University of South-Eastern Norway

Improvement of onboard crew safety by applying personal tracking and monitoring technologies

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Abstract

This study deals with the improvement of onboard safety through personal tracking and monitoring technologies. It focusses on the relationship between safety, reporting (formal and informal) and monitoring of the crew, and the reasons behind common violation of procedures, and potential technological solution for adding a barrier to potential accidents.

The qualitative strategy was more suitable in this study for an in-depth understanding of procedural violations on chemical tanker vessels and the potential of tracking and monitoring technologies in improvement of safety practices on vessels. A semi-structured interview is applied to cover the topics through different paths, that were associated with the research questions according to the thoughts and opinions of the ratings and marine experts.

This study implies that the chemical tanker vessels are more susceptible to safety violations by individuals onboard a vessel. Moreover, the company experts try to improve the safety management system and organizational safety culture by taking some measures such as scheduled onboard inspections and training. However, human failures still occur by the seafarers. This thesis shows that these human failures mostly fall into the category of the routine and situational type failures. Therefore, routine monitoring, appropriate supervision and positive safety culture are proposed as the solutions to resolve these issues.

Furthermore, the lack of communication between ratings and upper ranks onboard is identified as one of the main contributing factors to the violation of safety by the crew onboard. The tracking and monitoring technologies show promise to solve this problem by continuous monitoring of crew and increasing their awareness.

Keywords: Maritime Safety, Safety Management System, Human Failures, Personal Tracking and Monitoring.

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Lastly and foremost, this thesis is dedicated to my parents for inspiring me to pursue a master's degree and for encouraging me throughout my studies with their endless love throughout my life.

Yusa Utku Genc

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List of Symbols and Abbreviations

A/B – Able Seaman

CDI - Chemical Distribution Institute

EMSA - European Maritime Safety Agency

GEMS - Generic Error Modelling System

GPS - Global Positioning System

HSE - Health and Safety Executive

IMO - International Maritime Organisation

ICS - International Chamber of Shipping

ISM Code - International Safety Management Code

LFI - Learning from Incident

LOS - Line of Sight

RFID - Radio Frequency Identification

SHEQ - Safety, Health, Environment and Quality

SIRE - Ship Inspection Report Programme

SMS - Safety Management Systems

SOLAS - International Convention for the Safety of Life at Sea

STCW - International Convention on Standards of Training, Certificate and Watchkeeping for Seafarers

UK - United Kingdom

UMS - Unmanned Machinery Spaces

UNCLOS - United Nations Convention on the Law of the Sea

UNCTAD - United Nations Conference on Trade and Development

USCG - The United State Coast Guard

UWB - Ultra Wideband

1 Introduction

1.1 Research Background and Motivation

Shipping has a large importance in the world's economy as international shipping transport covers around 80% of global trade all over the world (UNCTAD, 2018). In addition, shipping is an essential component for future sustainable economic growth. Therefore, it is drawing more attention due to economic growth and its role in global trade. On the other hand, there are various types of risks associated with this industry, which may lead to injuries, loss of human life or environmental pollution.

"Shipping is perhaps the most international of all the world's great industries - and one of the most dangerous."(IMO, 2019b)

As it is emphasised by International Maritime Organization (IMO), shipping is a high-risk industry which includes numerous procedures and regulations for the different daily operations onboard a vessel regarding personal safety and protection of the environment. In particular, safety is a major concern in the oil and chemical shipping due to tragic consequences (Sætrevik & Hystad, 2017).

As stated by IMO, it is well accepted in order to improve safety at sea, international regulations for the maritime industry must be carefully implemented (IMO, 2019b). As a result, IMO was formally established in 1948. The first task of IMO is developing the new version of the International Convention for the Safety of Life at Sea (SOLAS).

The most important convention for the maritime industry is SOLAS which regulations had already been in place before IMO was established. The first version was adopted in 1914, and since then, it has been updated over the years (IMO, 2019a). The 1974 convention has been amended and even the 2014 version which is enforced today refers to the 1974 version.

According to Rothblum (2000), the maritime industry has already started to focus on ship design, reliability of the vessel and management systems to increase efficiency and safety over the last 40 years. The technological improvements on the ship systems do not significantly reduce the risk of accidents since they play a small role in the safety equation while the most significant part of the safety equation is the human factor in the maritime industry (Rothblum, 2000). The IMO was more focused on issues such as the construction of vessels and safety equipment onboard instead of the human factor and management systems until International Safety Management Code (ISM) was adopted in 1993 (Batalden & Sydnes, 2014).

ISM code has become mandatory under SOLAS chapter IX “Management for the Safe Operation of Ship”. The code provides a framework for companies to integrate Safety Management Systems (SMS) for reducing probable accidents that are caused by human error (Rodriguez & Hubbard, 1998). The purpose of the code is forcing companies to establish safeguards against all the identified risks and develop, implement and maintain a Safety Management System (SMS) (Oltedal, 2010).

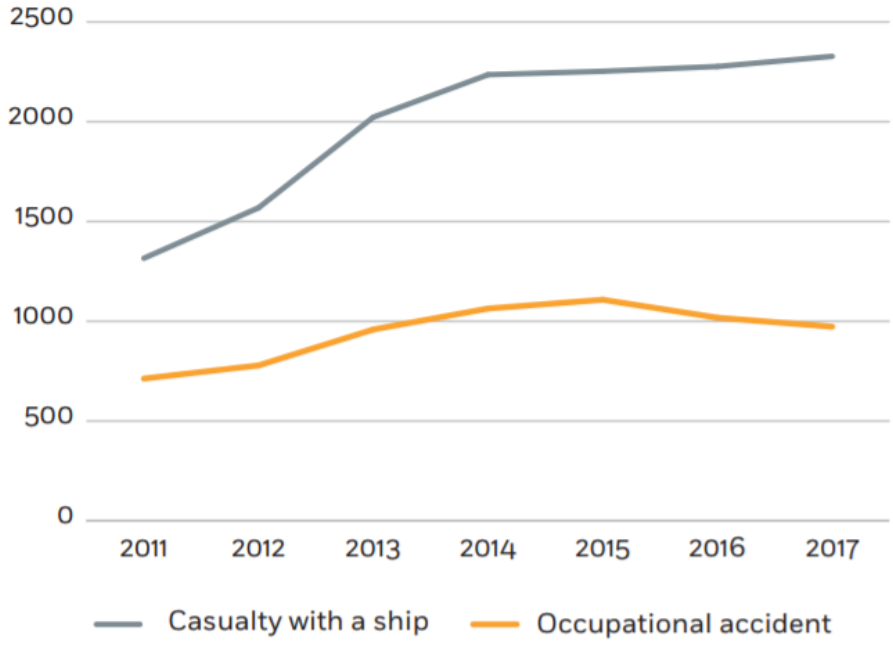

Figure 1 Marine casualties and incidents by type occurred between 2011 and 2017 (EMSA, 2018)

According to statistics reported by the European Maritime Safety Agency (EMSA) (2018), a total of 14002 casualties involving a ship and 6614 occupational accidents were recorded between 2011 and 2017. As can be seen from Figure 1, there is no meaningful reduction trend in the numbers by years, despite all the stricter safety regulations and seafarer training. Accident statistics show that many accidents have occurred due to no compliance with the safety management procedures and it usually results in personal injury and even loss of life. The United State Coast Guard (USCG) report shows that between 75-96% of fatality happened due to human error (Rothblum, 2000).

Therefore, new solutions are needed that would improve safety through the utilisation of existing technologies. The idea in this master thesis is to use the tracking and monitoring technologies that would track and monitor crew movements in order to prevent potential occupational accidents onboard.

The motivation of this study arose from my personal working experience as a safety officer onboard a chemical tanker when a fire explosion occurred. As there were problems identifying the position of several crew members, that past incident increased my interest in technologies for personal tracking and monitoring technology solutions. These systems can assist safety practitioners in improving procedures for tackling emergency as well as procedural violation cases.

1.2 Research Objectives

This research is mainly concerned with the relationship between safety, reporting (formal and informal) and monitoring of the crew. By formal and informal reporting, we mean the communication between the upper-class officers and the ratings. For instance, before commencing specific tasks, it is important that this is reported to the officer in charge or the Master in order to obtain a permit and keep them aware in case of danger. These types of tasks that are considered as high-risk will be listed accordingly in the literature review.

The study applies a qualitative research methodology where semi-structured interviews were conducted to collect data from ratings and marine experts from a shipping company which operates a chemical tanker fleet. The rating means a member of the ship's crew other than the master or an officer (IMO, 2011a) such as; Able Seaman (A/B), oilers, bosun, fitter etc. Marine experts are Safety, Health, Environment and Quality (SHEQ) inspectors and fleet managers.

The overall aim of this master thesis is to investigate the human failures associated with safety violations onboard a vessel and subsequently study the potential of tracking and monitoring technologies in improvement of safety practices on vessels.

In particular, this master thesis addresses these research questions:

- What are the main types of procedural violations made by ratings onboard chemical tankers?
- How can tracking and monitoring technologies contribute to the improvement of onboard personal safety?

1.3 Thesis Structure

This master thesis is organized as follows:

- In chapter 2, the literature review is given with an emphasis on safety, safety culture and safety management, human element, human failures, safety rules and regulations and tracking and monitoring technologies.
- Chapter 3 gives a description of the methodology and approach used in this thesis.
- Chapter 4 presents the findings of this study, which are obtained based on the designing interviews.
- Chapter 5 interprets the results given in the previous chapter and suggest.
- Finally, chapter 6 outlines the conclusions of this study addressing the research questions proposed earlier. Some recommendations for further research are also given.

2 Literature Review

This chapter is divided into five parts. First, the importance of safety and relevant definitions are given. The second part presents the safety culture and safety management. The third part focusses on the human element and human behaviour. The fourth part addresses human failures. The fifth section looks at safety rules and regulations within the maritime industry. Lastly, the tracking and monitoring technologies will be presented.

2.1 Definition of Safety

To define safety is quite difficult since it is a very broad concept and the meaning of it tends to vary widely. According to Kuo's research which was accomplished with 1500 participants from the United Kingdom, Europe, America, Canada and South East Asia, the main context of safety is training, design, culture, attitude, operation, human factors, procedures, communication and regulation (Kuo, 2007).

In different research conducted by the same author, the results show engineers, operators and researchers or academic people have different perspectives for safety meaning. Also, the results show that engineers believe safety is about producing a design to comply with rules and regulations, operators perspective is that safety is following the operational procedures and researchers' is that safety is obtained after a risk analysis has been carried out (Kuo, 2007).

Safety has been defined by Kuo as follows:

"Safety is a human perceived quality that determines to what extent the management, engineering and operation of a system are free of danger to life, property and the environment." (Kuo, 2007)

Hollnagel has given the etymology of safety in his book. According to Hollnagel (2014), the meaning of the word has been changed throughout historical reveals. According to his research, the word safety comes from the old French word *"sauf"* that is from the Latin word *"salvus"* (Hollnagel, 2014). The meaning of *sauf* is "uninjured or unharmed", and the meaning of *salvus* is "uninjured, healthy or safe" (Hollnagel, 2014). As he stated that the meaning of the "safe" has changed throughout history, from the late fourteenth century the meaning was "not being exposed to danger" and first recorded term for safety was "free from risk" in the 1580s (Hollnagel, 2014). More detailed generic definition by Hollnagel as follow:

"Safety is the system property or quality that is necessary and sufficient to ensure that the number of events that could be harmful to workers, the public, or the environment is acceptably low." (Hollnagel, 2014, p. 1)

Another definition given by Kristiansen (2013) for safety, is that safety is the freedom from danger and it is achieved by doing things right the first time and every time.

2.2 Safety Culture and Safety Management

ISM Code states that one of its key objectives is to establish a 'safety culture' in shipping companies, but it does not define the meaning of the term safety culture. However, safety culture is described by International Chamber of Shipping (ICS) as the values and practices shared by management and personnel that should be maximised to ensure the risks are always minimised and reduced (2013).

In other words, the prevention of accident and pollution is always the highest priority with an effective safety culture. The company and its personnel will always automatically consider the impact on the safety of each of their action, rather than only following externally applied safety procedures (ICS, 2013).

Safety management is defined as keeping operations safe through systematic and safety-minded organisation and safeguarding of both human and physical resources (Kuo, 2007). After understanding the human and organisational factor on safety, safety management received attention from industry and international regulatory bodies. That is the reason that human element and safety regulations with regards to safety management are analysed separately for better understanding.

Another conclusion about the relationship between safety culture and safety management is that safety culture is attitudinal besides structural and it relates both to organisations and individuals (Sorensen, 2002).

Safety management seems to be a safety culture, and managing safety is a key aspect of safety culture (Håvold, 2010). Both safety management and safety culture are necessary in order to achieve safe practice onboard vessels. For instance, SMS itself is not enough to achieve safety goals. Without organisational safety culture, SMS will be a paper exercise. Likewise, if there is safety culture but not SMS, then the way that safety is implemented in a complex organisation is at risk of being an inconsistent, inadequate or wrong source (Håvold, 2010).

2.3 Human Element

The human element has a variety of different topics and meaning. The term human element can be used as a synonym to “human factor”, “human error” and “human resource” (Michael L. Barnett). The definition of the human element was applied to shipping in 2003 by IMO’s resolution A.947(23):

“The human element is a complex multi-dimensional issue that affects maritime safety, security and marine environmental protection. It involves the entire spectrum of human activities performed by ships’ crews, shore-based management, regulatory bodies, recognised organisations, shipyards, legislators, and other relevant parties, all of whom need to co-operate to address human element issues effectively (IMO, 2003).”

According to Schager (2008), it is important to understand human ways of functioning for being successful while adopting technologies and allowing it to helps us. Technology is growing exponentially, and human knowledge is increasing dramatically, but on the other hand, our psychological condition, mind function, way of thinking and behaviour has not changed (Schager, 2008).

2.4 Human Failures

Regarding the Health and Safety Executive (HSE) (1999), human error is an action or decision that is devoid of an intended standard or deviating from an accepted standard and causing an undesirable outcome or accident.

Reason (1990) generated a model, the Generic Error Modelling System (GEMS): it differentiates between skill based, rule-based, and knowledge-based errors. The GEMS model is used by HSE (1999) to describe human failure types as it is shown in Figure 2. There are two different types of human failures: violations and errors (HSE, 1999). Errors are action or decision which was not intended, and violation is a deliberate deviation from the procedure (HSE, 1999).

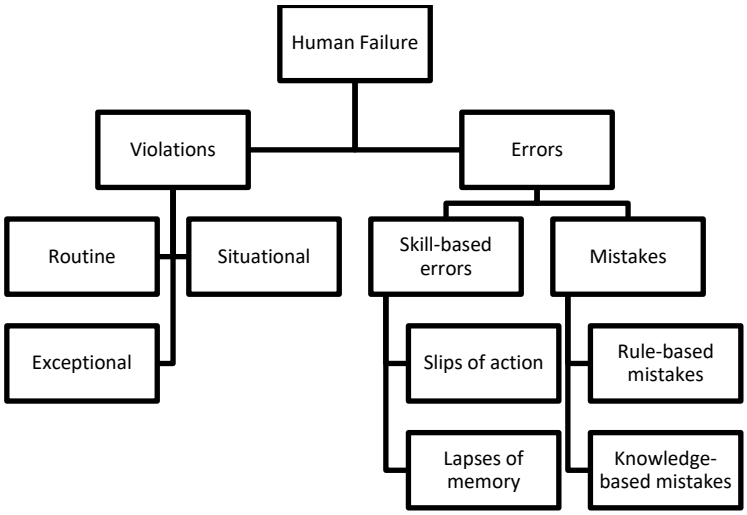

Figure 2 Types of human failures (HSE, 1999, p. 12)

Violations are divided into three categories: routine, situational and exceptional. Routine violations are defined by HSE (1999) as *"breaking the rule or procedure has become a normal way of working within the workgroup"*. Situational violations is defined as breaking the rule due to pressures from the work such as time and workload pressures (HSE, 1999). Exceptional violations happen rarely and only when something has gone wrong (HSE, 1999).

Errors are categorised into two groups: skill-based errors and mistakes. Skill-based errors that are slips and lapses explained by HSE (1999) as *"they occur in very familiar tasks which we can carry out without much need for conscious attention"*. The mistakes occur when people do the wrong thing but believing it to be right.

It is necessary to find a human error, to identify active and latent failures in order to understand accident reasons and how it might be prevented from happening again in the future (Hanzu-Pazara, Barsan, Arsenie, Chiotoroiu, & Raicu, 2008).

The most well-known accident model is the Swiss Cheese Model, also known as the Reason Accident Model. The model describes that there are some layers added to prevent an accident, in an ideal world they are intact but in reality, there are some holes, and it is illustrated like cheese slices. Based on Reason (2000), advanced technology systems provide us with more defensive layers: some are engineered (alarms, physical barriers, automatic shutdowns, etc.), some layers rely on workers, and some of them depend on procedures and administrative controls. The layers function is to prevent a potential accident from local hazards but there are always weaknesses on these layers, and unpredictable events can occur (Reason, 2000).

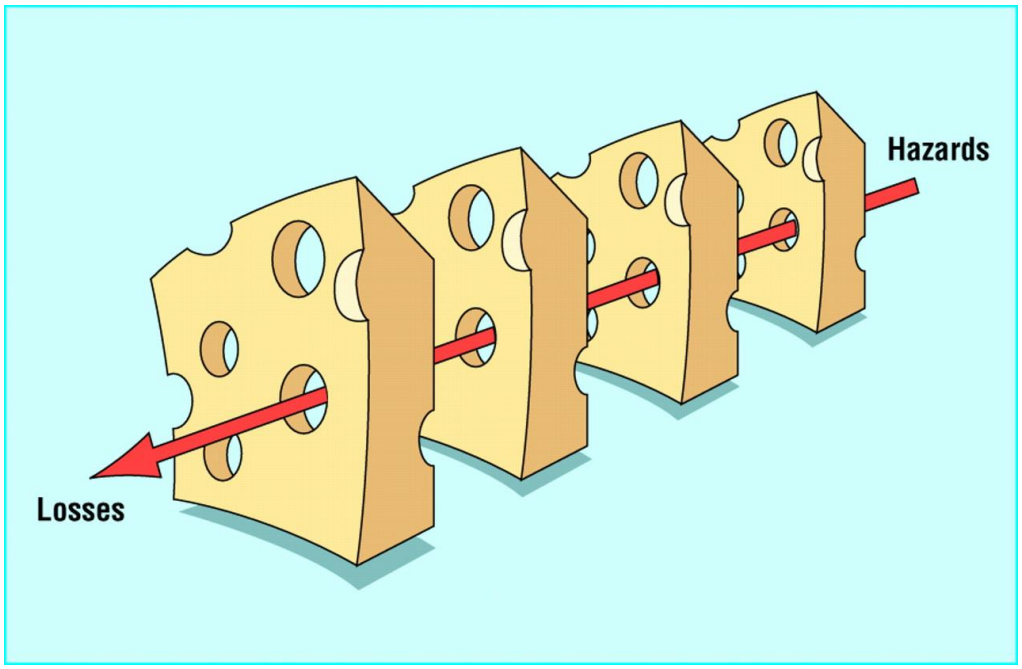

Figure 3 The Swiss cheese model (Reason, 2000)

The holes in the barriers occur due to two reasons: active failures and latent conditions (Reason, 2000). First, the active failures are defined as unsafe acts executed by people, and these acts take various forms as slips, lapses, fumbles, mistakes, and procedural violations (Reason, 2000). Another reason that latent conditions appear is due to the decision makers like designers, builders, procedure writers or senior managers, and all these wrong decisions have the potential to make holes in the system (Reason, 2000).

2.5 Safety Rules and Regulations

With the establishment of the United Nations and the IMO after World War II, international regulations became more comprehensive (Anderson, 2003). For instance, the International Convention for the Safety of Life at Sea (SOLAS) of 1974, the Standards of Training, Certification and Watchkeeping Convention (STCW) 1978, and the United Nations Convention on the Law of the Sea (UNCLOS) of 1982, systemizing the responsibilities of flag states (Batalden & Sydnes, 2014).

International safety regulations started by the establishment of Load Line Regulation in 1934 and it continued with SOLAS. Safety and pollution considerations and regulations were focused on construction and equipment before ISM was established (Anderson, 2003). Changing on international safety perspective addressed the people worked onboard ships and as a response to this, IMO adopted in 1993 a resolution A.741(18) which became mandatory

under SOLAS Chapter IX “Management for the Safe Operation”. In this chapter, it is stated that International Safety Management (ISM) Code which is the International Management Code for the Safe Operation of Ships and Pollution Prevention, is adopted by the IMO as an amendment (IMO, 2009).

The ISM Code aims to provide a framework to companies for establishing their Safety Management Systems (SMS) to minimise the human errors onboard. ISM Code states that the operator companies shall hold Document of Compliance certificate which is issued by Administration or organisation recognised by the Administration (IMO, 2009).

The ISM Code is a small document. The main intention of the Code is to induce the shipping companies to establish their own Safety Management System. The Code doesn’t state in detail how the companies should create their SMS. It states only main principles that must be included in SMS. The idea behind this, SMS should be prepared as an integral part of the management system of a company. In other words, SMS should comply with the ISM Code and also it should be implemented in a way that culture, organisation and decision-making processes of the company would be in harmony (Kristiansen, 2013).

Another Code for improving SMS onboard a vessel is the Code of Safe Working Practices which is intended primarily for seafarers on United Kingdom (UK) registered merchant vessels. It became mandatory to have it onboard UK registered vessels in 1998 (Maritime Coastguard Agency, 2011).

Since one of the objectives of this thesis is determining the works which need to be reported or get a permit before commencing task, it is essential to focus on Chapter 16 – Permit to work system in the Code of Safe Working Practices for Merchant Seaman.

The code states that there are several types of operations onboard a vessel. For example, a routine action which is taken by a crew member can endanger others, and that’s the reason that before specific operations, it is essential to make sure that the series of actions are taken accordingly to the rules and recorded procedures (Maritime Coastguard Agency, 2011). Therefore, the Code suggests a permit to work system with organised and predefined safety procedures.

The following categories are suggested by the Code of Safe Working Practices for Merchant Seaman for a Permit to Work:

- Work in Unmanned Machinery Spaces (UMS)

- Entry into enclosed or confined space
- Machinery or equipment
- Hot Work
- Working aloft/overside
- General electrical
- Electrical high voltage (Maritime Coastguard Agency, 2011)

There are additional permits that are not given by the Code for specific jobs which depend on the type of the vessels and the departments (engine and deck).

According to SMS of a chemical tanker management company, the following works are subject to permit system:

- Hot work
  - Hot work inside a designated space
  - Hot work outside a designated space
- Entry into enclosed spaces
  - Cargo tanks entry
  - Ballast pump room entry
  - Deck trunk entry
  - Bow thruster room entry
  - Nitrogen room entry
- Sea Water systems work Permit
- Cold work permit
- Small craft alongside
- Underwater work permit
- Working on pipelines and pressurised pipes
- Permit to go open deck and unprotected space at heavy weather
- Working aloft and outboard activities

In addition to the permit systems, there are several tasks that have informing procedures. These tasks are necessary to be reported to officers, engineers or masters before taking any action, such as entering unmanned machinery space which is also stated by the Code of Safe Working Practices for Merchant Seaman. Anyone from the crew who enters the machinery space alone or during unmanned operation should report to the deck officer in charge before

entry, at regular intervals while in the space and on leaving the space. Time of entries and leaving are needed to be recorded by a deck officer in the safety management system (Maritime Coastguard Agency, 2011).

Regarding the enclosed spaces, they are defined as space which has some of the characteristics such as; limited openings for entry and exit, inadequate ventilation, is not designed for continuous worker occupancy. Also, IMO mentions that the list of enclosed spaces can differ from ship to ship, and it should be prepared for ship by ship based on the definition of enclosed space (IMO, 2011b).

2.6 Personal Tracking and Monitoring Technologies

In recent years localisation systems for indoor have been improved. Several technologies can be used for tracking and identifying people or objects. These technologies can have a very important component in different industries and scenarios such as asset tracking, health care, location-based network access, manufacturing, government, logistics, security etc. The possibilities of localisation and tracking technologies are many, but the challenge is when these technologies are dealing with the indoor or outdoor environment. For this respect, localisation technologies are classified in the literature as indoor and outdoor localisation systems (Deak, Curran, & Condell, 2012), (Sedlacek, Slanina, & Kovac, 2016).

Indoor localisation systems are classified into two categories - the active and passive tracking systems as shown in Figure 4. Active systems require tracked persons to participate actively, and passive systems use passive localisation (Deak et al., 2012). Actively participating means that the person needs to carry an electronic device to send information to the localisation system for detecting the position of the person. The passive location systems do not require carrying any devices since the system estimating the location based on the measured signal or video process. Since this study aims to understand the potential benefits in enclosed spaces on conventional merchant vessels, so the focus will be in the indoor localisation systems. Also, the GPS (Global Positioning System) is widely used for outdoor positioning, and it cannot estimate locations indoor because this technology needs Line-of-Sight (LoS) to make a connection with the satellite (Deak et al., 2012).

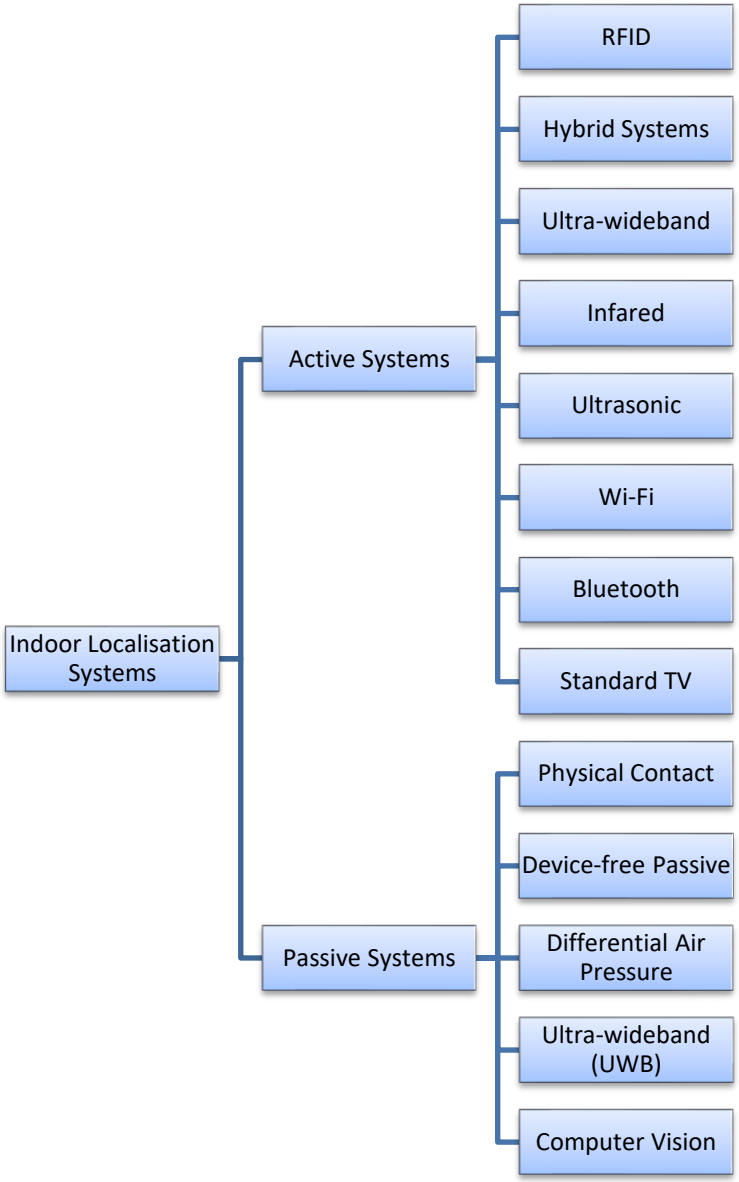

Figure 4 Localisation techniques taxonomy (Deak et al., 2012)

Tracking technologies have already been adopted and continue to adapt in many industries such as construction, health care etc., and it has been identified as one of the ten greatest contributory technologies of the 21st century (Sun, Jiang, & Jiang, 2013). Also, it is used within the maritime industry for logistics solutions, seaports, shipbuilding yards, oil & gas and cruise vessels. On the other hand, there is not any usage for tracking and monitoring crew has been found or taken attention to conventional oil & chemical tanker vessels.

As an example of the usage of this technology within the maritime industry is from the offshore sector. The system has been installed to an offshore platform that is owned and operated by Equinor in the North Sea (Offshore-Technology, 2011). The aim of the system is

to be used as an offshore emergency preparedness system instead of continued personnel surveillance. In case of emergency and mustering, personnel present themselves at the muster station, their unique tag is automatically read and the system identifies the person (Offshore-Technology, 2011). The system counts the number of people who attend muster station and lead them to the right lifeboat (Offshore-Technology, 2011). If the person is at the correct muster point, the device flashes green light and the person can proceed directly onto the lifeboat. On the other hand, if the person is at the wrong muster point, then the device flashes amber light and it notices to the station leader to decide or lead the crew member to correct lifeboat (Offshore-Technology, 2011). It is proven that this system has reduced muster and reconciliation time to under seven minutes, translated to more than 70% time reduction (Offshore-Technology, 2011). A design for offshore rigs from Identec Solutions is as visualised below:

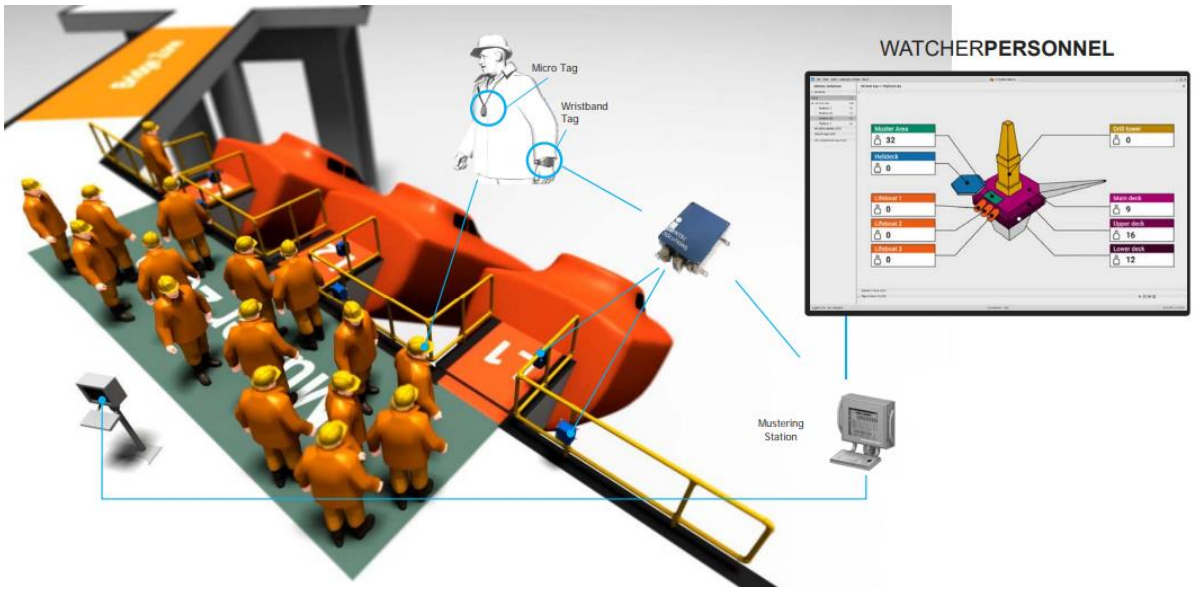

Figure 5 A design for Offshore industry (Identec Solutions, 2017)

There are several discussions about the legal and ethical issues involved when observing someone in a work environment (Yerby, 2013). And the privacy laws are different in states and countries. The best protection from ethical and privacy issues are given by as follow:

- The company must be responsible and reasonable for monitoring
- The company must explain to employers what they monitor and get their consent for monitoring
- There must be a disciplinary plan to punish employees for computer-usage policy violations (Yerby, 2013).

3 Research Methodology

This chapter gives the details of the methodology used in this study to answer research questions. First, the research process, strategy and design are explained. Second, it is explained how the data is collected. Third, it is described how the collected data is analysed. And lastly, the quality of the research is elaborated in terms of validity, reliability and ethical consideration.

3.1 Research Process, Strategy and Design

3.1.1 Research Process

Before going on the details of research methodology and techniques, it is functional to give a brief overview of the research process. The research process includes a series of steps needed to conduct research effectively (Kothari, 2004).

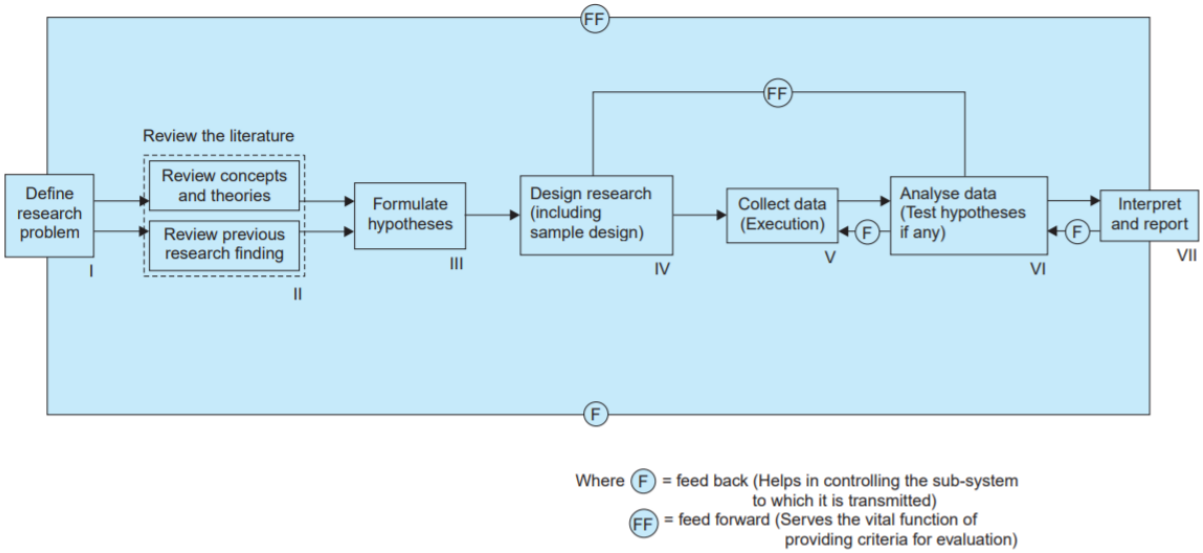

Figure 6 Research process in the flow chart (Kothari, 2004, p. 11)

The chart shown in Figure 6 illustrates a research process as shown through I to VII according to Kothari (2004), and this process is followed in this master thesis.

3.1.2 Research Strategy

According to Denscombe (2010), a strategy is a plan that is designed to achieve a specific target. There are two research strategies, quantitative and qualitative, which have different data collecting and analysing methods (Bryman, 2012). Therefore, it is essential to define whether the research is qualitative or quantitative.

Qualitative research strategy focuses on obtaining rich, high-quality data, examining the sample with deep understanding, and to ease a more comprehensive understanding of complex issues (Denscombe, 2010). The qualitative strategy defined by Kothari as follows:

"Qualitative approach to research is concerned with subjective assessment of attitudes, opinions and behaviour." (Kothari, 2004, p. 5)

Quantitative research strategy focusses on collecting large quantitative data as stated by Bryman (2012) that is a deductive approach to make the relationship between theory and research, and it is testing of theories.

As it is stated before, this study aims to propose suitable solutions that would contribute to the improvement of safety practices on vessels, also understanding of the relationship between safety, reporting (formal and informal) and monitoring of the crew. The qualitative strategy was more suitable in this study for the best understanding of this relationship and to propose solutions according to the thoughts and opinions of the ratings and marine experts.

3.1.3 Research Design

According to Bryman (2012), research design differs between five main types: experimental design, cross-sectional or survey design, longitudinal design, case study design and comparative design.

The case study design has been chosen for this study. With the case study, the case is an object of interest, and the researcher's goal is to deliver an in-depth explanation of the case (Bryman & Bell, 2011). Case study design can be employed both in qualitative and quantitative research strategies and can also be associated both with theory generation and theory testing (Bryman & Bell, 2011).

The intensive study by the qualitative method is taken for a case. A chemical tanker ship management company is chosen for the case study because the safety is a major concern in the oil and chemical tankers due to tragic consequences (Sætrevik & Hystad, 2017), and high risks for an occupational accident. Also, it has a large number of procedures compared to other major types of vessels. Therefore, a chemical tanker organisation was chosen as a case study.

The chosen company is a chemical tanker management company that provides technical and operational tanker management services for the transport of chemical and petroleum products. The management office of the organisation is in Turkey. The company operates 22

modern chemical tankers ranging from 4,000 to 20,000 DWT and belongs to 8 different owners. It employs about 50 office workers and 750 seafarers. Managed vessels transport about 7.5 million tons of oil and chemical cargoes yearly. The fleet is traded mostly in the spot market globally.

The fleet under their management has a good safety and environmental reputation, and the company holds ISM, ISO 9001, 14001 and 18001 certifications. The Port State Control (PSC) detention rate of the company has been compared with the Paris MoU database, and it was considerably lower than the industry-wide average (Paris MoU, 2019).

3.2 Data Collection

Once the research design has been chosen, it is necessary to decide how the data will be collected. According to Yin (2011), the data can be collected from four field-based methods: interviewing, observing, collecting and examining (materials) and feeling in qualitative research. In this thesis, the semi-structured interview method is used for collecting data from the case company.

3.2.1 Qualitative Semi-Structured Interviews

The semi-structured interview covers a subject that the interviewer has a list of questions that are in an interview guide. However, the interviewer has some flexibility to ask some further questions (Bryman, 2012) to cover the topics through different paths, that were associated with the research questions.

The semi-structured interviews are conducted face-to-face at the company office that is located in Istanbul, Turkey. Interviews are divided into two categories after discussed with supervisors. Those categories are divided based upon participants' roles in the company. The first interview category consists of ratings (able seaman, bosun, oiler, fitter etc.) on board. The second interview category consists of marine experts and managers within the company. Semi-structured interviews are planned to use for both interview categories. After the decision of categorising them in the early stage of the thesis work, the author arranged meetings at the company office in Istanbul to discuss with human resource manager and general manager of the company about the possibility of the interviews within the company. After obtaining permission from the managers to do interviews, interview guides for both groups are prepared. Both interview guides are given in Appendixes 1 and 2.

The first interview category that is planned to deal with ratings (engine and deck) who will embark or have already disembarked. The interview with ratings aims to indicate the interrelated patterns of their perceptions of and attitudes towards the SMS and their thoughts about personal tracking and monitoring technology' usage onboard vessels.

The purpose of the second interview category that with the marine experts is to give a more thorough understanding of the overall situation, underlying processes, their experiences with the SMS and their thoughts about tracking technologies as safety practice onboard.

It has been given attention during interviews that finding a private and silent place, maintaining eye contact with the participants and active listening (Bryman, 2012) to make participants feel comfortable and safe. During interviews, interviewees got help to clarify unclear questions from me. Also, detailed information about the subject was given.

Interviews with marine experts and managers are recorded by voice recording application on the phone for transcription. On the other hand, for interviews with ratings, voice recording method has not been used. It has discussed with supervisors that it is better not to record them because of trust between interviewer and interviewees since the subject is sensitive. They might not feel comfortable while answering the questions about their safety perspectives or behaviours on board. Their interviews have been written by hand by authors during interviews.

3.2.2 Sampling Strategy and Participants Overview

There are several sampling techniques for research. Two main types of sampling are probability and non-probability sampling techniques, and they have further subcategories in the table below:

Table 1 Types of Sampling Methods

Probability Sampling	**Non-probability Sampling**
Simple Random Sampling	Purposive Sampling
Stratified Random Sampling	Convenience Sampling
Systematic Sampling	Snow-ball Sampling
Cluster Sampling	Quota Sampling
Multi-stage Sampling	-

Note: Adapted from Studyandexam (2018).

One of the main types of sampling that is non-probability sampling is used for both interview groups. The sub-category of the non-probability sampling method is convenience sampling used for the first group that includes ratings. They have been chosen by the author while waiting in the human resource office in Istanbul. For group 2 that consists of marine experts, the purposive technique is used. It has been decided after discussions with supervisors. The participants for group 2 are chosen from the safety department of the company which includes marine, technical superintendents and SHEQ managers.

The number of the participants are decided seven people per each group but some of the experts were out of the office, and there wasn't enough rating participant available at the office. In total five people (marine experts and managers) from office personnel were interviewed, with each interview on average lasting for half an hour. Also, 5 Ratings who were going to embark and have already disembarked have attended an interview at the company, and each interview took about half an hour. All interviews are carried out individually with participants face to face at the management office in Istanbul.

The chosen company didn't have multicultural workforces: all the employees (shore and offshore) were Turkish. Most of the interviews are preferred to be in the Turkish language by participants. It has been accepted for a deep understanding of participants and collecting the right answers.

Table 2 Overview of the rating (Group 1) participants

Seafarer Participants	**Age**	**Rank**	**Years at sea**	**Years on chemical tankers**
A	58	A/B	25	20
B	39	Fitter	17	14
C	28	A/B	7	2
D	38	Bosun	20	15
E	30	A/B	7	6

Table 3 Overview of the Marine Expert (Group 2) participants

Marine Experts	Age	Job Title	Years at the maritime industry	Years at sea	Years onboard chemical tankers
F	39	SHEQ Superintendent	25	11	10
G	36	SHEQ Superintendent	15	10	10
H	40	Technical Superintendent	18	7	6
I	39	SHEQ Manager	17	7	7
J	43	Fleet Manager	19	7	7

3.3 Data Analysis

Analysing the qualitative data collected from interviews or participant observation is not direct as with quantitative data analysis because qualitative data includes unstructured textual material that is not straightforward to analyse (Bryman, 2012). The main difficulties with qualitative research are those which generate large data from interview transcriptions, notes, or documents (Bryman, 2012). Miles (1979) describes qualitative data as an 'attractive nuisance' because the data is rich and attractive but on the other hand, it is difficult to find analytic paths to that richness.

During the data collection process, analysis began early to help focus the data collection and assist with improving the interview guide (Charmaz, 2014). Voice records from marine expert interviews are transcribed manually to word documents. Handwritten documents from ratings' interviews are transferred to word documents. Most of the interviews are done in Turkish. After transcribing them, they are translated into English by me.

The data analysis is based on the grounded theory approach. The first and most important task was becoming thoroughly familiar with the data which means reading and re-reading the transcripts then cross-reference the material with field notes that are taken for better understanding of the data in context and further inspections (Denscombe, 2010). After a deep understanding of the data in context, codes are labelled to the raw data. The next task was grouping and classifying the carious component under the key headings (Denscombe, 2010).

After, with another lengthy review of the organised data, regrouped again into categories for reducing the numbers. At the end of all this process, they stepped in the 'data analysis spiral' which means each task is revised in more than one case by developing and refining codes, categories and concepts (Denscombe, 2010). The grounded theory approach and its steps are given with Figure 7.

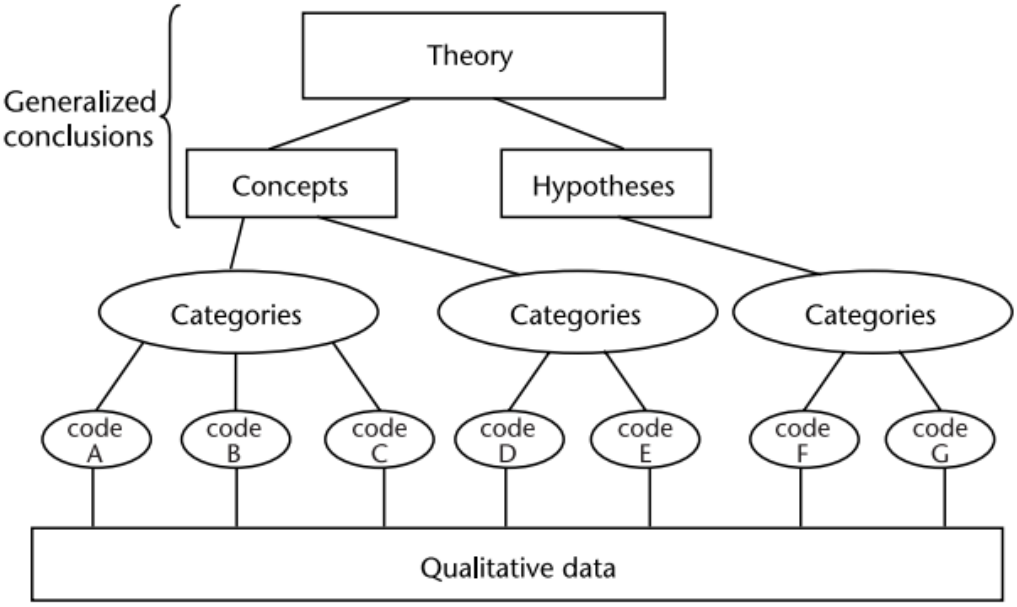

Figure 7 The grounded theory approach (Denscombe, 2010, p. 286)

3.4 Research Quality

3.4.1 Reliability and Validity

Reliability and validity are vital elements in creating and evaluating the quality of quantitative research. However, there have been a various discussion about the relevance of qualitative research by qualitative researchers (Bryman & Bell, 2011). Patton (2002) also states that reliability and validity are two factors that qualitative researchers should consider while designing a study, analysing results and evaluating the quality of the research.

According to Denscombe (2010), a good level of reliability means that the research generates the same data anytime on each occasion that it is used. There are two types of reliability those of external and internal (Bryman & Bell, 2011). External reliability defines the degree to which research can be replicated (Bryman & Bell, 2011). However, it is difficult to meet in qualitative research since, *"to 'freeze' a social setting and the circumstances of an initial study to make it replicable in the sense in which the terms is usually employed"* (Bryman & Bell, 2011, p. 395). It is possible to replicate this study and get the same results if the same

questions and time are given to the same social setting. Internal reliability is explained as *"whether or not, when there is more than one observer, members of the research team agree about what they see and hear"* by Bryman and Bell (2011, p. 395). The interview guides are designed with my supervisors to ensure collecting rich data from participants. Participants gave similar answers to interview questions and the same patterns were noted within two groups. It makes the data reliable and consistent. On the other hand, there was not availability for another researcher for the analysis of the collected data.

Validity is divided into internal and external. External validity with another name generalizability is defined by Bryman and Bell (2011) that generalizability of the findings across social settings. It is also argued by LeCompte and Goetz that external validity is difficult for qualitative researches due to the frequently used research design - case study and the limited size of samples (Bryman & Bell, 2011). The majority of qualitative researchers agreed that issue and needs of a different approach for using in qualitative research (Denscombe, 2010). It has been pointed out by researchers that research based on small numbers of participants and qualitative data needs an alternative way to test generalizability (Denscombe, 2010). This alternative way was called by Lincoln and Guba (1985) as 'transferability'. Transferability provides others with a research database for making judgements about the possible transferability of findings to other contexts (Bryman & Bell, 2011). The findings of this study are transferable. Even though the findings might not represent the general, it gives some perspectives from both rating and marine expert sides about safety. Particularly, the developed concept in the present study could be useful in further investigations.

Internal validity is described by Bryman and Bell (2011, p. 395) as *"whether or not there is a good match between researchers' observations and the theoretical ideas they developed"*. It is a strength for qualitative research if the correct data is used to answer research questions (Bryman & Bell, 2011). The interview guides were prepared based on related literature reviews to ensure the internal validity of the study.

3.4.2 Ethical Consideration

The ethical aspects of the study were taken into consideration at all research process stages. Norwegian Data Protection (NSD) regulations have been considered before interviews. Notification test has been carried out on NSD's web site (www.nsd.no), and it results as "subject to notification" category. The direct information about participants such as name, personal identification number, or other unique personal identifiers is not asked to participants. On the

other hand, the study was a single case study, and indirect information is planned to be collected from participants such as background information, age, the title of their jobs etc. For this respect, the author has applied to NSD with the reference code 117907 for processing to begin the interviews. The notification form can be seen in Appendix 3. The form is used for NSD application and interviews. Interview guides are prepared carefully to keep anonymity. Also, in this study participant are anonymised to protect the participants.

Before starting interviews, information letter has been given to the participants and received their consent for an interview. All the data collected from both groups have been stored and encrypted on a personal computer. As declared to the NSD and permission from them, all the data will be processing general categories of personal data until 13.06.2019. On the deadline of the NSD permission, all the data will be deleted from the personal computer.

Also, other ethical and legal considerations are considered during the study such as copyright, honesty in the translation of the interviews.

4 Findings

In this chapter, the findings of the study and in-depth analysis will be presented. They are categorised and organised according to the literature reviews, interview guides and participants' answers. Since there are two different interview guides and participant categories, this chapter is divided into two main parts. They are findings from ratings' interviews and marine experts' interviews. Some of the codes are found common within two participant categories but analysed differently. In the discussion part, both findings from the participant groups will be discussed together.

4.1 Findings from Ratings' Interviews

Five main themes are created based on findings and literature reviews. The themes and related findings from ratings' interviews are illustrated as below table:

Table 4 Summary of the ratings' findings

Themes	Main findings
Dangerous working places and sources of hazards	Nature of the offshore job.
	Characteristics of the cargoes.
	Phycology of the seafarers while being offshore causes lack of attention on safety and tasks.
Onboard communication	Lack of communication between ratings and officers.
	Sometimes the bosun is unaware of his staff.
	The hierarchy of maritime culture leads to a lack of communication.
	Escaping from work without informing.
Human Failures	Underestimating the potential risks.
	Saving time and effort.
	Work and time pressure.
Perspectives for Tracking and Monitoring Technologies	Good as a safety practice.
	Gaining time in case of the emergency.
	May make feel seafarers uncomfortable due to being monitored by leaders.
The entry of enclosed spaces	Underestimating some of the enclosed spaces' hazards.
	Entries some of the enclosed spaces without obtaining a permit.

4.1.1 Dangerous working places and sources of hazards

To provide more detailed insights into the study, it is essential to understand the ratings' perspectives and considerations about safety and the danger of the working on chemical tanker vessels. Also, unsafety acts and reasons behind it are focused.

All ratings think that working onboard especially on chemical tanker vessels is considered a dangerous workplace. As sources of hazards onboard, some common and some different thoughts have appeared.

The common answers about the sources of hazard were nature of the offshore job and characteristics of that are cargoes that toxic, explosive and flammable which are carried on chemical tanker vessels. They also pointed out the importance of giving full attention to work for safety.

The other appeared thoughts were on psychology and mental health of the seafarers. Three of the ratings mentioned about the psychology of workers onboard which affects unsafety acts. The effect of psychology or mental health on safety is explained as causing a lack of attention to their jobs and safety.

Psychology of the seafarers has a huge impact on occupational safety, being away from the social life and family effect on workers mood and it results in unsafe acts onboard.

These participants were suggesting improving social life of seafarers onboard and more connectivity with onshore life.

Seafarers' mental health issues can be eliminated with more communication possibilities with their family or increasing their social life on board.

4.1.2 Onboard communication

According to a question about onboard communication between ratings and officers or engineers for reporting and informing during daily work, four out of five participants declared they don't inform or communicate with officers, master or engineers during daily work. Also, they were all agreed about the importance of communication, informing and reporting.

Participant A emphasised as below that they report to bosun or other seamen about their tasks. He also mentioned there are times when there is even a lack of communication between themselves.

Seamen generally have communications with officers or engineers only during resting times. I believe that it is important to know each other where we are and what we do during work. During daily operations, we inform bosun or another seaman about where we go or where we work. But of course, there are times when that information is not communicated.

Participant B emphasised almost the same things as participant A, but as an addition to it, he mentioned that sometimes bosuns are unaware of their team.

In general, the bosun knows the places where we are and what we do because he coordinates the staff. But of course, the bosun sometimes is unaware of his staff.

Participant C emphasised that informing only the bosun is because of the maritime culture.

In general, we don't communicate with officers during working hours. We receive work orders from bosun and informing him. He is the one who communicates with the chief officer. It is because of the hierarchy of maritime culture.

The hierarchy and work order flow on Turkish vessels have been explained by ratings during interviews. Especially for the deck team, the job orders are given by the chief officer, master or both to bosun. Bosun distributes and forwards tasks to seamen. It is needless to say that seamen do not get daily work orders from chief officers or masters. It has also been checked with a company procedure that calls toolbox meeting. Every day before starting daily work, dedicated officers, engineers, bosun and fitter plan and discuss the daily works and bosun as a lower manager of the deck team presents them to workers.

Only the participant who works in the engine team mentioned that engine ratings always have communication with engineers during work, but he also emphasised because of some of the ratings' working ethics, they sometimes do not inform where they are.

We always keep everyone informed where we go or what we do during daily operations. Even engineers inform us where they go. On the other hand, some ratings do not inform, and they disappear to escape the work.

4.1.3 Human failures

According to understanding the types of human failures, especially about the violation of the safety procedures onboard and the reasons behind them, questions are asked to both ratings and marine experts.

Three out of five ratings emphasised about underestimating the potential risks. As one of them said:

All the procedures are for our safety, but sometimes workers think they are unnecessary. For instance, some engine room members do not follow UMS entering procedures when they need something from workshops which is near to the engine control room, but it is still inside of the engine room. They think it is not needed to follow the entering procedures because they do not think anything will happen.

Another underestimation of the risk is taken from an example of a participant mentioned below:

For example, according to procedures that a vest must be worn during lowering the pilot ladder. But sometimes, other ratings and I do not wear vest in good weather conditions because it is difficult and seems unnecessary for me to wear them in good weather conditions. But at night and in severe weather conditions, I do.

Another rating explained the reason for this situation with saving time or effort.

I believe that we sometimes underestimate risks and make decisions by ourselves that generally result in procedural omissions. These situations lead to minor or major accidents. I believe these situations generally occur because we try to save time or effort.

A different reason for human failure is due to work and time pressure has been mentioned by a participant that:

Sometimes, we run against time due to some unexpected situations or failure of critical parts. They empower us to proceed onboard by ourselves due to lack of spare parts or missing supplies. This kind of situations is generally causing violations of procedures due to pressures. If the companies give more attention to putting all spare parts or more equipment on board, this kind of situations can be eliminated.

4.1.4 Perspectives for tracking and monitoring technologies

Two different interview guides had different questions about the tracking and monitoring technologies, and the aims were different. According to an interview guide for ratings, it is aimed to understand how they will feel if they are continuously monitoring their position on board by officers, engineers or masters during daily operations. All the participants

find this system good as a safety practice, but three of them are worried if the system is used in the wrong way by officers, engineers or master onboard.

Participant B who is from the engine team was emphasising his worry with his example as below:

Monitoring seafarers' position on board is a good idea. Especially, finding crew members' position in emergencies may help to gain time. On the other hand, this technology can be used in the wrong way such as breaking personal privacy which can make people nervous. For instance, many companies have installed Closed-Circuit Televisions (CCTV) in the engine room for fire patrols, but some officers or masters watch how the seafarers work, and force or command people to work harder. These situations make seafarers uncomfortable at work.

Another participant emphasised that they sometimes hide something from their leaders and he explained it with a simple example:

The system seems super and logical. However, technology has good sides, as well as bad sides. For example, seafarers do not bore themselves too much while doing the paintwork onboard. During this type of works, seafarers sometimes laze around messrooms or try smoking or resting elsewhere without any notice. In such cases, seafarers may feel uncomfortable due to being monitored by leaders. To be honest, there are some things that we hide from the master and officers.

The other two participants' answers were short, and they just mentioned they would not feel uncomfortable if their position onboard is monitored.

4.1.5 The entry of enclosed spaces

Two different interview guides had different questions about the entry of enclosed spaces, and the goals for those questions were different. According to an interview guide for ratings, it is aimed to understand their knowledge about entry procedures and how the procedures work in practice.

All participants were aware of the dangerous hazards in enclosed spaces especially the cargo tanks. They know the places that are defined as enclosed spaces on board, and they know the general procedures for entries. The first thing that appeared from all participants' answers

was underestimating some of the enclosed spaces' hazards and entries without permits and informing as emphasised from a participant below:

The cargo and ballast tank entries are the most dangerous ones: we generally enter these places under officer control. However, we do not report or inform to the officer in charge while entering to other enclosed places such as bow thruster room, the nitrogen room, the pump room, sample room, CO2 room etc.

Another example of the underestimating has been emphasised by another participant:

Sometimes, we enter some enclosed spaces such as the pump room with giving notice to one of our rating colleagues (another seaman, bosun), though, we do not give notice to the cargo control room for these entries in general. And, of course, there are sometimes when we do not inform anyone, but these situations are rare.

A participant explained an accident that he witnessed on board. The accident happened during tank entry due to entering without obtaining a permit:

The last time when I was working onboard a vessel, I witnessed an occupational accident. Automatic tank cleaning was finished, and the cargo tanks were filled with nitrogen for the next cargo. Entries for the cargo tanks were prohibited due to nitrogen. The pumpman was taking out the waters around deep well pump by a portable pump from the tank covers. The suction side of the hose slipped from the water location. He wanted to go down to fix the hose location. He thought that he could keep his breath because he thought it wouldn't take a long time. He entered into the tank without asking or telling anyone. He fainted on the stairways and fell down on the tank floor. Fortunately, a seaman wanted to check where he was, and he saw that he was laying on the bottom of the tank. After all, the rescue operation started, it was difficult, but he was rescued.

4.2 Findings from Marine Experts' Interviews

Five main themes are created based on findings and literature reviews. The themes and related findings from marine experts' interviews are illustrated in Table 5.

Table 5 Summary of the marine experts' findings

Themes	Main findings
Safety management system	Onboard verification with crosschecking filled ISM documents.
	Explaining the importance of the ISM checklists to the crew onboard.
	Measuring the efficiency of the system by internal and external audits.
	Making the crew feel that they are under control.
Human failures	Routine and repetitive tasks
	Underestimating the risks
	Self-confidence of seafarers
Shore-based training	Briefings to the crew at the office before embarking a vessel.
	Keeping the seafarers up to date, and trying to increase their safety awareness
	Learning and collecting information from seafarers during training.
Monitoring Crew	The main task of the officers is to follow up the crew.
	Important and beneficial from the safety perspective.
	Potential negative events can be prevented by it.
	Important and useful in emergencies.
Perspectives for tracking and monitoring Technologies	It can be beneficial for safety and reporting violations.
	It may result that the crew give more cautious to procedures and safety during work.
	Unauthorised enclosed space entries can be inspected and reduced.
	It may encourage people to follow procedures.
	It can affect job efficiency.

4.2.1 Safety management system

The safety management system has been stated in literature part and to understand the company Safety Management System (SMS), the efficiency of their system and the company strategies to implement the ISM code on ships effectively, some questions were asked to marine experts.

All participants have emphasised that they visit vessels that are under their management at least once in six months to check how their SMS works. They also arrange individual interviews with all employees onboard. They also crosscheck filled ISM documents with officers or engineers. They ask questions to them about the tasks need to fill ISM documents, and according to their answers, they can see that ISM is just a paperwork exercise or are they being applied. Participant F emphasised about this situation as follow:

Onboard verification shows us almost everything. For example, when we check the ISM checklist with a dedicated officer. We ask the officers what they need to control according to

an ISM checklist and it can be understood from their answers. Because, if an officer uses ISM as a paperwork exercise, he or she can't explain this kind of questions. With their answer, there is always something missed. This way, we try to explain the importance of checklists. We show them without these papers there will be some criteria that they forget. I believe if they become aware of the importance of checklists, ISM won't be only paperwork for them.

Participant G was emphasising the same things that they observe, ask questions to employees and control ISM documents when they visit vessels. He emphasised that to make employees understanding of ISM documents' importance is as follow:

Making people understand the importance of those documents and information in these forms is important. If people believe in it, to do something for real, not only fill in a document to proof something, then ISM Code can become effective.

Addition to onboard verification strategy as company policy, participant J emphasised as below:

With visiting vessels, we make seafarers feel that we are serious about SMS and safety onboard and I think they take safety procedures seriously because of our seriousness. Also, we measure the efficiency of ISM code onboard with ISM audits, internal audits, external audits. Especially external audits are important because we also can see our shortcomings in our SMS by them.

Participant H was emphasising the role of control pressure factor for the safety management as; *If the crew feel that they are under control, they apply procedures properly. I think our company is good at this.*

4.2.2 Human failures

Participants have been asked questions about human failures and procedural violations onboard. Different thought about reasons behind it has appeared from interviews.

Four out of five participants have mentioned the reason of procedural violations with routine tasks and underestimation. As participant F emphasised as below, that routine tasks cause excessive self-confidence on seafarers, and this leads to procedural violations.

The crew start to feel that they know everything well due to the works that they do every day or often. And they start thinking like I've done this task many times and nothing happened that's why nothing will happen. I think eventually they gain excessive self-confidence by it, and

they don't give attention to procedures and underestimating the risks. They underestimate the risks of some places and try to finish the tasks quickly. For instance, they don't wait for a permit to enter enclosed places or don't ask for it. According to my own experiences, Pumpman, bosuns and seamen have this way of thinking in general.

Participant G has explained the correlation between routine works and human failures as follows:

When the tasks become routines, there starts human failures and procedure violations. For example, if a task is done for the first time onboard, all procedures are meticulously applied such as permits, risk assessments etc. However, when the work starts to be repetitive, the crew's safety mind changes and they start thinking the task doesn't have risks as we thought, and they start making concessions from procedures. We explain this situation to the staff in the routine safety meetings and try to avoid this kind of concessions. I believe that a seafarer with 20-25 years offshore experience has more possibility to have an accident than a new seafarer. Because the experience that gained from many years leads over self-confidence that causes violations.

Participant J explained the reason for human failure with an example as following:

The job and procedures become unimportant by repeated jobs. This situation then becomes a dangerous state and turns into procedure violations. As an example from ashore life, car accident rates differ between new drivers and experienced ones. The seafarers try to do everything according to the rules and procedures at the early stage of their career, but this changes after a while.

4.2.3 Shore-based training

Company personal training strategies and the participant's' thoughts about safety training are asked to participants. It has seen that ratings get a briefing before embarking a vessel at the company office from company Designated Person Ashore (DPA). The briefing contains Shell Learning from Incident (LFI) training, safety alerts from company and industry, and accident reports from the industry. On the other hand, it is answered that they don't give training about company SMS to ratings. All the participants emphasised that those training or briefings are beneficial, and it is believed that it increases personal safety awareness, as said by a participant:

I think this training is useful and beneficial. Our goal is to keep our seafarers up to date, and I believe that they increase personal safety awareness.

And three out of five participants emphasised that office workers also learn something from seafarers via those briefing. As participant J said:

First, this training increases the seafarer's awareness. Second, we also learn some things from them or collect information about our fleet, employees or ship-land communication deficiencies.

4.2.4 Monitoring crew

Four out of five marine experts mentioned about the importance of monitoring crew for safety during daily operations in a vessel. As it is emphasised by participant G that:

It is important to monitor seafarers onboard because everyone is responsible for everybody's life onboard a vessel and they must follow and monitor their colleagues. When an officer allocates work to seafarers, he needs to know where the seafarer is going and what they are going to do. As a matter of fact, the main tasks of the officers are to monitor the work, follow up with the crew and to be sure that there is no threat to seafarers' safety.

Another perspective from participant H was that monitoring crew can prevent possible negative events. As he said:

I believe that monitoring the crew is important and beneficial from the safety perspective due to the working environment and the danger of the work. By monitoring crew efficiently, possible negative events can be prevented.

The importance of monitoring the crew has been explained with an example by participant J as:

The crew must be aware of each other because it is important for their safety. For example, a person who does not appear for a certain period of time he may have a fallen or an accident has happened somewhere in a compartment of a vessel. It's better to know where he went before and for what. In case of this kind of situations, it can be intervented faster, and the life of the seafarer can be saved.

4.2.5 Perspectives for tracking and monitoring technologies

Four out of five participants were strongly confirming this technology as a safe practice and big potential for reducing safety violations. As participant F emphasised below:

These technologies can be beneficial for safety and reporting violations. Also, the crew may give more cautious to procedures and safety during work due to knowing that he/she is being monitored. In additional to that entering to enclosed spaces and the engine room without informs or permits can be inspected and reduced.

Participant G also emphasised that;

I think it would be a very logical application. At least, it will encourage people to follow procedures, because everything that is monitored and recorded will force people to do their jobs according to procedures, especially during enclosed space entries. On the other hand, I don't think it is needed while working on the open deck.

Participant H also was emphasising the benefits of monitoring technologies as others and in addition, he mentioned it would increase the job efficiency.

It might be useful for safety by controlling the uncontrolled or unauthorised accesses to any enclosed space. The crew may also give more attention to safety because they will know that they are monitored. In addition to safety, it can affect job efficiency. If a seafarer escapes from a job or is somewhere which is not a working place, officers, engineers or master can be warned about where they are and what they do.

Participant J also mentioned about its potential effect on ratings in terms of safety behaviours and beneficial usages.

The crew may give more attention to their jobs and safety procedures when doing their job because they will know that everything that they do will be monitored. In emergencies, it can help to find missing person's location. It may also be useful to control access to enclosed spaces that require a permit — also, control of the engine room access.

Only the participant "I", who is a technical superintendent, didn't think that technology can reduce safety violations or become a safety practice. On the other hand, he mentioned that it could work in an emergency:

Of course, there are important points that this technology can be helpful with. This can be especially important in emergencies. It might be useful to determine the location of people who do not come to muster station to gather there during the emergency alert. However, I do not think that this would be very important in daily routine works.

5 Discussion

This chapter presents the analytical discussion of the findings with the consistency of the literature review. The findings from both interview categories; ratings and marine experts are combined and discussed together. Also, related finding subjects are sorted and discussed under the same sections. The discussion themes and related findings from ratings and marine experts are shown in Table 6.

Table 6 Summary of the discussions coupled with relevant findings

Discussion Themes	Main findings	Interview group
Safety and Safety Management	Dangerous working places and sources of hazards	Ratings
	Safety management system	Marine Experts
	Shore-based training	Marine Experts
Human Failures	Human Failures	Both Groups
	The entry of enclosed spaces	Ratings
Onboard Communication and Monitoring Crew	Onboard Communication	Ratings
	Monitoring Crew	Marine Experts
Tracking and Monitoring Technologies	Perspectives for tracking and monitoring technologies	Both Groups

5.1 Safety and Safety Management System

This discussion contains a combination of three different finding sections which are 'Dangerous working places and sources of hazards', 'Safety management system' and 'Shore-based training'. These findings are ratings' safety perspectives about dangerous working places and sources of hazards on chemical tanker vessels, and the perspectives of the company' marine experts about the company's safety management system effectiveness and shore-based training. Since the company training policies are part of the safety management system, they are combined and discussed together.

It was essential to understand ratings' safety perspectives and their thought about how dangerous their working environment is and what the sources of hazards are. The findings show that all the rating informants were claiming that working on board, especially on chemical

tanker vessels is a dangerous workplace. The common reasoning of dangerous workplace onboard a chemical tanker was the nature of the offshore job and characteristics of the cargoes that can be toxic, explosive or flammable, and quite threatening to human life. The importance of safety due to hazards on oil & chemical tanker vessels and tragic consequences of potential accidents were highlighted by Sætrevik and Hystad (2017).

One factor for unsafe acts has been emphasised by three of ratings that relating to psychology and mental health of the seafarers. According to the participants, being away from shore-based life influences seafarers' psychology, and it reduces their attention and focuses on their tasks and safety awareness. As defined in the literature review, safety is the freedom from danger, and it can be achieved by doing tasks right every time (Kristiansen, 2013). It is assumed that the lack of attention on tasks may result in the possibility of not doing the tasks right. According to Kuo (2007), the researchers' perspective for safety is obtained after a risk analysis has been carried out. This perspective can relate to the lack of attention on the tasks because the risk analysis of the tasks is not carried out properly due to lack of attention.

It has been noticed that the responsibilities of the company's marine experts are not only creating safety policies or procedures but also controlling the safety management system operations. The findings show that marine experts visit vessels minimum twice a year for onboard inspections, and they crosscheck ISM documents by interviewing officers, engineers, and ratings. If the ISM documents are compliant with onboard practises, they verify that the system works properly. In addition to their internal inspections, they also perform external inspections such as SIRE, CDI, Class, flag state and port state inspections that improve their safety management system. As Kuo (2007) highlighted, safety management is for keeping operations safe and safeguarding both human and physical resources. That is what the case studied company try to do. Also, several researchers have highlighted the relationship between safety management and safety culture of the individual (Håvold, 2010; Sorensen, 2002). For this respect, some of the marine experts emphasised that they try to explain and teach crew the importance of the SMS and ISM documents. Also, marine experts believe that if the crew were aware of the importance of the SMS and ISM procedures, then it would not be just a paper exercise. This can result in an improvement of safety culture in the company's fleet. Therefore the adoption of safety culture can lead to ease and success of safety management (Håvold, 2010). The SMS itself is not enough for implementing procedures; the system needs organisational safety culture (Håvold, 2010).

In an additional subject that was found in the findings is seafarer's shore-based training with regards to safety. Since the company's training is under the company's safety management system or policies, it is discussed in this section. The Designated Person Ashore (DPA) or general manager gives a briefing to the crew in the company, before joining a vessel. These briefings include Shell Learning from Incident (LFI) training, safety alerts from company or industry and accident reports from the industry. The marine experts highlighted that training is beneficial for increasing safety awareness of the people and so the safety culture. Training is essential not only for the awareness of the organisation also for the awareness of the individuals when it comes to safety culture and safety management (Sorensen, 2002).

5.2 Human Failures

In this section, human failures are discussed both from rating's and marine experts' perspectives. In addition to that violation on enclosed space entry procedures that are found from ratings' interviews, will be discussed here, since there is a type of human failure.

The appearances from rating's perspectives were underestimating risks, taking short cuts, and workload and time pressure as the reasons for human failures. Three out of five ratings highlighted the underestimation of risks and lack of enforcement of rules which causes violation of safety procedures. Two more participants explained that they implement this type of violations due to making shortcuts, and workload and time pressures onboard. Also, some human failures types are found in the entry of enclosed spaces. All participants were aware of the hazards in the enclosed spaces, but there was an underestimation of potential hazards in some of the enclosed spaces. As a result of it, there is a violation of procedures for enclosed space entries.

The findings from marine experts' interviews show that the reasons for human failures and procedural violations onboard are excessive self-confidence in ratings, and losing the importance of the safety measures due to repetitive jobs. It is explained by a marine expert that the crew's self-confidence grows high due to routine tasks and it results in paying less attention to procedures or losing the importance of the procedures, then this situation becomes a dangerous state, and turns into short cuts on procedures.

These findings are important because as Hanzu-Pazara et al. (2008) stated it is necessary to identify latent failures and to understand the reasons behind, and prevent repetitions in the future. The reasons for violations are applied and compared with Generic Error Modelling

System (GEMS) from (Reason, 1990) and (HSE, 1999). The comparison between findings and GEMS shows that there are Non-Compliance error and two failure types which are “Routine” and “Situational”. As a routine type of failures described by HSE (1999), it can be the desire to cut corners and save time and energy, and also the perception that the rules are too restrictive and lack of enforcement of the rules. Therefore, the underestimation of risks, lack of enforcement of the rules and saving time and effort from the ratings as the findings showed are defined as “Routine Failures”. And with a routine violation, breaking procedures are becoming a normal way of working (HSE, 1999). The other reason from a rating’s point of view is that time and workload pressure are categorised as “Situational Failure” by (HSE, 1999). Situational failure type is defined by HSE (1999) that breaking the rules is due to pressures from the job such as being under time pressure, insufficient staff for the workload, the right equipment not being available, or even extreme weather conditions.

HSE (1999) advices the managers to decrease routine human failures with routine monitoring, making rules and procedures relevant, and explaining the reasons for these procedures to the employees.

To deal with situational human failures, HSE (1999) advises the following: improvement of the working environment, provision of appropriate supervision, improvement in job design and planning, and establishment of a positive health and safety culture.

5.3 Onboard Communication and Monitoring Crew

The findings from ratings about onboard communication and the findings from marine experts monitoring crew are discussed in this section.

All rating participants confirmed that communication with officers, master or engineer in terms of informing and reporting during daily work is important for the safety. On the other hand, it is found that sometimes there is a lack of communication, informing or reporting. Two reasons are found for this issue. The first reason for not communicating properly, informing or reporting to officers, master or engineers, is due to the hierarchy onboard. Ratings from the deck department affirm that they inform only to the bosun who is the foreman of the deck team. The second reason is due to bad working ethics because some of the ratings are either absent or try to escape from the work area. Also, it has been found that they do not inform anyone or getting a permit from the officer in charge for entering to some of the enclosed spaces that are subject to permit systems (Maritime Coastguard Agency, 2011) such as bow thruster room,

nitrogen room, pump room, sample room, CO2 room etc. This situation needs to be given more attention because, for example, a rating described an accident that happened during cargo tank entry due to missing permit and not informing the officers in charge prior to the entry. Also, a dangerous action taken by a crew member can endanger others also, and this is the reason that prior to specific operations, it is essential to make sure that the series of actions are taken accordingly to the rules and procedures (Maritime Coastguard Agency, 2011).

Four out of five marine experts highlighted the importance of monitoring the crew during daily works. It has been confirmed by marine experts that monitoring the crew by officers, master or engineers can prevent possible accidents or the save time in rescuing injured crew operations. It is the officers', master's and engineers' responsibility to make sure there is no threat to ratings' safety, before a series of actions are taken in the workplace (Maritime Coastguard Agency, 2011).

5.4 Tracking and Monitoring Technologies

The findings from both ratings and marine experts about tracking and monitoring technologies are discussed in this section. The findings from ratings are their thoughts about the technology, and how they would feel if they are tracked and monitored during daily operations. The findings from marine experts that how tracking and monitoring technologies can be beneficial for safety, and potential scenarios in which tracking and monitoring technologies would be the best for, are discussed.

All rating participants agreed that the system is good and logical for safety practice. On the other hand, some of the ratings were worried about the usage of technology in a bad way which means officers, master or engineers can force them to work harder. They were worried because with this technology they cannot hide their location. It may result in feeling less freedom during work.

Four out of five participants were strongly confirming this technology as a safe practice and big potential for reducing safety violations. Besides, the system has been found useful in case of emergency cases. It can determine the location of missing people in an emergency. Therefore, it can influence in gaining time in an emergency. Also, It has been found from the marine experts' perspectives that this technology application can coerce people to give more caution to procedures because seafarers will know that all their actions will be monitored. Another potential improvement in safety by this technology is to control unauthorised accesses

to enclosed spaces and the engine room. As it is discussed before, one of the solutions for reducing the chances of routine human failures is routine monitoring HSE (1999). The chance of routine human failures can be reduced or eliminated by tracking and monitoring technologies due to continuous monitoring. This advanced technology system can fill the holes in the barriers or add an extra defensive layer on Reason (2000)'s the Swiss cheese model.

5.5 Research Limitations

This study has several limitations that deserve to be noted. First, the generalizability of the findings is questionable, since the data was collected from only one company within the oil and chemical tanker industry. Second, the interviews were taken from five ratings and five marine experts that are Turkish, and there was a lack of multi-cultural viewpoint. Third, the general manager of the company didn't give permission to collect data from their near miss and accident report databases. Fourth, there wasn't available literature that includes experiment or observation reports about the usage of the tracking and monitoring technologies on merchant vessels. Fifth, most of the interviews were taken in Turkish and then translated into English by me. That may change the original meaning and therefore lead to misinterpretation of data.

6 Conclusion

In light of the theory, findings, and discussion above, the research questions can be addressed as follows.

Safety has high importance on chemical tanker vessels due to the nature of the offshore job and characteristics of the cargoes that can be toxic, explosive or flammable, and so threatening to human life. Therefore, the company's marine experts control the efficiency of their safety management system and try to improve organisational safety culture with company seafarer training. Despite the company's safety management system, human failures still occur by seafarers. Furthermore, these human failures are found mostly as routine and situational types. Related literature and interview findings indicate that these types of human failures can be minimised by routine monitoring, appropriate supervision and positive safety culture. Moreover, this study also implies that there is a lack of communication and informing between ratings and upper ranks onboard during daily operations.

Routine monitoring, appropriate supervision and safety culture are vital for the prevention of common human failures. Tracking and monitoring technologies can be promising alternatives to fulfil the need of communication and monitoring to improve safety onboard. It can provide continuous crew monitoring and potentially increase the awareness of the ratings on their tasks. To sum up, tracking and monitoring technology system can fill the holes in the barriers or play a role as an extra defensive layer on Reason's "Swiss cheese model".

This thesis contributes to the increase of awareness for safety issues in the maritime industry. Also, it highlights the potential for onboard safety improvements by tracking and monitoring applications on chemical tanker vessels. In addition, this is an innovative idea since it has not been implemented on conventional merchant vessels to my knowledge until today.

6.1 Suggestions for Further Research

Considering the limitations of the present study, the suggestions are proposed. First, this research can be examined in multi-cultural social setting and applications in different maritime sectors can be accomplished to generalize the findings. Second, the near miss and accident reports can be collected and analysed with the quantitative strategy for further studies. Lastly and foremost, the most suitable personal tracking and monitoring technology can be implemented to a vessel for observing the effects onboard safety after technical considerations.

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Appendix 1

Interview questions for Ratings

The purpose of this interview is to learn about the relationship between safety, reporting (formal and informal) and monitoring of the crew. Also, study the potential of tracking and monitoring technologies in the improvement of safety practices on vessels. The participation of the interview is a voluntary basis. The information that you provide will remain completely anonymous, and it will be ONLY used for research purposes. I assure you that your participation in the interview and your responses will be strictly confidential to the researchers and will not be divulged to any other party (including your company).

Section 1 Respondent Background

1. What is your age?
2. What is your rank?
3. How long have you been at sea?
4. How long have you been working on the chemical tanker vessels?

Section 2 Safety and Practices

5. Do you think working onboard is considered to be a dangerous workplace?
    a. What are the sources of hazards?
    b. How do you make it safer?
6. Would you say that you always prioritise safety procedures onboard?
    a. If not, what has come before safety procedures?
7. What kind of unsafe practices is happening on the chemical tanker vessels?
    a. How?
    b. Why does it occur?
8. Have you had any injury/incident onboard?
    a. Could you describe it?
9. Could you name the enclosed spaces on the vessel that you were working?
10. Do you always inform the officer in charge before entering and after exiting the engine room, tanks, ballast pump room, deck trunk, bow thruster room and nitrogen room?
11. What do you think about entering places that they need to report or obtain a permit before entry?
12. Which conditions lead to violation of entry procedures?

13. Would you feel uncomfortable if your position is monitored by the master, officers or engineers during daily work?
    a. If Yes, Why?
14. How often do you communicate with officers or engineers or inform them about your working place during daily operations?

Appendix 2

Interview questions for Marine Experts

The purpose of this interview is to learn about the relationship between safety, reporting (formal and informal) and monitoring of the crew. Also, study the potential of tracking and monitoring technologies in the improvement of safety practices on vessels. The participation of the interview is a voluntary basis. The information that you provide will remain completely anonymous, and it will be ONLY used for research purposes. I assure you that your participation in the interview and your responses will be strictly confidential to the researchers and will not be divulged to any other party (including your company).

Section 1 Respondent Background

1. What is your age?
2. What is the official title of your job?
3. How long have you been in the maritime industry?
4. How long have you been at sea?
5. How long have you been working onboard chemical tanker vessels?

Section 2 Safety and Practices

1. How do you keep the ISM system from becoming a paper exercise?
2. How do you measure the efficiency of the ISM Code onboard vessels that you are responsible with?
3. What do you think about the violation of safety procedures for operational aspects that happens on vessels? Which are the most common?
4. Why seafarers violate safety procedures that are for their safety?
5. Do you notice that crew enters places (engine room, tanks, ballast pump room, deck trunk, bow thruster room and nitrogen room) that they need to report or obtain a permit before entry? If yes, why do you think it happens? What is your strategy to prevent these behaviours?
6. What kind of training do you provide to seafarers about safety and procedures?
    a. What are they specifically aimed at it?
    b. Onboard or ashore?

Appendix 3

Are you interested in taking part in the research project

"Improvement of onboard crew safety by applying personal tracking and monitoring technologies"?

This is an inquiry about participation in a research project where the main purpose is to study the potential of tracking and monitoring technologies in the improvement of safety practices on vessels by identifying procedures that the crew onboard does not follow, as well as the reasons behind it and possible digital solutions for this issue. In this letter, we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

On this master thesis, the focus is on the relationship between safety, reporting (formal and informal) and monitoring of the crew. By formal and informal reporting, we mean the communication between the upper-class officers and the ratings. For instance, before commencing specific tasks, it is important that this is reported to the officer in charge or the Master in order to obtain a permit and keep them aware in case of danger. The aim of this master thesis is to propose suitable solutions that would contribute to the improvement of safety practices on vessels by identifying procedures that the crew onboard does not follow, as well as the reasons behind it and possible digital solutions for this issue.

The study uses a qualitative research methodology where semi-structured interviews were conducted to collect data from ratings and marine experts from a shipping company which manages chemical tanker fleet. Finally, potential technological solutions will be discussed for possible usages to decrease human failures.

Thus, the research questions of this master thesis are as follows:

- What are the main types of procedural violations made by ratings onboard chemical tankers?
- How can tracking and monitoring technologies contribute to the improvement of onboard personal safety?

Who is responsible for the research project?

Department of Maritime operations at the University of South-Eastern Norway is the institution responsible for the project.

Why are you being asked to participate?

Interviews have been divided into two groups; the first group includes ratings. The second group includes marine experts (superintendents) and managers within the chosen company that is located in Turkey. Hence it is a case study, second group participants (office employees) are going to be interviewed when they have available time. There will be seven interviews for the second group.

Selection of first interview group participants (Ratings) will be convenience samples in the company. The company has approx. Seven hundred fifty offshore employees whereas seven will be selected randomly and willingly for interview.

What does participation involve for you?

First interview group:

If you chose to take part in the project, this would involve that you will be interviewed. It will take approx. 30 minutes. The interview includes questions about occupational safety onboard vessel and violation of safety procedures. Your answers will be recorded on paper by the interviewer (me).

The second interview group:

If you chose to take part in the project, this would involve that you will be interviewed. It will take approx. 30 minutes. The interview includes questions about safety onboard vessel and safety management. Your answers will be recorded by a voice recorder.

Participation is voluntary
Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw. It will not affect your treatment with your work or employer.

Your personal privacy – how we will store and use your personal data
We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

- Only the student and supervisor will have access to personal data.
- There will be no name or contact details will be asked or used.

Only participants' age, the title of their job, duration of their sea service and on the chemical tanker and occupational accident/injury or near miss accident experiences (if exist) will be used as personal information. The name of the company that participants work will not be stated, and since there is a huge population of the ratings and marine experts outside, participants will not be recognisable.

What will happen to your personal data at the end of the research project?
The project is scheduled to end 13.06.2019. At the end of the project, all the recorded papers and voice files will be deleted permanently.

Your rights
So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?
We will process your personal data based on your consent and based on an agreement with University of South-Eastern Norway, NSD – The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?
If you have questions about the project, or want to exercise your rights, contact:

- University of South-Eastern Norway via MSc. Student **Yusa Utku Genc** or the master thesis supervisor **Halvor Schøyen**.

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- Our Data Protection Officer: Mette Kammen, by email: mette.kammen@usn.no or by telephone: +47 35 57 50 36.

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Yours sincerely,

Prof. Halvor Schøyen
Master thesis Supervisor

Yusa Utku Genc
MSc. Student