

Master's degree thesis

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Situational awareness in Demanding Marine Operations

Vivek kumar

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Preface

The thesis is submitted in partial fulfillment of the requirements for degree in Master in Product and System Design Engineering from Aalesund University College. I am being supervised by Associate Professor Magne Aarset. The work has been done in the field of situation awareness in demanding marine operations. Professor Magne has guided me from time to time and his ideas helped me in achieving desired results in allotted span of time.

The idea for the topic "Situational awareness" comes from his side from one of his present work in the field of human factors and situational awareness. I was interested in taking topic in the field of risk management in marine operations but when I approached him for discussing possible topic for my master thesis in autumn semester, he introduced me with the concept of situational awareness ,its importance and increasing popularity in the present time. We discussed it for few times before we the topic for my master thesis. Another driving force to select this as my master thesis topic is that, not much work has been done in the field of situational awareness in maritime industry. Though lot of work has been done in the field of situational awareness in the aviation field which become motivation for me to pursue it in the field of maritime industry.

Writing the thesis was not that easy and I got help from lot of people from my supervisor and other teachers through new ideas, comments and the literature in the form of study material.etc

AUC, 30 May 2104

Abstract

It has been observed that mostly cause of the accidents in the maritime industry is due to lack of primary situational awareness and secondary loss of SA. Moreover it is difficult to estimate the exact reasons for the loss of SA in real time simulations because of varying work load and fatigue issues. This study examined situational awareness among licensed captains and pilots of the maritime time industry by feedback obtained through set of questionnaire covering the factors which could contribute to loss of situational awareness of the crew on board a vessel. A questionnaire is made and filled out by the professionals working in different companies serving different vessels and have different background and different set of work experience. The personnel include ship captains, crew members, first engineers, second engineers, technical personnel etc.

The data is collected and analyzed to find out commonalities and issues regarding the understanding of situation. From the survey and questionnaire the factors like fatigue, lack of SA, loss of SA, lack of knowledge, stress, communication gap, dangerous drugs and alcohol influence and mental load conditions are evaluated to know the SA of experts and the students. The impact of these factors and degree of their effect has direct influence on the current situational awareness in case of maneuvering the vessel towards the shore.

These factors were compared and resulted in the identification of mental workload as the predominant factor affecting situational awareness. Upon further examination of mental workload, it was found that loss of situational awareness is likely to occur when a vessel captain is distracted by some external factors cell pho like useless alarms on board which distracts the pilot or crew members on board from carrying out essential steps to avoid accidents. In addition, the results also indicated complacency potential, a function of attitude toward automation and perception of mental workload.

Acknowledgements

It will not be wrong to say that there is a contribution of lot of people in different ways at different times. I would like to express my special thanks to my advisor Professor Magne Aarset, who has been a mentor, guide, and a teacher for me. I would like to thank him for encouraging me from time to time. His advice on both researches as well as on guiding me has been priceless. I would also like to thank him for making my master thesis defense an enjoyable and stress free moment. I once again thank him for brilliant guidance, comments and suggestions which enlightened the desire and thirst to complete the task well in time. I would especially like to thank all the faculty members for their kind help from time to time. All of you have been there to support me when I need their help.

A special thanks to my family. It is difficult to express in words how much grateful I am to my parents for kind of sacrifices they made for me. Their well wishes and prayers gave me inner strength to sustain in difficult times. They not only supported me from time to time but they enlightened me and gave me courage to face the reality with strength. I would also like to thank all of my friends who supported me in writing, and incented me to strive towards my goal. I would also like to thank OSC, Offshore Simulation Centre and all the instructors working there who guided me and helped me in conducting various interviews and surveys.

I would like to extend my gratitude to all professionals including Captains, crew members,engineers,management people who extended their support to me by giving their valuable time to me by participating in various interviews and surveys.

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Abbreviations

SA	Situational awareness
VTS	Vessel traffic service
AIS	Automatic Identification System
ABS	American Bureau of Shipping
SAC	Safety Advisory Committee
U.S.C.G	United States Coast Guard
VHF	Very high frequency
FM	Frequency Modulation
AIST	Automatic Identification system Transponder
MRO	Medical Review Officer
IMO	International Marine Organisation
QA	Quality Assurance
EC	Electronic Charts
MW	Mental workload
RV	Recreational vessels
CEMS	Crew Endurance Management Systems
CPRS	Complacency Potential Rating Scale
BPS	Boredom Proneness Scale
ECS	Electronic Charting System
SMS	Safety Management System
SMI	System Maintenance and Improvement

Introduction

Norway is renowned for its feet in the field of maritime industry. The cluster of shipping is spread all over the country with its unique specialization in depth. One can easily see the variety, penetration in the shipping industry with latest and modern technologies in the field. It is easy to see big manufacturing yards, lot of big manufacturing companies dealing with ship equipments and lot of supporting companies working in close collaboration with each other. The distribution of business in maritime industry is closely observed with uniqueness in expertise varying from one place to another. For instance, the financial side of it is heavily distributed in capital city Oslo which acts as a hub to link and spread the business with the world, the city of Bergen is renowned for commercial side of maritime industry. Many multinational companies are working in Norway and providing a platform for technology spread across the country and helps in making a name in the world. Many big companies like DNV, NOV, Rolls Royce and Aker solutions have their headquarters in the country and working in close collaborations with the local companies.

The west coast of Norway is renowned for having leading yards and supporting industries for ship equipment in close collaborations with offshore firms. There are many other big names like Kongsberg, Schumberger etc which holds leading stature in the maritime industry. Some of them are specialized in the manufacturing, some of them have their name in providing support facilities, and some of them are good in providing technical solutions. The companies like ABB, DNV works in the rules and classification not only at micro level but at international level in maritime industry. Many reputed institutions, universities like NTNU, University of Stavanger are working in close collaborations with big companies thereby spreading firsthand knowledge to potential students .

As most of universities and university colleges are working in close collaborations with maritime industries, it gives immense knowledge to the students to gain interest in maritime industry thereby sharpening their skills in the field of maritime industry. Most of the programs being run in Norwegian universities and colleges have special emphasis on marine sector and there are many courses in bachelor and master curriculum that are linked with maritime industry.

The wide spread of maritime industry in the country attracts global companies to work with local companies thereby creating awareness and exchange of technology. Due to the popularity of maritime industry, many institutions, colleges and universities are offering courses on maritime to the international students thereby contributing in gaining awareness on global scale.

1.1 Demanding Marine operations

In the project we will study how people make decisions during demanding and advanced marine operations, particularly under stress. The main purpose of the thesis is to find out the optimal systems and solutions which will cater for Situational Awareness (SA) and support for the decision to be taken during the hard times. Advanced and demanding marine operations have brought up the complexity in the system because of quest to go long way in search of providing vast number of services and mastering the system.

The complex systems with automation embedded brought complexity into the system. It is generally found with the quest to go deep waters, maneuvering with heavier load, tackling with harsh environment under lot of work load and stress conditions. Because of the complexity in the system alone, there is substantial need of thrusting new technologies which will not only add functionality but also gives unique direction to the technical system.



Figure 1.1: Demanding marine operations on board a vessel

The frequent problem on board is availability of enormous data which makes task even more difficult to recognize the importance of the information needed to carry out particular operation successfully in hand. The data available to the use and information which is important for a particular operation to be carried out is very important and need to be addressed in right way.

The thesis intents to alter the trend of growing complexity in the system due to the presence of enormous inputs by following user centered design which not only simplify the system but also provide point to point interfaces to be connected there by eliminating the useless information which is present in the form of input data ,thereby making the process simpler and efficient.

The task primarily revolves around importance of changing the epicenter technology centered to task centered. In the technology centered user is provided enormous amount of input which some times in the hour of stress lead to catastrophic event as user has to make tough decision to select appropriate input from the vast available data thereby by making the process more complex and error prone. By changing it to the task centered, the user has less input data in hand and thereby he is in good position to analyze the situation right as he has been aware of the situation, process, the input and what he has to do in decision making.

We will therefore start with a literature study followed by detailed analysis of one or two advanced marine operations and a System Design Specification. We will also focus on how to support all phases of an operation (planning, execution and evaluation) including human aspects like the need for education, skill training as well as crew resource management training.

1.2 Problem Statement

The studies of vessel accidents in general don't provide concrete information regarding various factors that has led to the disaster. In other words, the studies done so far in the vessel accidents do not identify the factors that influence the situational awareness of the working crew on board a vessel. This can be evident from the statistics obtained which shows that loss of situational awareness accounted only 36% of human error in maritime industry where as in reality this figures should be much higher considering the fact that lapse of situational awareness accounts around 70% of human error(Horberry and Grech).

The primary reason behind this varying figure is due to the fact that in most of the marine accidents, the emphasis has been laid only on certain areas which seem important in terms of company preferences in face saving and economy. Moreover in between, there are numerous incidents of near miss situations which otherwise could have served as reference if quoted and brought in sight. These incidents not only would have provided the information but at the same time highlighted lapses on the part of crew working on vessels. The study draws upon the incidents and experiences of licensed captains and pilots of marine industry to determine the underlying factors affecting situational awareness.

1.3 Purpose

The purpose of the study is to collect the information and data which helps in defining various factors that can account for influencing the situational awareness on board a vessel that could end up resulting in vessel accidents or near miss situations. All the factors are compared to come up with most predominant factor causing lapse or loss of situational awareness. This information will be used to create a foundation for root-cause analysis, to provide recommendations for addressing the predominant factor, and to suggest areas for future research in the maritime industry.

1.4 Terminology

American Bureau of Shipping (ABS) - It is a classification society whose primary role is to consider the safety of life, property and the environment by following some standard rules and regulations. These rules are developed and verified for the standards in the field of design, construction and maintenance of marine related facilities.

Automatic Identification System (AIS):-AIS is an automatic tracking system which is used in ships and vessels to control the traffic and to identify the position of the vessel by electronically exchanging the data with nearby ships AIS base stations and satellites.

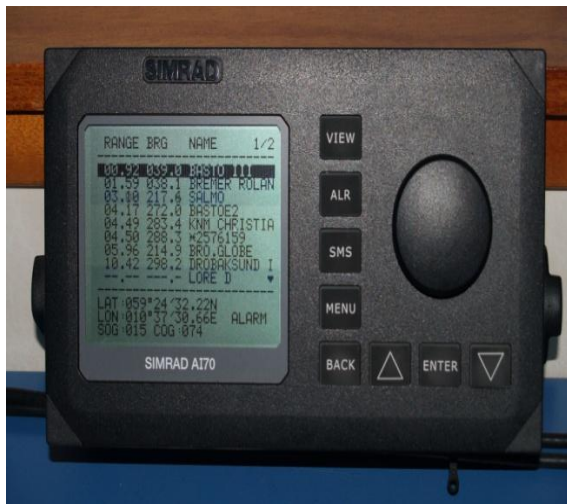


Figure 1.2: Automatic identification System

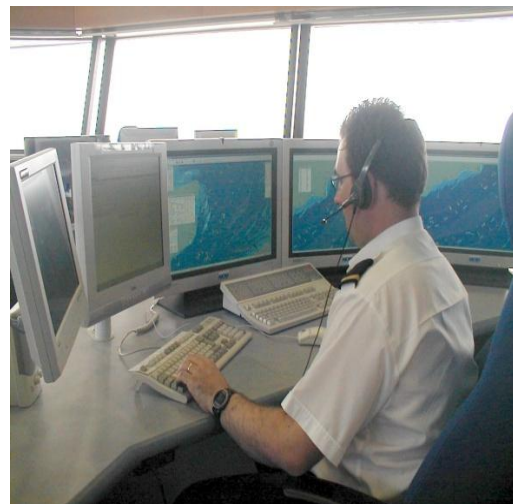


Figure 1.3 Vessel Traffic Service.

Courtesy of Wikipedia online Encyclopedia < [http:// en.wikipedia.org/wiki/Vessel-Traffic-Service](http://en.wikipedia.org/wiki/Vessel-Traffic-Service), Automatic Identification System

Crew member/Deckhand:-An individual performing deck equipment maintenance, line handling and lookout duties on board a vessel.

Port-Left. Often used during the arrangements with other vessels e.g. port to port passing.

Starboard-Right. Often used during passing arrangements with other vessels (e.g. starboard to starboard passing).

Vessel traffic service (VTS): - VTS is a system which is used to guide vessels of the presence of other vessels and was established to regulate and help to maintain a steady flow of vessel traffic in rivers and harbors worldwide.

1.5 Research Focus

What are human factors and how the human factors influence situational awareness?

What are various factors that affect situational awareness?

How the factors affect navigation and decision making in context of situational awareness?

Which is the predominant factor that affects the situational awareness on board a vessel and influences the decision making to large extent?

How the predominant factor be addressed to mitigate its effect on situational awareness?

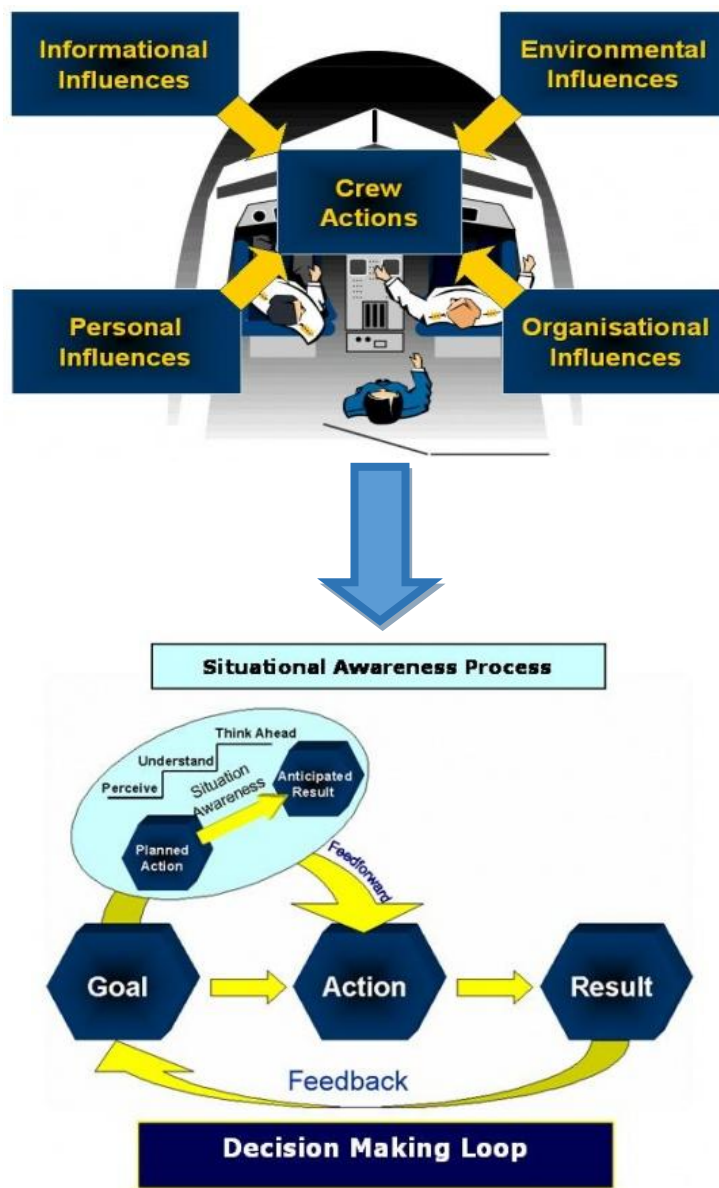


Figure 1.4 Inter connectivity between factors and Situational awareness in a Loop

Chapter 2

Literature Survey

2.1 Theory of Situational Awareness

According to a comparison of measures study, HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007, the term Situational awareness itself is argumentive because of its vast description in terms of measurement and understanding through model making. If we study the term SA through academic literature the term has been explained and constructed via number of theoretical models through vast number of approaches in order to explain the SA measurement techniques and methods. Further, a range of different SA measurement approaches have been developed. Of the theories presented in the literature, Endsley's three-level model is the most popular and its counterpart measurement approach which takes into account information processing, the Situation Awareness Global Assessment Technique (SAGAT; Endsley, 1995b) is the most commonly used procedure for measuring SA, despite questions regarding its validity as an SA measure. Many researchers have argued that further investigation is required in the area of SA measurement in complex systems, particularly in the area of team SA (e.g. Artman, 2000; Gorman, Cooke & Winner, 2006, Patrick, James, Ahmed & Halliday, 2006; Salmon, Stanton, Walker and Green, 2006) and also that in order to understand the construct within collaborative environments, a different perspective may be required (e.g. Artman & Garbis, 1998; Shu and Furuta, 2005; Siemieniuch & Sinclair, 2006) in the report HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007.

According to the report of comparison of measures" HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007. and Measuring Situation Awareness in complex systems by Paul M.Salmon, Neville A .Stanton, Guy H.Walker, Daniel Jenkins " The interconnectivity over the description of SA theoretical models and its measurement approaches will continue to be the driving force for constructing simpler and more practical and error free model for SA.SA is a vital factor as it is related to the individual and the team performance and related directly to the design of the control systems,command,training programs and procedures to be laid down in SA". It follows then that system designers and also training and procedure designers need to be able to accurately describe and measure individual and team SA in these environments, as do analysts wishing to evaluate SA in collaborative environments. Therefore it becomes important to measure the operator or user SA not only in terms of the theoretical SA related theory but also in conjunction to the system, design, procedures and evaluation efforts. Researchers need valid and reliable methods of assessing operator SA in order to test and advance SA theory, whilst system, procedure and training program designers need ways of assuring that SA is improved and not degraded

by a new system, interface, procedure or training program. SA is the decorative term which depicts the level of awareness a user or individual has while undergoing some decision making process or performing a complex process. It is the measure of the dynamic understanding of “ what is actually going on” (Endsley, 1995a). SA found its emergence from the operation point of view when it is used for the first time for the analysis of military aircraft crews during the first world war (Press, 1986; cited in Endsley, 1995a). Even with the introduction of the concept of SA, it doesn't have that much information to support the need to get the attention in the academic and research literature until late (Stanton and Young, 2000), when SA related research began to emerge within the aviation and air traffic control domains.

According to Endsley,(1993 b),It is also pertinent to mention here that despite of the term SA highlighted on global scene with its utility primarily focused in the field of aviation and air traffic control, not much work has been done with SA techniques and measurement procedures to build up useful model in maritime industry to supplement the decision making processes and their interdependencies in safety issues of the operations.(Endsley, 1993).

SA was becoming a broader term ,the literature published in a special issue of Human factors journal on SA (Endsley,1995a,b) clearly shows SA become topic which was discussed by various researchers and been related in various diversified field of the academic studies. The research since evolved within the system design and evaluation for the procedures and continued to dominate the human factors research worldwide.

Indeed, it is beyond the scope of this thesis to present these definitions in their entirety. But the classical and most commonly used definition of SA used on broad scale is used by Endsley, who defines SA as a product which find its origin from the process of situational assessment of the individual; or user undergoing a particular operation or decision making process.

In report comparison of measures in HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007, the understanding of the user or individual which defines the boundaries of the system alone includes “The perception of the elements in the environment within time and space, and the understanding of their meaning in relation to their occurrence in the present and dependency in near future the comprehension of their meaning, and the projection of their status in the near future” (Endsley , 1995a, p.36).

In the report “Comparison of measures “Smith and Hancock (1995) define SA as ‘adaptive, externally directed consciousnesses. Bedny and Meister (1999) argue that SA provides, “dynamic orientation in a situation, the opportunity to reflect not only on the present but the past and future, as well as not only actual but potential features of situations. This dynamic reflection contains logical conceptual, imaginative, conscious and unconscious components. Based on these, individuals develop mental models of external events” (Bedny and Meister, 1999, p.71).

Apart from the preliminary definitions proposed by Endsley, more researchers have attempted to define the construct (e.g. Adams, Tenney & Pew, 1995, Sarter and Woods, 1991, Taylor, 1990). With more

research going on, the shift was clearly seen from defining the SA from only awareness to the user dynamic internal representation of the ongoing situation which takes input from the data in hand and also from the past results of the similar events happened.

With the introduction of various definitions of SA, the conflict lies between the definition laid down by Endsley, 1995a who describes SA as product of awareness on the behalf of individual performing some decision making process, Fracker in 1991 who describes SA as process itself for gaining the awareness of the process by undergoing it without having prior knowledge in the form of events and Smith and Hancock, 1995 who consider SA as combination of both Endsley and Fracker interpretation in defining the term SA .

This is a debate that will no doubt continue unabated; however, we argue that in order to fully appreciate the construct, an understanding of both the process and the product is required (Stanton, Chambers & Piggott, 2001).

2.2 Situation Awareness Theory by Endsley

According to the report "Comparison of measures", HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007 ,SA theories were primarily based on SA of the individual operators undergoing set of decision making process as stated by (e.g. Endsley, 1995a) and the models that currently dominate the literature are individual oriented theories, including Endsley's three-level model (Endsley, 1995a), Smith and Hancock's perceptual cycle model (Smith and Hancock, 1995) and Bedny and Meister's activity theory model (Bedny and Meister, 1999). These models have been divided on the basis of process (Fracker) vs. product (Endsley) vs. combination of both product and process (Hancock and Smith).

These models differ from each other in terms of psychological approach which takes into account the logic behind describing SA. The three level model (Endsley, 1995a) takes into account an information processing approach, Smith and Hancock (1995) use a perceptual cycle model approach, and Bedny and Meister (1999) use an activity theory model to describe SA. Within the literature, it is these three theoretical perspectives that currently dominate (Stanton, Chambers & Piggott, 2001).

2.3 The Three-Level Model

Endsley's three-level model describes SA as a product comprising three hierarchical levels that describes situational assessment of the operator or individual to achieve the SA which separates it from the processes. According to " Comparison of measures", HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007.

The Endsley model is a basic model which takes into consideration information as a input given to the system or the individual performing some complex operation or involved in some decision making

process and it only after the individual gets the information, he is in the position to perceive the information from the set of inputs he got and later leads to the decision making and action execution.

According to the model (By Endsley) SA acquisition and maintenance is influenced by individual (e.g. experience, training, workload etc), task (e.g. complexity) and systemic factors (e.g. interface design) (Endsley, 1995a). A brief description of the three levels of SA is given below.

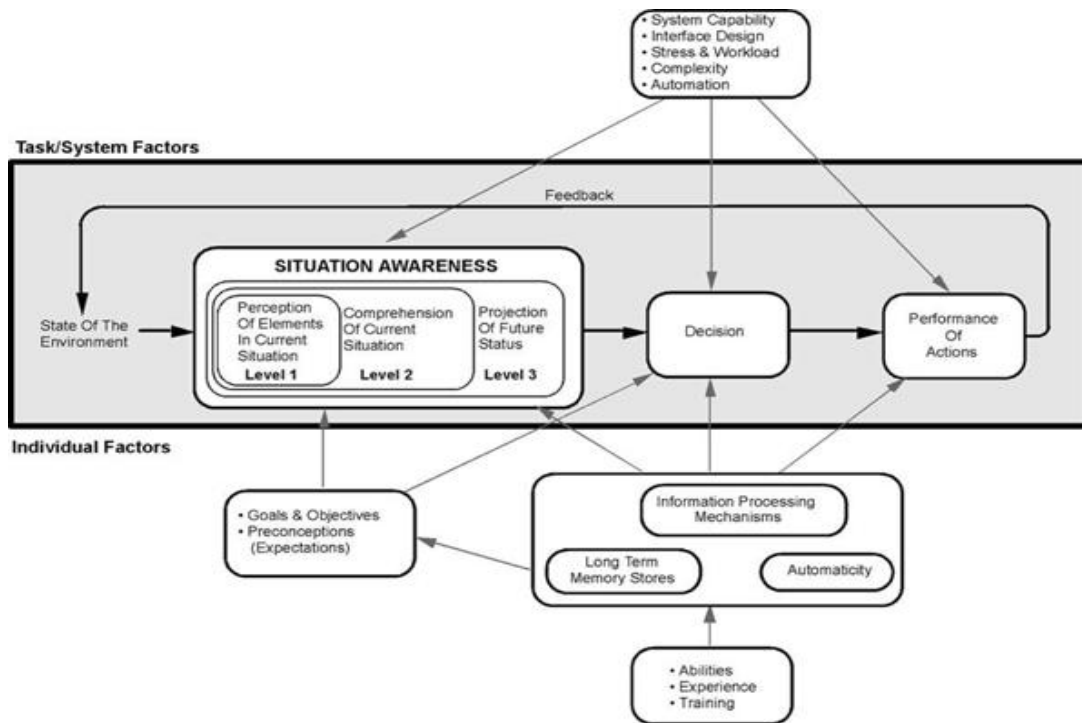


Figure 2.1: Endsley's model of Situational Awareness. Courtesy of Wikipedia online Encyclopedia <
<http://en.wikipedia.org/wiki/endsley>

Level 1: Perception of the Elements

The first step involves perceiving the status, attributes and dynamics of task-related elements in the surrounding environment (Endsley, 1995a). In the report "Comparison of measures", HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007, Endsley states at this time the only thing which is important is to perceive the input data and no further processing of data have to be considered. The data perceived by the individual undergoing the decision making process depends on variety of factors which includes the nature of task, complexity of the operation, nature of input information, level of difficulty, dependent variables, operator goals, experience of the individual, expectations of the process and operator, design interface, system design complexity, man machine interaction, capabilities and automation of the machinery. According to Endsley (1995a), "a person's goals and plans direct which aspects of the environment are attended to in the development of SA" (Endsley, 1995a, Page no 47).

Level 2: Comprehension of the Current Situation

According to Endsley as stated in the report of comparison of measures “HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007”, The Level 2 SA Level takes one step ahead from perceiving the data to interpretation the data level 1 to level 2. Level 2 SA involves understanding for user or individual to comprehend or realize the importance of the data in relation to the task and goals ahead. It is very important stage as the goals of the task depends on the understanding of important data which can accomplish a particular work task in much effective and safe way. During the acquisition of level 2 SA “the decision maker forms a holistic picture of the environment, comprehending the significance of objects and events” (Endsley, 1995a, pg 37).

Similar to level 1 SA, the interpretation and comprehension of SA-related data is influenced by an individual's goals, expectations, experience in the form of mental models, and preconceptions regarding the situation. The only difference here is the ability of individual or operator to recognize the important elements or inputs which are most important for achieving the goals of particular work task. Use of experience in the form of mental models to facilitate the acquisition of level 2 SA. According to Endsley, individual with more experience will use their experience from the past to facilitate the combination of level 1 SA with Level 2 SA to achieve its goals in much better way.

Level 3: Forecasting Future System States

In the report of comparison of measures HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007, Endsley and by Paul M. Salmon, the level 3 SA takes into account future system states meaning it involves in determining future states of the system and its elements for the complex and different decision making processes which involves intense thinking and assessment to achieve a desired goal in the future event which is unknown to this time of level 2 SA. Using a combination of level 1 and 2 SA-related knowledge, and experience in the form of mental models, individuals can forecast likely future states in the situation.

For example, pilot flying military aircraft uses Level 1 and level 2 SA related information to decide the course of action of the enemy plane, its position, location and objectives as depicted by Endsley, 1995a. Another random example is captain of ship sailing in region with bad weather or environment can take into account his past experience and the input data available which depicts some key leads for that particular region. The captain of the ship can do this through perceiving and understanding the speed, location, formation and movements of tides and environment inputs and comparing this to experience (in the form of mental models) of similar situations. This comparison of situational data with past experience allows operators to project future situational states.

Therefore it becomes an obvious statement that 3 level model plays an important role in the development and maintenance of SA. Features in the environment are mapped to mental models in the operators mind, and the models are then used to facilitate the development of SA (Endsley, 1995a).

Mental models (formed by training and experience) are used to facilitate the achievement of SA by directing attention to critical elements in the environment (level 1), integrating the elements to aid understanding of their meaning (level 2) and generating possible future states and events (level 3).

2.4 Interactive Sub-Systems Theory

In the interactive sub system theory proposed by Bedny and Meister (1999) stated in the report of comparison of measures “HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007”, Endsley takes into account a different approach as compared to product theory proposed by Endsley 1995a, which describes SA as merely an activity approach focusing various processes that associated with desired work task to be performed by human taking into account the human behaviour towards the desired task in hand. The theory of activity takes into consideration that individuals possess goals which shows the end state of the activity, motives that direct them towards the end state and course of actions, methods that help in achieving these goals and end states By (Bedny and Meister, 1999).The model is shown below:-

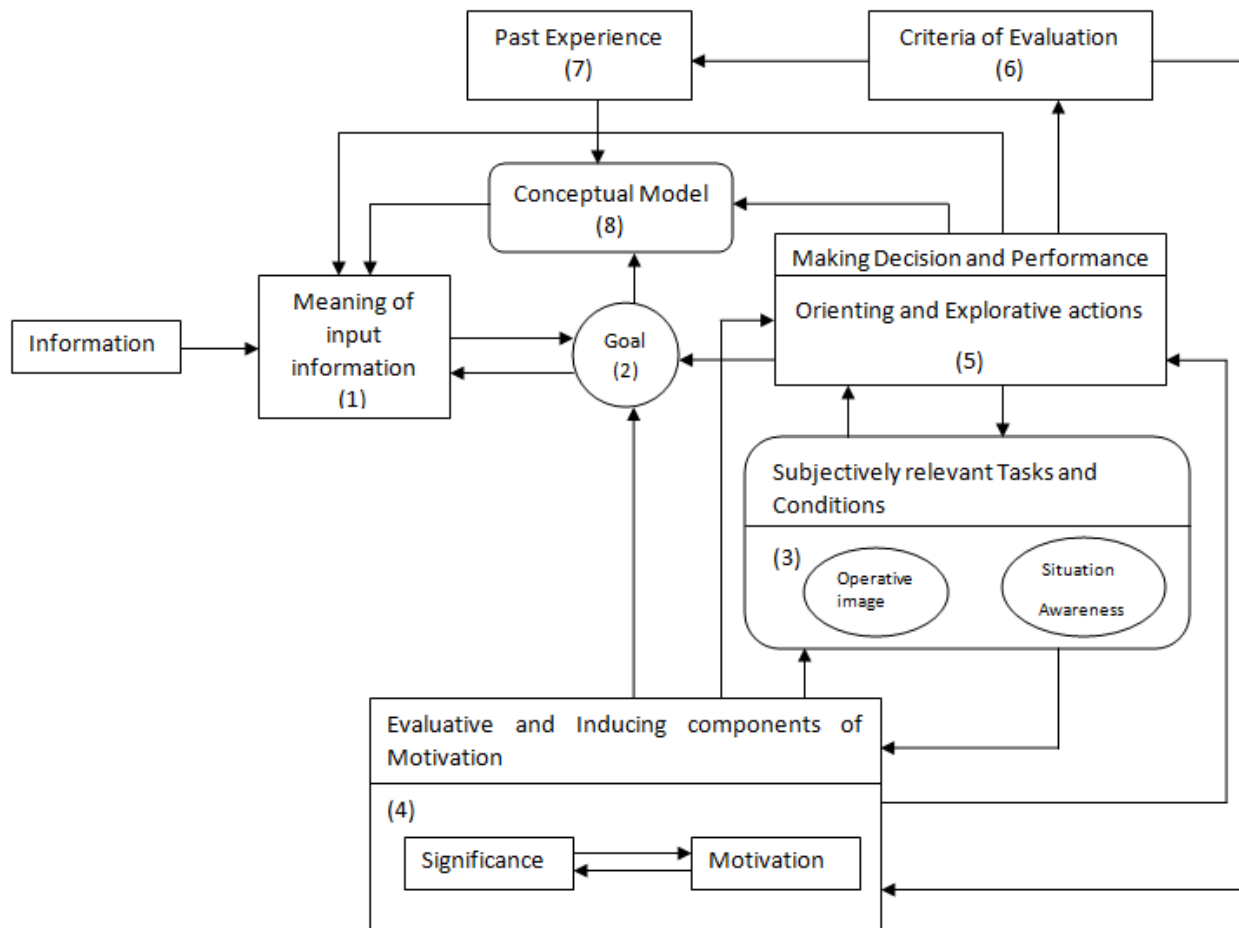


Figure 2.2: Interactive Sub Theory model of Situational Awareness

The differences between the goals and the present situation motivate an individual to take action towards achieving the goal. The end state activity comprises three stages: the orientation stage, the executive stage and the evaluative stage (Bedny and Meister, 1999). The orientation stage focuses the initial development stage where the internal picture of the current situation is accessed. The executive stage involves proceeding towards a desired goal via decision-making and action execution.

According to Bedny and Meister (1999) as stated in the report "HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007" comparison of situational awareness measures, Endsley propose that each and every functional block presented in the above figure has particular role to play in the development and maintenance of SA and the blocks are the activities which upon fulfilment helps in achieving the desired outputs through SA. It is also important to mention here that model itself is prototype of basic 3 level model proposed by (Endsley, 1995a) which accounts for Level 1, 2 and 3 SA. eg the interpretation of information as input is influenced by internal block with meaning of input information as to what kind of information is needed for the said goal, which information is important for the goal and how it is relevant to the system. In short, these block carrying information depend on each other to attain their specific goals. The interpretation of incoming information (function block 1) is influenced by an individual's goals (function block 2), conceptual model of the current situation (function block 8) and past experience (function block 7). This pattern of interpretation then modifies goals and model of current situation. Critical environmental features are then identified (function block 3) which is primarily based on their importance in task or final goal with evaluative and inducing components of motivation which include a) Sense b) Motivation functional block 4, which directs their interaction with the world (function block 5). The extent to which individual proceeds to engage the task goals is determined by their goals (Block 2) and their evaluation of current situation (Block 6). The result of the individual/operator interaction with world is recorded and is stored as experience (Block 7) which is related to conceptual model (Block 8).

According to the model, the core processes involved in the acquisition of SA are the conceptual model (functional block 8), the image-goal (functional block 2) and the subjectively relevant task conditions (function block 3). "Bedny and Meister" (1999) therefore suggest that the conceptual model (function block 8), the image goal (function block 2) and the subjectively relevant task conditions (function block 3) are the key blocks involved in the development of SA (Stanton et al, 2001).

2.5 The Perceptual Cycle Approach

In the literature from the report comparison of situational awareness during command and control activity; HFIDTC/2/1.2.5/3 Version 2/ 25 September 2007, Endsley approach has been employed by Smith and Hancock's (1995) who considered SA as database of knowledge creation and to use the knowledge to take actions. Smith and Hancock's model was influenced by perceptual cycle model by Niesser's (1976) which take into account the individual's interaction with the world and role of sequence of information's in our interactions. The perceptual model includes the perception of the individual on external explorations

which is again the subset of the knowledge model designed to perform the task. It has been observed that outcome of the interaction with the world result in modifying original knowledge model which in turn directs further exploration. This process of directed interaction and modification continues in an infinite cyclical nature. Using this approach Smith and Hancock (1995) came to the conclusion that SA is neither present in the world nor in the individual itself but it is the knowledge which individual gains through repeated interactions with the world. Smith and Hancock (1995) found that the process of achieving and maintaining SA takes into account internal mental models inherited inside the individual which he attains either by repeated conversation with the world or by past experience of similar situations.

These mental models thereby acts as intermediate for undergoing the situational events bringing an individual to the level where he is position to pay attention to the environment to meet certain specific tasks and directing them to take appropriate course of action depending upon the prior knowledge attained by them through repeated interactions or through past similar experiences (Hancock and Smith model). So by doing this according to him, individual would find him in better position to understand the situation for meeting their ultimate end goals. In the meanwhile, some uncertainties and unexpected events give birth to changes in the already existing model which is illustrated in detail in the figure shown below:-

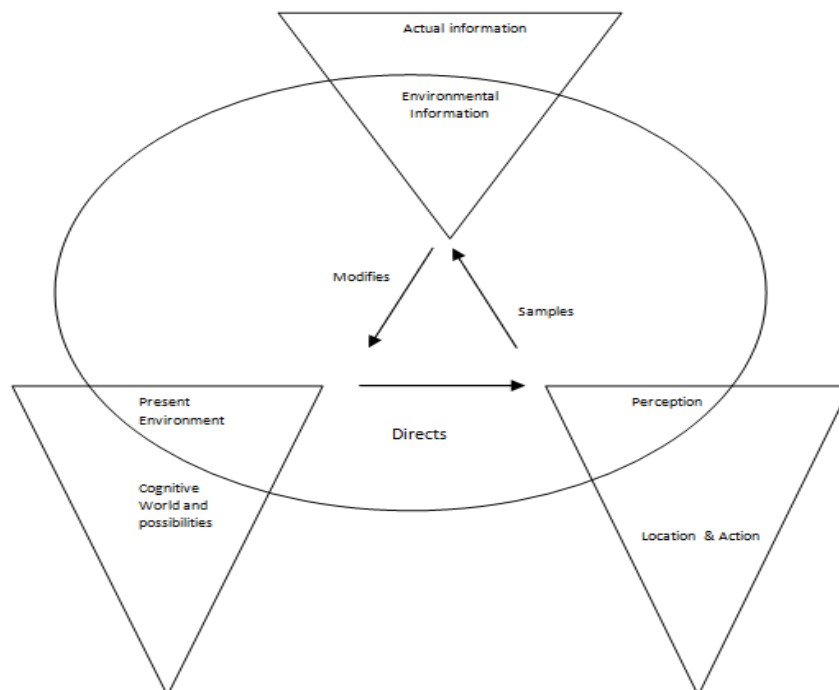


Figure 2.3: Perpetual cycle model of Situational Awareness. Courtesy of Wikipedia online Encyclopedia<

<http://en.wikipedia.org/wiki/perpetual>

So unlike the three level models which consider SA as product model, according to Endsley (1995a) and is in isolation to process. Here the SA is viewed as both process and the product giving a product which is separate from the processes, SA is viewed as both process and product, offering an explanation of the cognitive activity involved in achieving SA and also a judgment as to what the product of SA comprises. Smith and Hancock's (1995) model therefore based on the representations of situational awareness in different environments. For example, in reference to air traffic controllers 'losing the picture', Smith and Hancock suggest that "SA is not the controller's picture. Rather it is the controllers SA that builds the picture and that enables them to know that what they know is insufficient for the increasing demands." (Smith and Hancock, 1995, p. 142). To summarise, each theory has its useful components. As Stanton et al (2001) point out, 'there appears to be an element of truth in all of them'. In terms of theoretical utility, Smith and Hancock's model is perhaps the most useful, since it caters for the dynamic aspects of SA (Stanton et al, 2001), whereas the theory of activity model is useful since it details the internal activities involved in developing SA when an individual performs activity. Endsley's three level model, on the other hand, offers a very neat and intuitive description of SA which allows researchers to measure the construct simplistically and also to abstract SA requirements at each level. As a consequence of this, the three level model is the most useful for researchers wishing to describe the nature and content of operator SA in complex systems and also for measuring the construct. Further, Endsley's work has proved to be the most useful for informing system design and evaluation (e.g. Endsley, Bolte & Jones, 2003, Endsley & Garland, 2000).

2.6 The Problem with Accident Studies

In order to nail down the possible factors affecting the lapse in the situational awareness, many approaches could be followed. One possible way is to go by conventional way of investigating the record or data base of maritime accidents occurred in the past. Generally not much has been said and recorded in terms of accountability of human errors and practices that could help in analyzing the situational awareness.

It has also been observed that the records of maritime accidents have some vital parameters missing in terms of human involvement or errors as most of the companies do face saving by hiding the information which if revealed would result in bad name for their company. There has also been some instances where there is lack of information and data which resulted in miscommunication and misleading the investigation.

Therefore depending only on the records and data of maritime accidents in the past is not wise step to evaluate the broad term situational awareness. Mica Endsley stated that the term situational awareness is much bigger and board term which could cover wide range of information gathered from reports, literature review, near miss reports and even normal operations on board the vessel which could result in some other loss of situational awareness.

Besides the above incredible achievements in the maritime industry with the introduction of so many advanced and sophisticated machinery, technology on board. It is unfortunate that maritime causality rate is still on the higher side which is beyond the point of acceptance. The next thing which comes out in our mind is what could be the reason behind it which triggers panic on board causing unexpected accidents thereby causing great loss in terms of human and material. The first thing which comes in our mind is failure in the machinery on board a vessel. Yes off course this is one of the reasons why accidents do happen. But it is also important to mention here that 56% of the accidents happen on board are due to one or other kind of human negligence often called as Human error where as 30% of the accidents do occur either due to lack of knowledge, lack of SA or even loss of SA due to some distracting events happening on board a vessel(TSAC-6).From the data we have from TSAC-6,the approximate figures for the percentage of the accidents occurring either due to lack of SA or human errors account for 80-88% of tanker accidents,75% of towing vessels undergoing groundings,85-95% of collisions ,70% of collisions and approximately 72% of accidents occurring due to fire and explosions.

Keeping in view the rate of accidents and amount of casualties occurring, it is most important to focus what is causing what. What would be most important areas to be focused and addressed in order to keep the incidents to minimum and foremost area of concern which comes into the mind on first instance is human error and lack of SA.

A Dutch study of 100 marine casualties found that the number of causes per accident ranged from 7 to 58, with a median of 23.It often starts with minor errors or minor mistakes which doesn't seem threatening to cause a major catastrophe but when these minor things and events converge they result in major causality. It has been observed that majority of the accidents which happen due to human error is caused by combination of human error. It means it is incapability of human ,individual or operator to recognise and put check on the minor mistakes committed by him and due to this lack of SA,leads to wrong assessment of the situation and thereby resulting to an unavoidable accident .

In majority of the accidents caused due to human negligence, it is often caused by more than one or two people which result in creating condition for the accident if not addressed in appropriate way. That means that if just one of those human errors had not occurred, the chain of events would have been broken, and the accident would not have happened. Therefore, it becomes an important issue not only to address the safety on board but also to be awarded of other dependent events which if not addressed in proper way would result into catastrophic results.

This forms the hypothesis for the involvement of events focusing on the SA awareness and how to work in close collaboration in order to have better understanding of each and every step in an ongoing process.

By keeping this we can have better command and there by having the capability to break the chain of errors and mistakes thereby providing better and safety of the system.



Figure 2.4: Showing fatal accidents/Collisions due to human error/Loss of SA. Courtesy of Wikipedia online Encyclopaedia < <http://en.wikipedia.org/>

2.7 Examples of accidents

(Literature reviewed from report on Marine accidents by National Transport Safety Board)

The first example is the collision of the M/V SANTA CRUZ II and the USCGC CUYAHOGA, which occurred on a clear, calm night on the Chesapeake Bay. The visibility was good and both the vessels saw each other as the radar do. So what could have been the reason for the collision when everything seems going smoothly in perfect weather conditions that day. CUYAHOGA turned in front of the SANTA CRUZ II. In the collision that ensued, 11 Coast Guardsmen lost their lives. What could have caused such a tragedy? Equipment malfunctions?

It was clear example of human error on board vessel. There were primarily two errors made, first one was made by CUYAHOGA's captain, he miss read the configuration of running lights on SANTA CRUZ II and thereby resulting in wrong approximation about the heading and size of the vessel. As the number of crew on board was cut short to less number there by over stressing the crew to do all the operations alone. They were in the state of excessive stress caused by over workload. Fatigue and excessive workload have been considered as the major reasons for the catastrophic collision.

The second example is the grounding of the vessel TORREY CANYON. This also happened at the time of clear weather-day time when it was sunshine, daylight on the English Channel proceeding through Scilly Islands. The ship ran around and thereby spilling around 100,000 tons of oil.

From the report four human errors were found which were held responsible for the accident. The first one was the enormous economic pressure exerted by the management on the master to keep to schedule. He was about to unload cargo and for that he has to head into deep water terminal in Wales.

In the above two cases, we have seen that human errors are of different kinds. It could be simple lack of knowledge of the scenario, it could be total loss of SA and wrong assessment to due lack of experience and inability to read the equipment .So in short human error is much bigger and wider term as compared to operator or individual making an error.

Some more examples of accidents involving human errors have been demonstrated without undergoing in detail and are as follows:-

STAB 1975 (Glasgow)

Tanker, EDITH TERKOL

A Danish tanker, EDITH TERKOL in 1975 having GZ curves capsized in the Baltic Sea near Swedish island of Goaland. There was sudden rolling of the vessel and immediately capsized. She was on the ballast journey. Only two persons on board survived.

STAB 1982 (Tokyo)

The "ALEXANDER L. KIELLAND" was initially made as a drilling rig, but had been served as an accommodation platform for Ekofish field in the North Sea. So in order to transform the vessel to cater new needs for accommodation purposes, some modifications have been introduced in the structure in which new containers were mounted on the deck, forward to the drilling tower. Due to overloading the structure, enormous stress was produced and structure failed. The fatigue started with fatigue crack in the Bracing D-6 and other five bracing which are connected to column D subsequently exposed to enormous fatigue and finally failed due to over loading resulting in the total loss of the column.

STAB 1986 (Gdansk, Poland)

Similarly Large Stern Trawler on 6th January 1982, a large stern trawler of 549 gross tonnages, similar to the "GAUL", capsized and founded during hauling a net in the Bering Sea. In the accident out of 33 crew members on board, only one survived and 32 people lost their lives.

STAB 1994 (Florida, EEUU)

Another human error responsible for the capsizing of vessel "ZENOBIA", due to load shifting onboard caused by uncontrollable manoeuvre motion.

“STARTS PRIDE II” Fishing vessel

The paper “STRAITS PRIDE II”, 1994 illustrates the capsizing of the small fishing vessel. The analysis shows the importance of Para vanes with respect to the stability of the ship and is considered to be the most important element to be taken into account during the designing process. This study focused on the capsizing of this small fishing vessel, which partially lost the side pare vane in the capsize, and pointed at other capsizes where the par vane was considered to be a contributing factor.

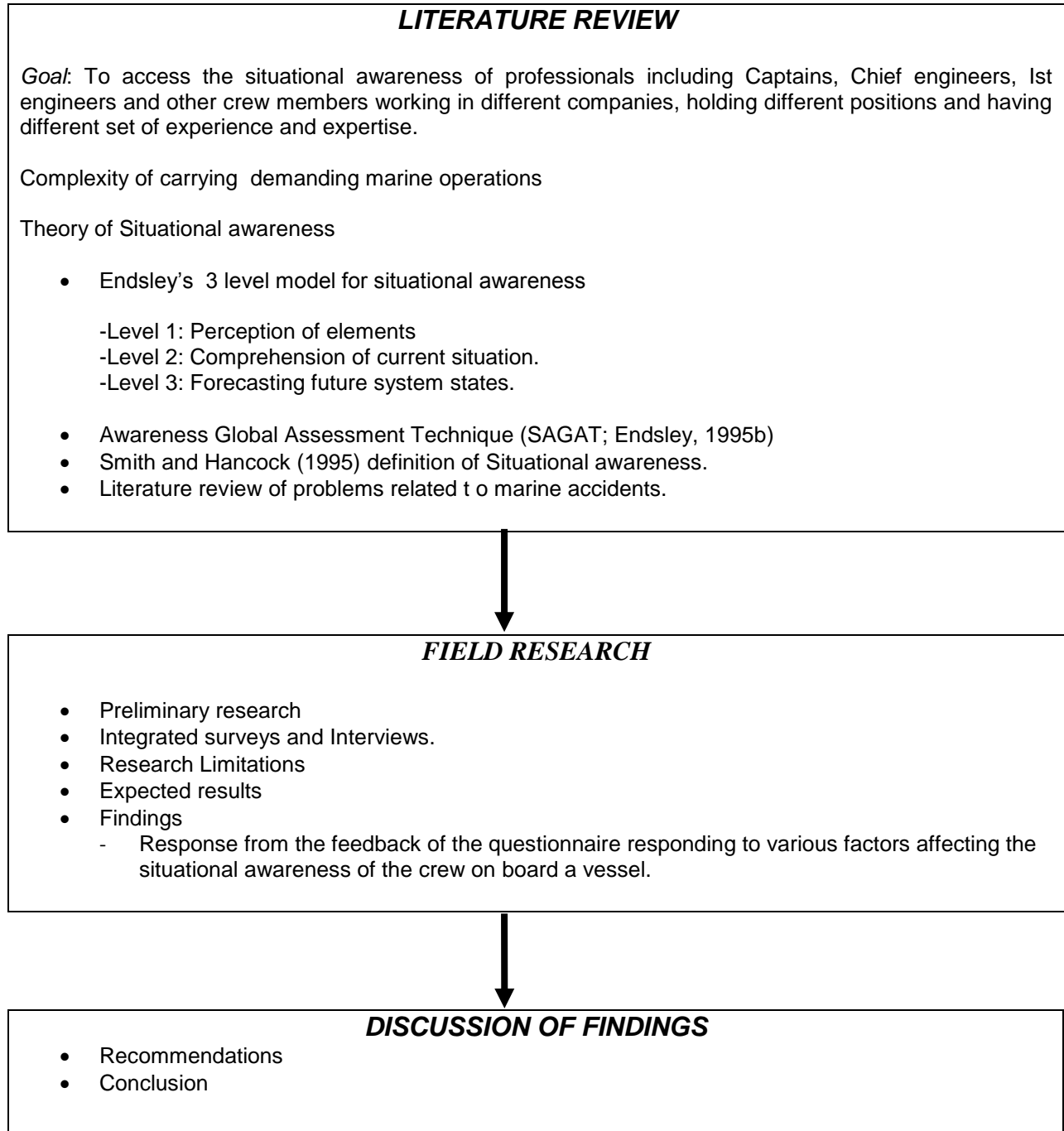
STAB 1997 (Varna)

Another chapter underlying the human error resulting in the sinking of cargo ship in front of Catalonia Coast in Spain just after two hours of departure when the weather was clear. The accident was investigated by company and the port authorities in order to find out the possible reasons for capsizing of the vessel. It was observed the accident occurred due to the stability of the ship which got disturbed due to sudden shift of load on the vessel due to sharp manoeuvre motion.

Chapter 3

Methodology

3.1 Flow chart



3.2 Theory

It has been observed that in the maritime industry, situational awareness plays major role and can be affected by psychological reasons for instance stress and fatigue issues on board the vessel. It could also be lack of communication between the crew members, use of restricted commodities like alcohol, drugs and also because of the presence of social stress elements in the minds of the crew on board the vessel. However, the most commonly observed cause of lapse in the situational awareness are fatigue issues, mental workload and social stresses. However there are number of programs which are run by the companies in service that help the crew to have better situational awareness of the system and activities they performing.

The aim of these programs is to highlight the possible loopholes resulting in the lapses in situational awareness of crew members working on the vessel. These programs consider the possible human errors made by the crew members on carrying out their regular normal activities on the vessel. Identifying the possible lapses in the situational awareness resulting from human error would not be enough to go in deep to find out what went wrong. It is also important to find out the appropriate reasons as to what made the person to commit a mistake and under what circumstances and situations it happened.

Therefore it is important to pin point the possible factors that are responsible in effecting the normal functioning of the crew and thereby reducing the human errors on board the vessel. There for an effort has been made to find out the possible factors and reasons which affect the situational awareness of the crew members there by addressing the issue and come up with possible recommendations that would eliminate the errors from the system and thereby making the maritime operations much safer in future.

3.3 Preliminary Research

The Preliminary research was conducted from 2006 to 2007. The aim of the research is to get the information and knowledge of vessel operations and various elements associated with its functioning. For this, a questionnaire has been developed which covers various factors from fatigue issues on board vessel to social stresses and mental load. The Preliminary research also included some surveys and interviews with licensed captains and pilots onboard the vessel in the past.

3.4 Integrated Survey and Interviews

The survey portion of the interview consisted of several sections and was developed and altered on the basis of studies of situational awareness in the maritime industry and feedback acquired from the personnel working on ships holding different positions and having different skills and experience. The final survey was altered several times prior to feedback (see appendix A). Section one of the survey covers background information; responses in this section were used to determine the experience levels of the participants and help ensure accuracy of the data. Section 2 highlighted connections between fatigue and situational awareness. Section three identified the relationship between communication and situational awareness. Section four highlighted the relationship between social stress and situational awareness. Section six of the survey identified connections between mental workload and situational awareness. The questionnaire was formed and distributed among 12 personnel in the first session having different background, age, experience, and expertise and work experience. A comparison of the situational awareness factors was conducted and the predominant factor was identified.

3.5 Research Limitations

The scope of this research is limited to a few numbers of personnel engaged in the maritime industry working in different ships and performing certain specified roles. Research does not include interviews of other crewmembers such as deckhands, engineers, or cooks. It is also important to mention that data collected have been restricted to the operations carried out in some specified time of the year and things have been generalized after analyzing the factors. This could not be exact as it is difficult to generalize the data and to make recommendations based on a particular time of the year. Also in different times of years there is different intensity of traffic and this could easily vary the amount of stress level, mental load and situational awareness needed.

3.6 Expected Results

The findings show various factors that affect the situational awareness of the crew members working on board the vessel and how this lapse in the situational awareness results in causing fatal accidents or possible catastrophic incidents. This study was also expected to highlight trends in the relationship between the participants' background and situational awareness. Getting the feedback from the questionnaire filled by participants helped in generalizing the outcomes that could play an important role in determining factors affecting situational awareness on board the vessel. The results would suggest areas for future research.

Chapter 4

Results

4.1 Background of Participants

The questionnaire has been spread in two groups. In the group we have 12 people. All are from different backgrounds, working in different companies, performing different roles and have different experience levels. The level of experience varies from captain of the ship to Chief Engineers, engineers, first officers, Second Officers and some recent graduates who joined the ship recently. The experience level of the participants interviewed is between 2 to 25 years. Time spent underway ranged from 90 days to 180 days per tour of duty. When asked to describe their current health, nine participants stated that they were in excellent health, while seven stated they were in good health and 4 stated they were in fair health.

4.2 Fatigue

Fatigue was described as a state of exhaustion that affects concentration and induces feelings of concern about vessel accident.

Table 4.1 Methods to address fatigue.

NOISE,VIBRATIONS AND INSULATION	09
MULTI SHIFTS,6 HOUR ON-6 HOUR OFF	07
ENFORCEMENT OF 12 HOUR RULE	03
WORKING OVERTIME	11

Table 4.1 shows the breakdown of the methods employed by personnel on board the vessel to address the fatigue issues. On the basis of the data acquired from the questionnaire, we can be in better position to measure the situational awareness of fatigue. The results of this study show that nine vessels on which captains/crew/ engineers are currently employed (50%) have installed noise and vibration absorbing barriers onboard their vessels. Noise and vibration barriers are the modifications in the engineering context on board the vessel that can reduce the extent of noise and vibrations originating from the engine.

This does not include muffler systems, which only reduce engine noise, but not engine vibration. For one participant it doesn't matter what kind of shift he is given and 02 participants doesn't want to comment on the issue.

Under 46 CFR 15.705 (c), an operator steering a vessel bigger than 26ft is not allowed to work for a period more than 12 hours in 24 hour period. The results from Table show that 07 people working in different companies enforce multi shifts which is 6 hour on and 6 hour off, where as only 03 people working in three different companies described that they enforce of 12 hour rule or their desire to work in straight 12 hour shift .

Table 4.2 Crew Endurance Training.

Often	01
Seldom	04
Never	03
Doesn't know/Don't want to answer	04

Table 4.2 measures how many companies take measures to conduct fatigue or crew endurance training. Table shows that 9% (approx) of companies, who employ the licensed officers interviewed, conduct this training on a regular basis, while 33% conduct this training on an occasional basis ,25% of companies never conduct this training and 33% of companies or participants doesn't know about the program.

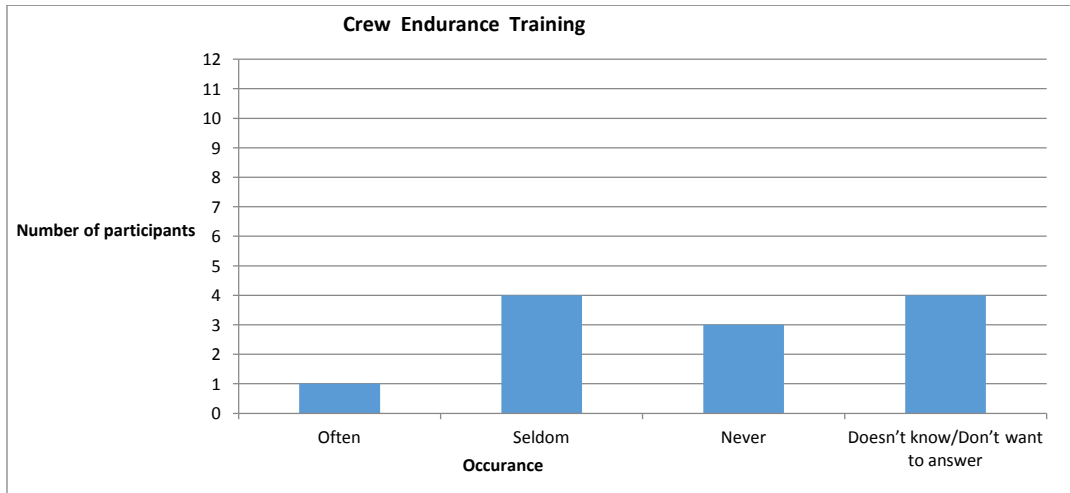


Table 4.3 Working over time.

Often	04
Seldom	07
Never	01
Doesn't know/Don't want to answer	00

Table 4.3 shows how many companies/participants work overtime for conducting their normal duties on board vessel for last one year of their sailing. It shows that 04 participants (33.33%) often have to work overtime on board vessel to carry out their normal duties,07 participants (58.33%) does overtime occasionally when there is a need to do so,01 participant (9%) doesn't overtime on board vessel to perform his normal duties.

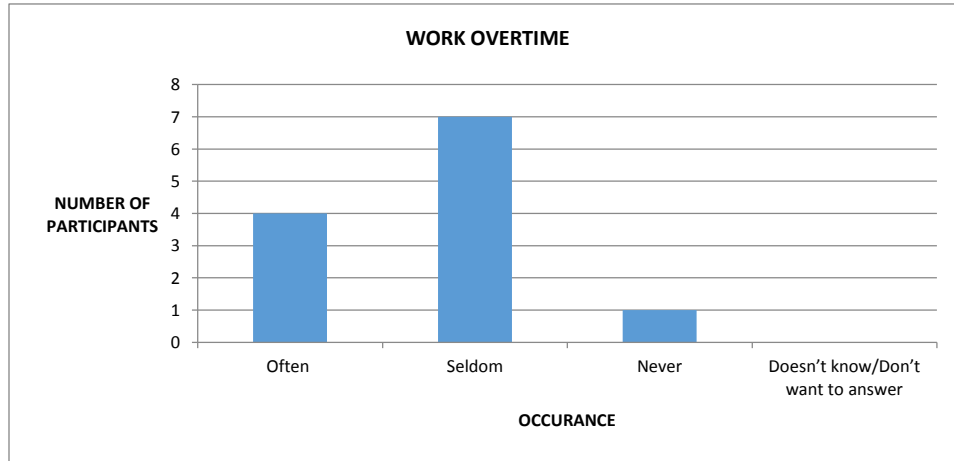


Table 4.4 Fatigue from engine noise

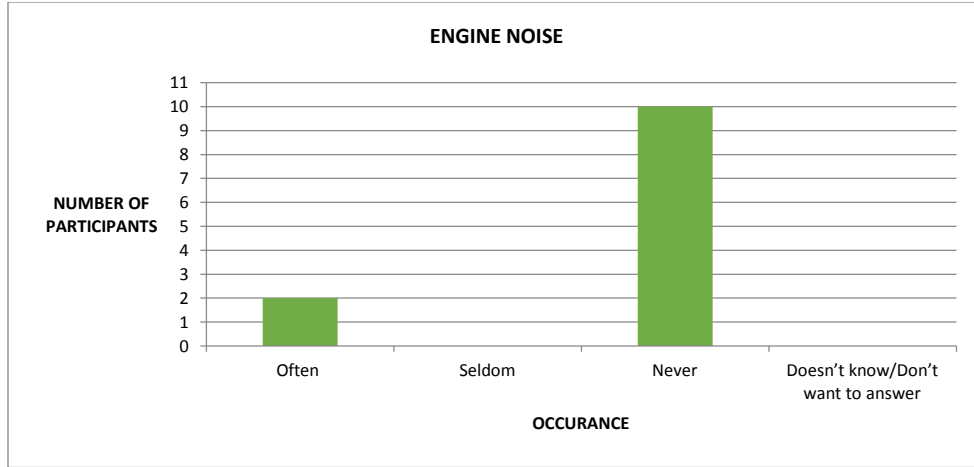
Often	02
Seldom	00
Never	10
Doesn't know/Don't want to answer	00

Table 4.5 Fatigue from engine vibration

Often	01
Seldom	03
Never	08
Doesn't know/Don't want to answer	00

Tables 4.4 and 4.5 measure whether engine noise and vibration qualify as fatigue factor causing in convenience to the crew while sleeping in the night.

According to Tables 4.4, 02 participants (16%) often get fatigue from the noise of engine which causes discomfort to them from sleeping sound in the night, where as majority of participant on board a vessel 10 participant(83.33%) never get fatigue from the noise of engine there by having no problem in getting sound sleep after normal working on board a ship.



According to Table 4.5 ,01 participant (9%) often gets fatigue from the vibration of the engine which prevent him from getting sound sleep after normal working hours,03 participants (25%) participants occasionally gets fatigue from the engine vibrations which prevent them from getting sound sleep where as majority 08 participants (66.66%) doesn't get any fatigue from the engine vibrations there by getting sound sleep after normal working hours.

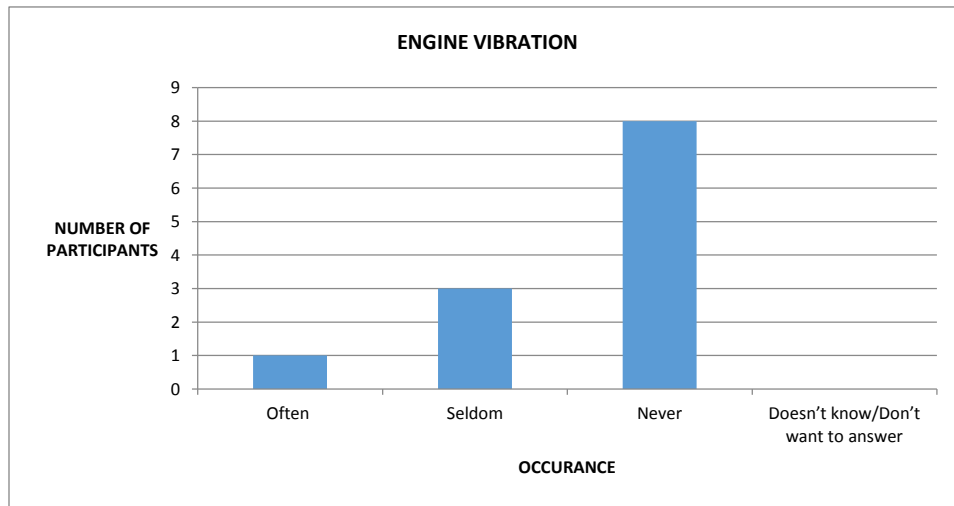


Table 4.6: Quality of sleep on board a vessel as compared to home

Good	02
Fair	10
Poor	00
Doesn't know/Don't want to answer	00

Table 4.6 shows the quality of sleep on board as compared to sleep at home. It shows that 02 participants(16%) have no problem with the quality of sleep on board vessel, they are of the opinion that quality of sleep on vessel is good where as majority 10 participants (83.33%) feel that the quality of sleep on board a vessel is fair as compared to what they have at home. This account for some kind of fatigue which could be result of inconveniences caused by the above mentioned factors in the tables above i.e. noise from the engine, vibrations and over time etc.

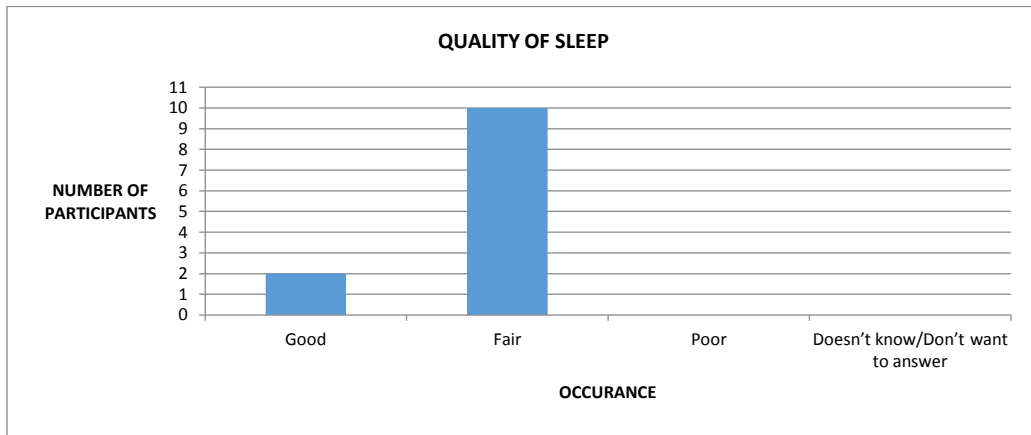
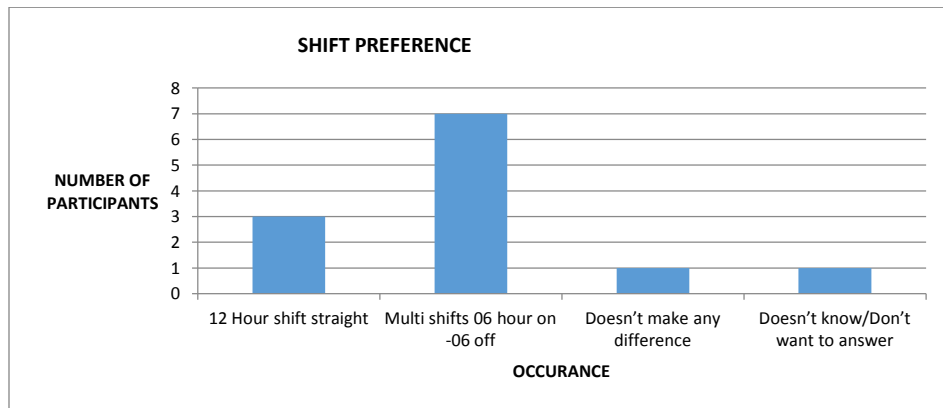


Table 4.7: Preference of shifts while working on board a vessel

12 Hour shift straight	03
Multi shifts 06 hour on -06 off	07
Doesn't make any difference	01
Doesn't know/Don't want to answer	01

Table 4.7 shows the preference of working shifts and it shows that 03 participants (33.33%) prefer to work on 12 hour straight shift,07 participants (58.33%) prefer to work on multi shifts of 6 hour on and 6 hours off, for one participant it doesn't matter if he choose to work on single 12 hour shift or work in multi shift of 6 hour on and 6 hour off and 01 participant doesn't want to answer the query.



4.3 Communication

Communication was described as communication with crewmembers, other vessels, or VTS and how much this helps them in attaining situational awareness.

Table 4.8. Deckhands report the results of rounds.

Often	04
Seldom	07
Never	00
Doesn't know/Don't want to answer	01

Table 4.8 shows how often the deckhands report to the captain regarding their routine rounds every single day. It shows that 04 participants (33.33%) feel that deckhand often report about the rounds to the captain, where as 07 participants (58.33%) feels that deckhands seldom report the rounds to the captain and one participate doesn't want to comment on the issue.

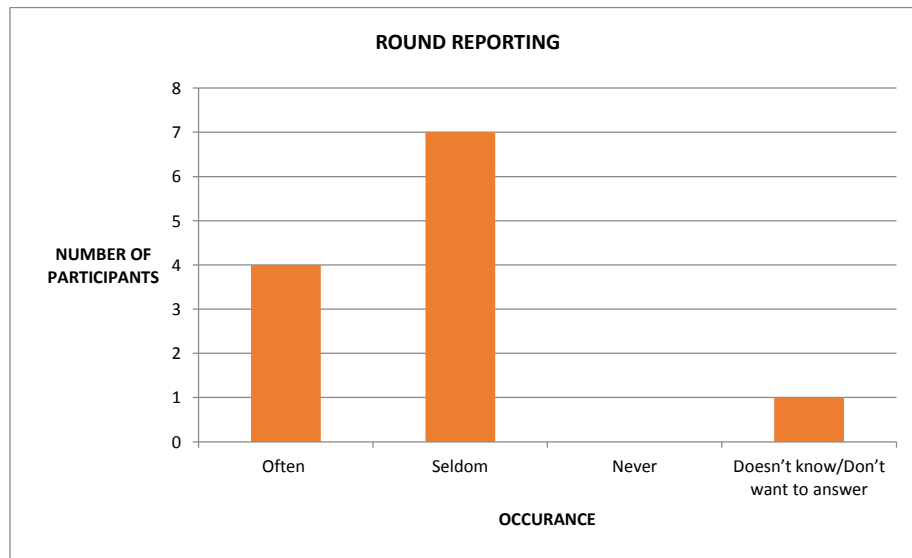


Table 4.9. Deckhands report the hazard to navigation at night.

Often	03
Seldom	05
Never	01
Doesn't know/Don't want to answer	03

Table 4.9 shows the reporting of hazard to navigation at night. It shows 03 participants (25%) feels that deckhands report the hazard to navigation at night, 05 participants (41%) feels that deckhands occasionally report the hazard to navigation at night, where as 01 participants feels that deckhands never report the hazard to navigation at night and 03 participants (25%) doesn't want to answer the query.

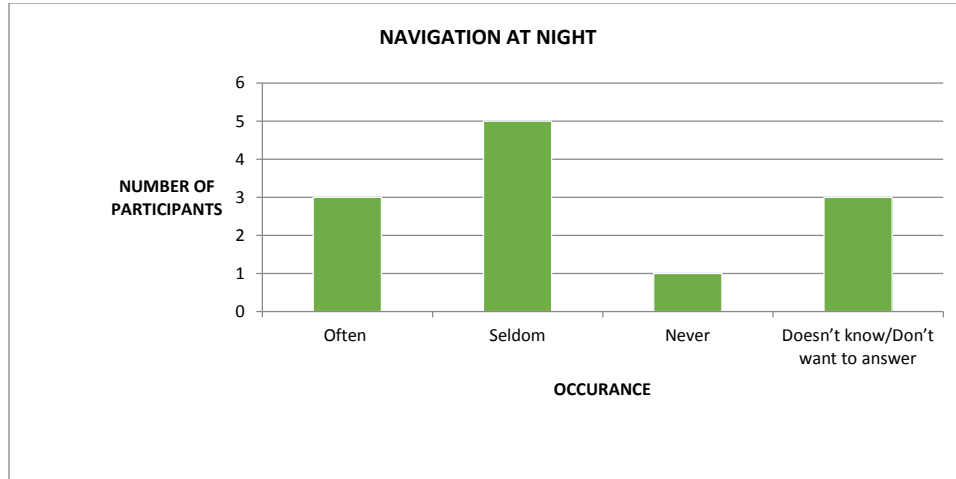


Table 4.10: Understanding of wind and current upon watch relief

Often	10
Seldom	00
Never	00
Doesn't know/Don't want to answer	02

Table 4.10 shows the understanding of wind and current upon watch relief. It shows 10 participants (83.33%) have sound understanding of wind and current upon watch relief, where as 02 participants (16.67%) doesn't want to answer the query.

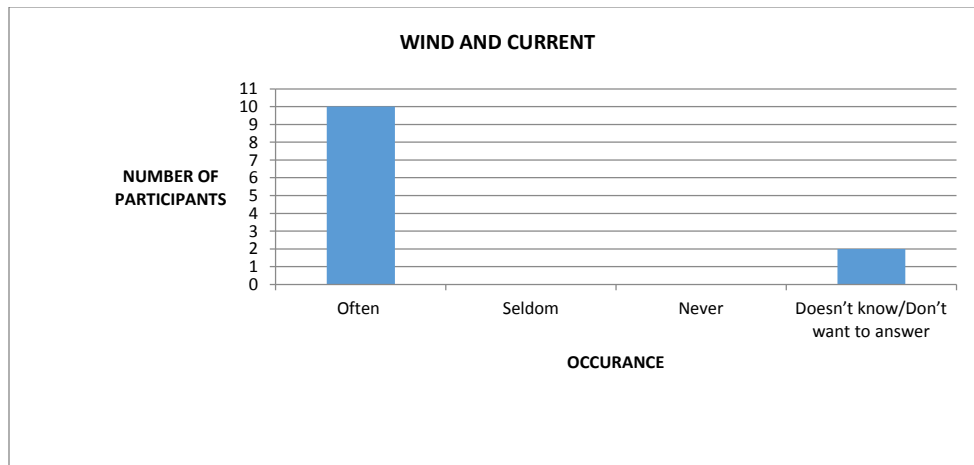


Table 4.11: Understanding of location of other vessels and hazards to navigation upon watch relief.

Often	09
Seldom	01
Never	00
Doesn't know/Don't want to answer	02

Table 4.11 shows the participant understanding of location of other vessels and hazards to navigation upon watch relief. It shows that 09 participants (75%) have the sound understanding of other vessels and hazard to navigation upon watch relief, where as one participant feels that he occasionally have the understanding of the other vessels and seldom report the hazards to navigation upon watch relief where as 02 participants doesn't want to comment on the issue.

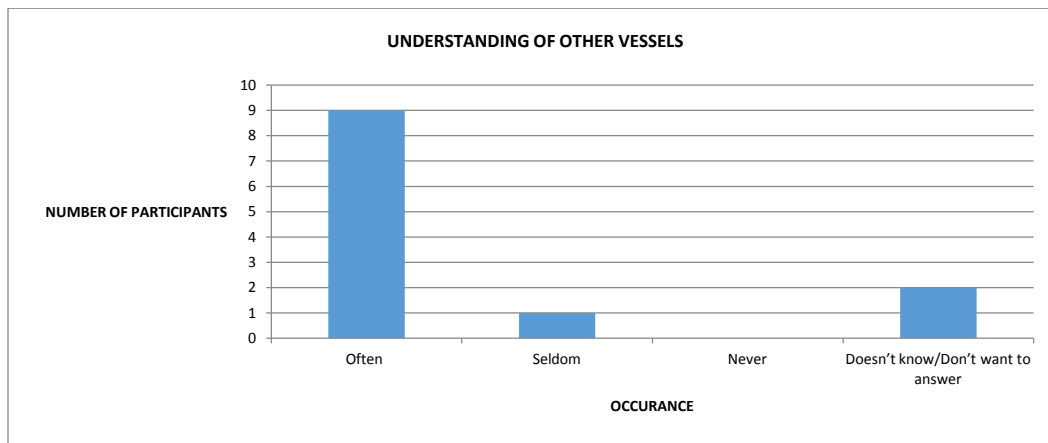


Table 4.12: Understanding of vessel navigation light configuration

Often	07
Seldom	02
Never	00
Doesn't know/Don't want to answer	03

Table 4.12 shows crew understanding of vessel navigation light configuration. It is important for the crew to have the understanding of vessel light configuration when passing across each other. From the questionnaire we see that 07 participants (58.3%) often have the understanding of vessel navigation light configuration, 02 participants (16.67%) occasionally understand the vessel navigation light

configuration and 03 participants (25%) doesn't want to comment on the issue may be due to policies of the company or having least knowledge about the system.

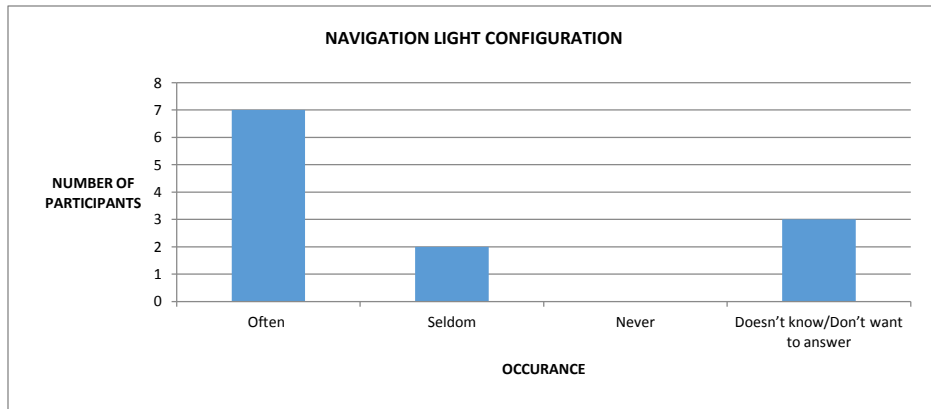


Table 4.13: Understanding of communication to other vessels through VHF-FM radio.

Often	07
Seldom	03
Never	01
Doesn't know/Don't want to answer	01

Table 4.13 shows the understanding of communication to other vessels through VHF-FM radio. It shows 07 participants (58.33%) often understand the communication to be given to other vessels through VHF-FM radio, 03 participants (25%) occasionally understand the communication with other vessels through VHF-FM radio where as 01 participant doesn't have any information regarding the communication to be made to other vessel through VHF-FM radio and one participant doesn't want to comment on the issue due to lack of knowledge.

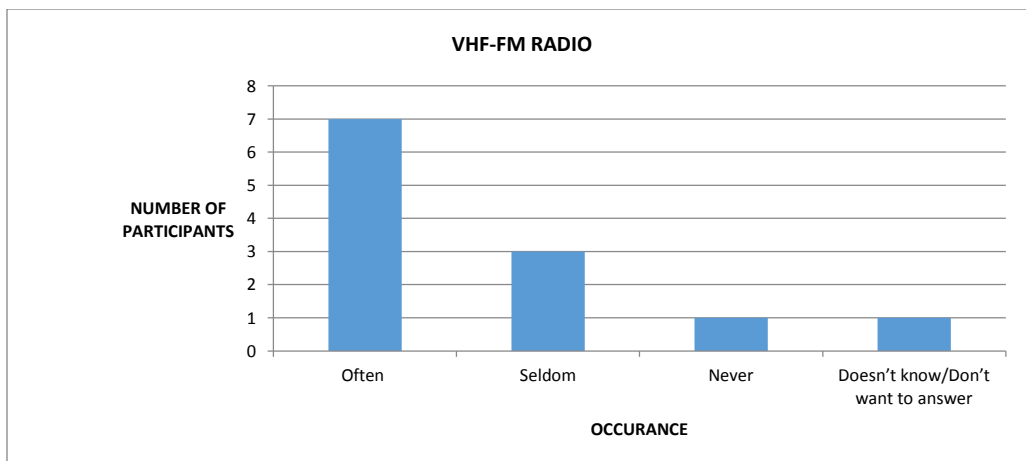


Table 4.14: Other commercial vessels to respond through VHF-FM radio.

Often	08
Seldom	02
Never	00
Doesn't know/Don't want to answer	02

Table 4.14 shows communication of other commercial vessels through VHF-FM radio. 08 number of participants often believes that other commercial vessels respond through VHF-FM radio, 02 number of participants believes that other commercial vessels occasionally respond with VHF-FM radio and 02 number of participants doesn't want to comment on the issue because of lack of information about it.

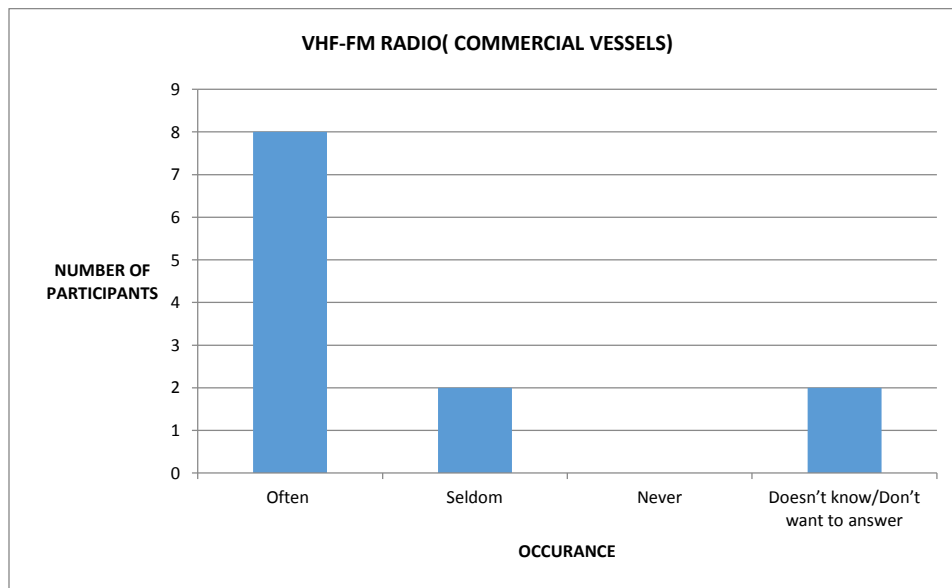


Table 4.15: Understanding of navigational light configuration by other commercial vessels.

Often	06
Seldom	02
Never	00
Doesn't know/Don't want to answer	04

Table 4.15 shows the understanding of navigational light configuration by other commercial vessels. 06 numbers of participants often believe that other commercial vessel do have understanding of navigational light configuration, 02 participants believes that only sometimes commercial vessels understand the navigation light configuration where as 04 number of participants doesn't want to comment on the issue due to lack of information.

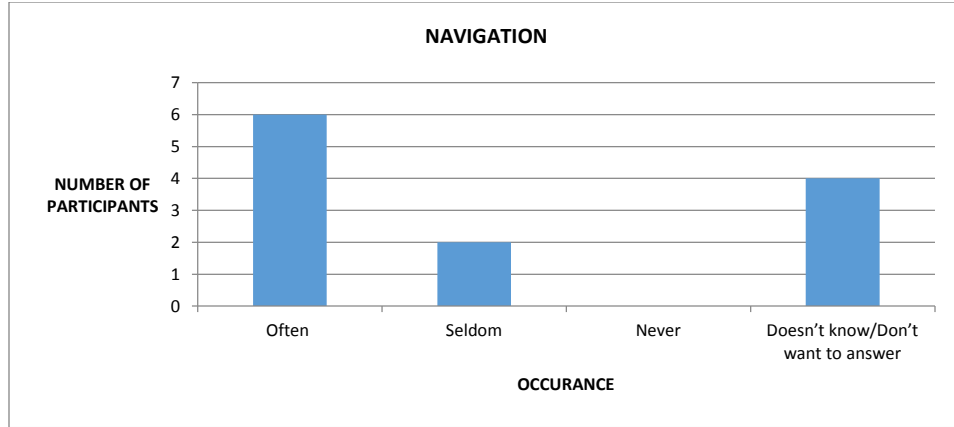


Table 4.16: Understanding of communication to other recreational vessels through VHF-FM radio.

Often	04
Seldom	04
Never	00
Doesn't know/Don't want to answer	04

Table 4.16 shows the crew member understanding of communication through VHF-FM radio with other recreational vessels. 04 number of participants often believe that they have understanding of communication through VHF-FM radio with other recreational vessels and equal number 04 participants believe they seldom have the knowledge and understanding of communication by VHF-FM radio with other recreational vessels and also 04 number of participants doesn't want to comment on the issue.

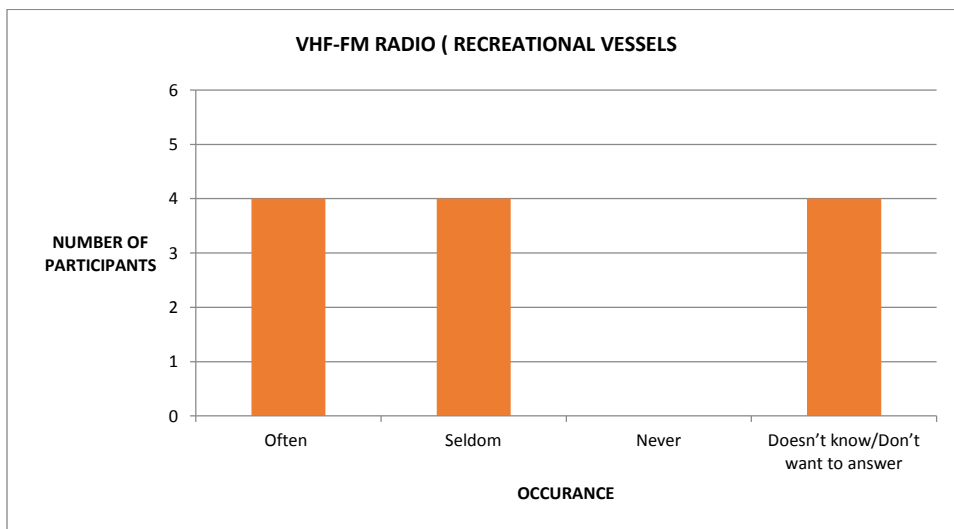


Table 4.17: Understanding of meaning of 1 and 2 whistle signal by recreational vessels.

Highly	02
Seldom	05
Never	01
Doesn't know/Don't want to answer	04

Table 4.17 shows the understanding of 1 and 2 signals by recreational vessels. 2 number of participants often believe that other recreational vessels understands the meaning of 1 and 2 whistle signal, whereas 05 number of participants seldom believe that other recreational vessels understand the meaning of 1 and 2 whistle signals and 04 number of participants doesn't want to comment on the issue.

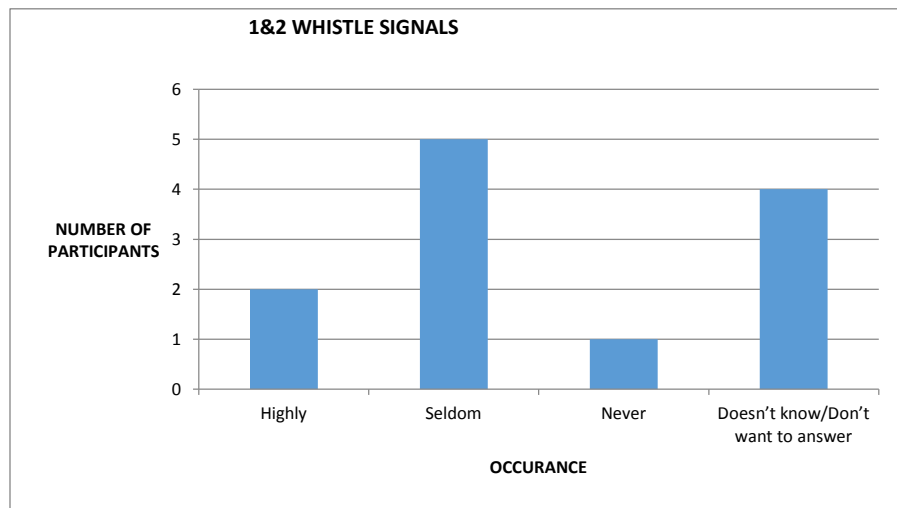


Table 4.18: Understanding of navigational light configuration by recreational vessels.

Highly	04
Seldom	03
Never	02
Doesn't know/Don't want to answer	03

Table 4.18 shows the understanding of navigational light configuration by recreational vessels. 04 number of participants often believe that other recreational vessels understand the navigation light configuration, 03 participants seldom believe that other recreational vessels understands the navigational light configuration whereas 02 number of participants believe that recreational vessels doesn't understand the navigation light configuration and 03 number of participants doesn't want to comment on the issue.

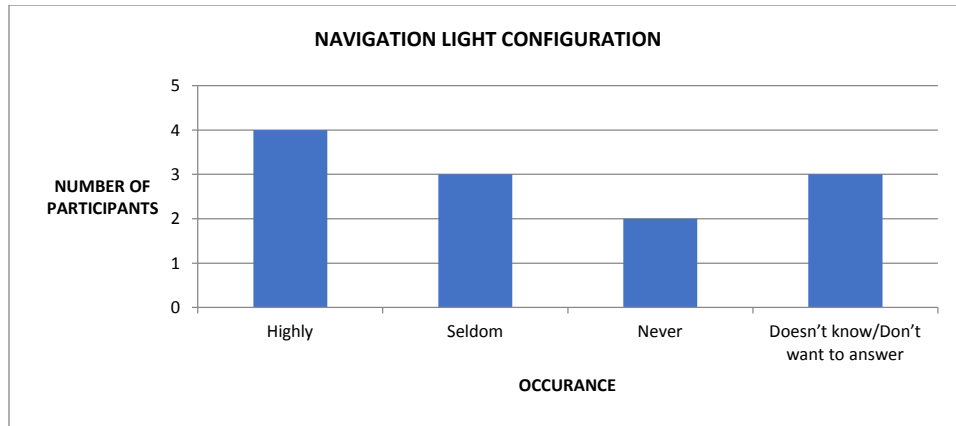


Table 4.19: Understanding of communication through whistle or spot light to attract the attention of recreational vessels.

High	02
Seldom	06
Never	01
Doesn't know/Don't want to answer	03

Table 4.19 shows ability of crew to understand the communication through whistle or spot light to attract the attention of recreational vessels. 02 number of participants highly believe that they use communication through whistle or spot light to attract other recreational vessels, 06 number of participants seldom believe that they make communication with whistle or spot light to attract the attention of other recreational vessels, 01 number of participant doesn't communicate with whistle or spot light to attract other recreational vessels and 03 number of participants doesn't want to comment on the issue.

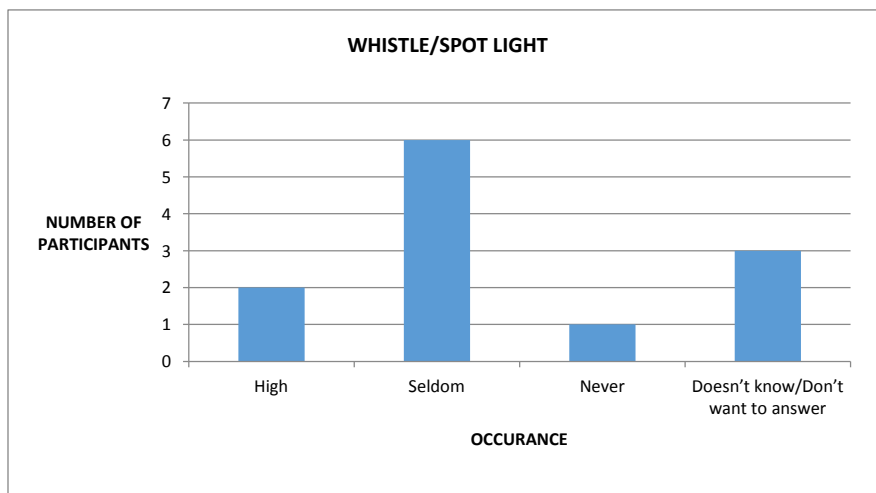


Table 4.20: Understanding the response of whistle /spotlight by recreational vessels.

Often	03
Seldom	02
Never	02
Doesn't know/Don't want to answer	05

Table 4.20 shows response of recreational vessels on getting signal through whistle and spot light. 03 number of participants often believe that recreational vessels maneuver upon getting response through whistle or spot light, 02 number of participants seldom believe that recreational vessels maneuver upon getting the signals, 02 number of participants don't believe that they understand the signals and 05 number of participants doesn't want to comment on the issue.

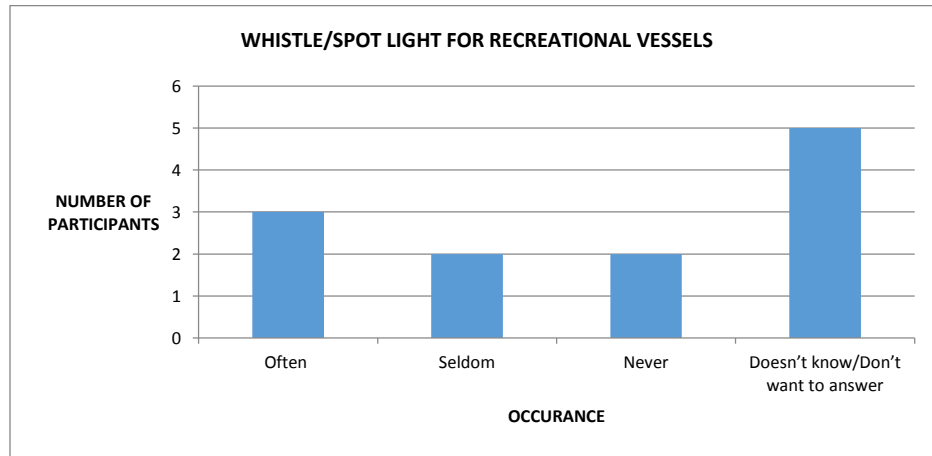


Table 4.21: Understanding of communication by flash light or by whistling while making passing arrangements with other commercial vessels.

Often	02
Seldom	01
Never	05
Doesn't know/Don't want to answer	04

Table 4.21: Shows use of whistle or spot light while making passing arrangements with other commercial vessels.) 2 number of participants often believe that they use spot light and whistle as communication with other commercial vessels while making passing arrangements, 01 number of participant seldom believe that he makes communication like spot light or whistle to make passing arrangement with other commercial vessel, 05 number of participants doesn't make use of whistle or spot light while making

passing arrangements with other commercial vessels and 04 number of participants doesn't want to comment on the issue.

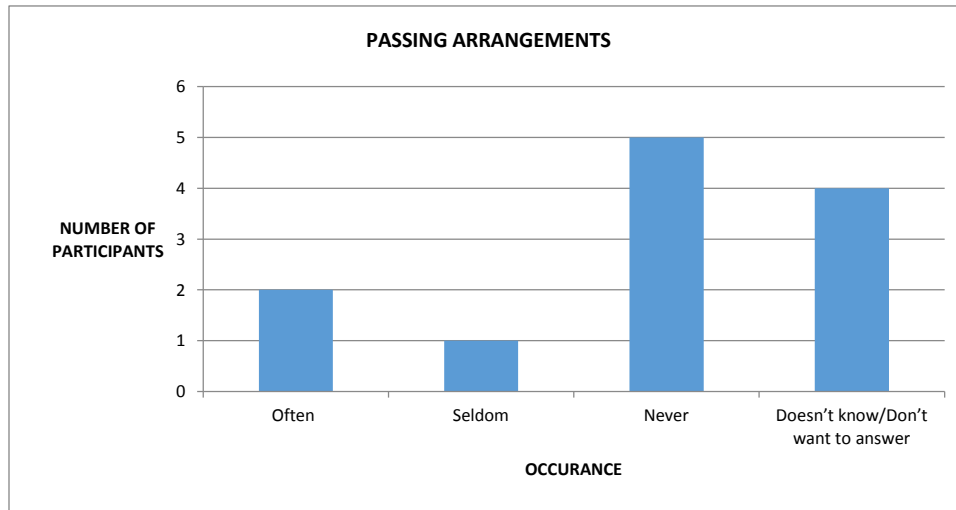


Table 4.22: Usefulness of radar to avoid the collisions

Very	06
Seldom	02
Never	00
Doesn't know/Don't want to answer	04

Table 4.22 shows usefulness of radar to avoid collisions.06 number of participants often believe that they find information through radar as important to avoid the collisions,02 number of participants seldom find the information through radar as important and 04 number of participants doesn't want to comment on the issue.

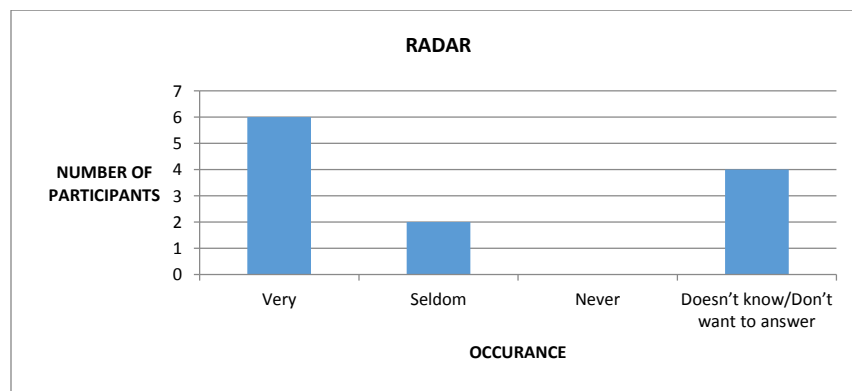


Table 4.23: Usefulness of AIS/Electronic charts to plan ahead and avoid potential collisions with other vessels.

Very	04
Seldom	03
Never	00
Doesn't know/Don't want to answer	05

Table 4.23 shows the usefulness of AIS /Electronic charts. .04 number of participants often believe that they find information through AIS/Electronic charts as important to plan ahead and avoid the collisions,03 number of participants seldom find the information through AIS/Electronic charts as important and 05 number of participants doesn't want to comment on the issue.

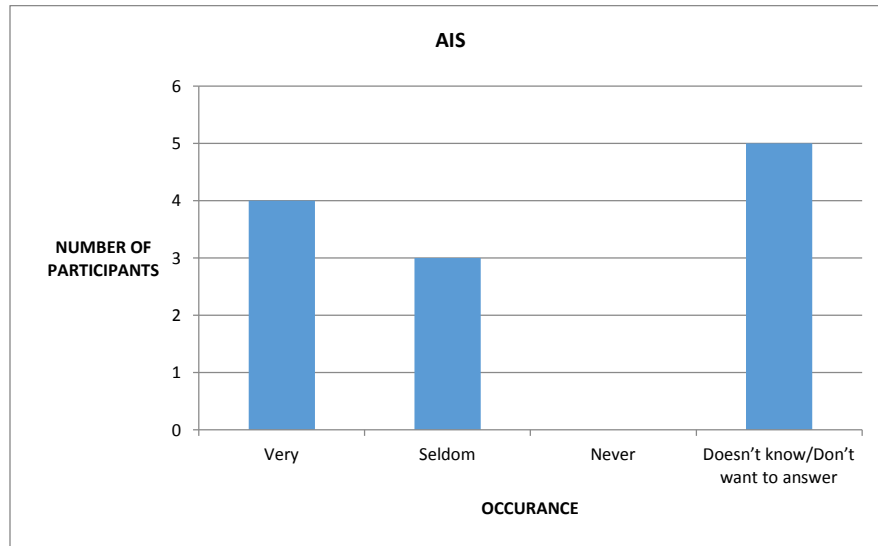


Table 4.24: Usefulness of VTS.

Very	05
Seldom	02
Never	00
Doesn't know/Don't want to answer	05

Table 4.24 shows the usefulness of VTS. .05 number of participants often believe that they find information through VTS as important ,02 number of participants seldom find the information through VTS as important and 05 number of participants doesn't want to comment on the issue.

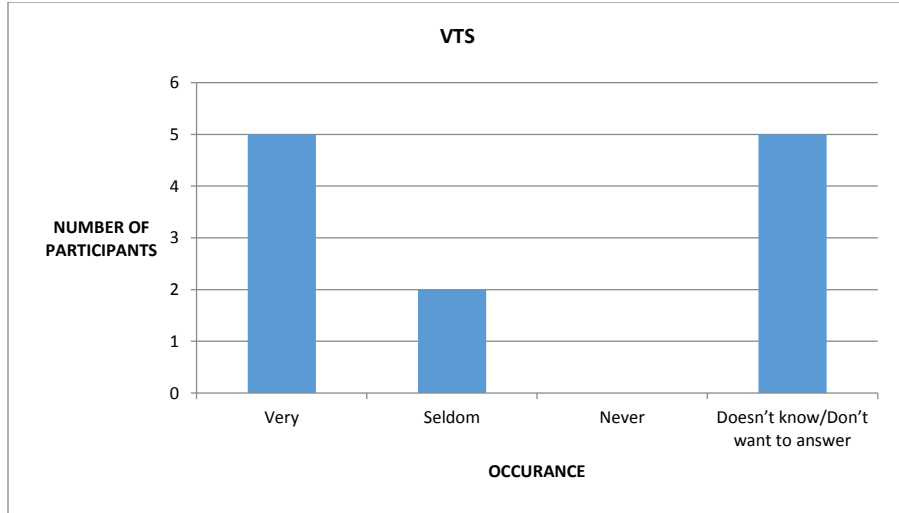
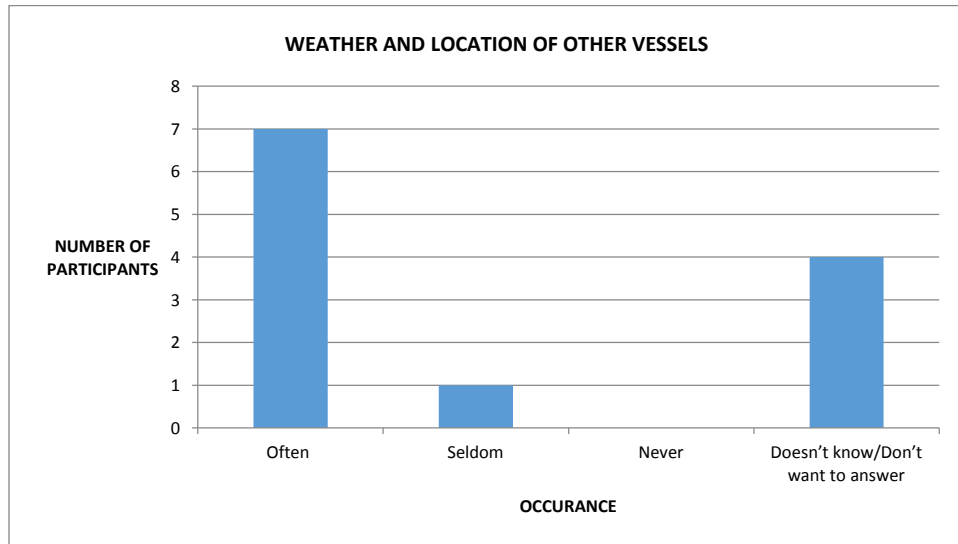


Table 4.25: Understanding of crew of weather and location of other vessels

Often	07
Seldom	01
Never	00
Doesn't know/Don't want to answer	04

Table 4.25 shows the understanding of crew regarding weather and location of other vessels. .07 number of participants often believe that they have understanding of weather and location of other vessels ,01 number of participants seldom believe that he have understanding of weather and location of other vessels and 04 number of participants doesn't want to comment on the issue.



4.4 Social stress

Table 4.26: Loosing the Job

Often	00
Seldom	06
Never	06
Doesn't know/Don't want to answer	00

Table 4.26 shows the fear in the minds of crew of losing the job. 06 number of participants often believe that they have fear in their minds of losing the job and equal number 06 participants believe that they never ever had any fear regarding losing their jobs.

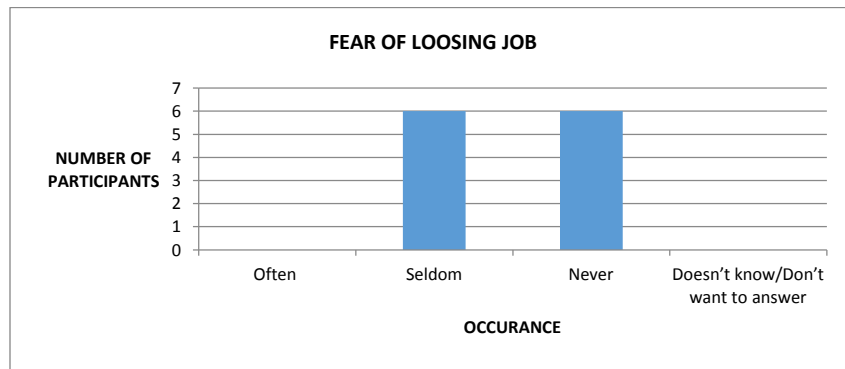


Table 4.27: Current marital status

Married	07
Single	05

Table 4.27 shows the marital status of the participants. Out of 12 numbers of participants, 07 numbers of participants are married and 05 numbers of participants are single.

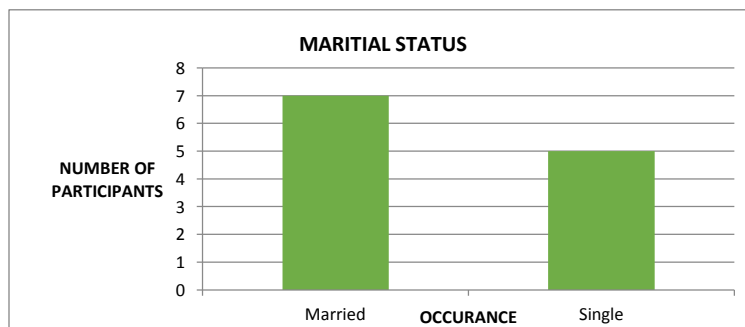


Table 4.28: Stability of relationships with the family

Often	01
Seldom	08
Never	03
Doesn't know/Don't want to answer	00

Table 4.28 shows the stability in the relationships of crew members with their family when on board the vessel. Out of 12 numbers of participants, 01 number of participant often believe that he worry about the relationship with his family on board the ship, 08 numbers of participants seldom worry about the relationships with their family members when on board the vessel where as 03 numbers of participants never worry about their relationships when on board the vessel.

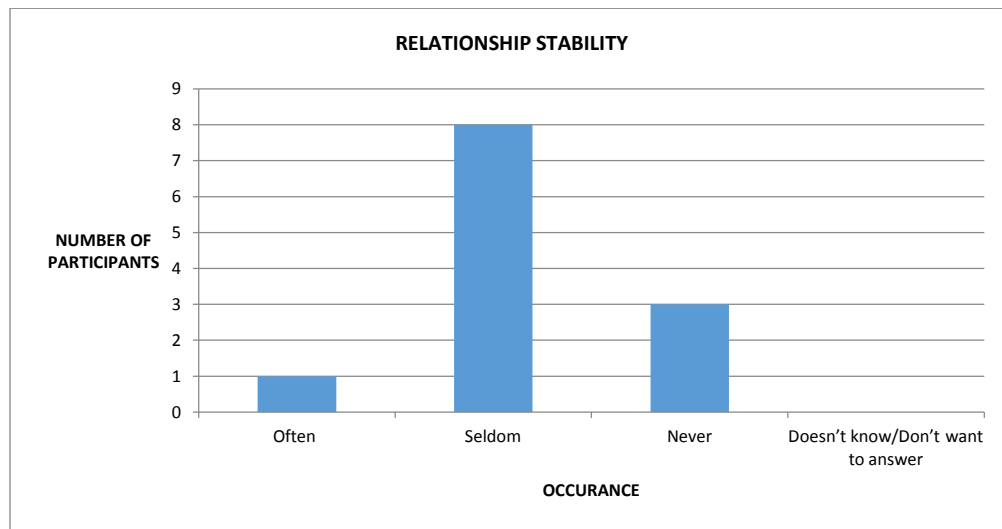


Table 4.29: Support to the family and paying the bills

Often	00
Seldom	03
Never	09
Doesn't know/Don't want to answer	00

Table 4.29 shows the support of crew members to their family members for paying the bills. Out of 12 numbers of participants, 03 number of participant seldom worry about lending support to their family members and pay their bills where as 09 numbers of participants never worry about support to their family and paying the bills.

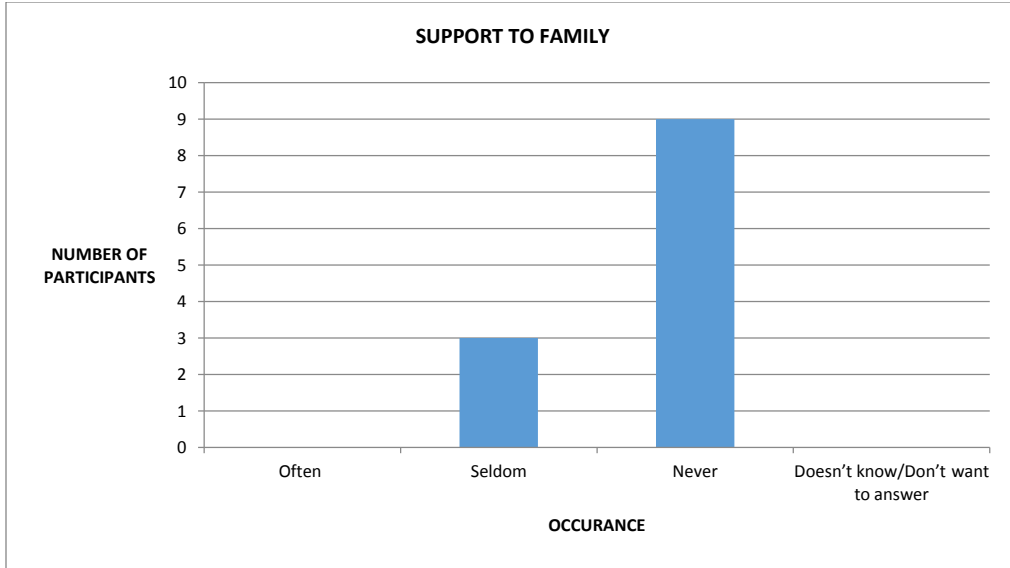


Table 4.30: Role of cell phones/ emails in the stability of the family

Often	12
Seldom	00
Never	00
Doesn't know/Don't want to answer	00

Table 4.30 shows the role of cell phones/emails in the stability of the family when on board the vessel. All of the participants 12 in number believes that cell phones/email often play an important role in providing the stability towards their family members while working on the ship.

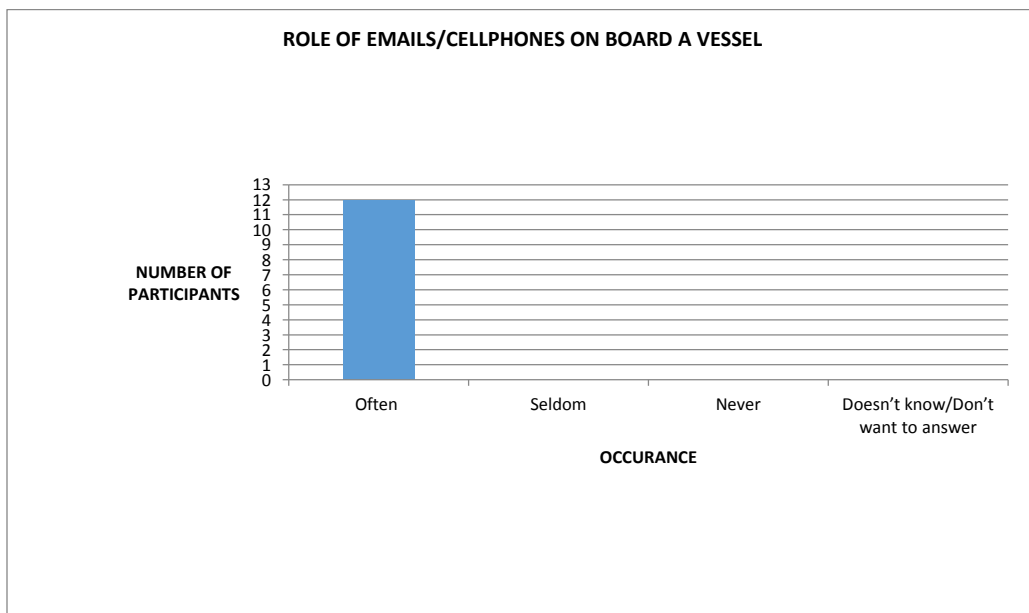
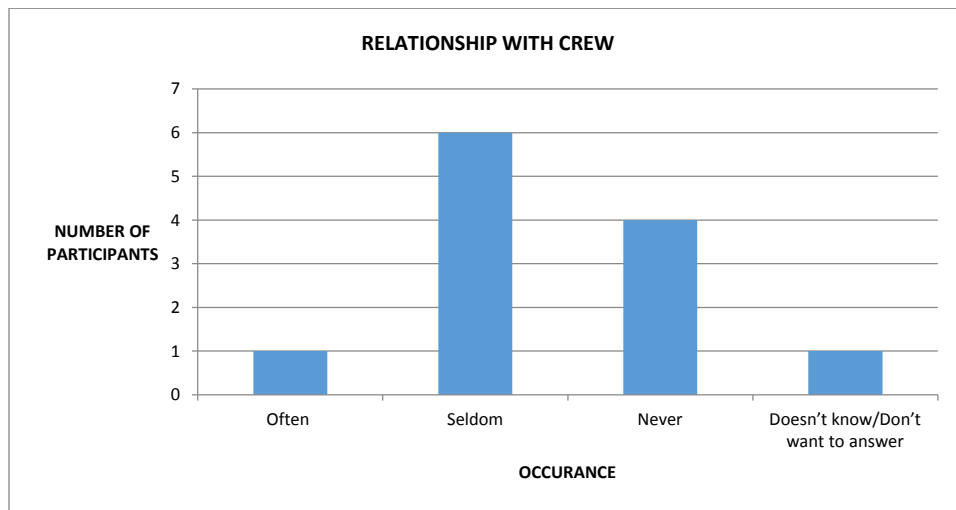


Table 4.31: Tense relationship with the crew members.

Often	01
Seldom	06
Never	04
Doesn't know/Don't want to answer	01

Table 4.31 shows relationship between crew members working on board the vessel. Out of 12 participants only one of participant believe that he often have tense relationship with other crew members, where as 06 number of participants occasionally have tense relationships with their crew members where as 04 number of participants never had any tense relationship with other crew members while working on board the vessel.



4.5 Mental workload

Table 4.32: Worry about other captain understanding, When Steering the vessel in front of other vessels

Often	06
Seldom	01
Never	01
Doesn't know/Don't want to answer	04

Table 4.32 shows the worry of crew about other captain understanding while steering the vessel in front of other vessels. Out of 12 participants 06 number of participants believe that they often worry about

other captain understanding when steering the vessel in front of other vessels, where as 01 number of participant never worry about other captain understanding when steering the vessel in front of other vessels where as 04 number of participants doesn't want to comment on the issue.

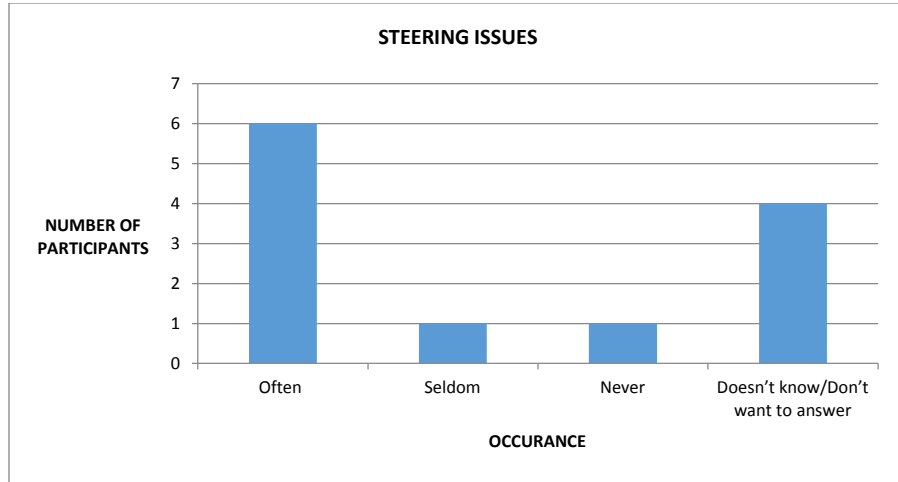


Table 4.33: Worry about the other operator's understanding of our vessel's maneuvering limitations.

Often	03
Seldom	04
Never	01
Doesn't know/Don't want to answer	04

Table 4.33 Worry of the crew members about other operator understands of their vessel maneuvering limitations. Out of 12 participants, 03 numbers of participants often worry about the other operator understanding of their vessel maneuvering limitations, 04 numbers of participants seldom worry about the other operator understanding of their vessel maneuvering limitations and 04 numbers of participants don't want to comment on the issue.

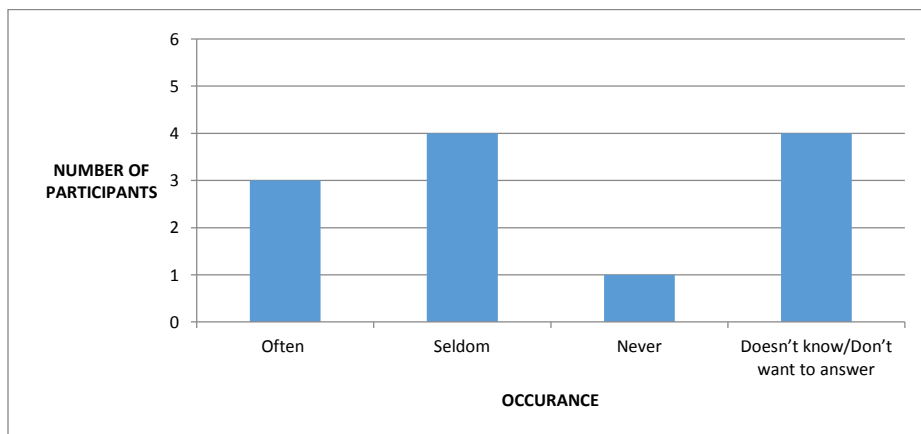


Table 4.34: Boredom in straight- away without any traffic.

Often	03
Seldom	04
Never	02
Doesn't know/Don't want to answer	03

Table 4.34 shows crew boredom in straight away without any traffic. Out of 12 participants, 03 numbers of participants often get bored while passing through non traffic zone, 04 numbers of participants seldom get bored while passing through non traffic zone ,02 number of participants never get bored while passing through non traffic zone and 03 numbers of participants don't want to comment on the issue.

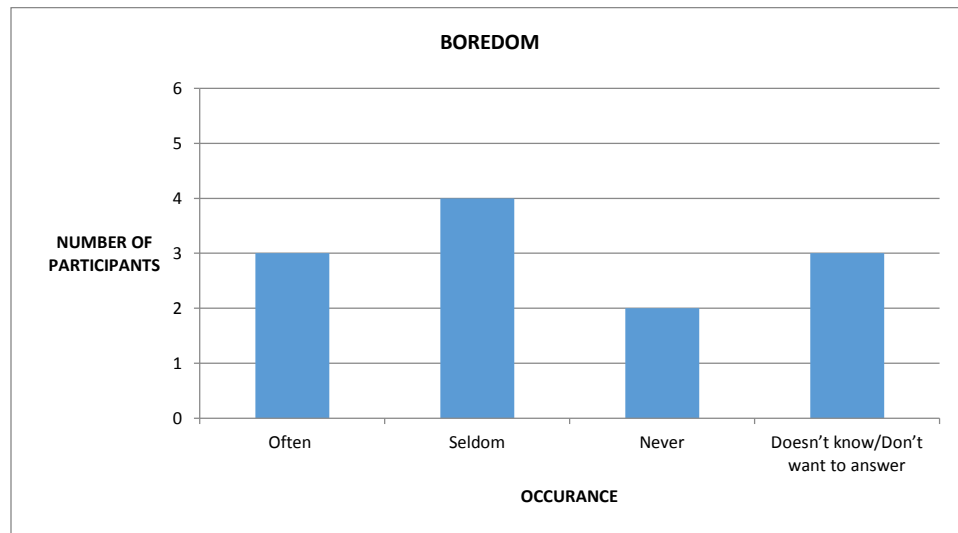


Table 4.35 Distraction of cell phone calls in busy waters

Often	06
Seldom	03
Never	01
Doesn't know/Don't want to answer	02

Table 4.35 shows crew distraction by cell phone calls in busy waters. Out of 12 participants, 06 numbers of participants often get distracted by phone calls when they are passing through high traffic zone ,03 numbers of participants seldom get distracted by phone calls when they are passing through high traffic zone,01 number of participants never get distracted by phone calls when they are passing through high traffic zone and 02 numbers of participants don't want to comment on the issue.

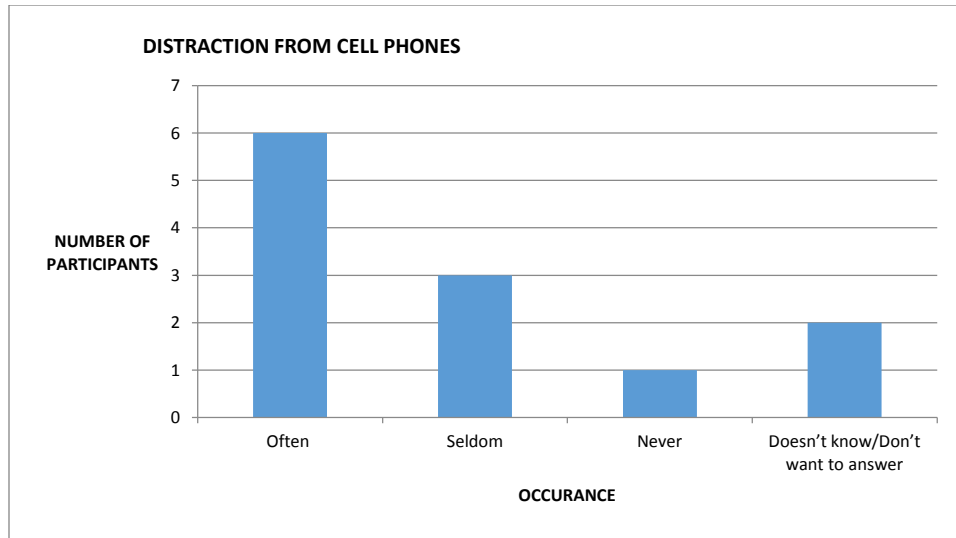


Table 4.36 Distraction of cell phone calls in Non busy waters

Often	02
Seldom	03
Never	05
Doesn't know/Don't want to answer	02

Table 4.36 shows crew distraction by cell phone calls in non busy waters. Out of 12 participants, 02 numbers of participants often get distracted by phone calls when they are passing through no traffic zone, 03 numbers of participants seldom get distracted by phone calls when they are passing through no traffic zone, 05 number of participants never get distracted by phone calls when they are passing through no traffic zone and 02 numbers of participants don't want to comment on the issue.

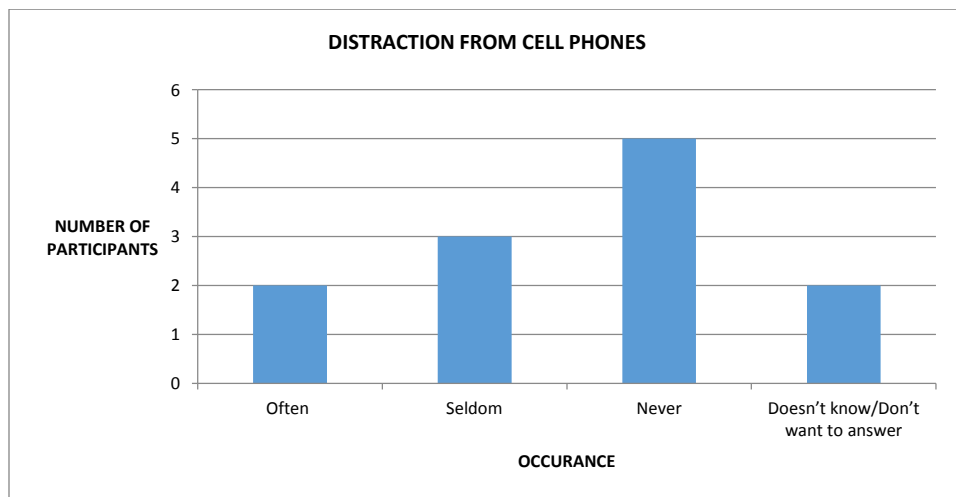


Table 4.37: Dependence on navigational aids and landmarks.

Electronic charts	08
Paper charts	03
Radar	07
Publications/Notices	04

Table 4.37 shows crew dependence on navigational aids. Out of 12 participants, 08 numbers of participants often depends on electronic charts for navigational aids and landmarks, 03 numbers of participants often depends on paper charts for navigational aids and landmarks, 07 numbers of participants often depends on radar for navigational aids and landmarks and 04 numbers of participants depends on publications /notices for navigational aids and landmarks.

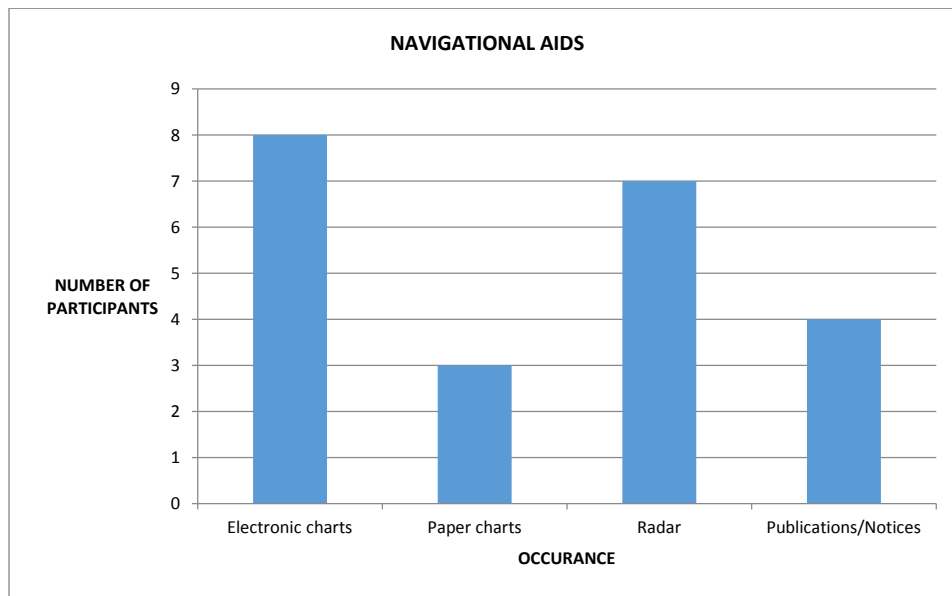


Table 4.38: Dependence on equipments for knowing other vessels location.

AIS	10
Radar	10
VHF-FM RADIO	05

Table 4.38 shows crew dependence on navigational aids. Out of 12 participants, 10 numbers of participants often depends on AIS and Radar for navigational aids and landmarks and 05 numbers of participants depends VHF-FM radio for navigational aids and landmarks.

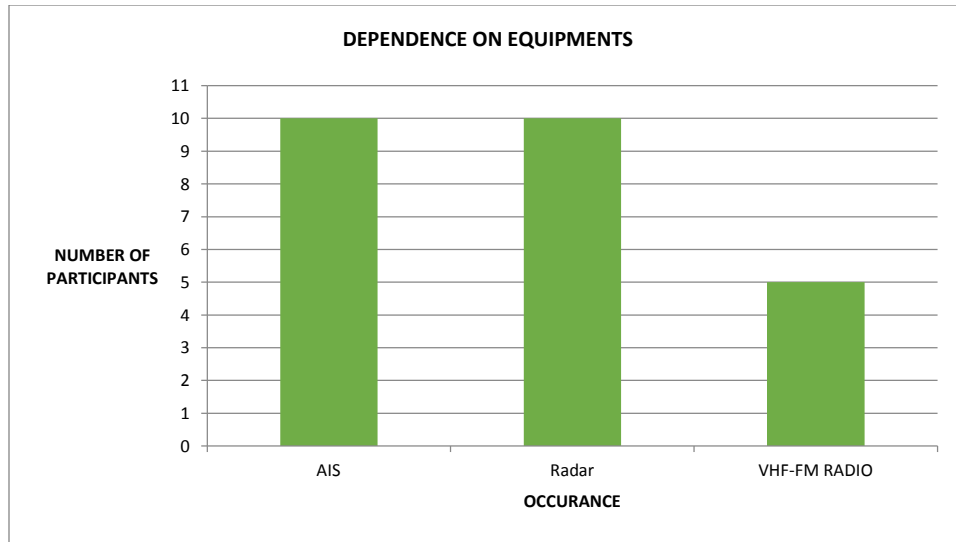


Table 4.39: Reliability of radar in comparison to AIS for knowing vessel locations

More reliable than	09
As reliable as	01
Not as reliable as	00
I don't know/Don't want to answer	02

Table 4.39 shows reliability of radar in comparison to AIS for knowing vessel locations. Out of 12 participants, 09 numbers of participants often find radar communication means more reliable than AIS for knowing the vessel locations, 01 numbers of participant find radar communication means as reliable as AIS for knowing the vessel locations, and 02 numbers of participants doesn't want to comment on the issue.

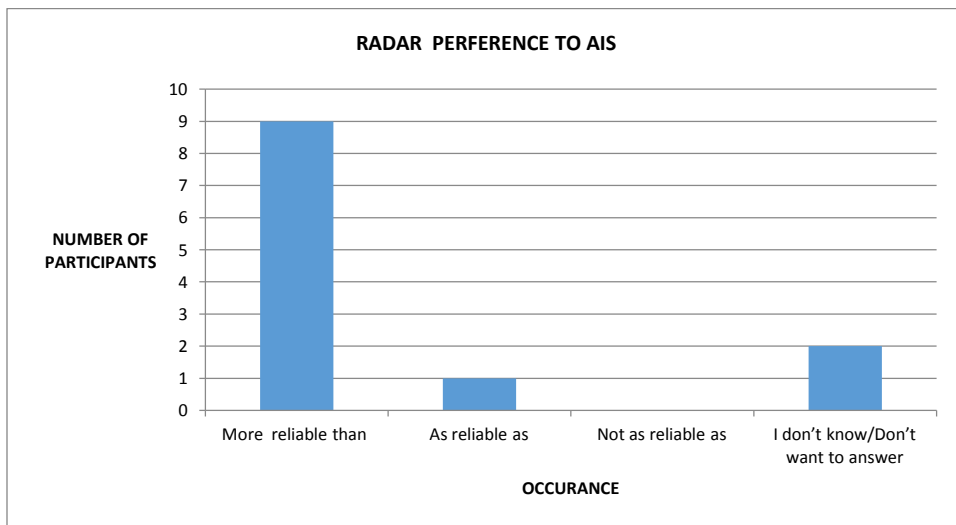


Table 4.40: Paper charts reliability in comparison to electronic charts for navigational purposes

More reliable than	02
As reliable as	02
Not as reliable as	04
I don't know/Don't want to answer	04

Table 4.40 shows reliability of paper charts in comparison to electronic charts for navigational purposes. Out of 12 participants, 02 numbers of participants find paper chart communication means more reliable than electronic charts for navigational purposes, 02 numbers of participant find paper chart communication means as reliable as electronic charts for navigational purposes, 02 numbers of participants thinks that paper charts are not as reliable as electronic charts and 04 number of participants doesn't want to comment on the issue.

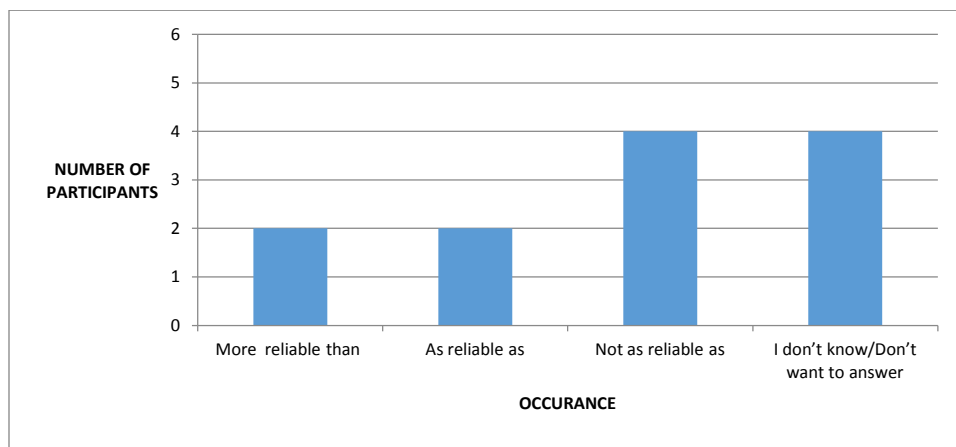


Table 4.41: Difficulty in operation of electronic charts

Often	00
Seldom	03
Never	06
Doesn't know/Don't want to answer	03

Table 4.41 shows difficulty in operation of electronic charts for navigational purposes. Out of 12 participants, 03 numbers of participants seldom find difficulty in reading and operating electronic charts for navigational purposes, 06 numbers of participants never find difficulty in reading and operating electronic charts for navigational purposes and 03 numbers of participants doesn't want to comment on the issue.

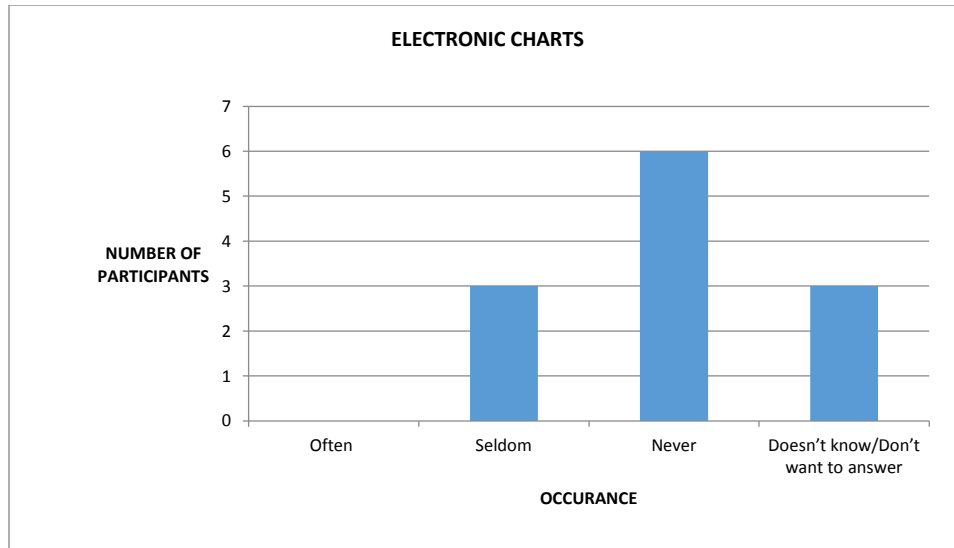


Table 4.42: Difficulty in operating AIS transponder.

Often	00
Seldom	02
Never	08
Doesn't know/Don't want to answer	02

Table 4.42 shows difficulty in operation of AIS transponder for navigational purposes. Out of 12 participants, 02 numbers of participants seldom find difficulty in operating AIS transponder for navigational purposes, 08 numbers of participants never find difficulty in operating AIS transponder for navigational purposes and 02 numbers of participants doesn't want to comment on the issue.

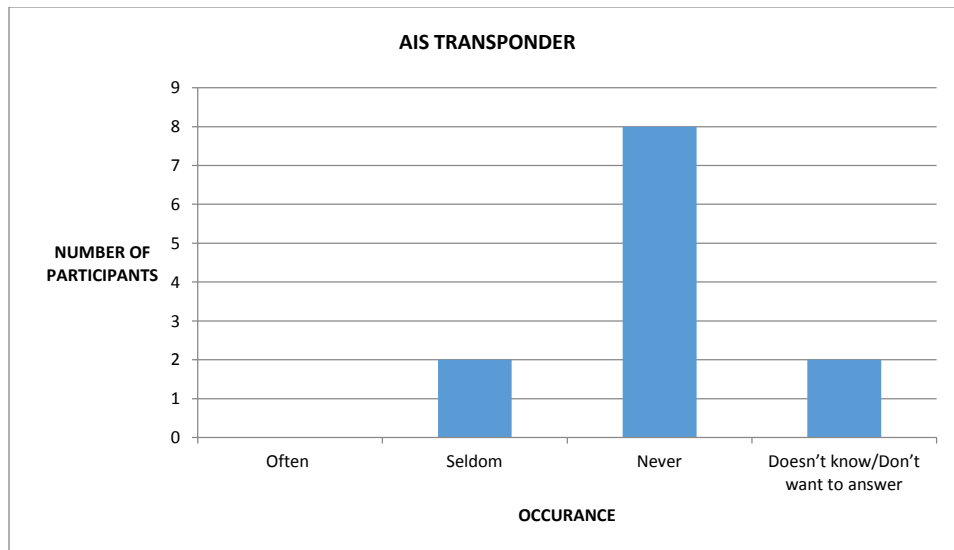


Table 4.43: Dependence on Pilot house alarms for informing the problems about engine

Often	03
Seldom	01
Never	03
Doesn't know/Don't want to answer	05

Table 4.43 shows the dependency of crew on pilot house alarms for informing the problems about the engine. Out of 12 participants, 03 numbers of participants often depend on pilot house alarms for informing the problems related to engines, 01 numbers of participant seldom depend on pilot house alarms for informing the problems related to engines and 03 numbers of participants never depend on pilot house alarms for informing the problems related to engines 05 numbers of participants doesn't want to comment on the issue.

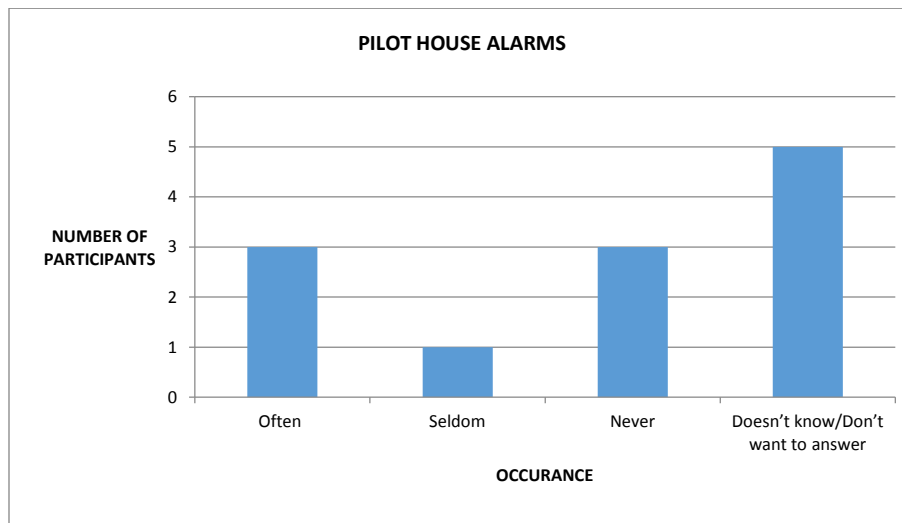


Table 4.44: Vessel engines running at optimal performance

Often	05
Seldom	01
Never	01
Doesn't know/Don't want to answer	05

Table 4.44 shows the knowledge of crew over optimal performance of engine. Out of 12 participants, 05 numbers of participants often believe that vessel engines are running at optimal performance, 01 numbers of participant seldom believe that vessel engines are running at optimal performance, and 01

number of participant never believe that vessel engines are running at optimal performance and 05 numbers of participants doesn't want to comment on the issue.

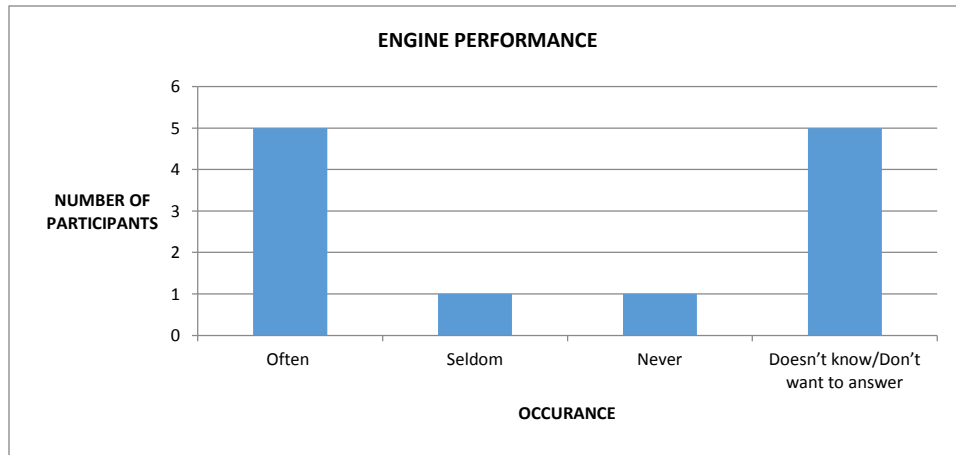


Table 4.45: Steering the same course through the lock

Often	03
Seldom	02
Never	00
Doesn't know/Don't want to answer	07

Table 4.45 shows the knowledge of crew over steering the same course through the lock. Out of 12 participants, 03 numbers of participants often believe that they are steering the same course through the lock, 02 numbers of participants seldom believe that that they are steering the same course through the lock, and 07 numbers of participants doesn't want to comment on the issue.

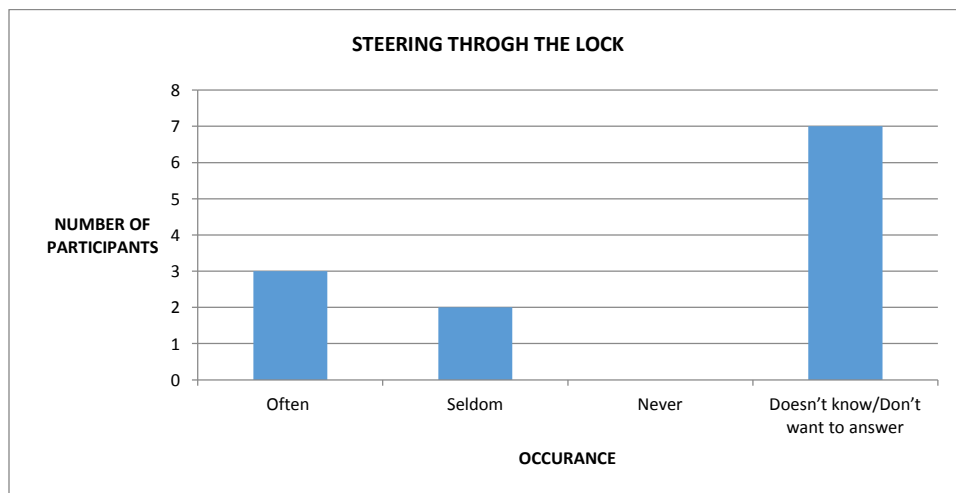


Table 4.46: Steer the same course through the bridge

Often	06
Seldom	01
Never	00
Doesn't know/Don't want to answer	05

Table 4.46 shows the knowledge of crew over steering the same course through the Bridge. Out of 12 participants, 06 numbers of participants often believe that they are steering the same course through the bridge, 01 numbers of participants seldom believe that that they are steering the same course through the bridge, and 05 numbers of participants doesn't want to comment on the issue.

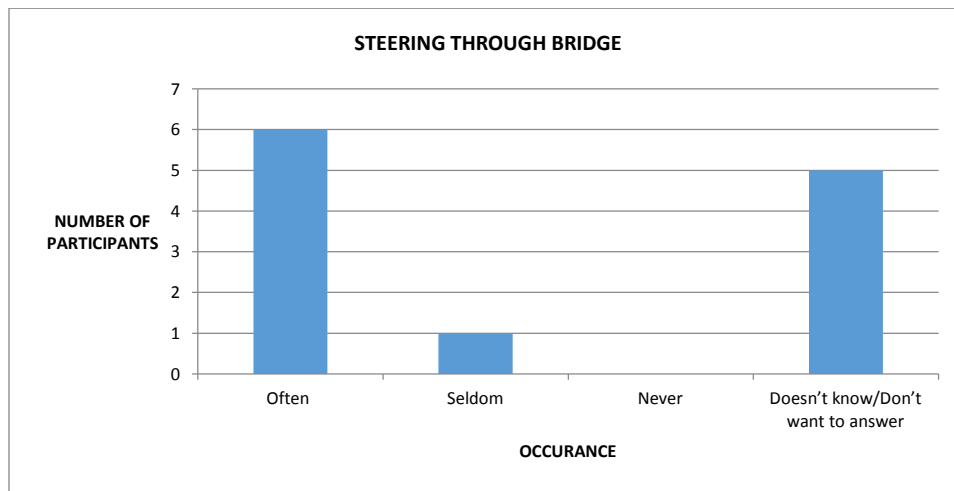


Table 4.47: Encountering same commercial vessels on subsequent transits

Often	01
Seldom	04
Never	01
Doesn't know/Don't want to answer	06

Table 4.47 shows the crew encountering the same commercial vessels on subsequent transits. Out of 12 participants, 01 numbers of participant often believe that he is encountering the same commercial vessels on subsequent transits, 04 numbers of participants seldom believe that they are encountering the same commercial vessels on subsequent transits, 01 numbers of participant never believe that he is encountering the same commercial vessels on subsequent transits and 06 numbers of participants doesn't want to comment on the issue.

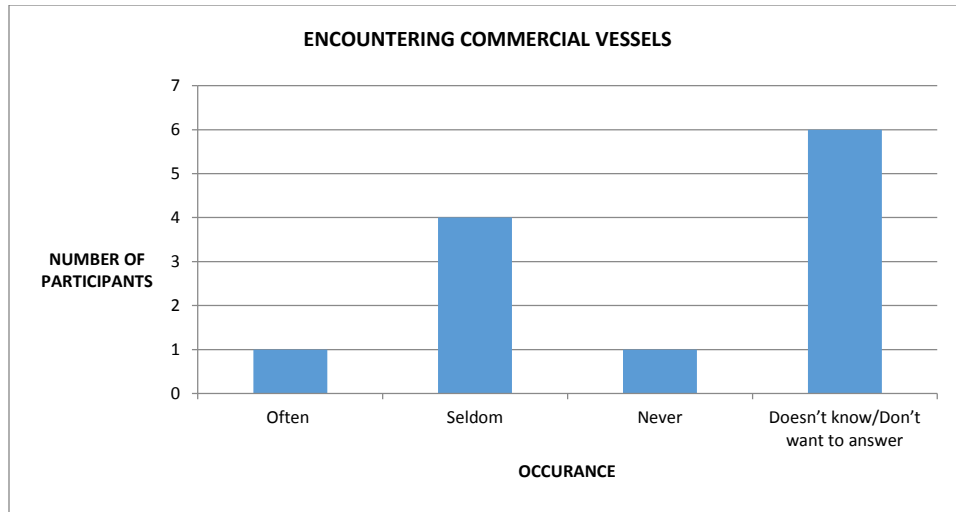


Table 4.48: Encountering same passing arrangements with commercial vessels

Often	04
Seldom	03
Never	00
Doesn't know/Don't want to answer	05

Table 4.48 shows the crew encountering the same passing arrangements with commercial vessels. Out of 12 participants, 04 numbers of participant often believe that they are encountering the same passing arrangements with commercial vessels, 03 numbers of participants seldom believe that they are encountering the same passing arrangements with commercial vessels, and 05 numbers of participants doesn't want to comment on the issue.

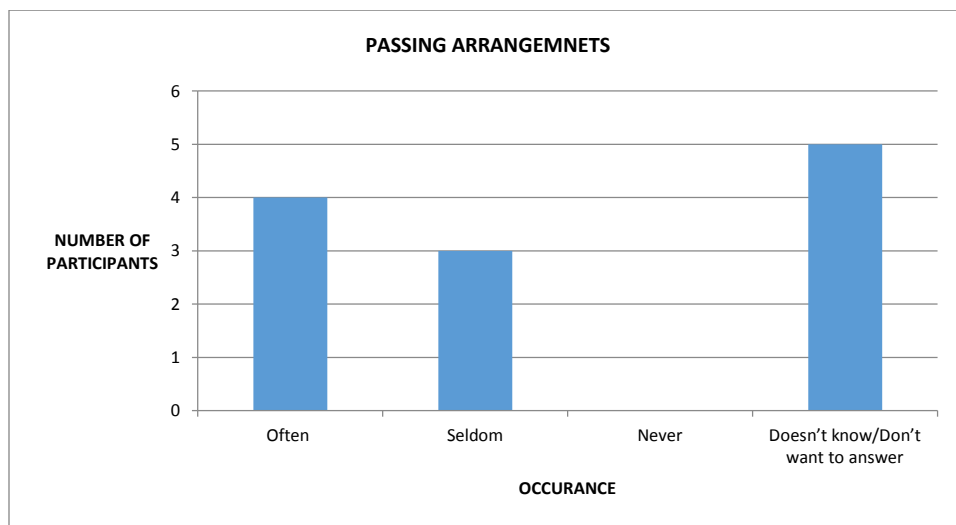
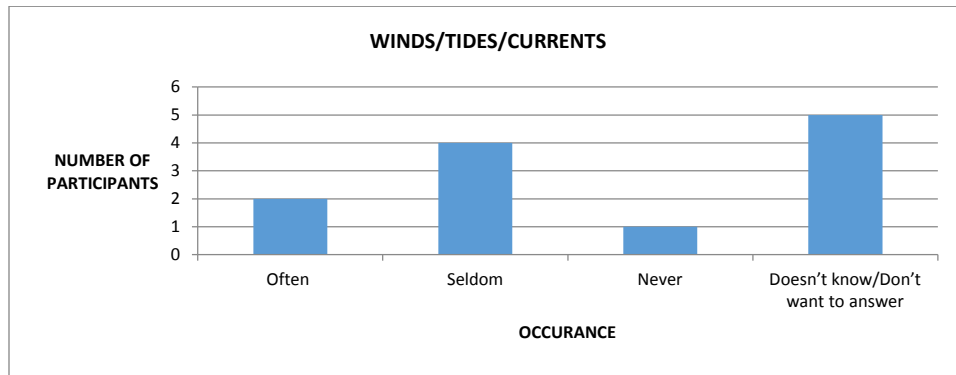


Table 4.49: Situation of wind / Tides/Currents presence by surprise.

Often	02
Seldom	04
Never	01
Doesn't know/Don't want to answer	05

Table 4.49 shows sudden encounter to wind/Tides/Currents .Out of 12 participants, 02 numbers of participant often believe that they encounter situation of wind, tides and currents suddenly by surprise, 04 numbers of participants seldom believe that they encounter situation of wind, tides and currents suddenly by surprise, 01 number of participant never believe that he encounter situation of wind, tides and currents suddenly by surprise and 05 numbers of participants doesn't want to comment on the issue.



4.3 Combined results (All factors)

Figure 4.1: Showing combined effect of various factors

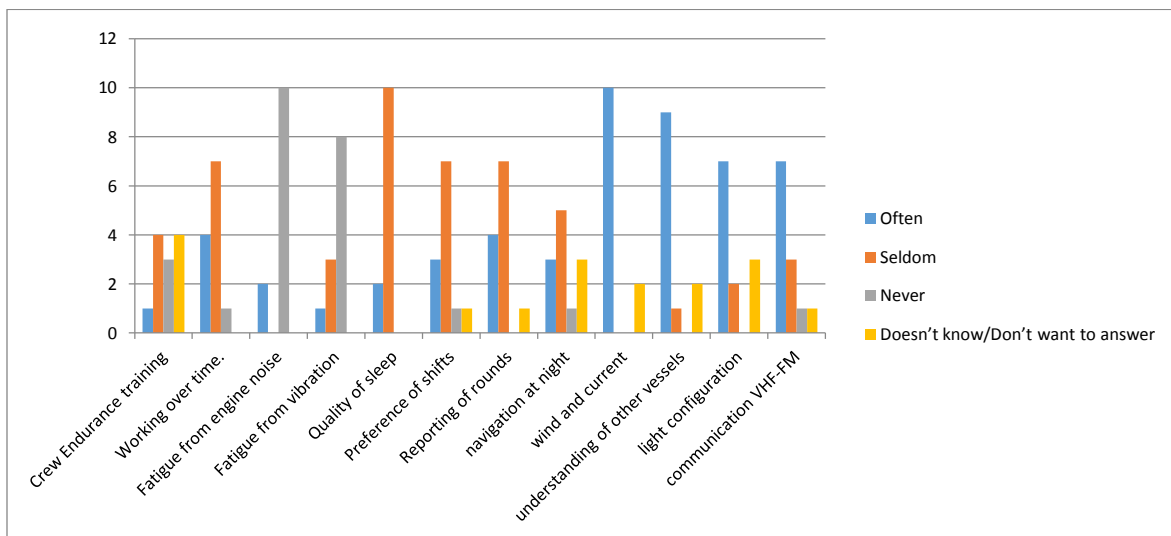


Figure 4.2: Showing combined effect of factors

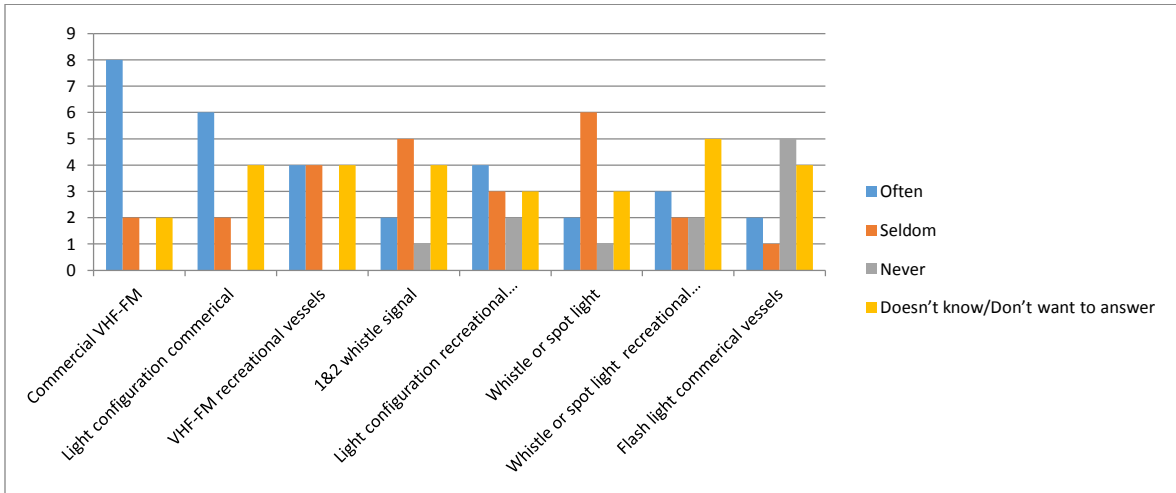
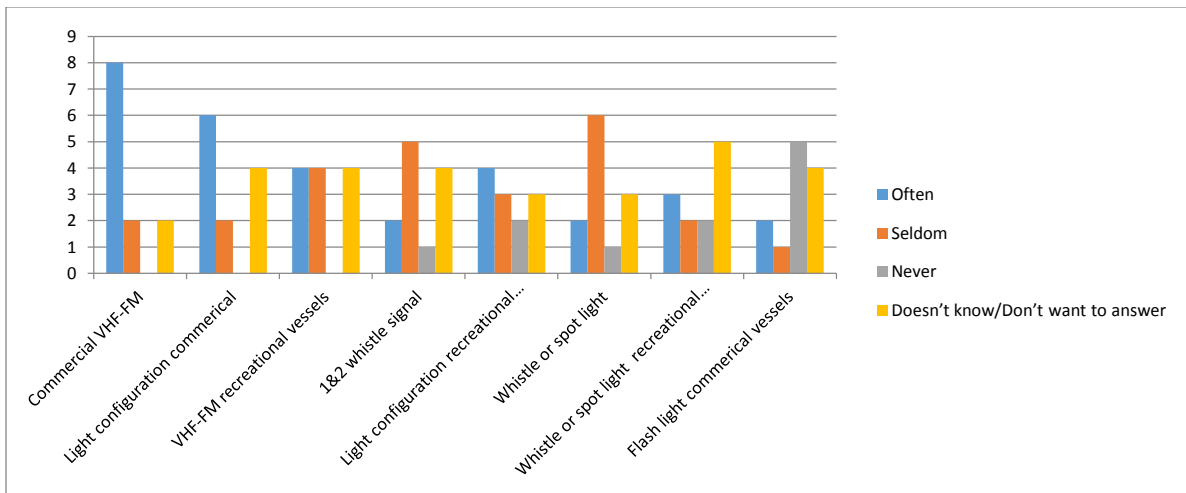


Figure 4.3: Showing combined effect of factors



Chapter 5

Discussion of results

5.1 Fatigue Analysis

From the feedback of the participants, it was evident that there has not much effect of fatigue on the normal working performance of the crew on board the vessel. This attribute to the awareness of the companies on fatigue issues through various programs. From the questionnaire, we can see that most of the crew doesn't have any problems from the engine noise or vibrations which itself concluded the awareness and possible work done by the company to provide insulation and sound proof accommodation to the crew in order to avoid the fatigue issues. In addition to it, the working hours for the crew and captain have been modeled in such a way that they don't encounter fatigue issues by working overtime and that way avoiding any possible loss of situational awareness. In addition to above mentioned steps, companies are committed to provide crew endurance management programs (See Tables (2, 3, 4, 5 and 6).

Apart from positives, we can also see in tables that some of participants feel that they are subjected to fatigue issues due to improper sleep caused by noise coming from the engines and vibrations. In simple words some of the companies are still lagging behind in providing sound proof accommodations to its crew members which becomes primary reason for their crew to experience fatigue issues. This could result in some catastrophic incidents. But the positives which we can take from the survey that more and more companies have been indulged in providing better living conditions on board the vessel and in future we see more companies will provide better accommodation for the crew by incorporating sound proof facilities.

5.1.1 *Company awareness of fatigue issues*

From the finding of the fatigue issues from the feedback acquired from the participants working in different companies and positions, we find that most of the companies are aware of fatigue issues and lot of work has been done by them by incorporating some management and engineering solutions to overcome the problem of fatigue on board a vessel(See table1).In addition to it some other management programs like crew endurance management program(see table 2),providing better working hours(see table 6) where the management provide shift preference system to make sure that their crew doesn't expose to working overtime. Moreover lot of work has been done by their companies in combating the problem of noise coming from the engine and vibrations according to the participants. This has been done by providing sound proof decks, doors bulkheads etc

In brief the conclusion is that participant companies have been working in providing better work atmosphere from better stress free accommodations to provision of flexible shifts, introduction of management programs etc .This result in acquiring better situational awareness of the work on board the vessel.

5.1.2 Crew Endurance Management System

Table 2 measures how many companies take measures to conduct fatigue or crew endurance training. Table shows that 9% (approx) of companies, who employ the licensed officers interviewed, conduct this training on a regular basis, while 33% conduct this training on an occasional basis ,25% of companies never conduct this training and 33% of companies or participants doesn't know about the program. From the analysis, it is evident that around 42% of companies from the feedback of participants are aware of crew endurance management system and programs which have been implemented in their training as part of imparting knowledge. But still from the analysis of data majority of the participants feels that they are not aware of CEMS and don't know about its strengths.

The CEMS is primarily attributed to U.S Department of Homeland Security, United States Coast Guard with the purpose "This Instruction establishes the requirements and the delivery system to support a program, Crew Endurance Management (CEM), to identify and control endurance risk for personnel conducting cutter, boat, aviation, marine inspection and pollution response, security, command and control operations and activities. This program serves all active duty, reserve, Auxiliary, and civilian Coast Guard personnel".

The review of endurance and fatigue management reveals key elements that should be included in CEM to ensure its effectiveness on real grounds. They are as follows:-

- 1) Workload balancing.
- 2) Appropriate scheduling.
- 3) Training (for staff and supervisors).
- 4) Tools to plan and monitor crew endurance.
- 5) Consideration of environmental conditions.
- 6) Promotion of physical fitness.
- 7) Diet/nutrition considerations.

The workload balancing is vital element in CEMS by the virtue of which proper utilization of resources can be performed. From the analysis of the data obtained from the questionnaire regarding work load balancing shows that 03 participants (33.33%) prefer to work on 12 hour straight shift,07 participants (58.33%) prefer to work on multi shifts of 6 hour on and 6 hours off, for one participant it doesn't matter if he choose to work on single 12 hour shift or work in multi shift of 6 hour on and 6 hour off

and 01 participant doesn't want to answer the query. See Table 6. Most of the participants working in different companies believe that workload balancing is very important for better functioning as well as avoid stress level on board a vessel. The introduction of different work shifts reduces the chances of the crew to undergo working overtime, thereby providing better management of the crew (See table 3).

Appropriate scheduling of manpower with proper formulation of time schedules enable crew to act in much better and safe way on board a vessel.

Training to the crew including the management programs like crew endurance management system to identify and control endurance risk for personnel performing command and control operations and activities (See Table 3).

5.1.3 Potential of fatigue

From the feedback of the questionnaire, it is evident that most of the participants working in different companies have no issues with fatigue arising from mechanical, structural and engineering sources. According to Tables 4, 02 participants (16%) often get fatigue from the noise of engine which causes discomfort to them from sleeping sound in the night, whereas majority of participant on board a vessel 10 participant (83.33%) never get fatigue from the noise of engine there by having no problem in getting sound sleep after normal working on board a ship.

In similar way in case of discomfort from the noise and vibration of engines, According to Table 5, 01 participant (9%) often gets fatigue from the vibration of the engine which prevent him from getting sound sleep after normal working hours, 03 participants (25%) participants occasionally gets fatigue from the engine vibrations which prevent them from getting sound sleep whereas majority 08 participants (66.66%) doesn't get any fatigue from the engine vibrations there by getting sound sleep after normal working hours.

It concludes that majority of the crew doesn't encounter any discomfort arising from the engine noise and vibrations as most of the companies today consider it important to have insulation around the accommodation and thereby providing better living conditions for the crew to remain stress and fatigue free. Though in some of the cases as evident in response of some participants that they encounter discomfort either from the noise of the engine or vibrations itself.

It is possible to see accident due to the fatigue factor in maritime industry, the Exxon Valdez case draw lot of attention of the maritime organizations on the fatigue issue." The Role Of Human Fatigue Factor Towards Maritime Casualties" Maritime Transport & Navigation Journal, Vol. 2 (2010), No. 2. The US tanker Exxon near Alaska's coast got stranded on 24th March 1989 (Cardiff University, 1996). The primary reason which came up in front from the investigation was the fatigue issue" there was no rested officer to undergo the navigation during the voyage"

5.2 Communication Analysis

The communication on board vessel is very important and plays vital role in safety of the vessel. The communication can broadly be divided into internal communication which is communication between crew and captain of the same ship or vessel or external communication between the captain and crew of different vessels. Mostly with the decisions, signals and message sending between each other.

The main issue with communication appears to be associated with the lack of verbal communication between the vessels, resulting in the increased use of the vessel's whistle or spotlight as an alternate means to verbal communication. It is not possible for the captain alone to know about all the activities occurring on board vessel, so it becomes an equally important for crew/deckhands to inform about the activities happening around. In the questionnaire itself, majority of the participants feel that deckhands inform about the activities happening around the vessel to the captain to have better view.(See Table 07).

Table 7 shows how often the deckhands report to the captain regarding their routine rounds every single day. It shows that 04 participants (33.33%) feel that deckhand often report about the rounds to the captain, where as 07 participants (64%) feels that deckhands seldom report the rounds to the captain and one participate doesn't want to comment on the issue.

5.2.1 Communication with Other Commercial Vessels

There is no doubt in the fact that communication between two vessels captain is not only effective but also effect tremendously in safety of the vessels through situational awareness. In the questionnaire it is evident that verbal communication between two commercial vessels is important as most of the participants believe that some kind of verbal communication is happening between two vessels. See Tables 10, 11,12,13,14 and 15. This verbal communication forms the basis of the communication including formulation and sending of the message, transmitting and receiving of the message and understanding and acting on the message as described by Endsley, 1995.

The communication loop is demonstrated by Tables from 10-16, where most of the participants interviewed were frequently able to conduct two-way passing arrangements with other commercial vessels on VHF-FM radio. Further not only the crew feels highly confident in achieving the knowledge of their navigation attributes through non verbal modes of signal like spot light and whistling (See Table 16) but at same time acquires the situational awareness about the location of the other vessels around them. Radar and AIS (especially with electronic chart integration) can be considered as optional and additional modes of non verbal means of communications which further strengthens the ability to acquire situational awareness on board vessel to combat catastrophic incidents.(See Table 21,22 and 23).

5.2.2 *Communication with VTS*

The use of VTS plays an important role in attaining the situational awareness in terms of communication regarding the location, course of action and speed of other vessel transiting the waters. The information attained from VTS helps the captain to adjust the speed and course to accommodate the passing arrangements for other vessels. See Table 20.VTS as tool helps in broadcasting the location of the vessels. See Table 23.In the questionnaire, 05 number of participants often believe that they find information through VTS as important ,02 number of participants seldom find the information through VTS as important and 05 number of participants doesn't want to comment on the issue. In general, all the captains consider that information acquired from VTS is highly reliable and helps in preventing catastrophic collisions with other vessels around.

5.2.3 *Communication with Recreational Vessels*

The main issue with the communication between normal and recreational vessel is repeated use of non verbal means of communication.(See Tables 15,16,17,18 and 19).The analysis shows that most of the time only way of communication between commercial and recreational vessels in non-verbal using 1 and 2 type of whistle because of lack of radio equipments. However it has been observed that using non verbal means of communication doesn't affect situational awareness in both type of communications message is formulated, generated, transmitted and received and finally acted upon.

5.3 **Social Stress Analysis**

Social stress was not determined to be a significant factor in loss of situational awareness. This result can be credited to the captain's socio-economic status and supportive relationships among family and vessel crew. Socioeconomic status (SES) is generally measures in terms of education, occupation and income. It is commonly conceptualized as the social standing or class of an individual or group. When viewed through a social class lens, privilege, power, and control are emphasized. Furthermore, an examination of SES as a gradient or continuous variable reveals inequities in access to and distribution of resources. SES is relevant to all realms of behavioral and social science, including research, practice, education, and advocacy.

5.4 **Workplace Stress Analysis**

Multiple factors can affect the decision making of the captain working on board a vessel. Research shows that strain in the job and repetitive hazardous work conditions may impose serious effects in situational awareness of ongoing activity generally because of loss of information or awareness. Stress experienced

and perceived can affect a person's psychological well-being. Work stress research has examined the psychological demands of a work load, workers' perceived sense of control over their performance, safety stressors, work organization, and work atmosphere (Clarke, 2006; Aittomäki, Lahelma, & Roos, 2003; Gillen, Baltz, Gassel, Kirsch, & Vaccaro, 2002; Dembe, Erickson, Delbos, & Banks, 2005; MacDonald, Harenstam, Warren, & Punnett, 2008; Landsbergis, Cahill, & Schnall, 1999).

From the questionnaire, the primary factors that can influence the decision making on board the vessel are marital status of the crew, stability in the relationship with the family support to the family in paying their bills, use of cell phones in communicating the family members at the time of sailing, relationship with crew members etc

From the questionnaire, Table 25 telling the pressure in the minds of the crew to lose the job. This can play an important role in situational awareness lapse primarily due to the fear in the mind of the crew to lose the job. From the analysis it was mix result as exactly half participants believe that they have fear in the mind to lose their jobs while they are away from their family.

Stability of relationship with family plays an important role which again has mixed results in the questionnaire. Table 27 shows the stability in the relationships of crew members with their family when on board the vessel. Out of 12 numbers of participants, 01 number of participant often believe that he worry about the relationship with his family on board the ship, 08 numbers of participants seldom worry about the relationships with their family members when on board the vessel where as 03 numbers of participants never worry about their relationships when on board the vessel.

Support to the family and paying the bills is another factor that could create confusion and uncertainty in the minds of personnel working on board a vessel. But from the questionnaire most of the participants are of the opinion that they don't often worry of supporting family and paying the bills. While this again depends on the location and country your are from. Since the economic condition of people in general in Norway is better than most other countries because of the organized system rendered by the government institutions which almost cover all important aspects of human needs like housing, health and economic conditions. So most of the participants don't think much of the support to the family in terms of money (See Table 28).

Table 28 shows the support of crew members to their family members for paying the bills. Out of 12 numbers of participants, 03 number of participant seldom worry about lending support to their family members and pay their bills where as 09 numbers of participants never worry about support to their family and paying the bills.

Tense relationship with crew members on board a vessel plays huge affect on the thinking capability and situational awareness of the crew. It can affect the decision making capability of the individual and it is

evident from the questionnaire, that most of the crew members have cordial relationship and seldom see any conflict of interest between them.

Table 30 shows relationship between crew members working on board the vessel. Out of 12 participants only one of participant believe that he often have tense relationship with other crew members, where as 06 number of participants occasionally have tense relationships with their crew members where as 04 number of participants never had any tense relationship with other crew members while working on board the vessel.

5.5 Mental workload analysis

Mental workload is vital in evaluating the performance of captain, crew members, a duty officer, dockhand, a helmsman and a pilot. Mental workload is useful to evaluate performance of ship bridge teammates: a captain, a duty officer, a helmsman, and a pilot. The physiological indices, heart rate variability and nasal temperature, are good indices of the mental workload found in ship handling; however, it is best if we get response and evaluation results quickly on the spot.

In fact, a further breakdown of mental workload shows that loss of situational awareness could be possible in case of some external distractions like a cell phone call from family or from the company at the time when vessel is passing through high traffic zone in between number of recreational vessels. The urgency of call some time divert the attention of the captain and may result in loss of situational awareness and end up in catastrophic incidents.

It could be worry about other captain understanding, when steering the vessel in front of other vessels, it could be because of boredom while sailing through straight waterways without traffic around, it could also be because of distraction from the cell phones while passing through high traffic zones. See Tables 31, 33 and 34.

In addition to above mentioned factors some time situational awareness can also be result of repetitive work pattern which develop complacency among the crew and posses' serious threat to the safety Furthermore, the results shows that lapses often occur due to complex design and operation of some operations.

5.6 Distraction and Loss of Situational Awareness

In most of the cases the potential loss of situational awareness is because of lack of confidence, competencies or decision making at crucial juncture of time. See Tables 31 and 32. This is due to lack of confidence in the competencies or predictability of the recreational vessel operator, especially in regards to the operator's lack of understanding of the meaning of whistle signals and navigational light

configuration and lack of understanding about the maneuverability of the vessel. The lack of confidence and competence among the crew is predominately because of increased fear, lack of attention, distraction, worry of other vessel operator's skills. See Table 31 and 32.

5.7 Mental workload analysis vs. Situational awareness

There is direct relation between mental workload and situational awareness, though situational awareness has not gained that focus as compared to factors like fatigue or stress. Situation awareness is defined as the perception of various elements present in the environment within volume of time and space. It is primarily a cognitive phenomenon which supports the actions but it is not the part of the action itself. There is interaction between mental workload and the situational awareness. The relationship between situation awareness and mental workload is explained by operator experience and skills. Skilled operators can generally preserve situational awareness with lower resource cost (Wickens, 2001)

If we see deep into mental workload, we come across the exact correlation with term complacency. In other words due to repetitive nature of operation or job, there developed a casual approach of the operator to do that operation there by creating loss of situational awareness and finally accident. In particular it is difficult to come across exact reasons for loss of situational awareness or complacency on human part while doing a particular operation. It could be dull nature of work, repetitive cycles, distraction of any kind, and mental stress, and workload, difficulty in coping with complex technologies, system design complexity and complex interfaces. Moreover lot of research has been done in finding out exact reasons of complacent behavior on the part of human to make those mistakes. However there are some similarities in both aviation and maritime industry as both are falling under the category of transportation and it is highly possible that the factors which lead to complacency on human part in aviation find some similarities in maritime industry.

5.8 Complacency Theories to maritime industry/Vessels

The result from the complacency theory in maritime industry is likely to occur in case the captain of ship steering the vessel in normal environmental conditions undergoing same set of repetitive operations and following the same path each and every time. Every time following the same checklists, passing same commercial vessels, using same means of communication every time, using same charts and means to navigate. This repetitive nature of operation performed by captain and crew members over longer duration often develops environment of boredom and operators, crew or captain develop causal way of performing the same set of things with a mindset that he cannot be wrong pretending to be master in performing the operations. This often results in forming loss of situational awareness and thereby resulting in disaster.

Chapter 6

Risk Management

6.1 Theory

There is always risk involved during the marine operations. Risk management technique is employed to identify and then manage threats that could severely impact on operations. Generally, the process take into consideration the various operations involved in identifying potential threats to the organization and the chances or likelihood of their occurrence, and then after analyzing the data, steps or actions to address the most likely threats.

In every situation where there is urgency to make decision, there is always amount of doubt and uncertainty in the minds of decision makers who have to see pro and cons of the decision and the impact it brings with it." Uncertainty exists where the all possible consequences of an event are unknown, the probability of either the hazards and/or their associated consequences are uncertain, or both the consequences and the probabilities are unknown", Bitaraf, Saminehsadata and Mohammad Shahriaria. The immediate step to carry out in order to assess the impact of risk, it is foremost important to study the root cause analysis of various steps from possible risk involved, the frequency of occurrence, possible impact of it. This phenomenon where attention is paid on evaluation of risk involved and finding out what impact it will have on the system is called as Risk assessment.

The main threats in carrying out operations are can be technical causes, organizational causes and maintenance issues. But it has been observed that major causes of accidents are due to lapse of situational awareness on the part of crew that ultimately results in happening of catastrophic incident. The required considerations and appropriate actions to reduce the risks levels as a result of identified variables have been analyzed for the selected possible hazardous scenarios.

The implementation of this model in the selected case study proves that the model has the ability to support decision makers and managers in the working environment to take up immediate necessary action or steps by addressing the important key variables which cause potential threat for hazard situation.

6.2 The concept of risk:-

Risk is the probability that a hazard will turn into a disaster. In general everyone has its own way of expressing the term risk and as child we all been told often that don't do this, don't do that as there is an element of risk involved in it.

Even though the result of taking risk could be devastating but still we all take risks simply because we calculate the impact and possible consequences of it is called as calculated risk. Example we all know that driving a motor bike or car ,climbing a mountain or investing money in share market is risky affair and is like do or die situation but still we take it as we evaluate it carefully and believe that the chances of its occurrence are rare.

When we evaluate a risk, therefore, we take into account two factors - the probability of something happening that we don't want, and the consequences if it does.

Another example which could be stated is journey by airplane as every one of us are aware of consequences if something bad happen. The chances of survival are negligible but at the same time we never hesitate to travel by plane, simply because it is very rare that it will happen."The Probability of it is very small nearly 1 in 52 million according to National Transportation Safety Board. Therefore it low possibility of occurrence make the risk very acceptable.

So whether we choose to accept or decline a risk depends on the mix of two factors:

- **probability**; and
- **consequence**

Therefore identifying, evaluating and understand risk is very important and crucial part. The first part in defining risk management process is to define the risk involved in particular operation to be performed. For example in our case operation with engine on board a vessel, we need to define the whole operation of the engine along with possible risk factors that are threat to its operation.

After defining the possible risks involved in carrying out engine operation, the next step is to analyze the possible risks. By doing it we can possibly find out that what causes what. In other words which factor has the potential to breakdown the engine while it is performing or what could be the possible consequence of the failure. By analysis we are in better position to define various risks involved with a particular operation and at the same time we have made a check list which is equipped enough to define causes and consequences or failure. It is also called as Risk analysis and it is further divided into two categories viz risk identification and Risk evaluation. In these two categories, majority of times a check list is developed which states how much is the risk involved in carrying out a particular operation, what could be possible reasons for the failure and what would be the consequences.

The next step in risk management process is risk control and risk financing. In the risk control emphasis has been laid on elimination of risks, following some rules and policies to reduce the risks involved in carrying out operations.

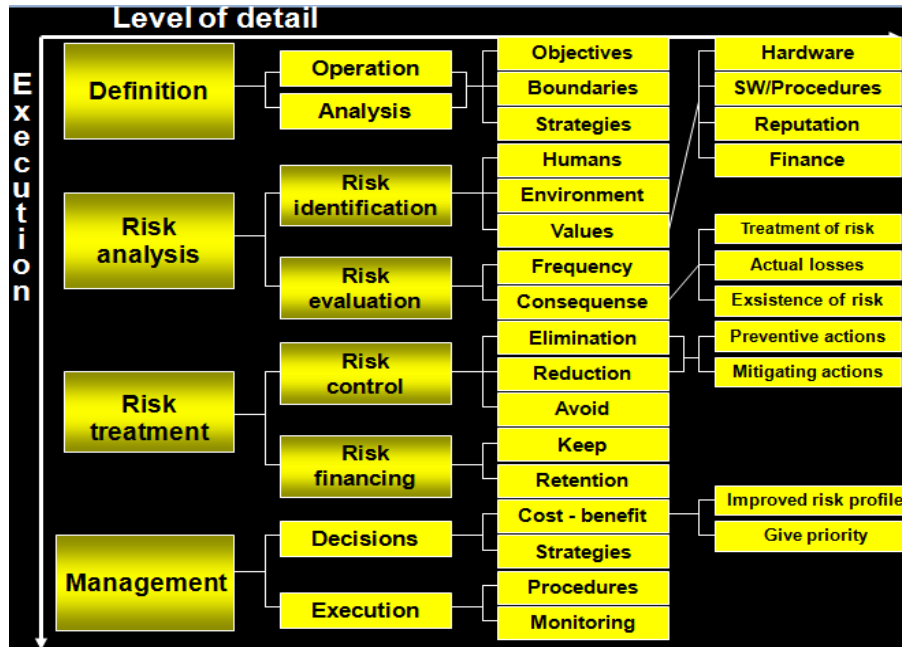


Figure 6.1: Risk Management Process, Courtesy of Textbook, Risk, Issues and Crisis Management, Magne Aarset

6.3 Managing risks

In order to manage the risks in demanding marine operations, it is very important to carry out over all risk assessment within marine operations. The risk assessment of operations is designated to formulate procedure which defines which operation is critical and associated with greater amount of risk. According to DNV three-step process for management of risks within marine operations: – “An overall risk assessment of the operations to define them within low (L), medium (M) or high (H) potential risk categories”.

Based on the intent of risk involved in a particular operation, a detailed risk identification program should be established by the virtue of which a potential risk in a particular operation is reduced to an acceptable level through specific actions and risk reducing activities.

The risk assessment has been carried out by following:-

1. FMEA (Failure Mode and Effect Analysis)
 - a. (FMEA Analysis techniques for system reliability)
 - b. (FMEA Practices for heavy mechanical machinery Applications)
 - c. (Design FMEA, Process FMEA and Machinery FMEA)
2. FMECA (Failure Modes, Effects and Criticality Analysis)
3. FTA (Fault Tree Analysis)
4. HAZOP (Hazard and Operability Analysis)

5. CCA (Cause Consequence Analysis)
6. MORT (Management Oversight Risk Tree)
7. SMORT (Safety Management Organization Review Technique)
8. 4 M's method.
9. Functional flow chart oriented methodology.
10. Monte-Carlo simulation method.

6.4 METHODOLOGY

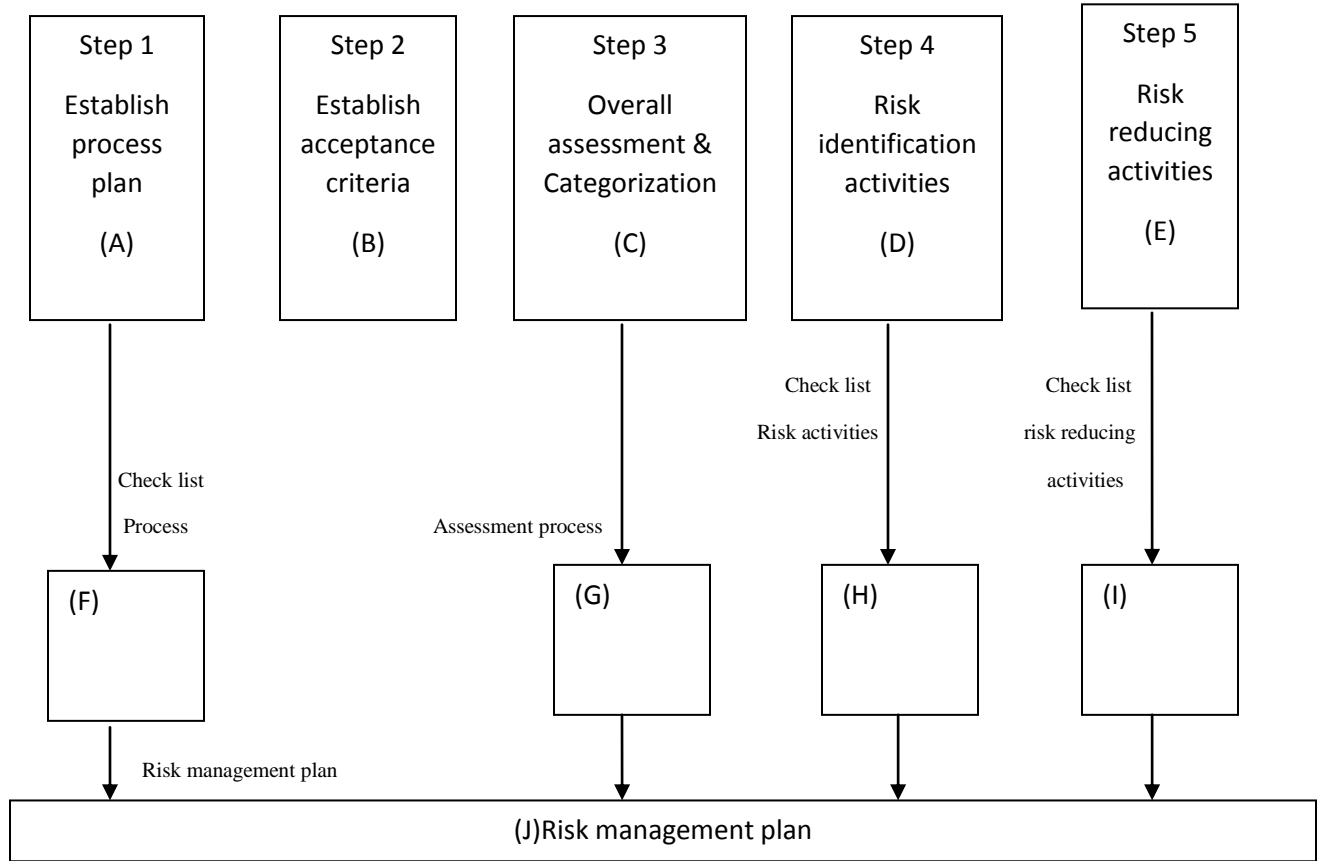


Figure 6.2: Methodology to carry out risk management process

(A) --- HSE Philosophy ownership, (B)---Risk acceptance criteria (C)--- Categorization of operations. (D)--- Mandatory tools (E) --- Optional tools (J) ----- Risk management program

(A) HSE Philosophy and Strategy:-In risk management process specific HSE policy and strategy should be formulated which targets to achieve safety and reputation in the following areas:- Personnel safety, Environment, Assets and Reputation

(B) Risk Acceptance criteria:-They should be broadly categorized into two types:

Consequence categories and Probability categories. In consequence categories, consequence should be divided into categories. Each category should have specific criteria in compliance with HSE

policy and goals. The probability categories should be qualitatively described with supplementary guidance if needed.

Risk categories: - The consequence and probability category describes risk. They should be under categories with higher risk, lower risk and medium risks categories.

Acceptable Risk: The Low Risk category is considered acceptable subject to application of the principle of ALARP and activities as specified in this RP.

(B) Categorizations of Operations: According to DNV, "HSE policy should be defined, and as basis for specifying required QA activities, risk identification activities and risk reducing activities for the planned operations should be categorized into the following potential risk categories": -Low, medium and high.

6.5 How risk is associated with loss of situational awareness?

The four stages to mitigate risk involves are Appraisal, Planning, Execution and Monitoring. The first step in the process is collecting the information needed before planning stage. This is the first step where the situational awareness is gained. In this stage of the process all relevant information and data is collected to be used in the next stage.

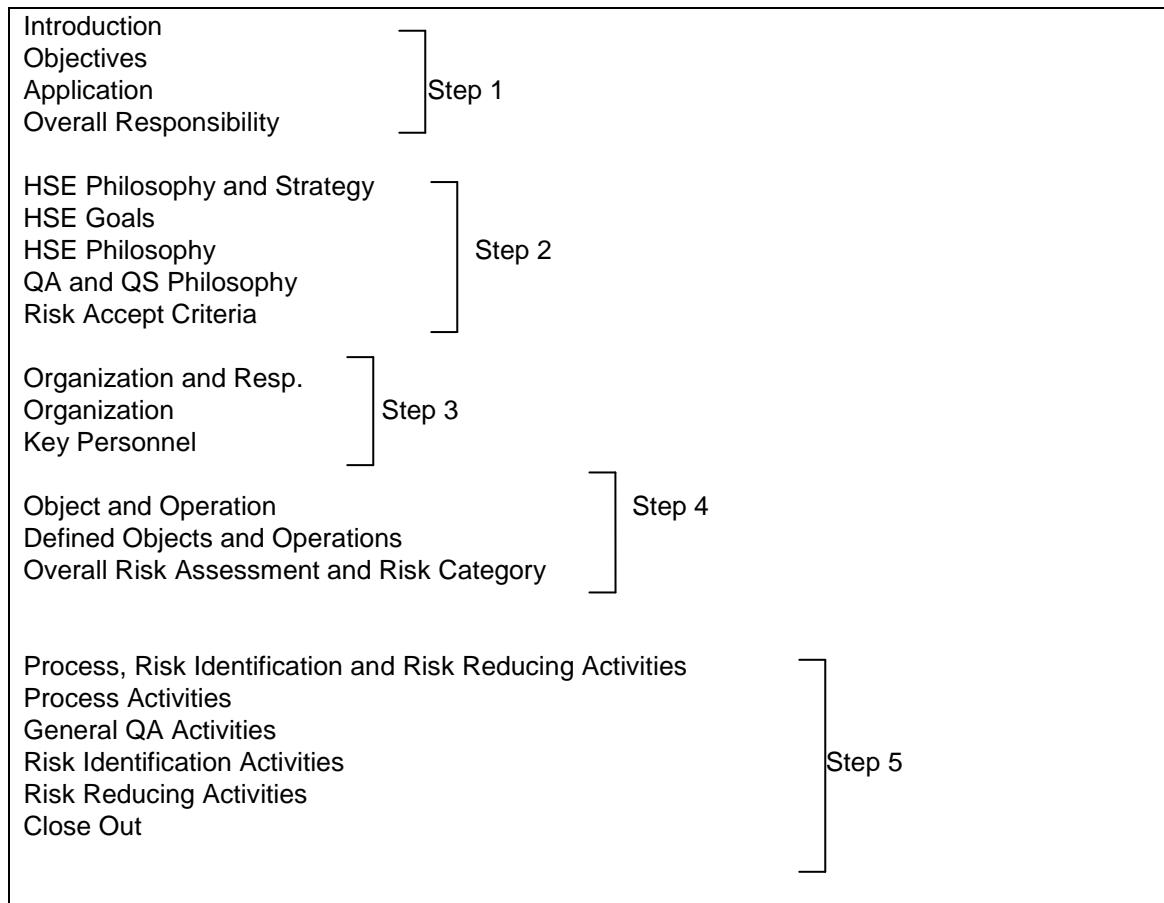
The second stage is planning itself. In this step the information and data which is collected is projected ahead. The next stage in passage planning is planning itself. This is equivalent to understanding and projecting ahead. The navigation of entire vessel has always been challenge and must be adequately planned with unique strategies.

Execution and monitoring are the next two stages of planning. The right combination of these is very important for projecting the situational awareness. While executing and monitoring, the team members shall maintain a close and continuous monitoring of the vessel's position.

In fact in all the factors taken into consideration in the questionnaire from usefulness of communication means like VHF-FM radio, Usefulness of radar and electronic charts, passing arrangements of vessels, understanding of navigational aids, steering through bridge and lock etc.

There is always an enormous amount of risk associated and therefore it becomes very important to carry out proper risk management program to carry out these operations in very effective and risk free manner.

6.5 Risk management plan



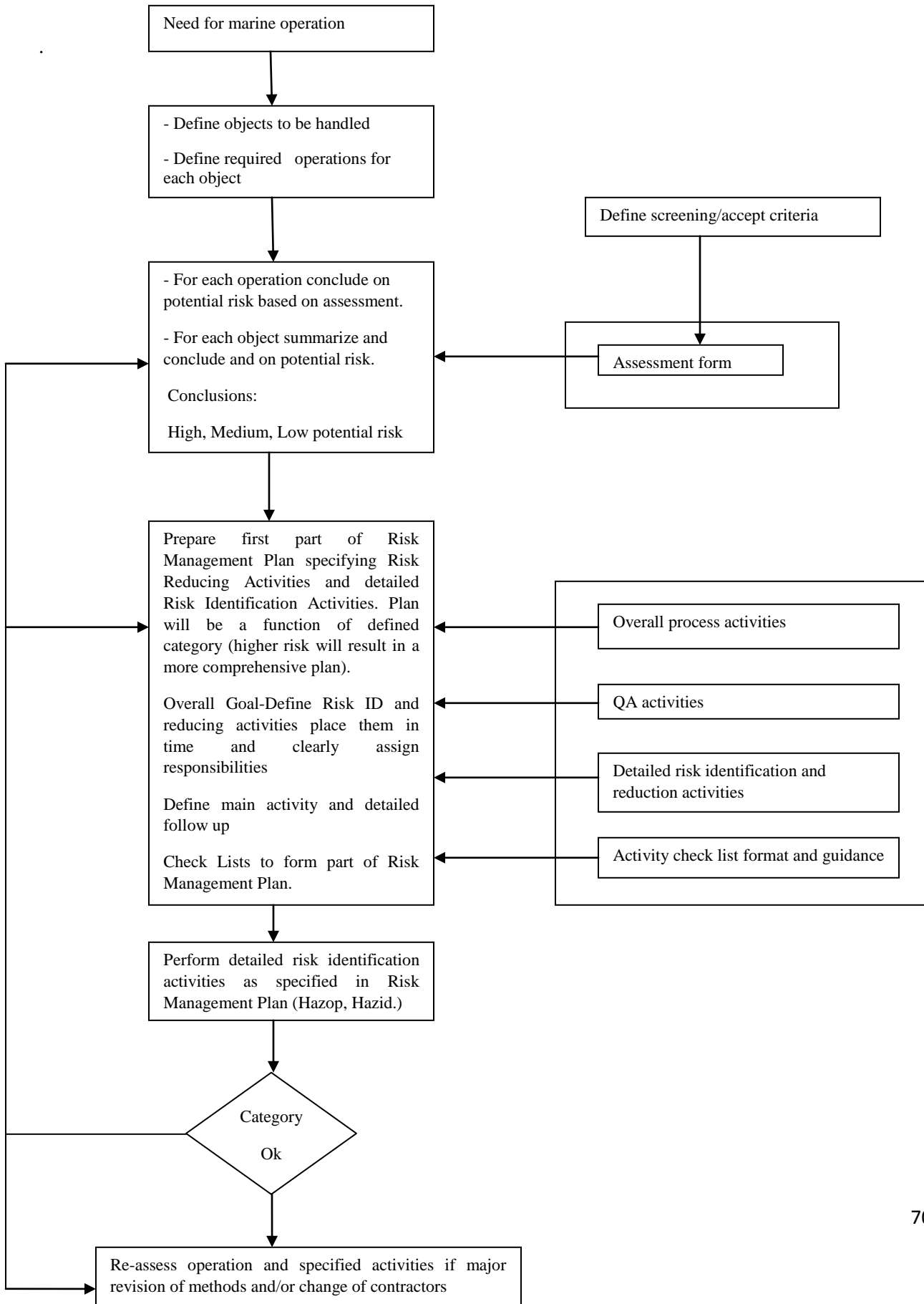
6.6 Hazard Identification activities

The hazard identification is generally dependent on the type of activity or process like if it is engineering process, procedural process, mechanical process or activity based.

In general applications where there is involvement of human or some task has been accomplished by human, task analysis or procedural HAZOP is right tool for identification of hazard and it generally account for human error while undergoing that task.

FMEA (Failure mode effect analysis) is carried out where there is criticality in terms of information of failure modes of the equipment or process alone.

6.8 Methodology flow chart



Chapter 7

Recommendations

7.1 Management Support

The most important criteria to address situational awareness and safety on board a vessel is to ensure the inclusion of management support at right time. It has been found that management support is often handy in long-term improvement on board a vessel. Each ship board management team mostly comprises of two Masters and two chief engineers which are responsible for the overall care of the vessels. The idea of introduction of management support stimulates the interest and involvement in their own vessel by active involvement to ensure optimal maintenance and meeting technical requirements in long terms to cut down the costs.

The Masters and Chief Engineers work together, while on board and are primarily responsible for the overall functioning of vessel and includes budgets, spares and stores, and repairs and maintenance. In addition to this, both are also responsible for the risk management, inclusion of safety and regulatory issues in addition to recruitments of right personnel and ratings. The balance between offshore and management on vessel is very important and lapse in this often result in occurrence of catastrophic incident. The shore organization should provide technical support, crewing and co-ordination between the personnel etc. By including management support there is tremendous improvement in the system in terms of making fast decisions, improving the cost effectiveness and motivating the people. workers, officers to work effectively with lesser risks.

7.2 Identification of costs

The cost incurred in case of accidents is categorized into direct and indirect costs. Direct costs are the costs that include loss of inventory, commodities, vessel breakdown, damage to the structure, the cost involved in the repair of the vessel and the compensation to be given to the workers. The costs to be incurred in medical aid to the workers, personnel include medical expenses for hospitals, doctors, drugs and health insurance etc.

The indirect costs are the costs which are to be paid in terms of contingent costs like the damage done to the environment, pollution caused due to the accident, marine life disturbed and the other factors which are directly linked to the environment. These indirect costs are something which is difficult for the ship owners or the company to evaluate and often end up in disaster to the company in terms of money. In some of the cases the extent of damage to the environment is that much that it is

often observed that sum total of all the expenses from the indirect costs is much more than direct costs involved in the accidents. Therefore it is very important to include better management and safety programs in order to avoid the accidents there by saving enormous amount of capital which otherwise be disaster to the company.

7.3 Inclusion of Safety Management program

In most of the cases nearly 70-80% of the accidents and casualties occur due to the negligence of human called human error or human element. Human element plays huge role in causing marine casualties, including those where structural or equipment failure. Consequently, the international maritime community and the U.S. Coast Guard saw the need to emphasize shipboard safety management practices to minimize human errors or omissions. Therefore inclusion of safety management program is very important element in avoiding any catastrophic incident to occur.

7.4 Objectives of safety management program:-

- To provide safe working conditions and safe practices in ship operations in accordance with rules and regulations of IMO with special consideration to environment and safety.
- To incorporate risk management program like preventive risk management program etc.
- To enhance the skills and knowledge of the working crew members in identifying the risks and mitigating at their own.

A Safety management program consists of following elements:-

- a) Safety and Environmental Protection Policy
- b) Company Responsibility and Authority
- c) Designated Persons
- d) Master's Responsibility
- e) Resources and Personnel
- f) Vessel Operating Procedures
- g) Emergency Preparedness
- h) Reporting Procedures
- i) Maintenance
- j) Documentation
- k) Company Verification and Review

7.5 Safety and Environmental Protection Policy

There should be very clear safety and environment policy that clearly defines the responsibilities and commitment to the safety of the crew and vessel in accordance with the environment rules. The company's objectives and standards must be set at the highest level that is reasonable for the company to enforce. **(As per Safety Management System manual Guidebook), by Commandant (G-MSO-2) U.S. Coast Guard.** At the very least, the company shall comply with all mandatory rules and regulations. The policy should describe:

- The policy should describe all the interacting elements in very clear way.
- The policy should describe how the following objectives are to be met and various procedures.
- The policies should describe all the safeguards against every possible risk on board a vessel.
- Avoidance of damage to the vessel and the property.

The policy should encourage continuous improvement in safety awareness and safety management skills. It should be signed by the owner or comparable decision-maker and should be reviewed at regular intervals to ensure that it remains relevant and effective.

7.6 Company Responsibility and Authority

In accordance with Section 33 CFR 96.230 (b), "A company must document the responsibility, authority and interaction of all personnel who manage, perform and verify the work relating to and affecting safety and pollution prevention". **(As per Safety Management System manual Guidebook), by Commandant (G-MSO-2) U.S. Coast Guard.**

Responsibility

In accordance to Section 33 CFR 96.230, responsibilities have to be fixed at first place and are as follows:-

- 1) Appropriate details of the ship operator(s)
- 2) The full name and entity of the operator responsible for operation of the ship if not the owner himself must have been brought to the notice of Coast guard.
- 3) The person(s) or position(s) with the highest authority in the development, implementation, and maintenance and how they can be contacted.
- 4) The person(s) or position(s) with the responsibility to carry out overall operational responsibility and authority to govern procedures for safety, environmental protection.

7.7 Master's responsibility

Master's responsibility plays an major role and formulated and referenced in the Section 33 CFR 96.250(d,e),(*As per Safety Management System manual Guidebook*), by *Commandant (G-MSO-2) U.S. Coast Guard* as follows:-

- 1) The company should always documents the roles and responsibilities with regard to safety and environmental policies of the company.
- 2) Motivating the crew to follow and understand the policies.
- 3) Make sure that policies have been implemented by the personnel on board the vessel.
- 4) Reporting in case of non understanding and the deficiencies to the shore management at the earliest as possible.

7.8 Resources and personnel

In accordance to Section 33 CFR 96.250 (f), (*As per Safety Management System manual Guidebook*), by *Commandant (G-MSO-2) U.S. Coast Guard*, rules for resources and personnel should be implemented and are as follows:-

The recruitment of the master(s) is very important and should only be appointed if -

- 1) They have required amount of training under their belt.
- 2) They are medically fit.
- 3) They must hold experience and valid certifications from international operations.
- 4) They have ample experience to carry out the operations on type of vessel assigned to them.

7.9 Communication

It is the responsibility of the Master to ensure that all the crew members are able to communicate with each other as well as with the passengers on board.

Effective communication between the crew and their passengers can be crucial in the outcome of an emergency situation.

7.10 Vessel operating procedures

It is very important that company should document various procedures that are linked with plans and instructions for vessel operations concerning the safety of the ship and the prevention of pollution. The various tasks involved should be defined and assigned to qualified personnel. This information should be easily understood by all relevant shipboard personnel.

7.11 Hints and Suggestions

For instance all the documentation regarding various procedures, implementation procedures and instructions should be kept very simple and understandable in terms of implementation. Checklists may help to guarantee that all routines in a particular operational phase are covered.

Two areas have to be covered one is regulatory and other is Non regulatory. **(As per Safety Management System manual Guidebook), by Commandant (G-MSO-2) U.S. Coast Guard**

Regulatory

Certification of Inspection - 46 CFR 176

Certificates and Documentation - SOLAS

Discharge of Oils and Garbage - 33 CFR 151

Working Hours - 46 CFR 15.710

Personnel Management and Standards - 46 CFR 10

On Board Medical Arrangements - 46 CFR 184.710, 160.041

Checking Stability - 46 CFR 185.315, 185.340

Assessment of Weather Conditions - 46 CFR 185.304

Securing Loading Doors, Hatches, and All Openings - 46 CFR 185.330, 185.335

Pre-Underway Checklist - 46 CFR 185.320

Voyage Plan and Verification of Nautical Charts and Publications - 46 CFR 184.420, 185.503; 33 CFR 62.21

Loading and Discharging Passengers - 46 CFR 185.506, 185.504 Fuelling and Ventilation Requirements for Gas Powered Vessels - 46 CFR 182.460

Bridge Watch keeping Arrangements - Rule 5, Inland Navigational

Regulations for Preventing Collisions at Sea, 1972; and Rule 5, Inland Navigational Rules Act of 1980 (33 U.S.C. 2005)

Other Watch keeping Arrangements - 46 CFR 15.705; Rule 5, Inland Navigational Regulations for Preventing Collisions at Sea, 1972; and Rule 5, Inland Navigational Rules Act of 1980 (33 U.S.C. 2005)

Special Requirements for Bad Weather and Fog - 46 CFR.510, 185.512

7.12 Emergency Preparedness

The company should establish procedures to prepare for various emergencies involving pollution and the safety of the vessel, crew, and passengers. The various tasks involved should be defined and assigned to qualified personnel.

(As per Safety Management System manual Guidebook), by Commandant (G-MSO-2) U.S. Coast Guard

Regulatory

Fire Fighting Drills and Training - 46 CFR 185.524

Abandon Ship and Man Overboard Drills and Training - 46 CFR 185.512, 185.520, 180.210

Discharge of Oil, Garbage, and Response to Pollution - MARPOL 73/78 Regulation 26, Protocol I

Fire - 46 CFR 185.524

Flooding and Flood Control - 46 CFR 182.500-530

Man Overboard - 46 CFR 185.510

First Aid - 46 CFR 184.710, 160.041

7.13 Reporting procedures

In accordance to Section 33CFR 96(g).***As per Safety Management System manual Guidebook), by Commandant (G-MSO-2) U.S. Coast Guard***, there should be scope of documenting the reporting procedures as “The reporting of accidents, hazardous situations, and discharges of oil and garbage should be done in a timely manner. Corrective measures taken should improve safety and pollution prevention. Procedures and responsibilities for reporting these events will be clearly established.

Non-conformities may be identified by any crew member at any time or during an SMS internal audit. Non-conformity reports should be available for use by any crew member who identifies non-conformity. This form describes the non-conformity, proposed corrective actions, and corrective actions taken. It lists and has the signatures of the person(s) involved in the detection and correction of the non-conformity”.

7.14 Maintenance

In accordance to section 33 CFR 96.250 (j). (*As per Safety Management System manual Guidebook*), *by Commandant (G-MSO-2) U.S. Coast Guard*, the company should make all possible efforts to document various maintenance procedures for each vessel and are as follows:-

- 1) To hold inspections at appropriate intervals.
- 2) To report non-conformities with possible cause, if it is known.
- 3) To take corrective measures and actions
- 4) To formulate preventive maintenance programs, maintain records of inspections, non-conformities and corrective actions for future actions.

In accordance to Section 33 CFR 250.96 (j), the following areas to be covered under regulatory

Dry-dock and internal examinations - 46 CFR 176.600 through 670

Hull inspection - 46 CFR 176.802

Machinery inspection - 46 CFR 176.804

Electrical inspection - 46 CFR 176.806

Lifesaving Equipment inspection and maintenance - 46 CFR 176.808, Part 185 Subpart G

Firefighting Equipment inspection and maintenance - 46 CFR 176.810, 181.120, NFPA 10

Pressure Vessel and Boiler inspections - 46 CFR 176.812

Steering System inspection - 46 CFR 176.814

Miscellaneous Systems and Equipment inspections - 46 CFR 176.816

Chapter 8

Conclusion

In this study we have evaluated various factors which could have some impact on the situational awareness of the crew on board a vessel. These factors are as follows: - Fatigue, drugs, social stress, mental load etc.

These factors if not addressed properly will certainly going to have adverse effect on the situational awareness of the operator or crew which can lead to catastrophic incidents. These factors were compared and mental workload was identified as the most predominant factor that caused loss of situational awareness. Various possibilities have been discussed in this study taking into consideration ground situation of crew/captain and other staff working on the vessel.

The feedback obtained from the questionnaire duly filled by the people working in different companies, having different field of experience and have different set of skills and predominant factors and their outcomes have been documented in sequence. A further examination of mental workload revealed that loss of situational awareness is likely to occur during situations where the vessel captain is discussing business matters with the company on cell phone or steering in the vicinity of recreational vessels.

It has also been found out that in some cases complacency factor is responsible for the lapse and loss of situational awareness thereby increasing the possibility of accident.

The loss of situational awareness could be avoided by having good awareness of various safety and management programs implemented by the companies to measure unsafe behaviors, to avoid regular repetitive operations etc. Variation and avoidance of routine operations can be an effective tool for addressing complacency potential.

Further work

- To develop procedure to measure situational awareness during real time simulations on simulator using Freeze probe and Real Time Probe Techniques.
- To suggest the matrices for situational awareness with respect to risks.
- To make simulations on simulator using Observer Rating, SAGAT and SART Approaches.

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APPENDIX: INTREGRATED SURVEY AND INTERVIEW

This is a questionnaire for use in a pilot study at Aalesund University College comparing perception of situational awareness during operations in the aviation and the marine industry.

The information in this questionnaire will be treated completely anonymous, exclusively for scientific research and there will be no possibilities for tracking any of the respondents.

Thank you for your participation!

Section A

1. Gender:
2. Age:
3. What is your position on the vessel you are sailing on regularly?
4. For how many years have you been holding a License for this position (see question 3)?
.....
5. How many days are you usually onboard the vessel (see question 3) per year?.....
6. How would you like to describe your present condition of physical health? (Mark the alternative below.)
a) Excellent b) Good c) Fair d) Poor

Section B (Fatigue)

1. How often have you experienced fatigue issues, which you feel compromised safety on board the ship for the latest year?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know / I don't want to answer

2. Have you been trained with respect to crew endurance management?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know / I don't want to answer

3. How often have been working overtime while at sea for the latest year?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know/ I don't want to answer

4. Do you find it difficult to sleep because of the noise coming from the engine room?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know/ I don't want to answer

5. Do you find it difficult to sleep because of the vibration coming from the engine room?
 - a) Often
 - b) Seldom
 - c) Never

d) I don't know/ I don't want to answer

6. How would you rate the quality of sleep on board the vessel as compared to normal sleep you have when at home?

a) Good

b) Fair

c) Poor

d) I don't know/ I don't want to answer

7. What do you prefer regarding shifts on board?

a) I prefer one 12 hour shift

b) Prefer Multi-shifts like 6 Hours on - 6 hours off

c) Doesn't make any difference

d) I don't know/ I don't want to answer

SECTION C – Communication

Here, the questions are regarding communication on board the vessel you are sailing on regularly, and could e.g. be communication between crewmembers or members of the crew on other vessels.

Here, by “Deckhand” we mean a member of the crew who performs manual labor on board.

1. The deckhand's _____ report the results of their rounds of the vessel?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know/ I don't want to answer

2. The deckhand's _____ can be counted on to report hazards to navigation at night?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know/ I don't want to answer

3. I am _____ satisfied that I understand wind and current when I relieve the watch?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know/ I don't want to answer

4. I am _____ satisfied that I understand the location of other vessels and hazards to navigation when I relieve the watch?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know/ I don't want to answer

5. I am _____ confident that I understand my vessel's navigation light configuration and change it whenever required by the rules to do so.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

6. I _____ communicate passing arrangements to other commercial vessels via VHF-FM radio?

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

7. Other commercial vessels _____ respond via VHF-FM radio?

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

8. I am _____ confident that other commercial vessels understand navigation light configuration?

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

9. I _____ communicate passing arrangements to other recreational vessels via VHF-FM radio?

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

10. Other recreational vessels _____ respond via VHF-FM radio or other signal device?

- a) Often
- b) Seldom
- c) Never
- d) I don't know/I don't want to answer

11. I am _____ confident that recreational vessels understand the meaning of 1 and 2 whistle signal?

- a) Highly
- b) Seldom
- c) Never
- d) I don't know/I don't want to answer

12. I am _____ confident that recreational vessels understand my navigation light configuration?

- a) Highly
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

13. I _____ use my whistle or spotlight to attract the attention of other recreational vessels?

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

14. The recreational vessels _____ maneuvers out of the way upon hearing my whistle or seeing my spotlight?

- a) Often
- b) Seldom
- c) Never

d) I don't know/ I don't want to answer

15. I _____ flash my spotlight or use my whistle when making passing arrangements with other commercial vessels?

a) Often

b) Seldom

c) Never

d) I don't know/ I don't want to answer

16. I find that information on vessel characteristics from radar is _____ critical to being able to plan ahead and avoid potential collisions with other vessels.

a) Very

b) Seldom

c) Not

d) I don't know/ I don't want to answer

17. I find that information on vessel characteristics from AIS / Electronic Chart is _____ critical to being able to plan ahead and avoid potential collisions with other vessels

a) Very

b) Seldom

c) Not

d) I don't know/ I don't want to answer

18. I find that information from VTS is _____ critical

a) Very

b) Seldom

c) Not

d) I don't know/ I don't want to answer

19. Do crew have clear understanding of weather and location of other vessels?

a) Often

b) Seldom

c) Never

d) I don't know/ I don't want to answer

SECTION D: Social stress

1. I _____ worry about losing my job?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know/ I don't want to answer

2. What is your current marital status?
 - a) Married
 - b) Single

3. When underway, I _____ worry about the stability of my relationship with my family?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know/ I don't want to answer

4. I _____ worry about being able to support my family and pay the bills?
 - a) Often
 - b) Seldom
 - c) Never
 - d) I don't know/ I don't want to answer

5. E-mail / Cell phones are _____ helpful for the stability of my relationship?

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

6. I _____ have tense relations with other crew-members?

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

SECTION E: Mental load

Mental Workload is the amount of mental work associated with information processing from steering a vessel; time spent communicating with other vessels or using electronic charts and radar.

1. When steering a vessel in the presence of other vessels, I _____ worry about the other Captain's understanding of my vessel's maneuvering limitations.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

2. When steering a vessel in the presence of other recreational vessels or fishing vessels, I _____ worry about the other operator's understanding of my vessel's maneuvering limitations.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

3. I _____ feel bored when steering on long straight-aways or areas with little to non vessel traffic.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

4. I find that cell phone calls I receive in a busy section of the waterway are _____ distracting.

- a) Often
- b) Seldom

- c) Never
- d) I don't know/ I don't want to answer

5. I find that cell phone calls I receive in a non-busy section of the waterway are _____ distracting.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

6. I rely heavily on _____ for information regarding navigational aids and landmarks (check all that apply).

- a) Electronic charts
- b) Paper charts
- c) Radar
- d) Publications/Notices

7. During the day, I rely heavily on _____ for knowing vessel locations when not in visual sight (check all that applies).

- a) AIS
- b) Radar
- c) VHF-FM Radio

8. At night, Radar is _____ AIS for knowing vessel locations.

- a) More reliable than
- b) As reliable as
- c) Not as reliable as
- d) I don't know/ I don't want to answer

9. Paper charts are _____ Electronic Charts for information of navigational aids and landmarks.

- a) More reliable than

- b) As reliable as
- c) Not as reliable as
- d) I don't know/ I don't want to answer

10. I _____ have a difficult time trying to operate the Electronic Chart.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

11. I _____ have a difficult time trying to operate the AIS transponder.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

12. I _____ rely on the pilothouse alarms to inform of problems with the vessel's engines.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

13. I am _____ confident that the vessel's engines are running at optimal performance.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

14. I _____ steer the same course through a lock.

- a) Often
- b) Seldom

- c) Never
- d) I don't know/ I don't want to answer

15. I _____ steer the same course through a bridge.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

16. I _____ encounter the same commercial vessels on subsequent transits.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

17. I _____ encounter the same passing arrangements with commercial vessels.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer

18. I _____ encounter situations where the wind / tide/ currents catch me by surprise.

- a) Often
- b) Seldom
- c) Never
- d) I don't know/ I don't want to answer