub-department by rank and qualifications. Table 7 identifies which person from each rank by sub-department was used to create the 14 jobs.

Table 7. Jobs List

ME01	ID	ME02	ID	ME03	ID	ME04	
1 x AB (out of 5)	105	1 x AB (out of 5)	14	1 x AB (out of 3)	8	1 x AB (out of 4)	127
1 x LS (out of 2)	34	1 x LS (out of 2)	73	1 x LS (out of 2)	15	1 x LS (out of 2)	154
1 x PO (out of 1)	246	1 x PO (out of 2)	163	1 x PO (out of 1)	102		
1 x CPO (out of 2)	18	1x LEUT (out of 3 LEUT/SBLT)	184	1x LCDR (out of 1)	89		

c. Assign Roles to Identified Jobs

To complement the collected *Warramunga* data, additional “standard operating” routines (RAN, 2013) were researched and validated by FFH SMEs to ensure accurate population of planned activities, unplanned events, and the trump matrix for orders of priority. Of note, this selected period immediately follows an intense work up period and as such, only one fire/damage control exercise, which occurred on the first day, was conducted throughout the 8-day period. This process is typical and allows the crew to catch up on “routine” shipboard tasks.

Figure 11 is an excerpt of the Job Roles and Jobs Lists developed from *Warramunga*’s dataset. Of note, Job Roles and Jobs Lists in this model have been identified as one and the same. Making no distinction between Job Roles and Jobs Lists allowed an activities schedule to be developed for each sub-department and rank that utilized the same schedule for each member of that sub-department and rank. As an example, the job roles for ME01 AB had five people (jobs) identified against it; similarly, the Assistant Marine Engineering Officer (AMEO) had two jobs assigned to the AMEO job role. Each job role was assigned the number of personal posted to the ship during the trial.

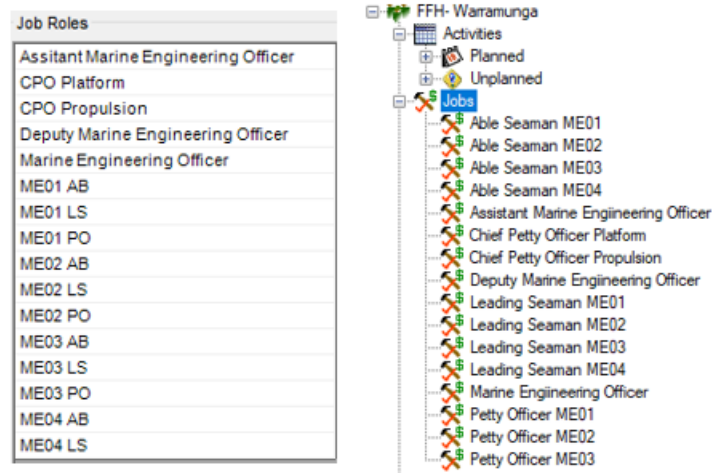


Figure 11. Job Roles and Job List

d. Develop Planned Activities

The planned activities included in the model were kept aligning with the 14 sub-categories captured from the *Warramunga* trial with the exception of Personal Time, Hygiene, and Watchkeeping and can be seen in Figure 12.

“Personal time” and “Hygiene” time were not captured during the *Warramunga* trial, which left gaps in the summarized data. MTs predominantly work in high heat and “dirty” environments. Therefore, they are allotted a minimum of two showers per day to ensure high levels of hygiene are maintained. Hygiene-related activities were added to the schedules as appropriate either before or after sleeping and/or prior to messing while still applying the correct start and stop times for sleep and work activities. “Personal time” was allocated to the periods of time outside of the sleep and work hours (blank hours in the data) and was required to ensure that every minute for the 8-day period was accounted for in the activities schedule.

Watchkeeping was another activity not specifically detailed in *Warramunga*’s collected data. Watchkeeping as an activity of itself, however, is important and requires that the MCR is continuously manned. During the creation of the activity schedules for each rank per sub-department, information on work and sleep patterns allowed for the

identification of the watchkeepers and the watches they kept. Specifying watchkeeping as a planned activity was required for the trump matrix to be successful in prioritizing tasks.

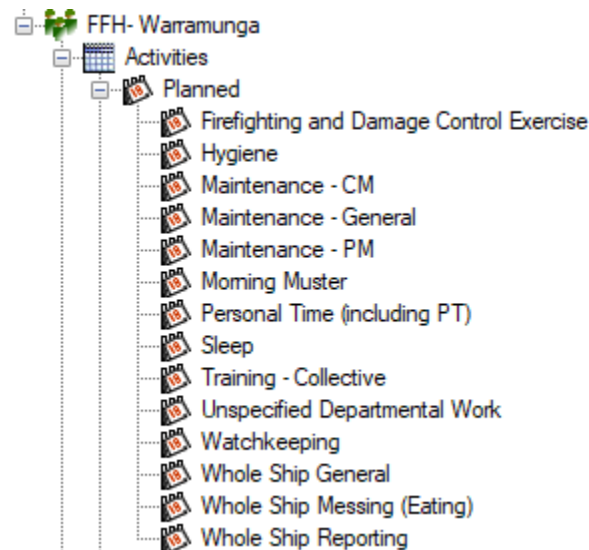


Figure 12. Planned Activities in Alphabetical Order

Each planned event has two parameters assigned to it. The first parameter is its priority (which translates into the trump matrix) and the second is the ability to select the events sleep activity. Sleep activity can be either “True” or “False,” where selection of “True” for an event means that only a crewmember that was well rested would get interrupted if an unplanned activity of higher priority occurred. The selection in my IMPRINT model for all planned activities was set as “False” as this is not a realistic expectation.

e. Identify, Develop and Define Unplanned Events

Initially, a list of unplanned events was developed. This list was refined and validated with information provided by RAN SME engineering personnel from FFH ships. Figure 13 shows the final list of unplanned events in alphabetical order, not the order of priority. There are 13 unplanned events identified that range from a whole ship major fire or flood event down to a Divisional/Personnel Management General event. Note that even

though Firefighting and Damage Control Exercise has been included as planned activity, it was also included to allow the addition of unplanned events.

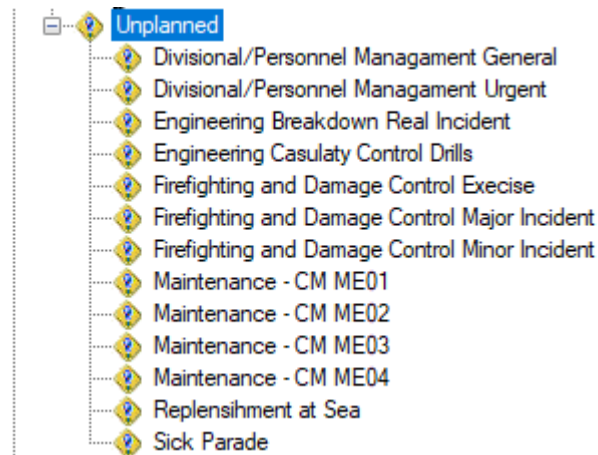


Figure 13. Unplanned Events as verified by RAN SMEs

Each unplanned event has a selectable Priority, Sleep Activity (True/False), Interrupt Strategy, the amount “Required” and “Desired” job roles for the completion of the task, the effect Additional Crew Members has on task completion, Start time, Duration, Cancel parameters, Repeat requirements, and when to Stop Repeating.

Figure 14 shows an example of the Unplanned Event window. Sleep activity is selected as True, meaning that the triggering of this event will look for a more rested crewmember over a non-rested crewmember. The event has a priority of 15 with an interrupt strategy of resume, this means that if the event is interrupted due to a higher priority task then when the other task is completed this activity will resume. You can see that as a minimum, there is a requirement for 1x AMEO, 1x DMEO and the MEO. However, if available up to 2x AMEOs are desired as well as both of the CPOMTS. The ability to have additional desired crewmembers allows the reduction of time spent on the task. This example shows that for this event, a reduction in time of 50% per additional crewmember up to a maximum of 4 people, noting that the minimum requirement is 3, the addition of an extra crewmember reduces the time by half. The lower portion of the screen shows selectable tabs that allow either a specific time or a distributed time to be set. The

IMPRINT Pro Forces Model has the ability to assign assets but due to the nature of our analysis and data, this feature was not used.

Divisional...ent Urgent

Unit Name: FFH- Warramunga

Activity: Divisional/Personnel Managment Urgent

Sleep Activity: True Priority: 15 Interrupt Strategy: Resume

Job Roles

Role	Required	Desired
Assitant Marine Eng	1	2
CPO Platform	0	1
CPO Propulsion	0	1
Deputy Marine Eng	1	1
Marine Engineering	1	1
ME01 AB	0	0
ME01 LS	0	0
ME01 PO	0	0

Adding Crew Members

☐ has no effect

☐ reduces Time Proportionally

☒ reduces Time Somewhat

Maximum # crew members: 4

Maximum # crew members: 4

% reduction per additional: 50.00

Asset Features

Feature	Required	Desired
---------	----------	---------

Start Duration Cancel Repeat Stop Repeat

☐ Enter Time ☒ Use Distributions ☐ Use Expression (evaluates to hours)

Distribution: Normal

Mean: 12:00 D HH:MM

Standard Deviation: 07:00 D HH:MM

Figure 14. Unplanned Event—Divisional/Personnel Management Urgent

The parameters of the basic attributes of all unplanned events (i.e., Start time, Duration, Cancel, Repeat) were stochastic using a normal distribution. Detailed information on attributes and parameters of all unpanned events is shown in Table 8.

Table 8. Unplanned Events Attributes and Parameters

Activity Type	Activity Conducted	Pty	Start		Duration		Cancel Cancelled “x” hours after start time	Repeat		Sleep Activity	Interrupt Strategy	Reduces time by:	Qty	Max crew	Rqd	Desired
			Mean	SD	Mean	SD		Mean	SD							
Unplanned	FF, DC, Toxic Hazard or Casualty Major Incident	1	4 00:00	3 23:00	4:00	1:30				FALSE	Resume	No Effect			35	35
Unplanned	Engineering Breakdowns Real Incident	2	1 0:00	12:00	1:00	0:40		1 0:00	12:00	FALSE	Resume	Somewhat	25%	24	14	35
Unplanned	FF, DC, Toxic Hazard or Casualty Minor Incident	3	2 12:00	1 22:00	1:00	0:30		2 00:00	1 22:00	FALSE	Resume	Somewhat	30%	18	6	18
Unplanned	Replenishment at Sea	5	6 12:00	4:00	1:20	0:20				TRUE	Abort	No Effect			10	16
Unplanned	FF and DC Exercise	6	1 14:30	7:00	0:45	0:15	2:00	1 0:0	7:00	FALSE	Abort	Somewhat	10%	10	6	12
Unplanned	Maintenance CM - ME01	8	12:00	12:00	1:15	0:30		1 12:00	12:00	TRUE	Resume	Somewhat	25%	4	2	10
Unplanned	Maintenance CM - ME02	8	12:00	12:00	1:15	0:30		2 0:00	12:00	TRUE	Resume	Somewhat	25%	4	2	10
Unplanned	Maintenance CM - ME03	8	12:00	12:00	1:15	0:30		2 0:00	12:00	TRUE	Resume	Somewhat	25%	4	2	8
Unplanned	Maintenance CM - ME04	8	12:00	12:00	1:15	0:30		2 0:00	12:00	TRUE	Resume	Somewhat	25%	4	2	9
Unplanned	Sick Parade	13	8:00	0:45	0:30	0:15	0:45	1 0:0	0:15	FALSE	Abort	No Effect			0	35
Unplanned	Divisional/Personnel Management Urgent	15	12:00	7:00	2:00	1:30		3 12:00	2 12:00	TRUE	Resume	Somewhat	50%	4	3	6
Unplanned	Engineering Casualty Control Drills	21	14:00	5:00	1:00	0:30	2:00	2 0:00	5:00	TRUE	Abort	Somewhat	25%	18	5	35
Unplanned	Divisional/Personnel Management General	23	12:00	7:00	4:00	2:00		2 12:00	1 16:00	TRUE	Resume	Somewhat	50%	4	2	6

f. Prioritize Events and Activities in the Trump Matrix

The trump matrix results from assigning priorities to planned activities and unplanned events. The methodology employed for this thesis used Excel to create all the variables needed for planned and unplanned events that incorporated the priorities and allowed verification by FFH SMEs. To confirm that the data was correctly entered into the IMPRINT model, the trump matrix can be displayed in IMPRINT and used to adjust any of the events priorities if changes are required.

Figure 15 shows the trump matrix as displayed in IMPRINT. Of note, not all unplanned events have higher priorities to planned activities. Priorities for unplanned and planned events can also be the same, which is the case for CM, and CM for each of the sub-departments that all have a priority level of 8. A planned event was required to account for the time spent during the 8-day sea period where actual CM was conducted. The addition of the unplanned CM events for each sub-department allows randomness and variability to the model.

The unplanned event “Firefighting and Damage Control Major Incident” had the highest priority. In terms of planned activities, Watchkeeping had the 4th highest priority, which ensures that the watchkeeping role is always maintained. When an incident of a higher priority to watchkeeping occurs, the actions required by the ME department are controlled from the Machinery Control Room (MCR), which is where watchkeeping is performed. The lowest priority in the trump matrix was assigned to Personal Time (including physical training). This aligns with current work practices and is always the first activity to be “cut away” as higher priority activities occur.

Activities		
Priority	Name	Type
1	Firefighting and Damage Control Major Incident	Unplanned
2	Engineering Breakdown Real Incident	Unplanned
3	Firefighting and Damage Control Minor Incident	Unplanned
4	Watchkeeping	Planned
5	Replensihment at Sea	Unplanned
6	Firefighting and Damage Control Exercise	Planned
6	Firefighting and Damage Control Execise	Unplanned
8	Maintenance - CM	Planned
8	Maintenance - CM ME01	Unplanned
8	Maintenance - CM ME02	Unplanned
8	Maintenance - CM ME03	Unplanned
8	Maintenance - CM ME04	Unplanned
13	Sick Parade	Unplanned
15	Divisional/Personnel Managment Urgent	Unplanned
16	Training - Collective	Planned
17	Whole Ship Reporting	Planned
18	Whole Ship General	Planned
20	Sleep	Planned
21	Engineering Casulaty Control Drills	Unplanned
22	Whole Ship Messing (Eating)	Planned
23	Divisional/Personnel Managment General	Unplanned
24	Unspecified Departmental Work	Planned
26	Maintenance - PM	Planned
28	Maintenance - General	Planned
30	Hygiene	Planned
38	Morning Muster	Planned
40	Personal Time (including PT)	Planned

Figure 15. Trump Matrix for IMPRINT Pro Forces Model

g. Define Schedules of Planned Activities for Identified Jobs

A total of 14 schedules were created, each with an 8-day duration. Schedules ranged between 102–146 individually identified planned activities for the 8-day period at sea. A schedule was created for each rank and sub-department to allow consistency and similar task assignment when identifying the qualification requirements required or desired for an unplanned event.

Work Schedules	
Schedule	Duration (Days)
Able Seaman Marine Technician ME01	8
Able Seaman Marine Technician ME02	8
Able Seaman Marine Technician ME03	8
Able Seaman Marine Technician ME04	8
Chief Petty Officer Marine Technician	8
Deputy Marine Engineering Officer	8
Leading Seaman Marine Technician ME01	8
Leading Seaman Marine Technician ME02	8
Leading Seaman Marine Technician ME03	8
Leading Seaman Marine Technician ME04	8
Marine Engineering Officer	8
Petty Officer Marine Technician ME01	8
Petty Officer Marine Technician ME02	8
Petty Officer Marine Technician ME03	8

Figure 16. FFH *Warramunga* ME Department Work Schedules

Each schedule was assigned the number of personnel per rank and sub-department, and assigned to a job (identified by rank and sub-department). For example, for the duties of an Able Seaman Marine Technician ME01 there were five crewmembers assigned to this schedule/job. The same was done for each of the other schedules/jobs created. When assigning the number of personnel to Chief Petty Officer, and Deputy Marine Engineering Officer's Schedules the jobs were specifically identified as either Chief Petty Officer Platforms or Chief Petty Officer Propulsion. The same rule was used for separating the jobs between Deputy and Assistant Marine Engineering Officers. The purpose of separating jobs while using the same schedule allowed better refinement of allocated responsibilities when dealing with unplanned events. Table 9 shows the number of personnel assigned to each schedule/job.

Table 9. Allocation per Person for Schedules of *Warramunga* 8-Day Period

Schedule and ID number	Rank and number per schedule																Total
	MEO	DMEO	AMEO	CPO Plat	CPO Prop	PO ME01	PO ME02	PO ME03	LS ME01	LS ME02	LS ME03	LS ME04	AB ME01	AB ME02	AB ME03	AB ME04	
AB ME01 ID number 105													5				5
LS ME01 ID number 34									2								2
PO ME01 ID number 246						1											1
AB ME02 ID number 14														5			5
LS ME02 ID number 73									2								2
PO ME02 ID number 163							2										2
AB ME03 ID number 8															3		3
LS ME03 ID number 15											2						2
PO ME03 ID number 102								1									1
AB ME04 ID number 127																4	4
LS ME04 ID number 154												2					2
CPO ID number 18				1	1												2
LEUT ID number 184		1	2														3
LCDR ID number 89	1																1
Total																	35

3. Running the Models

To run the IMPRINT model multiple times the IMPRINT Batch Launcher was used. Figure 17 shows the IMPRINT Batch Launcher, which is a simple interface that allows model selection, number of runs (1 up to 999), ability to separate reports, and the selection of an output folder.

IMPRINT is able to produce reports that include Activity Data, Time Total by Individual Resource, Crew Effects on Duration, Unplanned Activity Status, Unplanned Activity Status Summary, Unplanned Activity Required vs. Met, Unplanned Activity Resource Participants, and Unplanned Specialty Usage. IMPRINT is also able to produce two charts in Excel that show Time Total by Resource and Time Total by Schedule.

Each run has the random seed value increased by 1 each time, the first run used the same random seed number (100) allocated in my trial runs. By selecting the “separate report” check box the batch launcher saves all the files associated with that run in to an individual folder in the specified destination folder.

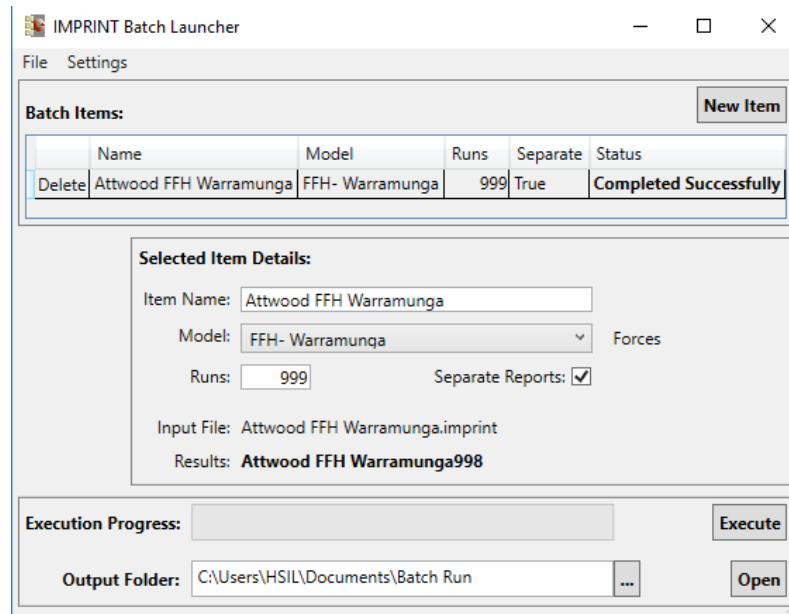


Figure 17. IMPRINT Batch Launcher

Once the batch run was completed, the 999 folders containing separate IMPRINT files needed to be merged. To do this merge, a data software extraction tool (Upton, 2020) was used to extract all files and merges them in five separate “Comma-Separated Values” (CSV) files. Due to the number of rows in some of the files exceeding Excel’s row limit and therefore its ability to import the data from each CSV file, JMP Pro 15 was to import and conduct the final analysis.

IV. RESULTS

A. SLEEP AND WORK HOURS ON THE HMAS *WARRAMUNGA*

Across the entire ship, the average daily sleep duration was 6.96 ± 0.77 hours, the average total work was 11.9 ± 2.32 hours, and the average time spent in messing was 2.66 ± 0.28 hours. The daily sleep duration (DSD) for the ship's crew is less than the NSW guidelines of 8 hours per day by 1.04 hours ($t [148] = 16.5, p < 0.001$). The NSW defines productive time at 10 hours per day (not factoring reduced work hours for a Sunday sea routine) by ($t [148] = 9.87, p < 0.001$). However, the mean daily work hours of the ship's crew during the trial period exceeds this criterion. Messing, as defined in the NSW, has a stipulated average of 2 hours per day and thus, the crew are spending significantly more time than allocated on messing by ($t [148] = 29.2, p < 0.001$).

1. Descriptive Results by Department and Sub-department

Figure 18 shows the average DSD, daily work hours, and messing hours per day by department. Vertical lines denote the standard error of the mean (SEM). The black horizontal lines depict the NSW criteria.

a. *Daily Sleep Duration, Total Work Time, and Messing by Departments*

Crewmembers in the Executive (Exec) department ($n=64$ sailors) sleep less (6.69 ± 0.65 hours) and work more (11.3 ± 2.42 hours) than sailors in the Weapons Engineering (WE) department ($n=25$ sailors) who have the highest DSD (7.57 ± 0.69) and work less (10.7 ± 2.5 hours). Sailors in the Marine Engineering (ME) department ($n=35$ sailors) sleep roughly the same (6.71 ± 0.76 hours) as the Exec department. Members of the ME department, however, work more (12.9 ± 1.08 hours) than the Exec department. Even though the Supply department works similar hours (13.0 ± 2.12 hours) to the ME department, their average DSD is higher (7.39 ± 0.64 hours). Messing time per day for the ME department was the lowest (2.56 ± 0.24 hours) followed by Exec department (2.67 ± 0.25 hours), then Supply department (2.74 ± 0.24 hours) with WE department having the highest messing hours (2.85 ± 0.33 hours).

On average, sailors in all departments sleep less than the time allotted by the NSW guidelines. Similarly, work hours for each department remain on average above the NSW guidelines. Time spent on messing, however, is on average above the 2 hour/day guideline in the NSW.

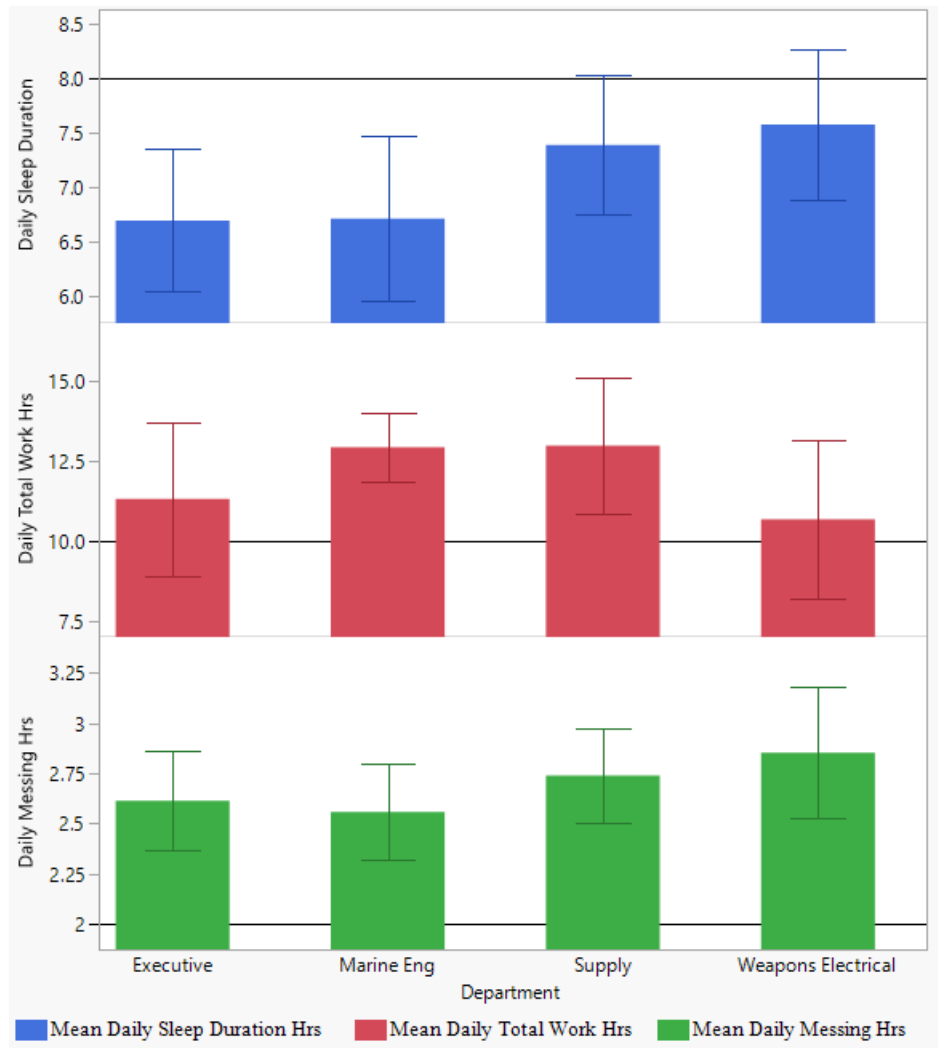


Figure 18. Mean - Daily Sleep Duration, Total Daily Work, and Daily Messing by Department

b. Daily Sleep Duration, Total Work Time, and Messing by Sub-departments

When analyzing sub-departments, as defined in the Methodology (Figure 9), results depicted in Figure 19 show that Sensors/Communications (n=4) had the largest DSD (8.16 ± 0.36 hours) and was the only sub-department that exceeded the NSW daily sleep

guidelines. The sub-departments with the lowest DSD were junior officers under training (JOUT, n= 3, 6.36 ± 0.71 hours) and ME02 (n=9, 6.37 ± 0.93 hours). Even though the JOUT sub-department had the lowest DSD, their daily total work hours were also the lowest (5.79 ± 0.69 hours).

With the exception of the ME department, results in Figure 19 indicate that work between sub-departments within the same department show large variations with respect to each other. The ME and Supply departments are the only two categories that have all sub-departments working in excess of NSW daily guidance. The officer sub-departments (irrespective of their department) all show high daily total work hours: Supply (n=3, 14.9 ± 1.11 hours), Command (n=5, 14.3 ± 1.69 hours), ME (n=6, 14.0 ± 1.67 hours), MWOs (n=7, 13.1 ± 1.96 hours), and WEE (n=6, 12.9 ± 1.51 hours). Out of the sub-departments, five of the top nine sub-departments are officers, the top four sailor categories are: Cooks (n= 8, 13.6 ± 0.97 hours), Stewards (n=6, 13.4 ± 0.66 hours), ME01 (n=8, 13.1 ± 0.88 hours), and ME03 (n=6, 12.9 ± 0.95 hours).

All sub-departments show daily messing times higher than NSW guidelines. The WE Sensors sub-department (n=3) had the highest daily messing hours (2.98 ± 0.35 hours) and ME04 (n=6) had the lowest (2.39 ± 0.28 hours).

c. Comparison of Unspecified Departmental Work, Reporting, Total Training and Whole Ship—General by Sub-departments

Figure 20 compares departments/sub-departments across the following categories: Unspecified Departmental Work (UDW), Reporting, Training, and Whole ship—General duties. Analysis of Training show that the Medical/Writers (n=4) sub-department are the only ones that conduct less than one hour per day (0.93 ± 0.72 hours). All other sub-departments are in excess of the one-hour NSW guideline for training hours per day, the Sensors/Communications sub-department (n=4) have the highest allocation to training per day (2.08 ± 0.37 hours).

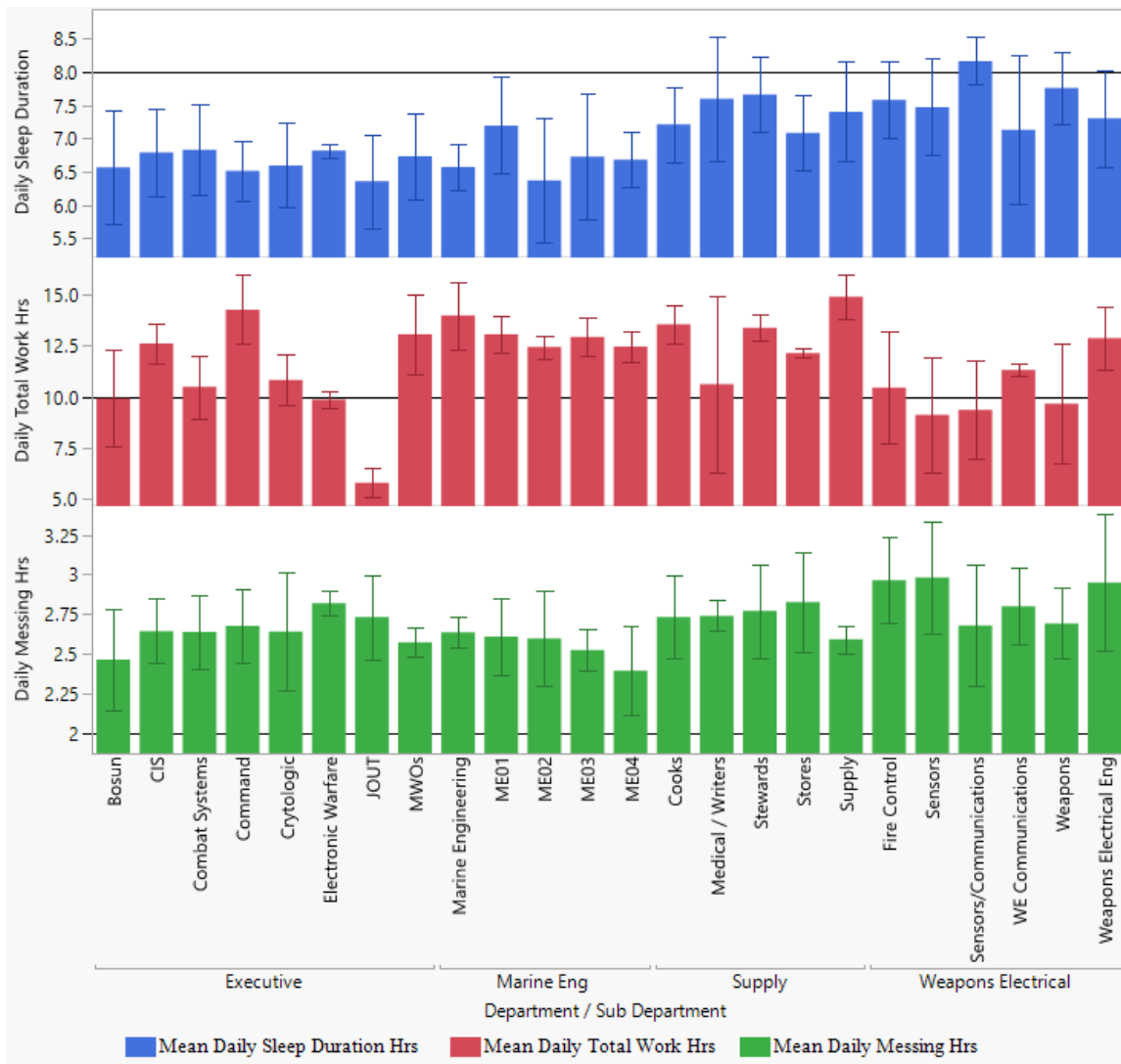


Figure 19. Mean - Daily Sleep Duration, Total Work and Ship Activities by Sub-department

Reporting activities vary significantly between all sub-departments irrespective of their department. The officer sub-departments: MWOs ($n=7$, 4.83 ± 2.00 hours), Supply ($n=3$, 4.10 ± 3.56 hours), Command ($n=5$, 4.05 ± 2.28 hours), ME ($n=6$, 3.25 ± 2.48 hours), and WE ($n=6$, 2.79 ± 3.11 hours) show the five highest average daily hours. Sub-department Medical/Writers ($n=4$) have the highest reporting levels for non-officers (2.69 ± 3.13 hours). Reporting and UDW do not have NSWV black lines depicted against them as they fall under the “Productive Time” guideline of 10 hours per day.

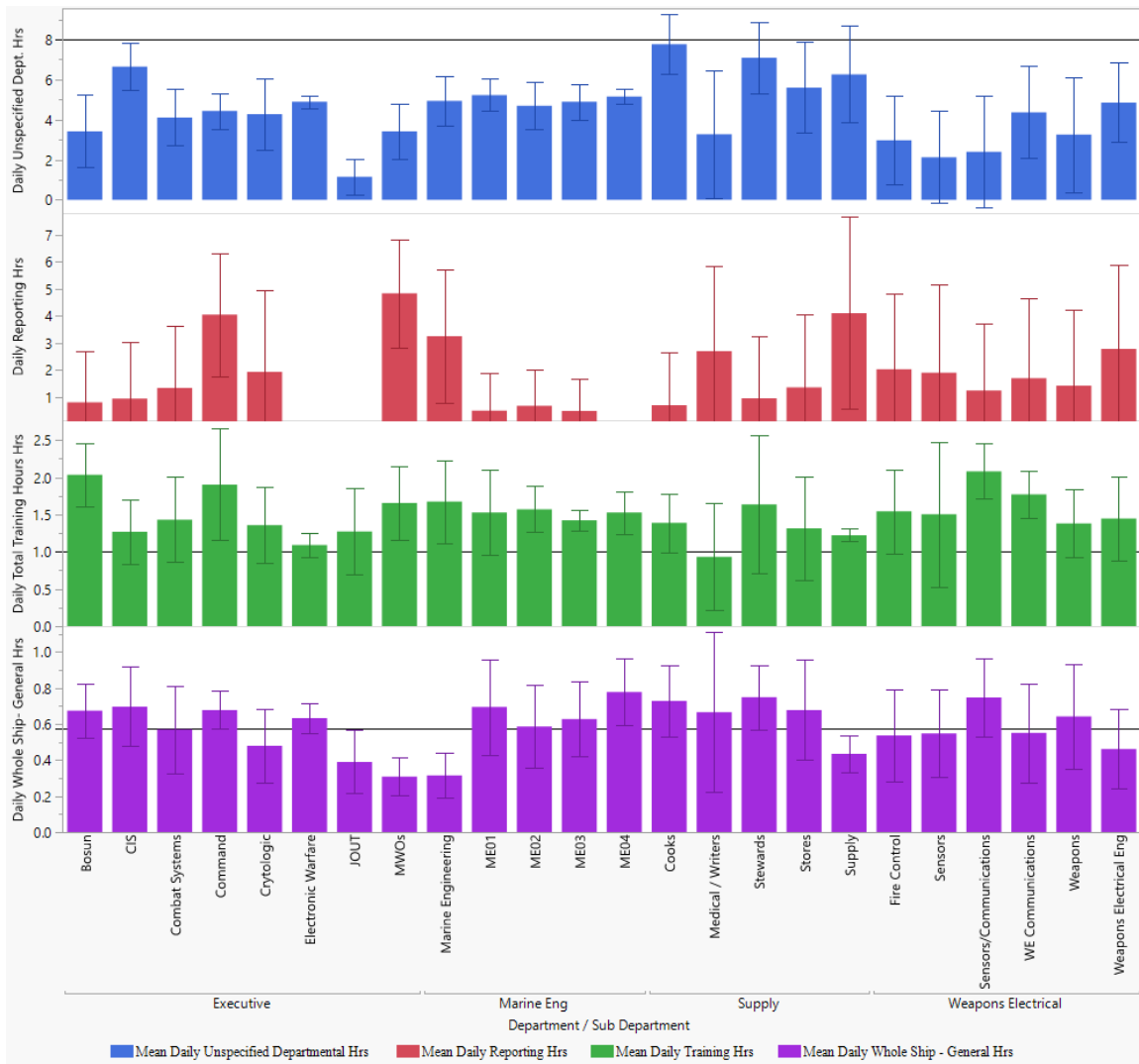


Figure 20. Daily Mean Unspecified Departmental Work, Reporting, Training, and Whole ship—General by Sub-department/Department

d. Comparison of Maintenance—Corrective, Preventative, and General

Maintenance conducted on a ship is primarily performed by the Marine and Weapons Electrical Departments, with survival equipment maintenance conducted by the Boatswain’s sub-department “Boatswain -SE.” However, Boatswain-SE was not identified in the dataset, and they also did not record any maintenance activities throughout the trial. As such, maintenance analysis was conducted only on the ME and WE departments for all

ranks. Figure 21 accounts for maintenance (preventative, corrective, general, and total) conducted during the 60 days that *Warramunga* spent at sea throughout the trial period.

The ME sub-departments on average completed more maintenance than the WE sub-departments. ME03 (n=6) completed the highest amount of total maintenance hours daily (2.75 ± 0.79 hours) followed by ME04 (n=6, 2.53 ± 0.70 hours), ME01 (n=8, 2.50 ± 0.30 hours), and ME02 (n=9, 2.26 ± 0.47 hours). The WE sub-department with the highest average daily maintenance recorded was Fire Control (n=5, 0.18 ± 0.16 hours), while the Sensors sub-department (n=3) recorded the lowest daily average (0.04 ± 0.08 hours).

General Maintenance (GM) was not conducted consistently throughout the trial and as such, when averaged over the 60 sea days across the engineering departments, only accounts for 0.06 ± 0.04 hours per day. Of the engineering sub-departments, GM was not conducted by either Sensors/Communications or Sensors sub-departments. The top four GM sub-departments in hours per day were from the ME department; ME04 (0.11 ± 0.15 hours), ME02 (0.09 ± 0.10 hours), ME03 (0.09 ± 0.06 hours), and ME01 (0.08 ± 0.11 hours). However, the SD for all but ME03 sub-departments have a larger value/range than their respective means.

The ME03 sub-department was found to conduct the highest average planned maintenance (PM) per day (1.32 ± 0.63 hours). ME02 had the lowest mean daily PM (1.02 ± 0.40 hours) but was still higher than the Weapons sub-department (0.10 ± 0.07 hours) which was the highest from the WE department.

Similarly, corrective maintenance (CM) was consistently performed by the ME departments; ME03 (1.38 ± 0.58 hours) had the highest and ME04 (1.10 ± 0.24 hours) had the lowest amount of CM. The highest WE department was Sensors (0.04 ± 0.08) and the lowest was Fire Control sub-department (0.02 ± 0.05 hours).

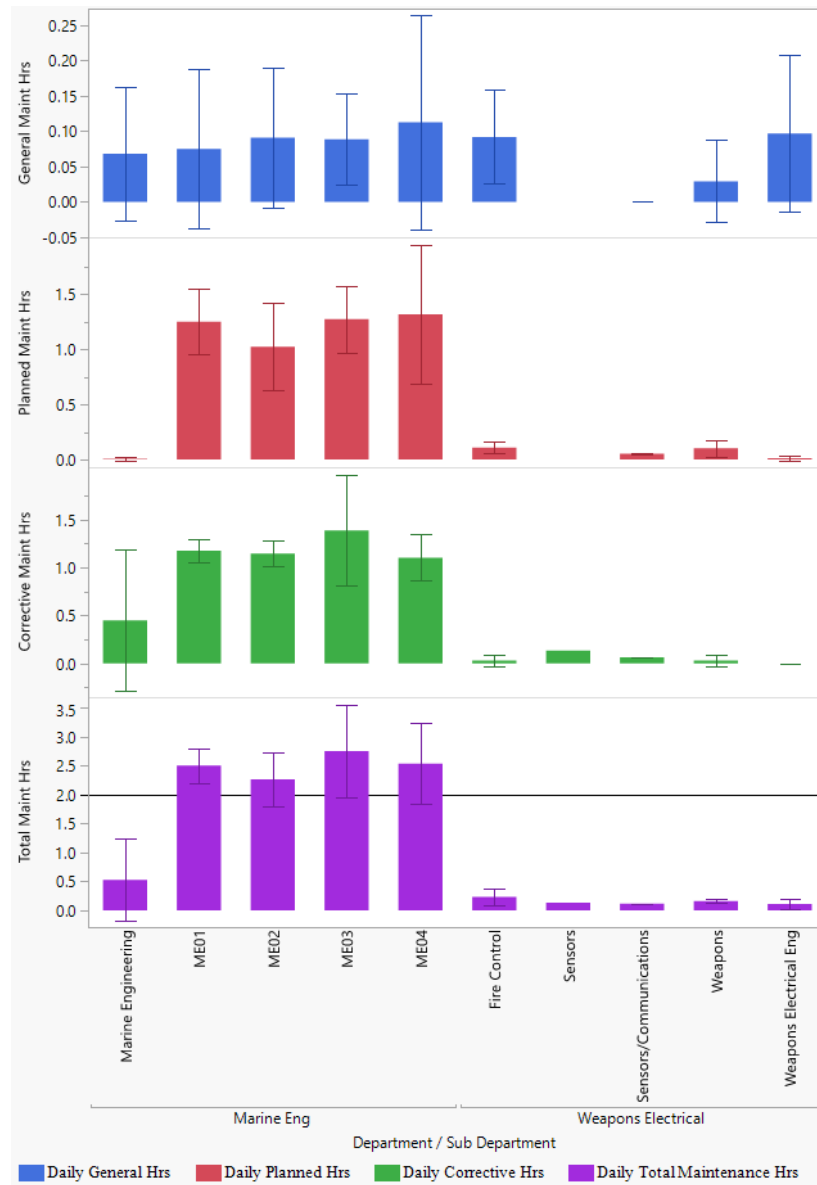


Figure 21. Mean Daily Maintenance - Planned, Corrective, General and Total by Sub-department

The NSW guidelines for available productive time/work (PT) is 70 hours per week and, in the context of this data set, includes the following categories: watchkeeping, maintenance, reporting, whole ship—general, and UDW. Noting that the whole ME department does not watchkeep, the use of the aforementioned one-in-four watch rotation for MTs shown in Table 10 has been used to understand how much time PT is available beyond watchkeeping commitments.

Table 10. Watchkeeping—One in Four Routine for MT at Sea

Title/Position	Typical Rank	Watchkeeping per Person Hours per Week	Watchkeeping per Qualification Hours per Week
MSM x3	PO or LS	42	126
MSC x3	LS or AB	42	126
MST x3	AB or SMN	42	126
MSM U/T x3 (one watch per day)	PO or LS	28	84
MSC U/T x3 (one watch per day)	LS or AB	28	84
MST U/T x3 (one watch per day)	AB or SMN	28	84
Total Hours			630

There are 29 personnel available to conduct maintenance and watchkeep between the ranks of SMN up to PO within the ME department. The 29 sailors have a combined weekly PAF of 2030 hours minus the 630 hours (for watchkeeping) which leaves 1400 hours available per week for maintenance and “other work” (as described from the NSWV guidelines).

The combined mean for SMN-PO from the ME department’s daily total maintenance per person is 2.51 ± 0.05 hours. This number equates to approximately 510 $\pm$ 40.5 hours maintenance conducted per week, leaving 890 hours available per week for other work tasks from the 29 sailors of the ME department. When calculated for an individual, that leaves on average 30.7 ± 1.4 hours per week, or 4.4 ± 0.2 hours daily per sailor.

2. Analyzing by Rank Group

a. *Daily Sleep Duration, Total Work Time, and Messing by Rank Group*

Next, sleep and work data were analyzed by rank group. In Figure 22, it can be seen that POs/CPOs/WO (senior sailors, n=28) on average have the highest daily sleep duration (DSD) (7.14 ± 0.70 hours) of all ranks. The rank group assigned to LEUTs (junior officers, n=13) has the lowest mean DSD (6.66 ± 0.57 hours), and LCDR/CMDRs (senior officers, n=5) have more DSD hours (6.88 ± 0.81 hours) than ABSLT/SBLT (JOUT, n=6, 6.78 ± 0.80 hours). The largest group, SMN/AB/LS/CPL (junior sailors), sleep (n=97, 6.96 ± 0.81

hours) more than senior officers but less than senior sailors. However, all rank groups are sleeping less than the NSW guidelines for DSD of 8 hours of sleep per day.

Mean daily total work hours by rank group show JOUT work under the 10 hours a day NSW guidelines (9.45 ± 4.07 hours), and senior officers have the longest daily total work hours (15.0 ± 0.52 hours) of all rank groups. Junior officers (13.4 ± 1.69 hours) and senior sailors (13.2 ± 1.59 hours) worked longer than junior sailors (11.3 ± 2.09 hours) and were all higher than the NSW guidelines.

The NSW guidelines for messing were exceeded by all rank groups for daily messing hours. All rank groups had very similar messing times; when averaged for the whole ship, the mean is 2.65 ± 0.04 hours. However, junior officers had the highest daily messing hours (2.70 ± 0.33 hours), and the senior sailors had the lowest daily messing hours (2.61 ± 0.18 hours).

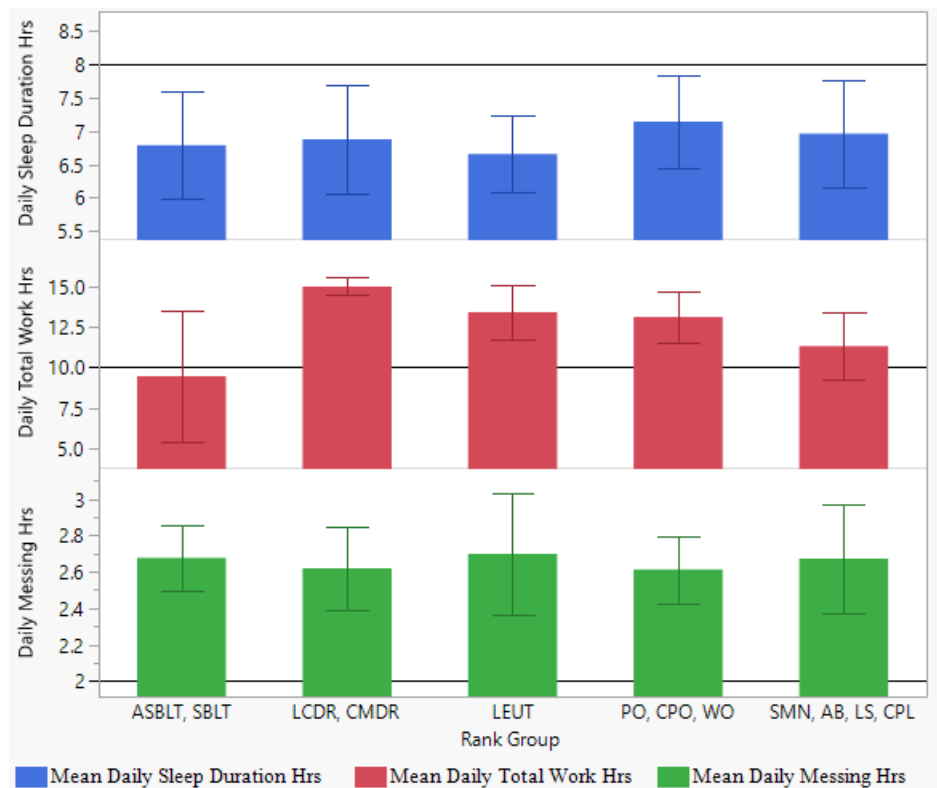


Figure 22. Mean - Daily Sleep Duration, Total Work and Daily Messing by Rank Group

b. Comparison of Unspecified Departmental Work, Reporting, Total Training, and Whole Ship General Duties by Rank Group

When investigating Unspecified Departmental Work (UDW), Reporting, Total Training and Whole Ship General duties by rank group, Figure 23 shows that junior sailors conduct more UDW (5.42 ± 2.0 hours) than any other rank group. Senior sailors have the least amount of UDW (3.07 ± 1.33 hours), followed by junior officers (3.76 ± 1.38 hours), senior officers (4.03 ± 0.54 hours), and JOUTs having the second highest UDW (4.56 ± 3.91 hours).

Reporting duties/work were reported as zero for JOUTs and junior sailors, senior officers have the highest hours of daily reporting (5.59 ± 0.69 hours), followed by senior sailors (4.88 ± 0.85 hours) with junior officers (4.75 ± 2.01 hours) only slightly lower but with a higher SD.

Total Training (not including DC/Firefighting) conducted by rank group shows a surprisingly low value for JOUTs (1.15 ± 0.45 hours). However, it is still above the NSW guidelines of one hour per day. Senior officers recorded the highest daily training hours (1.77 ± 0.91 hours), followed by the junior officers (1.57 ± 0.45 hours). Junior sailors (1.52 ± 0.54 hours) and senior sailors (1.49 ± 0.53 hours) conducted training (not including DC/Firefighting) and are all only separated by marginal values.

Junior sailors conduct the most daily Whole Ship—General (WS-G) duties (0.74 ± 0.15 hours) followed by senior officers (0.58 ± 0.07 hours). Junior officers conduct the least amount of time per day (0.31 ± 0.11 hours) of WS-G. JOUTs (0.35 ± 0.13 hours) and senior sailors (0.33 ± 0.13 hours) spend more time than junior officers but less than senior officers.

Time spent conducting firefighting and damage control per day ranged from 0.57 ± 0.32 hours for JOUTs up to 0.93 ± 0.35 hours for junior sailors. Junior officers (0.84 ± 0.13 hours) and senior sailors (0.81 ± 0.25 hours) conducted the second and third highest daily hours. This pattern is most likely due to the requirement to facilitate and assess training damage control incidents. The NSW includes damage control/firefighting under the training category which, when combined for each rank group, averages as an extra 0.77

± 0.14 hours. This makes the total training (including DC and firefighting) equivalent to 2.28 ± 0.24 hours training hours per day, which is nearly 2.5 times more than the allocated 1 hour per day laid out in the NSW.

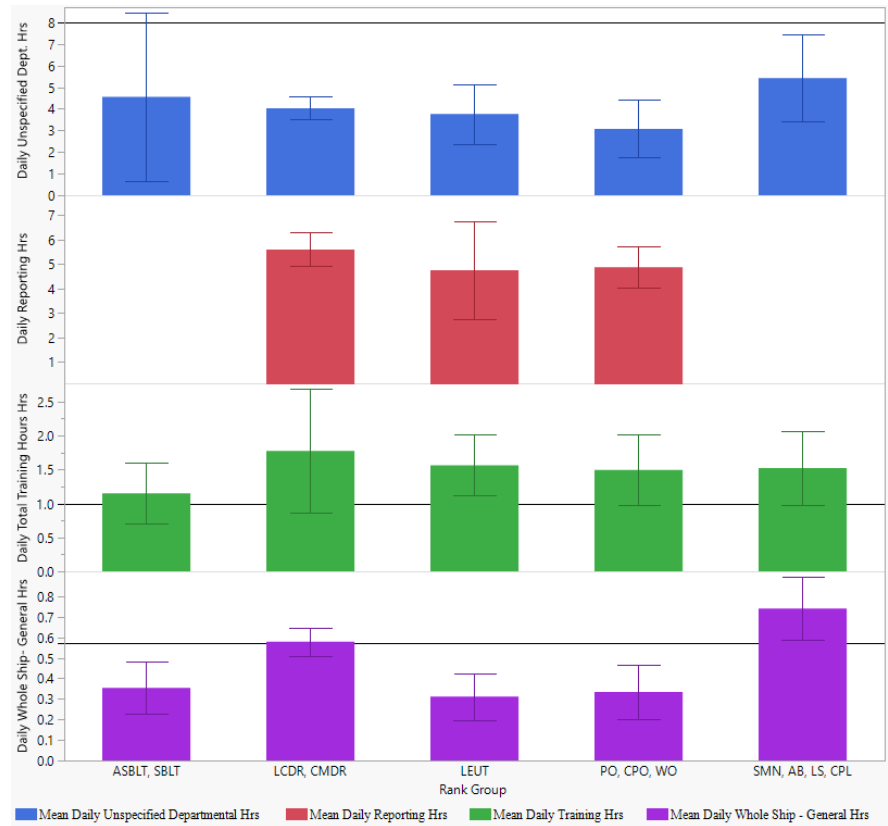


Figure 23. Mean Daily—Unspecified Departmental Work, Reporting, Total Training, and Whole ship General Hours by Rank Group

B. IMPRINT MODEL ANALYSIS

1. Model and Comparison to Navy Standard Work Week

a. Total Work Hours per Day

Daily total work hours by sailor were calculated based on the median over all model runs. Table 11 shows the average total daily work hours by sub-department. Sailors in ME03 spend on average 14.0 ± 1.28 hours/day in total work which is closely followed by ME02 with 13.9 ± 1.07 hours/day. Sailors in ME01 have the lowest total work time with an average of 12.1 ± 0.21 hours/day, while ME04 has 12.3 ± 0.38 hours/day. The Marine

Engineering sub-department (MEO, DMEO, AMEOs, and CPOMTs) has an average of 12.5 ± 0.79 hours/day. As modeled in IMPRINT, none of the crewmembers in the Marine Engineering sub-department has watchkept. Even though AMEOs would be likely to keep one standing watch a day, their profiles were created from the DMEO's daily schedule (who does not watchkeep); as such, they do not show as having any watchkeeping hours in the model.

The average total hours a day for watchkeeping by sub-department aligns with expectations, because not all members of each sub-department watchkeep and some are only keeping one watch per day. This is evident when looking at ME03 with an average of 4.79 ± 2.05 hours/day of total watchkeeping whilst this sub-department spends on average 9.29 ± 2.23 hours/day on non-watchkeeping tasks. When comparing sub-departments against the NSW guidelines of 10 hours/day for total work time, ME01 exceeds the average daily total working hours by 2.12 hours, Marine Engineers by 2.52 hours, and ME03/ME04 were both approximately 4 hours above the NSW guidelines.

Table 11. ME Department Total Work by Sub-department (hours/day).

Sub-department	Number of personnel	Total Work— Including Watchkeeping	Total Work— Excluding Watchkeeping	Watchkeeping
Marine Engineering	6	12.5 ± 0.79	12.5 ± 0.79	0.00 ± 0.00
ME01	8	12.1 ± 0.21	5.72 ± 2.56	7.41 ± 0.13
ME02	9	13.9 ± 1.07	6.63 ± 1.33	7.47 ± 0.26
ME03	6	14.0 ± 1.28	9.29 ± 2.29	4.79 ± 2.05
ME04	6	12.3 ± 0.38	4.52 ± 0.46	7.89 ± 0.06

b. Daily Sleep Duration, Personal Time, Hygiene, and Messing

Results in Table 12 show that on average, all sub-departments have a Daily Sleep Duration (DSD) of less than the 8 hours of recommended sleep. ME03 has the lowest average median DSD of 6.08 hours (20th percentile: 5.16 hours/day). ME02 was the only sub-department to be within 1 hour of NSW guidelines with an average median of 7.39

hours of DSD (20th percentile: 7.00 hours). The ME officers and senior sailors' average median was 6.56 hours DSD (20th percentile: 6.33 hours).

Personal Time and Hygiene are combined in the NSW guidelines as 2 hours per day. The average median combined Personal Time and Hygiene for ME01 was 3.52 ± 0.30 hours, 2.80 ± 0.11 hours for ME04, 2.73 ± 0.99 hours for Marine Engineering, and 2.31 ± 1.65 hours for ME03 with all sub-departments exceeding the 2-hour criterion. ME02 had an average median combined Personal Time/Hygiene of 1.21 ± 0.60 hours (80th percentile: 1.22 hours/day) which is below the 2-hour NSW guideline.

Sailors in the ME02 sub-department spend on average 1.46 ± 0.56 hours/day in messing and Sailors in the ME03 0.31 hours/day, with both sub-departments on average below the 2 hours NSW guideline. ME04 has an average messing time (2.01 ± 0.39 hours/day; 80th percentile: 2.06 hours) which is close to the NSW guideline. On average, however, both the ME01 (2.07 ± 0.06 hours/day; 80th percentile: 2.12 hours/day) and Marine Engineering sub-departments (2.26 ± 0.08 hours/day; 80th percentile: 2.26 hours/day) are in excess of the NSW guidelines.

Table 12. ME Department Daily Sleep Duration, Personal Time, Hygiene, and Messing by Sub-department (hours/day).

Sub-department	Daily Sleep Duration	Personal Time	Hygiene	Whole Ship Messing	Non-Available
Marine Engineering	6.56 ± 0.27	2.16 ± 1.00	0.56 ± 0.03	2.26 ± 0.08	11.5 ± 0.79
ME01	6.40 ± 0.38	2.91 ± 0.31	0.61 ± 0.11	2.07 ± 0.06	11.9 ± 0.21
ME02	7.39 ± 0.41	0.52 ± 0.68	0.69 ± 0.14	1.46 ± 0.56	10.0 ± 1.07
ME03	6.08 ± 1.25	1.53 ± 1.52	0.78 ± 0.19	1.66 ± 0.31	10.0 ± 1.28
ME04	6.95 ± 0.09	2.11 ± 0.17	0.69 ± 0.06	2.01 ± 0.40	11.7 ± 0.38

c. Daily Total Training, Maintenance, and Whole Ship Reporting

To compare daily training requirements, all Firefighting and Damage Control exercises, Engineering Casualty Control Drills and Collective Training were combined with results shown in Table 13. Sailors in the Marine Engineering sub-department spent on average 2.22 hours/day in training, which is likely as a result of their requirement to be engaged in all forms of training due to their oversight/management of training exercises. Results for the remaining sub-departments, as expected, reflect that the priority assigned to training is less than the NSW guidelines and most likely due to watchkeeping. The priority level assigned training was decided upon due to the fact that while watchkeeping they are the first/immediate responders to an incident (real or training), but this time is allocated against watchkeeping. Additional personnel were therefore predominantly set as “desired to attend” ECCDs rather than “required” (as shown in the Methodology). ME02’s 80th percentile was in line with the NSW recommended 1 hour per day of training.

Table 13. ME Department Combined time spent on Training by Sub-department (hours/day).

Sub-department	Median Training	Min Training	Max Training	Quantiles 80 th Training
Marine Engineering	2.22	0.52	2.80	2.41
ME01	0.63	0.00	0.93	0.63
ME02	0.81	0.25	1.15	1.02
ME03	0.43	0.19	1.49	0.45
ME04	0.53	0.01	0.86	0.53

Maintenance figures per sub-department were combined to allow direct comparison between the NSW of 2 hours per day. the respective sub-departments are reflected in Table 14. Of the sub-departments, only ME03 had their maintenance average time (2.26 hours/day) in excess of NSW guidelines. The figure for ME03 coincides with the total work hours expected because of their lower daily watchkeeping requirements.

Table 14. ME Department Combined time spent on Maintenance by Sub-department (hours/day).

Sub-department	Median Maintenance	Min Maintenance	Max Maintenance	Quantiles 80 th Maintenance
Marine Engineering	0.5	0.00	4.46	3.84
ME01	1.50	0.71	2.83	1.61
ME02	1.23	0.65	1.83	1.32
ME03	2.26	1.27	6.85	2.47
ME04	1.32	0.56	1.62	1.42

Whole Ship Reporting results in Table 15 show that Marine Engineering has the highest average (3.98 hours/day) and the highest maximum value (6.05 hours/day) of all sub-departments. Due to no additional unplanned report activities being incorporated into the model, ME04 remains with 0 hours recorded against it.

Table 15. ME Department time spent on Whole Ship Reporting by Sub-department (hours/day).

Sub-department	Median Whole Ship Reporting	Min Whole Ship Reporting	Max Whole Ship Reporting	Quantiles 80 th Whole Ship Reporting
Marine Engineering	3.98	1.05	6.05	4.39
ME01	3.86	3.25	4.00	3.93
ME02	1.00	0.60	1.04	1.04
ME03	1.66	1.12	1.71	1.71
ME04	0.00	0.00	0.00	0.00

As part of the PT analysis, the NSW guidelines estimate that 4 hours per week (0.57 hours/day) are spent on Service Diversion tasks. Service Diversion tasks were combined (Sick Parade, Morning Muster, and Whole Ship General) to align with the wording stipulated in the NSW. Table 16 shows that all ME sub-departments spent, on average, more time in Service Diversion with ME02 having the highest average of 1.25 hours/day and ME04 (0.82 hours/day) the lowest.

Table 16. ME Department time spent on Total Service Diversion by Sub-department (hours/day).

Sub-department	Median Total Service Diversion	Min Total Service Diversion	Max Total Service Diversion	Quantiles 80 th Total Service Diversion
Marine				
Engineering	1.11	0.29	1.52	1.25
ME01	1.06	0.26	1.65	1.35
ME02	1.25	0.21	1.70	1.37
ME03	0.91	0.12	1.43	1.13
ME04	0.82	0.49	1.81	1.13

2. Unplanned Events Completion Rates

Completion rates of unplanned events are displayed in Figure 24. These completion rates are directly relatable to the workload experienced by the crew and the priority assigned to each unplanned event.

When analyzing the level of completion for Replenishment at Sea (RAS), only once was there sufficient resources available to successfully complete a RAS. The priority and quantity of RAS (n=1 per model run) was selected based on the modeled operating conditions of the ship conducting an 8-day transit between two ports. The RAS event was included as a possible activity to be achieved but not an absolute requirement to be completed. If the ship was operating in different circumstances and required a RAS to maintain tasking, then the priority would have to be assigned a higher designator to ensure this event could occur, or a reduction in required personnel would need to be considered. However, increasing the RAS's priority there would be a follow-on effect of activities that were initially "successful" during these model runs becoming "failed" events instead.

As expected, a Firefighting and/or Damage Control Major Incident had a 100% completion rate due to its priority being assigned as 1, which is the highest priority of any task. Of concern in the real world, the minor Firefight and Damage Control incident in the model has a non-completion rate of 1.84% (n=56/3049). If this failure were to occur in real life, each one of these events would escalate into a major fire incident, resulting in a loss of capability and incursion of even more resources to extinguish. Engineering Breakdown Real Incidents had a non-completion rate of 1.56% (n=116/7420), which coincides with

the expectations of the trump matrix being the second highest priority in the trump matrix. Urgent divisional matters were attended to with a success rate of 89.5% (n=2277/2545). However, non-urgent (general) divisional matters were only dealt with 17.7% (n=593/3357) of the time.

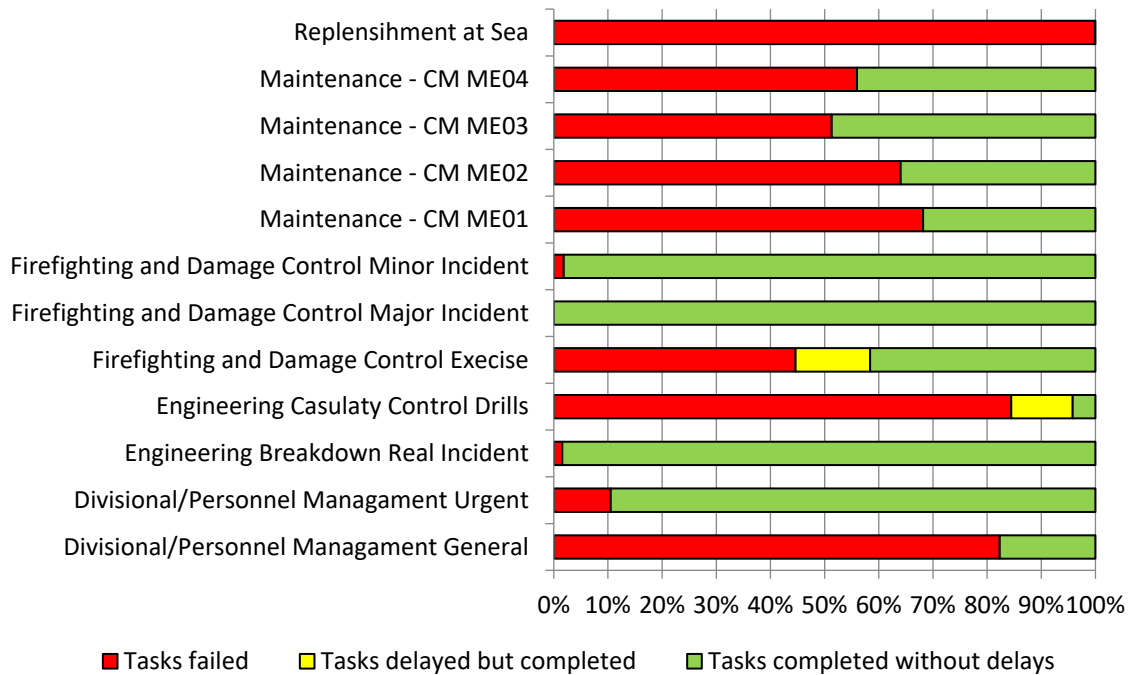


Figure 24. Completion Rates of Unplanned Events

Corrective Maintenance (CM) events, with an assigned priority of 8 in the trump matrix, were completed less than half the time. Specifically, CM ME01 had the lowest completion rate of 31.8% (n=1732/5445), followed by ME02 (36.0%, n=1966/5469), ME04 (44.0%, n=2415/5487), and ME03 had the highest completion rate for all CM of 48.7% (n=2648/5437).

Unplanned training events showed high non-completion rates. Firefighting and Damage Control exercises failed to complete in 43.9% of the modelled instances (n=3041/6933), completed with delays (shown in yellow in Figure 24) 13.5% of the time and completed without a delay 40.9% (n=2833/6933). Engineering Casualty Control Drills had an ever higher non-completion rate of 84.0% (n=3423/4090), whereas 11.2% of the

drills completed with delays and 4.18% ($n= 171/4090$) of the drills completed successfully without delays.

V. DISCUSSION

Performing an analysis of the *Warramunga* data was an important step in assessing the ability to model the data in IMPRINT. The focus on “At Sea” days was considered essential to draw comparisons between the crew’s work/sleep routines and the NSWV provisions. Across the entire ship, by department, and by rank group, the daily sleep duration (DSD) was on average less than the NSWV criterion of 8 hours per day. This finding highlights that sleep was not sufficiently prioritized, resulting in sleep deprived sailors across all departments and ranks. The ME senior sailors and officers (-0.01 hours) DSD had minimal change from the *Warramunga* data. The sub-departments ME01 (-0.8 hours) and ME03 (-0.65 hours) had a lower DSD than during the trial period. The remaining 2 sub-departments, ME02 (1.02 hours) and ME04 (0.27 hours), had an increase to their DSD when compared to the trial period, likely as a result of the members from which the schedules were developed.

Work hours during the trial and results from the model showed that the whole ship, by department, and by rank group (except JOUTs), was above the NSWV criterion of 10 hours of work per day, with senior officers exceeding this figure by five hours. A large range of data was classified as unspecified departmental work (UDW), due to the work not fitting within predefined categories by which the data were being collected. This finding could possibly mean that there is a lack of understanding of what the main work requirements are onboard our vessels. In the case of junior sailors across the ship, UDW accounted for over five hours per day. Nil additional unplanned UDW events were introduced in the IMPRINT model and as expected, the UDW decreased for the whole ME department due to the assigned priority. The concern with the UDW category is how, in the future, to understand and adequately forecast these requirements for selection of ships’ scheme of complement (SoC).

Based on the *Warramunga* data, Officers had the highest “reporting” requirements. Results from the IMPRINT model suggested that “reporting” requirements of the ME officers increased by more than 30 minutes per day. However, this increase would have been higher if the priority for reporting was higher. Due to the relatively low priority

assigned to additional unplanned general divisional events, there were large non-completion rates (82.3%).

Corrective and Planned maintenance for the technical branches has been identified as an important metric to be utilized when designing a ship's SoC in the RAN (RAN 2017). However, the *Warramunga* data show that the aforementioned holds true only for the ME department with little to no data being recorded for the WE department. Even though there were additional unplanned maintenance events included in the model, less time was spent on performing maintenance tasks than during the trial. All ME sub-departments decreased their ability to complete maintenance by a range of 0.5–1.2 hours. Similar to the model, this decline is reflective of the priorities assigned to maintenance real world trends (RAN 2018b).

Analysis of the *Warramunga* data showed that time spent on training was above the NSW criterion of one hour per day. However, results from the IMPRINT model showed a drop in training occurring across all sub-departments with the exception of the ME Officers and Senior sailors, which is reflective their involvement of additional unplanned events (DC/ Firefighting exercises and ECCDs). Unfortunately, there was a high non-completion rate for unplanned events (ECCDs 84% and DC/Firefighting exercises 43%) assigned under the training category due to the level of personnel required to attend and the lower priority assigned to these events. Messing time decreased for all sub-departments in the model with ME Senior sailors and officers dropping the least (on average 0.38 hours/day) and ME02 dropping the most (on average 1.13 hours/day). This finding follows the trend across all data showing that lower priority tasks/events are being reduced in time to account for increased workloads.

A. LIMITATIONS

The scope of this thesis has been restricted to an analysis of an FFH class of ship due to the availability of previously researched data from DSTO, and data that are readily identified and unclassified from the FFH class of ships and other RAN documentation. As such, comparisons have not been drawn across different classes of ship.

An actiwatch records “sleep” time only when the user is in a sufficiently non-active state, i.e., while sleeping or while sitting on a lounge/sleeping bag and watching television for many hours, or when self-selected by the member wearing the watch. Also, during our analysis of the *Warramunga* data, it became evident that work times were being recorded inconsistently or missing. The possible causes of this are:

- watches cannot be worn at all times due to hazardous working conditions (seamanship evolutions, mechanical repairs), as such, has the potential to show periods of time when a crewmember was working as rest time,
- not having an exact make up of watchkeepers at any one time,
- constant rotation of sailors that watchkeep, which created difficulties in identifying what activities were occurring during watches and what occurred outside of the watch rotations,
- The only start/stop times recorded during the trial were for sleep and all categories of “work,” meaning that individual activities during the trial did not explicitly have a start and stop time associated with their recorded hours per day.

To overcome these issues in the development of the IMPRINT model, when an inconsistency/overlap was identified between activity categories, the sleep hours were taken to be correct and other hours were worked out around these times. Definitions of categories appeared not to be clearly articulated and left room for misinterpretation from the crew when they were assigning their time to specific categories. When building the model, the time required to conduct pre-watch rounds (check machinery spaces for any obvious issues) and watch handover was not evident in the data and as such, was not included in the model. This extra step would incur at a minimum 25 minutes of additional time per watch per watchkeeper and should be included in undertime spent watchkeeping. Another component of time not factored into the IMPRINT model was the time required to “make ready and put away” for maintenance/whole of ship events (required to be at a place before a certain time).

Another factor not explored in this thesis, is the alongside time allocated to a ship and the expectations of crew workload during this time. The NSWV in its current state does not distinguish between time at sea or time alongside. This area needs thorough investigation to understand the implications of working a defined “harbor” routine that sets crew expectations of five core workdays a week between the hours of 0800–1530. When factoring in reduced work time as well as contractor liaison and oversight of externally appointed tasks, leave, and training requirements, high fatigue levels may also exist, resulting in increased risk to personnel and equipment.

During this analysis, consideration has not been given to broken sleep. A measure employed by the U.S. Coast Guard uses one or a combination of the following approaches to reduce fatigue levels on the crew. The preferred method is to allow any personnel conducting watches that end during the morning hours to be provided with an opportunity to retire prior to sunrise into a dark and non-disruptive location for a period of 7–8 hours (it is critical to have no interruptions during this period). Whole ship duties/activities should be scheduled to occur after the night watchkeeper’s wake-up time. Any leisure time should take place during the evening times to ensure that they too are able to participate. A second method to be utilized would be to extend the night watchkeepers routine to minimize the number of personnel exposed to night watches (whilst considering workload/capacity). For this action to succeed, the night watchkeeper must be able to complete work and be in their bunk prior to sunrise to prevent unwanted exposure to daylight and the resulting effects on the circadian rhythm (Comperatore et al., 2005).

VI. CONCLUSION AND RECOMMENDATIONS

In conclusion, the findings in this thesis indicate that the NSWW in its current state should not be solely used to define ships' SoC. There is a disparity between actual operating cycles onboard *Warramunga* and the criterion of the NSWW. As a result of this disparity, it is predicted that a SoC created using NSWW would require the crew to prioritize their time according to task priority, which will lead to significant administrative and maintenance tasks remaining unachieved. These administrative and maintenance tasks will compound and only be successfully completed when their priority becomes sufficiently important to outweigh previously higher prioritized tasks, which would then be outstanding.

It is clear in the IMPRINT model that the addition of unplanned activities and the resulting large non-completion rates of moderate to low priority tasks is a result of the crew operating at or near capacity already. It is also clear that a ship manned at critical levels leaves little to no ability to surge when required. With clearer understanding of the limitations on the ship imposed by crew size, decision-makers will be able to assign operational tasking based on knowledge of expected endurance of a ship and how long the ship will be able to maintain such a tempo.

The use of the IMPRINT Pro Forces Module provides valuable insight into additional workload effects on crew sizing and has many possible future applications for the RAN. Even though I recommend the use of the IMPRINT modelling software for assisting with designing SoC for the RAN, close liaison with experienced modelers from DNWR and class of ship specific (or replaced class) SMEs would need to occur to ensure tasks are accurately scheduled and prioritized. If forecast crew sizes are unrealistically high to achieve a ship's Statement of Operating Intent (SOI), then this tool will provide valuable weight to justify amending policy to ensure that the ship's crew are not excessively worked to comply with outdated/irrelevant policy whilst achieving mission.

I see another application of IMPRINT that could be a simplified version (for the operator) that ship's command teams can use to understand their manpower "risk state"

prior to sailing for a mission (post maintenance/leave period). This calculation could be achieved by analyzing the expected deficiencies from a ship sailing in an undermanned state with inputs from upcoming PM and previously calculated CM requirements injected into the model. Each model would need to be ship-class specific and could interact with existing software such as NMD (including MAPS) and AMPS with default crew position/qualification profiles and expected unplanned events. Selectable missions could also be included that would create optimal preset schedules for all personnel on the ship.

APPENDIX A. SCHEDULES OF SUB-DEPARTMENT AND RANK USED IN IMPRINT

A. PERSON ID: 105 RANK: AB SUB-DEPARTMENT: ME01

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:15	6:15
Hygiene	6:15	6:45	0:30
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Maintenance—CM	7:30	10:00	2:30
Whole Ship Messing (Eating)	10:00	10:15	0:15
Training—Collective	10:15	11:45	1:30
Whole Ship Messing (Eating)	11:45	12:30	0:45
Whole Ship General	12:30	13:00	0:30
Unspecified Departmental Work	13:00	14:00	1:00
Personal Time (including PT)	14:00	17:00	3:00
Hygiene	17:00	17:30	0:30
Whole Ship Messing (Eating)	17:30	18:00	0:30
Personal Time (including PT)	18:00	18:30	0:30
Unspecified Departmental Work	18:30	19:45	1:15
Watchkeeping	19:45	23:59	4:14
Personal Time (including PT)	23:59	1 01:34	1:35
Hygiene	1 01:34	1 01:49	0:15
Sleep	1 01:49	1 06:37	4:48
Hygiene	1 06:37	1 06:45	0:08
Whole Ship Messing (Eating)	1 06:45	1 07:15	0:30
Morning Muster	1 07:15	1 07:30	0:15
Unspecified Departmental Work	1 07:30	1 07:45	0:15
Watchkeeping	1 07:45	1 12:00	4:15
Whole Ship Messing (Eating)	1 12:00	1 12:30	0:30
Whole Ship General	1 12:30	1 13:00	0:30
Unspecified Departmental Work	1 13:00	1 14:00	1:00
Personal Time (including PT)	1 14:00	1 17:00	3:00
Hygiene	1 17:00	1 17:15	0:15
Whole Ship Messing (Eating)	1 17:15	1 19:00	1:45
Personal Time (including PT)	1 19:00	1 19:45	0:45
Watchkeeping	1 19:45	1 23:49	4:04
Hygiene	1 23:49	2 00:04	0:15
Sleep	2 00:04	2 06:49	6:45
Whole Ship Messing (Eating)	2 06:49	2 07:15	0:26
Morning Muster	2 07:15	2 07:30	0:15
Unspecified Departmental Work	2 07:30	2 07:45	0:15

Watchkeeping	2 07:45	2 12:00	4:15
Whole Ship Messing (Eating)	2 12:00	2 13:00	1:00
Whole Ship General	2 13:00	2 13:30	0:30
Unspecified Departmental Work	2 13:30	2 15:00	1:30
Personal Time (including PT)	2 15:00	2 17:00	2:00
Hygiene	2 17:00	2 17:15	0:15
Whole Ship Messing (Eating)	2 17:15	2 18:20	1:05
Maintenance—CM	2 18:20	2 19:45	1:25
Watchkeeping	2 19:45	2 23:50	4:05
Hygiene	2 23:50	3 00:15	0:25
Sleep	3 00:15	3 06:38	6:23
Whole Ship Messing (Eating)	3 06:38	3 07:15	0:37
Morning Muster	3 07:15	3 07:30	0:15
Unspecified Departmental Work	3 07:30	3 07:45	0:15
Watchkeeping	3 07:45	3 12:00	4:15
Whole Ship Messing (Eating)	3 12:00	3 13:00	1:00
Whole Ship General	3 13:00	3 13:30	0:30
Maintenance—CM	3 13:30	3 15:00	1:30
Personal Time (including PT)	3 15:00	3 17:00	2:00
Hygiene	3 17:00	3 17:15	0:15
Whole Ship Messing (Eating)	3 17:15	3 18:20	1:05
Maintenance—CM	3 18:20	3 19:20	1:00
Personal Time (including PT)	3 19:20	3 19:45	0:25
Watchkeeping	3 19:45	3 23:54	4:09
Hygiene	3 23:54	4 00:09	0:15
Sleep	4 00:09	4 07:03	6:54
Whole Ship Messing (Eating)	4 07:03	4 07:15	0:12
Morning Muster	4 07:15	4 07:30	0:15
Unspecified Departmental Work	4 07:30	4 07:45	0:15
Watchkeeping	4 07:45	4 12:00	4:15
Whole Ship Messing (Eating)	4 12:00	4 13:00	1:00
Unspecified Departmental Work	4 13:00	4 14:00	1:00
Maintenance—PM	4 14:00	4 15:00	1:00
Personal Time (including PT)	4 15:00	4 17:15	2:15
Hygiene	4 17:15	4 17:30	0:15
Whole Ship Messing (Eating)	4 17:30	4 18:20	0:50
Maintenance—CM	4 18:20	4 19:20	1:00
Personal Time (including PT)	4 19:20	4 19:45	0:25
Watchkeeping	4 19:45	5 00:02	4:17
Hygiene	5 00:02	5 00:17	0:15
Sleep	5 00:17	5 06:49	6:32
Whole Ship Messing (Eating)	5 06:49	5 07:15	0:26
Morning Muster	5 07:15	5 07:30	0:15

Unspecified Departmental Work	5 07:30	5 07:45	0:15
Watchkeeping	5 07:45	5 12:00	4:15
Whole Ship Messing (Eating)	5 12:00	5 12:30	0:30
Whole Ship General	5 12:30	5 13:00	0:30
Unspecified Departmental Work	5 13:00	5 14:00	1:00
Maintenance—PM	5 14:00	5 15:00	1:00
Personal Time (including PT)	5 15:00	5 17:15	2:15
Hygiene	5 17:15	5 17:30	0:15
Whole Ship Messing (Eating)	5 17:30	5 18:04	0:34
Maintenance—CM	5 18:04	5 19:20	1:16
Personal Time (including PT)	5 19:20	5 19:45	0:25
Watchkeeping	5 19:45	6 00:00	4:15
Hygiene	6 00:00	6 00:15	0:15
Sleep	6 00:15	6 06:00	5:45
Hygiene	6 06:00	6 06:15	0:15
Personal Time (including PT)	6 06:15	6 06:30	0:15
Whole Ship Messing (Eating)	6 06:30	6 07:15	0:45
Morning Muster	6 07:15	6 07:30	0:15
Unspecified Departmental Work	6 07:30	6 07:45	0:15
Watchkeeping	6 07:45	6 12:00	4:15
Whole Ship Messing (Eating)	6 12:00	6 12:30	0:30
Whole Ship General	6 12:30	6 15:00	2:30
Training—Collective	6 15:00	6 16:30	1:30
Personal Time (including PT)	6 16:30	6 17:15	0:45
Hygiene	6 17:15	6 17:30	0:15
Whole Ship Messing (Eating)	6 17:30	6 18:15	0:45
Maintenance—CM	6 18:15	6 19:15	1:00
Personal Time (including PT)	6 19:15	6 19:45	0:30
Watchkeeping	6 19:45	6 22:00	2:15
Hygiene	6 22:00	6 22:06	0:06
Sleep	6 22:06	7 06:20	8:14
Hygiene	7 06:20	7 06:45	0:25
Personal Time (including PT)	7 06:45	7 07:00	0:15
Whole Ship Messing (Eating)	7 07:00	7 07:15	0:15
Morning Muster	7 07:15	7 07:30	0:15
Unspecified Departmental Work	7 07:30	7 07:45	0:15
Watchkeeping	7 07:45	7 12:00	4:15
Whole Ship Messing (Eating)	7 12:00	7 12:30	0:30
Whole Ship General	7 12:30	7 14:00	1:30
Training—Collective	7 14:00	7 16:00	2:00
Personal Time (including PT)	7 16:00	7 17:15	1:15
Hygiene	7 17:15	7 17:30	0:15
Whole Ship Messing (Eating)	7 17:30	7 18:15	0:45

Unspecified Departmental Work	7 18:15	7 19:15	1:00
Personal Time (including PT)	7 19:15	7 19:45	0:30
Watchkeeping	7 19:45	7 23:45	4:00
Hygiene	7 23:45	7 23:49	0:04
Sleep	7 23:49	8 00:00	0:11

B. PERSON ID: 14 RANK: AB SUB-DEPARTMENT: ME02

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:15	6:15
Hygiene	6:15	6:45	0:30
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Maintenance—CM	7:30	9:00	1:30
Maintenance—PM	9:00	10:00	1:00
Whole Ship Messing (Eating)	10:00	10:15	0:15
Maintenance—PM	10:15	10:45	0:30
Training—Collective	10:45	11:45	1:00
Whole Ship Messing (Eating)	11:45	12:30	0:45
Firefighting and Damage Control Exercise	12:30	13:00	0:30
Training—Collective	13:00	15:00	2:00
Whole Ship General	15:00	16:00	1:00
Unspecified Departmental Work	16:00	17:14	1:14
Hygiene	17:14	17:30	0:16
Whole Ship Messing (Eating)	17:30	18:15	0:45
Personal Time (including PT)	18:15	18:52	0:37
Sleep	18:52	23:16	4:24
Hygiene	23:16	23:45	0:29
Watchkeeping	23:45	1 03:53	4:08
Sleep	1 03:53	1 09:51	5:58
Hygiene	1 09:51	1 10:21	0:30
Unspecified Departmental Work	1 10:21	1 11:15	0:54
Whole Ship Messing (Eating)	1 11:15	1 11:45	0:30
Watchkeeping	1 11:45	1 15:59	4:14
Unspecified Departmental Work	1 15:59	1 17:30	1:31
Whole Ship Messing (Eating)	1 17:30	1 18:15	0:45
Whole Ship General	1 18:15	1 18:45	0:30
Unspecified Departmental Work	1 18:45	1 20:21	1:36
Sleep	1 20:21	1 22:15	1:54
Hygiene	1 22:15	1 22:30	0:15
Unspecified Departmental Work	1 22:30	1 23:45	1:15
Watchkeeping	1 23:45	2 03:55	4:10
Hygiene	2 03:55	2 04:09	0:14
Sleep	2 04:09	2 09:48	5:39
Hygiene	2 09:48	2 10:03	0:15
Unspecified Departmental Work	2 10:03	2 11:15	1:12
Whole Ship Messing (Eating)	2 11:15	2 11:45	0:30
Watchkeeping	2 11:45	2 15:59	4:14
Unspecified Departmental Work	2 15:59	2 17:30	1:31
Whole Ship Messing (Eating)	2 17:30	2 18:15	0:45
Whole Ship General	2 18:15	2 18:45	0:30
Unspecified Departmental Work	2 18:45	2 20:36	1:51

Sleep	2 20:36	2 23:06	2:30
Hygiene	2 23:06	2 23:45	0:39
Watchkeeping	2 23:45	3 03:45	4:00
Hygiene	3 03:45	3 04:02	0:17
Sleep	3 04:02	3 10:42	6:40
Unspecified Departmental Work	3 10:42	3 11:30	0:48
Whole Ship Messing (Eating)	3 11:30	3 11:45	0:15
Watchkeeping	3 11:45	3 15:59	4:14
Unspecified Departmental Work	3 15:59	3 16:48	0:49
Sleep	3 16:48	3 17:28	0:40
Whole Ship Messing (Eating)	3 17:28	3 18:13	0:45
Whole Ship General	3 18:13	3 18:43	0:30
Unspecified Departmental Work	3 18:43	3 20:53	2:10
Sleep	3 20:53	3 23:06	2:13
Hygiene	3 23:06	3 23:45	0:39
Watchkeeping	3 23:45	4 03:45	4:00
Hygiene	4 03:45	4 04:02	0:17
Sleep	4 04:02	4 10:42	6:40
Unspecified Departmental Work	4 10:42	4 11:30	0:48
Whole Ship Messing (Eating)	4 11:30	4 11:45	0:15
Watchkeeping	4 11:45	4 15:59	4:14
Unspecified Departmental Work	4 15:59	4 16:48	0:49
Sleep	4 16:48	4 17:28	0:40
Whole Ship Messing (Eating)	4 17:28	4 18:13	0:45
Whole Ship General	4 18:13	4 18:43	0:30
Unspecified Departmental Work	4 18:43	4 20:45	2:02
Sleep	4 20:45	5 02:44	5:59
Hygiene	5 02:44	5 03:00	0:16
Unspecified Departmental Work	5 03:00	5 03:45	0:45
Watchkeeping	5 03:45	5 08:00	4:15
Whole Ship Messing (Eating)	5 08:00	5 08:15	0:15
Maintenance—PM	5 08:15	5 09:00	0:45
Training—Collective	5 09:00	5 11:00	2:00
Unspecified Departmental Work	5 11:00	5 11:30	0:30
Whole Ship Messing (Eating)	5 11:30	5 11:45	0:15
Unspecified Departmental Work	5 11:45	5 15:45	4:00
Watchkeeping	5 15:45	5 19:59	4:14
Unspecified Departmental Work	5 19:59	5 20:45	0:46
Hygiene	5 20:45	5 20:52	0:07
Sleep	5 20:52	6 03:13	6:21
Hygiene	6 03:13	6 03:45	0:32
Watchkeeping	6 03:45	6 08:00	4:15
Whole Ship Messing (Eating)	6 08:00	6 08:15	0:15
Maintenance—PM	6 08:15	6 09:00	0:45
Whole Ship General	6 09:00	6 11:30	2:30

Whole Ship Messing (Eating)	6 11:30	6 11:45	0:15
Unspecified Departmental Work	6 11:45	6 15:45	4:00
Watchkeeping	6 15:45	6 19:59	4:14
Unspecified Departmental Work	6 19:59	6 20:28	0:29
Maintenance—PM	6 20:28	6 20:45	0:17
Hygiene	6 20:45	6 20:52	0:07
Sleep	6 20:52	6 23:00	2:08
Hygiene	6 23:00	6 23:59	0:59
Maintenance—General	6 23:59	7 03:45	3:46
Watchkeeping	7 03:45	7 08:00	4:15
Whole Ship Messing (Eating)	7 08:00	7 08:15	0:15
Maintenance—PM	7 08:15	7 09:00	0:45
Whole Ship General	7 09:00	7 11:30	2:30
Whole Ship Messing (Eating)	7 11:30	7 11:45	0:15
Unspecified Departmental Work	7 11:45	7 15:45	4:00
Watchkeeping	7 15:45	7 19:59	4:14
Unspecified Departmental Work	7 19:59	7 20:28	0:29
Maintenance—PM	7 20:28	7 20:45	0:17
Hygiene	7 20:45	7 20:52	0:07
Sleep	7 20:52	8 00:00	3:08

C. PERSON ID: 8 RANK: AB SUB-DEPARTMENT: ME03

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:15	6:15
Hygiene	6:15	6:45	0:30
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Maintenance—CM	7:30	10:00	2:30
Whole Ship Messing (Eating)	10:00	10:15	0:15
Maintenance—PM	10:15	10:45	0:30
Training—Collective	10:45	11:45	1:00
Whole Ship Messing (Eating)	11:45	12:30	0:45
Personal Time (including PT)	12:30	13:00	0:30
Unspecified Departmental Work	13:00	14:00	1:00
Whole Ship General	14:00	16:00	2:00
Unspecified Departmental Work	16:00	17:00	1:00
Hygiene	17:00	17:30	0:30
Whole Ship Messing (Eating)	17:30	18:15	0:45
Personal Time (including PT)	18:15	18:30	0:15
Unspecified Departmental Work	18:30	21:00	2:30
Firefighting and Damage Control Exercise	21:00	21:30	0:30
Unspecified Departmental Work	21:30	22:30	1:00
Personal Time (including PT)	22:30	1 01:01	2:31
Hygiene	1 01:01	1 01:16	0:15
Sleep	1 01:16	1 06:53	5:37
Hygiene	1 06:53	1 07:00	0:07
Whole Ship Messing (Eating)	1 07:00	1 07:15	0:15
Morning Muster	1 07:15	1 07:30	0:15
Unspecified Departmental Work	1 07:30	1 10:00	2:30
Whole Ship Messing (Eating)	1 10:00	1 10:15	0:15
Unspecified Departmental Work	1 10:15	1 11:45	1:30
Whole Ship Messing (Eating)	1 11:45	1 12:30	0:45
Whole Ship General	1 12:30	1 13:00	0:30
Unspecified Departmental Work	1 13:00	1 17:00	4:00
Hygiene	1 17:00	1 17:30	0:30
Whole Ship Messing (Eating)	1 17:30	1 18:15	0:45
Personal Time (including PT)	1 18:15	1 18:45	0:30
Unspecified Departmental Work	1 18:45	1 21:15	2:30
Personal Time (including PT)	1 21:15	2 00:23	3:08
Hygiene	2 00:23	2 00:38	0:15
Sleep	2 00:38	2 06:51	6:13
Hygiene	2 06:51	2 07:06	0:15
Whole Ship Messing (Eating)	2 07:06	2 07:15	0:09
Morning Muster	2 07:15	2 07:30	0:15
Unspecified Departmental Work	2 07:30	2 10:00	2:30
Whole Ship Messing (Eating)	2 10:00	2 10:15	0:15

Unspecified Departmental Work	2 10:15	2 11:45	1:30
Whole Ship Messing (Eating)	2 11:45	2 12:30	0:45
Whole Ship General	2 12:30	2 13:00	0:30
Unspecified Departmental Work	2 13:00	2 16:45	3:45
Maintenance—CM	2 16:45	2 17:00	0:15
Hygiene	2 17:00	2 17:30	0:30
Whole Ship Messing (Eating)	2 17:30	2 18:15	0:45
Personal Time (including PT)	2 18:15	2 18:30	0:15
Maintenance—CM	2 18:30	2 19:45	1:15
Maintenance—PM	2 19:45	2 21:15	1:30
Personal Time (including PT)	2 21:15	3 00:23	3:08
Hygiene	3 00:23	3 00:38	0:15
Sleep	3 00:38	3 06:50	6:12
Hygiene	3 06:50	3 07:05	0:15
Whole Ship Messing (Eating)	3 07:05	3 07:15	0:10
Morning Muster	3 07:15	3 07:30	0:15
Unspecified Departmental Work	3 07:30	3 10:00	2:30
Whole Ship Messing (Eating)	3 10:00	3 10:15	0:15
Unspecified Departmental Work	3 10:15	3 11:45	1:30
Whole Ship Messing (Eating)	3 11:45	3 12:30	0:45
Whole Ship General	3 12:30	3 13:00	0:30
Unspecified Departmental Work	3 13:00	3 16:45	3:45
Maintenance—CM	3 16:45	3 17:00	0:15
Hygiene	3 17:00	3 17:30	0:30
Whole Ship Messing (Eating)	3 17:30	3 18:15	0:45
Personal Time (including PT)	3 18:15	3 18:30	0:15
Maintenance—CM	3 18:30	3 19:45	1:15
Maintenance—PM	3 19:45	3 21:15	1:30
Personal Time (including PT)	3 21:15	4 00:50	3:35
Hygiene	4 00:50	4 01:05	0:15
Sleep	4 01:05	4 06:43	5:38
Hygiene	4 06:43	4 06:58	0:15
Whole Ship Messing (Eating)	4 06:58	4 07:15	0:17
Morning Muster	4 07:15	4 07:30	0:15
Maintenance—CM	4 07:30	4 09:15	1:45
Maintenance—PM	4 09:15	4 10:00	0:45
Whole Ship Messing (Eating)	4 10:00	4 10:15	0:15
Unspecified Departmental Work	4 10:15	4 11:45	1:30
Whole Ship Messing (Eating)	4 11:45	4 12:30	0:45
Maintenance—PM	4 12:30	4 13:15	0:45
Unspecified Departmental Work	4 13:15	4 14:59	1:44
Personal Time (including PT)	4 14:59	4 17:00	2:01
Hygiene	4 17:00	4 17:30	0:30
Whole Ship Messing (Eating)	4 17:30	4 18:15	0:45
Personal Time (including PT)	4 18:15	4 23:27	5:12

Hygiene	4 23:27	4 23:42	0:15
Sleep	4 23:42	5 03:02	3:20
Hygiene	5 03:02	5 03:45	0:43
Watchkeeping	5 03:45	5 08:00	4:15
Whole Ship Messing (Eating)	5 08:00	5 08:30	0:30
Maintenance—PM	5 08:30	5 10:00	1:30
Whole Ship Messing (Eating)	5 10:00	5 10:15	0:15
Unspecified Departmental Work	5 10:15	5 11:45	1:30
Whole Ship Messing (Eating)	5 11:45	5 12:30	0:45
Unspecified Departmental Work	5 12:30	5 15:45	3:15
Watchkeeping	5 15:45	5 20:00	4:15
Whole Ship Messing (Eating)	5 20:00	5 21:00	1:00
Unspecified Departmental Work	5 21:00	5 21:15	0:15
Personal Time (including PT)	5 21:15	5 23:27	2:12
Hygiene	5 23:27	5 23:42	0:15
Sleep	5 23:42	6 03:03	3:21
Hygiene	6 03:03	6 03:45	0:42
Watchkeeping	6 03:45	6 08:00	4:15
Whole Ship Messing (Eating)	6 08:00	6 08:30	0:30
Maintenance—PM	6 08:30	6 10:00	1:30
Whole Ship Messing (Eating)	6 10:00	6 10:15	0:15
Unspecified Departmental Work	6 10:15	6 11:45	1:30
Whole Ship Messing (Eating)	6 11:45	6 12:30	0:45
Unspecified Departmental Work	6 12:30	6 13:08	0:38
Sleep	6 13:08	6 13:52	0:44
Maintenance—CM	6 13:52	6 15:00	1:08
Watchkeeping	6 15:00	6 20:00	5:00
Whole Ship Messing (Eating)	6 20:00	6 20:30	0:30
Maintenance—CM	6 20:30	6 20:45	0:15
Unspecified Departmental Work	6 20:45	6 23:06	2:21
Hygiene	6 23:06	6 23:30	0:24
Sleep	6 23:30	7 02:53	3:23
Watchkeeping	7 02:53	7 08:00	5:07
Whole Ship Messing (Eating)	7 08:00	7 08:30	0:30
Maintenance—PM	7 08:30	7 09:08	0:38
Maintenance—General	7 09:08	7 10:00	0:52
Unspecified Departmental Work	7 10:00	7 10:15	0:15
Maintenance—General	7 10:15	7 10:29	0:14
Unspecified Departmental Work	7 10:29	7 11:45	1:16
Whole Ship Messing (Eating)	7 11:45	7 12:16	0:31
Sleep	7 12:16	7 12:51	0:35
Training—Collective	7 12:51	7 14:51	2:00
Unspecified Departmental Work	7 14:51	7 15:45	0:54
Watchkeeping	7 15:45	7 20:00	4:15
Whole Ship Messing (Eating)	7 20:00	7 20:30	0:30

Unspecified Departmental Work	7 20:30	7 23:20	2:50
Hygiene	7 23:20	7 23:35	0:15
Sleep	7 23:35	8 00:00	0:25

D. PERSON ID: 127**RANK: AB****SUB-DEPARTMENT: ME04**

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:15	6:15
Hygiene	6:15	6:45	0:30
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Maintenance—PM	7:30	9:00	1:30
Maintenance—CM	9:00	10:00	1:00
Whole Ship Messing (Eating)	10:00	10:15	0:15
Training—Collective	10:15	11:45	1:30
Whole Ship Messing (Eating)	11:45	12:30	0:45
Personal Time (including PT)	12:30	13:00	0:30
Unspecified Departmental Work	13:00	14:00	1:00
Whole Ship General	14:00	15:00	1:00
Personal Time (including PT)	15:00	15:45	0:45
Watchkeeping	15:45	20:00	4:15
Personal Time (including PT)	20:00	21:00	1:00
Firefighting and Damage Control Exercise	21:00	21:30	0:30
Personal Time (including PT)	21:30	22:04	0:34
Hygiene	22:04	22:19	0:15
Sleep	22:19	1 03:28	5:09
Hygiene	1 03:28	1 03:45	0:17
Watchkeeping	1 03:45	1 08:00	4:15
Whole Ship Messing (Eating)	1 08:00	1 08:09	0:09
Sleep	1 08:09	1 11:36	3:27
Whole Ship Messing (Eating)	1 11:36	1 12:30	0:54
Maintenance—PM	1 12:30	1 15:15	2:45
Personal Time (including PT)	1 15:15	1 15:45	0:30
Watchkeeping	1 15:45	1 20:00	4:15
Personal Time (including PT)	1 20:00	1 22:06	2:06
Hygiene	1 22:06	1 22:21	0:15
Sleep	1 22:21	2 03:33	5:12
Hygiene	2 03:33	2 03:45	0:12
Watchkeeping	2 03:45	2 08:00	4:15
Whole Ship Messing (Eating)	2 08:00	2 08:35	0:35
Sleep	2 08:35	2 11:06	2:31
Hygiene	2 11:06	2 11:30	0:24
Whole Ship Messing (Eating)	2 11:30	2 12:30	1:00
Whole Ship General	2 12:30	2 13:00	0:30
Training—Collective	2 13:00	2 14:00	1:00
Maintenance—PM	2 14:00	2 15:45	1:45
Watchkeeping	2 15:45	2 20:00	4:15
Personal Time (including PT)	2 20:00	2 22:17	2:17
Hygiene	2 22:17	2 22:32	0:15
Sleep	2 22:32	3 03:33	5:01

Hygiene	3 03:33	3 03:45	0:12
Watchkeeping	3 03:45	3 08:00	4:15
Whole Ship Messing (Eating)	3 08:00	3 08:27	0:27
Sleep	3 08:27	3 11:23	2:56
Hygiene	3 11:23	3 11:30	0:07
Whole Ship Messing (Eating)	3 11:30	3 12:30	1:00
Whole Ship General	3 12:30	3 13:00	0:30
Maintenance—PM	3 13:00	3 14:00	1:00
Maintenance—General	3 14:00	3 14:37	0:37
Unspecified Departmental Work	3 14:37	3 15:45	1:08
Watchkeeping	3 15:45	3 20:00	4:15
Personal Time (including PT)	3 20:00	3 22:51	2:51
Hygiene	3 22:51	3 23:06	0:15
Sleep	3 23:06	4 03:16	4:10
Hygiene	4 03:16	4 03:45	0:29
Watchkeeping	4 03:45	4 07:50	4:05
Whole Ship Messing (Eating)	4 07:50	4 08:04	0:14
Sleep	4 08:04	4 11:26	3:22
Hygiene	4 11:26	4 11:45	0:19
Whole Ship Messing (Eating)	4 11:45	4 12:30	0:45
Whole Ship General	4 12:30	4 13:00	0:30
Maintenance—CM	4 13:00	4 14:00	1:00
Unspecified Departmental Work	4 14:00	4 16:30	2:30
Personal Time (including PT)	4 16:30	4 17:30	1:00
Whole Ship Messing (Eating)	4 17:30	4 19:00	1:30
Unspecified Departmental Work	4 19:00	4 19:45	0:45
Watchkeeping	4 19:45	4 23:59	4:14
Personal Time (including PT)	4 23:59	5 00:33	0:34
Hygiene	5 00:33	5 00:48	0:15
Sleep	5 00:48	5 07:04	6:16
Hygiene	5 07:04	5 07:15	0:11
Morning Muster	5 07:15	5 07:30	0:15
Whole Ship Messing (Eating)	5 07:30	5 07:45	0:15
Watchkeeping	5 07:45	5 12:00	4:15
Whole Ship Messing (Eating)	5 12:00	5 12:45	0:45
Maintenance—CM	5 12:45	5 13:45	1:00
Unspecified Departmental Work	5 13:45	5 16:30	2:45
Personal Time (including PT)	5 16:30	5 17:15	0:45
Hygiene	5 17:15	5 17:30	0:15
Whole Ship Messing (Eating)	5 17:30	5 19:00	1:30
Unspecified Departmental Work	5 19:00	5 19:45	0:45
Watchkeeping	5 19:45	5 23:59	4:14
Personal Time (including PT)	5 23:59	6 00:35	0:36
Hygiene	6 00:35	6 00:50	0:15
Sleep	6 00:50	6 06:37	5:47

Hygiene	6 06:37	6 07:15	0:38
Morning Muster	6 07:15	6 07:30	0:15
Whole Ship Messing (Eating)	6 07:30	6 07:45	0:15
Watchkeeping	6 07:45	6 12:00	4:15
Whole Ship Messing (Eating)	6 12:00	6 12:48	0:48
Sleep	6 12:48	6 14:00	1:12
Whole Ship General	6 14:00	6 14:30	0:30
Personal Time (including PT)	6 14:30	6 15:30	1:00
Unspecified Departmental Work	6 15:30	6 17:15	1:45
Hygiene	6 17:15	6 17:30	0:15
Whole Ship Messing (Eating)	6 17:30	6 19:00	1:30
Unspecified Departmental Work	6 19:00	6 19:45	0:45
Watchkeeping	6 19:45	6 23:59	4:14
Hygiene	6 23:59	7 00:15	0:16
Sleep	7 00:15	7 07:18	7:03
Hygiene	7 07:18	7 07:30	0:12
Whole Ship Messing (Eating)	7 07:30	7 07:45	0:15
Watchkeeping	7 07:45	7 12:00	4:15
Whole Ship Messing (Eating)	7 12:00	7 12:48	0:48
Training—Collective	7 12:48	7 14:00	1:12
Whole Ship General	7 14:00	7 14:30	0:30
Personal Time (including PT)	7 14:30	7 15:30	1:00
Unspecified Departmental Work	7 15:30	7 17:40	2:10
Hygiene	7 17:40	7 17:55	0:15
Whole Ship Messing (Eating)	7 17:55	7 18:20	0:25
Personal Time (including PT)	7 18:20	7 19:00	0:40
Unspecified Departmental Work	7 19:00	7 19:45	0:45
Watchkeeping	7 19:45	8 00:00	4:15

E. PERSON ID: 34**RANK: LS****SUB-DEPARTMENT: ME01**

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:15	6:15
Hygiene	6:15	6:45	0:30
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Maintenance—PM	7:30	9:30	2:00
Maintenance—CM	9:30	10:00	0:30
Whole Ship Messing (Eating)	10:00	10:15	0:15
Maintenance—CM	10:15	10:45	0:30
Training—Collective	10:45	11:15	0:30
Whole Ship Messing (Eating)	11:15	11:45	0:30
Watchkeeping	11:45	16:00	4:15
Personal Time (including PT)	16:00	17:15	1:15
Hygiene	17:15	17:30	0:15
Whole Ship Messing (Eating)	17:30	18:15	0:45
Personal Time (including PT)	18:15	19:20	1:05
Sleep	19:20	23:10	3:50
Hygiene	23:10	23:25	0:15
Whole Ship Messing (Eating)	23:25	23:45	0:20
Watchkeeping	23:45	1 03:45	4:00
Hygiene	1 03:45	1 03:51	0:06
Sleep	1 03:51	1 10:51	7:00
Hygiene	1 10:51	1 11:00	0:09
Personal Time (including PT)	1 11:00	1 11:15	0:15
Whole Ship Messing (Eating)	1 11:15	1 11:45	0:30
Watchkeeping	1 11:45	1 16:00	4:15
Personal Time (including PT)	1 16:00	1 17:15	1:15
Hygiene	1 17:15	1 17:30	0:15
Whole Ship Messing (Eating)	1 17:30	1 18:40	1:10
Personal Time (including PT)	1 18:40	1 19:00	0:20
Unspecified Departmental Work	1 19:00	1 21:00	2:00
Personal Time (including PT)	1 21:00	1 23:25	2:25
Whole Ship Messing (Eating)	1 23:25	1 23:45	0:20
Watchkeeping	1 23:45	2 03:45	4:00
Hygiene	2 03:45	2 04:00	0:15
Personal Time (including PT)	2 04:00	2 05:00	1:00
Unspecified Departmental Work	2 05:00	2 06:45	1:45
Whole Ship Messing (Eating)	2 06:45	2 07:15	0:30
Morning Muster	2 07:15	2 07:30	0:15
Maintenance—PM	2 07:30	2 09:00	1:30
Maintenance—CM	2 09:00	2 10:00	1:00
Whole Ship Messing (Eating)	2 10:00	2 10:15	0:15
Training—Collective	2 10:15	2 11:15	1:00

Whole Ship Messing (Eating)	2 11:15	2 11:45	0:30
Watchkeeping	2 11:45	2 15:45	4:00
Hygiene	2 15:45	2 16:01	0:16
Sleep	2 16:01	2 18:08	2:07
Whole Ship Messing (Eating)	2 18:08	2 19:00	0:52
Unspecified Departmental Work	2 19:00	2 20:45	1:45
Sleep	2 20:45	2 23:15	2:30
Whole Ship Messing (Eating)	2 23:15	2 23:45	0:30
Watchkeeping	2 23:45	3 00:33	0:48
Sleep	3 00:33	3 02:13	1:40
Maintenance—CM	3 02:13	3 02:16	0:03
Sleep	3 02:16	3 03:21	1:05
Maintenance—CM	3 03:21	3 04:30	1:09
Personal Time (including PT)	3 04:30	3 06:30	2:00
Hygiene	3 06:30	3 06:45	0:15
Whole Ship Messing (Eating)	3 06:45	3 07:15	0:30
Morning Muster	3 07:15	3 07:30	0:15
Maintenance—CM	3 07:30	3 09:00	1:30
Maintenance—PM	3 09:00	3 10:00	1:00
Whole Ship Messing (Eating)	3 10:00	3 10:15	0:15
Maintenance—CM	3 10:15	3 10:45	0:30
Training—Collective	3 10:45	3 11:15	0:30
Whole Ship Messing (Eating)	3 11:15	3 11:45	0:30
Watchkeeping	3 11:45	3 15:45	4:00
Hygiene	3 15:45	3 16:01	0:16
Unspecified Departmental Work	3 16:01	3 17:30	1:29
Whole Ship Messing (Eating)	3 17:30	3 19:00	1:30
Unspecified Departmental Work	3 19:00	3 20:56	1:56
Sleep	3 20:56	3 23:22	2:26
Whole Ship Messing (Eating)	3 23:22	3 23:45	0:23
Watchkeeping	3 23:45	4 04:00	4:15
Hygiene	4 04:00	4 04:16	0:16
Sleep	4 04:16	4 10:56	6:40
Hygiene	4 10:56	4 11:00	0:04
Personal Time (including PT)	4 11:00	4 11:15	0:15
Whole Ship Messing (Eating)	4 11:15	4 11:45	0:30
Watchkeeping	4 11:45	4 14:48	3:03
Sleep	4 14:48	4 15:51	1:03
Unspecified Departmental Work	4 15:51	4 16:45	0:54
Personal Time (including PT)	4 16:45	4 17:30	0:45
Whole Ship Messing (Eating)	4 17:30	4 18:30	1:00
Personal Time (including PT)	4 18:30	4 19:00	0:30
Unspecified Departmental Work	4 19:00	4 21:00	2:00
Personal Time (including PT)	4 21:00	4 23:25	2:25
Whole Ship Messing (Eating)	4 23:25	4 23:45	0:20

Watchkeeping	4 23:45	5 04:00	4:15
Personal Time (including PT)	5 04:00	5 04:14	0:14
Hygiene	5 04:14	5 04:29	0:15
Sleep	5 04:29	5 11:37	7:08
Whole Ship Messing (Eating)	5 11:37	5 11:45	0:08
Watchkeeping	5 11:45	5 16:00	4:15
Unspecified Departmental Work	5 16:00	5 17:00	1:00
Personal Time (including PT)	5 17:00	5 17:30	0:30
Whole Ship Messing (Eating)	5 17:30	5 18:30	1:00
Unspecified Departmental Work	5 18:30	5 19:30	1:00
Personal Time (including PT)	5 19:30	5 23:15	3:45
Whole Ship Messing (Eating)	5 23:15	5 23:45	0:30
Watchkeeping	5 23:45	6 04:00	4:15
Hygiene	6 04:00	6 04:10	0:10
Sleep	6 04:10	6 11:29	7:19
Whole Ship Messing (Eating)	6 11:29	6 11:45	0:16
Watchkeeping	6 11:45	6 16:00	4:15
Unspecified Departmental Work	6 16:00	6 17:00	1:00
Personal Time (including PT)	6 17:00	6 17:30	0:30
Whole Ship Messing (Eating)	6 17:30	6 18:30	1:00
Unspecified Departmental Work	6 18:30	6 19:30	1:00
Personal Time (including PT)	6 19:30	6 23:15	3:45
Whole Ship Messing (Eating)	6 23:15	6 23:45	0:30
Watchkeeping	6 23:45	7 04:00	4:15
Hygiene	7 04:00	7 04:10	0:10
Sleep	7 04:10	7 11:15	7:05
Whole Ship Messing (Eating)	7 11:15	7 11:45	0:30
Watchkeeping	7 11:45	7 16:00	4:15
Unspecified Departmental Work	7 16:00	7 17:00	1:00
Personal Time (including PT)	7 17:00	7 17:30	0:30
Whole Ship Messing (Eating)	7 17:30	7 18:30	1:00
Unspecified Departmental Work	7 18:30	7 19:30	1:00
Personal Time (including PT)	7 19:30	7 21:54	2:24
Sleep	7 21:54	8 00:00	2:06

F. PERSON ID: 73**RANK: LS****SUB-DEPARTMENT: ME02**

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:30	6:30
Hygiene	6:30	6:45	0:15
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Unspecified Departmental Work	7:30	7:45	0:15
Watchkeeping	7:45	12:00	4:15
Whole Ship Messing (Eating)	12:00	12:30	0:30
Firefighting and Damage Control Exercise	12:30	13:00	0:30
Training—Collective	13:00	14:00	1:00
Whole Ship General	14:00	16:00	2:00
Personal Time (including PT)	16:00	17:15	1:15
Hygiene	17:15	17:30	0:15
Whole Ship Messing (Eating)	17:30	18:30	1:00
Unspecified Departmental Work	18:30	19:00	0:30
Personal Time (including PT)	19:00	19:45	0:45
Watchkeeping	19:45	1 00:00	4:15
Hygiene	1 00:00	1 00:11	0:11
Sleep	1 00:11	1 06:41	6:30
Hygiene	1 06:41	1 06:56	0:15
Whole Ship Messing (Eating)	1 06:56	1 07:15	0:19
Morning Muster	1 07:15	1 07:30	0:15
Unspecified Departmental Work	1 07:30	1 07:45	0:15
Watchkeeping	1 07:45	1 12:00	4:15
Whole Ship Messing (Eating)	1 12:00	1 13:00	1:00
Training—Collective	1 13:00	1 15:00	2:00
Personal Time (including PT)	1 15:00	1 17:15	2:15
Hygiene	1 17:15	1 17:24	0:09
Whole Ship Messing (Eating)	1 17:24	1 19:00	1:36
Unspecified Departmental Work	1 19:00	1 19:45	0:45
Watchkeeping	1 19:45	2 00:00	4:15
Hygiene	2 00:00	2 00:05	0:05
Sleep	2 00:05	2 06:41	6:36
Hygiene	2 06:41	2 06:56	0:15
Whole Ship Messing (Eating)	2 06:56	2 07:15	0:19
Morning Muster	2 07:15	2 07:30	0:15
Unspecified Departmental Work	2 07:30	2 07:45	0:15
Watchkeeping	2 07:45	2 12:00	4:15
Whole Ship Messing (Eating)	2 12:00	2 13:00	1:00
Training—Collective	2 13:00	2 15:00	2:00
Personal Time (including PT)	2 15:00	2 17:15	2:15
Hygiene	2 17:15	2 17:30	0:15
Whole Ship Messing (Eating)	2 17:30	2 19:00	1:30
Unspecified Departmental Work	2 19:00	2 19:45	0:45

Watchkeeping	2 19:45	3 00:00	4:15
Hygiene	3 00:00	3 00:05	0:05
Sleep	3 00:05	3 06:45	6:40
Hygiene	3 06:45	3 07:00	0:15
Whole Ship Messing (Eating)	3 07:00	3 07:15	0:15
Morning Muster	3 07:15	3 07:30	0:15
Unspecified Departmental Work	3 07:30	3 07:45	0:15
Watchkeeping	3 07:45	3 12:00	4:15
Whole Ship Messing (Eating)	3 12:00	3 13:00	1:00
Maintenance—PM	3 13:00	3 13:30	0:30
Maintenance—CM	3 13:30	3 16:30	3:00
Hygiene	3 16:30	3 16:45	0:15
Personal Time (including PT)	3 16:45	3 17:30	0:45
Whole Ship Messing (Eating)	3 17:30	3 18:45	1:15
Unspecified Departmental Work	3 18:45	3 19:45	1:00
Watchkeeping	3 19:45	3 23:45	4:00
Hygiene	3 23:45	3 23:52	0:07
Sleep	3 23:52	4 06:42	6:50
Hygiene	4 06:42	4 06:57	0:15
Unspecified Departmental Work	4 06:57	4 07:15	0:18
Morning Muster	4 07:15	4 07:30	0:15
Whole Ship Messing (Eating)	4 07:30	4 07:45	0:15
Watchkeeping	4 07:45	4 12:00	4:15
Whole Ship Messing (Eating)	4 12:00	4 12:45	0:45
Training—Collective	4 12:45	4 13:45	1:00
Maintenance—CM	4 13:45	4 15:15	1:30
Unspecified Departmental Work	4 15:15	4 16:00	0:45
Personal Time (including PT)	4 16:00	4 17:15	1:15
Hygiene	4 17:15	4 17:30	0:15
Whole Ship Messing (Eating)	4 17:30	4 19:00	1:30
Unspecified Departmental Work	4 19:00	4 19:45	0:45
Watchkeeping	4 19:45	4 23:59	4:14
Hygiene	4 23:59	5 00:09	0:10
Sleep	5 00:09	5 06:48	6:39
Hygiene	5 06:48	5 07:00	0:12
Whole Ship Messing (Eating)	5 07:00	5 07:15	0:15
Morning Muster	5 07:15	5 07:30	0:15
Unspecified Departmental Work	5 07:30	5 07:45	0:15
Watchkeeping	5 07:45	5 12:00	4:15
Whole Ship Messing (Eating)	5 12:00	5 12:45	0:45
Maintenance—PM	5 12:45	5 13:30	0:45
Whole Ship General	5 13:30	5 14:00	0:30
Maintenance—CM	5 14:00	5 15:30	1:30
Personal Time (including PT)	5 15:30	5 17:15	1:45
Hygiene	5 17:15	5 17:30	0:15

Whole Ship Messing (Eating)	5 17:30	5 19:00	1:30
Unspecified Departmental Work	5 19:00	5 19:45	0:45
Watchkeeping	5 19:45	6 00:00	4:15
Hygiene	6 00:00	6 00:20	0:20
Sleep	6 00:20	6 07:35	7:15
Whole Ship Messing (Eating)	6 07:35	6 07:45	0:10
Watchkeeping	6 07:45	6 12:00	4:15
Whole Ship Messing (Eating)	6 12:00	6 12:45	0:45
Whole Ship General	6 12:45	6 15:15	2:30
Personal Time (including PT)	6 15:15	6 17:15	2:00
Hygiene	6 17:15	6 17:30	0:15
Whole Ship Messing (Eating)	6 17:30	6 18:00	0:30
Maintenance—CM	6 18:00	6 19:00	1:00
Unspecified Departmental Work	6 19:00	6 19:45	0:45
Watchkeeping	6 19:45	6 21:00	1:15
Hygiene	6 21:00	6 21:05	0:05
Sleep	6 21:05	7 06:56	9:51
Hygiene	7 06:56	7 07:15	0:19
Morning Muster	7 07:15	7 07:30	0:15
Whole Ship Messing (Eating)	7 07:30	7 07:45	0:15
Watchkeeping	7 07:45	7 12:00	4:15
Whole Ship Messing (Eating)	7 12:00	7 12:30	0:30
Whole Ship General	7 12:30	7 14:00	1:30
Training—Collective	7 14:00	7 16:00	2:00
Personal Time (including PT)	7 16:00	7 17:15	1:15
Hygiene	7 17:15	7 17:30	0:15
Whole Ship Messing (Eating)	7 17:30	7 18:15	0:45
Unspecified Departmental Work	7 18:15	7 19:45	1:30
Watchkeeping	7 19:45	8 00:00	4:15

G. PERSON ID: 15**RANK: LS****SUB-DEPARTMENT: ME03**

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:15	6:15
Hygiene	6:15	6:30	0:15
Personal Time (including PT)	6:30	6:45	0:15
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Maintenance—PM	7:30	9:00	1:30
Maintenance—CM	9:00	10:00	1:00
Whole Ship Messing (Eating)	10:00	10:15	0:15
Maintenance—CM	10:15	10:45	0:30
Training—Collective	10:45	11:45	1:00
Whole Ship Messing (Eating)	11:45	12:30	0:45
Firefighting and Damage Control Exercise	12:30	13:00	0:30
Unspecified Departmental Work	13:00	14:00	1:00
Whole Ship General	14:00	16:00	2:00
Unspecified Departmental Work	16:00	17:00	1:00
Hygiene	17:00	17:30	0:30
Whole Ship Messing (Eating)	17:30	18:15	0:45
Unspecified Departmental Work	18:15	18:45	0:30
Sleep	18:45	23:09	4:24
Hygiene	23:09	23:45	0:36
Watchkeeping	23:45	1 04:00	4:15
Sleep	1 04:00	1 10:48	6:48
Hygiene	1 10:48	1 11:15	0:27
Whole Ship Messing (Eating)	1 11:15	1 11:45	0:30
Watchkeeping	1 11:45	1 16:00	4:15
Training—Collective	1 16:00	1 17:00	1:00
Hygiene	1 17:00	1 17:30	0:30
Whole Ship Messing (Eating)	1 17:30	1 18:15	0:45
Unspecified Departmental Work	1 18:15	1 23:45	5:30
Watchkeeping	1 23:45	2 04:00	4:15
Hygiene	2 04:00	2 04:33	0:33
Sleep	2 04:33	2 10:37	6:04
Maintenance—CM	2 10:37	2 11:30	0:53
Whole Ship Messing (Eating)	2 11:30	2 11:45	0:15
Watchkeeping	2 11:45	2 16:00	4:15
Maintenance—CM	2 16:00	2 16:29	0:29
Maintenance—PM	2 16:29	2 17:30	1:01
Whole Ship Messing (Eating)	2 17:30	2 18:15	0:45
Unspecified Departmental Work	2 18:15	2 23:45	5:30
Watchkeeping	2 23:45	3 04:00	4:15
Personal Time (including PT)	3 04:00	3 04:21	0:21
Hygiene	3 04:21	3 04:36	0:15
Sleep	3 04:36	3 10:24	5:48

Maintenance—CM	3 10:24	3 11:30	1:06
Whole Ship Messing (Eating)	3 11:30	3 11:45	0:15
Watchkeeping	3 11:45	3 16:00	4:15
Maintenance—CM	3 16:00	3 16:29	0:29
Maintenance—PM	3 16:29	3 17:15	0:46
Sleep	3 17:15	3 17:59	0:44
Whole Ship Messing (Eating)	3 17:59	3 19:00	1:01
Maintenance—General	3 19:00	3 20:59	1:59
Sleep	3 20:59	3 23:00	2:01
Hygiene	3 23:00	3 23:45	0:45
Watchkeeping	3 23:45	4 04:00	4:15
Unspecified Departmental Work	4 04:00	4 04:20	0:20
Hygiene	4 04:20	4 04:48	0:28
Sleep	4 04:48	4 10:29	5:41
Unspecified Departmental Work	4 10:29	4 11:15	0:46
Whole Ship Messing (Eating)	4 11:15	4 11:45	0:30
Watchkeeping	4 11:45	4 16:00	4:15
Unspecified Departmental Work	4 16:00	4 17:30	1:30
Whole Ship Messing (Eating)	4 17:30	4 18:45	1:15
Unspecified Departmental Work	4 18:45	4 19:33	0:48
Sleep	4 19:33	4 22:58	3:25
Hygiene	4 22:58	4 23:45	0:47
Watchkeeping	4 23:45	5 04:00	4:15
Hygiene	5 04:00	5 04:12	0:12
Sleep	5 04:12	5 10:54	6:42
Unspecified Departmental Work	5 10:54	5 11:15	0:21
Whole Ship Messing (Eating)	5 11:15	5 11:45	0:30
Watchkeeping	5 11:45	5 16:00	4:15
Unspecified Departmental Work	5 16:00	5 17:30	1:30
Whole Ship Messing (Eating)	5 17:30	5 18:45	1:15
Whole Ship General	5 18:45	5 19:13	0:28
Sleep	5 19:13	5 20:04	0:51
Unspecified Departmental Work	5 20:04	5 23:45	3:41
Watchkeeping	5 23:45	6 04:00	4:15
Hygiene	6 04:00	6 04:05	0:05
Sleep	6 04:05	6 10:33	6:28
Training—Collective	6 10:33	6 11:33	1:00
Whole Ship Messing (Eating)	6 11:33	6 11:45	0:12
Watchkeeping	6 11:45	6 16:00	4:15
Unspecified Departmental Work	6 16:00	6 17:30	1:30
Whole Ship Messing (Eating)	6 17:30	6 18:45	1:15
Whole Ship General	6 18:45	6 20:02	1:17
Sleep	6 20:02	6 22:50	2:48
Hygiene	6 22:50	6 23:15	0:25
Unspecified Departmental Work	6 23:15	6 23:45	0:30

Watchkeeping	6 23:45	7 04:00	4:15
Hygiene	7 04:00	7 04:10	0:10
Sleep	7 04:10	7 10:45	6:35
Unspecified Departmental Work	7 10:45	7 11:33	0:48
Whole Ship Messing (Eating)	7 11:33	7 11:45	0:12
Watchkeeping	7 11:45	7 16:00	4:15
Maintenance—General	7 16:00	7 17:30	1:30
Whole Ship Messing (Eating)	7 17:30	7 18:30	1:00
Whole Ship General	7 18:30	7 20:00	1:30
Maintenance—General	7 20:00	7 21:32	1:32
Sleep	7 21:32	7 23:02	1:30
Hygiene	7 23:02	7 23:15	0:13
Maintenance—General	7 23:15	7 23:45	0:30
Watchkeeping	7 23:45	8 00:00	0:15

H. PERSON ID: 154**RANK: LS****SUB-DEPARTMENT: ME04**

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:30	6:30
Hygiene	6:30	6:45	0:15
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Unspecified Departmental Work	7:30	7:45	0:15
Watchkeeping	7:45	12:00	4:15
Whole Ship Messing (Eating)	12:00	12:30	0:30
Firefighting and Damage Control Exercise	12:30	13:00	0:30
Personal Time (including PT)	13:00	14:00	1:00
Whole Ship General	14:00	15:30	1:30
Personal Time (including PT)	15:30	17:00	1:30
Hygiene	17:00	17:30	0:30
Whole Ship Messing (Eating)	17:30	18:30	1:00
Unspecified Departmental Work	18:30	19:00	0:30
Personal Time (including PT)	19:00	19:45	0:45
Watchkeeping	19:45	1 00:00	4:15
Personal Time (including PT)	1 00:00	1 00:55	0:55
Hygiene	1 00:55	1 01:11	0:16
Sleep	1 01:11	1 07:08	5:57
Hygiene	1 07:08	1 07:15	0:07
Morning Muster	1 07:15	1 07:30	0:15
Whole Ship Messing (Eating)	1 07:30	1 07:45	0:15
Watchkeeping	1 07:45	1 12:00	4:15
Whole Ship Messing (Eating)	1 12:00	1 13:00	1:00
Unspecified Departmental Work	1 13:00	1 14:30	1:30
Personal Time (including PT)	1 14:30	1 17:15	2:45
Hygiene	1 17:15	1 17:24	0:09
Whole Ship Messing (Eating)	1 17:24	1 19:00	1:36
Unspecified Departmental Work	1 19:00	1 19:45	0:45
Watchkeeping	1 19:45	2 00:00	4:15
Hygiene	2 00:00	2 00:21	0:21
Sleep	2 00:21	2 07:09	6:48
Hygiene	2 07:09	2 07:15	0:06
Morning Muster	2 07:15	2 07:30	0:15
Whole Ship Messing (Eating)	2 07:30	2 07:45	0:15
Watchkeeping	2 07:45	2 12:00	4:15
Whole Ship Messing (Eating)	2 12:00	2 13:00	1:00
Maintenance—PM	2 13:00	2 13:30	0:30
Whole Ship General	2 13:30	2 14:00	0:30
Sleep	2 14:00	2 16:00	2:00
Hygiene	2 16:00	2 16:15	0:15
Personal Time (including PT)	2 16:15	2 17:30	1:15
Whole Ship Messing (Eating)	2 17:30	2 18:45	1:15

Unspecified Departmental Work	2 18:45	2 19:45	1:00
Watchkeeping	2 19:45	3 00:00	4:15
Maintenance—CM	3 00:00	3 00:23	0:23
Hygiene	3 00:23	3 00:38	0:15
Sleep	3 00:38	3 06:45	6:07
Hygiene	3 06:45	3 07:00	0:15
Whole Ship Messing (Eating)	3 07:00	3 07:15	0:15
Morning Muster	3 07:15	3 07:30	0:15
Unspecified Departmental Work	3 07:30	3 07:45	0:15
Watchkeeping	3 07:45	3 12:00	4:15
Whole Ship Messing (Eating)	3 12:00	3 13:30	1:30
Whole Ship General	3 13:30	3 14:00	0:30
Maintenance—General	3 14:00	3 14:37	0:37
Personal Time (including PT)	3 14:37	3 17:15	2:38
Hygiene	3 17:15	3 17:30	0:15
Whole Ship Messing (Eating)	3 17:30	3 19:00	1:30
Unspecified Departmental Work	3 19:00	3 19:45	0:45
Watchkeeping	3 19:45	3 23:43	3:58
Sleep	3 23:43	4 06:56	7:13
Hygiene	4 06:56	4 07:00	0:04
Whole Ship Messing (Eating)	4 07:00	4 07:15	0:15
Morning Muster	4 07:15	4 07:30	0:15
Unspecified Departmental Work	4 07:30	4 07:45	0:15
Watchkeeping	4 07:45	4 12:00	4:15
Whole Ship Messing (Eating)	4 12:00	4 13:30	1:30
Whole Ship General	4 13:30	4 14:00	0:30
Maintenance—General	4 14:00	4 14:37	0:37
Personal Time (including PT)	4 14:37	4 17:15	2:38
Hygiene	4 17:15	4 17:30	0:15
Whole Ship Messing (Eating)	4 17:30	4 19:00	1:30
Unspecified Departmental Work	4 19:00	4 19:45	0:45
Watchkeeping	4 19:45	4 23:45	4:00
Hygiene	4 23:45	4 23:50	0:05
Sleep	4 23:50	5 06:49	6:59
Hygiene	5 06:49	5 07:00	0:11
Whole Ship Messing (Eating)	5 07:00	5 07:15	0:15
Morning Muster	5 07:15	5 07:30	0:15
Unspecified Departmental Work	5 07:30	5 07:45	0:15
Watchkeeping	5 07:45	5 12:00	4:15
Whole Ship Messing (Eating)	5 12:00	5 13:30	1:30
Whole Ship General	5 13:30	5 14:00	0:30
Maintenance—CM	5 14:00	5 15:00	1:00
Personal Time (including PT)	5 15:00	5 17:15	2:15
Hygiene	5 17:15	5 17:30	0:15
Whole Ship Messing (Eating)	5 17:30	5 19:00	1:30

Unspecified Departmental Work	5 19:00	5 19:45	0:45
Watchkeeping	5 19:45	6 00:00	4:15
Personal Time (including PT)	6 00:00	6 00:46	0:46
Hygiene	6 00:46	6 01:01	0:15
Sleep	6 01:01	6 07:02	6:01
Hygiene	6 07:02	6 07:15	0:13
Morning Muster	6 07:15	6 07:30	0:15
Whole Ship Messing (Eating)	6 07:30	6 07:45	0:15
Watchkeeping	6 07:45	6 12:00	4:15
Whole Ship Messing (Eating)	6 12:00	6 13:00	1:00
Whole Ship General	6 13:00	6 15:00	2:00
Maintenance—CM	6 15:00	6 16:00	1:00
Personal Time (including PT)	6 16:00	6 17:15	1:15
Hygiene	6 17:15	6 17:30	0:15
Whole Ship Messing (Eating)	6 17:30	6 18:15	0:45
Unspecified Departmental Work	6 18:15	6 19:45	1:30
Watchkeeping	6 19:45	6 21:45	2:00
Hygiene	6 21:45	6 21:49	0:04
Sleep	6 21:49	7 05:48	7:59
Hygiene	7 05:48	7 06:03	0:15
Unspecified Departmental Work	7 06:03	7 07:15	1:12
Morning Muster	7 07:15	7 07:30	0:15
Whole Ship Messing (Eating)	7 07:30	7 07:45	0:15
Watchkeeping	7 07:45	7 12:00	4:15
Whole Ship Messing (Eating)	7 12:00	7 12:45	0:45
Whole Ship General	7 12:45	7 14:15	1:30
Maintenance—PM	7 14:15	7 16:15	2:00
Personal Time (including PT)	7 16:15	7 17:15	1:00
Hygiene	7 17:15	7 17:30	0:15
Whole Ship Messing (Eating)	7 17:30	7 18:15	0:45
Unspecified Departmental Work	7 18:15	7 19:45	1:30
Watchkeeping	7 19:45	7 23:50	4:05
Hygiene	7 23:50	8 00:00	0:10

I. PERSON ID: 246**RANK: PO****SUB-DEPARTMENT: ME01**

Activity	Start Time	End Time	Total Activity Time
Personal Time (including PT)	0:00	0:20	0:20
Sleep	0:20	5:49	5:29
Hygiene	5:49	6:04	0:15
Unspecified Departmental Work	6:04	6:50	0:46
Whole Ship Messing (Eating)	6:50	7:15	0:25
Morning Muster	7:15	7:30	0:15
Maintenance—PM	7:30	9:00	1:30
Maintenance—CM	9:00	10:00	1:00
Whole Ship Messing (Eating)	10:00	10:10	0:10
Maintenance—CM	10:10	10:40	0:30
Training—Collective	10:40	11:10	0:30
Whole Ship Reporting	11:10	11:50	0:40
Whole Ship Messing (Eating)	11:50	12:30	0:40
Firefighting and Damage Control Exercise	12:30	13:00	0:30
Whole Ship Reporting	13:00	14:00	1:00
Whole Ship General	14:00	16:00	2:00
Whole Ship Reporting	16:00	17:30	1:30
Whole Ship Messing (Eating)	17:30	18:15	0:45
Whole Ship Reporting	18:15	20:35	2:20
Unspecified Departmental Work	20:35	21:49	1:14
Personal Time (including PT)	21:49	23:06	1:17
Hygiene	23:06	23:21	0:15
Sleep	23:21	1 04:05	4:44
Hygiene	1 04:05	1 04:20	0:15
Personal Time (including PT)	1 04:20	1 06:00	1:40
Unspecified Departmental Work	1 06:00	1 06:40	0:40
Whole Ship Messing (Eating)	1 06:40	1 07:15	0:35
Morning Muster	1 07:15	1 07:30	0:15
Whole Ship Reporting	1 07:30	1 10:00	2:30
Whole Ship Messing (Eating)	1 10:00	1 10:15	0:15
Whole Ship Reporting	1 10:15	1 11:45	1:30
Whole Ship Messing (Eating)	1 11:45	1 12:40	0:55
Whole Ship Reporting	1 12:40	1 17:10	4:30
Hygiene	1 17:10	1 17:30	0:20
Whole Ship Messing (Eating)	1 17:30	1 18:45	1:15
Unspecified Departmental Work	1 18:45	1 20:05	1:20
Personal Time (including PT)	1 20:05	1 22:29	2:24
Hygiene	1 22:29	1 22:44	0:15
Sleep	1 22:44	2 03:09	4:25
Hygiene	2 03:09	2 03:24	0:15
Personal Time (including PT)	2 03:24	2 06:00	2:36
Unspecified Departmental Work	2 06:00	2 06:40	0:40
Whole Ship Messing (Eating)	2 06:40	2 07:15	0:35

Morning Muster	2 07:15	2 07:30	0:15
Maintenance—PM	2 07:30	2 09:00	1:30
Whole Ship Reporting	2 09:00	2 10:00	1:00
Whole Ship Messing (Eating)	2 10:00	2 10:15	0:15
Maintenance—CM	2 10:15	2 11:45	1:30
Whole Ship Messing (Eating)	2 11:45	2 12:40	0:55
Whole Ship Reporting	2 12:40	2 16:40	4:00
Unspecified Departmental Work	2 16:40	2 17:10	0:30
Hygiene	2 17:10	2 17:30	0:20
Whole Ship Messing (Eating)	2 17:30	2 18:45	1:15
Unspecified Departmental Work	2 18:45	2 20:35	1:50
Personal Time (including PT)	2 20:35	2 23:45	3:10
Hygiene	2 23:45	3 00:00	0:15
Sleep	3 00:00	3 03:09	3:09
Hygiene	3 03:09	3 03:24	0:15
Personal Time (including PT)	3 03:24	3 06:00	2:36
Unspecified Departmental Work	3 06:00	3 06:40	0:40
Whole Ship Messing (Eating)	3 06:40	3 07:15	0:35
Morning Muster	3 07:15	3 07:30	0:15
Maintenance—PM	3 07:30	3 09:00	1:30
Whole Ship Reporting	3 09:00	3 10:00	1:00
Whole Ship Messing (Eating)	3 10:00	3 10:15	0:15
Maintenance—CM	3 10:15	3 11:45	1:30
Whole Ship Messing (Eating)	3 11:45	3 12:40	0:55
Whole Ship Reporting	3 12:40	3 16:40	4:00
Unspecified Departmental Work	3 16:40	3 17:10	0:30
Hygiene	3 17:10	3 17:30	0:20
Whole Ship Messing (Eating)	3 17:30	3 18:45	1:15
Unspecified Departmental Work	3 18:45	3 20:35	1:50
Personal Time (including PT)	3 20:35	3 22:37	2:02
Hygiene	3 22:37	3 22:52	0:15
Sleep	3 22:52	4 03:30	4:38
Hygiene	4 03:30	4 03:45	0:15
Personal Time (including PT)	4 03:45	4 06:00	2:15
Unspecified Departmental Work	4 06:00	4 06:50	0:50
Whole Ship Messing (Eating)	4 06:50	4 07:15	0:25
Morning Muster	4 07:15	4 07:30	0:15
Maintenance—PM	4 07:30	4 09:00	1:30
Unspecified Departmental Work	4 09:00	4 10:00	1:00
Whole Ship Messing (Eating)	4 10:00	4 10:15	0:15
Maintenance—CM	4 10:15	4 11:45	1:30
Whole Ship Messing (Eating)	4 11:45	4 12:20	0:35
Unspecified Departmental Work	4 12:20	4 17:10	4:50
Hygiene	4 17:10	4 17:30	0:20
Whole Ship Messing (Eating)	4 17:30	4 18:15	0:45

Unspecified Departmental Work	4 18:15	4 20:35	2:20
Personal Time (including PT)	4 20:35	4 23:20	2:45
Hygiene	4 23:20	4 23:35	0:15
Sleep	4 23:35	5 06:50	7:15
Hygiene	5 06:50	5 07:05	0:15
Whole Ship Messing (Eating)	5 07:05	5 07:15	0:10
Morning Muster	5 07:15	5 07:30	0:15
Maintenance—PM	5 07:30	5 09:00	1:30
Unspecified Departmental Work	5 09:00	5 10:00	1:00
Whole Ship Messing (Eating)	5 10:00	5 10:15	0:15
Maintenance—CM	5 10:15	5 11:45	1:30
Whole Ship Messing (Eating)	5 11:45	5 12:15	0:30
Whole Ship General	5 12:15	5 12:45	0:30
Whole Ship Reporting	5 12:45	5 16:45	4:00
Unspecified Departmental Work	5 16:45	5 17:15	0:30
Hygiene	5 17:15	5 17:30	0:15
Whole Ship Messing (Eating)	5 17:30	5 18:05	0:35
Unspecified Departmental Work	5 18:05	5 21:35	3:30
Personal Time (including PT)	5 21:35	5 23:45	2:10
Hygiene	5 23:45	6 00:00	0:15
Sleep	6 00:00	6 06:30	6:30
Hygiene	6 06:30	6 06:45	0:15
Unspecified Departmental Work	6 06:45	6 07:05	0:20
Whole Ship Messing (Eating)	6 07:05	6 07:15	0:10
Morning Muster	6 07:15	6 07:30	0:15
Maintenance—PM	6 07:30	6 09:00	1:30
Unspecified Departmental Work	6 09:00	6 10:15	1:15
Maintenance—CM	6 10:15	6 11:45	1:30
Whole Ship Messing (Eating)	6 11:45	6 12:15	0:30
Whole Ship General	6 12:15	6 14:45	2:30
Unspecified Departmental Work	6 14:45	6 15:38	0:53
Sleep	6 15:38	6 17:39	2:01
Whole Ship Messing (Eating)	6 17:39	6 18:14	0:35
Unspecified Departmental Work	6 18:14	6 21:53	3:39
Personal Time (including PT)	6 21:53	7 00:07	2:14
Hygiene	7 00:07	7 00:22	0:15
Sleep	7 00:22	7 05:57	5:35
Hygiene	7 05:57	7 06:15	0:18
Personal Time (including PT)	7 06:15	7 06:45	0:30
Whole Ship Messing (Eating)	7 06:45	7 07:15	0:30
Morning Muster	7 07:15	7 07:30	0:15
Whole Ship Reporting	7 07:30	7 08:30	1:00
Maintenance—PM	7 08:30	7 09:09	0:39
Unspecified Departmental Work	7 09:09	7 09:40	0:31
Sleep	7 09:40	7 10:48	1:08

Maintenance—CM	7 10:48	7 11:45	0:57
Whole Ship Messing (Eating)	7 11:45	7 12:30	0:45
Whole Ship Reporting	7 12:30	7 15:30	3:00
Unspecified Departmental Work	7 15:30	7 17:15	1:45
Hygiene	7 17:15	7 17:30	0:15
Whole Ship Messing (Eating)	7 17:30	7 18:45	1:15
Unspecified Departmental Work	7 18:45	7 20:20	1:35
Maintenance—CM	7 20:20	7 20:53	0:33
Unspecified Departmental Work	7 20:53	7 21:13	0:20
Personal Time (including PT)	7 21:13	8 00:00	2:47

J. PERSON ID: 163**RANK: PO****SUB-DEPARTMENT: ME02**

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:15	6:15
Hygiene	6:15	6:45	0:30
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Whole Ship Reporting	7:30	7:45	0:15
Watchkeeping	7:45	11:45	4:00
Whole Ship Messing (Eating)	11:45	12:30	0:45
Firefighting and Damage Control Exercise	12:30	13:00	0:30
Unspecified Departmental Work	13:00	14:00	1:00
Whole Ship General	14:00	15:00	1:00
Unspecified Departmental Work	15:00	17:00	2:00
Maintenance—CM	17:00	17:30	0:30
Whole Ship Messing (Eating)	17:30	18:15	0:45
Unspecified Departmental Work	18:15	19:00	0:45
Personal Time (including PT)	19:00	19:45	0:45
Watchkeeping	19:45	23:54	4:09
Hygiene	23:54	1 00:09	0:15
Sleep	1 00:09	1 06:53	6:44
Hygiene	1 06:53	1 07:05	0:12
Whole Ship Messing (Eating)	1 07:05	1 07:30	0:25
Whole Ship Reporting	1 07:30	1 07:45	0:15
Watchkeeping	1 07:45	1 11:45	4:00
Whole Ship Messing (Eating)	1 11:45	1 12:30	0:45
Training—Collective	1 12:30	1 13:30	1:00
Unspecified Departmental Work	1 13:30	1 14:00	0:30
Whole Ship Reporting	1 14:00	1 15:00	1:00
Unspecified Departmental Work	1 15:00	1 17:00	2:00
Whole Ship Reporting	1 17:00	1 17:23	0:23
Sleep	1 17:23	1 19:06	1:43
Whole Ship Messing (Eating)	1 19:06	1 19:45	0:39
Watchkeeping	1 19:45	1 23:50	4:05
Hygiene	1 23:50	1 23:57	0:07
Sleep	1 23:57	2 06:28	6:31
Hygiene	2 06:28	2 06:43	0:15
Whole Ship Messing (Eating)	2 06:43	2 07:30	0:47
Whole Ship Reporting	2 07:30	2 07:45	0:15
Watchkeeping	2 07:45	2 11:45	4:00
Whole Ship Messing (Eating)	2 11:45	2 12:30	0:45
Training—Collective	2 12:30	2 14:30	2:00
Whole Ship General	2 14:30	2 15:00	0:30
Unspecified Departmental Work	2 15:00	2 15:48	0:48
Sleep	2 15:48	2 16:58	1:10
Hygiene	2 16:58	2 17:13	0:15

Personal Time (including PT)	2 17:13	2 17:32	0:19
Whole Ship Messing (Eating)	2 17:32	2 18:30	0:58
Whole Ship Reporting	2 18:30	2 19:45	1:15
Watchkeeping	2 19:45	2 23:50	4:05
Hygiene	2 23:50	3 00:03	0:13
Sleep	3 00:03	3 06:27	6:24
Hygiene	3 06:27	3 06:43	0:16
Whole Ship Messing (Eating)	3 06:43	3 07:30	0:47
Whole Ship Reporting	3 07:30	3 07:45	0:15
Watchkeeping	3 07:45	3 11:45	4:00
Whole Ship Messing (Eating)	3 11:45	3 12:45	1:00
Whole Ship Reporting	3 12:45	3 14:30	1:45
Maintenance—PM	3 14:30	3 15:37	1:07
Sleep	3 15:37	3 17:17	1:40
Hygiene	3 17:17	3 17:32	0:15
Whole Ship Messing (Eating)	3 17:32	3 18:30	0:58
Maintenance—PM	3 18:30	3 19:45	1:15
Watchkeeping	3 19:45	3 23:58	4:13
Hygiene	3 23:58	4 00:13	0:15
Sleep	4 00:13	4 06:55	6:42
Hygiene	4 06:55	4 07:10	0:15
Whole Ship Messing (Eating)	4 07:10	4 07:30	0:20
Whole Ship Reporting	4 07:30	4 07:45	0:15
Watchkeeping	4 07:45	4 11:45	4:00
Whole Ship Messing (Eating)	4 11:45	4 12:30	0:45
Training—Collective	4 12:30	4 13:00	0:30
Whole Ship Reporting	4 13:00	4 13:07	0:07
Sleep	4 13:07	4 14:22	1:15
Maintenance—PM	4 14:22	4 15:52	1:30
Unspecified Departmental Work	4 15:52	4 17:15	1:23
Hygiene	4 17:15	4 17:30	0:15
Whole Ship Messing (Eating)	4 17:30	4 18:30	1:00
Personal Time (including PT)	4 18:30	4 19:45	1:15
Watchkeeping	4 19:45	4 23:46	4:01
Sleep	4 23:46	5 06:48	7:02
Hygiene	5 06:48	5 07:03	0:15
Whole Ship Messing (Eating)	5 07:03	5 07:25	0:22
Whole Ship Reporting	5 07:25	5 07:45	0:20
Watchkeeping	5 07:45	5 11:45	4:00
Whole Ship Messing (Eating)	5 11:45	5 12:20	0:35
Training—Collective	5 12:20	5 12:50	0:30
Whole Ship Reporting	5 12:50	5 13:07	0:17
Maintenance—PM	5 13:07	5 14:20	1:13
Sleep	5 14:20	5 15:21	1:01
Unspecified Departmental Work	5 15:21	5 17:15	1:54

Hygiene	5 17:15	5 17:30	0:15
Whole Ship Messing (Eating)	5 17:30	5 18:15	0:45
Maintenance—CM	5 18:15	5 19:20	1:05
Sleep	5 19:20	5 20:13	0:53
Watchkeeping	5 20:13	5 23:59	3:46
Personal Time (including PT)	5 23:59	6 00:48	0:49
Hygiene	6 00:48	6 01:03	0:15
Sleep	6 01:03	6 08:27	7:24
Hygiene	6 08:27	6 08:42	0:15
Whole Ship Messing (Eating)	6 08:42	6 09:00	0:18
Whole Ship General	6 09:00	6 09:42	0:42
Training—Collective	6 09:42	6 10:12	0:30
Maintenance—CM	6 10:12	6 10:37	0:25
Sleep	6 10:37	6 12:20	1:43
Whole Ship Messing (Eating)	6 12:20	6 12:40	0:20
Whole Ship Reporting	6 12:40	6 13:07	0:27
Maintenance—PM	6 13:07	6 14:20	1:13
Unspecified Departmental Work	6 14:20	6 15:37	1:17
Sleep	6 15:37	6 17:46	2:09
Whole Ship Messing (Eating)	6 17:46	6 18:13	0:27
Maintenance—CM	6 18:13	6 19:20	1:07
Whole Ship Reporting	6 19:20	6 19:45	0:25
Watchkeeping	6 19:45	6 23:36	3:51
Sleep	6 23:36	7 07:01	7:25
Hygiene	7 07:01	7 07:10	0:09
Whole Ship Messing (Eating)	7 07:10	7 07:30	0:20
Whole Ship Reporting	7 07:30	7 07:45	0:15
Watchkeeping	7 07:45	7 11:45	4:00
Whole Ship Messing (Eating)	7 11:45	7 12:30	0:45
Training—Collective	7 12:30	7 14:30	2:00
Whole Ship Reporting	7 14:30	7 15:21	0:51
Unspecified Departmental Work	7 15:21	7 17:15	1:54
Hygiene	7 17:15	7 17:30	0:15
Whole Ship Messing (Eating)	7 17:30	7 18:15	0:45
Maintenance—PM	7 18:15	7 19:20	1:05
Personal Time (including PT)	7 19:20	7 19:45	0:25
Watchkeeping	7 19:45	8 00:00	4:15

K. PERSON ID: 102**RANK: PO****SUB-DEPARTMENT: ME03**

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	5:45	5:45
Hygiene	5:45	6:00	0:15
Whole Ship Reporting	6:00	7:00	1:00
Whole Ship Messing (Eating)	7:00	7:15	0:15
Morning Muster	7:15	7:30	0:15
Maintenance—PM	7:30	9:00	1:30
Maintenance—CM	9:00	10:15	1:15
Training—Collective	10:15	11:45	1:30
Whole Ship Messing (Eating)	11:45	12:10	0:25
Maintenance—CM	12:10	12:30	0:20
Firefighting and Damage Control Exercise	12:30	13:00	0:30
Maintenance—CM	13:00	14:00	1:00
Maintenance—PM	14:00	16:30	2:30
Maintenance—CM	16:30	17:30	1:00
Whole Ship Messing (Eating)	17:30	17:50	0:20
Maintenance—CM	17:50	19:15	1:25
Personal Time (including PT)	19:15	20:03	0:48
Hygiene	20:03	20:18	0:15
Sleep	20:18	1 03:11	6:53
Hygiene	1 03:11	1 03:26	0:15
Personal Time (including PT)	1 03:26	1 03:45	0:19
Watchkeeping	1 03:45	1 08:00	4:15
Whole Ship Messing (Eating)	1 08:00	1 08:30	0:30
Whole Ship Reporting	1 08:30	1 09:08	0:38
Sleep	1 09:08	1 11:29	2:21
Whole Ship Messing (Eating)	1 11:29	1 11:59	0:30
Training—Collective	1 11:59	1 13:59	2:00
Whole Ship Reporting	1 13:59	1 15:58	1:59
Unspecified Departmental Work	1 15:58	1 17:30	1:32
Whole Ship Messing (Eating)	1 17:30	1 18:30	1:00
Unspecified Departmental Work	1 18:30	1 20:13	1:43
Personal Time (including PT)	1 20:13	1 21:01	0:48
Hygiene	1 21:01	1 21:16	0:15
Sleep	1 21:16	2 02:55	5:39
Hygiene	2 02:55	2 03:05	0:10
Unspecified Departmental Work	2 03:05	2 03:45	0:40
Watchkeeping	2 03:45	2 08:00	4:15
Whole Ship Messing (Eating)	2 08:00	2 08:30	0:30
Whole Ship Reporting	2 08:30	2 09:00	0:30
Maintenance—PM	2 09:00	2 11:30	2:30
Whole Ship Messing (Eating)	2 11:30	2 12:00	0:30
Maintenance—PM	2 12:00	2 13:30	1:30
Training—Collective	2 13:30	2 14:30	1:00

Maintenance—CM	2 14:30	2 16:00	1:30
Maintenance—PM	2 16:00	2 17:00	1:00
Unspecified Departmental Work	2 17:00	2 18:00	1:00
Whole Ship Messing (Eating)	2 18:00	2 18:30	0:30
Unspecified Departmental Work	2 18:30	2 20:00	1:30
Whole Ship Reporting	2 20:00	2 20:38	0:38
Hygiene	2 20:38	2 20:43	0:05
Sleep	2 20:43	3 03:20	6:37
Unspecified Departmental Work	3 03:20	3 03:26	0:06
Hygiene	3 03:26	3 03:45	0:19
Watchkeeping	3 03:45	3 08:00	4:15
Whole Ship Messing (Eating)	3 08:00	3 08:30	0:30
Unspecified Departmental Work	3 08:30	3 09:00	0:30
Maintenance—PM	3 09:00	3 11:30	2:30
Whole Ship Messing (Eating)	3 11:30	3 12:17	0:47
Maintenance—General	3 12:17	3 13:30	1:13
Maintenance—PM	3 13:30	3 15:00	1:30
Maintenance—CM	3 15:00	3 17:30	2:30
Unspecified Departmental Work	3 17:30	3 18:00	0:30
Whole Ship Messing (Eating)	3 18:00	3 18:43	0:43
Maintenance—CM	3 18:43	3 19:43	1:00
Unspecified Departmental Work	3 19:43	3 21:18	1:35
Personal Time (including PT)	3 21:18	3 21:24	0:06
Hygiene	3 21:24	3 21:39	0:15
Sleep	3 21:39	4 03:26	5:47
Hygiene	4 03:26	4 03:45	0:19
Watchkeeping	4 03:45	4 08:00	4:15
Whole Ship Messing (Eating)	4 08:00	4 08:15	0:15
Unspecified Departmental Work	4 08:15	4 09:00	0:45
Maintenance—PM	4 09:00	4 11:30	2:30
Whole Ship Messing (Eating)	4 11:30	4 11:50	0:20
Maintenance—PM	4 11:50	4 13:50	2:00
Maintenance—CM	4 13:50	4 15:30	1:40
Whole Ship Reporting	4 15:30	4 17:30	2:00
Whole Ship Messing (Eating)	4 17:30	4 17:55	0:25
Maintenance—CM	4 17:55	4 18:45	0:50
Unspecified Departmental Work	4 18:45	4 21:15	2:30
Personal Time (including PT)	4 21:15	4 21:30	0:15
Hygiene	4 21:30	4 21:45	0:15
Sleep	4 21:45	5 03:15	5:30
Hygiene	5 03:15	5 03:30	0:15
Unspecified Departmental Work	5 03:30	5 03:45	0:15
Watchkeeping	5 03:45	5 08:00	4:15
Whole Ship Messing (Eating)	5 08:00	5 08:10	0:10
Unspecified Departmental Work	5 08:10	5 09:00	0:50

Maintenance—PM	5 09:00	5 11:30	2:30
Whole Ship General	5 11:30	5 11:50	0:20
Whole Ship Messing (Eating)	5 11:50	5 12:00	0:10
Maintenance—PM	5 12:00	5 14:00	2:00
Maintenance—CM	5 14:00	5 15:00	1:00
Whole Ship Reporting	5 15:00	5 17:45	2:45
Whole Ship Messing (Eating)	5 17:45	5 17:55	0:10
Whole Ship Reporting	5 17:55	5 19:40	1:45
Unspecified Departmental Work	5 19:40	5 21:50	2:10
Hygiene	5 21:50	5 22:00	0:10
Sleep	5 22:00	6 03:16	5:16
Hygiene	6 03:16	6 03:30	0:14
Unspecified Departmental Work	6 03:30	6 03:45	0:15
Watchkeeping	6 03:45	6 08:00	4:15
Whole Ship Messing (Eating)	6 08:00	6 08:15	0:15
Unspecified Departmental Work	6 08:15	6 09:00	0:45
Maintenance—PM	6 09:00	6 11:30	2:30
Whole Ship Messing (Eating)	6 11:30	6 12:00	0:30
Training—Collective	6 12:00	6 12:30	0:30
Whole Ship General	6 12:30	6 15:00	2:30
Maintenance—PM	6 15:00	6 16:30	1:30
Maintenance—CM	6 16:30	6 17:30	1:00
Whole Ship Messing (Eating)	6 17:30	6 18:15	0:45
Maintenance—CM	6 18:15	6 19:45	1:30
Unspecified Departmental Work	6 19:45	6 22:45	3:00
Hygiene	6 22:45	6 22:58	0:13
Sleep	6 22:58	7 00:00	1:02
Maintenance—General	7 00:00	7 03:45	3:45
Watchkeeping	7 03:45	7 08:00	4:15
Whole Ship Messing (Eating)	7 08:00	7 08:10	0:10
Unspecified Departmental Work	7 08:10	7 09:00	0:50
Maintenance—PM	7 09:00	7 10:30	1:30
Training—Collective	7 10:30	7 11:30	1:00
Whole Ship Reporting	7 11:30	7 11:40	0:10
Whole Ship Messing (Eating)	7 11:40	7 12:00	0:20
Maintenance—PM	7 12:00	7 13:30	1:30
Whole Ship Reporting	7 13:30	7 14:15	0:45
Training—Collective	7 14:15	7 15:15	1:00
Maintenance—PM	7 15:15	7 16:45	1:30
Maintenance—CM	7 16:45	7 17:45	1:00
Whole Ship Messing (Eating)	7 17:45	7 18:15	0:30
Whole Ship Reporting	7 18:15	7 19:45	1:30
Unspecified Departmental Work	7 19:45	7 22:45	3:00
Hygiene	7 22:45	7 22:55	0:10
Sleep	7 22:55	8 00:00	1:05

L. PERSON ID: 18**RANK: CPO****SUB-DEPARTMENT: ME**

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	6:15	6:15
Hygiene	6:15	6:45	0:30
Whole Ship Messing (Eating)	6:45	7:15	0:30
Morning Muster	7:15	7:30	0:15
Maintenance—CM	7:30	10:00	2:30
Whole Ship Messing (Eating)	10:00	10:30	0:30
Training—Collective	10:30	11:45	1:15
Whole Ship Messing (Eating)	11:45	12:30	0:45
Unspecified Departmental Work	12:30	13:00	0:30
Whole Ship General	13:00	13:30	0:30
Training—Collective	13:30	14:15	0:45
Whole Ship Reporting	14:15	15:55	1:40
Maintenance—CM	15:55	17:25	1:30
Hygiene	17:25	17:30	0:05
Whole Ship Messing (Eating)	17:30	18:15	0:45
Personal Time (including PT)	18:15	18:30	0:15
Unspecified Departmental Work	18:30	21:00	2:30
Firefighting and Damage Control Exercise	21:00	21:30	0:30
Hygiene	21:30	22:01	0:31
Sleep	22:01	22:54	0:53
Maintenance—CM	22:54	1 01:24	2:30
Sleep	1 01:24	1 06:15	4:51
Hygiene	1 06:15	1 06:30	0:15
Whole Ship Messing (Eating)	1 06:30	1 07:15	0:45
Morning Muster	1 07:15	1 07:30	0:15
Maintenance—CM	1 07:30	1 10:00	2:30
Training—Collective	1 10:00	1 11:45	1:45
Whole Ship Messing (Eating)	1 11:45	1 12:45	1:00
Unspecified Departmental Work	1 12:45	1 13:30	0:45
Training—Collective	1 13:30	1 14:45	1:15
Unspecified Departmental Work	1 14:45	1 16:00	1:15
Whole Ship Reporting	1 16:00	1 17:30	1:30
Whole Ship Messing (Eating)	1 17:30	1 18:15	0:45
Whole Ship Reporting	1 18:15	1 18:30	0:15
Unspecified Departmental Work	1 18:30	1 19:30	1:00
Whole Ship Reporting	1 19:30	1 19:45	0:15
Personal Time (including PT)	1 19:45	1 21:30	1:45
Hygiene	1 21:30	1 22:19	0:49
Sleep	1 22:19	2 05:48	7:29
Hygiene	2 05:48	2 06:03	0:15
Unspecified Departmental Work	2 06:03	2 06:45	0:42
Whole Ship Messing (Eating)	2 06:45	2 07:15	0:30
Morning Muster	2 07:15	2 07:30	0:15

Maintenance—CM	2 07:30	2 10:30	3:00
Training—Collective	2 10:30	2 11:45	1:15
Whole Ship Messing (Eating)	2 11:45	2 12:45	1:00
Unspecified Departmental Work	2 12:45	2 13:30	0:45
Training—Collective	2 13:30	2 15:15	1:45
Unspecified Departmental Work	2 15:15	2 16:15	1:00
Maintenance—CM	2 16:15	2 16:45	0:30
Personal Time (including PT)	2 16:45	2 17:15	0:30
Whole Ship Messing (Eating)	2 17:15	2 18:15	1:00
Maintenance—CM	2 18:15	2 19:45	1:30
Unspecified Departmental Work	2 19:45	2 22:15	2:30
Personal Time (including PT)	2 22:15	2 23:41	1:26
Hygiene	2 23:41	2 23:56	0:15
Sleep	2 23:56	3 06:21	6:25
Hygiene	3 06:21	3 06:36	0:15
Unspecified Departmental Work	3 06:36	3 06:45	0:09
Whole Ship Messing (Eating)	3 06:45	3 07:15	0:30
Morning Muster	3 07:15	3 07:30	0:15
Maintenance—CM	3 07:30	3 10:30	3:00
Training—Collective	3 10:30	3 11:45	1:15
Whole Ship Messing (Eating)	3 11:45	3 13:00	1:15
Unspecified Departmental Work	3 13:00	3 13:30	0:30
Maintenance—CM	3 13:30	3 15:15	1:45
Unspecified Departmental Work	3 15:15	3 16:00	0:45
Maintenance—CM	3 16:00	3 16:45	0:45
Whole Ship Reporting	3 16:45	3 17:30	0:45
Whole Ship Messing (Eating)	3 17:30	3 18:15	0:45
Maintenance—CM	3 18:15	3 19:15	1:00
Unspecified Departmental Work	3 19:15	3 19:47	0:32
Whole Ship Reporting	3 19:47	3 21:47	2:00
Personal Time (including PT)	3 21:47	3 22:15	0:28
Hygiene	3 22:15	3 22:30	0:15
Sleep	3 22:30	4 05:19	6:49
Hygiene	4 05:19	4 05:34	0:15
Unspecified Departmental Work	4 05:34	4 06:45	1:11
Whole Ship Messing (Eating)	4 06:45	4 07:15	0:30
Morning Muster	4 07:15	4 07:30	0:15
Maintenance—CM	4 07:30	4 10:30	3:00
Training—Collective	4 10:30	4 11:45	1:15
Whole Ship Messing (Eating)	4 11:45	4 13:00	1:15
Unspecified Departmental Work	4 13:00	4 16:45	3:45
Personal Time (including PT)	4 16:45	4 17:30	0:45
Whole Ship Messing (Eating)	4 17:30	4 18:45	1:15
Unspecified Departmental Work	4 18:45	4 22:19	3:34
Personal Time (including PT)	4 22:19	4 23:00	0:41

Hygiene	4 23:00	4 23:15	0:15
Sleep	4 23:15	5 06:11	6:56
Hygiene	5 06:11	5 06:26	0:15
Unspecified Departmental Work	5 06:26	5 06:45	0:19
Whole Ship Messing (Eating)	5 06:45	5 07:15	0:30
Morning Muster	5 07:15	5 07:30	0:15
Whole Ship Reporting	5 07:30	5 10:30	3:00
Training—Collective	5 10:30	5 11:45	1:15
Whole Ship Messing (Eating)	5 11:45	5 12:30	0:45
Unspecified Departmental Work	5 12:30	5 16:00	3:30
Whole Ship Reporting	5 16:00	5 17:00	1:00
Unspecified Departmental Work	5 17:00	5 17:30	0:30
Whole Ship Messing (Eating)	5 17:30	5 18:45	1:15
Unspecified Departmental Work	5 18:45	5 21:15	2:30
Sleep	5 21:15	6 06:34	9:19
Hygiene	6 06:34	6 06:49	0:15
Whole Ship Messing (Eating)	6 06:49	6 07:15	0:26
Morning Muster	6 07:15	6 07:30	0:15
Maintenance—CM	6 07:30	6 10:30	3:00
Training—Collective	6 10:30	6 11:45	1:15
Whole Ship Messing (Eating)	6 11:45	6 12:30	0:45
Whole Ship General	6 12:30	6 15:00	2:30
Maintenance—CM	6 15:00	6 17:00	2:00
Unspecified Departmental Work	6 17:00	6 17:30	0:30
Whole Ship Messing (Eating)	6 17:30	6 18:45	1:15
Unspecified Departmental Work	6 18:45	6 23:15	4:30
Personal Time (including PT)	6 23:15	6 23:59	0:44
Hygiene	6 23:59	7 00:14	0:15
Sleep	7 00:14	7 05:56	5:42
Hygiene	7 05:56	7 06:11	0:15
Unspecified Departmental Work	7 06:11	7 07:00	0:49
Whole Ship Messing (Eating)	7 07:00	7 07:15	0:15
Morning Muster	7 07:15	7 07:30	0:15
Whole Ship Reporting	7 07:30	7 10:30	3:00
Training—Collective	7 10:30	7 11:45	1:15
Whole Ship Messing (Eating)	7 11:45	7 12:15	0:30
Maintenance—CM	7 12:15	7 14:15	2:00
Training—Collective	7 14:15	7 15:15	1:00
Unspecified Departmental Work	7 15:15	7 17:30	2:15
Whole Ship Messing (Eating)	7 17:30	7 18:15	0:45
Unspecified Departmental Work	7 18:15	7 20:17	2:02
Personal Time (including PT)	7 20:17	7 21:52	1:35
Hygiene	7 21:52	7 22:07	0:15
Sleep	7 22:07	8 00:00	1:53

M. PERSON ID: 184**RANK: LEUT SUB-DEPARTMENT: ME**

Activity	Start Time	End Time	Total Activity Time
Sleep	0:00	4:30	4:30
Hygiene	4:30	4:45	0:15
Personal Time (including PT)	4:45	7:00	2:15
Whole Ship Messing (Eating)	7:00	7:15	0:15
Morning Muster	7:15	7:35	0:20
Whole Ship Reporting	7:35	10:05	2:30
Whole Ship Messing (Eating)	10:05	10:15	0:10
Training—Collective	10:15	11:45	1:30
Whole Ship Messing (Eating)	11:45	12:30	0:45
Whole Ship Reporting	12:30	13:00	0:30
Whole Ship General	13:00	13:30	0:30
Whole Ship Reporting	13:30	16:00	2:30
Unspecified Departmental Work	16:00	17:00	1:00
Hygiene	17:00	17:30	0:30
Whole Ship Messing (Eating)	17:30	18:20	0:50
Whole Ship Reporting	18:20	18:30	0:10
Personal Time (including PT)	18:30	21:00	2:30
Firefighting and Damage Control Exercise	21:00	21:30	0:30
Hygiene	21:30	21:58	0:28
Sleep	21:58	1 04:57	6:59
Hygiene	1 04:57	1 05:12	0:15
Personal Time (including PT)	1 05:12	1 06:30	1:18
Whole Ship Messing (Eating)	1 06:30	1 07:15	0:45
Morning Muster	1 07:15	1 07:35	0:20
Whole Ship Reporting	1 07:35	1 10:00	2:25
Whole Ship Messing (Eating)	1 10:00	1 10:15	0:15
Training—Collective	1 10:15	1 11:45	1:30
Whole Ship Messing (Eating)	1 11:45	1 12:30	0:45
Whole Ship Reporting	1 12:30	1 13:00	0:30
Whole Ship General	1 13:00	1 13:30	0:30
Training—Collective	1 13:30	1 15:00	1:30
Whole Ship Reporting	1 15:00	1 17:30	2:30
Whole Ship Messing (Eating)	1 17:30	1 18:30	1:00
Whole Ship Reporting	1 18:30	1 19:05	0:35
Unspecified Departmental Work	1 19:05	1 20:05	1:00
Personal Time (including PT)	1 20:05	1 20:38	0:33
Hygiene	1 20:38	1 20:53	0:15
Sleep	1 20:53	2 03:07	6:14
Hygiene	2 03:07	2 03:22	0:15
Personal Time (including PT)	2 03:22	2 06:30	3:08
Whole Ship Messing (Eating)	2 06:30	2 07:00	0:30
Unspecified Departmental Work	2 07:00	2 07:15	0:15
Morning Muster	2 07:15	2 07:35	0:20

Whole Ship Reporting	2 07:35	2 10:00	2:25
Whole Ship Messing (Eating)	2 10:00	2 10:15	0:15
Training—Collective	2 10:15	2 11:45	1:30
Whole Ship Messing (Eating)	2 11:45	2 12:30	0:45
Unspecified Departmental Work	2 12:30	2 13:30	1:00
Training—Collective	2 13:30	2 15:00	1:30
Whole Ship Reporting	2 15:00	2 17:00	2:00
Unspecified Departmental Work	2 17:00	2 17:30	0:30
Whole Ship Messing (Eating)	2 17:30	2 18:30	1:00
Whole Ship Reporting	2 18:30	2 19:05	0:35
Unspecified Departmental Work	2 19:05	2 20:20	1:15
Personal Time (including PT)	2 20:20	2 21:29	1:09
Hygiene	2 21:29	2 21:44	0:15
Sleep	2 21:44	3 04:35	6:51
Hygiene	3 04:35	3 04:50	0:15
Personal Time (including PT)	3 04:50	3 06:30	1:40
Whole Ship Messing (Eating)	3 06:30	3 07:15	0:45
Morning Muster	3 07:15	3 07:35	0:20
Whole Ship Reporting	3 07:35	3 10:00	2:25
Whole Ship Messing (Eating)	3 10:00	3 10:15	0:15
Training—Collective	3 10:15	3 11:15	1:00
Whole Ship Reporting	3 11:15	3 11:30	0:15
Whole Ship Messing (Eating)	3 11:30	3 12:30	1:00
Whole Ship Reporting	3 12:30	3 13:30	1:00
Training—Collective	3 13:30	3 15:00	1:30
Whole Ship Reporting	3 15:00	3 17:30	2:30
Whole Ship Messing (Eating)	3 17:30	3 18:30	1:00
Whole Ship Reporting	3 18:30	3 20:20	1:50
Unspecified Departmental Work	3 20:20	3 21:20	1:00
Personal Time (including PT)	3 21:20	3 21:43	0:23
Hygiene	3 21:43	3 21:58	0:15
Sleep	3 21:58	4 04:35	6:37
Hygiene	4 04:35	4 04:50	0:15
Unspecified Departmental Work	4 04:50	4 05:30	0:40
Personal Time (including PT)	4 05:30	4 06:30	1:00
Whole Ship Messing (Eating)	4 06:30	4 07:15	0:45
Morning Muster	4 07:15	4 07:35	0:20
Unspecified Departmental Work	4 07:35	4 10:00	2:25
Whole Ship Messing (Eating)	4 10:00	4 10:15	0:15
Training—Collective	4 10:15	4 11:15	1:00
Unspecified Departmental Work	4 11:15	4 11:30	0:15
Whole Ship Messing (Eating)	4 11:30	4 12:30	1:00
Unspecified Departmental Work	4 12:30	4 13:30	1:00
Training—Collective	4 13:30	4 15:00	1:30
Unspecified Departmental Work	4 15:00	4 17:30	2:30

Whole Ship Messing (Eating)	4 17:30	4 18:30	1:00
Unspecified Departmental Work	4 18:30	4 21:10	2:40
Hygiene	4 21:10	4 21:25	0:15
Sleep	4 21:25	5 04:17	6:52
Hygiene	5 04:17	5 04:32	0:15
Personal Time (including PT)	5 04:32	5 06:45	2:13
Whole Ship Messing (Eating)	5 06:45	5 07:15	0:30
Morning Muster	5 07:15	5 07:30	0:15
Whole Ship Reporting	5 07:30	5 09:30	2:00
Training—Collective	5 09:30	5 11:30	2:00
Whole Ship Messing (Eating)	5 11:30	5 12:00	0:30
Whole Ship Reporting	5 12:00	5 14:00	2:00
Whole Ship General	5 14:00	5 14:30	0:30
Unspecified Departmental Work	5 14:30	5 17:30	3:00
Whole Ship Messing (Eating)	5 17:30	5 18:00	0:30
Unspecified Departmental Work	5 18:00	5 20:30	2:30
Personal Time (including PT)	5 20:30	5 21:49	1:19
Hygiene	5 21:49	5 22:04	0:15
Sleep	5 22:04	6 04:42	6:38
Hygiene	6 04:42	6 04:57	0:15
Personal Time (including PT)	6 04:57	6 06:45	1:48
Whole Ship Messing (Eating)	6 06:45	6 07:15	0:30
Morning Muster	6 07:15	6 07:30	0:15
Whole Ship Reporting	6 07:30	6 10:00	2:30
Whole Ship Messing (Eating)	6 10:00	6 10:15	0:15
Training—Collective	6 10:15	6 11:15	1:00
Whole Ship Messing (Eating)	6 11:15	6 12:00	0:45
Whole Ship Reporting	6 12:00	6 13:30	1:30
Whole Ship General	6 13:30	6 16:00	2:30
Unspecified Departmental Work	6 16:00	6 17:30	1:30
Whole Ship Messing (Eating)	6 17:30	6 18:15	0:45
Unspecified Departmental Work	6 18:15	6 20:15	2:00
Personal Time (including PT)	6 20:15	6 21:08	0:53
Hygiene	6 21:08	6 21:23	0:15
Sleep	6 21:23	7 04:42	7:19
Hygiene	7 04:42	7 04:57	0:15
Personal Time (including PT)	7 04:57	7 06:45	1:48
Whole Ship Messing (Eating)	7 06:45	7 07:15	0:30
Morning Muster	7 07:15	7 07:30	0:15
Whole Ship Reporting	7 07:30	7 10:00	2:30
Whole Ship Messing (Eating)	7 10:00	7 10:15	0:15
Training—Collective	7 10:15	7 11:15	1:00
Whole Ship Messing (Eating)	7 11:15	7 12:00	0:45
Whole Ship Reporting	7 12:00	7 13:30	1:30
Training—Collective	7 13:30	7 14:30	1:00

Unspecified Departmental Work	7 14:30	7 17:30	3:00
Whole Ship Messing (Eating)	7 17:30	7 18:15	0:45
Unspecified Departmental Work	7 18:15	7 20:15	2:00
Personal Time (including PT)	7 20:15	7 23:22	3:07
Hygiene	7 23:22	7 23:37	0:15
Sleep	7 23:37	8 00:00	0:23

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APPENDIX B. SUCCESS AND FAILURE RATES OF UNPLANNED ACTIVITIES

Activity group	Unplanned Activity	N Rows	Activity delayed	Activity not delayed	Neither failed nor successful	Delayed and Failed	Delayed and Successful	Failed but not Delayed	Successful without delays	Successful	% of delayed activities	Tasks failed	Tasks delayed but completed	Tasks completed without delays
Administration	Divisional/Personnel Management General	3357	0	3357	0	0	0	2764	593	593	0.00%	82.34%	0.00%	17.66%
Administration	Divisional/Personnel Management Urgent	2545	0	2545	0	0	0	268	2277	2277	0.00%	10.53%	0.00%	89.47%
Real Event	Engineering Breakdown Real Incident	7420	0	7420	0	0	0	116	7304	7304	0.00%	1.56%	0.00%	98.44%
Exercise	Engineering Casualty Control Drills	4090	3915	175	37	3423	459	0	171	630	95.72%	83.69%	11.22%	4.18%
Exercise	Firefighting and Damage Control Exercise	6933	4013	2920	121	3041	938	0	2833	3771	57.88%	43.86%	13.53%	40.86%
Real Event	Firefighting and Damage Control Major Incident	815	0	815	0	0	0	0	815	815	0.00%	0.00%	0.00%	100.00%
Real Event	Firefighting and Damage Control Minor Incident	3049	0	3049	0	0	0	56	2993	2993	0.00%	1.84%	0.00%	98.16%
Corrective Maintenance	Maintenance - CM ME01	5445	0	5445	0	0	0	3713	1732	1732	0.00%	68.19%	0.00%	31.81%
Corrective Maintenance	Maintenance - CM ME02	5469	0	5469	0	0	0	3503	1966	1966	0.00%	64.05%	0.00%	35.95%
Corrective Maintenance	Maintenance - CM ME03	5437	0	5437	0	0	0	2789	2648	2648	0.00%	51.30%	0.00%	48.70%
Corrective Maintenance	Maintenance - CM ME04	5487	0	5487	0	0	0	3072	2415	2415	0.00%	55.99%	0.00%	44.01%
Real Event	Replenishment at Sea	999	0	999	0	0	0	998	1	1	0.00%	99.90%	0.00%	0.10%
Service diversion	Sick Parade	7992	0	7992	728	0	0	0	7264	7264	0.00%	0.00%	0.00%	90.89%

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