FSA Based Analysis of Deck Officers' Non-Technical Skills in Crisis Situations

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ABSTRACT

A review of maritime accidents conducted in 2006 confirms that human error is the main contributing factor in maritime accidents. This study illustrates that major maritime accidents are not caused by technical problems but by failure of the crew to respond to the situation appropriately.

Non-technical skills (NTS) encompass both interpersonal and cognitive skills such as situation awareness, teamwork, decision-making, leadership, managerial skills, communication and language skills, etc. In a crisis situation good NTS allow the deck officers to recognise a problem quickly and manage the situation and team safely and effectively. As a result, the evaluation and grading of deck officers' NTS is necessary to assure safety at sea.

This research aims to identify the links between maritime accidents and deck officers' NTS and identifies significant criteria and their contributions to the deck officers' NTS by using the Formal Safety Assessment concept. Taxonomy of deck officers' non-technical skills was developed by conducting interviews with experts and collecting NTS weighting data for calculating each NTS weight by the AHP (Analytical Hierarchy Process) method.

Based on the taxonomy of the deck officers NTS behavioural markers were developed for the assessment of their NTS in the bridge simulator. A set of bridge simulator crisis scenarios was developed to assess deck officers' NTS.

Two sets of Chief Mate volunteer students' NTS performance was assessed in the bridge simulator. One set of students are those who have not obtained NTS training i.e. HELM (Human Element Leadership and Management) and the other set of students are those who have obtained the HELM training as part of their main course of study. All groups' NTS performances are calculated by the ER (Evidential Reasoning) Algorithm and are compared to see if there are any improvements in the NTS performance with the HELM training. After comparison it was found that NTS performance of the groups with HELM training was only 0.8% better than the NTS performance of the groups without HELM training.

HELM course effectiveness is evaluated and suggestions are given for further improvements to the course. Cost benefit analysis for improving deck officers' NTS was carried out by Bayesian Network and Decision Tree Model.

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ABBREVATIONS

2/O	Second Officer
3/O	Third Officer
AHP	Analytical Hierarchy Process
AIS	Automatic Identification System
ANTS	Anaesthetists’ Non-Technical Skills
AQP	Advanced Qualification Programme
ARPA	Automatic Radar Plotting Aid
ASRS	Aviation Safety Reporting System
AW	Air Warfare
BBN	Bayesian Belief Network
BN	Bayesian Network
BRM	Bridge Resource Management
BTM	Bridge Team Management
C/O	Chief Officer
CAA	Civil Aviation Authority
CARMA	Crisis Avoidance and Resource Management for Anaesthetists
CDM	Critical decision Method
CI	Consistency Index
CIC	Combat Information Centre
CM	Chief Mate
CPA	Closest Point of Approach
CR	Consistency Ratio
CRM	Crew Resource Management
CTA	Cognitive Task Analysis

CTSB	Canadian Transport Safety Board
DAG	Directed Acyclic Graph
DOP	Deck Officers’ Performance
DR	Dead Reckoning
D-S	Dempster-Shafter
DSC	Degital Selective Calling
ECDIS	Electronic Chart Display Information System
EPIRB	Emergency Position Indicting Radio Beacon
ER	Evidential Reasoning
ERO	Emergency Response Organisation
FAA	Federal Aviation Authority
FSA	Formal Safety Assessment
GMDSS	Global Maritime Distress Safety System
GPS	Global Positioning System
HELM	Human Element Leadership and Management
HND	Higher National Diploma
IAMU	International Association of Maritime Universities
IMO	International Maritime Organisation
ISM	International Safety Management
JAA	Joint Aviation Authorities
JARTEL	Joint Aviation Regulation – Translation and Elaboration of Legislation
LJMU	Liverpool John Moores University
LOFT	Line Oriented Flight Training
LOSA	Line Operation Safety Audit
MAIB	Marine Accident Investigation Branch

MCA Maritime and Coastguard Agency

MCA Maritime and Coastguard Agency

MCDM Multi-Criteria Decision Making

MF Medium Frequency

MNTB Merchant Navy training Board

MRCC Maritime Rescue Coordination Centre

MSC Maritime Safety Committee

MV Motor Vessel

NAEST M Navigation Aids, Equipment and Simulator Training (Management)

NASA National Aeronautics and Space Administration

NDM Naturalist Decision Making

NOTECHS Non-Technical Skills

NOTSS Non-Technical Skills for Surgeons

NTS Non-Technical Skills

NTSB National Transportation Safety Board

OOD Officer of the Deck

OOW Officer of the Watch

OSC On Scene Commander

PCA PC Architecture

QSS Quality Standard System

RI Random Index

SA Situation Awareness

SAGAT Situation Awareness Global Assessment Technique

SOLAS Safety Of Life At Sea

STAR Surgical Team Assessment Record

STC	South Tyneside College
STCW	Standards of Training, Certification and Watchkeeping
SWO	Surface War Officer
TADMUS	Tactical Decision Making Under Stress
TNA	Training Needs Analysis
TSS	Traffic Separation Scheme
VHF	Very High Frequency
VTIS	Vessel Traffic Information System
WMU	World Maritime University

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Since the establishment of the International Maritime Organisation (IMO) in 1948, the existence of Classification Societies since 1760 and the intervention of other maritime bodies involved to improve safety, large numbers of marine accidents have continued to take place.

> The most well-known marine accidents include the Herald of Free Enterprise in 1987, with 188 fatalities; the Exxon Valdez in 1989 leaving the polluted seas with 37,000 tons of crude oil; the Scandinavian Star in 1990 with 158 dead; the Estonia in 1994 with 900 fatalities; the Erika in 1999 with up to 25,000 tons of oil spill; the Samina Express in 2000 with 80 dead and the Prestige in 2002 with 63,000 tons of oil pollution (Goulielmos et al., 2012).

Maritime accidents have many causes, as will be outlined in Chapter2, and until 1990 the IMO's main focus was on the technical aspect of the safety of shipping but since then its emphasis has shifted towards human factors and the first step towards improving the human side was the introduction of ISM (International Safety Management) in 1998 (ibid).

A review of maritime accidents' databases from the UK, USA, Norway and Canada conducted by Barnett *et al.* in 2006 confirms that human error is the main contributing factor in maritime accidents. This study by Barnett et al. (2006) illustrates that major maritime accidents are not caused by technical problems but by failure of the crew to respond to the situation appropriately. The following conclusions were drawn;

1. While the total number of accidents is declining, human error continues to be the dominant factor in 80% to 85% of maritime accidents.
2. Failures of situation awareness and situation assessment overwhelmingly dominate.
3. Human fatigue and task omission seem closely related to failures of situation awareness (ibid).

The MAIB (Marine Accident Investigation Branch) reported that among the technical failures caused there was team cohesion failure when non-standard emergency situations occurred which led to rising levels of personal stress. Engineer officers have shown lack of diagnostic skills while deck officers have failed to operate as an effective bridge team (Habberley et al., 2001).

Based on the above fact, it is now assumed that the training and assessment of the main non-technical skills (NTS) of co-operation, leadership and management skills, situation awareness and decision making, needs to be established in the maritime industry.

1.2 STATEMENT OF PROBLEM

In response to the 'Green Lilly' incident, in 2001 the Maritime and Coastguard Agency (MCA) commissioned a research project to study 'simulator training for handling escalating emergencies' (Habberley et al., 2001). There were six recommendations of this research project:

1. A Training Needs Analysis (TNA) should be undertaken to analyse the training requirement and specify the functional requirements for the training equipment to be used within this training and assessment programme.
2. The main non-technical skills of co-operation, leadership and management skills, situation awareness, and decision making, that have to be mastered in order to handle escalating emergencies, need to be more fully defined.
3. A strategy needs to be developed to incorporate these skills into a training and assessment programme.
4. Crisis management standards of competence are ill defined and consequently so are their "behavioural markers" by which the standard may be assessed. More research is needed in this area, particularly in assessing the team working competencies.
5. Whatever training methods are used, crisis management training should be viewed as a long term process, embedded in the training of individuals from novice through to senior command, not as a set of "bolt-on" courses.
6. The most cost effective training option will be determined by local factors. Therefore, no mandatory option should be considered. At present, until the research above is completed, assessment by Full Mission Simulator constitutes the only viable option (ibid).

This present study aims to undertake a research based on the recommendations in the MCA study 'simulator training for handling escalating emergencies' and conduct an extensive literature review of the NTS and then develop a taxonomy for the deck officers' NTS and develop the behavioural markers for the training and assessment of these NTS. The research will also analyse the effectiveness of the HELM (Human Element Leadership and Management) training course at management level which has been made compulsory by the IMO since 2012 for deck and engineer officers at management and operations level in the STCW Manila amendments in 2010. However this study is only about deck officers the reasons for which will be explained in Section 1.5.1.

1.3 RESEARCH OBJECTIVES AND THEIR HYPOTHESIS

Firstly, the aim of this research is designed to contribute to the development and assessment of NTS required by deck officers by investigating its current practice after analysing empirical data from this study. The research will create a set of scenarios within a marine bridge simulator through which it will be possible to evaluate and grade the NTS of deck officers. The second aim is to develop a method which will enable trainers to quantitatively assess NTS in a ship's bridge simulator and identify further training requirements. Within this aim the research will evaluate the effectiveness of HELM training as made compulsory for deck officers by the IMO in the Manila amendment (IMO, 2011) to the STCW convention.

NTS encompasses both interpersonal and cognitive skills such as situation awareness, teamwork, decision-making, leadership, managerial skills, communication and language skills (Flin et al., 2003). In a crisis situation good NTS allow the deck officers to recognise a problem quickly and manage the situation and team safely and effectively. As a result, the evaluation and grading of deck officers' NTS is necessary to assure safety and security at sea. Furthermore, evaluation of a deck officer's NTS grade enables and facilitates maritime educators to assess the effectiveness of their training programmes.

The research programme will have the following objectives:

1. Complete a literature review, collect the available failure data and undertake a statistical analysis of maritime accidents.

2. Identify the links between maritime accidents and the deck officers' NTS.

3. Identify significant criteria and their contributions to the deck officers' NTS.

4. Develop a taxonomy for the deck officers' NTS.

5. Develop a set of scenarios as a method for demonstrating deck officers' competency based on objective 4 and interviews with experienced deck officers at management level.

6. Develop a methodology for assessing deck officers' NTS grade in a bridge simulator based on objective 5.

7. Evaluate the deviation between deck officers' NTS grades and assess the effectiveness of the training programmes and analyse training needs.

The above objectives are developed to address challenges faced by the ever changing complexity associated with human element issues in seafarer training. Possible goals to be achieved in this research include:

1. To develop training needs for facilitating the implementation of the HELM course.

2. To develop terms of reference on human element issues with respect to training needs for the HELM course.

3. To develop an evaluation system to see how trainees' performance is improved through training programmes using the deliverables developed in this research.

1.4 STRUCTURE OF THESIS

The thesis is compiled of eight chapters. Chapter One has outlined a brief introduction relating to the background and motivation of the research, the research aims and objectives, a statement emphasising the problems encountered and the structure of the thesis.

Chapter Two reviews the relevant literature influencing the current study. It includes the accident data caused by human error and the importance of NTS in the maritime industry and most safety critical industries. An overview of the aviation industry's CRM (Crew Resource Management) course evolution is given along with some other safety critical industries' efforts into NTS training and assessment is reviewed. A detailed review of the main cognitive (situation awareness and decision making) and social (leadership and teamwork) NTS provides the basis of the research. This will serve to draw attention to the possible inadequacy and limitation of the current status, thus demonstrating the need and justification of this research. Flin *et al.* (2008)'s book "Safety at the sharp end" has influenced part of literature review, particularly Section 2.3, however a much larger body of literature is reviewed in Chapter Two.

Chapter Three outlines the overall methodology of the research which is based on Formal Safety Assessment (FSA). The use of mathematical models are explained which include the Analytical Hierarchy Process (AHP), Evidential Reasoning (ER), Bayesian Networks (BN)'s and the Decision Tree Model. Some limitations of each method are explained. The importance of ethical issues with reference to the present study are discussed.

In Chapter Four the significant criteria and their contributions to the deck officers' NTS are identified and a preliminary model with an hierarchal structure as a taxonomy for the deck officers' NTS is developed and the elements of the taxonomy are justified. The interview schedule is developed to be conducted with the experienced seafarers to validate the effectiveness of the taxonomy. The interview is divided into three parts: 1) performance example (the interviewee is asked to describe a real case from his own experience that was particularly challenging), 2) distinguishing skills (the interviewee is asked to think of the skills and attributes he considers to be characteristic of a deck officers' effective performance in crisis situations on the bridge of a ship), 3) sorting task (the interviewee was asked to rank the criteria that are presented in the model/taxonomy or suggest additional criteria). Furthermore, data presented by the interviews is carefully reviewed and a weight is assigned to each criterion by using a mathematical decision making method AHP.

Chapter Five presents the behavioural markers for team working, leadership and managerial skills, situation awareness, and decision making developed by a relevant literature review. Based on the behavioural markers the assessors in a ships bridge simulator are able to mark each element of a trainee's NTS. For assessment of a delegate's NTS in a ship's bridge simulator, three sets of scenarios that are executable there are produced. Two sets of volunteer students after completion of their training programmes (i.e. STCW Chief Mate Certificate of Competency) are selected. One set of students are those who have not obtained the HELM training and the other set of students are those who have obtained the HELM training. Based on the developed scenarios, and developed behavioural markers, students' NTS grades in a ships bridge simulator are assessed. The results are analysed and compared using a mathematical model, the ER Algorithm and a Utility Value. The main aim of using a utility approach is to obtain a single crisp number for the top-level criterion (the final result or goal) in order to rank the group performance for the purpose of the comparison.

Chapter Six analyses the other safety critical industries' efforts into NTS and the possibility of the adaption of such useful proven practices into the maritime domain. Based on some of those proven methods, options are created to improve the HELM training for deck officers. A cost benefit analysis is carried out using a BN and a Decision Tree Model for making decisions.

Chapter Seven discusses the findings of the research in detail. It discusses and reflects on the achievements of the aims. This chapter also ascertains whether this research has made a contribution to knowledge and highlights avenues for future research.

Chapter Eight presents the conclusions of the overall research.

Appendices include STCW and Merchant Navy Training Board (MNTB) HELM outcomes, Liverpool John Moores University (LJMU) ethical approval, introduction letter to participants, participants' information sheets and consent form sample, NTS comparative data for AHP calculations collected from interviewers, simulator observation data and a list of published work as a result of this research.

1.5 LIMITATIONS OF THE STUDY

The following sub sections highlight the limitations of the study including the reasons for a deck officer only study and restrictions of using interview and simulator observations.

1.5.1 Reason for Focusing Deck Officers Only

The reason this research is focused on deck officers' only is that it is evident from the literature review that human element has proven to be major contributory factor for many maritime accidents and the majority of these accidents have been caused by deck officers' errors. Examples such as data from UK Mutual (See Section 2.2) and UK Club (See Section 2.2) (Goulielmos et al., 2012), Herald of Free Enterprise disaster (Gill and Wahner, 2012), Torrey Canyon grounding (Hetherington et al. 2006) and other accidents show the high percentage of deck officers' errors in maritime accidents. The incidence of accidents caused by engineer officers is very low as compared to deck officers, less than 5% (See Section 2.2.1), and hence engineer officers are not included in this research.

1.5.2 Interview Study

The research conducted attempts to highlight a comprehensive and practical analysis of the NTS required by a deck officer in crisis situations on the bridge of a ship. Lack of volunteer experts to be involved in the interview study made it difficult to gather the data. In the end only 12 volunteer experts agreed to participate out of which only 8 experts' results were consistent enough to be included in the study. The number of volunteer experts was expected to be 20 at the beginning of the research.

1.5.3 Simulator Observation Study

Due to time constraints the current study was not able to observe large numbers of groups of deck officer students in a ship's bridge simulator. The study could only make observations of twelve groups of Chief Mate students, nine at LJMU and three at STC (South Tyneside College). Many colleges across the UK were contacted and asked to contribute to the research but only STC responded positively

1.5.4 Overseas Data Collection

Collection of data was envisaged from at least one overseas institute so as not be limited to research in only one country. For interview study, the researcher travelled to Malmo, Sweden to conduct interviews with experienced seafarers who were pursuing higher education at the World Maritime University (WMU). However for the simulator study, contacts were also made with overseas nautical establishments and two institutes, Durban University, South Africa and the Seamen's Training Centre, Karachi, Pakistan agreed to take part in the research. Both institutes could not deliver the HELM course in time: Durban University due to operational problems and the Seamen's Training Centre could not obtain HELM course approval from the local administration in time. Hence the researcher could not make any NTS observations of the deck officers in the bridge simulator in any overseas nautical training institute.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

The shipping industry has become safer over the past two decades, evidenced by an improving safety record during this period (Hetherington et al., 2006), however, accidents are still happening and analysts and researchers have found many causes, such as seafarer training and technical failure (MCA, 2010: v), fatigue (Akhtar and Utne, 2014), stress (Hetherington et al., 2006) and human error (Gill and Wahner, 2012). Technical failures and seafarer training have been addressed in detail in the STCW 95 (Standard of Training, Certification and Watchkeeping, 1995) and measures have impacted positively on the industry (MCA, 2010: v). Recently the IMO introduced the STCW Manila amendment 2010, part of which focuses on NTS training, in an attempt to eliminate or minimise the effects of human error.

NTS training was first introduced in aviation in the early 1980s (Helmreich et al., 1999) and then in other safety critical industries such as anaesthesia (Fletcher *et al.,* 2003a), nuclear power (Crichton and Flin, 2004) and surgery (Yule et al., 2006) also adopted the training to improve safety and reduce accidents. Effectiveness of such training is measured in various studies and have mostly been found effective. For the purpose of this study only aviation and anaesthesia sector's efforts into the development of such training will be discussed here as some of their good practices may be found beneficial and adapted into the maritime sector. The reason for focusing on aviation and anaesthesia is that the research data of these sectors is widely available (CAA, 2006; ANTS, 2014)

2.2 CAUSES OF MARITIME ACCIDENTS

Accidents in the maritime industry are not new and a major contributing factor to most of these accidents is human error (Safahani, 2015a). A major P&I club analysis shows that human error was responsible for more than 62% of all claims made (Ung and Shen, 2011). This figure has not reduced since but the other major contributing cause to accidents, technical failures, has reduced by two thirds since then (MCA, 2010: v). Modern technical systems are quite advanced and in the maritime sector, STCW 95 has served its purpose in addressing the technical issues but now ‘the human element’ is recognised.

2.2.1 Human Error

Various studies have been conducted to analyse the effect of the human element in maritime accidents. Wagenaar and Groeneweg (1987) have suggested that the human error contribution to maritime accidents is as high as 96% whereas others suggest only 49% (Hetherington et al., 2006). These studies will be discussed here to determine the major cause of maritime accidents.

A report concerning the research of 100 sea accidents, conducted by Wagenaar and Groeneweg (1987) showed that the number of accidents caused by human error failure ranged from 7 to 58 per accident. It was found there were 350 human error causes in a total of 2250 causes. The ratio suggests that human error is a minor factor in all accidents but in 345 of these human error was crucial. Only four of every 100 accidents occurred without the effect of any human error, hence 96% of accidents had one or more human error contributions and people involved in those accidents could and should have prevented the accidents (ibid). Accident reporting was not very concise in the 1980s (Hetherington et al., 2006) thus these conclusions should be treated with caution.

In 1995-96, the Maritime Safety Authority of New Zealand reported 49% (ibid) of shipping incidents were caused by human factors with the remaining incidents being caused by technical failure and environmental factors. Error of judgement and keeping an improper lookout were the most common human factors (ibid). Error of judgement can be classed as human error but keeping an improper lookout is a competency failure and may not fall under human error.

The Herald of Free Enterprise disaster in 1987 is one of the recent disasters in which the master has shown poor situation awareness skills when the ship sailed with the bow doors open and capsized just outside of Zeebrugge harbour (DoT, 1987; Gill and Wahner, 2012). There was more to this accident than human error, as found in the investigatory report of the accident such as the vessel’s design vulnerability, shipboard failure to adhere to procedure, disregard of a prior significant incident and office management failure (ibid). All the other factors involved in the accident increased the likelihood and seriousness of the consequences coming from human error (Gill and Wahner, 2012).

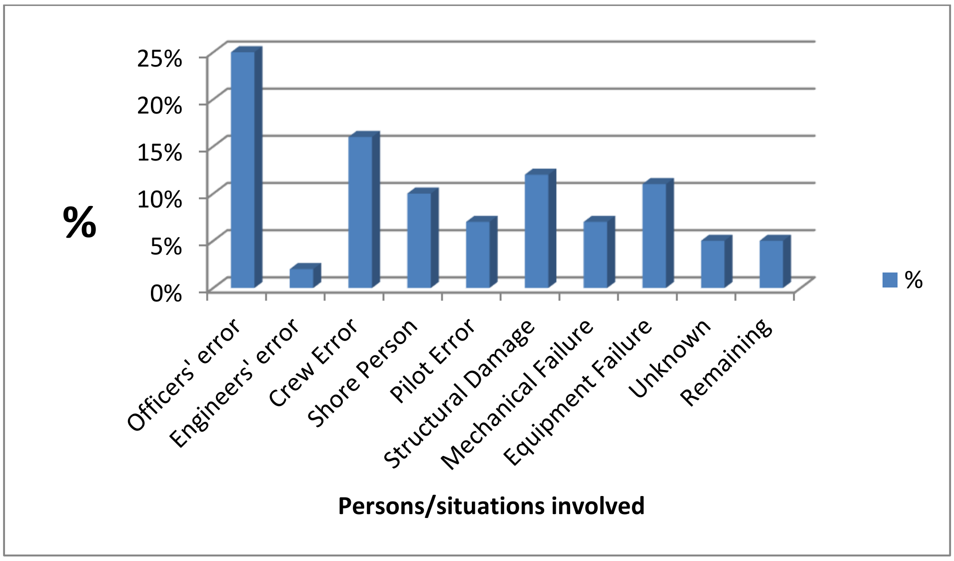

Figure 2.1 Causes of main claims in UK Mutual Steamship Association Ltd (1991)

Source: Constructed on data from "UK mutual" (1991) (Goulielmos et al., 2012)

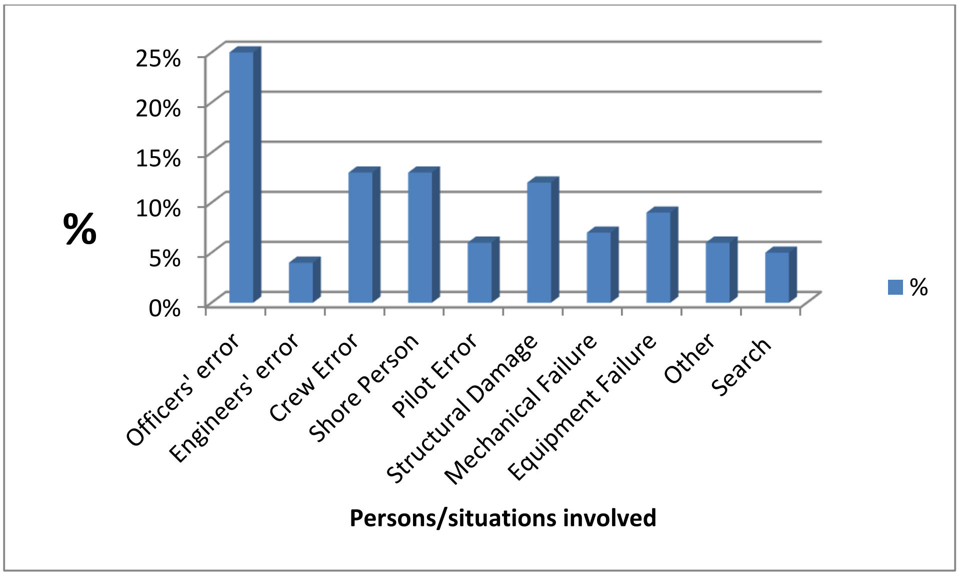

Figure 2.2 Persons involved in claims against UK Club (1993)

Source: Constructed on data from UK Club (1993) (Goulielmos et al., 2012)

Data from UK mutual (Figure 2.1) shows that in 1991 deck officers' errors are highest at 25% (Goulielmos *et al*., 2012) plus 7% of those of pilots, who can be considered as part of the bridge team. Subsequently the data from the UK Club (Figure 2.2) shows that in 1993 deck officers' errors are the same at 25% (ibid) and pilots' errors have reduced slightly to 6%. In the UK mutual data (Figure 2.1) it is evident that human error claims (deck officers, engineering officers, crew, shore persons and pilots) were 58% and the remaining were due to structural damage, mechanical failure, equipment failure plus some unknown and remaining. The point to consider here is that part of the unknown and remaining claims may be due to human error which would increase the human error contribution. The claims due to human error increased to 59% in 1993 as shown in the UK club data (Figure 2.2).

The above data may be biased towards human error as it is not confirmed that reporting is very accurate. The percentage of human error causes in maritime accidents in the above data i.e 58% in 1991 and 59% in 1993 is quite low with respect to the other researches in other safety critical industries where human error accounts for more than 80% of accidents (Flin et al., 2008: 1; Stojiljkovic et al., 2012; Havold, 2000).

The human error issue has been addressed by some other safety critical industries. In these almost 80% of all accidents are believed to be the result of human error contributions (ibid).

2.2.2 Safety culture

Apart from human error involvement in various safety critical industries' accidents, other factors such as safety culture and safety climate are involved. Wang et al. (2013) identifies the importance of human error but stresses focusing on the prerequisite of unsafe behaviour, unsafe supervision and organisational problems.

A person's attitude towards a company's approach to safety, his perception of the magnitude of the risks he faces and his belief in the necessity, practicality and effectiveness of measures to control risk is called safety culture. It is made up of those shared beliefs, values and practices affecting the safety of surroundings. In a safe working environment, safe and professional practices are expected to be normal behaviour and are reinforced and supported by management (CASA, 2013: 172). In this type of culture, accidents tend to be reduced by safe practice by all involved.

The IMO defines safety culture as: “An organization with a "safety culture" is one that gives appropriate priority to safety and realises that safety has to be managed like other areas of the business. For the shipping industry, it is in the professionalism of seafarers that the safety culture must take root” (IMO, 2015a)

A study of Danish seafarers’ fatal injuries was carried out using the data of 147 cases obtained from maritime authorities, an insurance company, shipping companies, hospitals and death registers between 1986 and 1993. The results show that injuries were 11.5 times higher than average rates of any male worker ashore in Denmark (Hanson, 1996). Other similar studies conducted in the United Kingdom have also shown similar results (Havold, 2007). Even with this high rate of injuries and fatalities, enough research is not carried out in this area to improve safety.

To improve safety onboard ships, the International Safety Management (ISM) code came into force in 1998 through SOLAS (Safety Of Life At Sea) Chapter IX, “Management for the safe Operations of Ships”. The purpose of the ISM code is to provide an international standard for the safe management and operation of ships and for pollution prevention (MCA, 2015). Some recent studies conclude that the ISM has not achieved the goal it was meant to achieve (Bhattacharya, 2012; Lappalainen et al., 2012). Bhattacharya (2012) determined one of the reasons of the failure of ISM is the difference between the perception of managers and seafarers of the ISM Code and its expected outcomes.

Employee relations with their managers and effective employee participation in the workplace health and safety management were found to be other causes to have impacted the injury rates in various workplace settings (Bhattacharya and Tang, 2013; James and Walters, 2002). In the shipping organisation structure, Bhattacharya and Tang (2013) found a separation between onshore management, onboard management and seafarers. This structure restricts seafarers, most exposed to workplace hazards, contributing to the health and safety management issues.

2.3 HUMAN ERROR AND NTS

Human error is a general term which is used for the range of unsafe acts, omissions, unsafe behaviours and unsafe conditions or a combination of all these factors. It is now accepted in the maritime industry that human error is the major contributing factor in the accidents. A brief review of literature shows human error accounts for more than half of maritime accidents (Safahani, 2015a).

NTS are those specific human competencies such as leadership, teamwork, situation awareness and decision making, which affect human error or its impact (Flin et al., 2003). By good use of these skills human error may be minimised (Helmreich et al., 1999). The four main NTS are subdivided into two categories; social and cognitive (Flin et al., 2003). Social skills are those which are easily observable *i.e* leadership and team-working (ibid) and cognitive skills are those which are difficult to observe *i.e* situation awareness and decision making (ibid). These skills and their relation to the maritime domain will be discussed in this section.

2.3.1 Team working

Team working is very important in effective operations in any safety critical industry. Teams must work towards a common goal and must function effectively from the beginning of the task. Team working skills such as co-ordination, co-operation and communication are very important for achieving the task goals, which rely heavily on effective team working for example effective control room operations in the nuclear power industry or berthing operations for a ship (Flin et al., 2008: 94)

Team-building and maintaining

Yukelson (1997) suggests that team-building is a continuous process and results in team members working together to achieve one common goal. Teamwork can improve the overall performance, effectiveness, and efficiency of organisations. Building high performance teams in safety critical organisations is a key to success. Martin and Davis (1995) studied the impact of outdoor pursuits on team-building by observing 22 soccer players in a 5 day army training course. The results suggested that by simply spending time together there is a positive impact on players' well-being.

Supporting others

It has been concluded by expert psychologists (Darch-Zahavy, 2004) that supporting others in team working enhances team performance and promotes a member's comfort. Team support improves other team members' team performance (Zaccaro et al., 2001)).

Four facets of team support are identified here;

1. Emotional: This form of team support refers to the notion of a shoulder to cry on, an encouraging word, and sympathetic understanding of another's emotional pain.
2. Informational: This refers to the extent to which team members exchange necessary information for the task functioning.
3. Instrumental: This type of support focuses on the practical support that team members offer each other. It has to do with tangible assistance such as helping an overloaded member with his duties of substituting for him during illness.
4. Appraisal: This support refers to the help individual team members can provide each other in making sense of a particular problem situation. Ideally this should provide a range of alternative solutions to any given problem situation (Darch-Zahavy, 2004).

Conflict resolution

Significant research has been carried out to understand how conflicts impact on team task outcomes (Kankanhalli et. al., 2006). Task and relationship are the two main categories of the conflict. With task conflict, team performance is decreased, decision making becomes poor, relationship conflict evokes stress and functioning of the group is affected (Ayoko et al., 2008).

The difference between top performance executives and average performance managers is resolving conflict effectively (Hagemann & Stroope, 2012). This is a skill that can be learned over time (ibid). The following three skills and abilities of conflict resolution are identified;

1. Fostering useful debate, while eliminating dysfunctional conflict.
2. Matching the conflict management strategy to the cause and nature of

the conflict
3. Using integrative.e (win-win) strategies rather than distributive (win-lose) strategies (West, 2012: 64).

Communication

Communication is a key skill to effective and safe task operations in any safety critical industry (Clarke, 2012). Clear and concise communication will eliminate any doubts regarding the issue addressed hence operations can be performed successfully (Kleij, 2009). Language is one of the main communication problems found on ships. The STCW specify a fluency level in the ship's declared language and it is suggested that this may not be currently achieved (Hethrington et al., 2006).

Team working in maritime

A study was conducted by the Canadian Transportation Safety Board (CTSB) in 1995 analysing 273 incidents between 1981 and 1992 in Canadian waters (CSTB, 1995). The main aim of the study was to analyse the master/pilot and pilot/watch-keeper relationship with the main focus on team working and communication. Most respondents have agreed that teamwork is as important as technical proficiency with 96% of masters, 100% of bridge officers and 85% of pilots agreeing with the study. In a question to pilots asking if it is possible to establish an effective relationship with the master and Officer of the Watch (OOW), 45% of pilots said it was always possible and 36% said it was often possible. In response to experience working as a team 51% of masters, 46% of OOW and 38% of pilots stated that they always work as a team. In the same study it was found that poor communication or lack of understanding between pilot and master or OOW caused 42% of the incidents (ibid). The report concludes that "Notwithstanding the evidence that poor teamwork on the bridge results in accidents, there appears to be some reluctance to acknowledge that improved cooperation between pilots and masters can result in safer navigation in pilotage waters" (ibid).

2.3.2 Leadership

A leader motivates and inspires people whereas a manager organises the current operation and plans for the future (Lau et al., 2014). Leadership and management are linked to and support each other in every organisation (Glamuzina, 2015). Leadership is defined as a process of social influence which motivates people to pursue set goals (Quinn and Quinn, 2015: 8). In a time of crisis a leader of an organisation is very important and becomes more so when making sense of the situation (Combe and Carrington, 2015). The literature has identified two types of leadership which are most effective: transformational and transactional (Batool, 2013). A transformational leader stimulates and inspires colleagues whilst a transactional leader offers rewards and punishments to employees based on their performance (ibid).

Technical and routine problems can be solved by the knowledge of an experienced leader but a new problem requires a unique approach to the solution, which is called adaptive leadership. Five characteristics of adaptive leadership are identified below:

> 1) Identify the adaptive challenge and frame key questions and issues;
> 2) Let the organisation feel external pressures within a range it can stand;
> 3) challenge current roles and resist pressure to define new roles too quickly;
> 4) Expose conflict or let it emerge;
> 5) Challenge unproductive norms. (Eubank et al., 2012)

In this type of leadership a leader must remain on the scene of the problem, identify new challenges, raise productive questions and define new roles of the team members to fix the problem.

Leadership under stress

Stress is a mental condition which directly affects an individual's ability to perform a job or lead a team. In an organisation there is a need for strategies to be put in place to limit the stress factors (Gill, 2006). A leader's responsibility in any work domain is to make sure that operations are successfully completed by monitoring the process throughout. Sometimes in a demanding situation leaders in high risk organisations are required to manage an emergency situation or a crisis situation. A leader's knowledge, skills and styles will be key factors in handling the situation (Flin et al., 2008: 141).

Leadership in maritime

On-board ship it is the master's job to show good leadership qualities and encourage team members to work together. The master needs to make sure that a positive team atmosphere is created. A good leader will work on realistic targets and will always conduct a risk assessment before changing any plan. The Titanic is one of the classic accident examples of non-technical skills' failure as the master had shown poor leadership and decision making qualities. Capt. Smith increased the vessel's speed to 22 knots to arrive one day earlier in New York without adding extra lookouts through a known iceberg field and relied heavily on the structure of the ship whereas another ship in the vicinity, MV Californian, stopped for the night and did not sail through the iceberg field (Brown et al., 2013).

2.3.3 Situation Awareness (SA)

SA has proven to be one of the major causes in many accidents in safety critical industries such as the nuclear accidents at Chernobyl in 1986 and Three Mile Island in 1979. In both accidents operators lost the SA and were working on a different mental model of the situation (Flin et al., 2008: 18). The captain of the Herald of Free Enterprise sailed from the port of Zeebrugge not knowing the bow doors were open and the person responsible for closing the bow doors, (the assistant bosun), was sleeping in his cabin. The chief officer never counter checked the bow doors (DoT, 1987; Goulielmos and Goulielmous, 2005).

Many researchers have now concluded that SA is one of the main causes of the accidents in many safety critical industries. During the First World War SA was identified as a very important tool by military aircraft crew. It received global attention when major researches on this topic were carried out in the 1980s by aviation and air traffic control. (Salmon et al., 2009: 7).

Several SA definitions are introduced but most are specific to certain domains. Mostly, they all point to 'what is going on around you'. Endsley (1995a) provides us with the generic definition of SA: "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future."

Banbury and Tremblay (2004: 3) reviewed 26 SA definitions available in the existing literature and divided them into two classes as a 'State' or as a 'Process'. Sarter and Woods (1995) define SA as: "the term situation awareness should be viewed just as a label for a variety of cognitive processing activities that are critical to dynamic, event-driven, and multitasks fields of practice". Two approaches to SA are identified in the literature: operator-focused approach and situation-focused approach. The operator-focused approach concentrates on cognition of human mental state and the situation-focused point of view links and maps the information to form a SA mental picture (Banbury and Tremblay, 2004: 5).

Models of situation awareness

Various SA models are available in the literature. All models are individually focused theories such as Endsley's three level model (Endsley, 1995b), Smith and Hancook's perception cycle model (Salmon et al., 2009: 14) and Bedney and Meisters' Interactive subsystem approach to SA model (Salmon *et al.*, 2009: 12). All SA models vary in terms of their basic psychological approach. The Endsley's (1995b) three level model is a mental theory model that uses an information processing approach, Smith and Hancook's model uses an ecological approach and Bedney and Meister's approach is an activity based model to describe SA (Salmon et al., 2009: 12-13).

Endsley's (1995b) three level generic model (Fig 2.3) focuses on the effect of SA on the decisions made by an operator in crisis situations. Factors affecting SA are identified in the model. The three levels form a chain of information processing, with the first level being perception of the elements in the environment, the second level comprehends the information gained at the first level and projection of future status forms the third level (Salmon et al., 2009: 10; Flin et al., 2008: 23).

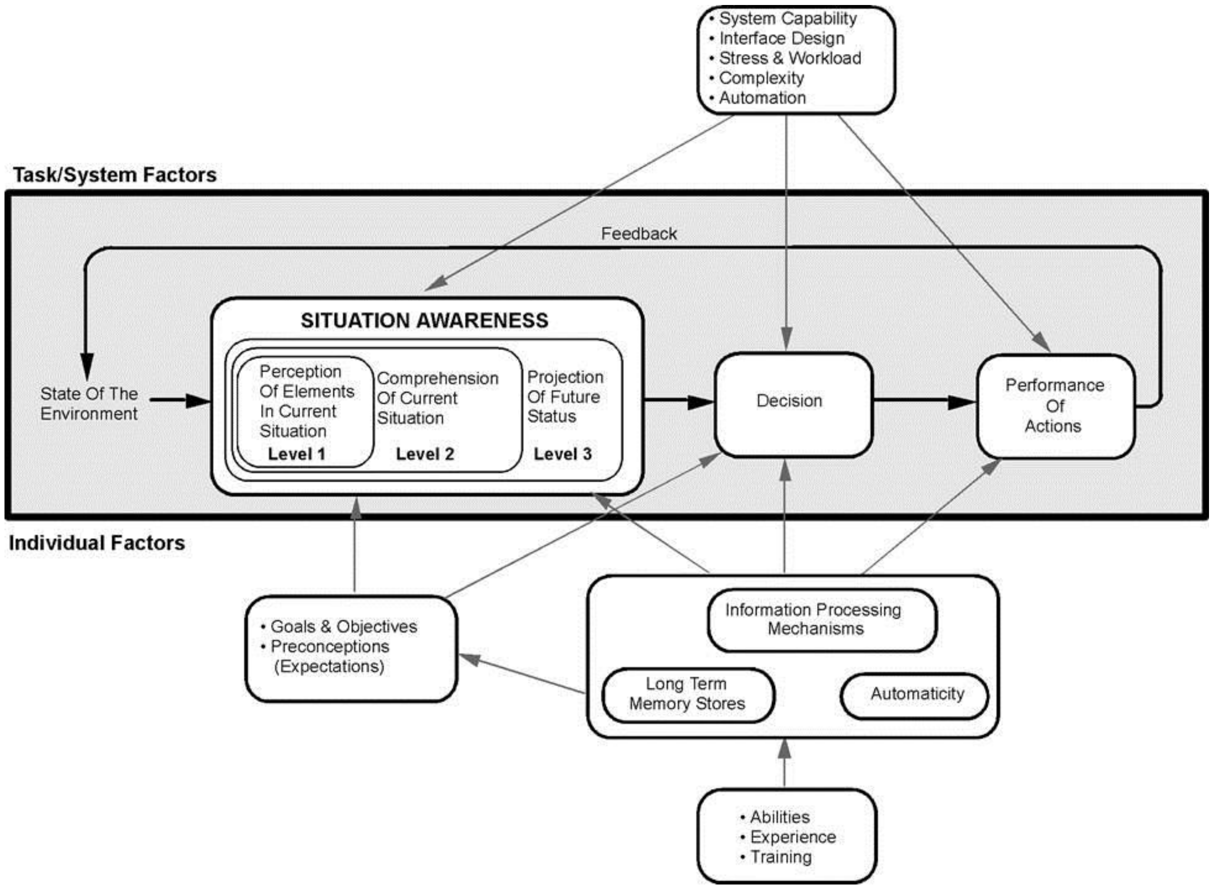

Figure 2.3: Model of situation awareness (Source: Endsely, 1995b: 35)

Level 1: Gathering information

The first stage of Endsley's (1995b) model of SA is called 'perception of the elements in the current situation'. On a ship's navigation bridge, this would mean the ship's course and speed, traffic, weather, etc. An aircraft pilot would maintain the perception of his information regarding traffic in the vicinity of mountains or warning lights (ibid).

To analyse the situation properly we need to obtain the right information. It is common to lose attention from one element or become focused on another and some key information is ignored. In 1978, a crash of a United Airlines DC-8 was caused because the fuel ran out, owing to the crew being too busy fixing a landing gear problem to observe the fuel indicator reading (Flin et al., 2008: 24).

Level 2: Interpreting the gathered information

Level 2 of SA requires the operator to go beyond gathering the information. This level requires the operator to process the incoming information and assess the significance of the information in the light of goals. Based on level 1 information elements, the decision maker forms a balanced picture of the environment appreciating the importance of the objects and the events. A ship's navigating officer must analyse the situation when two position fixing methods do not result in a position in the same place. Changes in expected results need to be investigated and this can be done by an experienced operator. In these circumstances a novice operator may just get the Level 1 SA information but will not be able to reach the level of interpretation. An experienced decision maker will be able to integrate various data elements along with the desired goals in order to assess the situation (Endsley, 1995b; Flin et al., 2008: 25).

Level 3: Anticipating future status

The third level of SA focuses on projecting the future. Based on the current information of the environment and the dynamics, an experienced operator can predict the future and take the necessary action to avoid any incident. If a military pilot knows that enemy aircraft is on the offensive in a known location then the pilot can predict the style of attack by doing mental simulation (Endsley, 1995b). Three levels of SA can be summarised as follows:

> SA is based on far more than simple perceiving information about the environment. It includes comprehending the meaning of that information in an integrated form, comparing it with operator goals, and providing projected future states of the environment that are valuable for decision making. In this respect situation awareness is a broad construct that is applicable across a wide variety of application areas, with many underlying cognitive processes in common (ibid).

A study was carried out using the Aviation Safety Reporting System (ASRS) database to determine SA related accidents. The search was conducted using the keyword 'situation awareness'. The accidents were then categorised to each level and it was found that 76.3% of the accidents were related to level 1, 20.3% accidents were related to level 2 and 3.4% were related to level 3 (Jones and Endsley, 1996). The high proportion of level 1 accidents indicate that a robust training system is required to improve the basic level of SA in the safety critical industries.

Situation Awareness in Maritime Accidents

An accident analysis was conducted of 177 maritime accident reports from eight countries. A wide range of accidents were included in the analysis such as collision, grounding and fire. The accidents occurred between 1987 and 2001 with the vessels' year of build ranging from1952 to 2000. Among all human error types 71% were found to be situation awareness (Grech et al., 2002). Based on Endsley's model (1995b) level 1 errors were 59%, level 2 errors were 33% and level 3 errors were 9% (Grech et al., 2002).

2.3.4 Decision Making

Flin et al. (2008: 41) defines decision making as "a process of reaching a judgement or choosing an option, sometimes called a course of action, to meet the needs of a given situation". Good decision making is an essential skill for successful operation in any high-risk organisation. Human beings process information and make decisions in two modes. First is thinking which is automatic and the other is logical and deliberate (Beshears and Gino, 2015). There are different decision making techniques available to the decision maker (Flin et al., 2008: 41). These techniques are dependent on situations and circumstances and some of those relevant to safety critical decisions are described in this section.

Traditional decision making theories

There are two types of decision making the slower and the faster (Kahneman, 2012: 13). Slower decisions are to be taken where the decision maker has unlimited time and all of the relevant information is available to carry out a decision analysis. In a dynamic environment a decision may be required instantly as there is not enough time to generate options and then evaluate each of those options to choose the best one. In such circumstances decisions are made on the individual's experience. To reach the right decision some very complicated thinking takes place in the mind of the experienced decision maker and a decision is reached based on his feeling or "gut feeling" (Flin, 1996: 141).

Naturalistic Decision Making (NDM)

Since the mid-1980s, there has been increasing interest by applied psychologists and researchers in NDM. The purpose of NDM research is to explain how expert decision makers reach decisions under uncertainty, stress and with limited information and time available. NDM has been useful in many high risk safety industries such as aviation, military, acute medicine and nuclear power generation (Flin et al., 2008: 44).

The early NDM researchers conducted field research to find out which strategies people used to make decisions and how they made tough decisions under uncertain conditions. The researchers concluded that while making decisions people were not generating and evaluating options. Instead people were using experience to match the situation and then make a decision (Klein, 2008).

Model of NDM

Several NDM models have been produced in the 1980s including Ramussen's (1983) model of cognitive control which used distinguished skill-based, rule-based and knowledge-based behaviour and Hammond's cognitive continuum theory which argues that decisions may vary as much as they rely on the intuition of the decision maker (Klein, 2008)

Flin et al. (2008: 44) has produced a simplified model of decision making to suit a range of operational work settings (Figure 2.4).

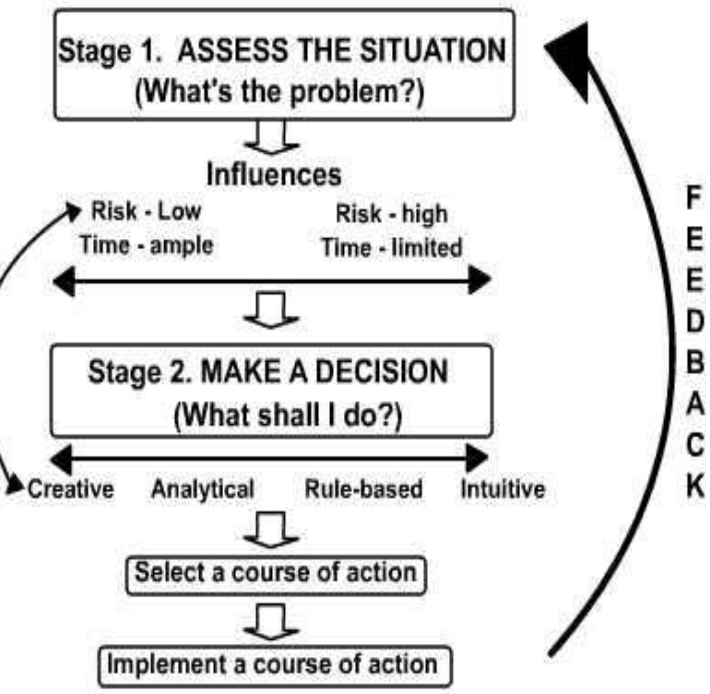

Figure 2.4: Decision Making Model (Source: Flin et al., 2008: 44)

Tactical Decision Making Under Stress (TADMUS)

On 3rd July 1988, an AEGIS cruiser named the USS Vincennes accidently shot down an Iranian passenger airbus, flight 655, over the Arabian Gulf killing 290 people. Incorrect identification of the aircraft was made by a USS Vincennes crew member and it was assumed to be an enemy aircraft. Three main reasons for incorrect identification were: 1) The Iranian aircraft was operating on the edge of the commercial air corridor (instead of the centre) and was heading directly towards the USS Vincennes; 2) absence of electronic radiation which is made by commercial airliners; 3) there were reports that F-14 fighter aircraft were operating from the Iranian port of Bandar Abbas and an Iranian patrol aircraft (P-3) was flying in the area. The USS Vincennes made efforts to contact the aircraft to request a course change but there was no response from the Iranian passenger airbus. A very limited time to make a decision forced them to shoot down the aircraft (Cannon-Bowers and Salas, 1998: 4).

As a result of this and some other incidents the Office of Naval Research sponsored a research and development programme named Tactical Decision Making Under Stress (TADMUS). The programme started in 1990 and was completed in 1997 costing $18 million. The budget was divided into two halves; $9 million was used for decision support research and the remaining $9 million was used for training research (Cannon-Bowers and Salas, 1998: 12). The goal of the programme was to develop training with the help of simulation to support the enhancement of decision making under stress (Hutcheon and Bevilacqua, 2010).

The objectives and approach of the TADMUS project are described as follows:

> The TADMUS programme was designed to: define the decision problems facing navy tactical teams and develop measures of tactical decision performance; collect empirical data to document the impact of stress on decision making; and develop principles for decision support, information display, training system design and simulation that will mitigate these stress effects. Several emerging areas of research are being exploited to accomplish these objectives, including: recognition primed decision theory, shared mental models, human performance modelling and team training (Cannon-Bowers and Salas, 1998: 10).

Under the TADMUS programme, consistent baseline data was collected on tactical decision making under stress. The research domain was to examine the Air Warfare (AW) task in the ship's Combat Information Centre (CIC). The CIC is the central information processing area where tactical decisions are made by the AW team detecting, tracking and identifying targets (Cannon-Bowers and Salas, 1998: 39).

Smith et al. (2004) conducted a study to evaluate the effectiveness of the TADMUS training model. The study recruited 90 US Navy officers and divided them into fifteen teams. Eight teams had TADMUS training and the remaining seven had conventional US Navy training. Each team performed three threat detection scenarios. The teams with TADMUS training were found to be significantly better than those with conventional training in detecting threats and making decisions and it was concluded that the TADMUS training model was effective.

The TADMUS programme mainly focused on navy decision making skills but the findings could be applied to other safety critical domains.

Decision Making in maritime operations

Decision making is one of the very important NTS in maritime operations as it is in other safety critical industries. A poor decision made by the master of a ship may lead to loss of lives on-board, loss of the ship and may pollute the waters. One of the best examples of poor decision making is the tanker Torrey Canyon grounding in 1967. The captain took a more direct route to save 6 hours in order to arrive at Milford Haven in time for the high tide. Even though the short route was deep enough, oil was moved to different tanks to reduce the draft by two inches. Nevertheless the vessel still went aground when passing through the Scilly Isles when trying to avoid collision with a fishing vessel and was not able to turn quickly enough (Hetherington et al., 2006).

2.4 STCW AND THE 2010 MANILA AMENDMENTS

The International Convention on Standards of Training, Certification and Watchkeeping (STCW) sets qualification standards for masters, officers and watchkeeping personnel on seagoing merchant ships (Tally, 2012: 326).

In the late 1950s and early 1960s, the IMO (International Maritime Organization) developed a comprehensive series of conventions to establish a framework of international law addressing maritime safety and in doing so the IMO recognized that one of the most important elements in the safe operation of any ship is the training and competence of its crew. (IAMU, 2010) It was noted that international regulations lacked a standard of competency for seafarers and as a result, in 1969, the IMO agreed to develop a draft STCW Convention (ibid).

2.4.1 STCW 1978 and 1995

The STCW was officially adopted by a conference at the IMO in 1978 to standardize the qualifications required for masters, officers and watch personnel on seagoing merchant ships. The 1978 STCW Convention had many limitations such as vague requirements left to the discretion of the parties; unclear standards of competence; no IMO oversight of compliance; limited port state control and inadequacies which did not address modern shipboard functions at that time (Tally, 2012: 326; MCA, 2013b). As a result of the grounding of the MV Aegean

Sea in 1992 on the rocks of the Spanish port of La Coruna, the United States proposed conducting a comprehensive review of the 1978 convention (IAMU, 2010). This proposal suggested the review specifically consider the role of the human element in maritime casualties. The IMO and its members agreed to concentrate on areas relating to people, training and operational practices, rather than issues dealing primarily with improving ship construction and equipment standards (ibid).

The STCW Convention was subsequently significantly amended in 1995 to include a code containing mandatory requirements and guidance information for the implementation of the convention. The comprehensive and detailed 1995 amendments established a level playing field among all parties to the convention to help ensure consistent training worldwide. These amendments also established competence based standards that placed emphasis on the requirements for training and assessments of skills in most facets of the mariner's profession (IMO, 2015b; IAMU, 2010).

The following are some notable changes made to the convention of 1995:

Examination and Demonstration of Skills

The requirements established minimum standards of competence for the range of certificates to be issued under STCW. The standards presented in tables specified competence; related a list of knowledge and associated competence; a method of demonstrating each competence and the criteria for assessing each competence (IAMU, 2010).

Quality Standard System (QSS)

The quality standard system required that all training, assessment and certification activities be continuously monitored to ensure achievement of a defined objective. The convention also required the quality standard system be subject to an independent evaluation every five years (ibid).

Port State Control

The 1995 amendments empowered the port state control provision of the convention by allowing port state control officers to look beyond merchant mariner certificates and conduct a direct assessment of the competence of merchant mariners (ibid).

2.4.2 Manila Amendments

In January 2006, in the 37th session of the STW (Standards of Training and Watchkeeping) Sub-Committee it was decided to review the STCW Convention to ensure that it met the new challenges facing the shipping industry today and in the years to come (Tally, 2012: 326). The new challenges being met included advancement in technology and the emergence of new equipment such as the Electronic Chart Display System (ECDIS). It was deemed necessary to prepare the officers to deal with new technology and discussion led to a list of human cognitive skills to cope with the technology and training of NTS, to avoid or minimise human error (Abou-Elkawam, 2015).

At its 38th session of the Sub-Committee, and following detailed discussions, it was agreed that the present structure of the convention had more than adequately served its purpose and that there was no need to review it in great detail. It was then agreed that the review should only embrace the following principles (IAMU, 2010):

1. Retain the structure and goals of the 1995 revision;
2. Do not down scale existing standards;
3. Do not amend the articles of the Convention;
4. Address inconsistencies, interpretations, outdated provisions, MSC (Maritime Safety Committee) instructions and clarifications already issued and technological advances;
5. Address requirements for effective communication;
6. Address requirements for non-technical skills;
7. Provide for flexibility in terms of compliance and for required levels of training and certification and watch keeping arrangements due to innovations in technology;
8. Address the special character and circumstances of short sea shipping and the offshore industry;
9. Address security-related issues.

Within the scope of this study Table 2.1 shows an abridged version of the STCW changes (IMO, 2011: p122) in relation to NTS training of management level officers of ships of 500 gross tonnage or more (See Appendix 1 for the complete list of STCW Section A-II/2);

Table 2.1: Section A-II/2 –

Masters and chief mates on ships of 500 gross tonnage or more (bridged version)

Competence	Use of leadership and managerial skills
1	Knowledge of shipboard personnel management and training
2	A knowledge of related international maritime conventions and recommendations, and national legislation
3	Ability to apply task and workload management
4	Knowledge and ability to apply effective resource management
5	Knowledge and ability to apply decision-making techniques
6	Development, implementation, and oversight of standard operating procedures

Based on the outcomes outlined in Section A-II/2 of the STCW Manila amendments, the Human Element Leadership and Management (HELM) training course became compulsory for all deck and engineering officers effective from 2012. The question arose here as to how the IMO reached the outcomes outlined in Section A-II/2. Did they conduct any formal research before reaching the conclusion that these are particular skills required by deck or engineering officers to overcome or minimise human error? A formal research was not conducted (Abou-Elkawam, 2015) into the domain specific NTS or to formalise the taxonomy or behavioural markers to be used for training and assessment of the NTS of the deck or engineering officers in the way that other safety critical industries have done (See Section 2.5). During the review process of the STCW convention and code the IMO consulted all its member states (Davitt and Holford, 2015). However consultation proved a weak process in this case as it can be seen that statements, definitions and competence criteria are extremely broad (appendix 1) which allows for different views of each administration (ibid). This will lead to lack of consistency in the HELM courses delivered at different places (Wall, 2015).

2.4.3 HELM Training

The IMO has now set minimum standards of NTS training by making HELM training compulsory for both operational and management level officers in the deck and engineering departments. This training can either be integrated into the main programme or delivered as a standalone course (MNTB, 2012). HELM (O) is the operational level course for which the required training time is 21 hours (MNTB, 2012) and HELM (M) is the management level course requiring training time of 35 hours.

In the UK, the MCA and the MNTB has implemented HELM training (MCA; 2013a) as a stand-alone short course for experienced seafarers wishing to transfer to officer grade and may be integrated for seafarers following the approved training programme. HELM (O) is of three days length and HELM (M) is of five days length.

The course covers almost all elements of human factors and in the UK the MNTB has outlined the outcomes of the course based on the STCW Section II/2 of the Manila amendments. Since this research focuses on management level HELM training, the outcome and learning objectives (MNTB, 2012) of HELM (M) are presented in an abridged version in Table 2.2. A full list of HELM (M) outcomes is presented in Appendix 2.

Table 2.2: HELM (M) outcome and Learning objectives

Outcome	The learner can use leadership and managerial skills to control the operation of the ship and care for persons onboard at the management level.
	Learning Objective
1	Identify the principles and good practice in shipboard human resource management.
2	Explain the relevance of the ‘human element’ in shipboard operations.
3	Apply relevant and related international maritime conventions and recommendations, national regulations, codes of practice and guidelines, while using leadership and managerial skills to control the operation of the ship and care for persons onboard at the management level.
4	Apply the principles of task and workload management, including planning, co-ordination, allocation and prioritisation of human and physical resources
5	Use project management as an aid to decision-making.
6	Explain effective resource management techniques
7	Apply the principles and practice of decision-making
8	Lead and manage the development, implementation and oversight of standard operating procedures
9	Identify the principles and good practice in shipboard training, learning, coaching, mentoring, assessment and developing shipboard personnel.

By comparing the two tables of learning outcomes (Table 2.1 and Table 2.2), the MCA outcomes can be seen to be in more detail than those of STCW but again there is no literature suggesting that any research was conducted by the MCA before introducing the outcomes (Wall, 2015). A research similar to anaesthetists’ non-technical skills (ANTS) (See Section 2.5.2) would have proved useful and may have more closely identified the necessary skills required by deck and engineering officers separately.

Presently the same course is delivered to both deck and engineering officers however the trainer finds the delivery difficult (Wall, 2015). The main reason for this is that the college phase (Higher National Diploma - HND) is compulsory for chief mate students in which they will have studied some leadership and management issues whereas for second engineer students (not following the approved training programme) the college phase is not compulsory and they only appear for the written exams (ibid). These exams are mainly technical in nature and thus they do not have any prior knowledge of the subjects of leadership and management (Wall, 2015). Separate learning outcomes for both, deck and engineering officers, mainly focused on their specific areas of operation, may have been useful.

The following list shows the requirements or the methods of study for the HELM course.

> Centres will need to present their training plans as part of the approval process. Centres are encouraged to fully engage learners in the learning process using interactive teaching methods supported by appropriate use of one or more of the following (MNTB, 2012):
>
> - Case studies;
> - Role play;
> - Scenarios;
> - Simulation; and
> - Team exercises
>
> .

The above requirement is wide open to training institutes as to how they deliver the course, using maybe only one of the methods listed above, in addition to classroom teaching. The requirement did not make simulation a compulsory part of the course. Simulation is an essential tool for NTS training as can be seen from experience in other safety critical domains (see Section 2.5). Again, with proper research conducted by the IMO (Abou-Elkawam, 2015) into domain specific NTS for deck and engineering officers before the course implementation, this area would also have been clarified.

There are two options for delivery of the course i.e. either integration into the main course or a stand-alone course (MNTB, 2012). In the MCA's impact assessment report (MCA, 2013b) of the STCW Manila amendment, the reasons for stand-alone HELM courses are clarified. The main reason is to accommodate experienced seafarers who wish to transfer to officer training. Again the issue is clear here that although deck officers would have some training at a college, engineering officers (not following the approved training programme) will not go through any formal training (Wall, 2015) and would not be able to go through an integrated course. The integrated course has proven successful in aviation's CRM course where underpinning knowledge of the CRM course is delivered within the main course (CAA, 2006).

HELM training is in its infancy and this may take time to approach perfection (Wall, 2015). The aviation industry took fifteen years from its first generation of the Crew Resource Management (CRM) course to fifth generation delivery (See section 2.5.1) and is said to be quite successful. It has also helped reduce accidents caused by human error (Diehl, 1991).

2.5 SAFETY CRITICAL DOMAINS' EFFORTS INTO NTS TRAINING AND ASSESSMENT DEVELOPMENTS

Some domains, such as aviation and anaesthesia, have conducted extensive research identifying domain specific NTS, training methods and behavioural marker systems for assessment. The Aviation industry is considered to be the pioneer in discovering the importance of NTS and researching and developing courses like crew resource management to supplement the main training. It is quite important to discuss the work of aviation and anaesthesia in the development of the NTS training and assessment to get an insight as to whether the maritime industry could benefit from their work and adapt some of their good practices. Some maritime research into NTS will also be discussed in this section.

2.5.1 Crew Resource Management (CRM) - Aviation

CRM training can be defined as

> a set of instructional strategies designed to improve teamwork in the cockpit by applying well-tested training tools (e.g., performance measures, exercises, feedback mechanisms) and appropriate training methods (e.g., simulators, lectures, videos) targeted at specific content (i.e., teamwork knowledge, skills, and attitudes) (Salas *et al*., 1999).

The CRM or NTS include situation awareness, decision making, leadership, teamwork and communications.

The concept of NTS was generated by the aviation industry when the National Transportation Safety Board (NTSB) in the USA investigated a number of airline accidents in the 1960s and 1970s. As a consequence of the following accident and others, the idea of Cockpit/Crew Resource Management (CRM) was born,

> On December 28, 1978, as a result of a relatively minor landing gear problem, a United Airlines DC-8 was in a holding pattern while awaiting landing at Portland, Oregon. Although the first officer knew the aircraft was low on fuel, he failed to express his concerns convincingly to the captain. The plane ran out of fuel and crashed, killing 10 (NTSB, 1998: 20).

A workshop was held in 1979, Resource Management on the Flight Deck, sponsored by the National Aeronautics and Space Administration (NASA). Human error aspects of the majority of air crash accidents were identified in this meeting. The main causes were found to be interpersonal communication, decision making and leadership failures. It was suggested that the training of NTS of pilots was required to reduce “pilot error” by making better use of the human resources on the flight deck. Since that time CRM training programmes have evolved in the United States into six generations. (Helmreich et al., 1999).

First Generation of CRM

The first CRM programme (called Cockpit Resource Management at that time and was later changed to Crew Resource Management) was proposed and developed by United Airlines in 1981 in the US and the course was called Command, Leadership and Resource Management. This was a seminar style training programme where participants diagnosed their own managerial style. The focus was on general concepts of leadership and general strategies of interpersonal behaviour but failed to provide definitions of appropriate behaviour in the cockpit (Helmreich et al., 1999; Kanki et al., 2010: 27).

Second Generation of CRM

NASA held a workshop in 1986 to discuss the progress of the CRM training programmes. By that time many airlines in the United States and around the world had started CRM training. It was concluded at this meeting that CRM training would disappear as a separate component of training and it would be a part of main flight training and flight operations (ibid).

In the second generation of the CRM training programme the name was changed to Crew Resource Management (CRM) to focus on team oriented factors. The new programmes focused on specific aviation concepts related to flight operations and were more team oriented in nature.

The training conducted focused on team building, situation awareness and stress management (Helmreich et al., 1999; Kanki et al., 2010: 29).

Third Generation of CRM

In the early 1990s a new shape of CRM was introduced which integrated CRM with standard technical training. The idea was to focus on specific skills and behaviours that pilots could use to operate flights more effectively and in a safe manner. Flight automation was under focus as many airlines introduced modules covering CRM issues linked with flight automation. At this stage CRM was also offered to other groups such as flight attendants and maintenance personnel. A special CRM was designed for captains to target leadership skills. (Helmreich et al., 1999).

Fourth Generation of CRM

The Advanced Qualification Programme (AQP) was introduced by the Federal Aviation Administration as a tool to improve the training and qualification of the flight crew. AQP was a voluntary programme which required carriers to provide CRM for all flight crews. This also required integrating CRM concepts into technical training. The requirement was to address the human factors (CRM) issues in the training. (ibid).

Fifth Generation of CRM

The fifth generation of CRM outlines the fact that human errors are inevitable but the effects of errors can be minimised by applying the following three lines of defence (Helmreich et al., 1999);

1. The avoidance of error.
2. The trapping of incipient errors before they are committed.
3. Mitigating the consequences of those errors that occur and are not trapped.

In addition to error management, airlines were required to take measures to determine the nature and source of error in their operations. The Aviation Safety Action Programme was announced by the US Federal Aviation Authority (FAA) which encouraged airlines to make incident reporting compulsory within organizations to improve safety (ibid).

Sixth Generation of CRM

Based on the fifth generation's error management theme, the CRM focus has widened from error management to threat management. In previous generations CRM skills and methods were applied to eliminate, trap or mitigate errors but the sixth generation focuses on the threats and errors which must be managed by flight crews to ensure safe flight (Wagener and Ison, 2014).

NOTECHS

The Federal Aviation Administration in the USA introduced the Advanced Qualification Program (AQP) in the 1990s and in the UK at the same time, the Civil Aviation Authority required a formal incorporation of non-technical (CRM) skills evaluation into all levels of flight crew training (CAA, 2006). The European Joint Aviation Authorities (JAA) has introduced the following regulation to implement the training and assessment of NTS under the CRM framework:

> The flight crew must be assessed on their CRM skills in accordance with a methodology acceptable to the Authority and published in the Operational Manual. The purpose of such an assessment is to: provide feedback to the crew collectively and individually and serve to identify retraining; and be used to improve the CRM training system (O'Connor et al., 2002a).

Based on this legislation, a research project, JARTEL (Joint Aviation Regulation – Translation and Elaboration of Legislation), was initiated by the JAA Human Factors group in 1996, to develop a suitable method to identify and assess an individual pilot's non-technical (CRM) skills. The project was sponsored by four European CAAs (Civil Aviation Authority). A research consortium consisting of pilots and psychologists from Germany, France, Holland and the UK was established to work on the NOTECHS (Non-Technical Skills).The system was to be used to assess the individual pilot's skill. It was to be suitable for use across Europe on all flight routes and must accommodate all European cultures (Flin et al, 2003).

A review was conducted of the existing behaviour rating system for pilots already being used by larger airlines in Europe and the USA. It appeared that none of the systems could be adopted in their original form because the available systems were either unclear for a Pan-European basis, or specific to a particular airline. Therefore, it was decided by the project team that to assess pilots' NTS a new taxonomy and rating method would be designed (ibid).

The development method included a detailed examination of available behavioural marker systems to assess a pilot's NTS. Airline captains with substantial experience worked as experts to advise on the final design of the NOTECHS system (ibid). The resulting NOTECHS system has four categories, each with elements of behaviour as shown in Table 2.3.

Table 2.3: NOTECHS Taxonomy (Flin et al, 2003)

Category	Element
1. Co-operation	Team-building and maintaining Considering others Supporting others Conflict solving
2. Leadership and Managerial Skills	Use of Authority and assertiveness Providing and maintaining standards Planning and co-ordination Work load management
3. Situation awareness	Awareness of aircraft systems Awareness of external environment Awareness of time
4. Decision Making	Problem definition and diagnosis Option generation Risk assessment and option selection Outcome review

Before designing NOTECHS the following principles were established. The aim of these principles was that each participant is assessed fairly within the NOTECH system (Kanki et al., 2010: 186):

1. Only observable behaviour is to be assessed – The evaluation must exclude reference to a crewmember's personality or emotional attitude and should be based only on observable behaviour. Behavioural markers were designed to support an objective judgement.
2. Need for technical consequence – For a pilot's non-technical skills to be

rated as unacceptable, flight safety must be actually (or potentially) compromised. This requires a related objective technical consequence.

3. Acceptable or unacceptable rating required – The JAR-OPS requires the airlines to indicate whether the observed non-technical skills are acceptable or unacceptable.
4. Repetition required – Repetition of unacceptable behaviour during the check must be observed to conclude that there is a significant problem.
5. Explanation required – For each Category rated as unacceptable the examiner must: (a) Indicate the Element(s) in that Category where unacceptable behaviour was observed. (b) Explain where the observed NTS (potentially) led to safety consequences. (c) Give a free-text explanation on each of the Categories rated unacceptable, using standard phraseology.

The main JARTEL study was an experimental rating task study. Eight video recorded scenarios, filmed in a Boeing 757 simulator, were used for the study. The scenarios simulated realistic flight situations highlighting behaviours from the NOTECHS element. The pilots' behaviours were rated ("poor practice" to "good practice"), using the NOTECHS system, by more than 100 assessors. A briefing and practice session was given before the start of each session. The assessors were asked to rate captains' and first officers' behaviours in each of the eight cockpit scenarios using the NOTECHS rating. (Flin et al., 2003; O'Connor et al., 2002a). In the evaluation questionnaire, the assessors were very satisfied with the NOTECHS rating system and the results of the experimental phase of this project were quite satisfactory for the further development of the NOTECHS method (Flin et al., 2003).

2.5.2 Anaesthesia

It has been determined through critical incident reporting that NTS are the major cause of accidents in anaesthesia crisis management. To focus on this area the Anaesthetists' Non-Technical Skills (ANTS) tool has been developed recently for the training and assessment of anaesthetists NTS (Yee et al., 2005). The ANTS is a behavioural marker framework and was developed in a project between the University of Aberdeen Industrial Psychology Research Centre and the Scottish Clinical Simulation Centre (Matveeskii et al., 2008). The programme followed the concepts of CRM, which was developed to improve NTS of aviation personnel (Flin & Maran, 2004).

ANTS (Anaesthetists Non-Technical Skills)

The Scottish Council for Postgraduate Medical and Dental Education partnered in a project to investigate the NTS in anaesthetists. The project was called 'The Identification and Measurement of Anaesthetists' Non-Technical Skills'. The main purpose of the project was to determine the importance of NTS required by the anaesthetists during operations. The project was divided into the following seven work packages (ANTS, 2014):

1. "Review of Human Factors Research in Anaesthesia. Report written by G. Fletcher, R. Flin and P. McGeorge; between 1999 and 2003.
2. Review of Behavioural Marker Systems in Anaesthesia. Report written by G. Fletcher, R. Flin and P. McGeorge; between (2000 - 2003).
3. Interview Study to Identify Anaesthetists' Non-Technical Skills. Report written by G. Fletcher, R. Flin and P. McGeorge; between 2001 and 2003.
4. Review of Incident Data - Confidential
5. Development of a Prototype Behavioural Marker System for Anaesthetista' Non-Technical Skills (ANTS). Report written by G. Fletcher, R. Flin, P. McGeorge, R. Glavin, N. Maran and R. Patey; between 2001 and 2003.
6. Preliminary Evaluation of the Prototype Behavioural Marker System for Anaesthetists' Non-Technical Skills (ANTS). Report written by G. Fletcher, R. Flin and P. McGeorge; between 2000 and 2003.
7. Experimental Report. Report written by G. Fletcher, R. Flin, P. McGeorge, R. Glavin, N. Maran and R. Patey; between 2002 and 2003" (ANTS, 2014).

The first work package of the project reviewed the human factors involvement in the anaesthesia sector. It describes the background of such a study of human factors in anaesthesia, as 80% of anaesthetic incidents are due to human error and most of them could have been avoided with the use of appropriate skills (Fletcher et al*.*, 2003a).

Incident reporting data was collected from around the world to analyse the extent of the problem. While collecting the incident data, limitation factors were considered. One factor being that all incidents are not reported for a variety of reasons and another being the reported factors may not provide an actual picture of the incident. As long as limitations are considered then there is great benefit from analysing incident reports in any domain (Fletcher *et al.*, 2003a).

Based on the interviews a taxonomy (Table 2.4) of anaesthetists' NTS, a prototype behavioural markers' system was developed for rating observed behaviours (Table 2.5) (Yee et al., 2005). After the preliminary evaluation of prototype behavioural markers system, the ANTS system was released to anaesthetics free of charge, for non-commercial use, by the University of Aberdeen in 2004 (Flin, 2013) and is now being used successfully across the world (Livingston, 2014).

Table 2.4: ANTS Taxonomy (Yee et al., 2005)

Category	Element
Task Management	Planning and preparing Prioritizing Providing and maintaining standards Identifying and utilizing resources
Team working	Coordinating activities with team member Exchanging information Using authority and assertiveness Assessing capabilities Supporting others
Situation awareness	Gathering information Recognizing and understanding Anticipating
Decision Making	Identifying options Balancing risks and selection options Re-evaluation

Table 2.5: ANTS Rating System (Yee et al., 2005)

Rating Level	Description
4 – Good	Performance was of a consistently high standard, enhancing patient safety. It could be used as positive example for others.
3 – Acceptable	Performance was of a satisfactory standard but could be improved.
2 – Marginal	Performance indicated cause of concern. Considerable improvement needed.
1 – Poor	Performance endangered or potentially endangered patient safety. Serious remediation is required.
Not observed	Skill could not be observed in this scenario.

The system has now been translated into many languages and is being used in anaesthesia simulation training and assessment in various countries including the UK, USA, India and Canada (Bhagwant, 2012; Flin, 2013).

2.5.3 NTS Research In Maritime

NTS have been drawn to attention in other safety critical industries after the CRM development in aviation. To better evaluate the role of NTS in ship operation safety, a thorough research is required to underpin the criteria for behavioural markers for the assessment of NTS. Such research is limited in the maritime domain (Davitt and Holford, 2015) and mostly not initiated by any regulatory body but conducted by universities as part of PhD theses or published papers. The only notable research conducted by a regulatory body is the MCA's 'simulator training for handling escalating emergencies' in which it has recommended further definition of the main NTS to handle escalating emergencies (Habberley et al., 2001). The MCA also produced a guide in 2006 outlining best practices in leadership and management (Davitt and Holford, 2015) which was based on a leadership research conducted by Arthur D Little (2004). Other notable researches are from Warsash Maritime Academy and the US Navy which will be discussed here.

Warsash Maritime Academy

After the success of various safety critical industries' development of behavioural markers for the assessment of competence or NTS in the simulators, Gatfield (2008) conducted extensive research and was first to develop behavioural markers for assessment of competence of marine engineering officers in simulators (Long, 2010). In this research a crisis scenario was developed in the marine engine simulator which was run twelve times (video recorded) with three engineers in each run. The behavioural markers observed during the exercises were then rated against four criteria (ease of observation, ease of evaluation, frequency of occurrence and relevance to competence) to filter the behaviour markers. Filtration was deemed necessary so as to keep to a minimum amount, the right number of behaviour markers for the ease of assessment (Gatfield, 2008).

Two groups of assessors, one group of six marine engineers and another group of six nondomain crisis management assessment experts were selected to assess each behaviour on a four rating scale (good, towards good, towards poor and poor). There was another group of seven expert crisis management assessors who were asked to use their 'gut' feeling to rank Chief Engineers in the scenario from best to worst crisis manager (ibid). It was concluded that the assessment framework be deemed as valid as there was a high degree of correlation between findings of assessors in all groups (ibid).

The US Navy

The US navy used a three stage methodology to develop domain specific behavioural markers for the Officer Of the Deck (OOD). The three stages comprised of literature review, focus group interview and critical incident review. The literature review identified lists of NTS found in other safety critical domains, such as aviation, anaesthesia and surgery, assumed to be necessary for effective performance (O'Connor and Long, 2011). A literature review identified little research was conducted in the maritime domain in the field of NTS (Heterington et al., 2006; O'Connor and Long, 2011).

Focus group interviews were conducted to filter the list to only those skills which were applicable to the OOD watch station to draw an initial OOD NTS taxonomy (Table 2.5). To evaluate the validity of the developed taxonomy the critical scenarios were developed in the third stage. The scenarios were used to generate interview data for analysis (O'Connor and Long, 2011). The interviews conducted had four stages; 1) Interviewee explains a relevant incident; 2) Interviewer repeats incident back to interviewee to confirm understanding; 3) Interviewer expands the discussion on the incident and looks for the cues and factors affecting NTS and 4) Interviewer probes further to extract more knowledge about NTS links (ibid). A total of 149 interview statements were collected and independently classified. The inter-rater reliability of all the analysis was found to be higher than normal hence no further changes were made to the original taxonomy (Table 2.6) (ibid).

Table 2.6: Initial OOD nontechnical taxonomy (Source: O'Connor and Long, 2011)

Category	**Element**
Leadership	Establishing authority Managing workload Maintaining the standards of the watch
Decision Making	Defining problem Generating possible solution Implementing best solution
Situational awareness	Actively gathering information Responding to changes in information Anticipating future events
Communication	Selecting correct medium Sending information clearly and concisely Effectively receiving information
Managing stress	Maintaining concentration Coping with stressors

2.5.4 Effectiveness of non-technical skills training

After discussing the various safety critical industries' investigations into the training of NTS to improve safety, it is difficult to conclude that the reduction in accidents is actually due to the additional NTS training. Some research has been conducted to measure the effectiveness of NTS training which will be discussed here.

Aviation

In aviation, for instance, accidents are very infrequent in any one particular airline and thus it would be difficult to prove whether reduction in accidents is mainly due to NTS training (Diehl, 1991). Evaluations were conducted of the US navy, the US air force and Petroleum Helicopters' accident rates after the implementation of the CRM course and have shown a major decrease in the accident rates (Table 2.7) (ibid).

Table 2.7: Effects of CRM (Source: Diehl, 1991)

Organisation	**Course**	**Accident Rates**
US Navy, all Helicopters, Crewmembers	CRM	28% Decrease
US Navy A6 Intruder, Crewmember	CRM	81% Decrease
US Air force MAC Transports, Crewmembers	CRM	51% Decrease
Petroleum Helicopters Inc. Commercial pilots	CRM	54% Decrease

O'Connor et al. (2002b) conducted research into the methods to evaluate the effectiveness of flight crew CRM training in the UK. They found that participants involved in the CRM training were generally positive about the course and were willing to change the attitudes and behaviours but concluded that it was not possible to find out the impact of the training on the overall industry or whether the effects of the course had improved safety.

A study of 74 NTS training evaluations was conducted by O'Connor et al. (2008). Only 16 studies were selected for further study as having sufficient data. The study included six and three evaluations performed with military and civil aviators respectively, four studies with medical personnel's NTS, two with civil aviation students and one with offshore oil production operators. It was found that generally NTS training effects were positive. It must be noted that all evaluation methods were either post training surveys or questionnaires asking participants' view about the course (ibid). This evaluation method may not be very effective as it is only the course perception of the delegates.

Anaeasthesia

A study was conducted in Toronto, Canada, to investigate the effects of simulation training of anaesthesia crisis management and NTS ability of anaesthesia residents. A total of 20 anaesthesia residents were recruited to participate in the management of three different simulated anaesthesia crisis situations in a patient simulator and those were assessed using the ANTS scoring system. Four main NTS were assessed in this study; each was further divided into a number of skill elements (Table 2.4). Each element was assessed on the ANTS rating system (Table 2.5) which was further divided into half points to provide enough flexibility for rating. The results from the study suggested that a single simulated session of all three situations improved the NTS of the anaesthesia residents. (Yee et al., 2005).

The Crisis Avoidance and Resource Management for Anaesthetists (CARMA) course was developed by anaesthetists and psychologists based on the ANTS system. The course focused on the NTS significant to anaesthetic practice. Anaesthetists NTS of the participants were assessed in simulated crisis situations based on the ANTS framework. Over 100 anaesthetic professionals, with a positive perspective, attended the first CARMA course. Communication and improved team working were the key areas identified by the course (Flin and Maran, 2004).

Maritime

A study was conducted to evaluate maritime Bridge Resource Management (BRM) in the National University of Ireland by observing the US Navy's BRM training (O'Connor, 2011). This study compared two groups of US Navy Surface War Officers (SWO); one with BRM training and the other without the training. The researchers found BRM training ineffective as it did not impact on the knowledge and attitude of the SWOs. The main reason for the ineffectiveness of the programme was found to be course content which did not meet the assessment needs of the surface warfare community.

2.5.5 Maritime Industry's Comparison with Aviation and Anaesthesia NTS

Aviation introduced NTS training in the early 1980s, anaesthesia in the early 2000s and the maritime industry implemented HELM training in 2012. The high visibility of the aviation industry triggered the industry to become first to find ways to reduce the accidents as one small failure could lead to an accident which could result in the loss of hundreds of lives. One wonders why maritime is quite late in introducing such an important element of training. It may be because one major cargo ship accident does not attract headlines. This does not justify the regulators ignoring such a key contribution to accidents as there have been major passenger ship accidents with hundreds of casualties. One of the main causes of these accidents (Stojiljkovic et al., 2012; Havold, 2000), which would attract the attention of the world, is seen as human error. In STCW 1995, the IMO focused on technical aspects of the training which has impacted positively on the reduction of maritime accidents (MCA, 2010: v).

The comparison of maritime with anaesthesia is quite difficult as anaesthetists are dealing directly with patients and ship officers are either dealing with cargo and/or passengers. Anaesthetists have adopted CRM methods to develop the taxonomy and ANTS system of behavioural markers for the assessment of anaesthetists' behaviours (Section 2.5.2). Such methodology is generic and could be adopted in the maritime industry to develop domain specific NTS.

Aviation's training model is quite impressive as NTS theoretical knowledge is covered in the initial training and the CRM course concentrates on the practical application of such skills by use of simulated exercises or case studies (CAA, 2006). The CRM course is repeated every three years, or when an individual changes aircraft or company. When the course is repeated it is focused on the weak areas within the individual or the company (ibid). The responsibility for conducting CRM courses is given to airline operators who must develop courses customised to company cultures and type of operations undertaken (O'Connor et al., 2002b).

The Maritime industry could adopt the CRM training methods by incorporating the underpinning knowledge of the human element into the main course and then the HELM course is delivered at the end of the main course with some practical exercises. In the maritime industry repeating a course may prove helpful only if the course is developed and delivered by the shipping company. In this case the company will focus on the weak areas of the company culture and the individual. Whereas a course repeated in a college may not have any improving effect as the course will merely be a repeat of the same content.

2.5.6 Other factors improving safety in aviation and anaesthesia

Over the years the airline industry has become quite safe with one passenger fatality per 7.1 million travellers which is a 42% improvement in the ten year period up to 2011 (Oster *et al*., 2013; Hersman, 2011). Technological advancement in aircraft, avionics and engines have contributed to the overall safety in the aviation industry (Oster et al., 2013). Pilot training has improved to ensure airline safety through the use of sophisticated flight simulators (ibid). The use of checklists have improved ever since the method was introduced. Checklists alleviate the burden of pilots from trying to remember the necessary steps. The FAA's regulations require the check lists of all critical operations such as starting an engine check, a take-off check, an approach check and so on (Cote, 2015). A Ground Proximity warning system has significantly reduced the number of a certain type of accidents known as controlled flights into terrain (Oster et al., 2013; Cote, 2015). The other factors include a traffic alert and collision avoidance system, better weather prediction and runway incursions (Cote, 2015).

One of the key elements in anaesthesia safety is the anaesthesia machine. Technological advancement in the last 100 years has improved the machine features significantly to improve patient safety. There has been improvement in patient monitoring, advances in anaesthesia machines, incubating devices, ultrasound for visualisation of nerves and vessels etc. The machine is required to be checked properly before being used on a patient to ensure patient safety (Subrahmanyam and Mohan, 2013).

2.6 THE ROLE OF SIMULATOR IN NTS TRAINING AND ASSESSMENT

Simulator training has proven to be very successful in high risk domains NTS training and assessments (Kozuba and Bondaruk, 2014; Wanger et al., 2013; Balci et al., 2014) which provides a realistic environment for trainees. Delegates can make mistakes without compromising safety and learn from their own mistakes.

The importance of simulation training was first realised in the aviation industry in the early 20th century by building a wooden monoplane to give pilots some experience of lateral control. During the Second World War an analogue computer was designed to solve aircraft motion equations. In the late 1960's a special purpose digital computer was developed for real time simulations. In 1971 the first television computer image generation system was produced to support simulator training of the pilots (The National Centre for Simulation, 2010).

The role of simulation has now increased in aviation and is an essential part of pilot training. Simulation is now used not only for pilot training but also in research studies in aircraft design and air accident investigations (Kozuba and Bondaruk, 2014).

Simulators are also quite a popular form of training in medicine since the method of training offered is risk free. A study was conducted to analyse the effectiveness of simulator training on a trainee's ability to diagnose congenital heart disease by using 10 trainees with 2 having little experience. After the tests results showed that there was significant improvement in the trainees' ability in the diagnosis of the disease, it was concluded that simulator based training could be very effective in the diagnosis of it (Wanger et al., 2013).

In a study, simulator training and traditional training of urology surgery were compared to investigate the effects of simulator training. Eight urologists were trained in a simulator and the other eight were trained using a conventional physical laparoscopic training box. All surgeons performed a specific surgery under the guidance. It was concluded that the simulator training method was an effective method with the group trained on simulators being slightly better than the other group (Balci et al., 2014).

Many safety critical industries, such as aviation and anaesthesia, have now adapted simulation as the recommended method of training and its effectiveness is regularly tested in various researches worldwide (Winter et al., 2012; Michael et al., 2014).

2.6.1 Simulator Training in the Maritime Sector

Modern technology has introduced simulators for training and assessments in the maritime sector. The mathematical model of a ship created on a computer demonstrates graphically the ship and its movement through the water which is nearly realistic and helps learners to learn effectively (Mohovic et al., 2012). The training provided by this medium has many benefits such as navigating vessels through restricted waters, dealing with emergency or crisis situations or using navigational aids (Pelletier, 2006). The biggest advantage of providing training by simulator is the ability to create various scenarios in different meteorological conditions in different sea areas using different target ships (Sniegocki, 2005).

One of the main disadvantages of simulator training is that many learners treat it as a video game and some of the master and mates students enjoy grounding a simulated VLCC ship in the British Channel rather than learning to navigate safely in the congested waters (Safahani, 2015b).

The simulator training is being used in the compulsory training of the officer of the watch (OOW) and Chief Mate course. At the OOW level the course is called NAEST (O) (Navigation Aids and Equipment Simulator Training – Operational) and at chief mate level NAEST (M) (Management). The NAEST (O) course is a basic level course where use of equipment and basic watch keeping and navigation skills are taught to students undertaking the OOW course. Whereas NAEST (M) is a management level course where advance navigation skills are taught to the students undertaking the chief mate course (Wall, 2015).

Bridge Team Management (BTM) or BRM is thought to be of CRM equivalent in the maritime sector and has been in operation for about two decades. Based on a seafarers' survey it is believed that the BTM course in the maritime sector is valid (Hetherington *et al*., 2006). The course is only recommended by ISM Code there being no mandatory requirement by any regulatory body (ibid). In the United States, the NTSB recommends that deck officers on US flagged ships attend BRM training (ibid). This is only a recommendation which is limited to one country. To make this course mandatory to improve safety of shipping worldwide Hetherington et al. (2006) states "It would be necessary for the IMO to implement guidelines for this to become internationally recognized as important".

Various studies are conducted to analyse the effectiveness of simulator training. A comparative study was conducted by the Memorial University of Newfoundland to see the impact of simulator training on ice navigation with lifeboats. A total of 19 individuals were recruited with some experience of operating powerboats but no experience with lifeboats. The participants were divided into three groups. The group one participants were trained in the lifeboats in calm and open waters with STCW learning outcomes. Water barrels and rafts were placed along the course to simulate ice patches. Group two were also trained the same as group one but with additional classroom training. Group three was solely trained using simulator technologies including a 2 hour ice curriculum. After conducting tests of all three groups in the simulated ice waters it was concluded that those participants who have taken simulator training were less likely to sustain damage to the lifeboat in iced waters (Power et al., 2011). It can be argued that the group three also had extra training of ice curriculum which may also have impacted positively on the outcome.

2.6.2 Use of Simulators in Maritime Research

Simulators have been used in various researches to analyse different maritime related topics such as the effectiveness of officer competence under various circumstances. These researches have proven beneficial as corrective measures have been taken to improve safety after the researches. Two notable researches, Project Horizon (WMA, 2012) and development of behavioural markers for the assessment of competence of engineering officers in crisis management (Gatfield, 2008), will be discussed here.

In an EU funded project, Project Horizon, undertaken by Chalmers University of Technology in Goteberg and Warsash Maritime Academy at Southampton Solent University the effects of fatigue were measured scientifically. A total of 90 experienced deck and engineering officers were recruited to take part in the study which involved watch patterns of four hours on / eight hours off and six hours on /six hours off. The project used bridge, engine and cargo simulators to simulate a 40,000 dwt oil tanker to undertake two round voyages from Southampton to Rotterdam over a seven day period. The participants' wore various sensors such as Actigraphy and Electroencephalogam to measure the sleep duration, record brain activity, eye movement and heart rates which enabled researchers to analyse the impact of sleepiness on decision making, situation awareness and other key skills. As a result researchers were able to use the data to develop a fatigue management tool kit to help arrange work schedules (WMA, 2012).

Another remarkable study was conducted by Gatfield (2008) who developed the behavioural marker system for the assessment of marine engineering officers' competency in an engine control room simulator (Section 2.5.3). It is crucial to develop a similar behavioural markers system for the assessment of participants in the simulators for deck officers.

2.7 CONCLUSION

Many safety critical industries introduced NTS training of their personnel quite a long time ago. The aviation industry is the one which realised the need for such training in the early 1980s and developed CRM training courses to improve NTS of airline pilots first and then the scope of the course was widened to include other crew members. The IMO has recently added NTS training to the course curriculum of the junior and senior officers with the deck and engine departments of the maritime industry.

So far there is no concrete evidence that reduction in accidents is due to the NTS training. Some researchers have conducted studies to evaluate the effectiveness of the course but the results are not very conclusive as most methods used were surveys and interviews. There was one very good comparative study conducted by Smith *et al.* (2004) which evaluated effectiveness of one element of NTS, Tactical Decision Making Under Stress (TADMUS), and the training method was found effective (Section 2.3.4).

As Diehl (1991) pointed out, it is difficult to analyse that reduction in accidents in any industry is actually due to the introduction of additional NTS training. The question there arises as to how accidents have reduced in the high risk industries such as aviation and anaesthesia. Some may argue that it may be due to the introduction of advanced equipments through which operators get more and quick information and they can make timely decisions. At the same time it can be argued that due to advanced equipment, operators are overloaded with information and cannot reach the second level of SA to make the right decision.

Simulator training is valuable training and an assessment tool which provides a realistic environment. There is a problem of participants' perception as some may think it is like a video game and do not take it seriously. Measures must be taken to make simulator sessions feel real and participants must put real effort to perform at their best. If delegates participate in simulator sessions with a positive attitude then the results obtained will be very helpful to research.

Assessments in simulators are dependant on the behaviour markers used for the asessments. Well developed behaviour markers, by the use of simulator research, will assist the assesor to identify good and poor behaviours. A good system to aggregate the results will help to get final results of participants' performance.

It can be concluded that human element is a major contributory factor in accidents in all critical industries. The maritime industry regulatory body the IMO, has also realised this fact and has made human element training compulsory for deck and engineering officers in the STCW code Manila amendments. In an attempt to evaluate the effectiveness of human element training, the HELM course for deck officers at management level, this research will compare delegates' performance with HELM training and without HELM training in a simulator. The observational results will be aggregated mathematically for the purpose of analysis.

The next chapter will outline the methods used in the research to fulfil the thesis aims and objectives. The research methodology follows the concept of Formal Safety Assessment (FSA) which is a structured methodology for use in the maritime domain for decision making.

CHAPTER THREE

RESEARCH METHODS

3.1 INTRODUCTION

A thorough research has been conducted of NTS in the previous chapter which highlighted the high importance of them among other factors to improve safety in various safety critical industries. The efforts of other safety critical industries, such as aviation, into the development and training of the NTS have proven successful as accident rates have reduced significantly (Diehl, 1991). This research concentrates on NTS required by deck officers for the safe operation of a ship.

3.2 RESEARCH METHODODLOGY

The proposed research is designed to contribute to the development and assessment of NTS required by deck officers. The research methodology followed the concept of Formal Safety Assessment (FSA). This is defined by the MCA (2014) as "a structured, systematic five-step methodology, aimed at enhancing maritime safety including the protection of life, health, the marine enviroment using risk analysis, cost benefit and regulatory influence to facilitate decision making."

FSA is a new approach to maritime safety which involves using the techniques of risk and cost-benefit assessment to assist in the decision making process (Wang, 2007: 71).

Wang (ibid) found that the application of FSA may;

1. Improve the performance of the current fleet, be able to measure the performance change and ensure that new ships are good designs.
2. Ensure that experience from the field is used in the current fleet and that any lessons learned are incorporated into new ships.
3. Provide a mechanism for predicting and controlling the most likely scenarios that could result in incidents.

Based on the formal safety assessment steps, as shown in Figure 3.1, the following methodology is derived to achieve the aims and objectives of this research;

1. Identification of significant criteria and the development of taxonomy and behavioural markers.
2. The assessment of deck officers' NTS.
3. Options that can improve deck officers' NTS.
4. Cost benefit assessment of the options.
5. Decisions on which option to select.

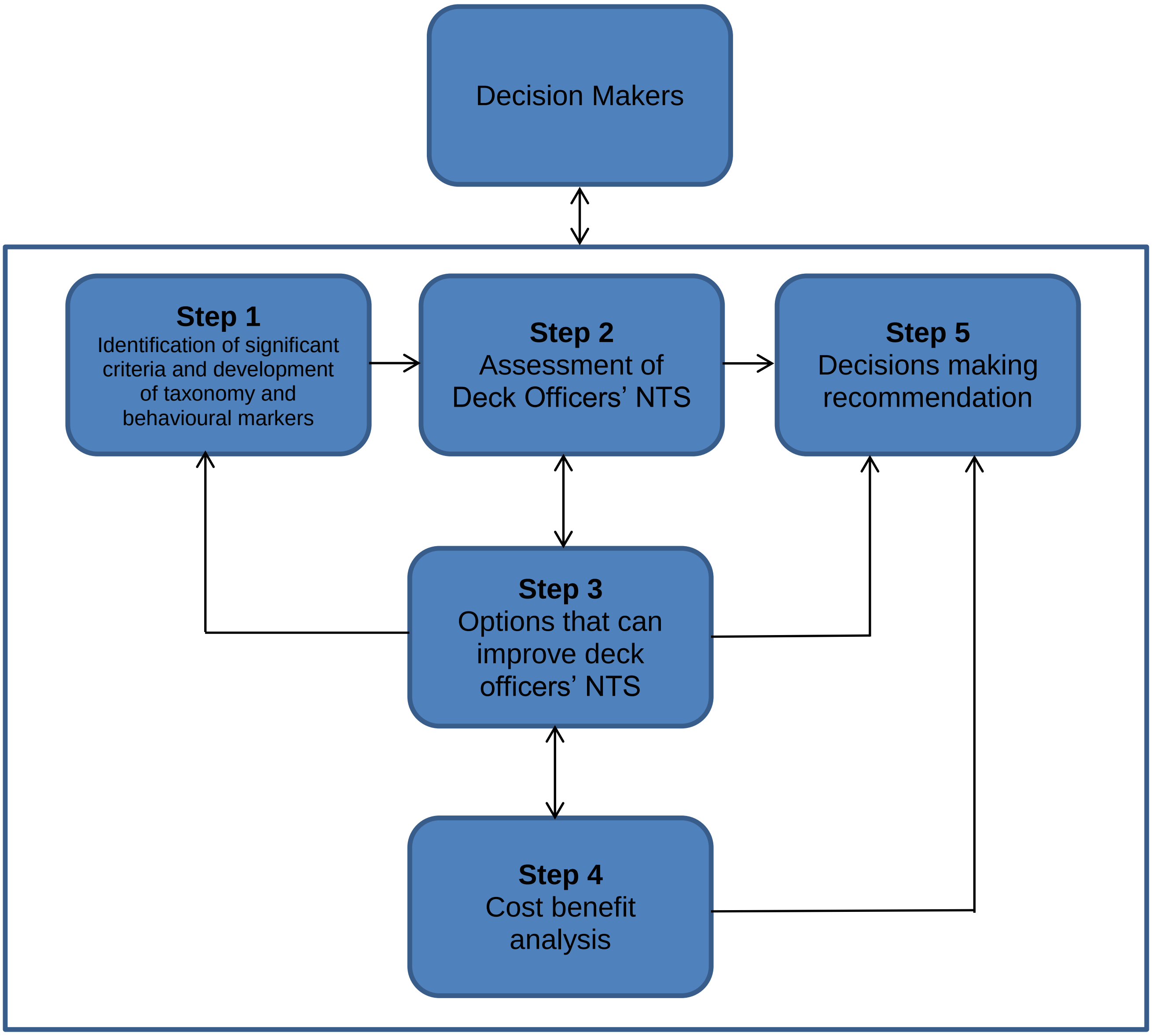

Figure 3.1: Formal Safety Assessment steps

3.2.1 Identification of significant criteria and development of taxonomy and behavioural markers (Step 1)

The first step of the methodology, "the identification of significant criteria and development of a taxonomy and behavioural markers" is further subdivided into the following steps and covered in Chapter Four:

1. Identify significant criteria and their contributions to the deck officers' NTS through interviews. To validate the effectiveness of the developed model, questionnaires were designed to select the significant criteria that are applicable for evaluation of a deck officer's NTS through interviews with experienced deck officers at management level.
2. Develop a taxonomy, to be reviewed by experts, for deck officers' NTS from a literature review. To assign a weight to each different criterion, questionnaires were designed to assign the possible values for ranking each different criterion through meetings and interviews with experienced deck officers.
3. Development of behavioural markers' assessment. A framework for this was constructed based on a literature review.
4. The weights assigned by experts were aggregated by the Analytical Hierarchy Process (AHP) method.

The identification of significant criteria is conducted by exploring marine accident reports. Initially, based on a literature review, a taxonomy of deck officers' NTS was developed and presented to volunteer experts for approval. Those approving the taxonomy were senior deck officers pursuing further studies either at the World Maritime University or Liverpool John Moores University. Experts were asked to assign a weight to each individual skill and element of the taxonomy and then the weights were aggregated by the well known pairwise comparision method AHP.

Analytical Hierarchy Process (AHP)

The AHP was pioneered by Saaty and is often referred to as the Saaty method (Coyle, 2004: 1). The method is popular and widely used in decision making and rating tasks. It is a multi-criteria decision making (MCDM) method that helps the decision-maker to make the right decision in a complex situation (Ishikaza and Labib, 2009). AHP case applications range from choice of career through to planning a port development (Coyle, 2004: 1).

Application of AHP is found in a variety of domains such as a hybrid forecasting system (Kim, 2013), a seafarer's reliability assessment (Riahi et al., 2012), group decision making by aggregating individual judgements (Aull-Hyde, 2004), evaluation of deep drilling in DaGang oilfields (Yi et al., 2014), environmental suitability analysis of resettlement site selection (Dagnachew Shibru et al., 2014) and new product development (Chin et al., 2008).

To make decisions in an organised way to generate priorities Saaty (2008) decomposes the decision into the following steps;

1. Define the problem and determine the kind of knowledge sought.
2. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criterion on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
3. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
4. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed value and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

Numbers and measurements are the core of mathematics and mathematics is crucial to science. So far, mathematics has assumed that all things can be assigned numbers by some way. Naturally, all this is predicted on the consideration that one has the necessary factors and all these factors are measureable (ibid).

To make comparison, a scale of numbers is required that indicates how many times more important one element is over another element with respect to what they are compared with, as shown in Table 3.1, based on Saaty (ibid) the scales are assigned.

Table 3.1: The fundamental scale of absolute numbers (ibid)

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective.
2	Weak or slight	
3	Moderate importance	Experience and judgement slightly favour one activity over another
4	Moderate Plus	
5	Strong importance	Experience and judgement strongly favour one activity over another
6	Strong Plus	
7	Very strong	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity I has one of the above non-zero numbers assigned to it when compared with activity j has the reciprocal value when compared with i	A reasonable assumption

There are three steps in following the AHP methodology (Bayazit, 2004). In the first step, group related components are arranged into an hierarchical order. With this approach a complex problem is structured into different hierarchical levels with a view of establishing the stated objectives of a problem. A matrix of pairwise comparisons is constructed in step 2. The strength of elements’ entries is indicated using the 1-9 number weight scales (Table 3.1). These values are used to determine the priorities of the elements of the hierarchy reflecting the relative importance among entities at the lowest levels of the hierarchy that enables the accomplishment of the objective of the problem. In step 3 these priorities are synthesized to obtain each alternative’s overall priority (ibid).

A weight was assigned to each category and element of the NTS taxonomy by the interviewees in part 3 of the interview process (which will be explained later in Section 4.4). Using the AHP to calculate the relative importance of each attribute requires a careful review of its principles and background (Saaty, 1990). When considering a group of attributes for evaluation, the main objectives of the technique are to provide judgements on the relative importance of these attributes and to ensure that the judgements are quantified to an extent that permits quantitative interpretation of the judgement among these attributes (Pillay and Wang, 2003). The weights were calculated of each skill and element of deck officers' NTS to prioritise the highest ranking skills and elements. The calculated weights were used in further calculations in Chapter Five.

There are other mathemetical methods available for expert judgement calculations but AHP was used here because this research is based on subjective judgement and AHP has been found to be the most suitable method to aggregate such judgements (Riahi, 2010). Salmon and Montevechi (2001) have conducted a research to compare the AHP method with other MCDM methods and concluded that for the attainment of good results, use of AHP will provide "an excellent, or may be, the optimum solution". The other methods available have some disadvantages with reference to this research. An ordinal sorting method for group decision making requires a group to agree on a category number (Jabeur and Martel, 2006), which may only be possible if a group is working together or interviewed together. A multiple criteria decision model with ordinal preference data is another method for making decisions. In this method weighting is calculated by analysts by AHP and presented to experts (Cook and Kress, 1990). This method is more suitable for marketing strategies (ibid) and hence was ignored in this research as this research required subjective judgements.

Limitations

A very low number of participants (See Section 1.5.2) was one of the limitations which was not expected initially. A higher number of participants may have produced different aggregated values for the skills and elements of deck officers' NTS.

3.2.2 Assessment of deck officers' NTS (Step 2)

The second step of the methodology, "the assessment of deck officers' NTS" is further subdivided in the following steps and is covered in detail in Chapter Five:

1. A set of simulator scenarios were developed for the assessment of deck officers' NTS.

2. A sample of volunteer Chief Mate students, after completion of their training programme, were selected. Based on the developed scenarios (step 1), their qualitative characteristics (e.g. situation awareness, decision making, etc.) were assessed subjectively in a bridge simulator. All input data was aggregated by using the evidential reasoning algorithm.
3. A utility value was assigned to each group performance for the purpose of comparisons. The utility value was obtained by calculation (Riahi et al., 2012).

Simulation training is becoming an integral part of maritime training as it provides obvious advantages such as a realistic environment. Using the simulator tool for deck officers' performance assessment, crisis senarios were developed and student groups were assessed by using developed scenarios in a ship's bridge simulator to observe their NTS behaviours. One set of chief mates volunteer students was those who have not obtained NTS training and the other set was those who have obtained this training by means of the HELM course. The performances were assessed on a five rating scale (very good to very poor) and a final value was calculated using the ER algorithm. Both sets of students' NTS performance were compared, to analyse if there was any improvement in such skills of deck officers after the HELM training.

Evidential Reasoning (ER)

The theory of evidence was first generated by Dempster (1967) and further developed by Shafter (1976: 3). It is often referred to as Dempster-Shafter (D-S) theory of evidence. The D-S theory was originally used for information aggregation in expert systems as an approximate tool and subsequently it has been used in decision making under uncertainty (Yager, 1992). In continuously researching and practising processes, based on the D-S theory, the ER algorithm has been developed (Riahi et al., 2012).

The use of ER as a decision making tool has been widely reported in the literature (Riahi, 2010). An important achievement of applying ER to decision analysis is to incorporate it into traditional MCDM methods (Beynon et al., 2000) The ER approach has been developed particularly for MCDM problems with both qualitative and quantitative criteria under uncertainty utilising individual's knowledge, expertise and experience in the forms of a belief function (Riahi, 2010).

ER is applied in many safety critical industries and other industries for different multi attribute problems and decision making. Riahi (2010) outlines the following advantages of the ER application in real world decision making:

- It has the capability to handle incomplete, uncertain and vague data as well as complete and precise data.
- It can efficiently provide its users with greater flexibility in allowing them to express their judgement in a quantitative manner.
- It is capable of accepting or representing the uncertainty and risk that is inherent in decision making.
- It has shown great effectiveness in processing and obtaining assessment output using mature computing software called the Intelligent Decision System (IDS).
- It is a tool that offers a rational and reproducible methodology to aggregate data in an hierarchical evaluation process.

ER has found wide applications in many real world decision making issues (Zhou et al., 2010) such as: the oil reserve forecast (Zhang et al., 2005), strategic research and development projects' assessment (Liu et al., 2008), expert systems (Beynon et al., 2001), new product development (Chin et al., 2008), security market forecasting (Yang et al., 2004), radar fault diagnosis (Li et al., 2005), marine safety analysis and synthesis (Wang et al., 1995) and risk analysis (Srivastava and Liu, 2003).

There are other methods available for solving MCDM problems such as TOPSIS or MACBETH but none of these methods address the uncertainty of belief degree (Xu and Yang, 2001). The other methods were criticised as ad hoc and to certain degree unjustified on theoretical and empirical grounds (Stewart, 1992) and the ER method, it was concluded was the most suitable method to aggregate qualitative and quantitative data under uncertainty using a belief degree of an expert assessor (Riahi, 2010) such as the data used to aggregate the deck officers' NTS in this research.

Limitations

Most students who were available for the research study were from India and there was only one student from Nigeria and so the research could not observe the participants from various cultural backgrounds which may have produced slightly different results.

It is a known fact that cultural difference can affect the performance in a workplace (Hopkin, 2009: 17). Students from different cultures may have produced different results. In the case of the one Nigerian student, it was evident that when he had a role of the master in group 6, the group performance was at the peak (see Section 5.5.6 and Table 6.1). The performance of the group was better due to good leadership skills possessed by the student which he had acquired previously as he did not take the HELM course before the observation. The fact that the group he lead had better results is not necessarily due to different culture as it could have been that he was a better manager.

3.2.3 Options, cost benefit analysis and decision making (Step 3, 4 and 5)

The remaining three steps of the methodology are covered in Chapter Six as follows:

1. A comparison with other safety critical industries' efforts into NTS research and training needs were conducted. The two main industries investigated were aviation and anaesthetics. Much has already been covered in chapter two. The possibility of the adoption of successful methods within aviation and anaesthesia were explored.
2. A cost benefit analysis was conducted of all the options explored in step (1). This was carried to weigh the costs against benefits of all options. The analysis was carried out by Bayesian Network (BN) and the Decision Tree Model.
3. Based on cost benefit analysis a decision was made as to which option to select.

Based on the results obtained in step two of the methodology and literature review, a need for options for further improvements to deck officers' NTS training were explored. This was done by the comparision with other safety critical industries' NTS development in training and assessment and the possibility that their good practices can be adopted for the maritime domain.

Suggestions to improve the NTS training of deck officers were given and, based on BN and decision tree analysis, cost benefit analysis was conducted to analyse if the benefits were cost effective.

BN and Decision Tree Model

The BN model is a graphical method and graphs have proven to provide an excellent language for communication and discussing dependence and independence relations among problem-domain variables (Kjaerulff and Madsen, 2014: 17). A large and important class of assumptions about dependence and independence relations expressed in factorised representations of joint probability distribution can be represented very compactly in a class of graphs known as Directed Acyclic Graphs (DAGs). Chain graphs are a generalisation of DAGs, capable of representing a broader class of dependence and independence assumption (Fydenberg, 1989; Wermuth and Lauritzen, 1990).

BNs represent a set of random variables and their conditional dependencies through a DAG. BNs are also known as

> "Bayesian Belief Networks (BBNs)", "Belief Networks", "Causal Probabilistic Networks", "Causal Nets", "Graphical Probability Networks", and "Probabilistic Cause-Effect" models are an emerging modelling approach of artificial intelligence research that aim to provide a decision-support framework for problems involving uncertainty, complexity and probabilistic reasoning (Fenton and Niel, 1999).

BNs were first developed at Stanford University in the 1970s (McCabe et al., 1998). The first book on BNs was published by Pearl in 1988 and since then several other text books have been published (Haddawy, 1999). The first world application of a BN was Munin (Andreassen et al., 1989). Since then, BNs have spread quickly and been used extensively to model many real world problems (Burnell and Horvits, 1995).

Absolutely anything can be modelled by a BN. The approach is based on conceptualising a model domain or system of interest as a graph of connected nodes and linkages. In the graph, nodes represent important domain variables and a link from one node to another represents a dependency relationship between the corresponding variables. Given their network structuring, BNs successfully capture the notation of modularity (i.e. a complex system can be built by combining simpler parts). Due to their Bayesian probability formalism, BNs provide a rational technique to combine both subjective (e.g. expert opinion) and qualitative (e.g. monitoring data) information (Das, 2000).

The reasons for choosing BNs can be summarised as follows:

- They are graphical models, capable of displaying relationships clearly and intuitively.
- They are directional, thus being capable of representing cause-effect relationships.
- They handle uncertainty through the established theory of probability.
- They can be used to represent indirect causation in addition to a direct one.

BN decision trees are valuable techniques, which are used to make a decision from a set of instances (Janssens et al., 2005). In a decision tree there are two types of nodes: decision nodes and leaves. Leaves are the terminal nodes of the tree and they specify the ultimate decision of the tree. The case is routed down the tree according to the values of attributes tested in successive decision nodes and when a leaf is reached, the instance is classified according to the probability distribution over all classification possibilities (ibid).

BNs are used in a number of studies in all domains such as the Hierarchical Bayesian approach for oil spill estimation as in the Deepwater Horizon accident (Yang et al., 2013), a Bayesian petrophysical decision support system for estimation of reservoir composition (Burgers et al., 2010) and a quantitative risk assessment of the offshore drilling operation such as the blowout preventer failure during the Deepwater Horizon rig accident (Skogdalen and Vinnem, 2011).

Limitations

The BN’s decision tree analysis was conducted based on the assumption that if one shipping company’s ship incurs an accident and that ship is a total loss, then what would be the size of that loss to that shipping company and then also if all the officers had the additional NTS training would that accident have been avoided? The example shipping company chosen was

Costa Cruise Lines and the accident ship was the Costa Concordia which partially sank in 2012 with 32 fatalities. Human error was one of the causes of the accident. This company and the accident were chosen for the research because data was available and the accident was quite recent.

3.4 ETHICAL ISSUES

The research required interviews with senior deck officers and then observation of the performance of deck officers (Chief Mate students) in a bridge simulator. Liverpool John Moores University Research Ethics Committee guidelines were followed and formal approval (12/ENR/003) (Appendix 3) was obtained before conducting interviews with subject experts and simulator study participants. The following ethical issues were considered;

- Subject matter was neither controversial nor sensitive.
- Adult participants were requested to volunteer their participation to whom the study was explained in detail and consent was obtained.
- The participants for the interview study were those who had senior management level experience onboard ships such as master or chief officer.
- The participants for simulator observation were Chief Mate students who volunteered for the study.
- An Interview Introduction Letter (Appendix 4) and an Interview Process Sheet (Appendices 5-6) were given out to potential participants.
- All participants taking part in the interview study were given an Interview Participant Information Sheet and filled in the Interview Participant Consent Form. (An Interview Participant Information Sheet sample is shown in Appendix 7 and a Participant Consent Form sample is shown in Appendix 9).
- All participants taking part in the simulator study were given a Simulator Participant Information Sheet and filled in the Simulator Participant Consent Form. (A Simulator Participant Information Sheet sample is shown in Appendix 8 and a Participant Consent Form sample is shown in Appendix 10).
- The participants had the right to refuse to participate and withdraw from the study any time. (Appendices 9 and 10).

- Interviews took place at a private room at an agreed location.
- The participants would not be identified in any report or publication that may result from the research and all the information will remain confidential. (Appendices 9 and 10).

3.5 CONCLUSION

This chapter outlined the methods used for the research, plus the reasons and limitations of each method used. The research methodology is based on Formal Safety Analysis which is divided into five steps. The research methods used in this research explained in this chapter are AHP, ER and the BN Decision Tree Model. Based on interview data, AHP is used to prioritise the skills and elements of deck officers' NTS, ER is used to aggregate deck officers' NTS simulator observations for the purpose of analysing HELM training effectiveness and a BN Decision Tree Model is used to select the option to further improve the NTS training.

The ethical issues were considered based on LJMU Ethics Committee guidelines and a formal approval was obtained before conducting the research.

In the next chapter the significant criteria and their contributions to the deck officers' NTS are identified and a preliminary model with an hierarchal structure as a taxonomy for the deck officers' NTS is developed. The elements of the deck officers' NTS taxonomy are justified. The interview schedule is developed to be conducted with experienced seafarers to validate the effectiveness of the taxonomy. Furthermore, data presented by the interviews is calculated using AHP.

CHAPTER FOUR

DEVELOPMENT AND ASSESSMENT OF THE DECK OFFICERS' NTS TAXONOMY

4.1 INTRODUCTION

The aim of this chapter was to develop a taxonomy of NTS required for deck officers in crisis situations by collecting information from experienced seafarers to identify the NTS required to support senior deck officers in crisis situations. Within this research the term 'NTS' is used to describe senior deck officers' attitude and behaviours in crisis situations which are not directly related to technical skills used to navigate a ship or to use the bridge equipment. This includes social and cognitive skills to deal with crisis situations and thus would cover skills and behaviours relating to teamwork, leadership, decision making, situation awareness and workload management. In a research conducted at Aberdeen University into anaesthetists' NTS (Fletcher, et al. 2003a) importance is given to good NTS. By enabling anaesthetists to work in such a way as to reduce the chances of problems occurring, they allow the anaesthetist to be fully aware of the situation thus he or she will be able to anticipate the problem or deal with unexpected occurrences. The same could be applied to the shipping industry as good NTS allow the deck officer to recognise the problem quickly and manage the situation and team safely and effectively (Chauvin et al., 2013).

While there are skills taxonomies and behavioural marker systems being used in training and assessment in other safety critical industries around the world, in the maritime industry, skills taxonomy is a relatively new concept and it is important to develop a skills taxonomy first. Based on a literature review of NTS and their use in the other safety critical industries, this has provided a valuable input as it indicates the type of areas that need to be addressed. Firstly, it was considered to conduct interviews to identify the NTS for deck officers.

4.2 METHODOLOGY

To develop the taxonomy of deck officers' NTS the following four steps were performed in this chapter;

1. Identify significant criteria and their contributions to the deck officers' NTS through interviews. To validate the effectiveness of the developed model, questionnaires were designed to select the significant criteria that are applicable for evaluation of a deck officer's NTS through interviews with experienced deck officers at management level.
2. Develop taxonomy for the deck officers' NTS. To assign a weight to each different criterion, questionnaires were designed to assign the possible values for ranking each different criterion through meetings and interviews with the experienced deck officers.
3. Development of behavioural markers' assessment framework took place based on a literature review.
4. The weights assigned by experts were aggregated by the AHP method.

4.3 COGNITIVE TASK ANALYSIS (CTA)

Human factors researchers use different methods of task analysis to design and evaluate systems, equipment and training, as it allows the tasks being carried out to be broken down into their constituent activities (Kirwan and Ainsworth, 1992: 4). Therefore, task analysis is a key component of training needs analysis, as the knowledge and skills needed to conduct them can be identified. Crandall et al. (2006: 9) defines the purpose of CTA is to capture the way the mind works, to capture cognition. A researcher who is carrying out a CTA study is usually trying to understand and describe how the participants view the work that they are doing and how they make sense of events. "If people are making mistakes in the workplace, the CTA study should explain what accounts for the mistakes" (ibid).

Since many of the skills required for deck officers in crisis situations are cognitive, it was necessary to conduct CTA. Based on Seamster et al. (1997: 4) "CTA identifies and describes the cognitive structures (e.g. knowledge-base and representation skills) and processes (e.g. attention, problem solving and decision making) underlying job expertise, and the knowledge and skills required for similar job components."

Crandall et al. (2006: 9) has identified following three primary aspects of CTA:

- Knowledge elicitation.
- Data analysis.
- Knowledge representation.

For a successful CTA study each of the above aspects are critical. Many researchers equate CTA with the first aspect, knowledge elicitation, because traditionally this has received most attention. However, Crandall et al. (2006: 9) argue that a good analysis of data is necessary otherwise collection of data become meaningless.

4.3.1 Knowledge Elicitation

Knowledge elicitation is the set of methods used to obtain information about what people know and how they know it: the judgement, strategies, knowledge and skill that underlie the performance. One way of classifying CTA knowledge elicitation is by the way data is collected. Four ways to collect data are listed as follows (Crandall et al., 2006: 10):

1. Self-reports (i.e. people talk about or record their behaviour and strategies),
2. Direct observation of performance or task behaviours,
3. Automated collection of behavioural data
4. Interviews

Self-Reports

Self-reporting methods vary from structured formats, such as surveys and questionnaires, to open-ended formats like diaries and logs. The advantage of a self-reporting format is that data collection does not require a skilled interviewer to be present, making the system more efficient. The quality of data generated by questionnaires depends in part on the structure of questionnaires. The research questionnaire method is useful for quantitative data collection because it reaches a wide variety of respondents through electronic media. The disadvantage of this method is that structured questionnaires do not allow for the element of discovery and exploration (Stone et al., 1999: 9; Crandall et al., 2006: 14).

A questionnaire method was considered inappropriate for the purpose of this research as data required is qualitative and would require using an exploratory technique to probe for information clarification.

Direct Observations

Direct observations can be conducted either at the workplace or in the simulated environment. If on-site observations are feasible, CTA researchers are strongly recommended to take advantage of the opportunity. The information obtained by this method is simply not possible to get any other way. "Observations provide opportunities for discovery and exploration of what the actual work demands are; what sorts of strategies skilled workers have developed for coping; how work flows across the environment, the team, and the shift and communication and coordination issues" (Crandall et al., 2006: 15).

It is not practicable to create a crisis situation scenario in real life for the purpose of this research, because of the risk to human life and the environment. It would even be difficult to identify the required NTS in the simulated crisis situation as most elements in such situations are cognitive and not easy to be observed. An attempt needed to be made to identify NTS required for deck officers in crisis situations in the simulated crisis situation scenario within this research.

Automated Collection of behaviour data

Endsley (1988) developed SAGAT (Situation Awareness Global Assessment Technique) to assess situation awareness, which is based on de Groot's strategy for comparing chess players at different skill levels. De Groot's method was to have a chess player study a game in progress and then unexpectedly remove all pieces. The players would then be asked to replace all the pieces. De Groot found that the more skilled players were more accurate in reconstructing the board than novice players. Similarly, the SAGAT method uses 'time freezing' in the midst of the aviation pilots' simulated session by switching all the instruments off and pilots are asked to reconstruct the instrument values. According to Endsley (1988), the better a person's situation awareness, the more accurate the reconstruction. It can be argued that situation awareness is improved with experience.

Interview

There are a number of different approaches to interviewing; the most appropriate for this type of research would be structured interviews or semi-structured interviews. The disadvantage with structured interviews is that the interviewer has to know which questions to ask and the responses are then restricted by the question, there is no flexibility to investigate further. In a semi-structured interview there is more flexibility for the interviewer to investigate the issues that arise during the interview and questions can be adapted to individual circumstances. In this approach the interviewer needs to have a fair degree of understanding about the subject area to be able to know when to probe further and what to ask (Fletcher et al., 2003b).

One of the most popular CTA techniques for investigating decision making expertise is the Critical Decision Making (CDM) designed specifically for looking at decision making in a naturalistic environment (Klien, et al. 1989). CDM has already been used effectively with neo-natal intensive care nurses to identify the cues experienced nurses use for recognising problems with infants (Fletcher, et al. 2003b). The CDM is based on Flanagan's (1954) Critical Incident technique, which is a method of identifying key behaviours and skills necessary for effective task performance. This approach is used in Anaesthesia by Altmaier et al. (1997) in the development of categories of behaviour defining aptitude for anaesthesia among anaesthesia residents. CDM involves subject matter experts recounting an incident, using the critical incident technique concept, for which their expertise was important in achieving the goals focusing particularly on the critical decision that was made. This process is repeated several times with various subject experts getting progressively more detail with each repetition. While most of the activity involves the interviewee recalling the events, the interviewer refines the interview structure using probe questions to obtain information about the cognitive decision making process being used. A particular concern of using recalled events is that the person may not remember the event exactly as it happened or their memory is subject to certain biases (Fletcher, et al. 2003b).

The semi structured interview method would allow collecting as much information as possible within the time allotted regarding the critical decisions made during crisis situations on the bridge of a ship. This method is deemed appropriate as in crisis situations on the bridge of a ship as many components are cognitive, and therefore unseen, the only practical way to investigate these skills is subjective assessment. While CDM is used to investigate decision making methods, there are other CTA techniques available for collecting data about different types of task.

One of the CTA techniques is ‘Knowledge Audit’. This CTA technique was used to draw expert knowledge to identify the key NTS required by deck officers for smooth operations. Experts were asked what skills or behaviours they considered necessary for a good deck officer. Baldwin *et al.* (1999) used a similar approach to investigate the skills required by basic surgical trainees. After collecting the data listing the skills, two further questions were asked. Firstly, how the skills are currently developed by trainees and secondly their opinion about differences or similarities in the skills needed for normal and crisis situations.

As part of CTA, after interviews, a ‘rating method’ and ‘sorting method’ may be used to rate and sort the skills and elements of the developed taxonomy. In the ‘rating method’ experts are asked to rate different combinations of the concepts like repertory grid, representational skills and knowledge. The ‘sorting method’ is used to show how different concepts are grouped together by the experts and so is considered useful for identifying how their understanding of the task is structured (Fletcher et al., 2003b). In a similar study ‘Identification and measurement of anaesthetists’ NTS Fletcher et al. (2003b) used the sorting and rating task as the third part of the interview. The rationale behind this was to discover how anaesthetists view NTS and the relationship between them with regard to their own tasks. The participants would have to sort the NTS identified in the second part of the interview into groups or categories they thought appropriate. The experts were then asked to rate each of the sorted items on the scale of 1 – 7 to rate the importance of the tasks according to their importance during the crisis situation. In this study a similar weighting task formed the third part of the interview and sorted items were rated on the scale of 1-9 to satisfy the AHP rating criteria.

4.4 INTERVIEW PROCESS (Step 1)

To develop a taxonomy of deck officers NTS, the interviews were conducted with experienced deck officers at management level to help identify the key skills to be included in the taxonomy. A semi-structured method of interviewing was considered suitable to extract maximum information from the interviewee regarding the NTS of the deck officer. Thus the aim of the interview was to identify the non-technical aspect of deck officers' task in crisis situations on the bridge of a ship and the skills needed for this, e.g. thinking and team working skills, decision making, situation awareness and leadership.

The interview was divided into three parts:

Part 1: Performance example – The interviewee was asked to describe a real case from his career that was particularly challenging which really tested his NTS. The example can be a real critical incident/near miss or a normal case where the experience and NTS were a significant outcome. The interviewee was asked in advance if he could think of this example before the interview. Furthermore this case was discussed to identify the most significant NTS components.

Part 2: Distinguishing skills – The interviewee was asked to think about the skills which are necessary for effective performance for deck officers in the crisis situation on the bridge of a ship.

Part 3: Weighting task – The interviewee was asked to assign a weight for the NTS taxonomy elements. The NTS taxonomy elements were presented to the interviewee which were already developed in this chapter.

Approximate times for the three interview parts were: Part 1 – 45 minutes, Part 2 – 15 minutes, Part 3 – 15 minutes. All the given information was held in confidence. The information is kept as anonymous and will be destroyed as per LJMU regulations.

4.4.1 Pilot Interview

To support development of the interview schedule, a pilot interview was undertaken with a senior deck officer. This took place at a fairly early stage to help make minor changes to the interview questionnaire (Appendices 4-7). This questionnaire is adapted from the study of 'Identification and measurement of anaesthetists' NTS (Fletcher et al. 2003b). The pilot interview recordings were listened by the researcher and the Director of Studies to make sure that the necessary information was being obtained from the interviews.

4.4.2 Identifying Participants

The first criterion for the selection of the participants was that they must hold a Master Mariner certificate of competency. The other criterion for taking part in the study was that the interviewees volunteered to take part. Fletcher et al. (2003b) argues that those people who are very interested in human factors will be more inclined to volunteer and this might lead to potential biases. However, given the sensitivity of the information being discussed, it would be unethical to interview unwilling participants. In the 'identification and measurement of anaesthetists' NTS 25-30 interviews were considered acceptable initially and they received a very good response from consultant anaesthetists to volunteer (ibid). The researcher in this project visited the World Maritime University, Malmo, to conduct interviews with experienced master mariners pursuing further studies. The researcher's aim was to conduct 10-15 interviews for this research but could only manage 12 interviews in total.

4.5 BEHAVIOURAL MARKER SYSTEMS

Behavioural marker systems are used for training and assessments of the participants in the simulators and were first developed in the aviation industry (Helmreich et al., 1999). Later on other safety critical industries such as anaesthesia and nuclear power generation have developed their own behavioural marker systems.

Klampfer et al. (2001) propose the following for designing good behaviour marker systems:

- Validity: in relation to performance outcome.
- Reliability: inter-rater reliability, internal consistency.
- Sensitivity: in relation to levels of performance.
- Transparency: the observer understands the performance criteria against which they are being rated, availability of reliability and validity data.
- Usability: easy to train, simple framework, easy to understand, domain appropriate language, sensitive to rater workload, easy to observe.
- Can provide a focus for training goals and needs.
- Baseline for performance criteria are used appropriately for experience level of a ratter.
- Minimal overlap between components.

Klampfer et al. (2001) further suggest that behavioural marker systems are limited because they "cannot capture every aspect of performance and behaviour" due to the:

- Limited occurrence of some behaviours such as conflict resolution.
- Limitation of human observers such as distraction or overload (e.g. in complex situations, or when observing large teams)

In developing behavioural markers systems for scrub practitioners' non-technical skills (SPLINTS system) Mitchell et al. (2013) established the following design criteria:

- Focus on the skills that are observable from behaviour.
- Be set as hierarchical structure with three levels of description; category, element, and behaviour.
- Use active verbs for skills and understandable language for definitions.
- Show a simple structure and layout with a rating scale that fits on one page that it can be easily used.

The behavioural marker assessment framework must, as far as possible, be designed to ensure that it is capable of capturing the fullest context of the environment in which the assessment is taking place (Gatfield, 2008). Behavioural markers are a valuable tool to assess or observe participants' technical and NTS in the real life or preferably in the simulator.

4.5.1 Development of behavioural markers

A review of behaviour marker systems available in other safety critical industries was conducted in this section. Aviation's NTS taxonomy and behavioural markers were a good starting point. The taxonomy and behavioural markers for deck officers were developed using a literature review. The taxonomy and behavioural markers were presented to each expert interviewee to confirm the elements of the taxonomy and behavioural markers of each element. After interviews a slight adjustment was made to the final taxonomy and behavioural markers (Table 4.1 – 4.5).

The initial taxonomy and behavioural marker systems had 26 elements and 4 categories. Based on the experts' opinion during the interviews and since some elements such as "conflict resolution" were non-observable; 6 elements out of 26 elements were removed from the taxonomy as well as behavioural markers.

Based on section 4.6 justification of the proposed taxonomy, as shown in Tables 4.2-4.5, a procedure for assessing the teamwork, leadership, situation awareness and decision making in a ship's bridge simulator, was developed. As a result Tables 4.2-4.5 were used as behavioural marker assessment frameworks and they were used during NTS observations in a ship's bridge simulator. There are five levels of performance in the behavioural marker systems ranging from very good practice to very poor practice. By using the behavioural markers an assessor is able to rate the students' performance in a ship's bridge simulator. All assessments are shown in Appendices 12-23.

4.6 JUSTIFICATION OF THE TAXONOMY AND BEHAVIOURAL MARKERS (Step 2 and 3)

Based on Aviation Crew Resource Management training and the literature review, as shown in Table 4.1, the skills taxonomy for deck officers is illustrated. The elements of skills taxonomy are justified in the following sub section.

4.6.1 Teamwork

The need for people to work together as a team and to work in coordinated ways to achieve objectives which contribute to the overall aims of the organisation has become increasingly important as organisations have increased in size and become more complex (West, 2004: 9). Because of the rapidly changing organisational environments and structure, teams are the best way to enact organisational strategy. Organisations with a team-based structure can respond quickly and effectively in the modern fast-changing environment (Cohen and Bailey, 1997).

Team working is very important to most work settings but is especially important in higher risk industries such as aviation, nuclear power industry, fire-fighting and maritime. Teams typically must function effectively from the moment they are established to achieve their team task. Team members must have a common understanding of how they will be expected to work together during the manoeuvring of a ship (CAA, 2003). For instance, onboard a ship, effective operation is highly dependent on the level of team performance involving skills such as communication, co-ordination, co-operation and control (Stanton, 1996: 197).

Table 4.1: NTS taxonomy of deck officers

Category	Element
1. Teamwork	Team-building and maintaining Considering others Supporting others Communication Information Sharing
2. Leadership and Managerial Skills	Use of Authority and assertiveness Providing and maintaining standards Planning and co-ordination Work load management Prioritisation Task delegation Initial Crisis Management
3. Situation awareness	Awareness of bridge systems Awareness of external environment Awareness of time Situation Assessment
4. Decision Making	Problem definition and diagnosis Option generation Risk assessment and option selection Outcome review

Team-building and maintaining

Team-building is a process of facilitating a group to accomplish a common task, "a process by which members of a group diagnose how they work together and plan changes which will improve their effectiveness" (Beer, 1980: 457). Onboard ships when a new crew joins team-building events are rarely organised because of the busy schedule. Teams are built during the course of work.

Considering others

In the Crew Resource Management course of the aviation industry 'considering others' is defined as "acceptance of others and understanding their personal condition" (Flin et al., 2003).

Considering others and supporting others could be grouped together as one element. However the difference is a person may request support and consideration may come from top management without any demand from the employee.

The Chief Officer's consideration towards a crews' mental state and feelings is very important onboard ship and especially during crisis situations. Considering proper rest periods and breaks for the crew in busy periods would improve the efficiency.

Supporting others

Team support refers to a broad spectrum of behaviours such as emotional team support, information team support, instrumental team support and appraisal team support. Emotional team support refers to sympathetic understanding of another's emotional pain. Information team support refers to team members' exchange of necessary information. Instrumental team support focuses on practical task support that team members offer each other. Appraisal support refers to helping each other in making sense of any problem situation (Drach-Zahavy, 2004).

As teams become the common work unit in today's organisations the value of supportive discretionary behaviour in those teams is proving crucial (Lepine and Dyne, 2001). West (2004: 181) during his research found that the more team members provide support to each other, the greater the improvement in team members' mental health and team performance.

Superior officers' support may be available in many forms onboard ships such as a new sailor being bullied by others such that he approaches the chief officer for support or the second officer needs the master's support in the appraisal stage of the passage planning.

Communication

One of the core skills central to effective and safe production and performance in any high-risk industry is communication. Yusof (2003) believes that the purposes of communication in group work are mainly in regulating, controlling, motivating, expressing feeling and conveying information. Blundel (2004: 395) believes that most conflicts and crises that happen inside an organisation are particularly caused by lack of transparent communication among members of the organisation.

Information Sharing

Information gathered by one team member can be transferred to his team members through feedback, help, advice or explanation. Exchange of information between team members brings information sources together and manipulates it into new information structures (Clark et al., 2002).

Distributing information from different sources among bridge team members (such as position, tidal stream, available depth or traffic) is called the Information Distribution Process (Van Offenbank, 2001). Information sharing or knowledge sharing within teams may occur via the advice-seeking behaviour of team members. A master on the bridge needs information about traffic or drift the ship is experiencing, as a master is likely to become more competent in handling the task (Woerkom & Sanders, 2009).

Based on subsection 4.6.1, teamworking elements and behavioural markers, as shown in Table 4.2, are illustrated.

Table 4.2: Teamworking elements and behavioural markers

Element	Very Good Practice	Good Practice	Acceptable Practice	Poor Practice	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others	Sufficiently encourages input and feedback from others	Just enough encouragement of input and feedbacks from others	Little encouragement of input and feedbacks from others	Keeps barriers between team members
	Does not compete with others	Little competition is evident	Moderate competition is evident	Sufficient competition is evident	Competes with others
Considering others	Take notice of the suggestions of other team members	Take substantial notice of the suggestions of other team members	Take moderate notice of the suggestions of other team members	Takes little notice of the suggestions of other team members	Ignores suggestions of other team members
	Considers condition of other team members and take them into account	Sufficiently considers the condition of other team members	Moderate consideration of the condition of other team members	Little consideration of the condition of other team members	Does not take account of the condition of other team members
	Provide detailed personal feedback	Provide sufficient personal feedback	Provide just enough personal feedback	Provide little personal feedback	Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation	Provide sufficient help to other team members in demanding situation	Provide adequate help to other team members in demanding situation	Provide minimal help to other team members in demanding situation	Do not help other team members in demanding situation
	Offers very good assistance	Offers good assistance	Offers enough assistance	Offers little assistance	Does not offer assistance
Communication	Establish total atmosphere for open communication	Establish substantial atmosphere for open communication	Establish moderate atmosphere for open communication	Establish little atmosphere for open communication	Blocks open communication
	Communicates very effectively	Communicates substantially effectively	Communicates moderately effectively	Communicates little effectively	Ineffective communication
Information sharing	Shares information among all team members	Shares relevant information among all team members	Shares moderate information among all team members	Shares little information among all team members	Does not share information properly among all team members

4.6.2 Leadership and Managerial Skills

It is important for a leader to raise the level of honesty and ethical behaviour to become an example for the team members. Delegating tasks to the appropriate team member is one of the key skills of a good leader. Maintaining team moral with confidence, positive attitude and commitment will get tasks accomplished successfully. The team leader is responsible for building an efficient team in order to boost task performance by ensuring safe and efficient team functioning (Flin et al., 2008: 129).

One of the examples of poor leadership is the Titanic disaster. Capt. Edward J. Smith was persuaded by White Star Line officials to proceed at a faster speed to arrive in New York a day early. Capt. Smith ordered the crew to light up the last two boilers to bring the speed to 22 knots. He did not add extra lookouts to watch for icebergs through a known ice field. Unfortunately the ship did hit an iceberg and 1500 people lost their lives. It was the poor leadership by Capt. Smith, who counted too much on impressive strategy, structure and technology (Brown et al., 2013).

Use of Authority and assertiveness

Flin et al. (2003) describes 'Use of Authority and Assertiveness' as creating a proper challenge response atmosphere. The authority of a master on board a ship should be adequately balanced with assertiveness and other bridge team members' participation. If the situation requires, decisive actions are expected (ibid) such as in pilotage waters when the master of a ship doubts any of the pilot's actions.

Providing and maintaining standards

The master as a leader must comply with standard operating procedures for task completion. If the situation requires, it may be necessary to deviate from the standard procedures. Such deviation should take place with consultation with other bridge team members. Any deviation from standard procedures should be mutually supervised by the bridge team members (Flin et al., 2003). The captain of the Costa Concordia did not maintain the standard operating procedures on 13th Jan 2012 and decided to change his original voyage plan without the agreement of the company and local authority and passed the vessel too close to the Giglio Island, Italy. As a result the cruise ship grounded on the rocks of Le Scole with 32 persons dead and 60 injured (Lieto, 2014).

Planning and co-ordination

An appropriate system of organised task sharing and delegation needs to be established to avoid fluctuation of workload and to achieve high performance. A ship's master needs to make sure all bridge team members understand the goals, plans and intentions to communicate well. This will ensure a good co-ordination among the team members in all activities (Flin et al., 2003).

Comprehensive planning is required to make safe passage from the loading port to the discharging port. Over the years it has been observed that many ships involved in groundings, collisions and other contact incidents was due to poor passage planning or deviating from the planned passage (Lieto, 2014). The passenger vessel Balmoral, carrying 213 passengers and 19 crewmembers, grounded on Dagger Reef, Gower Peninsular, on 18th October 2004, in fine weather and good visibility. The reason of grounding established that the master deviated from the planned track and took the vessel even closer to land (MAIB, 2005a).

Workload Management

A major element of workload management is shifting the workload from busy times to quiet times. This will be done at the planning stage and identifies when high workload periods will occur. Mismanagement of workload will degrade bridge team performance. As a result, tasks need to be evenly distributed among the other bridge team members. A leader will need to identify and resolve the signs of stress and fatigue so that performance is not affected (Flin et al., 2003).

MV Cosco Hong Kong grounded over Lixin Pai reef, in the South China Sea, in 2009, as a result of the increased workload on the OOW. The vessel was on a passage from Xiamen to Nansha, China at a speed of 21 knots when she encountered a large number of fishing vessels in the Dadanwei Shuidao channel. Even with the presence of a lookout/helmsman, the OOW manoeuvred the vessel himself by using the autopilot to the south of the track to keep clear of the fishing traffic. In doing so he forgot about the presence of the Lixin Pai reef, over which the charted depth was only 3.1m, which was highlighted as a danger on the paper chart in use (MAIB, 2009a). Although he should have used a helmsman to steer the vessel and he himself should have concentrated on the other tasks, due to poor workload management he manoeuvred the vessel by using the autopilot.

Prioritisation

Clear prioritisation of primary and secondary operational tasks should be made by the leader. Primary tasks are those tasks that a sufficiently skilled crew is required for such as harbour approaches and secondary tasks are routine maintenances jobs. Secondary operational tasks are prioritised to retain sufficient resources for primary bridge duties (Flin et al., 2003), such as ship's crew should not be engaged in heavy duties before port approaches instead priority should be given to retain sufficient rested crew members available for approach duties.

Task Delegation

When tasks are delegated by the team leader then a person is made responsible to perform one particular task. On the bridge of a ship the master needs to make sure the tasks are delegated properly to be sure that the whole operation is performed safely. In busy periods this is very difficult to manage and if tasks are not delegated properly omissions will happen which will lead to crisis (Fasano and Krischenman, 2012). On port approaches and for the successful operation, tasks are delegated to various team members, for instance OOW1 looking after the navigation of ship and plotting the position, OOW2 can be designated to dealing with all communications, helmsman designated to steering the vessel duties, lookout doing lookout duties and finally the master can look after the traffic and overall command.

Initial Crisis Management

The crisis is a situation which materialises unexpectedly and decisions are required urgently within a short period of time. In a crisis situation the sense of loss of control builds quickly and routine tasks become increasingly difficult. The leader should be able to identify specific threats and respond accordingly.

There are some initial procedures given in the Bridge Procedure Guide for the expected emergencies on ships such as steering failure, engine failure, collision, grounding, flooding, man overboard etc. Doubt is a particular indication of a crisis and a good watch officer must identify the cues of crisis building such as two methods of positioning, such as the GPS (Global Positioning System) position and a position obtained by radar ranges not being the same.

Based on subsection 4.6.2, leadership and managerial skills' elements and behavioural markers, as shown in Table 4.3, are illustrated.

Table 4.3 Leadership and managerial skills' elements and behavioural markers

Element	Very Good Practice	Good Practice	Acceptable Practice	Poor Practice	Very Poor Practice
Use of authority and assertiveness	Takes full initiative to ensure crew involvement and task completion	Takes substantial initiative to ensure crew involvement and task completion	Takes moderate initiative to ensure crew involvement and task completion	Takes little initiative to ensure crew involvement and task completion	Hinders or withholds crew involvement.
	Takes full control if situation requires	Takes substantial control if situation requires	Takes moderate control if situation requires	Takes little control if situation requires	Does not show initiative for decision
	Motivates crew by full appreciation	Motivates crew by sufficient appreciation	Motivates crew by average appreciation	Motivates crew by little appreciation	Does not show appreciation for the crew
	Totally reflects on suggestions of others	Substantially reflects on suggestions of others	Moderately reflects on suggestions of others	Shows little reflection on suggestions of others	Ignores suggestions of others
Providing and maintaining standards	Demonstrates complete will to achieve top performance	Demonstrate sufficient will to achieve top performance	Demonstrate moderate will to achieve top performance	Demonstrate little will to achieve top performance	Does not care for performance effectiveness.
Planning and co-ordination	Completely encourages crew participation in planning and task completion	Substantially encourages crew participation in planning and task completion	Moderately encourages crew participation in planning and task completion	Shows little Encouragement to crew participation in planning and task completion	Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed	Plan is clearly stated and confirmed	Plan is fairly stated and confirmed	Plan is briefly stated and confirmed	Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion	Clearly states goals and boundaries for task completion	Fairly states goals and boundaries for task completion	Briefly states goals and boundaries for task completion	Goals and boundaries remain unclear
Workload management	Completely notifies signs of stress and fatigue	Substantially notifies signs of stress and fatigue	Moderately notifies signs of stress and fatigue	Shows Little notification of signs of stress and fatigue	Ignores signs of fatigue
	Allots good time to complete tasks	Allots sufficient time to complete tasks	Allots just enough time to complete tasks	Allots little time to complete tasks	Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks	Demonstrate good prioritisation of tasks	Demonstrate average prioritisation of tasks	Demonstrate little prioritisation of tasks	Demonstrate no prioritisation of tasks
Task delegation	Delegates tasks in very good manner	Delegates tasks in good manner	Delegates tasks in average manner	Task delegation is quite poor	Do not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly	Identifies initial crisis situation quickly and respond accordingly	Identifies initial crisis situation after some time and respond accordingly	Identifies initial crisis situation quite late and respond accordingly	Does not identify initial crisis situation

4.6.3 Situation Awareness (SA)

Endsley (1995b) defines SA as: "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future."

It has been widely established and accepted that SA is a contributory factor to many accidents and incidents in high reliability safety industries (Salmon et al., 2009; Flin et al., 2008: 18). The importance of situation awareness in assessing and predicting operator competence in a complex and stressed environment has become increasingly apparent. Many accidents (Hetherington, 2006) have happened due to loss of SA such as the one described below.

During the evening of 11th February 2011 MV Boxford collided with fishing vessel, Admiral Blake, in the English Channel while on passage from Antwerp, Belgium to Gioia Tauro, Italy. The accident happened at 1839hrs when the chief officer went to check container lashing on deck and left the master in command. The master was busy checking the emails, discussing room repairs with a fitter and checking log entries of fire and boat drills. The deck cadet was performing lookout duties and reported a fishing vessel crossing from the starboard to the port side. The master was overworked in the last 36 hours and had misinterpreted the situation as the fishing vessel was being overtaken. So he only altered 10 degrees starboard and returned to discuss the repairs. But later his vessel collided with the fishing vessel with no casualties (MAIB, 2011). This accident is one of many accidents that happened due to loss of SA.

Awareness of Bridge Systems

Active knowledge of the mode and state of bridge systems, such as radar, Automatic Radar Plotting Aids (ARPA), ECDIS, Global Positioning System (GPS), echo sounder *etc.*, need to be maintained. Any changes in the systems' state need to be considered such as unexpected depth from the echo sounder or unexpected appearance of land feature on the radar (Flin et al., 2003). In the case of the Royal Majesty grounding the bridge team members failed to recognise the GPS position failure due to a faulty antenna for more than 34 hours. The Chief Officer, navigating officer and second officers were plotting GPS positions based on the DR (Dead Reckoning) position during that time. The echo sounder alarm settings were not changed from harbour settings of zero metres and hence did not warn of the problem in advance (NTSB, 1995).

Awareness of external environment

To avoid a crisis situation, a bridge team member is required to have active knowledge of the current and estimated position of the ship, weather information and traffic. This information must be shared among other bridge team members and necessary action needs to be taken to prevent consequences (Flin et al., 2003). MV Maersk Newport sailed from Le Havre for Algeciras on 10th November 2008 into force 9 winds with rough seas. Despite the forecasted poor weather no specific weather checks and measures had been carried out. The port anchor chain lashing arrangement failed because neither the extra lashing arrangements were fitted nor was the windlass brake sufficiently tightened (MAIB, 2009b).

Awareness of time

To avoid a crisis situation, a bridge team member needs to have a sense of available time and thinking ahead and to consider future conditions and contingencies (Flin et al., 2003). In a collision avoidance scenario, the rules (International Regulations for Preventing Collision at Sea) state that action taken to avoid collision shall be made in ample time. In a collision case between MV Hyundai Dominion and Sky Hope, watch officers of both ships spent valuable time on arguing the responsibilities of the action by the text messaging facility on AIS until finally they passed each other at a range of 0.2nm. (MAIB, 2005b)

Situation assessment

Situation assessment is the evaluation and interpretation of information obtained from different sources (including ship's position, course, speed, radar traffic, weather *etc.*). After conducting proper situation assessment of a changing situation, bridge team members must be able to recognise possible future problems. On 17th October 2006, MV Maersk Dover, which was en-route from Dover to Dunkerque, passed just one cable astern of MV Apollonia. The OOW on the Maersk Dover observed MV Apollonia at 1.9nm at 040° on her starboard bow, only when he was called by the deep sea pilot onboard the Apollonia. The OOW on the Maersk Dover did not do a proper situation assessment and initially made a succession of small alterations of course to starboard using the autopilot and then ordered the helmsman to begin hand steering to manoeuvre to avoid collision (MAIB, 2007)

Based on subsection 3.6.3 SA elements and behavioural markers, as shown in Table 4.4, are illustrated.

Table 4.4 Situation awareness elements and behavioural markers

Element	Very Good Practice	Good Practice	Acceptable Practice	Poor Practice	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states	Substantially monitors and report changes in systems' states	Moderately monitors and report changes in systems' states	briefly monitors and report changes in systems' states	Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)	Collects sufficient information about environment (own ship's position, traffic and weather)	Collects average information about environment (own ship's position, traffic and weather)	Collects little information about environment (own ship's position, traffic and weather)	Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members	Shares sufficient key information about environment with team members	Shares average key information about environment with team members	Shares little key information about environment with team members	Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members	Substantially discuss time constraints with other team members	Moderately discuss time constraints with other team members	Briefly discuss time constraints with other team members	Does not discuss time constraints with other crew members
Situation Assessment	Makes full assessment of changing situation	Makes substantial assessment of changing situation	Makes moderate assessment of changing situation	Makes little assessment of changing situation	Does not make an assessment of changing situation

4.6.4 Decision Making

In aviation, Decision Making is defined as "The process of reaching a judgement or choosing an option" (Flin et al., 2003). Although this definition is labelled as aeronautical decision making, this may be a universal definition for all high risk industries. Like an aeroplane pilot a ship's master also makes different types of decisions in different situations.

Decisions are dependent on various factors such as available options and support, crew qualifications and demands, company's standard procedures and policies for making decisions (ibid).

Problem definition and diagnosis

A decision maker should collect all the necessary information to determine the nature of the situation. Consider all explanations for the observed problem (Flin *et al.*, 2003). Onboard a ship, an example of a problem may be a close quarters' situation with various vessels at once or risk of collision or encountering fog in an area of heavy traffic. The first step for the OOW is to identify the problem and then generate the options for its solution.

Option generation

Option generation is a critical link in the decision-making process (Adelman et al., 1995). In a crisis situation, a decision maker will need to generate several options before analysing each to make a decision. A decision maker will formulate different approaches to deal with the problem. This will depend on available time and information (Flin et al., 2003). In a situation of close quarters in congested waters with various vessels at once, the OOW will generate the options of alteration of the course or reduction of speed.

Risk Assessment and option selection

Risk is the probability that a small hazard will turn into a crisis situation. The business dictionary defines risk assessment as "the identification, evaluation and estimation of the levels of risk involved in a situation, their comparison against benchmarks or standards and determination of an acceptable level of risk" (Business Dictionary, 2015). A decision maker will evaluate the level of risk and choose the best option. In the above close quarters' situation with various vessels at once, the OOW will need to choose the best option from the generated options of alteration of the course or reduction of speed.

Outcome review

A decision maker will consider the effectiveness of the chosen option against the current plan, once the course of action has been implemented (Flin et al., 2003). Onboard a ship any decision taken by the officer in charge must be reviewed for the outcome. He or she will run a forecast simulation in his mind regarding the effectiveness of his decision.

Based on subsection 4.6.4, decision making elements and behavioural markers, as shown in table 4.5, are illustrated.

Table 4.5 decision making elements and behavioural markers

Element	Very Good Practice	Good Practice	Acceptable Practice	Poor Practice	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem	Gather sufficient information to identify problem	Gather just enough information to identify problem	Gather little information to identify problem	Failure to diagnose the problem
	Review all casual factors with other crew members	Review enough casual factors with other crew members	Review some casual factors with other crew members	Review very few casual factors with other crew members	No discussion of probable cause
Option generation	States all alternative option	States enough alternative option	States some alternative option	States very few alternative option	Does not search for information
	Asks crew members for all options	Asks crew members for enough options	Asks crew members for some options	Asks crew members for very few options	Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options	Considers and shares substantial estimated risk of alternative options	Considers and shares just enough estimated risk of alternative options	Inadequate discussion of limiting factors with crew	No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action	Confirms and states enough selected options/agreed action	Confirms and states some selected options/agreed action	Confirms and states very few selected options/agreed action	Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan	Substantial checking of outcome against plan	Average checking of outcome against plan	Little checking of outcome against plan	Fails to check selected outcome against plan

4.7 ANALYTICAL HIERARCHY PROCESS (AHP) (Step 4)

Based on the literature reviews and with the help of information collected from experienced seafarers through interviews as presented in Appendices 4 - 10, a generic decision making model, as shown in Figure 4.1, is illustrated and approved. Furthermore, data presented by the interview, as shown in Appendix 11, are carefully reviewed and a weight is assigned to each criterion by using a mathematical decision making method called the AHP (Table 4.9). The process of evaluating a weight of a criterion is presented in the following subsection.

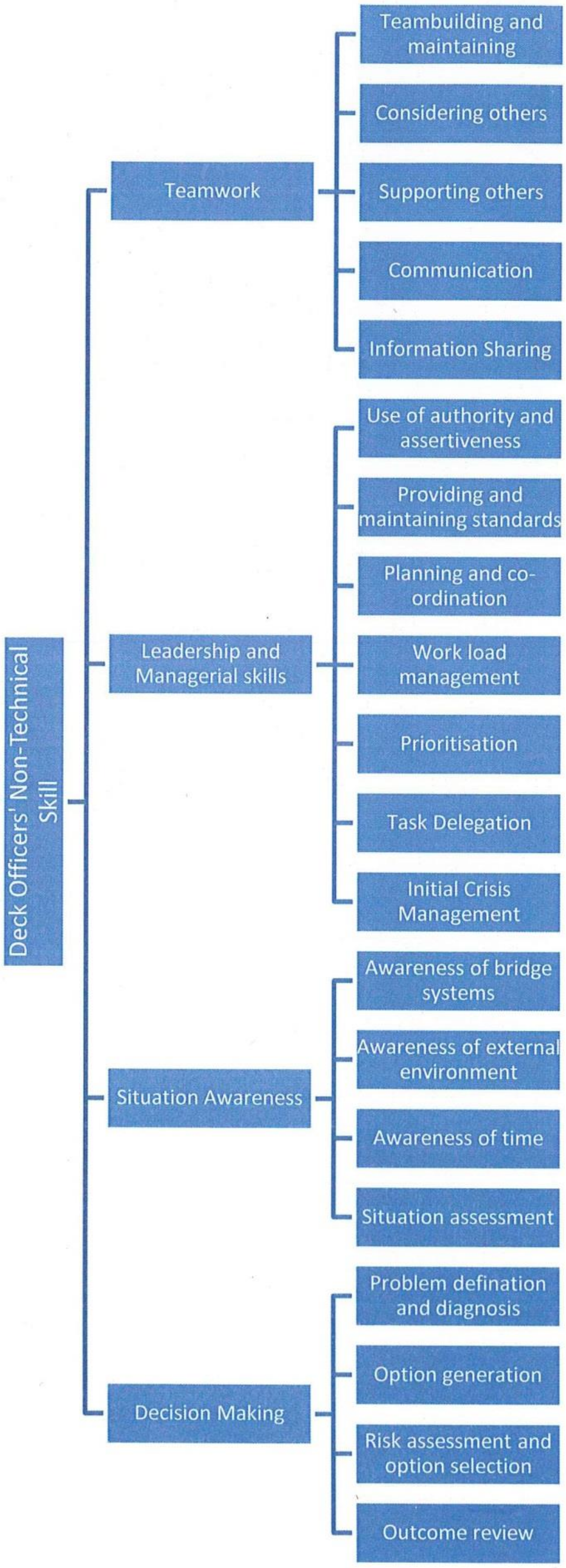

Figure 4.1: Deck Officers' Non-technical Skills Taxonomy

4.7.1 The AHP method

Riahi et al. (2012) has used Saaty's quantified judgements on pairs of attributes A_i and A_j represented by an n-by-n matrix D. The entries a_{ij} are defined by the following entry rules.

Rule 1. If $a_{ij} = \alpha$, then $a_{ji} = 1/\alpha$, $\alpha \neq 0$

Rule 2. If A_i is judged to be of equal relative importance as A_j, then $a_{ij} = a_{ji} = 1$

$$D = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix}$$

Where i, j = 1, 2, 3, …, n and each a_{ij} is relative importance of attribute A_i to attribute A_j.

Having recorded the quantified judgments of comparison on pair (A_i, A_j) as the numerical entry a_{ij} in the matrix D, what is left is to assign to the n contingencies A_1, A_2, …, A_n a set of numerical weights w_1, w_2, …, w_n that should reflect the recorded judgements. Generally weights w_1, w_2,…, w_n can be calculated by using the following equation;

$$\omega_k = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{kj}}{\sum_{i=1}^{n} a_{ij}}\ (k = 1,2,3, \dots, n) \tag{4.1}$$

Where a_{ij} represents the entry of row i and column j in a comparison matrix of order n.

The weight vector of the comparison matrix will provide the priority order but it cannot confirm the consistency of the pairwise judgement. The AHP provides a measure of the consistency of the pairwise comparisons by computing a Consistency Ratio (CR) (Riahi et al., 2012). The CR is devised in such a way that a value less than 0.10 is deemed consistent in the pairwise judgement. A decision maker should review the pairwise judgements if the resultant value is more than 0.10.

The CR value is calculated according to the following equations;

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{4.2}$$

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n - 1} \tag{4.3}$$

$$\lambda_{\max} = \frac{\sum_{j=1}^{n}\left[\left(\sum_{k=1}^{n} w_k a_{jk}\right)/w_j\right]}{n} \tag{4.4}$$

Where *CI* is the Consistency Index, *RI* is the average random index (Table 4.7), *n* is the matrix order and $\lambda_{\max}$ is the maximum weight value of the *n-by-n* comparison matrix D.

Table 4.7: Value of *RI* versus matrix order (Saaty, 1990)

n	RI
1	0
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

Numerical example

The following numerical example shows the method of evaluation of weights of main criteria (i.e. Situation Awareness, Decision Making, Leadership and Team Work) by an anonymous expert judgement (Table 3.8).

Table 4.8: Anonymous expert judgements

A. Goal: To Select the most important non-technical skills for deck Officers

1. Situation Awareness

How important is 'Situation Awareness' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making									x								
Leadership							x										
Teamwork										x							

2. Decision Making

How important is 'Decision Making' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership									x								
Teamwork											x						

3. Leadership

How important is 'Leadership' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork											x						

$$D = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix}$$

The matrix for main criterion was obtained from the table 4.8 as follows;

	SA	DM	LS	TW
SA	1	1	1/3	2
DM	1	1	1	3
LS	3	1	1	3
TW	1/2	1/3	1/3	1

Weights of main criteria are calculated using equation 4.1;

$$\omega_1 = \frac{1}{n}\left(\frac{a_{11}}{(a_{11}+a_{21}+a_{31}+a_{41})} + \frac{a_{12}}{(a_{12}+a_{22}+a_{32}+a_{42})} + \frac{a_{13}}{(a_{13}+a_{23}+a_{33}+a_{43})} + \frac{a_{14}}{(a_{14}+a_{24}+a_{34}+a_{44})}\right)$$

$$\omega_1 = \frac{1}{4}\left(\frac{1}{(1+1+3+0.5)} + \frac{1}{(1+1+1+0.3333)} + \frac{0.3333}{(0.3333+1+1+0.3333)} + \frac{2}{(2+3+3+1)}\right)$$

$$\omega_1 = 0.207260$$

$$\omega_2 = \frac{1}{n}\left(\frac{a_{21}}{(a_{11}+a_{21}+a_{31}+a_{41})} + \frac{a_{22}}{(a_{12}+a_{22}+a_{32}+a_{42})} + \frac{a_{23}}{(a_{13}+a_{23}+a_{33}+a_{43})} + \frac{a_{24}}{(a_{14}+a_{24}+a_{34}+a_{44})}\right)$$

$$\omega_2 = \frac{1}{4}\left(\frac{1}{(1+1+3+0.5)} + \frac{1}{(1+1+1+0.3333)} + \frac{1}{(0.3333+1+1+0.3333)} + \frac{3}{(2+3+3+1)}\right)$$

$$\omega_2 = 0.297538$$

$$\omega_3 = \frac{1}{n}\left(\frac{a_{31}}{(a_{11}+a_{21}+a_{31}+a_{41})} + \frac{a_{32}}{(a_{12}+a_{22}+a_{32}+a_{42})} + \frac{a_{33}}{(a_{13}+a_{23}+a_{33}+a_{43})} + \frac{a_{34}}{(a_{14}+a_{24}+a_{34}+a_{44})}\right)$$

$$\omega_3 = \frac{1}{4}\left(\frac{3}{(1+1+3+0.5)} + \frac{1}{(1+1+1+0.3333)} + \frac{1}{(0.3333+1+1+0.3333)} + \frac{3}{(2+3+3+1)}\right)$$

$$\omega_3 = 0.388447$$

$$\omega_4 = \frac{1}{n}\left(\frac{a_{41}}{(a_{11}+a_{21}+a_{31}+a_{41})} + \frac{a_{42}}{(a_{12}+a_{22}+a_{32}+a_{42})} + \frac{a_{43}}{(a_{13}+a_{23}+a_{33}+a_{43})} + \frac{a_{44}}{(a_{14}+a_{24}+a_{34}+a_{44})}\right)$$

$$\omega_4 = \frac{1}{4}\left(\frac{0.5}{(1+1+3+0.5)} + \frac{0.3333}{(1+1+1+0.333)} + \frac{0.3333}{(0.3333+1+1+0.3333)} + \frac{1}{(2+3+3+1)}\right)$$

$$\omega_4 = 0.106755$$

The weight values are found as 0.207260 (ω_1), 0.297538 (ω_2), 0.388447 (ω_3) and 0.106755 (ω_4). Consistency ratio is calculated by using equations 4.2 - 4.4.

Based on equation 4, λ_{max} was calculated as follows:

ω_{1x} = (1 × 0.207260) + (1 × 0.297538) + (0.333333 × 0.388447) + (2 × 0.106755) = 0.847790
ω_{2x} = (1 × 0.207260) + (1 × 0.297538) + (1 × 0.388447) + (3 × 0.106755) = 1.21351
ω_{3x} = (3 × 0.207260) + (1 × 0.297538) + (1 × 0.388447) + (3 × 0.106755) = 1.62803
ω_{4x} = (0.5 × 0.20726) + (0.33 × 0.297538) + (0.33 × 0.388447) + (1 × 0.106755) = 0.43905

$$\lambda_{max} = \frac{\left(\frac{0.847790}{0.207260}\right) + \left(\frac{1.21351}{0.297538}\right) + \left(\frac{1.62803}{0.388447}\right) + \left(\frac{0.43905}{0.106755}\right)}{4} = 4.118196$$

The mean value for λ_{max} is 4.118196. If any of the λ_{max} turns out to be less than n, which is 4 in this case, then there is an error in the calculation, which requires a thorough check.

The CI is calculated as follows;

$$CI = \frac{\lambda_{max} - n}{n - 1} = \frac{4.118196 - 4}{4 - 1} = 0.03939$$

Based on table 3.7, the Random Index (RI) for 4 criteria is 0.9. As a result, the CR value was calculated as follows;

$$CR = \frac{CI}{CR} = \frac{0.03939}{0.9} = 0.04376$$

The CR value for the main criteria is found 0.04376. CR value of less than or equal to 0.1 indicates that judgements are acceptable (Saaty, 1980). As a result, the consistency of pair-wise comparisons for main criteria is acceptable. The same calculation technique is applied to obtain weights of sub-criteria and to check the consistency of the expert opinions.

4.7.2 Geometric Mean Method

AHP initially was developed as a decision making tool for individual decision makers but by the use of the geometric mean method individual pairwise comparison metrics of any number of experts can be aggregated (Aull-Hyde et al., 2006).

Experts' judgement can be aggregated by using the geometric mean method;

$$GeometricMean_{ij} = [e_{1ij}. e_{2ij}. e_{3ij} \dots e_{kij}]^{\frac{1}{k}} \tag{4.5}$$

Where, e_{kij} is the k^{th} expert judgement on pair of attributes A_i and A_j.

4.8 DATA COLLECTION

Data was collected by conducting interviews with 12 experienced senior deck officers both in UK and Malmo (Appendix 11), Sweden. Only eight participants' results were considered for the following study as the remaining four participants' weighting data was inconsistent in light of the AHP formula. Table 4.9 shows the weights of all elements of the NTS.

Table: 4.9 NTS weights

Category	Element
1. Teamwork (0.1914)	Team-building and maintaining (0.2066) Considering others (0.1860) Supporting others (0.1831) Communication (0.2436) Information Sharing (0.1807)
2. Leadership and Managerial Skills (0.2878)	Use of Authority and assertiveness (0.1579) Providing and maintaining standards (0.0857) Planning and co-ordination (0.1437) Work load management (0.1280) Prioritisation (0.1255) Task delegation (0.1316) Initial Crisis Management (0.2276)
3. Situation awareness (0.2863)	Awareness of bridge systems (0.2433) Awareness of external environment (0.2375) Awareness of time (0.1860) Situation Assessment (0.3332)
4. Decision Making (0.2346)	Problem definition and diagnosis (0.2447) Option generation (0.2069) Risk assessment and option selection (0.2426) Outcome review (0.3058)

4.9 CONCLUSION

In this chapter, with the help of the literature review, a deck officers' NTS taxonomy was developed. The taxonomy was required to see which NTS and associated elements are important for a deck officer to possess to deal with crisis situations. To confirm the taxonomy elements' interviews were conducted with experienced seafarers. In the interviews participants discussed a real life scenario where they had to use NTS to deal with the situation. After the scenario discussion they were presented with the taxonomy to confirm the elements which all participants acknowledged. They were then asked to assign a weight for each individual skill and associated element against the other on a scale of 1-9 (Appendix 11). This individual weighting was then calculated by AHP to aggregate the final weight. This weighting was used in the next chapter where simulator assessments were carried out to analyse the actual skills possessed by a seafarer who has just completed the chief mate certificate of competence training. Further simulator assessments were carried out of the students with additional NTS training, HELM, and results were calculated and compared by the ER Algorithm.

CHAPTER FIVE

ASSESSMENT OF STUDENTS' NON-TECHNICAL SKILLS IN SIMULATED CRISIS SITUATIONS

5.1 INTRODUCTION

This chapter presents the behavioural marker assessments for team-working, leadership and managerial skills, situation awareness, and decision making developed by a relevant literature review and interviews with experts. Based on the behavioural markers the assessor in a ships' bridge simulator was able to mark each element of a participant's non-technical skill. For assessment of a participant's NTS in a ships' bridge simulator, three sets of simulator scenarios were produced in this section of research. Two sets of volunteer Chief Mate students were selected. One set of students are those who have not obtained the additional NTS training, HELM course, and the other set of students are those who had obtained the HELM training. Based on the developed scenarios and developed behavioural markers, students' NTS behaviours were assessed in a ships' bridge simulator. The results were analysed and compared using the ER Algorithm.

5.2 METHODOLOGY

Simulation training is becoming an integral part of maritime training as it provides obvious advantages such as a realistic environment. The simulation training allows trainees to make mistakes and then learn from their errors in a safe environment. This allows trainers the ability to train and assess technical and non-technical skills (Hassan et al., 2013).

This chapter is divided into the following steps:

1. A set of scenarios were developed for the assessment of deck officers' NTS.
2. Sample of volunteer students, after completion of their Chief Mate training programme, were selected. Based on the developed scenarios (step 1), their qualitative NTS characteristics were assessed subjectively in a bridge simulator. All input data was aggregated by using an evidential reasoning algorithm.

3. A utility value was calculated for each group's performance for the purpose of comparisons.

In the first step the scenarios were developed to test the students' NTS. After the scenarios were developed volunteer students, who have completed their Chief Mate course of study, were selected and assessed in a ships' bridge simulator. The students were divided into two groups, one who did not gain the training of NTS and other had obtained NTS training by means of HELM as part of the approved training programme. The students were assessed using the behavioural marker system (table 4.2 – 4.5) which was devised in Chapter Four.

The ER algorithm uses the expert weightings for each skill (Table 4.9) and the assessment ratings were calculated to find the aggregate of the overall performance of each group. This was carried out in step two and used to compare the performance of the groups with NTS training and the groups without the training.

In step three, a utility value was calculated and assigned to each group's NTS performance for the purpose of comparisons.

5.3 ER ALGORITHM

The ER algorithm can be analysed and explained as follows (Riahi et al., 2012):

Let R represents a set with five linguistic terms (i.e. very poor, poor, average, good and very good) with their associated belief degrees (i.e. β) and be synthesised by two subsets R_1 and R_2 from two different assessments. Then, for example, R, R_1 and R_2 can separately be expressed by:

$$\mathrm{R} = \{\beta^1 \text{Very Poor}, \beta^2 \text{Poor}, \beta^3 \text{Average}, \beta^4 \text{Good}, \beta^5 \text{Very Good}\}$$

$$\mathrm{R}_1 = \{\beta_1^1 \text{Very Poor}, \beta_1^2 \text{Poor}, \beta_1^3 \text{Average}, \beta_1^4 \text{Good}, \beta_1^5 \text{Very Good}\}$$

$$\mathrm{R}_2 = \{\beta_2^1 \text{Very Poor}, \beta_2^2 \text{Poor}, \beta_2^3 \text{Average}, \beta_2^4 \text{Good}, \beta_2^5 \text{Very Good}\}$$

Suppose that the normalised relative weights of two assessments in the evaluation process are given as w_1 and w_2 ($w_1 + w_2 = 1$). w_1 and w_2 can be estimated by using an AHP technique.

Suppose that M_1^m and M_2^m (m = 1, 2, 3, 4, 5) are individual degrees to which the subsets R_1 and R_2 support the hypothesis that the evaluation is confirmed to the five linguistic terms. Then, M_1^m and M_2^m are obtained as:

$$M_1^m = w_1\beta_1^m$$

$$M_2^m = w_2\beta_2^m$$

(5.1)

Suppose that H_1 and H_2 are the individual remaining belief values unassigned for M_1^m and M_2^m (m = 1, 2, 3, 4, 5). Then H_1 and H_2 are expressed as:

$$H_1 = \overline{H}_1 + \widetilde{H}_1$$

$$H_2 = \overline{H}_2 + \widetilde{H}_2$$

(5.2)

Where $\overline{H}_n$ (n = 1, 2) represent the degree to which the other assessor can play a role in the assessment, and $\widetilde{H}_n$ (n = 1, 2) is caused by the possible incompleteness in the subsets R_1 and R_2. $\overline{H}_n$ (n = 1 or 2) and $\widetilde{H}_n$ (n = 1, 2) are described as:

$$\overline{H}_1 = 1 - w_1 = w_2$$

$$\overline{H}_2 = 1 - w_2 = w_1$$

$$\widetilde{H}_1 = w_1(1 - \sum_{m=1}^{5} \beta_1^m)$$

$$\widetilde{H}_2 = w_2(1 - \sum_{m=1}^{5} \beta_2^m)$$

(5.3)

Suppose that $\beta^{m\prime}$ (m = 1, 2, 3, 4 or 5) represents the non-normalised degree to which the reliability evaluation is confirmed to each of the five linguistic terms as a result of the synthesis of the judgements produced by assessors 1 and 2. Suppose that H'_U represents the non-normalised remaining belief unassigned after the commitment of belief to the five linguistic terms because of the synthesis of the judgements produced by assessors 1 and 2. The ER algorithm is stated as:

$$\beta^{m\prime} = K(M_1^m M_2^m + M_1^m H_2 + M_2^m H_1)$$

$$\overline{H'}_U = K(\overline{H}_1 \overline{H}_2)$$

$$\widetilde{H'}_U = K(\widetilde{H}_1 \widetilde{H}_2 + \widetilde{H}_1 \overline{H}_2 + \widetilde{H}_2 \overline{H}_1)$$

$$K = \left(1 - \sum_{T=1}^{5} \sum_{\substack{R=1 \\ R \neq T}}^{5} M_1^T M_2^R \right)^{-1}$$

(5.4)

After the above aggregation, the combined degrees of belief are generated by assigning $\overline{H'}_U$ back to five linguistic terms using the normalisation process:

$$\beta^m = \frac{\beta^{m\prime}}{1 - \overline{H'}_U} \qquad (m = 1, 2, 3, 4, 5)$$

$$H_U = \frac{\widetilde{H'}_U}{1 - \overline{H'}_U}$$

(5.5)

Where, H_U is the unassigned degree of belief representing the extent of incompleteness in the overall assessment. The above gives the process of combining two subsets. If three subsets are required to be combined, the result obtained from the combination of any two subsets can be further synthesised with the third subset using the above algorithm. In a similar way, the judgements of multiple assessors of lower-level criteria in the chain system (i.e. components or subsystems) can be combined.

5.3.1 Numerical example

As an example, based on the ER algorithm two quantitative data (e.g. R_1 *and* R_2) are aggregated as follows:

R_1 stands for 'Problem definition and diagnosis' (sub criteria of decision making) assessed for a team performance (Appendix 12)

R_2 stands for 'Option generation' (sub criteria of decision making) assessed for a team performance (Appendix 12)

	Very Poor	Poor	Average	Good	Very Good	Weight (w_n)
R_1	0	0.5	0	0.5	0	0.2447
R_2	0.5	0.5	0	0	0	0.2069

$$w_1 + w_2 = 0.2447 + 0.2069 = 0.4516$$

Normalised weights $w_1 = 0.2447 \times 2.21435 = 0.54185$

Normalised weights $w_2 = 0.2069 \times 2.21435 = 0.45815$

$$\beta_1^1 = 0, \quad \beta_1^2 = 0.5, \quad \beta_1^3 = 0, \quad \beta_1^4 = 0.5, \quad \beta_1^5 = 0$$

$$\beta_2^1 = 0.5, \quad \beta_2^2 = 0.5, \quad \beta_2^3 = 0, \quad \beta_2^4 = 0, \quad \beta_2^5 = 0$$

$$M_1^1 = w_1\beta_1^1 = 0.54185 \times 0 = 0$$

$$M_1^2 = w_1\beta_1^2 = 0.54185 \times 0.5 = 0.27093$$

$$M_1^3 = w_1\beta_1^3 = 0.54185 \times 0 = 0$$

$$M_1^4 = w_1\beta_1^4 = 0.54185 \times 0.5 = 0.27093$$

$$M_1^5 = w_1\beta_1^5 = 0.54185 \times 0 = 0$$

$$M_2^1 = w_2\beta_2^1 = 0.45815 \times 0.5 = 0.22908$$

$$M_2^2 = w_2\beta_2^2 = 0.45815 \times 0.5 = 0.22908$$

$$M_2^3 = w_2\beta_2^3 = 0.45815 \times 0 = 0$$

$$M_2^4 = w_2\beta_2^4 = 0.45815 \times 0 = 0$$

$$M_2^5 = w_2\beta_2^5 = 0.45815 \times 0 = 0$$

$$\overline{H}_1 = 1 - w_1 = 1 - 0.54185 = 0.45815$$

$$\overline{H}_2 = 1 - w_2 = 1 - 0.45815 = 0.54185$$

$$\widetilde{H}_1 = w_1\left(1 - (\beta_1^1 + \beta_1^2 + \beta_1^3 + \beta_1^4 + \beta_1^5)\right) = 0.54185\left(1 - (0 + 0.5 + 0 + 0.5 + 0)\right) = 0$$

$$\widetilde{H}_2 = w_2\left(1 - (\beta_2^1 + \beta_2^2 + \beta_2^3 + \beta_2^4 + \beta_2^5)\right) = 0.45815\left(1 - (0.5 + 0.5 + 0 + 0 + 0)\right) = 0$$

$$H_1 = \overline{H}_1 + \widetilde{H}_1 = 0.45815 + 0 = 0.45815$$

$$H_2 = \overline{H}_2 + \widetilde{H}_2 = 0.54185 + 0 = 0.54185$$

$$K = \left(1 - \sum_{T=1}^{5} \sum_{\substack{R=1 \\ R \neq T}}^{5} M_1^T M_2^R \right)^{-1}$$

$$K = \left(1 - \sum_{T=1}^{5} (M_1^T M_2^1 + M_1^T M_2^2 + M_1^T M_2^3 + M_1^T M_2^4 + M_1^T M_2^5)\right)^{-1}$$

$$\begin{aligned} K = (1 - [&(M_1^1 M_2^2 + M_1^1 M_2^3 + M_1^1 M_2^4 + M_1^1 M_2^5) + (M_1^2 M_2^1 + M_1^2 M_2^3 + M_1^2 M_2^4 + M_1^2 M_2^5) \\ &+ (M_1^3 M_2^1 + M_1^3 M_2^2 + M_1^3 M_2^4 + M_1^3 M_2^5) \\ &+ (M_1^4 M_2^1 + M_1^4 M_2^2 + M_1^4 M_2^3 + M_1^4 M_2^5) \\ &+ (M_1^5 M_2^1 + M_1^5 M_2^2 + M_1^5 M_2^3 + M_1^5 M_2^4)])^{-1} \end{aligned}$$

$$K = 1.2288$$

$$\overline{H}_{U'} = K\,(\overline{H}_1 \overline{H}_2) = 0.3050$$

$$B^{1\prime} = K(M_1^1 M_2^1 + M_1^1 H_2 + M_2^1 H_1) = 0.1289$$

$$\beta^1 = \frac{B^{1\prime}}{1 - \overline{H}_{U'}} = 0.18547$$

$$B^{2\prime} = K(M_1^2 M_2^2 + M_1^2 H_2 + M_2^2 H_1) = 0.3857$$

$$\beta^2 = \frac{B^{2\prime}}{1 - \overline{H}_{U'}} = 0.55496$$

$$B^{3\prime} = K(M_1^3 M_2^3 + M_1^3 H_2 + M_2^3 H_1) = 0$$

$$\beta^3 = \frac{B^{3\prime}}{1-\overline{H}_{U\prime}} = 0$$

$$B^{4\prime} = K(M_1^4 M_2^4 + M_1^4 H_2 + M_2^4 H_1) = 0.1805$$

$$\beta^4 = \frac{B^{4\prime}}{1-\overline{H}_{U\prime}} = 0.25971$$

$$B^{5\prime} = K(M_1^5 M_2^5 + M_1^5 H_2 + M_2^5 H_1) = 0$$

$$\beta^5 = \frac{B^{5\prime}}{1-\overline{H}_{U\prime}} = 0$$

The following result is obtained from the above calculations:

	Very Poor	Poor	Average	Good	Very Good
$R_{12} = R_1 \oplus R_2$	18.547%	55.496%	0	25.971%	0

The calculation is repeated for R_3 and R_4 and then again repeated to aggregate the R_{12} (i.e. $R_1 \oplus R_2$) and R_{34} (i.e. $R_3 \oplus R_4$) to find the final value of the 'decision making' element of the group.

5.4 BRIDGE SIMULATOR SCENARIOS AND ASSESSMENTS (STEP 1)

The students were assessed on the last three exercises of the NAEST (M) bridge simulator course which is an eight days long course. The students were divided into sub groups and were assessed on the following scenarios;

5.4.1 Scenario 1

Two similar exercises were used for this scenario. One was set in Southampton and other in Algeciras. Both exercises are detailed as below.

The vessel was alongside the jetty in Southampton or Algeciras. Each team would have to pilot their own vessel and maintain all the records as agreed by the members. Each team would need to manoeuvre their own vessel with use of a bow thruster (team was not allowed to use tugs). There would be a number of inbound as well as outbound vessels during the departure. A grounded vessel in the vicinity of the Nab tower with a salvage operation underway would request a wide berth (Southampton only).

Just after passing Fawley Terminal in Southampton or coming out of the breakwater in Algeciras, Gyro No. 1 would start to drift at a rate of 1°/sec. Based on the position of each vessel at time of passing; there would be the possibility of interaction with large inbound containerships.

The exercise would require effective teamwork, situation awareness, leadership, and decision making skills.

5.4.2 Scenario2

The exercise was set in the approaches to the Bosphorus, Turkey. The master would commence the exercise in a debrief room and would be ready to be called to the bridge when required. The bridge equipment would need to be tested and checklists required to be completed prior to the exercise. The vessel would proceed to an anchorage for bunkering.

There would be a number of vessels in the concerned area (anchored, approaching, overtaking and numerous ferries crossing). The strong tide setting would make it hard to steer. The exercise would continue until the vessel was alongside a jetty. As time permits the vessel proceeded through the Bosphorus towards the Black Sea.

A number of south bound vessels, strong cross currents and ferry operations would require strict adherence to and monitoring of the passage plan as well as collision avoidance manoeuvres. The exercise would require effective teamwork, situation awareness, leadership, and decision making skills.

5.4.3 Scenario 3

The exercise would commence with a handover/ takeover of a watch. A Third Officer (3/O) from each of the three bridges would commence the exercise as an Officer of the Watch (OOW). An instructor would act as a lookout and would be on a walkie-talkie / telephone. Sufficient time would be given to the trainees prior to the commencement of the exercise such that they were able to check all the equipment and familiarise themselves with the pre-prepared passage plan.

A delegate from each of the three bridges would be in the role of Second Officer (2/0) and he would proceed to the bridge for takeover of the watch. The handover/ takeover would take place using the appropriate procedure and checklists. When agreement was reached, each relieved OOW would return to the debrief room and was ready to take up the role as a chief officer (C/O) in an assigned bridge.

Bridge 1 was situated in such a way that in the initial 20 minutes of running the exercise it was just in visual range of a target showing a strobe light (normally fitted on a life raft). This target had no or very poor radar returns. The target would be detected if radar controls are set appropriately. Another target to the north (i.e. distressed vessel) would provide a weak radar return but would not be in the visual range. Bridges 2 and 3 were in the Very High Frequency (VHF) range of Bridge 1.

The exercise was based on a scenario set in the Global Maritime Distress Safety System (GMDSS) sea area A2 (i.e. Medium Frequency range). Delegate assignment were in ranks of master, chief officer (C/O) and third officer (3/O) / lookout for all three bridges.

The exercise would progress in the anticipation that the OOW on Bridge 1 would identify the life raft, summon the Master and instigate a search and rescue plan. In the event that the OOW does not take the appropriate action, the virtual lookout (i.e. instructor) would call the bridge and report the sighting. The exercise would then be conducted in line with delegates' response; one of the bridges would be tasked with the On Scene Commander (OSC) role. There would be minimum intervention by the Maritime Rescue Coordination Centre (MRCC). There would be other vessels in the area. A warship to the west would be in MF (Medium Frequency) range and has an operational helicopter. A fishing vessel to the north would offer assistance and has the benefit of low freeboard. Her position would be such that an Emergency Position-Indicating Radio Beacon (EPIRB) position of the casualty could be checked if utilised immediately. The exercise would test all the non-technical skills of the delegates involved.

5.5 STUDENTS’ PERFORMANCE (Step 2)

The following is the students’ performance against each scenario. Students were rated against their performance on the behavioural markers assessment framework (Appendices A12 – A23).

5.5.1 Group 1 performance / Scenario 1 (Wednesday 17/04/2013) – NO HELM

The group was formed in the beginning of the NAEST (M) (Navigation Aids, Equipment and Simulator Training - Management) course and the teambuilding element was evident. The passage plan was already prepared a day before the exercise. The group tested all bridge equipment and completed the check lists. The exercise started when the bridge team was ready. Initially they had some doubts about departing the berth without tugs. The use of the bow thrust helped them to depart without any problems. The vessel was manoeuvred slowly and left the berth and headed towards the channel. The vessel speed was about 8 knots in the channel. The master was overall in charge, C/O and OOW were performing navigation and communication duties respectively. At one point the own vessel grounded and then re-floated quickly. The gyro started drifting but the bridge team considered that the vessel was drifting due to tide/current. The OOW suggested that the drifting was due to the gyro failure but the master did not investigate it further and it was assumed that the vessel was drifting due to heavy current. The master only realised the gyro failure once the large alteration of the vessel’s course was observed (i.e. about half an hour after the initial drift). Immediately action was taken by switching to gyro 2 and controlling the situation.

Gyro failure during the exercise was the key moment and it was expected that the bridge team would identify and take corrective measures immediately. The group’s poor performance was due to lack of situation awareness of the team and then the master’s over reliance on C/O information and not taking control of the situation himself.

The students’ behaviour markers are tabulated in Appendix A12.1, A12.2, A12.3 and A12.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck Officers’ NTS) and by using the ER algorithm, an output set is evaluated as shown in Table 5.1 and Figure 5.1.

Table 5.1: ER results of group 1

Very Poor	35.39%
Poor	33.71%
Average	28.05%
Good	2.85%
Very Good	0.0%

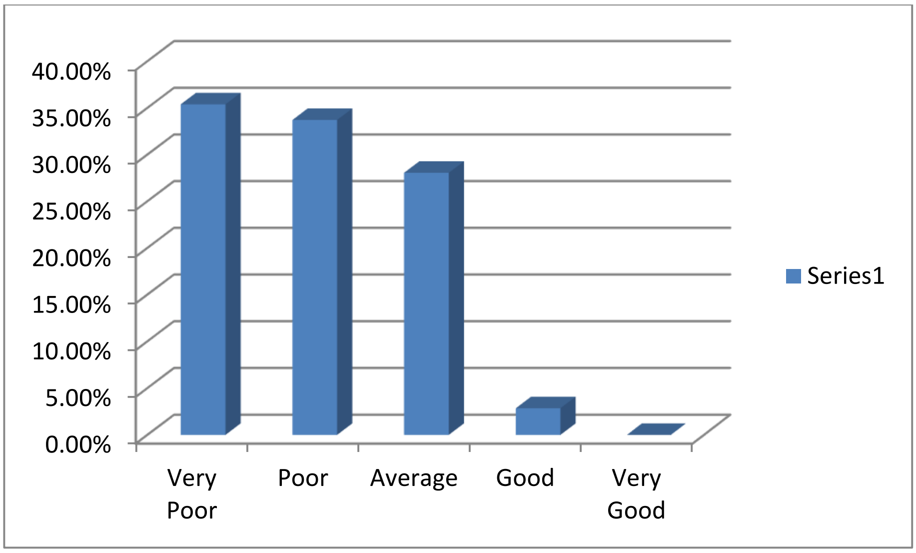

Figure 5.1: ER results of group 1

5.5.2 Group 2 Performance / Scenario 2 (Thursday 18/04/2013) – NO HELM

This was an exercise with a number of vessels in the area (anchored, approaching and overtaking) with numerous ferries crossing. The vessel was passing through the Dardanelle's TSS (Traffic Separation Scheme). At one point own vessel was in the opposite lane of the TSS due to the strong current. There was a tug on the starboard side being overtaken. The target was not initially picked up on the radar but was later on picked up visually. No immediate action was taken by the students. When the tug was less than one mile away the master of own ship started to alter the vessel's course in successions of 5° to port and the ship nearly went into the opposite lane for the second time in this exercise. As a result the target only passed one cable ahead of own ship. Immediately after passing the tug the own vessel collided with a fishing vessel which was not observed in the panic of clearing the tug.

This team have shown that the effect of training and procedures will be relinquished as a result of panic. The group has shown poor NTS and there was very weak leadership and teamwork. The group has also shown lack of situation awareness.

The students' behaviour markers are tabulated in Appendix A13.1, A13.2, A13.3 and A13.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck Officers' NTS) and by using the ER algorithm, the output set is evaluated as shown in Table 5.2 and Figure 5.2.

Table 5.2: ER results of group 2

Very Poor	10.52%
Poor	70.0%
Average	19.49%
Good	0.0%
Very Good	0.0%

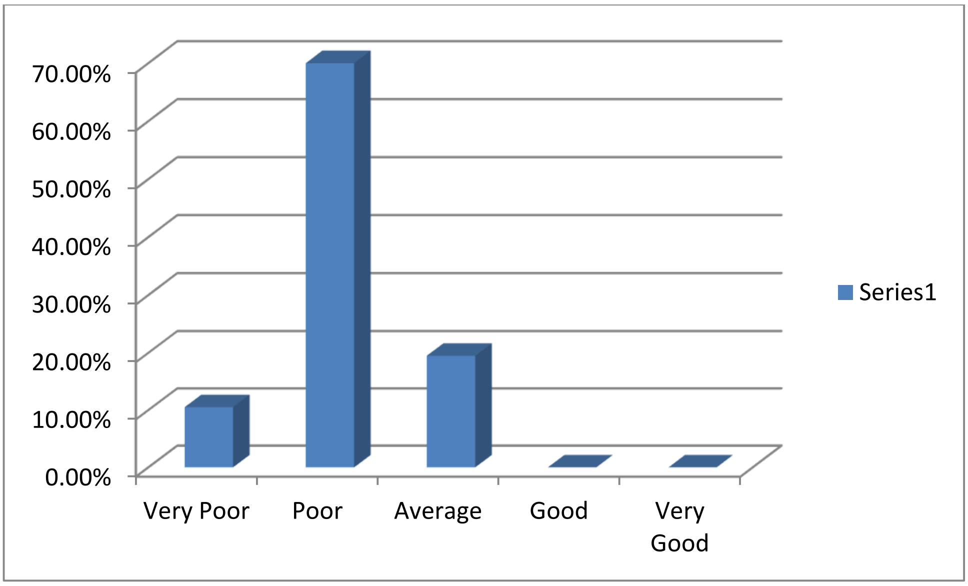

Figure 5.2: ER results of group 2

5.5.3 Group 3 performance / Scenario 3 (Friday 19/04/2013) – NO HELM

The exercise was set in the Western approaches to the English Channel. The exercise started with the OOW on the bridge and after some time the C/O arrived on the bridge to take over the watch. After the OOW left the bridge the C/O was alone on the bridge. Restricted visibility was encountered after about 30 minutes of the start of the exercise. The master was informed and the fog signal activated. Soon after that a survival craft was sighted and its position noted. The master carried out a Williamson Turn to recover the casualties from the life raft. A SECURITY message was transmitted on VHF channel 16 (but not on 2182). At the end of the turn a survival craft was sighted and the vessel stopped. Half an hour after the sighting a Mayday Relay message was received from Falmouth Coastguard as they got information from a sunken vessel's EPIRB. Three more vessels in the area responded and joined the search and rescue operations. After consultation with Falmouth Coastguard own vessel assumed on scene commander (OSC) role. Own vessel recovered five persons from the life raft out of twelve. One of the five rescued persons was badly wounded. The Master contacted the warship Halifax (which was in the area and offered assistance) for medical evacuation. The Halifax informed the master that a helicopter would be arriving in 30 minutes. Three more persons were rescued by one of the other vessels. Another vessel sighted two more survivors in the water. The helicopter was diverted towards the two survivors in the water. As per instruction of the OSC, after some time the injured person on own vessel became unconscious and required evacuation.

As per Falmouth Coastguard all four vessels proceeded to the rendezvous position to start a parallel search.

The students' behaviour markers are tabulated in Appendix A14.1, A14.2, A14.3 and A14.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck Officers' NTS) and by using the ER algorithm, an output set is evaluated as shown in Table 5.3 and Figure 5.3.

Table 5.3: ER results of group 3

Very Poor	4.15%
Poor	35.02%
Average	60.83%
Good	0.0%
Very Good	0.0%

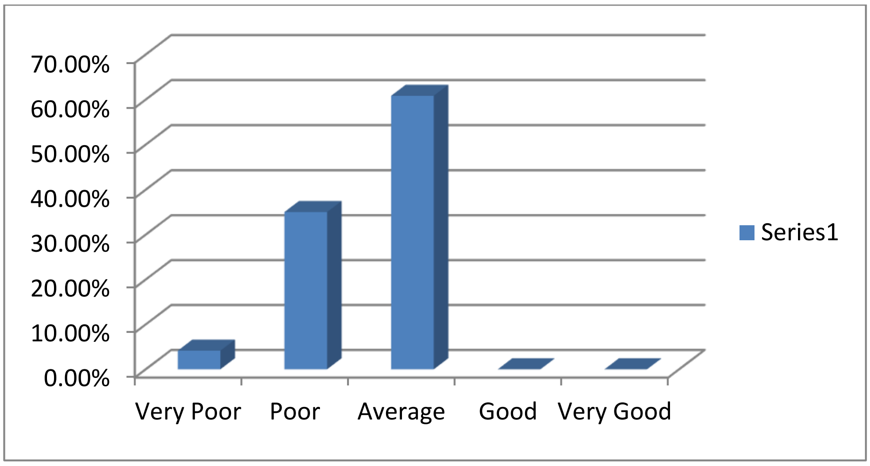

Figure 5.3: ER results of group 3

5.5.4 Group 4 performance / Scenario 1 (Tuesday 07/05/2013) – NO HELM

The group was formed in the beginning of the course and a teambuilding element was evident. The passage plan was already prepared a day before the exercise. The exercise started with the vessel berthed in Gibraltar and there was restricted visibility. There was a pilot onboard who helped to manoeuvre the vessel. 15 minutes after the pilot's departure the vessel made head on contact with another vessel just outside the harbour. The target was not plotted on the ARPA. Port Control was informed and the gyro started to drift at this stage. Clues to gyro drift were ignored as the "binoculars visual channel" was showing true heading which was different from the actual heading. It was considered that the error is due to heavy current. Although OOW1 informed the master regarding the gyro failure the master ignored him. The Gyro drift problem was detected 45 minutes after its initial failure.

The students' behaviour markers are tabulated in Appendix A15.1, A15.2, A15.3 and A15.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck Officers' NTS) and by using ER, an output set is evaluated as shown in Table 5.4 and Figure 5.4.

Table 5.4: ER results of group 4

Very Poor	47.66%
Poor	44.89%
Average	7.45%
Good	0.0%
Very Good	0.0%

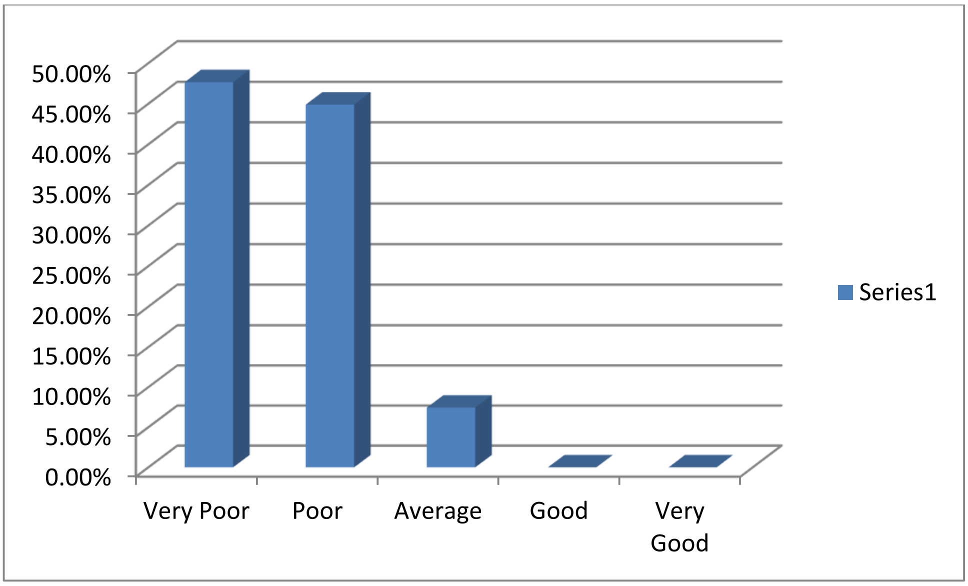

Figure 5.4: ER results of group 4

5.5.5 Group 5 performance / Scenario 2 (Wednesday 08/05/2013)

The exercise started in the Dardanelles TSS. Half an hour into the exercise the vessel ahead of own vessel went aground and own vessel had to reduce speed. After some time the vessel re-floated but by then own vessel could not control steering and moved into the opposite lane as a result of panic. There was a vessel coming down in the opposite lane and she passed on the port side very close and consequently the own vessel lost steering control and touched the breakwater on its starboard side and grounded. 15 minutes after grounding the vessel re-floated and was underway. Due to heavy currents own vessel experienced difficulty in steering throughout.

The students' behaviour markers are tabulated in Appendix A16.1, A16.2, A16.3 and A16.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck Officers' NTS) and by using the ER algorithm, an output set is evaluated as shown in Table 5.5 and Figure 5.5.

Table 5.5: ER results of group 5

Very Poor	7.26%
Poor	46.58%
Average	45.59%
Good	0.57%
Very Good	0.0%

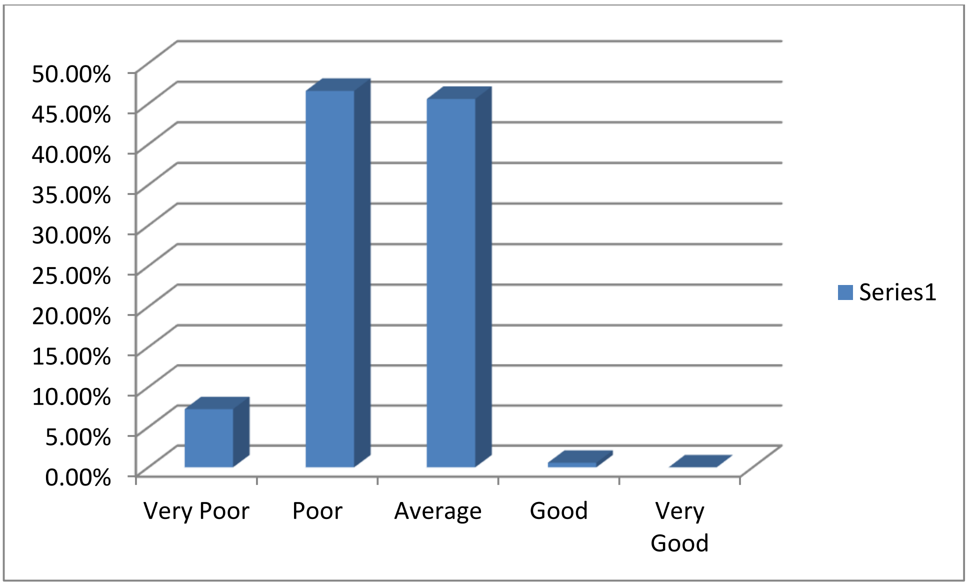

Figure 5.5: ER results of group 5

5.5.6 Group 6 performance / Scenario 3 (Thursday 09/05/2013) – NO HELM

The exercise was set in the Western approaches to the English Channel. The exercise started with OOW1 on the bridge and after some time OOW2 arrived on the bridge in order to take over the watch. After OOW1 left the bridge OOW2 was alone on the bridge. Restricted visibility was encountered after about 30 minutes after the start of the exercise, the master was informed and the fog signal activated. Soon after that a distress message was received on Digital Selective Calling (DSC) and a Mayday Relay received from Falmouth Coastguard on RT (Radio Telephony); own vessel reported to Falmouth Coastguard and requested to proceed to a distress position. The master was summoned on the bridge and altered the vessel's course to the distress position with ETA in 40 minutes; the master delegated tasks very well. Passenger Ferry Mukran was assigned OSC role.

The search pattern was advised by OSC and own vessel proceeded to delegated search position. The vessel started a parallel search once she arrived at the search position. About 90 minutes into the exercise, a target was sighted 4 nautical miles on the starboard beam. The OSC was informed and altered the vessel's course towards the target with a speed of 21.5 knots.

After approaching the life raft, the Bosun informs that there are no signs of life in the life raft. The ship crew was unable to launch the rescue boat due to heavy weather.

The students' behaviour markers are tabulated in Appendix A17.1, A17.2, A17.3 and A17.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck Officers' NTS) and by using the ER algorithm, an output set was evaluated as shown in Table 5.6 and Figure 5.6.

Table 5.6: ER results of group 6

Very Poor	0.00%
Poor	28.11%
Average	31.02%
Good	37.24%
Very Good	3.62%

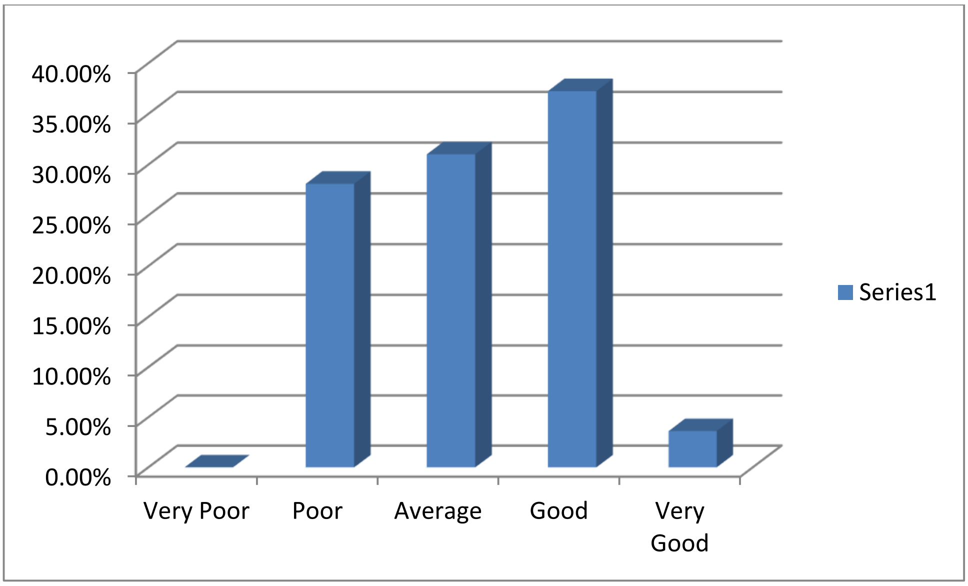

Figure 5.6: ER results of group 6

5.5.7 Group 7 performance / Scenario 1 (Monday / 05/08/2013 AM) – WITH HELM

The group was formed in the beginning of the course and the teambuilding element was evident. The passage plan was already prepared the day before the exercise. The vessel was alongside in the port of Algeciras. Visibility was less than one mile. The group tested all bridge equipment and completed the check lists. The exercise started when the bridge team declared ready. Initially they had some doubts about departing the berth without tugs when they were told no tugs were available. The use of a bow thrust helped them to depart without any problems. The vessel was manoeuvred slowly and left the berth and headed towards the channel. The Chief Officer was assumed to have a pilot exemption certificate so he manoeuvred the vessel in the beginning and then the master took over. A change of command from pilot to master was not clearly defined. After coming out of the harbour the plan was adjusted to avoid oncoming traffic. A helm order miscommunication took place with no incident happening (Master gave helm order starboard 20°, helmsman responded port 20°). The error was not picked up by the master. After sometime the engine room requested the reduction of the speed to slow ahead due to some problems in the engine room. This was followed and the problem was rectified very soon. Overall group performance was found to be average with some good practices in situation awareness and team working.

The students' behaviour markers are tabulated in Appendix A18.1, A18.2, A18.3 and A18.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck

Officers' NTS) and by using the ER algorithm, an output set was evaluated as shown in Table 5.7 and Figure 5.7.

Table 5.7: ER results of group 7

Very Poor	1.58%
Poor	20.53%
Average	64.17%
Good	13.73%
Very Good	0.00%

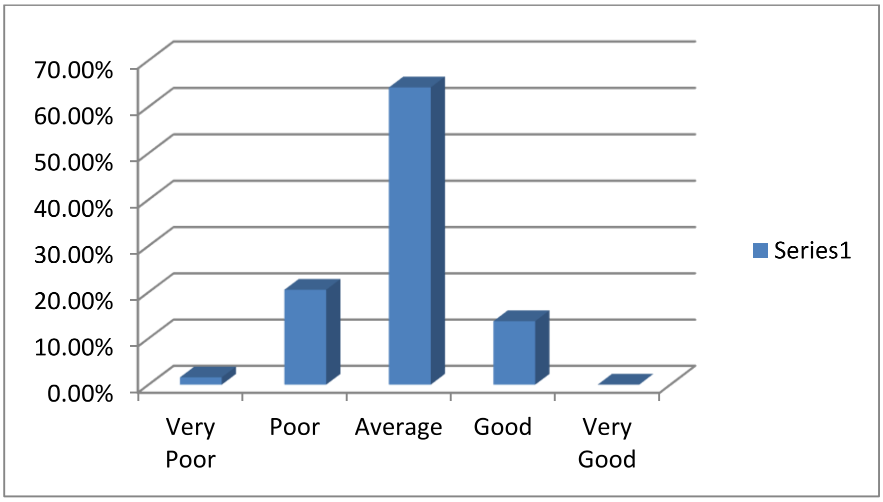

Figure 5.7: ER results of group 7

5.5.8 Group 8 performance / Scenario 2 (Monday / 05/08/2013 PM) – WITH HELM

The exercise started in the middle of the Dardanelles TSS. The master passed control to the C/O who was assumed to have a pilotage exemption certificate. The master did not show any leadership qualities throughout the exercise. A vessel ahead of the own vessel was proceeding at 7.5 knots as a result the own vessel reduced its speed and preferred not to overtake. Due to heavy currents it was difficult to steer and whilst the helmsman performed hard a port on the steering, the rudder stuck there. The instructor was advised and by using a limit switch the problem was rectified. Half an hour into the exercise the vessel went out of control and ran aground. At one point the own vessel passed within a short distance of an anchored naval vessel. The vessel went out of control again and went into the inshore traffic zone on the opposite lane and then collided with the shore and grounded.

The students' behaviour markers are tabulated in Appendix A19.1, A19.2, A19.3 and A19.4 as assessed by the researcher. As a result, after feeding the input data into the generic model (i.e. Figure 4.1; Taxonomy of Deck Officers' NTS) and by help of the ER algorithm, an output set was evaluated as shown in Table 5.8 and Figure 5.8.

Table 5.8: ER results of group 8

Very Poor	46.37%
Poor	47.21%
Average	6.42%
Good	0.00%
Very Good	0.00%

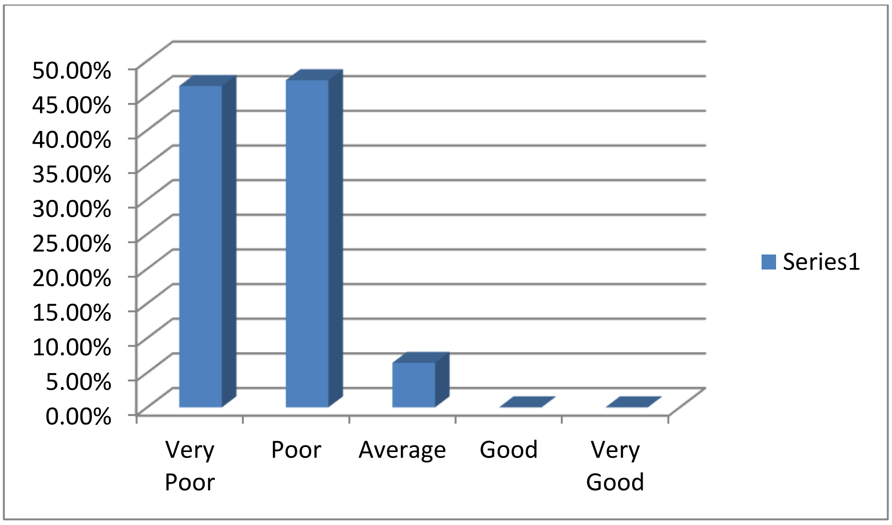

Figure 5.8: ER results of group 8

5.5.9 Group 9 performance / Scenario 3 (Monday / 07/08/2013 PM) – WITH HELM

The exercise was set in the Western approaches to the English Channel. The exercise started with the OOW on the bridge. Half an hour into the exercise the OOW sighted a life raft and called the master. The OOW also sighted a vessel with visible smoke. After few minutes a second life raft was sighted and the engine was stopped. (No distress relay sent and rescue party was not prepared.) After 15 minutes of the sighting of the first life raft and the vessel with visible smoke a VHF distress relay was sent without a MAYDAY prefix. After another 15 minutes a 2182 KHz message sent regarding the life raft sighting (2182 KHz is the international calling and distress frequency). The OOW decided to be the OSC without consulting with the master. Tasks were delegated very late, 45 minutes after the first sighting and a rescue party prepared. Own vessel was diverted to the first life raft to execute a rescue. The Bridge team relinquished the second life raft and only focused on the first life raft. A Distress message, relayed by Falmouth Coastguard was received and own vessel was informed that there were thirteen persons onboard the fishing vessel which caught fire. Five persons were rescued from the life raft and eight persons were remained unaccounted for.

The students' behaviour markers are tabulated in Appendix A20.1, A20.2, A20.3 and A20.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck Officers' NTS) and by using the ER algorithm, an output set was evaluated as shown in Table 5.9 and Figure 5.9.

Table 5.9: ER results of group 9

Very Poor	4.93%
Poor	78.27%
Average	16.80%
Good	0.00%
Very Good	0.00%

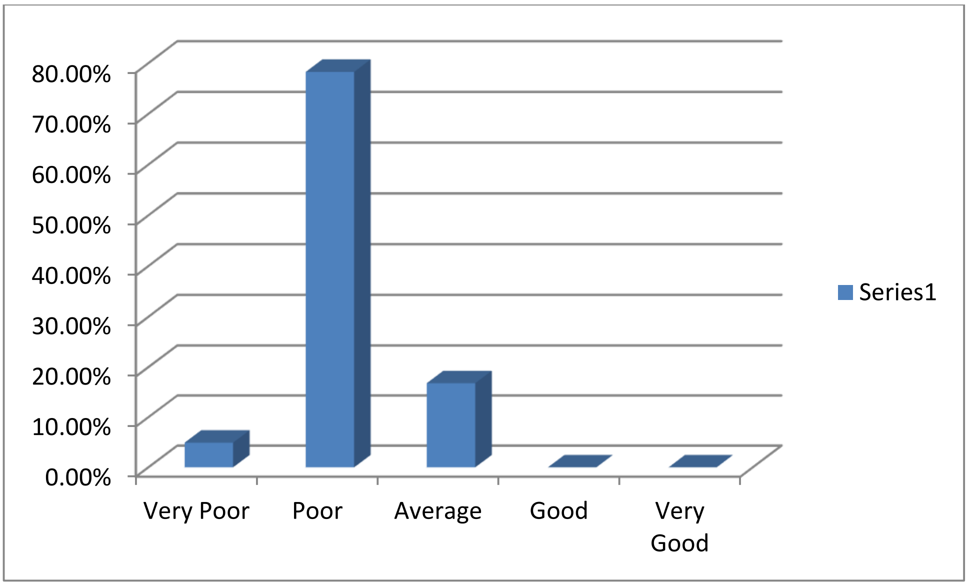

Figure 5.9: ER results of group 9

So far only LJMU students' behaviour markers were assessed in the ship's bridge simulator for the purpose of this study. To widen the research area it was decided to gather data from other maritime institutes in the UK. Only one institute, South Tyneside College, positively responded to the request sent to various maritime institutes across the UK. The researcher travelled to South Shields to observe the students' behaviour markers of those Chief Mates' students who had already completed the HELM course. The assessed exercises were part of the NAEST course and were different from the exercises used at LJMU for the assessments. This actually provided diversity of the exercise scenario.

5.5.10 Group 10 performance (STC) (Wednesday / 27/11/2013 PM) – WITH HELM

The exercise was set in Storebaelt TSS. The exercise started with a vessel ahead of the own vessel which was being overtaken. Own vessel's speed was 15.4 knots and the speed of other vessel was 15.0 knots. One vessel was crossing from port to starboard and another vessel was crossing from starboard to port. The own vessel altered its course to Starboard 10°. The engine room required 15 minutes' notice to changeover from heavy fuel oil to diesel oil; however, the master only gave notice to the engine room as marked on the planned chart. 20 minutes into exercise a vessel was observed on the starboard bow. Own vessel altered its course to 25° starboard in successions. One hour into the exercise the GPS malfunctioned. All three bridge team members actually thought that with GPS failure they were not able to plot a position by radar. Later on one of the students was able to plot the position with radar. One and a half hours in to the exercise the own vessel finally reached the destination and managed to drop the anchor.

It was poor to average teamwork throughout the exercise. In summary, the students' lack of anticipation skills and inability to adapt to the changing situation was observed. Not using the radar for fixing a position immediately after GPS failure was due to the lack of technical skills, as a result and due to the panic, control of the situation was lost.

The students' behaviour markers are tabulated in Appendix A21.1, A21.2, A21.3 and A21.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck Officers' NTS) and by using the ER algorithm, an output set was evaluated as shown in table 5.10 and Figure 5.10.

Table 5.10: ER results of group 10

Very Poor	1.30%
Poor	45.13%
Average	48.93%
Good	3.33%
Very Good	0.0%

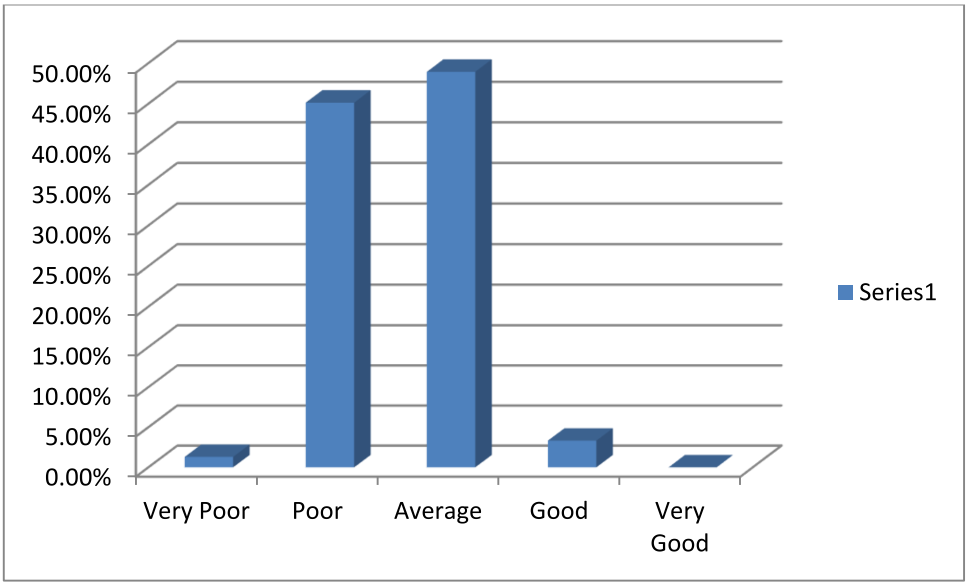

Figure 5.10: ER results of group 10

5.5.11 Group 11 performance (STC) (Thursday - 28/11/2013 AM) – WITH HELM

This was a restricted visibility exercise. There were several targets in the 12 miles range scale on the radar. The target on the starboard bow altered course to her port and gave a very close CPA (Closest Point of Approach) to own ship so the master decided to alter course 20° to starboard to increase the CPA to 9 cables. After 20 minutes of the first alteration another target appeared on the starboard bow with risk of collision. The Master first considered a reduction of speed but then he altered course 8° to starboard. There was a target behind own ship which was going to clear in 3 minutes after the alteration and the master announced that he would reduce speed after three minutes. The master reduced the speed and also made a succession of small alterations of course to starboard. Once the vessels cleared, own vessel made a broad alteration of course to port to come back to the original course. The exercise was stopped at this stage.

Overall it was an average performance by the group with some good elements such as team working. The students were poor in situation awareness and situation assessment. Leadership was of average standards.

The students' behaviour markers are tabulated in Appendix A22.1, A22.2, A22.3 and A22.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck

Officers' NTS) and by using the ER algorithm, an output set was evaluated as shown in table 5.11and Figure 5.11.

Table 5.11: ER results of group 11

Very Poor	0.0%
Poor	35.01%
Average	49.74%
Good	11.92%
Very Good	0.0%

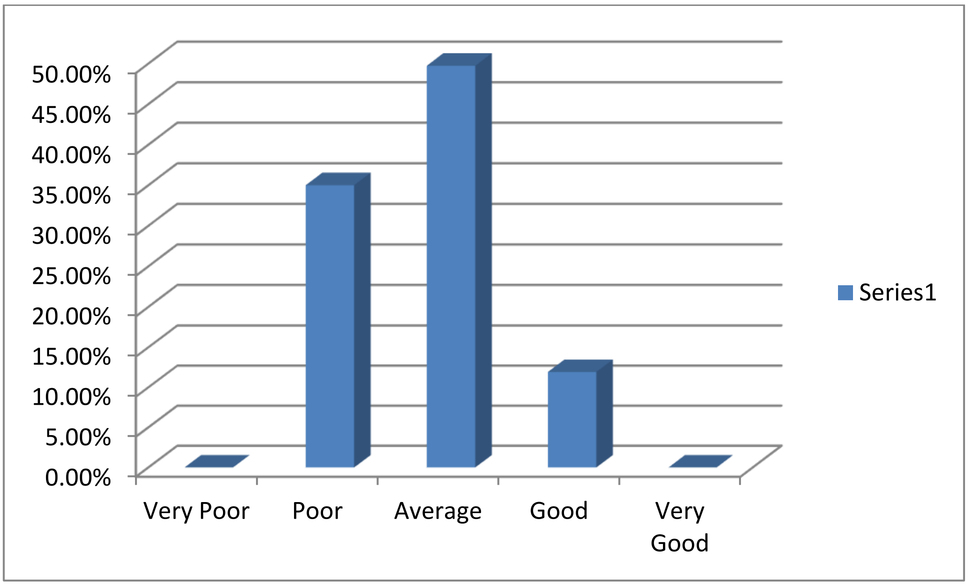

Figure 5.11: ER results of group 11

5.5.12 Group 12 performance (STC) (Thursday - 28/11/2013 PM) – WITH HELM

The exercise was set in the Singapore Strait with own vessel in the west bound lane. The exercise started with a vessel crossing from starboard with risk of collision. Own vessel reduced speed to Dead Slow Ahead and altered course 10° to starboard and then 20° to starboard to avoid collision. After clearing the target vessel own vessel returned to course slowly. Once back on course another target was observed on the starboard bow with risk of collision. This time the master increased speed to pass ahead of the target and as a result the target vessel passed very close to the stern of own vessel. Sometime time after this own vessel reduced speed to Half Ahead to let the MV Souter Bay overtake own vessel with a CPA of 1.4 cables. The own vessel further reduced to Dead Slow Ahead to let MV Tyne Trader overtake. The own vessel called the Vessel Traffic Information System (VTIS) to inform them of a speed reduction. The speed was increased to Slow Ahead fifteen minutes after reduction. Five minutes after increasing to slow ahead own vessel altered course to port for a vessel ahead which had reduced speed. Own vessel also reduced speed. Five minutes after the master ordered hard starboard when he was informed that the steering was not taking effect and the helmsman assumed a steering failure. The master did not investigate further and assumed the case and called for engineers. During this process own vessel missed another vessel very close. Engineers inspected the steering gear and informed that the steering was working properly and it never failed. By this time the vessel was heading in the opposite direction of the traffic lane. The master ordered hard a starboard to take a turn to the starboard side whereas there was more clear area on the port side. While altering course to starboard own vessel only missed another vessel by a very narrow margin.

The students lacked situation awareness and situation assessment skills. Leadership was quite weak as the master should have investigated the steering failure. Actually at that time the vessel was doing about 3kts and the steering needed some more speed to be effective. This was again down to lack of technical skills. The lack of anticipation resulted in poor decisions made by the master such as turning from the starboard side whereas there was much more room on the port side.

The students' behaviour markers are tabulated in Appendix A23.1, A23.2, A23.3 and A23.4. As a result, after feeding the input data to the model (i.e. Figure 4.1; Taxonomy of Deck Officers' NTS) and by using the ER algorithm, an output set was evaluated as shown in table 5.12 and Figure 5.12.

Table 5.12: ER results of group 12

Very Poor	28.03%
Poor	42.60%
Average	25.02%
Good	01.69%
Very Good	0.0%

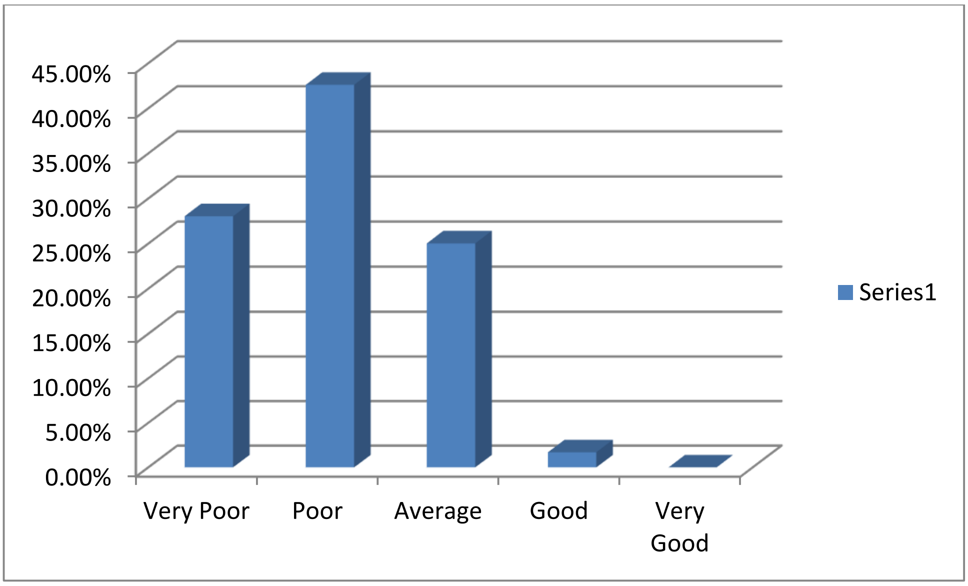

Figure 5.12: ER Results of Group 12

5.6 OBTAINING UTILITY VALUE (STEP 3)

The main aim of using a utility approach was to obtain a single crisp number for the top-level criterion (the final result or goal) of each alternate in order to rank them. Let the utility of an evaluation grade H_n be denoted by $u(H_n)$ and $u(H_{n+1}) > u(H_n)$ if H_{n+1} is preferred to H_n; $u(H_n)$ can be estimated using the decision marker's preferences. If no preference information is available, it could be assumed that the utilities of evaluation grades are equidistantly distributed in a normalised utility space. The utilities of evaluation grades that are equidistantly distributed in a normalised utility space are calculated as

$$u(H_n) = \frac{V_n - V_{min}}{V_{max} - V_{min}}$$

(5.6)

Where V_n is the ranking value of the linguistic term H_n that has been considered, V_{max} is the ranking value of the most-preferred linguistic term H_N *and* V_{min} is the ranking value of the least-preferred linguistic term H_l.

The utility of the top level or general criterion S€ is denoted by *u(S(E))*. If $\beta_H \neq 0$ (i.e. the assessment is incomplete, $\beta_H = 1 - \sum_{n=1}^{N} \beta_n$) there is belief interval $[\beta_n, (\beta_n + \beta_H)]$, which provides likelihood that *S(E)* is assessed to H_n. Without loss of generality, suppose that the least-preferred linguistic term having the lowest utility is denoted by $u(H_l)$ and the most-preferred linguistic term having the highest utility is denoted by $u(H_N)$. Then the minimum, maximum and average utilities are defined as follows respectively (Riahi et al., 2012);

$$u_{min}\big(S(E)\big) = \sum_{N=2}^{N} \beta_n u(H_n) + (\beta_l + \beta_H) u(H_l)$$

$$u_{max}\big(S(E)\big) = \sum_{n=1}^{N-1} \beta_n u(H_n) + (\beta_N + \beta_H) u(H_N)$$

$$u_{average}\big(S(E)\big) = \frac{u_{min}\big(S(E)\big) + u_{max}\big(S(E)\big)}{2}$$

(5.7)

Obviously if all the assessments are complete, then $\beta_H = 0$ and the maximum, minimum and average utilities of S(E) will be the same. Therefore, *u(S(E))* can be calculated as

$$u\big(S(E)\big) = \sum_{n=1}^{N} \beta_n u(H_n)$$

(5.8)

The above utilities are used only for characterising an assessment and not for criteria aggregation.

5.6.1 Numerical example

First $u(H_n)$ values were calculated for belief values (Very Good = 5, Good = 4, Average = 3, Poor = 2, Very Poor = 1)

$$u(H_n) = \frac{V_n - V_{min}}{V_{max} - V_{min}}$$

$$u(H_5) = \frac{5-1}{5-1} = 1$$

$$u(H_4) = \frac{4-1}{5-1} = \frac{3}{4} = 0.75$$

$$u(H_3) = \frac{3-1}{5-1} = \frac{2}{4} = 0.5$$

$$u(H_2) = \frac{2-1}{5-1} = \frac{1}{4} = 0.25$$

$$u(H_1) = \frac{1-1}{5-1} = 0$$

Following Group 1's (17th April 2013) ER algorithm output values were used for the example calculations;

β_1 = *0.3539*

β_2 = *0.3371*

β_3 = *0.2805*

β_4 = *0.0285*

$\beta_5 \quad = \quad 0.000$

Total $\quad 1.000$

If $\beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 = 1$ then following equation will be used;

$$u(S(E)) = \sum_{n=1}^{N} \beta_n u(H_n)$$

$$u(S(E)) = \beta_1 u(H_1) + \beta_2 u(H_2) + \beta_3 u(H_3) + \beta_4 u(H_4) + \beta_5 u(H_5)$$

$$u(S(E)) = 0.2459$$

5.7 COMPARING THE STUDENTS' PERFORMANCE WITH AND WITHOUT HELM TRAINING

After conducting extensive simulator observations (Section 5.5) a comparison was made between the average performance of the groups with HELM and groups without HELM. To do this the utility value of each group is used and a mean of each group is calculated to compare the average group performance.

Table 5.13 shows each group's non-technical performance based on utility value with their respective rank and Table 5.14 shows the rank wise sequence of all groups. It can be seen from Table 5.14 that all the groups are staggered in the ranks which indicates that the groups with HELM training have not performed any better than groups without HELM training.

Table 5.15 compares the average utility value of the groups with HELM and without HELM. The improvement of the average value of groups with HELM is only 0.8% which is nearly negligible.

Table 5.13: NTS group performance ranks

		Utility Value	Rank
Group 1	Without HELM Training	0.2459 (24.59%)	10
Group 2	Without HELM Training	0.2724 (27.24%)	8
Group 3	Without HELM Training	0.3917 (39.17%)	4
Group 4	Without HELM Training	0.1459 (14.59%)	12
Group 5	Without HELM Training	0.3487 (34.87%)	6
Group 6	Without HELM Training	0.5409 (54.09%)	1
Group 7	With HELM Training	0.4751 (47.51%)	2
Group 8	With HELM Training	0.1501 (15.01%)	11
Group 9	With HELM Training	0.2797 (27.97%)	7
Group 10	With HELM Training	0.3888 (38.88%)	5
Group 11	With HELM Training	0.4423 (44.23%)	3
Group 12	With HELM Training	0.2576 (25.76%)	9

Table 5.14: NTS group performance ranks wise

Rank			**Utility Value**
1	**Group 6**	Without HELM Training	0.5409 (54.09%)
2	**Group 7**	With HELM Training	0.4751 (47.51%)
3	**Group 11**	With HELM Training	0.4423 (44.23%)
4	**Group 3**	Without HELM Training	0.3917 (39.17%)
5	**Group 10**	With HELM Training	0.3888 (38.88%)
6	**Group 5**	Without HELM Training	0.3487 (34.87%)
7	**Group 9**	With HELM Training	0.2797 (27.97%)
8	**Group 2**	Without HELM Training	0.2724 (27.24%)
9	**Group 12**	With HELM Training	0.2576 (25.76%)
10	**Group 1**	Without HELM Training	0.2459 (24.59%)
11	**Group 8**	With HELM Training	0.1501 (15.01%)
12	**Group 4**	Without HELM Training	0.1459 (14.59%)

Table 5.15: NTS group comparison

Without HELM Training	With HELM Training
0.2459 (24.59%)	0.4751 (47.51%)
0.2724 (27.24%)	0.1501 (15.01%)
0.3917 (39.17%)	0.2797 (27.97%)
0.1459 (14.59%)	0.3888 (38.88%)
0.3487 (34.87%)	0.4423 (44.23%)
0.5409 (54.09%)	0.2576 (25.76%)
Average = 32.4%	**Average = 33.2%**

Based on Table 5.15, the average utility value of groups with the HELM training is only improved by 0.8%. It was evident during the observations that the students with the HELM training did not apply the NTS which were taught during the course. Generally students were found weak in situation awareness and decision making. Lack of anticipation resulted in poor decisions. In some instances task delegation was not clear which resulted in task omission. In some instances leadership was quite weak such as the chief officer was actually controlling the master.

Feedback from students regarding the course and the body language of the students showed that they only enjoyed parts of the course where sessions were interactive. It seemed difficult for students to adapt to the new concept of NTS with topics like situation awareness, decision making, leadership, teamwork and communication.

At this stage an analysis of students' performance against their academic achievements was carried out to see if there is any relation between the two.

5.8 ANALYSIS OF STUDENTS' ACADEMIC PERFORMANCE

It was decided to analyse the students' academic performance to see if there is any link between their academic performance and their practical performance. If academically weak students are performing weakly then it can be said that weak students' NTS are weak. To do this we used AHP again to obtain the weights;

	Master	C/O	OOW
Master	1	2	3
C/O	1/2	1	2
OOW	1/3	1/2	1

Following weights are obtained from AHP calculations;

Master = w_1 = 0.5396

C/O = w_2 = 0.2970

OOW = w_3 = 0.1634

Following equation is used to achieve group's average results;

$$A_R = \sum_{i=1}^{4} W_i R_i = w_1 R_1 + w_2 R_2 + w_3 R_3 \tag{5.9}$$

Where,

A_R stands for Average academic results for the group

R_i stands for Academic results of i^{th} student

W_i stands for the weight of the i^{th} person's role

Group 1's results are found as follows;

$A_R = (0.5396 \times 74) + (0.2970 \times 73.22) + (0.1634 \times 65.88)$

$A_R = 72.4415$

The results obtained from equation 5.9 for each individual group were compared with the Utility Value obtained for the group ER calculations in Chapter 4. Only LJMU student groups were used for the following study as the researcher did not have access to STC students' academic results.

It can be seen from Table 5.16 that there is no link between students' academic results and simulator performance. Group four's, for instance, utility value is lowest and academic results are second highest. Group one is highest in the academic marks but stands to rank 7 in utility value. Academic results of all groups range from 64% to 72%, hence a difference of only 8% whereas utility values range from 14% to 54%, a difference of 40%.

Table 5.16: Group non-technical performance against academic achievements

	Utility Value	**Average Academic Results (A_R)**
Group 1	0.2459 (24.59%)	72.4415
Group 2	0.2724 (27.24%)	69.1997
Group 3	0.3917 (39.17%)	69.6401
Group 4	0.1459 (14.59%)	71.3070
Group 5	0.3487 (34.87%)	67.7628
Group 6	0.5409 (54.09%)	68.0092
Group 7	0.4751 (47.51%)	69.1886
Group 8	0.1501 (15.01%)	64.2523
Group 9	0.2797 (27.97%)	68.9911

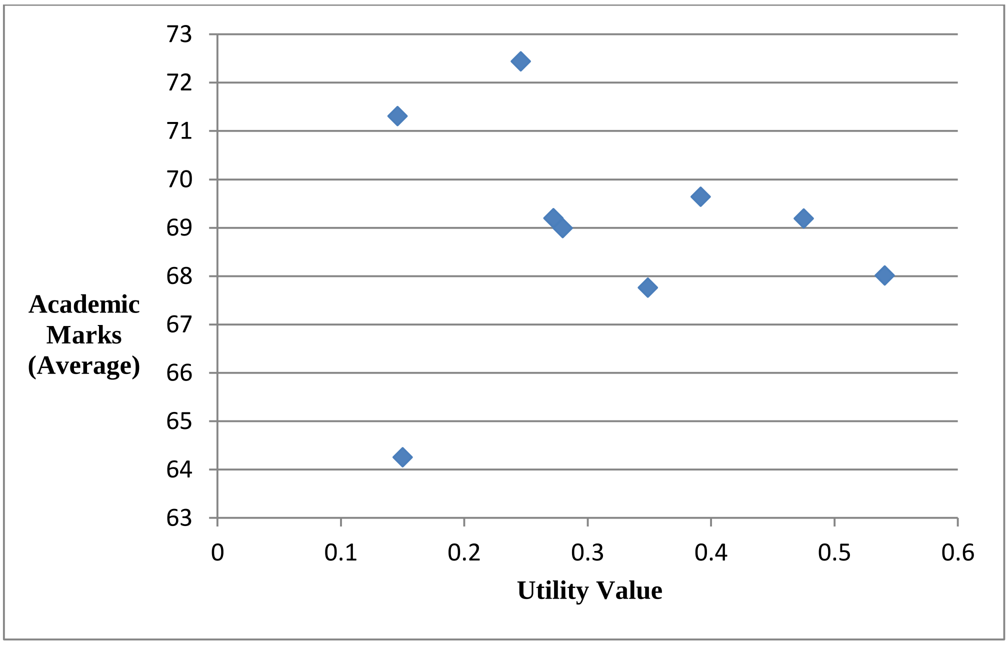

Figure 5.13: Group non-technical skills performance against academic achievements

5.8.1 Sample Correlation

The measure which is most widely used to gauge the strength of the relationship between pairs of data is called sample correlation, represented by r. The sample correlation is a measure of how closely the points on a scatter plot lie on a straight line. If the points lie exactly on a straight line with positive slope, $r = 1$, whereas with a negative slope, $r = -1$. The more the points scatter about the line the closer r is to 0. When r = 0 there is no linear relationship between the points although they might form some other pattern (Swift, 1997: 815).

The sample correlation is calculated with following equation;

$$r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} \tag{5.10}$$

Where;

$$S_{xx} = \sum x^2 - \frac{(\sum x)^2}{n}$$

$$S_{yy} = \sum y^2 - \frac{(\sum y)^2}{n}$$

$$S_{xy} = \sum xy - \frac{\sum x \sum y}{n}$$

Table 5.17: Sample correlation values

Utility Value = x	Academic Performance = y	x^2	y^2
0.2459	72.4415	0.0605	5247.7709
0.2724	69.1997	0.0742	4788.5985
0.3917	69.6401	0.1534	4849.7435
0.1459	71.3070	0.0213	5084.6882
0.3487	67.7628	0.1216	4591.7906
0.5409	68.0092	0.2926	4625.2513
0.4751	69.1886	0.2257	4787.0624
0.1501	64.2523	0.0225	4128.3581
0.2797	68.9911	0.0782	4759.7719
$\sum x$ = 2.8504	$\sum y$ = 620.7923	$\sum x^2$=1.0500	$\sum y^2$=42863.0418

$$S_{xx} = \sum x^2 - \frac{(\sum x)^2}{n} = 1.0500 - \frac{(2.8504)^2}{9} = 0.1472$$

$$S_{yy} = \sum y^2 - \frac{(\sum y)^2}{n} = 42863.0418 - \frac{(620.7923)^2}{9} = 42.6996$$

$$S_{xy} = \sum xy - \frac{\sum x \sum y}{n} = 196.5727 - \frac{1769.5064}{9} = -0.0391$$

Therefore;

$$r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} = \frac{-0.0391}{\sqrt{0.1472 \ x \ 42.6996}} = -0.0156$$

The sample correlation between students' academic results and their practical performance utility value is found to be -0.0156, which means there is no linear relationship between the two.

5.10 CONCLUSION

In this part of the research volunteer chief mate students were assessed in a ship's bridge simulator crisis situation. The students were divided into two groups, one group with HELM course training and other without HELM course training. The students were assessed in a bridge simulator using a behavioural marker system (Tables 4.1 – 4.4) which was devised as part of the literature review and confirmed by the experts during the interviews conducted in the first part of the project.

The assessor observed the students' NTS in a ship's bridge simulator by using behavioural markers, the assessment data were aggregated by the ER algorithm. As part of the ER calculations, a utility value was obtained for each group's NTS, which provided a crisp number. The utility value of each group is used to compare the performance of the groups with HELM course training and the groups without the training in the section 5.7. It is evident from the comparison that there is no improvements in the NTS of the students who have taken the HELM course.

A comparison of students' academic performance and their NTS performance was carried out in section 5.9 by taking the average percentage of each student's academic results at the completion of the Chief Mate programme of study. The average results were aggregated by AHP for each group and then compared with the utility value of each group's NTS performance to find any relationship between the two. It was found by correlation method that there was no relationship between the students' academic performance and their practical performance.

Chapter Six is going to explore and analyse the options to improve the HELM training for deck officers. Other safety critical industries' efforts are reviewed and the possibility to adapt their proven methods into the maritime domain are analysed. With different options a cost benefit analysis is conducted by Bayesian Network and Decision Tree Model to decide which option makes a suitable choice.

CHAPTER SIX

CONTROL OPTIONS AND COST BENEFIT ANALYSIS OF IMPROVING DECK OFFICERS' NTS TRAINING

6.1 INTRODUCTION

In the previous chapter students' NTS performances were measured based on the developed scenarios in a ship's bridge simulator. After comparing the average performance of the groups with HELM and groups without HELM (Table 5.15) across two nautical training establishments in the UK and after analysing students' performance against their academic achievements (Section 5.8.1) it is now clear that the HELM training course in its present form is not very effective. Based on other safety critical industries efforts into NTS training and assessment, this chapter suggests the improvements to the HELM training course and examines costs associated with the improvements.

To improve the NTS training course, HELM, firstly it is necessary to develop domain specific NTS taxonomy and behavioural markers for the assessments in the simulator. This study has achieved this with some limitations and could be evaluated and further improved with wider research. Secondly, based on other safety critical industries efforts into NTS research, a training model is required to be developed. Both elements are discussed in detail later in this chapter.

A cost benefit analysis would be carried out using BN's Decision Tree Model to work out if there are any benefits to the industry of applying such methods to improve HELM training. To conduct a cost benefit analysis an example shipping company, Costa Cruise Lines, is chosen in this research. The accident of the Costa Concordia in 2012, which was mainly caused by human error (Lieto, 2014), cost the company £480m. By calculating the costs of further NTS research and training and comparing the same with the cost of the accident an analysis is undertaken to see if it is beneficial to the company to implement the additional training to improve the NTS of company's deck officers.

6.2 METHODOLOGY

The methodology for this chapter is divided into the following three steps;

1. Based on the comparison with other safety critical industries' efforts into NTS research and training conducted in Chapter Two, the possibility of the adaption of the successful methods of aviation and anaesthesia are explored and options are generated.
2. A cost benefit analysis is conducted of all the options explored in step 1. The analysis is carried out by Bayesian Network and Decision Tree Model.
3. Based on the cost benefit analysis, a decision is made for which option to select.

6.3 ADAPTION OF OTHER SAFETY CRITICAL DOMAINS' NTS RESEARCH AND TRAINING METHODS (Step 1)

Based on the deck officers' NTS taxonomy and behavioural markers for the training and assessment an effective training model may be developed by conducting a workshop where educational and subject experts and psychologists are to be invited. The first task would be to find out what would be the best mode of training such skills. Aviation, anaesthetics and other safety critical industries use simulator based training to train the NTS of their personnel.

Many safety critical industries have conducted a thorough research into domain specific human elements before implementing a NTS training course. Anaesthetics, for example, conducted the domain specific NTS research, which took five years for six full time researchers before implementing a comprehensive and reliable NTS assessment tool called the Anaesthetists' Non-Technical Skills (ANTS) (Yee et al., 2005) (See Section 2.5). Although this present research has developed deck officers' NTS taxonomy and behavioural markers with some limitations (See Section 1.5), a further research, with industry support, could improve the outcomes further. Further research is suggested to develop the behavioural markers for the assessment of deck officers NTS in a bridge simulator based on the methods carried out by Gatfield (2008) (See Section 2.5.3) for engineering officers. This would further improve the training and assessment of deck officer's NTS in the simulators. An evaluation of deck officers' taxonomy and behavioural markers in this new research is also required to be conducted to measure the effectiveness of the developed methods. The cost associated to conduct further research and evaluation is discussed later in Section 6.4.2.

In aviation much of the NTS theoretical knowledge is covered in the initial training and it is not repeated when delegates attend a CRM course in the end. Whereas in the maritime domain HELM is a five day course where theoretical knowledge is taught together with practical exercises. When students start the course they do not have any prior underpinning knowledge of the subject. One of the students' suggestion in the workshop conducted after the course (See Section 5.9) was to integrate the HELM course into the main chief mate course. This was then discussed with research supervisors and all agreed that this method may improve the training.

The research supervisors agreed to the suggestion that the underpinning knowledge of NTS is integrated into the main course and then extensive simulator training conducted at the end with carefully thought out exercises developed to cover each skill and element of the NTS. This method is followed by CRM and research suggests that the course is quite effective (See Section 2.5.4). The present idea of delivering underpinning knowledge within five days of the course may not be very effective as it does not give enough time for students to study the NTS material. It is possible that if a module is introduced into the main course by teaching 3-4 hours every week over 10-12 weeks, this would give an opportunity to students to absorb the knowledge slowly and then the exam at the end will test their NTS theoretical knowledge. The outcome may be that NTS skills are more readily attained.

In the maritime industry presently training institutes are responsible for conducting such training and the HELM course is offered only as one off training. In the aviation industry flight operators are responsible for conducting NTS training of flight crew and the course is repeated regularly (See Section 2.5).

In a similar way to aviation, shipping companies may need to develop the NTS training specific to their own area of operation. The courses may be developed by focusing on different cargo operations such as oil, chemical, cargo, container and bulk. The course needs repeating regularly and a deck officer's NTS assessment would be conducted before the repeat of the course. This would help to identify the weak areas of an individual and the repeat course would focus on those areas to improve the performance. The whole process of the NTS training model needs evaluating for the purpose of analysing its effectiveness. The costs associated with the new course and the evaluation costs are discussed later in Section 6.4.2.

6.4 COST BENEFIT ANALYSIS (Step 2)

Cost benefits are calculated using a Decision Tree Model which is based on BN's interference formulism.

6.4.1 Interference Formulism of BN

The basis of reasoning under uncertainty in BNs is called Bayesian interference formulism, which is developed for the task of computing the probability of each value of a node in a BN when other variables' values are known (Richardson, 1997). The uncertainty may be due to imperfect understanding of the domain, incomplete knowledge of the state of the domain at the time where a given task is to be performed, randomness in the mechanism governing the behaviour of the domain, or a combination of these. One of the main advantages of BNs is that they allow interference based on observed evidence. The model can be updated in accordance with observation using Bayes rule. For random variables *"X_1"* and *"X_2",* as shown in Figure 5.1, Bayes rule states:

$$P(X_1|X_2) = \frac{P(X_2|X_1)P(X_1)}{\sum_{all..i} P\,(X_2|X_1 = x_i)P(X_1 = x_i)}$$

(6.1)

Assume for instance that variable *"X_2"* is observed to be in state x_j. The probability of a parameter value given the observation is referred to as the posterior probability. This distinguishes it from the prior probability held by the analyst prior to collection and analysis of the observation. By applying Equation 4.1 to each state of *"X_1"* the probability distribution *"$P(X_1 \mid X_2 = x_j)$"* is computed:

$$P\left(X_1 \middle| X_2 = x_j\right) = \frac{P\left(X_2 = x_j \middle| X_1\right)P(X_1)}{\sum_{all..i} P\left(X_2 = x_j \middle| X_1 = x_i\right)P(X_1 = x_i)}$$

(6.2)

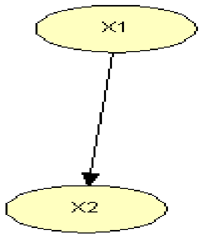

Figure 6.1: BN consisting of two nodes

Similar computations may be performed for large networks, allowing users to investigate different scenarios. Manually updating by this method is practical only if the network is small and each node represents only a few states. However, in the 1980s researchers discovered propagation algorithms that make it possible to break the overall graph down into smaller sub-sets within which information flows are largely self-contained (Lauritzen and Spiegelhalter, 1988). With the introduction of software tools that implement these algorithms it is now possible to use BN to solve a complex problem without doing it manually.

6.4.2 Decision Tree calculation

The improvement in the deck officers' NTS will improve a shipping company's performance and hence will improve the profits. The company has to make a decision whether to take an action or not to improve the deck officers' performance. The company is uncertain whether the performance of the company's deck officers (i.e. Deck Officers' Performance or DOP) is high, average or low. The cost of an action is C_1. It is believed by taking an action and enhancing the performance of the deck officers (i.e. with average performance) the reliability of the company's vessels will increase and accordingly the profit and net profit associated with an action will be increased. The profit and net profit can be estimated as B_1 and (B_1 – C_1) respectively. Similarly for the deck officers with low performance, the profit and net profit associated with an action can be estimated as B_2 and (B_2 – C_1) respectively. An assessment programme (i.e. Audit) will help the company to determine the company's performance (i.e. CP). The cost of an assessment programme (i.e. Audit) is C_2. Based on the performance data from Chapter 4 (see Section 5.7) as shown in Table 5.1, and the following rule, it can be observed that 0%, 50% and 50% of the company's deck officers have high, average and low performance respectively. Based on experts' opinion the relationship between a company's performance and its employees is shown in Table 6.2.

If a group’s NTS is less than 0.33, then the performance is Low.

If a group’s NTS is between 0.33 and 0.66, then the performance is Average.

If a group’s NTS is between 0.66 and 1.0, the performance is High.

Table 6.1: NTS performance data

		Utility Value
Group 1	Without HELM Training	0.2459 (24.59%)
Group 2	Without HELM Training	0.2724 (27.24%)
Group 3	Without HELM Training	0.3917 (39.17%)
Group 4	Without HELM Training	0.1459 (14.59%)
Group 5	Without HELM Training	0.3487 (34.87%)
Group 6	Without HELM Training	0.5409 (54.09%)
Group 7	With HELM Training	0.4751 (47.51%)
Group 8	With HELM Training	0.1501 (15.01%)
Group 9	With HELM Training	0.2797 (27.97%)
Group 10	With HELM Training	0.3888 (38.88%)
Group 11	With HELM Training	0.4423 (44.23%)
Group 12	With HELM Training	0.2576 (25.76%)

Table 6.2: Conditional probability table

CP \ DOP	High (H)	Average (A)	Low (L)
High (H)	0.8	0.1	0.1
Average (A)	0.15	0.8	0.2
Low (L)	0.05	0.1	0.7

Based on Bayes chain rule the following equation can be evaluated;

$$P(CP = H) = P(CP = H|DOP = H) \times P(DOP = H) + P(CP = H|DOP = A) \times (P(DOP = A) + P(CP = H|DOP = L) \times (P(DOP = L)$$

$$P(CP = H) = (0.8 \times 0) + (0.1 \times 0.5) + (0.1 \times 0.5) = 0.1$$

$$P(CP = A) = P(CP = A|DOP = H) \times P(DOP = H) + P(CP = A|DOP = A) \times (P(DOP = A) + P(CP = A|DOP = L) \times (P(DOP = L)$$

$$P(CP = A) = (0.15 \times 0) + (0.8 \times 0.5) + (0.2 \times 0.5) = 0.5$$

$$P(CP = L) = P(CP = L|DOP = H) \times P(DOP = H) + P(CP = L|DOP = A) \times (P(DOP = A) + P(CP = L|DOP = L) \times (P(DOP = L)$$

$$P(CP = L) = (0.05 \times 0.1) + (0.1 \times 0.5) + (0.7 \times 0.5) = 0.4$$

Based on equation 17:

$$P(DOP = H \mid CP = H) = \frac{P(CP = H|DOP = H) \times P(DOP = H)}{P(CP = H)}$$

$$P(DOP = H \mid CP = H) = \frac{0.8 \times 0}{0.1} = 0$$

$$P(DOP = A \mid CP = H) = \frac{P(CP = H|DOP = A) \times P(DOP = A)}{P(CP = H)}$$

$$P(DOP = A \mid CP = H) = \frac{0.1 \times 0.5}{0.1} = 0.5$$

$$P(DOP = L \mid CP = H) = \frac{P(CP = H|DOP = L) \times P(DOP = L)}{P(CP = H)}$$

$$P(DOP = L \mid CP = H) = \frac{0.1 \times 0.5}{0.1} = 0.5$$

$$(DOP = H \mid CP = A) = \frac{P(CP = A|DOP = H) \times P(DOP = H)}{P(CP = A)}$$

$$P(DOP = H \mid CP = A) = \frac{0.15 \times 0}{0.5} = 0$$

$$(DOP = A \mid CP = A) = \frac{P(CP = A|DOP = A) \times P(DOP = A)}{P(CP = A)}$$

$$P(DOP = A \mid CP = A) = \frac{0.8 \times 0.5}{0.5} = 0.8$$

$$(DOP = L \mid CP = A) = \frac{P(CP = A|DOP = L) \times P(DOP = L)}{P(CP = A)}$$

$$P(DOP = L \mid CP = A) = \frac{0.2 \times 0.5}{0.5} = 0.2$$

$$P(DOP = H \mid CP = L) = \frac{P(CP = L|DOP = H) \times P(DOP = H)}{P(CP = L)}$$

$$P(DOP = H \mid CP = L) = \frac{0.05 \times 0}{0.5} = 0$$

$$P(DOP = A \mid CP = L) = \frac{P(CP = L|DOP = A) \times P(DOP = A)}{P(CP = L)}$$

$$P(DOP = A \mid CP = L) = \frac{0.1\ x\ 0.5}{0.4} = 0.125$$

$$P(DOP = L \mid CP = L) = \frac{P(CP = L|DOP = L) \times P(DOP = L)}{P(CP = L)}$$

$$P(DOP = L \mid CP = L) = \frac{0.7 \times 0.5}{0.4} = 0.875$$

(6.3)

A decision tree is a diagram that represents, in a special organised way, the decisions and the main external or other events that influence uncertainty, as well as possible outcomes of all those decision and events. Figure 6.2 shows a decision tree representation and solution to this problem. In Figure 6.2, squares represent decisions and the lines coming out of each square show all available distinct options that can be selected at the decision analysis point. For instance, as shown in Figure 6.2, to perform an assessment programme (i.e. Audit) or not to

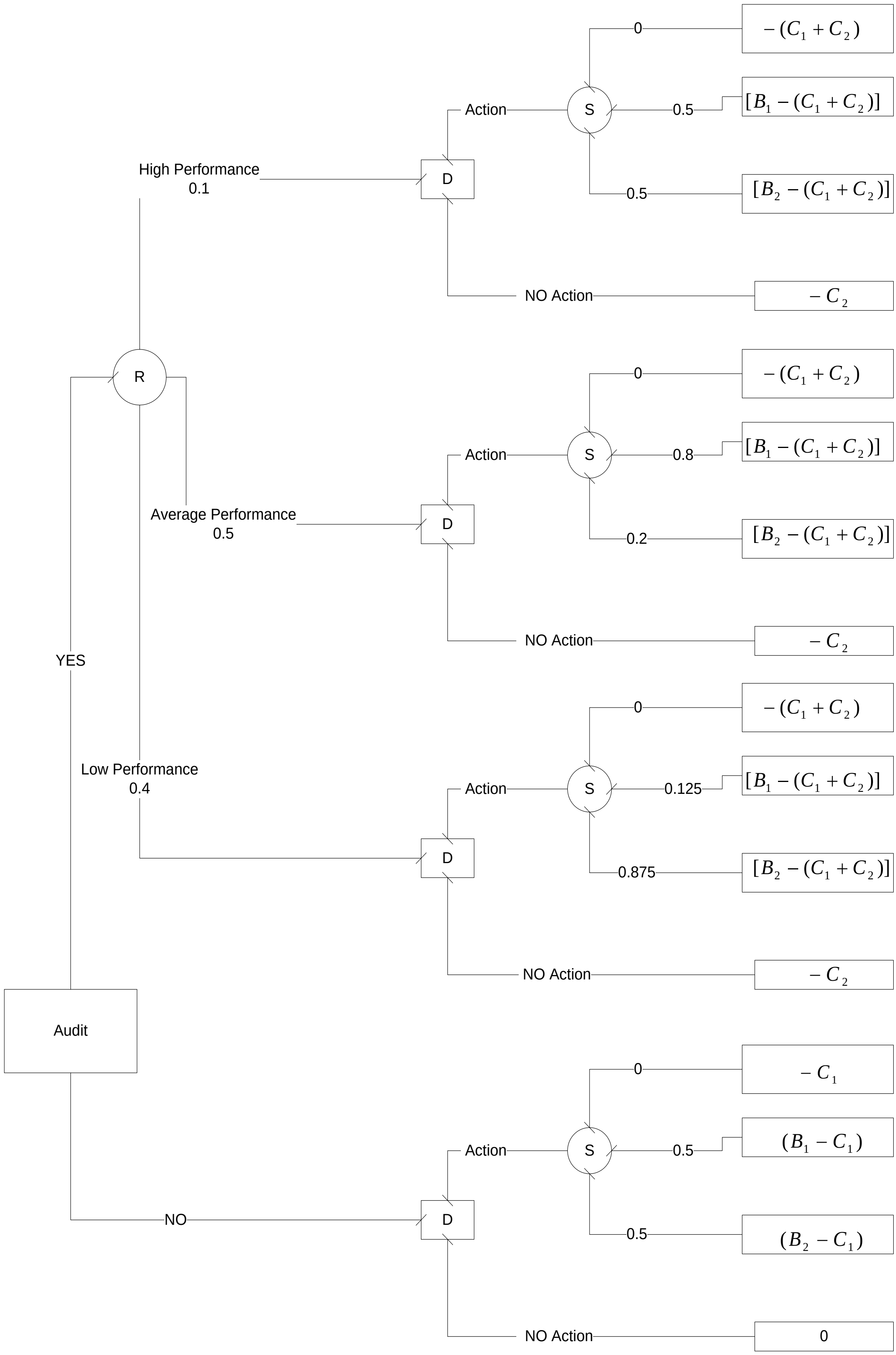

Figure 6.2: Decision Tree

perform, two lines coming out of "audit square" show all available distinct options (i.e. Yes or No) that can be selected by the manager. Circles show various circumstances that have uncertain outcomes and the lines that come out of each circle denote a possible outcome of that uncertainty. For instance, the "circle R" shows the result of an assessment programme and the line that comes out of "circle R" denote possible outcomes of that uncertainty (i.e. a company's performance is high, average or low). Based on Equation 6.3 the probability of each outcome is written on each respective line. Based on Figure 6.2, the manager can calculate the overall desirability of those choices. For instance, if a manager makes a decision to perform the audit and based on the audit's result the company's performance is found to be high, then the desirability for taking an action can be calculated as follows:

$$0 \times (C_1 + C_2) + 0.5 \times [B_1 - (C_1 + C_2)] + 0.5 \times [B_2 - (C_1 + C_2)]$$
$$= 0.5 \times B_1 + 0.5 \times B_2 - (C1 + C2)$$

(6.4)

If the assessment (i.e. evaluated by Equation 6.4) is lesser than "-C", then no action has to be taken. Thus:

$$0.5 \times \mathrm{B}_1 + 0.5 \times \mathrm{B}_2 - (\mathrm{C}_1 + \mathrm{C}_2) < (-\mathrm{C}_2)$$

$$0.5 \times \mathrm{B}_1 + 0.5 \times \mathrm{B}_2 < \mathrm{C}_1$$

(6.5)

If the company makes a decision to perform the audit, with similar techniques Equations 6.4 and 6.5 are evaluated, the desirability for the other choices can be assessed. Thus, the three conditions can be summarised as follows:

1. If a company's performance is high and $C_1 > 0.5\, x\, B_1 + 0.5\, x\, B_2$, then take no action.
2. If a company's performance is average and $C_1 > 0.8\, x\, B_1 + 0.2\, x\, B_2$, then take no action.
3. If a company's performance is low and $C_1 > 0.125\, x\, B_1 + 0.875\, x\, B_2$, then take no action.

As an illustrative example, the Italian Cruise liner Costa Cruise Line own 27 ships with revenues of 3.1 billion euros and 2.3 million guests in year 2011 (Costa Cruises, 2014). One of the Costa Cruise Line ships, Costa Concordia partially sank when it ran aground at Isola del Giglio on 13th January 2012 with loss of 32 lives. The accident was mainly caused by human error (Lieto, 2014). After the salvage of Costa Concordia the total cost of the accident is estimated to be $800 million (£480 million) (NBC News, 2014).

For the purpose of the following calculations it is assumed that the total loss to the company due to poor performance of the deck officers is £480 million due to the accident. For the company to turn the loss into a profit it has to take some actions. After taking an appropriate action profit will become B_2 for a company having officers with low performance as explained earlier in this section.

Assume $B_2 = 2 \times B_1$. Thus:

$$B_1 + B_2 = £480\text{m}$$

$$B_2 = 2 \times B_1$$

$$B_1 = £160\text{m}$$

$$B_2 = £320\text{m}$$

The company may decide to improve the NTS of the deck officers by introducing further Human Element training. This needs evaluation based on the proposed methodology in the research (see Section 5.3.1), developing a NTS training model (see Section 5.3.2) and implementing a CRM style training cycle (See Section 5.3.3). The cost of evaluation of NTS taxonomy is estimated as £200,000. For 27 ships a company would have 216 deck officers so the training cost of deck officers is £216,000 (i.e. 216 x £1000). So the total estimated cost of C_1 is £416,000. The cost of an assessment programme (i.e. C_2) is estimated as £200,000. The assessment programme could be implemented by sending experts onboard ships to assess the performance of the deck officers in the real life such as a Line Operations Safety Audit (LOSA) program. During LOSA observation, an observer records and codes potential threats to safety, how the threats were addressed and the errors generated, how the errors were managed and how the observed behaviour could be associated with incidents and accidents (Pedigo et al., 2011).

1. £416,000 > 0.5 x 160m + 0.5 x 320m

   £416,000 > £240m = Condition not satisfied

2. £416,000 > 0.8 x 160m + 0.2 x 320m

   £416,000 > £192m = Condition not satisfied

3. £416,000 > 0.125 x 160m + 0.875 x 320m

   £416,000 > £300m = Condition not satisfied

As a result conditions 1, 2 and 3 are not satisfied. Consequently and based on Figure 6.2, the expected profit associated with this strategy is calculated as:

$$0.1 \times \{-0 \times (C_1 + C_2) + 0.5 \times [B_1 - (C_1 + C_2)] + 0.5 \times [B_2 - (C_1 + C_2)]\} +$$

$$0.5 \times \{-0 \times (C_1 + C_2) + 0.8 \times [B_1 - (C_1 + C_2)] + 0.2 \times [B_2 - (C_1 + C_2)]\} +$$

$$0.4 \{-0 \times (C_1 + C_2) + 0.125 \times [B_1 - (C_1 + C_2)] + 0.875 \times [B_2 - (C_1 + C_2)]\} =$$

= £239,384,000

(6.6)

Based on Figure 6.2, the expected profits associated with taking an action and not performing the assessment programme is calculated as:

$$0 \; x \; (-C_1) + 0.5 \; (B_1 - C_1) + 0.5 \; (B_2 - C_1) =$$

$$0.5 \; B_1 + 0.5 \; B_2 - C_1 = £239{,}584{,}000$$

(6.7)

Based on Equations 6.6 and 6.7, the optimal strategy is to take an action immediately.

For the above example and by assuming that the utility function is a linear function of the monetary profit, a BN decision making model, as shown in Figure 6.3, is illustrated. In Figure 6.3, squares represent decisions and diamonds (i.e. U_1 and U_2) represent utilities. The values for U_1 and U_2 are shown in Tables 6.3 and 6.4. In Figure 6.3, the expected profits associated with taking an action and performing the audit (i.e. yes) or not performing the audit (i.e. no) are estimated as £239.38m and £239.58m respectively.

Table 6.3: Values of U_1

Audit	Yes	No
U_1	-£200,000	0

Table 6.4: Values of U_2

Action	Yes			No		
SSP	High	Average	Low	High	Average	Low
U_2	-£0.416m	£159.584m	£319.584m	0	0	0

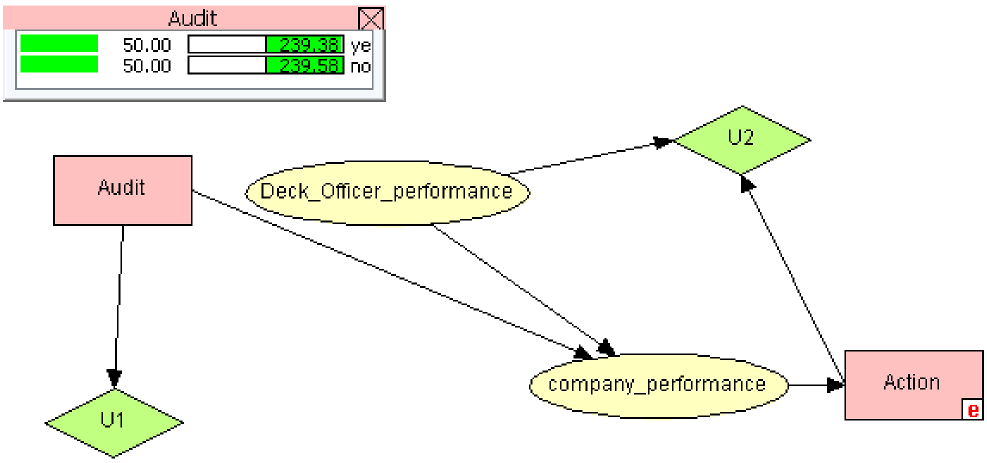

Figure 6.3: BN Decision Making Model for Measuring the Shipping Company's Profit

6.5 OPTIONS (step 3)

After conducting decision tree calculations now there are the following three options available;

1. Do not take any action and continue with existing HELM course arrangements.
2. Follow the suggestions in section 5.3 to evaluate deck officers' NTS taxonomy and behavioural markers system, integrate the HELM theory into the main course and run HELM simulator training at the end of the main course and implement an aviation style training cycle.
3. In addition to following the suggestions in section 5.3, an assessment programme is implemented.

By choosing option 1 the accidents will continue to happen, innocent seafarers will lose their lives and the industry will bear the cost of $541m per year caused by human error (P&I, 2014). It is apparent from the decision tree calculations (Equations 6.6 - 6.7) that there is more profit to the company by just carrying out the evaluation of deck officers' NTS taxonomy and the behavioural marker system, integrating the HELM theory into the main course and running HELM simulator training at the end of the main course and implementing aviation style training cycle and not running the assessment programme.

It can be concluded from the decision tree calculations that option 2 is the most profitable and feasible option to choose at this stage.

6.6 CONCLUSION

After comparing the average performance of the groups with HELM and groups without HELM (Table 5.15) and after analysing students' performance against their academic achievements (Table 5.16) in Chapter Five it became clear that the HELM course is not very effective in its present form. This chapter suggested the areas to improve HELM training based on other safety critical domains' efforts into NTS research and training such as anaesthetics and aviation and the possibility of adapting some of their proven methods. The anaesthetics research method could be adopted to develop the deck officers' NTS taxonomy and behavioural marker systems for the bridge simulator and training assessment. The aviation style training model implementation would help improve HELM training in the maritime domain. To improve HELM training it would require further research, more resources and more time to train the deck officers. The cost of this additional research, resources and time was calculated by choosing an example shipping company. A cost analysis was carried out by the Decision Tree method, to work out if there are any benefits of applying such methods to improve HELM training to the industry. The results of cost analysis have shown that there is a benefit to the industry by carrying out further research and implementing further training.

The next chapter discusses the findings of the overall research. A reflection on the satisfaction of objectives and thus the achievement of aims is given. It also highlights the contribution to research and avenues for future research.

CHAPTER SEVEN

DISCUSSION

7.1 INTRODUCTION

This chapter will bring together various researched threads that have been developed in previous technical chapters and will reflect on the satisfaction of the objectives and thus whether the aims were achieved. A reflection on the contribution to knowledge and avenues for future research will also be given.

7.2 ACHIEVEMENT OF AIMS AND OBJECTIVES

This section describes the satisfaction of the objectives and achievements of the aims of the thesis and the reflection on the achievement of each aim.

7.2.1 Objectives

There were seven objectives of the research which were accomplished as follows;

Objectives One and Two were achieved in chapter Two by reviewing relevant literature on NTS and maritime accidents data and a link was established between them. Objectives Three and Four were achieved in Chapter Four by conducting interviews with experts to identify significant criteria and their contribution to deck officers' NTS and the taxonomy was developed. Objectives Five and Six were achieved in Chapter Five by developing a methodology for assessing deck officers' NTS in a bridge simulator and conducting the assessment. Objective Seven was achieved in Chapter Five by comparing the results of simulator observation data to assess the effectiveness of the HELM training programme and then in Chapter Six a training needs analysis was conducted and suggestions given for improving the HELM course further.

7.2.2 First Aim

The first aim of this research was designed to contribute to the development and assessment of the NTS required by deck officers by investigating its current practice after analysing empirical data from this study. Based on the literature review the taxonomy of deck officers' NTS was developed. Since it was not sufficient to rely on the literature review only it was deemed necessary to confirm the skills and elements contained in the taxonomy by experts, hence interviews were conducted and the taxonomy was confirmed. This proved useful as some elements such as 'conflict resolution' were removed from the initial taxonomy as it was suggested by some experts that it would be difficult to simulate this and thus it was not possible to easily assess in the simulator. The experts were asked to assign an appropriate weight against each skill and element by comparing with others. This was necessary to prioritise the importance of skills and elements in the list of taxonomy in the view of the experts. Different experts may have given a different order of prioritisation of skills but this is one of the limitations which is discussed earlier in the Section 1.5. The expert weights were aggregated by the AHP mathematical model. This was necessary as aggregated weights were used in the further NTS observation assessments calculations. To this end the first aim was achieved successfully by developing the deck officers' taxonomy of NTS.

7.2.3 Second Aim

The second aim was to develop a method which would enable trainers to quantitatively assess NTS in a ship's bridge simulator and identify further training requirements and to evaluate the effectiveness of HELM training. Based on the taxonomy of the deck officers' NTS behavioural markers were developed with the help of the literature review. Considering the time constraints and available resources this was the only feasible idea to develop behavioural markers this way i.e by reviewing the relevant literature. If there was more time and resources then behavioural markers could have been developed similar to those Gatfield (2008) has developed for engineering officers. He developed those as part of his PhD and his research was focused only to develop the behavioural markers where as in this research developing behavioural markers was only part of the second aim.

By the help of developed behavioural markers and the mathematical decision making model, ER Algorithm, a unique method of deck officers' NTS assessment in a bridge simulator was developed. The assessment model proved successful as it allowed assessors to easily assess the behaviour of participants on a five rating scale (from very good to very poor) and then by using the ER mathematical model and utility value approach, calculate the 'final result' or 'crisp number' of a performance. This 'final result' or 'crisp number' allowed the researcher to make comparisons of different group performances.

Twelve bridge teams divided into two major groups of 'with HELM training' and 'without HELM training' were observed and compared. More bridge teams at different institutes may have produced different results as explained in the Section 1.5 but this sample was deemed sufficient to carry out the observations for the purpose of this research.

All twelve bridge teams' NTS performances were observed and assessed, using the behavioural markers in the pre-planned bridge simulated scenarios. All bridge teams' NTS observations were analysed by using the ER mathematical model developed earlier. The comparison was made of two major groups' average performance result (Table 5.15) and it was found that the group with HELM training has performed only 0.8% better than the group without HELM training.

As a result, based on the present study and considering its limitation, it may be suggested that the present setup of HELM training is not as effective as was expected. It may be too early to conclude this as the course is in its early stages and it needs more time to develop and evolve. Aviation's CRM course did not show positive results in the beginning and took the industry about two decades to reach the present structure of the course, i.e the sixth generation, which is assumed to be quite effective (See Section 2.5.4).

To explore the options for the improvement of the HELM training course, the research focused again on the other safety critical industries' NTS achievements such as anaesthetics research into development of domain specific NTS taxonomy and aviation's training model (See Section 2.5), which may be adapted in the maritime industry for improving the NTS training.

With options available to adapt the anaesthetics' and aviation's method, this would incur an extra cost. A cost benefit analysis was conducted by the Decision Tree Analysis method to discover if it is feasible to implement such methods to improve HELM training. An example shipping company was chosen, Costa Cruise Lines, with one accident caused mainly by human error, Costa Concordia. The research could have chosen any company or any other accident but Costa Concordia accident was chosen because it was a recent accident with one of the causes of accident being human error and the accident data was widely available. The results may have been different if any other accident was chosen for the purpose of cost benefit analysis.

After conducting the cost benefit analysis it was observed that after taking the options to improve the deck officers' NTS performance the company will accrue a profit of £239,384,000 (See Section 6.4). It is not desired that the research cost of developing the taxonomy of the deck officers' NTS and behavioural markers is borne by one company. This is only a one-time cost and it could be spread over a pool of companies, flag state authorities and other stake holders. The cost of delivering HELM training, like aviation, may be borne by the shipping companies as it will be to the benefit of the companies, by developing company specific HELM courses.

7.3 CONTRIBUTION OF THE RESEARCH

This study has conducted a detailed research into developing the taxonomy of the deck officers' NTS and the behavioural markers for the assessment of the NTS behaviours in a ship's bridge simulator. The research has conducted ship's bridge simulator observations of Chief Mate students to analyse the effectiveness of the HELM course which, based on the observations in this study appears to be ineffective. Some suggestions for the improvement of the HELM course are given in this research which would improve the HELM training and will make for safer operations.

This research has produced the taxonomy of the deck officers' NTS which can be used in nautical training institutes for the training of NTS to deck officers. There were no comprehensive behavioural markers available before this research for the assessment of the deck officers' NTS in the bridge simulator. This research has produced a simple behavioural marker system which can be used by nautical training institutes in the assessment of the deck officers' NTS without the need for much training of the trainer as the behaviours described are very simple and easily observable. The ER algorithm can be used for aggregation of criteria and to obtain a single crisp number the utility value approach can be used. The utility value can be used to measure the overall NTS performance of an individual. It can be said that this research has provided an effective assessment tool for the maritime industry as well as maritime academies for the assessment of the deck officers' NTS.

The suggestions for improving HELM training given in this research are based on some proven methods developed by other safety critical industries. It is assumed that once suggested methods are implemented, the individual performance onboard ship and shipping company performance may be enhanced. The implementation and evaluation of suggested methods needs conducting under another research for the effectiveness of those training methods in the maritime domain.

7.4 AVENUES FOR FUTURE RESEARCH

This research has provided a generic model for the assessment of the deck officers' NTS. It is worth mentioning that this generic model is tested on a small scale due to time restrictions (i.e. one part time researcher working over the period of four years). The same research could be carried out, with the help of the proposed generic model, on a large scale with at least 3-4 experienced full time researchers working on the project for 3-4 years. The research needs to be able to attract more volunteer experts to participate in the interview study and more bridge simulator observation data could be obtained from various different nautical institutes across different countries. Instead of observing students' NTS it would be appropriate to invite the experienced seafarers into the roles of the scenarios. A comprehensive behavioural markers system of deck officers NTS may be developed following the methods used by Gatfield (2008) for engineering officers (See Section 2.5.3).

This new research would also develop the training model of deck officers' NTS and test various modes of study such as integrating NTS underpinning knowledge into the main course of study and then providing extensive simulator based practical training.

7.5 CONCLUSION

This chapter explained how the aims and objectives were achieved by reflecting on the whole research. Some positive points came out of this research such as development of deck officers NTS taxonomy and a unique method of assessment of NTS behaviours in a ship's bridge simulator. To this end it can be concluded that the aims of this research were successfully achieved. The next chapter provides the conclusion to the overall study.

CHAPTER EIGHT

CONCLUSION

The following conclusions have been drawn from this research.

Human element is one of the major causes of accidents, which can be improved with appropriate training as has been proved by the efforts into NTS training and assessment by other safety critical industries. To improve the safety of shipping and to improve the performance of deck officers, the IMO implemented the HELM training course in 2012.

The present structure of the HELM course has been shown to be ineffective when comparing various bridge team performances in a bridge simulator. The taxonomy of deck officers' NTS, which includes decision making, situation awareness, teamwork and leadership, shows the skills and elements required to be possessed by a deck officer in a crisis situation to carry out safe operations. These skills and elements were not present as were expected when NTS simulator observations were carried out of the students who attended the HELM training course.

A calculation was made by sample correlation formulae allowing the conclusion to be made that the practical performance of a student is not linked with his academic performance as students with good academic results have shown poor NTS performance in the bridge simulator.

A method of assessment was developed where it is possible to quantitatively assess a deck officer's NTS in a ship's bridge simulator. Within this method the final result of the NTS performance (which is a 'crisp number') in a bridge simulator can be achieved using the ER Algorithm. Behaviours of deck officers can be observed by simple and overt behavioural markers. Using the behavioural markers developed in this research, an assessor does not require additional training because the markers are apparent and clear and are assessed on a five rating scale (from very poor to very good).

The other safety critical industries' efforts into NTS developments can be used to advantage by adapting their successful methods into the maritime industry's NTS training such as the HELM course.

REFERENCES

Abou-Elkawam, Mohab (2015) Senior Lecturer LJMU, Consultant IMO. Interview, 29th May, 2015.

Adelman, L., Gualtieri, J. and Stanford, S. (1995) Examining the effect of casual focus on the option generation process: An experiment using protocol analysis. *Organisational Behaviour and Human Decision Process*, 61 (1), pp. 54-66.

Akhtar, M. A. and Utne, I. B. (2014) Human fatigue's effect on the risk of maritime groundings – A Bayesian Network modelling approach. *Safety Science*, 62 (2014), pp. 427-440.

Altmaier, E. M., From, R.P., Pearson, K.S., Gorbatenko-Roth, K.G. and Ugolini, K. A. (2003) A Perspective study to select and evaluate anaesthesiology residents: Phase 1, the Critical Incident Technique. *Journal of clinical Anaesthesia*, 9 (8), pp. 629-636.

Andreassen, S., Jensen, F.V., Andersen, S.K., Falck, B., Kjærulff, U., Woldbye, M., Sørensen, A., Rosenfalck, A. and Jensen, F. (1989) MUNIN – An Expert EMG Assistant. *Computer-aided Electromyography and Expert Systems*, Desmedt, J.E. (eds.), Elsevier Science Publishers, Amsterdam, pp. 255-277.

ANTS (2014) A behavioural marker system for rating Anaesthetists' Non-technical Skills. [online], *Industrial Psychology Research Centre, Aberdeen University*, available at: http://www.abdn.ac.uk/iprc/ants/ [Accessed 12th Feb 2014]

Arther D. Little (2004) Driving safety culture: Identification of leadership qualities for effective safety management, *Final report to Maritime and Coastguard Agency*, October 2004.

Aull-Hyde, R., Erdogan, S. and Duke, J. D. (2006) An experiment on the consistency of aggregated comparison matrices in AHP. *European journal of operational research*, 171, pp. 290-295.

Ayoko, O. B., Callan, V.J. and Hartel C. E. J. (2008) The influence of team emotional intelligence climate on conflict and team members' reaction to conflict. *Small Group Research*, 39 (2), pp. 121-149.

Balci M. B. C., Tas, T., Hazar, A. I., Aydin, M., Onuk, O., Cakiroglu, B., Fikri, O., Ozkan, A. and Nuhoglu, B. (2014) Applicability and effectiveness of virtual reality simulator training in urology surgery: A double-blind randomised study. *Noble medicus* 29, 10 (2), pp. 66-71.

Baldwin, P., Paisley, A. and Paterson-Brown, S. (1999) Consultant surgeons' opinions of the skill required of basic surgical trainees. *British Journal of Surgery*, 86 (8), pp. 1078-1082.

Banbury, S. and Tremblay, T. (2004) *A cognitive approach to situation awareness: Theory and application*. Ashgate Publishing Limited.

Barnett, M., Gatfield, D. and Peckan, C. (2006) Non-technical skills: the vital ingredient in world maritime technology. *2nd World maritime technology conference*; WMTC 2006 maritime innovation delivering global solutions, London 6-10 March 2006.

Batool, B. F. (2013) Emotional intelligence and effective leadership. *Journal of business studies quarterly*, 2013, 4 (3) pp.1-12.

Bayazit, O. (2004) Use of AHP in decision making for flexible manufacturing systems. *Journal of manufacturing technology management*, 16 (7), pp. 808-819.

Beer, M. (1980) *Organizational change and development: A system review*. Glenview, IL: Scott, Fotesman.

Beshears, J. and Gino, F. (2015) Leaders and Decision Architects. *Harvard Business Review*, May 2015, pp. 52-63.

Beynon, M., Cosker, D. and Marshall, D. (2001) An expert system for multi-criteria decision making using Dempster-Shafter theory. *Journal of expert systems with applications,* 20, pp. 357-367.

Beynon, M., Curry, B. and Morgan, P. (2000) The Dempster-Shafter Theory of evidence: An alternative approach to multi criteria decision modelling. *OMEGA-International journal of management science*, 28, pp. 37-50.

Bhagwat, M. (2012) Simulation and anaesthesia. *Indian journal of Anaesthesia*, 56 (1), Jan-Feb 2012, pp. 14-20.

Bhattacharya, S. (2012) The effectiveness of the ISM Code: A qualitative enquiry. *Maritime Policy*, 36, pp. 528-535.

Bhattacharya, S. and Tang, L. (2013) Middle managers' role in safeguarding OHS: the case of the shipping industry. *Safety science*, 51, pp. 63-68.

Blundel, R. (2004) *Effective organisational communication: Perspectives, principles and practices*. Second Edition. Harlow: FT Prentice Hall.

Brown, S., Mcdonagh, P. and Schultz Ii, C. J. (2013) Titanic: Consuming the Myths and Meanings of an Ambiguous Brand. *Journal of consumer research*, Inc., 40, pp. 595-614.

Burgers, W. S., Wiegerinck W. A. J. J., Kappen, H. J. and Spalburg, M. R. (2010) A Bayesian petro-physical decision support system for estimation of reservoir compositions. *Elsevier*, 37 (12), pp. 7526-7532.

Burnell, L. and Horvitz, E. (1995), Structure and Chance: Melding Logic and Probability for Software Debugging. *Communications of the ACM*, 38 (3), pp. 31-41.

Business Dictionary (2015) [online] Available at: http://www.businessdictionary.com/definition/risk-assessment.html [Accessed 3rd September 2015]

CAA (2003) Aviation Maintenance Human Factors (EASA/JAR145 Approved Organisations. Sussex: CAA Safety Regulation Group, CAP 716, 18th December 2003.

CAA (2006) Crew Resource Management Training: Guidance for flight crew, CRM instructors (CRMIS) and CRM instructor-examiners (CRMIES). *Civil Aviation Authority*, CAP 737, 26 November 2006.

Cannon-Bowers, J. A. and Salas, E. (1998) *Making decision under stress*. American Psychological Association.

CASA (2013) Human Factors resource guide for engineers. *Civil Aviation Safety Authority*, Australia.

Chauvin, C., Lardjane, S., Morel, G., Clostermann, J. P. and Langard, B. (2013) Human and organisational factors in maritime accidents: Analysis of collision at sea using the HFACS. *Accidents Analysis and Prevention*, 59 (2013) pp. 26-37.

Chin K. S., Xu, D. L., Yang, J. B. and James Ping-Kit, L. (2008) Group based ER-AHP System for product project screening. *Expert systems with applications*, 35 (4), pp. 1909-1929.

Clarke, K. B. (2012) Non-technical skills required in train driver role: Developing an integrated approach to NTS training and investment. *Rail Safety and Standards Board Ltd*. Research programme.

Clarke, M. A., Amundsen, S.D. and Cardy, R. L. (2002) Cross-functional team decision-making and learning outcomes: A qualitative illustration. *Journal of Business and management*, 8(3), pp. 217-236.

Cohen, S. G. and Baily, D. E. (1997) What makes teams work? Group effectiveness research from the shop floor to the executive suite. *Journal of Management*, 23, pp. 239-90.

Combe, I. A. and Carrington, D. J. (2015) Leaders' sensemaking under crises: Emerging cognitive consensus over time within management teams. *The leadership quarterly*, 26, pp. 307-322.

Cook, W. D. and Kress, M. (1990) A multiple criteria decision model with ordinal preference data. *European journal of operational research*, 54, pp. 191-198.

Costa Cruise (2014) Company Profile [online]. Available at http://www.costacruise.com/B2C/USA/Corporate/The+company/aboutourselves/aboutourselves.htm [Accessed 20th Feb 2014]

Cote, V. T. (2015) Airplane Safety Issues. Salem Press Encyclopedia, January 2015 [online] Available at http://eds.a.ebscohost.com/eds/detail/detail?sid=3b3bd212-0c15-495a-bcdc-a3e56c6ddd55@sessionmgr4004&vid=3&hid=4210&#db=ers&AN=89876859 [Accessed 15th June 2015]

Coyle, G. (2004) *The Analytic Hierarchy Process (AHP).* Practical Strategy. Open Access Material. AHP. Pearson Education Limited.

Crandall, B., Klein, G. and Hoffman, R.R. (2006) *Working Minds – A Practitioner's guide to Cognitive Task Analysis.* A Bradford Book, The MIT Press, Cambridge, Massachusetts, London, England.

Crichton, M.T. & Flin, R. (2004) Identifying and training non-technical skills of nuclear emergency response teams. *Annals of Nuclear Energy,* 31, pp. 1317-1330.

CTSB (1995) A safety study of the operational relationship between ship masters/watchkeeping officers and marine pilots [online], *Canadian Transport Safety Board* http://www.bst-tsb.gc.ca/eng/rapports-reports/marine/etudes-studies/ms9501/ms9501.asp [Accessed 2nd June 2015]

Dagnachew Shibru, M., Suryabhagavan, K. V., Mekuria, A. and Hameed, S. (2014), Application of AHP for environmental suitability analysis of resettlement site selection: Chawaka district, Western Ethiopia. *International journal of geo informatics*, 10 (2), pp. 63-72.

Das, B. (2000) Representing Uncertainties Using Bayesian Networks. Technical Report, DSTO-TR-0918, *Defence Science & Technology Organisation Electronics and Surveillance Research Laboratory*, Salisbury, Australia. pp. 1-30.

Davitt, K. and Holford, S. (2015) The development of resource management and leadership behavioural marker for the merchant navy. *Warsash Maritime Academy*, Southampton Solent University, pp. 1-24.

Depster A.P. (1967) Upper and lower probabilities induced by a multi valued mapping. *Ann Math Statist* 1967; 38(1): pp. 325-339.

Diehl, A. E. (1991) Does cockpit management training reduce aircrew error? Paper presented at the 22nd international seminar, *international society of air safety investigators*, Canberra Australia, November 1991.

DoT (1987) MV Herald of Free Enterprise. *Department of Transport*, Report of court no. 8074, Formal investigation, Corwn copyright 1987.

Drach-Zahavy, A. (2004) Exploring team support: the role of team's design, values, and leader's support. *Group dynamics: Theory, research and practice*, 8 (4), pp. 235-252.

Endsley, M. R. (1988) Situation Awareness Global Assessment Technique (SAGAT). Proceedings for the *National Aerospace and Electronics Conference* – NAECON 1988, Dayton, USA, pp. 789-795.

Endsley, M. R. (1995a) Measurement of Situation Awareness in Dynamic Systems. *Human Factors*, 1995, 37(1), pp. 65-84.

Endsley, M. R. (1995b) Towards a theory of situation awareness in dynamic systems. *Human Factors*, 1995, 37(1), pp. 32-64.

Eubank, D., Geffken, D., Orzano, J. and Ricci, R. (2012) Teaching adaptive leadership to family medicine residents: What? Why? How? *Families, systems and health*. 2012, 30 (3) pp. 241-252.

Fasano, A. and Kirschenman (2012) Behind Every Successful Leader Lies a Great Delegator. *Leadership and Management in Engineering*, pp. 341-343.

Fenton, N. and Neil (1999) A Critique of Software Defect Prediction Models. IEEE Transactions on software Engineering, 25 (5), pp. 675-689.

Flanagan, J. C. (1954) “The Critical Incident Technique”, *Psychological Bulletin*, 51 (4), pp. 1-33.

Fletcher, G., Flin, R and Mcgeorge, P. (2003a) “Review of human factors research in anaesthesia”, *University of Aberdeen* SCPMDE Project: RDNES/991/C.

Fletcher, G., Flin, R and Mcgeorge, P. (2003b) Interview study to identify anaesthetists’ non-technical skills. *University of Aberdeen* SCPMDE Project: RDNES/991/C.

Flin, R. (1996) *Sitting in the Hot Seat: Leaders and Teams for Critical Incident management*. Chichester: Wiley.

Flin, R., Martin, L., Geosters, K., Hoermann, J., Amalberti, R., Valot, C., and Nijhuis, H. (2003) Development of the NOTECHS (Non-Technical Skills) system for assessing pilots’ CRM skills. *Human Factors and Aerospace Safety*, 3 (2), pp. 95-117.

Flin, R. and Maran, N. (2004) Identifying and training non-technical skills for teams in acute medicine. *Qual Saf Health Care* 2004; 13 (1), pp. 80-84.

Flin, R., O’connor, P. and Crichton, M. (2008) *Safety at the sharp end*. Ashgate Publishing Limited.

Flin, R. (2013) Non-technical skills for anaesthetists, surgeons and scrub practitioners (ANTS, NOTTS and SPLINTS). *The Healthcare Foundation*, July 2013, pp. 1-9.

Frydenberg, M. (1989), The Chain Graphs Markov Property. *Scandinavian Journal of Statistics*, 17, pp. 333–353.

Gatfield D., (2008) *Behavioural markers for the assessment of competence in crisis management*. PhD thesis, Southampton Solent University.

Gill, A. S., Flaschner, A. B. and Shachar, M. (2006) Mitigating stress and burnout by implementing transformational-leadership. *International journal of contemporary hospitality management*, 18 (6), pp. 469-481.

Gill, G. W. And Wahner, C. M. (2012) The Herald of Free Enterprise casualty and its effect on maritime safety philosophy. *Marine technology society journal*, 2012, 46 (6), pp. 72-84.

Glamuzina, M. (2015) Levels of leadership development and top management's effectiveness: is there a clear-cut relationship? *Management*, 20, Special issue, pp. 89-131.

Goulielmos, A. M. and Goulielmos, M. A. (2005) The accident of m/v Herald of Free Enterprise: A failure of the ship or of the management? *Disaster prevention and Management*, 14 (4), pp. 479-492.

Goulielmos, A. M., Lathouraki, G. and Giziakis, C. (2012) The quest of marine accidents due to human error, 1998 – 2011. *International journal of emergency services*, 1 (1), pp. 39-70.

Grech, M. R., Horberry, T. and Smith, A. (2002) Human error in maritime operations: Analysis of accident reports using the leximancer tool. *Proceedings of the Human factors and Ergonomics society 46th annual meeting*, Baltimore, September 30-October 4, 2002.

Habberley, J., Barnett, M., Gatfield, D., Musselwhite, C. and Mcneil G. (2001) Simulator training for handling escalating emergencies. *United Kingdom Maritime and Coastguard Agency research project* 467. Southampton: The Maritime and Coastguard Agency.

Haddawy, P. (1999) An overview of some recent developments in Bayesian Network problem-solving techniques. *AI Magazine*, 20 (2), pp. 11-19.

Hagemann, B. And Stroope, S. (2012) Conflict Management: Lesson from the second grade. *American Society for Training and Development*, 66 (7), pp. 58-61.

Hanson, L. H (1996) Surveillance of deaths onboard Danish merchant ships, 1986-93: implications for prevention. *Occupational and environmental medicine*, 53, pp. 269-275.

Hassan H.M, and Morrison J. (2013) The role of simulation training and skill evaluation in maintenance of certification [online]. Available at http://laparoscopy.blogs.com/prevention_management_3/2010/09/the-role-of-simulation-training-and-skill-evaluation-in-maintenance-of-certification.html [Accessed 18th November 2013]

Havold, J. I (2007) National cultures and safety orientation: A study of seafarers working for Norwegian shipping companies. *Work and Stress*, 21(2), pp. 173-195.

Havold, J. I. (2000) Culture in maritime safety. *Maritime policy and management*, 27 (1), pp. 79-88.

Helmreich, R. L., Merritt, A. C., and Wilhelm, J. A. (1999) The evolution of Crew Resource Management Training in commercial aviation. *The International Journal of Aviation Psychology*, 9(1), pp. 19-32.

Hersman, D. A. P. (2011) Assuring safety in aviation's second century. Royal aeronautical society, 8th Annual Assad Kotaite lecture, Montreal, Quebec, Canada [online] http://www.ntsb.gov/news/speeches/DHersman/Pages/Assuring_Safety_in_Aviations_Second_Century_8th_Annual_Assad_Kotaite_Lecture_Montreal_Quebec_Canada.aspx [Accessed 15th June 2015]

Hetherington, C., Flin, R. and Mearns, K. (2006) Safety in shipping: the human element. *Journal of safety research*, 37, pp. 401-411.

Hopkin, B. (2009) *Cultural differences and improving performance*. Gower publishing limited. London.

Hutcheon, D. and Bevilacqua, M. (2010) TADMUS Pairing CBT sstrategies with job responsibilities to reduce stress and increase return to work potential for affect disordered clientele. *Americal psychotherapy*, ANNALS summer 2010, pp. 32-42.

IAMU (2010) International Association of Maritime Universities' review of Manila amendments. *International Association of Maritime Universities Annual General Assembly* 14-18th October 2010, Pusan, Korea.

IMO (2011) *STCW Convention and STCW Code – Including 2010 Manila Amendments*. International Maritime Organisation, London, www.imo.org , ISBN 978-92-801-11528-4.

IMO (2015a) Safety Culture [online]. International Maritime Organisation, Available at http://www.imo.org/OurWork/HumanElement/SafetyCulture/Pages/Default.aspx [website accessed 01/06/2015]

IMO, (2015b) Brief History of IMO [online] International Maritime Organisation, available at http://www.imo.org/About/HistoryOfIMO/Pages/Default.aspx [Accessed 1st June 2015]

Ishizaka, A. and Labib, A. (2009) Analytic Hierarchy Process and Expert Choice: Benefits and Limitation, *OR Insight*, 22(4), p201-220.

Jabeur, K. and Martel, J. M. (2006) An ordinal sorting method for group decision making. *European Journal of Operational Research*, 180, pp. 1272-1289.

James, P. and Walters, D. (2002) Worker representation in health and safety: options for regulatory reforms. *Industrial Relations Journal*, Blackwell Publishers Ltd., 33(2), pp. 141-156.

Janessens, D., Wets, G., Brijs, T., Vanhoof, T., Arentze, T. and Timmermans, H. (2005) Integrating Bayesian networks and decision trees in a sequential rule-based transportation model. *European Journal of Operational Research*, 175, pp. 16-34.

Jones, D. and Endsley, M. (1996) Sources of situation awareness errors in aviation. *Aviation, Space and Environment Medicine*, 67 (6), pp. 507-512.

Kahneman, D. (2012) *Thinking, Fast and Slow*. Penguin.

Kankanhalli, A., Tan, B. C. Y. and Wei, K. K. (2006) Conflict and Performance in Global Virtual Teams. *Journal of Management Information System*, 23 (3), pp. 237-274.

Kanki, B.G., Helmreich, R. L. and Anca, J. (2010) *Crew Resource Management*. Elsevier.

Kim, S. (2013) Hybrid forecasting system based on case-based reasoning and analytical hierarchy process for cost estimation. *Journal of Civil Engineering and Management*, 19(1): pp 86-96.

Kirwan, B. and Ainsworth, L.K. (1992) *A Guide to Task Analysis*. Taylor and Francis, London.

Kjaerulff, U. B. and Madson (2014) *Baysian Networks and influence diagrams: A guide to construction and analysis*. Springer, 2nd Edition, ISBN 9781461451044.

Klampfer, B., Flin, R. Helmreich R., Hausler, R., Fletcher, G., Field, P., Staender, S., Lauche, K., Dieckmann, A. and Amacher, A. (2001) Behavioural Markers Workshop. Group interaction in high risk environment (GIHRE) project. *GIHRE-Aviation: Swiss Federal Institute of Technology (ETH) Zurich*, Swiss training centre, 5-6 July 2001.

Kleij, R., Schraagen, J. M., Werkhoven, P. and Dreu, C. K. W. (2009) How Conversation Change Over Time in Face-to-Face and Video-Mediated. Small Group Research, 40 (4), pp. 355-381.

Klein, G. (2008) Naturalistic decision making. *Human factors*, 50 (3), pp. 456-460.

Klein, G.A., Calderwood, R. and Macgregor D. (1989) Critical decision method for eliciting knowledge. *IEEE Transactions on Systems, man and cybernetics*, 19 (3), pp. 462-472.

Kozuba, J. and Bondaruk, A. (2014) Flight simulator as an essential device supporting the process of shaping pilot’s situational awareness. *International conference of scientific paper*, AFASES 2014, Brasor, 22-24 May 2014, pp. 695-714.

Lappalainen, F.J., Kuronen, J. and Tapaninen, U. (2012) Evaluation of the ISM Code in the Finish shipping companies. *Journal of Maritime Research*, 9 (1), pp. 23-32.

Lau, R., Cross, W., Moss, C. Campbell, A., Castro, M. D. and Oxley, V. (2014) Leadership and Management skills of general practice nurses: Experience or education? *International Journal of Nursing Practice*, 20, pp. 655-661.

Lauritzen, S.L. and Spiegelhalter, D.J. (1988) Local computation with probabilities on graphical structure and their application to expert systems. *Journal of Royal statistics Society B*, 50 (2), pp. 157-194.

Lepine, J.A. and Van Dyne, L. (2001) Peer responses to low performers: An attributional model of helping in the context of groups. *Academy of Management Review*, 26, pp. 67-84

Li, H. P., Wang, Z. P. and Huang Y. H. (2005) Research on radar faults diagnosis method based on D-S Evidential theory. *Journal of system engineering electron*, 27 (8), pp. 1379-1383.

Lieto, A. D. (2014) Costa Concordia Anatomy of an organisational accident [online] Avialable at http://www.enav-international.com/wosmedia/273/costaconcordiaanatomyofanorganisationalaccident.pdf. [Accessed 25th March 2014]

Liu, X. B., Zhou, M., Yang, J. B. and Yang, S. L. (2008) Assessment of strategic R&D projects for car manufacturers based on the evidential reasoning approach. *Journal of Computer Intelligent System*, 1, pp. 24-49.

Livingston, P., Zolpys, L., Mukwesi, C., Twagirumugabe, T., Whynot, S. and Macleod (2014) Non-technical skills of anaesthesia providers in Rwanda: an ethnography. *Pan Africa Medical Journal*. 2014; 19:97 doi:10.11604/pamj.2014.19.97.5205, pp. 1-7.

Long, W. M. (2010) *Development of the nontechnical skills for officer of the deck (NTSOD) rating form*. Thesis, Naval Postgraduate School, Monterey, California.

MAIB (2005a) Report on the investigation of passenger vessel Balmoral. *Marine Accident Investigation Branch*, report number 14/2005.

MAIB (2005b) Report on investigation of the collision between Hyundai Dominion and Sky Hope.*Marine Accident Investigation Branch*, report number 17/2005.

MAIB (2007) Report on the investigation of the close-quarters situation between Maersk Dover and Apollonia. *Marine Accident Investigation Branch*, report number 9/2007.

MAIB (2009a), Grounding of container vessel Cosco Hongkong [online], *Marine Accident Investigation Branch*, Available at http://www.maib.gov.uk/publications/completed_preliminary_examinations/completed_preliminary_examinations_2009/cosco_hongkong.cfm, [Accessed on 10/01/14]

MAIB (2009b) Report on the investigations of heavy weather damage of board the container ship Maersk Newport. *Marine Accident Investigation Branch,* report number 13/2009.

MAIB (2011) Collision between MV Boxford and FV Admiral Blake 29nm south of Start Point, English Channel. *Marine Accident Investigation Branch,* report number 17/2011.

Martin, R. and Davis, K. (1995) The effects of group development techniques on a professional athletic team. *The journal of social psychology*, 135 (4), pp. 533-535.

Matveeskii A. S. and Gravenstein N. (2008) Role of simulators, educational programmes, and non-technical skills in anaesthesia resident selection, education and competency assessment. *Journal of clinical care*, 23, pp. 167-172.

MCA (2010) *The human element – guide to human behaviour in the shipping industry*. The stationary office, UK.

MCA (2013a) Human Element Leadership and Training. MIN (Marine Information Note), *Maritime and Coastguard Agency*, 455, Crown copyright 2013.

MCA (2013b) Merchant shipping (STCW) regulation impact assessment. Maritime and Coastguard Agency, IA No: DfT00256, Date 31/10/2013.

MCA (2014) Formal Safety Assessment, [Online] Available at http://www.dft.gov.uk/mca/mcga07-home/shipsandcargoes/mcga-shipsregsandguidance/fsa.htm [Website accessed 10/03/2014].

MCA (2015) International Management Code for the Safe Operation of Ships and for Pollution Prevention (The ISM Code) – Instruction for the guidance of Surveyors. Crown Copyright, MSIS 2/Rev 03/15.

Mccabe, B., Abourizk, M.S. and Randy, G. (1998) Belief networks for construction performance diagnostics. *Journal of Computing in Civil Engineering*, 12 (2), pp. 93-100.

Micheal, M., Abboudi, H., Ker, J., Khan, M. S., Dasgupta, P. and Ahmed, K. (2014) Performance of technology-driven simulators for medical students – A systemic review. *Journal of surgical research*, 192, pp. 531-543.

Mitchell L., Flin R., Yule S., Mitchell J., Coutts K. and Youngson G. (2013) Development of a behavioural marker system for scrub practitioners' non-technical skills (SPLINTS system). *Journal of evaluation in clinical practice*, 19, pp.317-323.

MNTB (2012) Human Element Leadership and Management – Operational and Management Levels. 1st Edition, Merchant Navy Training Board.

Mohovic, R., Rudan, I. and Mohovic, D. (2012) Problems during simulator training in ship handling education. *Scientific Journal of Maritime Research*, 26 (1), pp.191-199.

Neapolitan, R.E. (1990) Probabilistic Reasoning in Expert System: Theory and Algorithms. John Willey & Sons, Inc., NY, USA.

NBC News (2014) Costa Concordia Salvage Operations [online]. Available at http://www.nbcnews.com/news/world/watch-time-lapse-video-massive-salvage-operation-set-costa-concordia-v20517915 [Accessed on 20th Feb 2014].

NTSB (1995) "Grounding of the Panamanian passenger ship Royal Majesty on Rose and Crown shoal near Nantucket, Massachusetts". *National Transport Safety Board Accident report*, Washington, DC 20594.

NTSB (1998) *We are all safer*. National Transportation Safety Board, Washington, DC 20594, Second edition, July 1998.

O'Connor, P., Hormann, H., Flin, R., Lodge, M., Goeters, K., And The Jartel Group (2002a) Developing a method for evaluating crew resource management skills: a European perspective. *International Journal of Aviation Psychology*, 12 (3), pp. 265-288.

O’Connor, P., Flin, R., Fletcher, G. and Hemsley, P. (2002b) Methods used to evaluate the effectiveness of CRM training: A survey of UK aviation operators. *Journal of Human Factors and Aerospace Safety*, 2(3), pp. 235-256.

O’Connor, P., Campbell, J., Newon, J., Melton, J., Salas, E. And Wilson, K. A. (2008) Crew resource management training effectiveness: A meta-analysis. *The international journal of aviation psychology*, 18(4), pp. 353-368.

O’Connor, P., (2011) Assessing the effectiveness of bridge resource management training. *The international journal of aviation psychology*, 21(4), pp. 357-374.

O’Connor, P. and Long, W. M. (2011) The development of a prototype behavioural marker system for US navy officer of the deck. *US Navy research*, Paper 39, pp. 1381-1387.

Oster V. C., Strong, J.S. and Zorn, C. K. (2013) Analyzing aviation safety: problems, challenges, opportunities. *Research in transportation economics*, 43, pp. 148-164.

Pedigo, M., Ma, J., Gildea, K., Holcomb, H., Hackworth, C. And Hiles, J. J. (2011) The line operations safety audit program: transitioning from flight operations to maintenance and ramp operations. *Federal Aviation Administration*, DOT/FAA/AM-11/15, Office of Aerospace Medicine, Washington, DC 20591.

Pelletier, S. (2006) The role of navigation simulator technology in marine pilotage. *International Maritime Pilotage Association 18th Congress*, Havana, Cuba, 23rd November 2006, pp. 1-5.

Pillay, A. and Wang, J. (2003) A risk ranking approach incorporating fuzzy set theory and grey theory. *Reliability Engineering System safety* 2003, 79(1): pp. 61-67.

Power, S. M., Power, J. Mackinnon, S. and Simoes Re, A. (2011) “Effect of simulator training on novice operators’ abilities to navigate in ice”, NRC Publication Archive (NPArC), National Research Council Canada, Report no. TR-2011-15, Nov 2011.

Quinn, R. W. and Quinn, R.E. (2015) Lift: *The fundamental State of Leadership*. Second Edition. Berrett-Koehler.

Rasmussen, J. (1983) Skill, rules and knowledge: signals, signs, and symbols, and other distinctions in human performance models. *IEEE Transactions on systems, man and cybernetics*, SMC-13 (3), pp. 257-267.

Riahi, R. (2010) *Enabling security and risk-based operation of container line supply chains under high uncertainties*. PhD thesis, Liverpool John Moores University, UK.

Riahi, R., Bonsall, S., Jenkinson, I. and Wang, J. (2012) A Seafarer's reliability assessment incorporating subjective judgements. *Journal of Engineering for the maritime environment*, 226 (4), pp. 313-334.

Richardson, T, (1997) A review of an introduction to Bayesian networks. *Journal of the American Statistical Association*, 92 (439), pp. 1215-1216.

Saaty T. L. (1990) How to make decisions: The Analytic Hierarchy Process. *European Journal of operational Research*, 48 (1): pp. 9-26.

Saaty, T. L (2008) Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, 1 (1), 2008, pp. 83-98.

Safahani, M. (2015a) Human errors and non-technical skills [online]. *IRISL Maritime Training Institute*. Avaialable at www.he-alert.org/filemanager/root/site_assets/...pdfs...-/he00910.pdf [Accessed 7th June 2015]

Safahani, M. (2015b) Can the simulator replace onboard training [online]. *IRISL Maritime Training Institute*. Available at www.he-alert.org/filemanager/root/site_assets/...pdfs...-/HE00890.pdf [Accessed 18th June 2015]

Salas, E., Prince, C., Bowers, C., Stout, R., Oser, R. L., and Cannon-Bowers, J. A. (1999) A methodology for enhancing crew resource management training. *Human Factors*, 41 (1), pp. 161–172.

Salmon, P. M., Stanton, N. A., Walker, G. H. and Jenkins, D. P. (2009) *Distributed situation awareness, theory, measurement and application to teamwork*. Ashgate Publishing Limited.

Salmon, V. A. P. and Montevechi, J.A.B (2001) A compilation of comparisons on the analytic hierarchy process and others MCDM methods: Some cases developed in Brazil. *ISAHP* 2001, Berne, Switzerland, August 2-4, 2001, pp. 413-420.

Sarter, N. B. and Woods, D.D. (1995) How in the world I ever get into that mode: Mode error and awareness in supervisory control. *Human Factors*, 37(1), pp. 5-19.

Seamster, T.L., Redding, R.E. and Kaempf, G.L. (1997) *Applied Cognitive Task Analysis in Aviation.* Ashgate Publishing Limited.

Shafter, G. (1976) *A mathematical theory of evidence*. Princeton, NJ: Princeton.

Skogdalen, J. E. and Vinnem, J. E. (2011) Quantitative risk analysis of oil and gas drilling, using Deepwater Horizon as case study. *Reliability engineering and system safety*, 100, pp. 58-66.

Smith, C. A. P., Johnston, J. and Paris, C (2004) Decision support for air warfare: detection of deceptive threats. *Groups decisions and negotiations*, 13, pp. 129-148.

Sniegocki, H. (2005) Impact of the usage of visual simulator on the students training results. Conference paper, *International Conference on modelling and simulation general application and models in engineering science*, Gdynia Maritime University.

Srivastava, R. P. and Liu, L. (2003) Application of belief functions in business decision, a review. *Journal of information systems frontiers*, 5 (4), pp. 359-378.

Stanton, N. (1996) *Human factors in nuclear safety*. London: Taylor and Francis.

Stewart, T. J. (1992) A critical survey on the status of multiple criteria decision making theory and practice. *OMEGA International Journal of Management Science*, 20 (5/6), pp. 569-586, 1992.

Stojiljkovic, E., Grodanovic, M. and Stojiljkovic, P. (2012) Human error assessment in electric power company of Serbia. *IOS Press*, Work 41 (2012) 3207-3212, DOI: 10.3233/WOR-2012-0584-3207, pp. 3207-3212.

Stone, A. A., Bachrach, C. A., Jobe, J. B., Kurtzman, H. S. and Cain, V. S. (1999) *The Science of Self-reports: Implications for research and Practice*. Taylor and Francis, London.

Subrahmanyam, M. and Mohan, S. (2013) Safety features in anaesthesia machine. *Indian Journal of Anaesthesia*, 57 (5), pp. 472-480.

Swift, L. (1997) *Mathematics and Statics for Business, management and Finance*. Macmillan Press Ltd. London.

Tally, W. K. (2012) *Blackwell companion to maritime economics*. Blackwell publishing limited.

The National Centre for Simulation (2010) Early History of Flight Simulators [online] Available at http://www.simulationinformation.com/education/early-history-flight-simulation, [Accessed on 6th October 2010].

Ung, S. T. and Shen, W. M. (2011) A novel human error probability assessment using fuzzy modelling. *Risk Analysis*, 31 (5), pp. 745-757.

Van Offenbeek, M. (2001) Processes and outcomes of team learning. *European Journal of Work and Organizational Psychology*, 10, pp. 303-317.

Wagenaar, W. A. and Groeneweg (1987) Accidents at sea: Multiple causes and impossible consequences. *International Journal of Man-Machine Studies*, 27, pp. 587-598.

Wagener, F. and Ison, D. C. (2014), Crew resource management application in commercial aviation. *Journal of aviation technology and engineering*. 3 (2), pp. 2-13.

Wall, A. D. (2015), Subject Head, LJMU, Interview, 27th May, 2015.

Wang, H., Jiang, H. and Yin, L. (2013) Cause mechanism study to human factors in maritime accidents: towards a complex system brittleness analysis approach. *13th COTA conference of* *transportation professionals (CICTP 2013)* Procedia – *Social and Behavioral Sciences*, 96, pp.723-727.

Wang, J., Yang, J. B. and Sen, P. (1995) Safety analysis and synthesis using fuzzy sets modelling and evidential reasoning. *Reliability Engineering & system Safety*, 47 (3), pp. 102-118.

Wang, J. and Trbojevic, V.M. (2007) *Design for safety of large marine and offshore engineering products*. Institute of Marine Engineering, Science and Technology (IMarEST), London, UK, ISBN: 1-902536-58-4.

Wanger, R., Razek, V., Grafe, F., Berlarge, T., Janousek, J., Daehnert, I., and Weidenbach, M. (2013), Effectiveness of simulator-based echocardiography training of non-cardiologists in congenital heart diseases. *Echocardiography*, Wiley periodicals, Inc.DOI:10.1111/echo. 12118, pp. 693-698.

Wermuth, N. and Lauritzen, S.L. (1990) On Substantive Research Hypotheses, Conditional Independence Graphs and Graphical Chain Models. *Journal of the Royal Statistical Society,* Series B, 52 (1), pp. 21–50.

West, M. (2012) *Effective Teamwork, Practical lessons from organizational research*. BPS Blackwell.

Winter, J. C. F, Dodou, D. and Mulder, M (2012) Training effectiveness of whole body flight simulator motion: A comprehensive EMta-Analysis. *The International Journal of Aviation Psychology*, 22(2), pp. 164-183.

WMA (2012) Project Horizon [online]. Warsash Maritime Academy, Available at http://www.warsashacademy.co.uk/about/our-schools/maritime-research-centre/horizon-project/about-horizon.aspx , [Accessed 12th June 2015]

Woerkom, M. and Sanders (2009) The romance of learning from disagreement. The effect of cohesiveness and disagreement on knowledge sharing behaviour and individual performance within teams. *Journal of Bus Psychology*, 25, pp. 139-149.

Xu, L. and Yang, J. B. (2001) *Introduction to multi-criteria decision making and evidential reasoning approach*. Manchester School of Management, University of Manchester Institute of Science and Technology, PO Box 88, ISBN 1 86115 111 X, pp. 3-21.

Yager, R. R. (1992) On the specificity of a possibility distribution. *Fuzzy Sets and systems*, 50, pp. 279-292.

Yang, M., Khan, F. I. and Lye, L. (2013) Precursor-based hierarchical Bayesian approach for rare event frequency estimation: A case of oil spill accidents. *Elsevier*, 91 (5), pp. 333-342.

Yang, S. L., Zhu, W. D. and Ren, M. L. (2004) Learning based combination of expert opinions in securities market forecasting. *Journal of System Engineering*, 10/9 (1), pp. 94-98.

Yee, B., Naik, V., Joo, H. S. *et al*. (2005) Non-technical skills in Anaesthesia Crisis Management with Repeated exposure to simulation-based education. *Anaesthesiology*, 103 (2), pp. 241-248.

Yi, Z., Ying-Hu, Z., Teng-Fei, S., Zhao-Hui, C. and Yan-Jing, L. (2014) Improved AHP Analysis method in the evaluation of DaGang deep drilling applications. *Electronic journal of geotechnical engineering*, 19 D: pp. 947-954.

Yukelson, D. (1997) Principles of effective team-building interventions in sport: A direct services approach at Penn State University. *Journal of Applied Spot Psychology*, 9, pp. 73-96.

Yule, S., Flin, R., Peterson-Brown, S., Maran, N. and Rowley, D. (2006) Development of a rating system for surgeons' non-technical skills. *Medical Education*, 40, pp.1098-1104.

Yusof, A. A. (2003) Gelagat organisasi: Teori, isu dan aplikasi. (1st ed.) Kuala Lumpur, Cited in Sulaiman, W., Mahbob, M. and Hassan, B. (2012) An analysis on the effectiveness of Team Building: The impact on Human Resources. *Asian Social Sciences*, 8 (5), pp. 29-36.

Zaccaro, S. J., Rittman, A. L. and Marks, M. A. (2001) Team Leadership. *The Leadership Quaterly*, 12, pp. 451-483.

Zhang, X. D., Zhao, H. and Wei, S. Z. (2005) Research on subjective and objective evidence fusion method in oil reserve forecast. *Journal of system simulation*, 10 (17), pp. 2537-2540.

Zhou, M., Liu, X. B. and Yang, J. B. (2010) Evidential Reasoning based nonlinear programming model for MCDA under fuzzy weights and utilities. *Journal of intelligent systems*, 25, pp. 31-58.

Appendix 1: STCW Section A-II/2

Section II/1 – The Operational Level Deck Officer

Function: Navigation at operational level

- Competence: Maintain a safe navigational watch
- Knowledge, understanding and proficiency:
    - Bridge resource management
    - Knowledge of bridge resource management principles, including:
        1. Allocation, assignment and prioritization of resources
        2. Effective communication
        3. Assertiveness and leadership
        4. Obtaining and maintaining situational awareness
- Methods for demonstrating competence
    - Assessment of evidence obtained from one or more of the following:
        1. Approved training
        2. Approved in-service experience
        3. Approved simulator training
- Criteria for evaluating competence
    - Resources are allocated and assigned as needed in correct priority to perform necessary tasks.
    - Communication is clearly and unambiguously given and received.
    - Questionable decisions and/or actions result in appropriate challenge and response.
    - Effective leadership behaviours are identified.
    - Team member(s) share accurate understanding of current and predicted vessel state, navigation path, and external environment.

Function: Controlling the operation of the ship and care for persons on board at the operational level.

- Competence: Application of leadership and teamworking

- Knowledge, understanding and proficiency:
    - Working knowledge of shipboard personnel management and training
    - A knowledge of related international maritime conventions and recommendations, and national legislation
    - Ability to apply task and workload management, including:
        1. Planning and co-ordination
        2. Personnel assignment
        3. Time and resource constraints
        4. Prioritization
    - Knowledge and ability to apply effective resource management:
        1. Allocation, assignment, and prioritization of resources
        2. Effective communication onboard and ashore
        3. Decisions reflect consideration of team experience
        4. Assertiveness and leadership, including motivation
        5. Obtaining and maintaining situational awareness
    - Knowledge and ability to apply decision-making techniques:
        1. Situation and risk assessment
        2. Identify and consider generated options
        3. Selecting course of action
        4. Evaluation of outcome effectiveness
- Methods for demonstrating competence
    - Assessment of evidence obtained from one or more of the following:
        1. Approved training
        2. Approved in-service experience
        3. Approved simulator training
- Criteria for evaluating competence
    - The crew are allocated duties and informed of expected standards of work and behaviour in a manner appropriate to the individuals concerned.
    - Training objectives and activities are based on assessment of current competence and capabilities and operational requirements.
    - Operations are demonstrated to be in accordance with applicable rules.
    - Operations are planned and resources are allocated as needed in correct priority

to perform necessary tasks.

- Communication is clearly and unambiguously given and received.
- Effective leadership behaviours are demonstrated
- Necessary team member(s) share accurate understanding of current and predicted vessel and operational status and external environment.
- Decisions are most effective for the situation

Section II/2 – Masters and chief Mates on ships of 500 gross tonnage or more

Function: Controlling the operation of the ship and care for persons on board at the management level.

- Competence: Use of leadership and managerial skill
- Knowledge, understanding and proficiency:
  - Knowledge of shipboard personnel management and training
  - A knowledge of related international maritime conventions and recommendations, and national legislation
  - Ability to apply task and workload management, including:
    1. Planning and co-ordination
    2. Personnel assignment
    3. Time and resource constraints
    4. Prioritization
  - Knowledge and ability to apply effective resource management:
    1. Allocation, assignment, and prioritization of resources
    2. Effective communication onboard and ashore
    3. Decisions reflect consideration of team experience
    4. Assertiveness and leadership, including motivation
  - Knowledge and ability to apply decision-making techniques:
    1. Situation and risk assessment
    2. Identify and consider generatde options
    3. Selecting course of action
    4. Evaluation of outcome effectiveness

5. Obtaining and maintaining situation awareness action

- Development, implementation, and oversight of standard operating procedures

- Methods for demonstrating competence
  - Assessment of evidence obtained from one or more of the following:
    1. Approved training
    2. Approved in-service experience
    3. Approved simulator training
- Criteria for evaluating competence
  - The crew are allocated duties and informed of expected standards of work and behaviour in a manner appropriate to the individuals concerned.
  - Training objectives and activities are based on assessment of current competence and capabilities and operational requirements.
  - Operations are demonstrated to be in accordance with applicable rules.
  - Operations are planned and resources are allocated as needed in correct priority to perform necessary tasks.
  - Communication is clearly and unambiguously given and received.
  - Effective leadership behaviours are demonstrated
  - Necessary team member(s) share accurate understanding of current and predicted vessel and operational status and external environment.
  - Decisions are most effective for the situation
  - Operations are demonstrated to be effective and in accordance with applicable rules

Appendix 2: MNTB HELM (M) AIMS AND OUTCOMES

SECTION THREE: HUMAN ELEMENT, LEADERSHIP AND MANAGEMENT – MANAGEMENT LEVEL

Aim

To give all masters and officers the education and training in the human element leadership and management at management level meeting the knowledge, understanding and proficiency (KUP) requirements set out in the following:

Table A-II/2 (masters and chief mates on ships of 500 gross tonnage or more)

Table AIII/2 (chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 750kW or more)

Function: Controlling the operation of the ship and care for persons on board at management level

Competence: Use leadership and management skills

Entry requirements

Learners shall hold a deck or engineering certificate of competency at the operational level and meet the minimum seagoing service requirements for the issue of a management level CoC.

Outcomes

There is one outcome to the training.

Outcome: The learner can use leadership and managerial skills to control the operation of the ship and care for persons on board at the management level.

Staff to learner ratio

The trainer to learner ratio should not exceed 1:12. The training centre, having due regard to health and safety and the objectives of the training, should determine other staffing requirements.

Training duration

The training is to be provided as a full-time block course of not less than 35 hours of instruction and assessment, spread over five days.
Some training centres may have manpower, equipment and facilities such that the standards of competence can be achieved over different timescales. Any departure from the above guidelines is subject to the approval the MCA's chief examiner.

Certification and documentation

A certificate cannot be issued prior to approval of the training by the MCA. On achievement of the desired standard of competence, a certificate will be issued by the centre in the format shown in annex F. The centre shall maintain a record of the certificates issued as per the conditions of approval.

OUTCOMES

Outcome 1

The learner can use leadership and managerial skills to control the operation of the ship and care for persons on board at the management level.

Learning objectives

1. Identify the principles and good practice in shipboard human resource management.

2. Explain the relevance of the 'human element' in shipboard operations.

3. Apply relevant and related international maritime conventions and recommendations, national regulations, codes of practice and guidelines, while using leadership and managerial skills to control the operation of the ship and care for persons on board at the management level.

4. Apply the principles of task and workload management, including planning, co-ordination, allocation and prioritisation of human and physical resources.

5. Use project management as an aid to decision-making.

6. Explain effective resource management techniques with regard to:

a) Allocation, assignment and prioritisation of resources for effective task and workload management including:

i. The difference between leadership and management;

ii. Attributes of an effective leader;

iii. Attributes of an effective manager;

iv. Models of best practice in leadership and management;

v. Identifying and selecting appropriate leadership and management styles;

vi. Judgement and decision-making; and

vii. Leadership in normality and crisis including recognising and countering adverse reactions in stressful situations.

b) Effective communication principles and practice including:

i. Communicating effectively with those on board and ashore;

ii. Listening clearly; and

iii. Providing constructive feedback.

c) Leading and managing teams including:

i. Considering team experiences;

ii. Recognising team potential and limitations;

iii. Optimising the skills and abilities of the team;

iv. Leading multi-cultural teams effectively; and

v. Establishing a culture of fairness and respect.

d) Assertiveness and leadership, including:

i. Basic motivation theories;

ii. Motivating the team;

iii. Setting clear and achievable goals;

iv. Using authority and influence effectively;

v. Setting and maintaining high standards; and

vi. Avoiding a blame culture and promoting a ‘just culture’.

e) Obtaining and maintaining situational awareness including:

i. How to obtain and maintain situational awareness;

ii. Challenges to obtaining and maintaining situational awareness; and

iii. Ensuring that teams have ‘shared mental models’ (‘shared situational awareness’).

7. Apply the principles and practice of decision-making while:

a) Taking account of the situation and of the risk assessment;

b) Identifying and generating options;

c) Using creative problem-solving strategies;

d) Applying lateral thinking strategies;

e) Selecting a course of action; and

f) Evaluating outcome effectiveness.

8. Lead and manage the development, implementation and oversight of standard operating procedures.

9. Identify the principles and good practice in shipboard training, learning, coaching, mentoring, assessment and developing shipboard personnel.

Appendix 3: LJMU ETHICAL APPROVAL

By email

15 October 2012

Dear Farhan,

Proportionate Review – Full Ethical Approval: Application for Ethical Approval No.: 12/ENR/003 An analysis of Deck Officers' non-technical skills in the crisis situation

Dr Sue Spiers and Dr Adam Mackridge have considered the application on behalf of Liverpool John Moores University Research Ethics Committee (REC). I am pleased to inform you that ethical approval has been granted and the study can now commence.

Approval is given on the understanding that:

- any adverse reactions/events which take place during the course of the project are reported to the Committee immediately;
- any unforeseen ethical issues arising during the course of the project will be reported to the Committee immediately;
- the LJMU logo is used for all documentation relating to participant recruitment and participation eg poster, information sheets, consent forms, questionnaires. The LJMU logo can be accessed at http://www.ljmu.ac.uk/corporatecommunications/60486.htm

Where any substantive amendments are proposed to the protocol or study procedures further ethical approval must be sought.

Applicants should note that where relevant appropriate gatekeeper / management permission must be obtained prior to the study commencing at the study site concerned.

For details on how to report adverse events or request ethical approval of major amendments please refer to the information provided at http://www.ljmu.ac.uk/RGSO/RGSO_Docs/EC8Adverse.pdf

Please note that ethical approval is given for a period of five years from the date granted and therefore the expiry date for this project will be October 2017. An application for extension of approval must be submitted if the project continues after this date.

Yours sincerely

Mrs Maria Roberts
Research Support Officer
Research Support Office, 4th Floor
Kingsway House
Hatton Garden
Liverpool, L3 2AJ
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web: http://www.ljmu.ac.uk/

Appendix 4: INTERVIEWEE INTRODUCTION LETTER

Interviews to identify deck officers' non-technical skills

As part of the project to develop taxonomy of deck officers' non-technical skills, interviews are conducted with experienced deck officers at management level to help identify the key skills that need to be included in the taxonomy. The interview will follow a semi-structured format using methods developed for analysing cognitive tasks. Thus the aim of the interview is to find out about the non-technical aspect of deck officers' task in crisis situations on the bridge of a ship and the required skills (i.e thinking and teamworking skills, and not to make judgements about individual performance). There are no right or wrong answers to any part of the interview.

The interview is divided into three parts:

Part 1: Performance example – You will be asked to describe a real case from your own experience that was particularly challenging and possibly difficult for you as a senior deck officer. This can be a real critical incident/near miss or a normal case that just really tested all your skills as a senior deck officer and where your experience was a significant outcome. It would be very helpful if you could think of this example before the interview. You are welcome to bring any notes of the event if this helps you. This event will be discussed to identify the key non-technical aspects.

Part 2: Distinguishing skills – You will be asked to think of the skills and attributes you consider to be characteristic of the effective performance in the crisis situations on the bridge of a ship.

Part 3: Weighting task – You will be asked to compare the elements as shown in Appendix C.

Approximate times for the three interview parts are: Part 1 – 45 minutes, Part 2 – 15 minutes, Part 3 – 15 minutes. To assist in collecting the information, with your agreement, a digital voice recording device will be used. This reduces the amount of time that has to be spend making notes and so allow better discussions to develop. The voice recorded files will be permanently deleted once the audio is transcribed.

All the information you give will be held in confidence and will be de-identified to ensure participants and any other individuals are not recognisable; results will be prepared at a group summary level only.

The interview will take place in private room at an agreed place and time convenient to you. If you have any further questions about the interviews or project in general, please contact me at the numbers given below.

Thank you for your interest in the project, and I look forward to your possible involvement in the study. If you decide to take part we can discuss the practical arrangements and details of the interview nearer the time.

Farhan Saeed

Senior Lecturer Maritime Studies

Liverpool John Moores University

James Parsons Building, Byrom Street,

Liverpool L3 3AF

0151 231 2468

APPENDIX 5: INTERVIEW PROCESS

Part 1 – Performance Example

Explain task:

You were asked if you could think about a case from your experience in advance – I hope you were able to do this. (If not describe the requirements and give a few minutes for the interviewee to think about it.)

Will be asked to "walk-through" the case a number of times:

- Brief description of case.
- Interviewer repeats back the key aspects to check time frame and understanding.
- Describe the case in more detail focusing on non-technical aspects.
- Interviewer will ask questions where necessary to help understanding.

Re-iterate: not interested in making any judgement about your performance.

Request: as much information as possible but not specific personal details about any bridge team member.

Begin:

Thinking of your case, please could you describe it to me from your perspective, starting from the point you first encountered the situation. Please remember to focus on the non-technical aspects.

I will probably make some notes to help me and start constructing a time line of events to help our discussion and my understanding.

Interviewee describes the case

I will now repeat the case back to you, as I have understood it. Please correct me if I have not understood anything properly.

Interviewer repeats back event

Interviewer and interviewee develop timeline

Question: Can you tell me why you picked this case? Why was this case so challenging for you?

Building on this description of the event I would now like you to go through the case again, as you experienced it, giving me a detailed description of the type of things you were thinking about, decision you had to make, communications with colleagues, planning and co-ordination of tasks, etc.

If I think something is particularly important I will ask questions for more information.

Interviewee re-describes the event, interviewer probes as required

Additional questions:

- Now that we have been through the event, is there anything else you would like to add about non-technical skills in this situation?
- What kind of things could have gone wrong for you in this situation?
- How do you think someone with less experience (e.g. a junior deck officer,) might have handled the situation? Can you think of any problems they might have encountered?
- What were you thinking about?
- Was there any breakdown in communication?
- What sort of teamwork was there within the bridge?
- Who was in leadership role?

- What would have happened if the team members had been different (less, more, unknown, experienced)?
- What cues were you using to help understand the situation?
- What information did you use in recognising the situation / making the decision?
- What non-technical skills were you using in dealing with the situation?
- Were you able to draw on any comparisons from previous experience?
- What were your goals during the managements of the case at this time?
- What options were open to you at that moment? How did you decide which option to take? Was there any influence from the team?
- How did you arrive at your chosen course of action? What factors affected your decision? What strategy did you use in reaching your decision?
- How did you maintain situation awareness? To what extent did some of your situation awareness come from the team? What sort of projections were you making into the future? What sort of things would you have to be anticipating for? What are the major elements you have to keep track of to develop/maintain the big picture?
- What sort of resources did you have available to support you?
- What factors might have influenced your performance? What role did the team have on the case?
- What is the importance of the education/training you had to become a senior deck officer in dealing with such situation? What improvement do you want to see in the deck officer training?

Part 2: Distinguishing Skills

I want you to think about the type of skills that you think make a good and effective deck officer (in terms of non-technical skills) and that distinguish a really experienced deck officer from an inexperienced deck officer (if indeed you think these skills are developed with experience or training).

Question: What kind of non-technical skills do you think are important or make a good deck officer? Again I am particularly interested in the non-technical skills aspect of the performance.

Senior deck officer gives examples, interviewer probes/confirms as required

Additional questions:

- How do you think these skills are currently developed? For example how might a trainee gain these vital non-technical skills?
- Do you think there are any differences or similarities between skills needed for normal situation and crisis situation?

Part 3: Weighting Task

Part 3: Weighting task – The interviewee will be asked to assign a number in front of a non-technical skills taxonomy presented against the each skill and element (Attached).

End of interview – questions; thanks; contact details.

APPENDIX6: AHP WEIGHTING TASK FORM

Taxonomy of the Non-technical Skills for Deck Officers in Crisis Situations

A. Goal: To Select the most important non-technical skills for deck Officers

Situation Awareness

How important is 'Situation Awareness' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making																	
Leadership																	
Teamwork																	

Decision Making

How important is 'Decision Making' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership																	
Teamwork																	

Leadership

How important is 'Leadership' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork																	

B. Goal: To Select the most important element of teamwork

Teambuilding and maintaining

How important is 'Team Building and maintaining' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Considering others																	
Supporting others																	
Communication																	
Information sharing																	

Considering others

How important is 'Considering Others' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Supporting others																	
Communication																	
Information sharing																	

Supporting others

How important is 'Supporting Others' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Communication																	
Information sharing																	

Communication

How important is 'Communication' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Information sharing																	

C. Goal: To Select the most important element of Leadership and Managerial Skills

Use of authority and assertiveness

How important is 'Use of authority and assertiveness' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Providing and maintaining standards																	
Planning and co-ordination																	
Work load management																	
Prioritisation																	
Task delegation																	
Initial Crisis Management																	

Providing and maintaining standards

How important is 'Providing and maintaining standards' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Planning and co-ordination																	
Work load management																	
Prioritisation																	
Task Delegation																	
Initial Crisis Management																	

Planning and co-ordination

How important is 'Planning and Co-ordination' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Work load management																	
Prioritisation																	
Task Delegation																	
Initial Crisis Management																	

Work load management

How important is 'Workload management' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Prioritisation																	
Task Delegation																	
Initial Crisis Management																	

Prioritisation

How important is 'Prioritisation' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Task Delegation																	
Initial Crisis Management																	

Task Delegation

How important is 'Task Delegation' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Initial Crisis Management																	

D. Goal: To Select the most important element of Situation awareness

Awareness of bridge systems

How important is 'Awareness of bridge systems' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of external environment																	
Awareness of time																	
Situation assessment																	

Awareness of external environment

How important is 'Awareness of external environment' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of time																	
Situation assessment																	

Awareness of time

How important is 'Awareness of time' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Situation assessment																	

E. Goal: To Select the most important element of Decision Making

Problem definition and diagnosis

How important is 'Problem definition and diagnosis' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Option generation																	
Risk assessment and option selection																	
Outcome review																	

Option Generation

How important is 'Option generation' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Risk assessment and option selection																	
Outcome review																	

Risk assessment and option review

How important is 'Risk assessment and option review' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Outcome review																	

APPENDIX 7: INTERVIEW PARTICIPANT INFORMATION SHEET

LIVERPOOL JOHN MOORES UNIVERSITY

PARTICIPANT INFORMATION SHEET

An analysis of Deck Officers' non-technical skills in the crisis situations

Farhan Saeed, Sr. Lecturer, School of Engineering, Technology and Maritime Operations.

You are being invited to take part in a research study regarding the importance of the non-technical skills for the deck officers in the crisis situation . Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Ask us if there is anything that is not clear or if you would like more information. Take your time to decide if you want to take part or not.

1. What is the purpose of the study?

Accidents in maritime industry are not new and a major contributing factor to most of these accidents is human error. Analysis in a number of industrial sectors has indicated that up to 80% of accident causes can be attributed to human factors. Non-technical skills is relatively new concept in maritime industry and thus so far a little research has conducted.

The objective of the first part of the project is to develop and validate the taxonomy of non-technical skills required for deck officers' in the crisis situations. Within this project the term 'non-technical skills' is used to describe senior deck officers' attitude and behaviours in crisis situations not directly related to technical skills used to navigate a ship or to use the bridge equipment. A non-technical skills taxonomy is developed from literature review and will be validated by conducting interviews with experts.

Once the taxonomy of the non-technical skills is validated in the first part, a simulator study will be conducted in the second part of the project to assess the validated non-technical skills. A set of volunteer students, who have completed DipHE Nautical science, will be assess in 2-3 simulated scenarios with crisis situation which would require the students to apply the non-technical skills.

A second set of volunteer students, who have completed DipHE Nautical science and HELM (IMO approved non-technical skills course), will be assess in the same simulated scenarios which were used with first set of the students. The results of the both simulator assessment will be compared, hence validating the taxonomy of the non-technical skills for the deck officer in the crisis situations.

2. Do I have to take part?

You are invited to take part in the first part of the study, ie interview. This is a voluntary participation and it up to you to decide whether or not to take part. If you do you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason. A decision to withdraw will not affect your rights/any future treatment/service you receive.

3. What will happen to me if I take part?

The interview will take upto 90 minutes. The date and time of the interview will be agreed with you in advance. The interview data will be kept anonymous and you will not be contacted after interview is completed.

The research will take about three years to complete. The outcome of the research can be send to you if you decide to receive this information.

4. Are there any risks / benefits involved?

Interview process is a short process and unlikely to cause any risk. There is no specific benefit to individual but there is overall benefit to the whole maritime industry.

5. Will my taking part in the study be kept confidential?

Yes, taking part in the study will be kept confidential.

<u>Contact Details of Researcher</u>

Farhan Saeed

Senior Lecturer Maritime Studies

Liverpool John Moores University

James Parsons Building, Byrom Street,

Liverpool L3 3AF

0151 231 2468

f.saeed@ljmu.ac.uk

APPENDIX 8: ISIMULATOR PARTICIPANT INFORMATION SHEET

LIVERPOOL JOHN MOORES UNIVERSITY

PARTICIPANT INFORMATION SHEET

An analysis of Deck Officers' non-technical skills in the crisis situations

Farhan Saeed, Sr. Lecturer, School of Engineering, Technology and Maritime Operations.

You are being invited to take part in a research study regarding the importance of the non-technical skills for the deck officers in the crisis situations. Before you decide it is important that you understand why the research is being done and what it involves. Please take time to read the following information. Ask us if there is anything that is not clear or if you would like more information. Take your time to decide if you want to take part or not.

6. What is the purpose of the study?

Accidents in maritime industry are not new and a major contributing factor to most of these accidents is human error. Analysis in a number of industrial sectors has indicated that up to 80% of accident causes can be attributed to human factors. Non-technical skills is relatively new concept in maritime industry and thus so far a little research has conducted.

The objective of the first part of the project is to develop and validate the taxonomy of non-technical skills required for deck officers' in the crisis situations. Within this project the term 'non-technical skills' is used to describe senior deck officers' attitude and behaviours in crisis situations not directly related to technical skills used to navigate a ship or to use the bridge equipment. A non-technical skills taxonomy is developed from literature review and will be validated by conducting interviews with experts.

Once the taxonomy of the non-technical skills is validated in the first part, a simulator study will be conducted in the second part of the project to assess the validated non-technical skills. A set of volunteer students, who have completed DipHE Nautical science (without HELM course), will be assess in 2-3 simulated scenarios with crisis situation which would require the students to apply the non-technical skills.

A second set of volunteer students, who have completed DipHE Nautical science and HELM (IMO approved non-technical skills course), will be assess in the same simulated scenarios which were used with first set of the students. The results of the both simulator assessment will be compared, hence validating the taxonomy of the non-technical skills for the deck officer in the crisis situations.

7. Do I have to take part?

You are invited to take part in the second part of the study, ie simulation observations. This is a voluntary participation and it up to you to decide whether or not to take part. If you do you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason. A decision to withdraw will not affect your rights/any future treatment/service you receive.

8. What will happen to me if I take part?

There will be two simulations observations of three hours each. In one scenario you will be sole watchkeeping officer and in the other you will be working with a team.
The research will take about three years to complete.

9. Are there any risks / benefits involved?

The process is same as you have already attended in the NAEST simulator exerices during the DipHE Nautical Science course so there is no risk in these exercises.
These exercises may improve your non-technical skills.

10. Will my taking part in the study be kept confidential?

Yes, taking part in the study will be kept confidential.

Contact Details of Researcher

Farhan Saeed

Senior Lecturer Maritime Studies

Liverpool John Moores University, James Parsons Building, Byrom Street,

Liverpool L3 3AF, phone: 0151 231 2468, email: f.saeed@ljmu.ac.uk

APPENDIX 9: INTERVIEW PARTICIPANT CONSENT FORM

LIVERPOOL JOHN MOORES UNIVERSITY

CONSENT FORM

An analysis of Deck Officers' non-technical skills in the crisis situation

Researcher: Farhan Saeed

School: School of Engineering, Technology and Maritime Operations

I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily ☐

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights. ☐

I understand that any personal information collected during the study will be anonymised and remain confidential ☐

I agree to take part in the above interview study. ☐

Name of Participant Date Signature

Name of Researcher Date Signature

Note: When completed 1 copy for participant and 1 copy for researcher

APPENDIX 10: SIMULATOR PARTICIPANT CONSENT FORM

LIVERPOOL JOHN MOORES UNIVERSITY

CONSENT FORM

An analysis of Deck Officers' non-technical skills in the crisis situations

Researcher: Farhan Saeed
School: School of Engineering, Technology and Maritime Operations

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights. ☐
3. I understand that any personal information collected during the study will be anonymised and remain confidential ☐
4. I understand that the simulation observations will be video recorded and I am happy to proceed ☐
5. I agree to take part in the above simulation observation study. ☐

Name of Participant	Date	Signature
Farhan Saeed Name of Researcher	Date	Signature

Note: When completed 1 copy for participant and 1 copy for researcher

Appendix 11 – AHP Weighting Data

Table A11.1 - Expert weights - Participant 01

Taxonomy of the Non-technical Skills for Deck Officers in Crisis Situations

A. Goal: To Select the most important non-technical skills for deck Officers

Situation Awareness

How important is 'Situation Awareness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making								x									
Leadership								x									
Teamwork								x									

Decision Making

How important is 'Decision Making' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership										x							
Teamwork										x							

Leadership

How important is 'Leadership' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork										x							

B. Goal: To Select the most important element of teamwork

Teambuilding and maintaining

How important is 'Team Building and maintaining' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Considering others									x								
Supporting others									x								
Communication								x									
Information sharing							x										

Considering others

How important is 'Considering Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Supporting others									x								
Communication								x									
Information sharing									x								

Supporting others

How important is 'Supporting Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Communication								x									
Information sharing									x								

Communication

How important is 'Communication' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Information sharing											x						

C. Goal: To Select the most important element of Leadership and Managerial Skillls

Use of authority and assertiveness

How important is 'Use of authority and assertiveness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Providing and maintaining standards										x							
Planning and co-ordination								x									
Work load management								x									
Prioritisation							x										
Task delegation									x								
Initial Crisis Management								x									

Providing and maintaining standards

How important is 'Providing and maintaining standards' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Planning and co-ordination							x										
Work load management							x										
Prioritisation							x										
Task Delegation								x									
Initial Crisis Management							x										

Planning and co-ordination

How important is 'Planning and Co-ordination' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Work load management										x							
Prioritisation										x							
Task Delegation												x					
Initial Crisis Management											x						

Work load management

How important is 'Workload management' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Prioritisation										x							
Task Delegation										x							
Initial Crisis Management									x								

Prioritisation

How important is 'Prioritisation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Task Delegation									x								
Initial Crisis Management									x								

Task Delegation

How important is 'Task delegation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Initial Crisis Management									x								

D. Goal: To Select the most important element of Situation awareness

Awareness of bridge systems

How important is 'Awareness of bridge systems' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of external environment										x							
Awareness of time										x							
Situation assessment								x									

Awareness of external environment

How important is 'Awareness of external environment' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of time										x							
Situation assessment								x									

Awareness of time

How important is 'Awareness of time' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Situation assessment							x										

E. Goal: To Select the most important element of Decision Making

Problem definition and diagnosis

How important is 'Problem definition and diagnosis' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Option generation										x							
Risk assessment and option selection								x									
Outcome review								x									

Option Generation

How important is 'Option generation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Risk assessment and option selection							x										
Outcome review							x										

Risk assessment and option review

How important is 'Risk assessment and option review' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Outcome review								x									

Table A11.2 - Expert weights - Participant 02

Taxonomy of the Non-technical Skills for Deck Officers in Crisis Situations

A Goal: To Select the most important non-technical skills for deck Officers

Situation Awareness

How important is 'Situation Awareness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making										x							
Leadership								x									
Teamwork											x						

Decision Making

How important is 'Decision Making' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership								x									
Teamwork											x						

Leadership

How important is 'Leadership' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork										x							

B. Goal: To Select the most important element of teamwork

Teambuilding and maintaining

How important is 'Team Building and maintaining' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Considering others								x									
Supporting others								x									
Communication								x									
Information sharing								x									

Considering others

How important is 'Considering Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Supporting others										x							
Communication										x							
Information sharing										x							

Supporting others

How important is 'Supporting Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Communication								x									
Information sharing										x							

Communication

How important is 'Communication' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Information sharing										x							

C. Goal: To Select the most important element of Leadership and Managerial Skillls

Use of authority and assertiveness

How important is 'Use of authority and assertiveness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Providing and maintaining standards										x							
Planning and co-ordination										x							
Work load management										x							
Prioritisation										x							
Task delegation										x							
Initial Crisis Management										x							

Providing and maintaining standards

How important is 'Providing and maintaining standards' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Planning and co-ordination										x							
Work load management										x							
Prioritisation										x							
Task Delegation										x							
Initial Crisis Management										x							

Planning and co-ordination

How important is 'Planning and Co-ordination' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Work load management										x							
Prioritisation										x							
Task Delegation										x							
Initial Crisis Management										x							

Work load management

How important is 'Workload management' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Prioritisation										x							
Task Delegation							x										
Initial Crisis Management										x							

Prioritisation

How important is 'Prioritisation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Task Delegation										x							
Initial Crisis Management										x							

Task Delegation

How important is 'Task delegation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Initial Crisis Management										x							

D. Goal: To Select the most important element of Situation awareness

Awareness of bridge systems

How important is 'Awareness of bridge systems' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of external environment										x							
Awareness of time										x							
Situation assessment										x							

Awareness of external environment

How important is 'Awareness of external environment' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of time								x									
Situation assessment										x							

Awareness of time

How important is 'Awareness of time' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Situation assessment									x								

E. Goal: To Select the most important element of Decision Making

Problem definition and diagnosis

How important is 'Problem definition and diagnosis' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Option generation										x							
Risk assessment and option selection										x							
Outcome review									x								

Option Generation

How important is 'Option generation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Risk assessment and option selection									x								
Outcome review									x								

Risk assessment and option review

How important is 'Risk assessment and option review' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Outcome review									x								

Table A11.3 - Expert weights - Participant 03

Taxonomy of the Non-technical Skills for Deck Officers in Crisis Situations

A. Goal: To Select the most important non-technical skills for deck Officers

Situation Awareness

How important is 'Situation Awareness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making												x					
Leadership									x								
Teamwork									x								

Decision Making

How important is 'Decision Making' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership							x										
Teamwork									x								

Leadership

How important is 'Leadership' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork											x						

B. Goal: To Select the most important element of teamwork

Teambuilding and maintaining

How important is 'Team Building and maintaining' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Considering others										x							
Supporting others									x								
Communication									x								
Information sharing									x								

Considering others

How important is 'Considering Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Supporting others								x									
Communication								x									
Information sharing								x									

Supporting others

How important is 'Supporting Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Communication									x								
Information sharing									x								

Communication

How important is 'Communication' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Information sharing									x								

C. Goal: To Select the most important element of Leadership and Managerial Skillls

Use of authority and assertiveness

How important is 'Use of authority and assertiveness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Providing and maintaining standards							x										
Planning and co-ordination								x									
Work load management								x									
Prioritisation									x								
Task delegation									x								
Initial Crisis Management										x							

Providing and maintaining standards

How important is 'Providing and maintaining standards' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Planning and co-ordination									x								
Work load management								x									
Prioritisation									x								
Task Delegation									x								
Initial Crisis Management							x										

Planning and co-ordination

How important is 'Planning and Co-ordination' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Work load management									x								
Prioritisation										x							
Task Delegation									x								
Initial Crisis Management									x								

Work load management

How important is 'Workload management' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Prioritisation										x							
Task Delegation										x							
Initial Crisis Management									x								

Prioritisation

How important is ‘Prioritisation’ compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Task Delegation								x									
Initial Crisis Management									x								

Task Delegation

How important is ‘Task delegation’ compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Initial Crisis Management								x									

D. Goal: To Select the most important element of Situation awareness

Awareness of bridge systems

How important is 'Awareness of bridge systems' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of external environment									x								
Awareness of time										x							
Situation assessment									x								

Awareness of external environment

How important is 'Awareness of external environment' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of time										x							
Situation assessment									x								

Awareness of time

How important is 'Awareness of time' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Situation assessment								x									

E. Goal: To Select the most important element of Decision Making

Problem definition and diagnosis

How important is ‘Problem definition and diagnosis’ compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Option generation											x						
Risk assessment and option selection									x								
Outcome review									x								

Option Generation

How important is 'Option generation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Risk assessment and option selection								x									
Outcome review								x									

Risk assessment and option review

How important is 'Risk assessment and option review' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Outcome review									x								

Table A11.4 - Expert weights - Participant 04

Taxonomy of the Non-technical Skills for Deck Officers in Crisis Situations

A. Goal: To Select the most important non-technical skills for deck Officers

Situation Awareness

How important is 'Situation Awareness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making										x							
Leadership									x								
Teamwork									x								

Decision Making

How important is 'Decision Making' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership											x						
Teamwork											x						

Leadership

How important is 'Leadership' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork										x							

B. Goal: To Select the most important element of teamwork

Teambuilding and maintaining

How important is 'Team Building and maintaining' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Considering others									x								
Supporting others									x								
Communication									x								
Information sharing									x								

Considering others

How important is 'Considering Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Supporting others										x							
Communication										x							
Information sharing										x							

Supporting others

How important is 'Supporting Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Communication										x							
Information sharing										x							

Communication

How important is 'Communication' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Information sharing										x							

C. Goal: To Select the most important element of Leadership and Managerial Skillls

Use of authority and assertiveness

How important is 'Use of authority and assertiveness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Providing and maintaining standards									x								
Planning and co-ordination										x							
Work load management										x							
Prioritisation										x							
Task delegation										x							
Initial Crisis Management										x							

Providing and maintaining standards

How important is 'Providing and maintaining standards' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Planning and co-ordination									x								
Work load management								x									
Prioritisation									x								
Task Delegation									x								
Initial Crisis Management								x									

Planning and co-ordination

How important is 'Planning and Co-ordination' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Work load management								x									
Prioritisation									x								
Task Delegation									x								
Initial Crisis Management								x									

Work load management

How important is 'Workload management' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Prioritisation									x								
Task Delegation									x								
Initial Crisis Management								x									

Prioritisation

How important is 'Prioritisation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Task Delegation									x								
Initial Crisis Management								x									

Task Delegation

How important is 'Task delegation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Initial Crisis Management								x									

D. Goal: To Select the most important element of Situation awareness

Awareness of bridge systems

How important is 'Awareness of bridge systems' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of external environment									x								
Awareness of time									x								
Situation assessment								x									

Awareness of external environment

How important is 'Awareness of external environment' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of time									x								
Situation assessment										x							

Awareness of time

How important is 'Awareness of time' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Situation assessment									x								

E. Goal: To Select the most important element of Decision Making

Problem definition and diagnosis

How important is 'Problem definition and diagnosis' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Option generation										x							
Risk assessment and option selection										x							
Outcome review									x								

Option Generation

How important is 'Option generation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Risk assessment and option selection										x							
Outcome review									x								

Risk assessment and option review

How important is 'Risk assessment and option review' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Outcome review									x								

Table A11.5: Expert weights - Participant 05

Taxonomy of the Non-technical Skills for Deck Officers in Crisis Situations

A. Goal: To Select the most important non-technical skills for deck Officers

Situation Awareness

How important is 'Situation Awareness' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making											x						
Leadership										x							
Teamwork										X							

Decision Making

How important is 'Decision Making' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership									x								
Teamwork									x								

Leadership

How important is 'Leadership' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork									x								

B. Goal: To Select the most important element of teamwork

Teambuilding and maintaining

How important is 'Team Building and maintaining' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Considering others										x							
Supporting others										x							
Communication								x									
Information sharing									x								

Considering others

How important is 'Considering Others' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Supporting others									x								
Communication								x									
Information sharing									x								

Supporting others

How important is 'Supporting Others' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Communication								x									
Information sharing									x								

Communication

How important is 'Communication' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Information sharing										x							

C. Goal: To Select the most important element of Leadership and Managerial Skillls

Use of authority and assertiveness

How important is 'Use of authority and assertiveness' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Providing and maintaining standards									x								
Planning and co-ordination							x										
Work load management							x										
Prioritisation							x										
Task delegation							x										
Initial Crisis Management						x											

Providing and maintaining standards

How important is 'Providing and maintaining standards' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Planning and co-ordination									x								
Work load management									x								
Prioritisation									x								
Task Delegation								x									
Initial Crisis Management							x										

Planning and co-ordination

How important is 'Planning and Co-ordination' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Work load management									x								
Prioritisation									x								
Task Delegation										x							
Initial Crisis Management							x										

Work load management

How important is 'Workload management' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Prioritisation							x										
Task Delegation									x								
Initial Crisis Management						x											

Prioritisation

How important is 'Prioritisation' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Task Delegation										x							
Initial Crisis Management						x											

Task Delegation

How important is 'Task delegation' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Initial Crisis Management							x										

D. Goal: To Select the most important element of Situation awareness

Awareness of bridge systems

How important is 'Awareness of bridge systems' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of external environment									x								
Awareness of time									x								
Situation assessment							x										

Awareness of external environment

How important is 'Awareness of external environment' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of time									x								
Situation assessment							x										

Awareness of time

How important is 'Awareness of time' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Situation assessment							x										

E. Goal: To Select the most important element of Decision Making

Problem definition and diagnosis

How important is 'Problem definition and diagnosis' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Option generation											x						
Risk assessment and option selection									x								
Outcome review							x										

Option Generation

How important is 'Option generation' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Risk assessment and option selection									x								
Outcome review							x										

Risk assessment and option review

How important is 'Risk assessment and option review' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Outcome review						x											

Table A11.6: Expert weights - Participant 06

Taxonomy of the Non-technical Skills for Deck Officers in Crisis Situations

A. Goal: To Select the most important non-technical skills for deck Officers

Situation Awareness

How important is 'Situation Awareness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making										x							
Leadership								x									
Teamwork									x								

Decision Making

How important is 'Decision Making' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership										x							
Teamwork									x								

Leadership

How important is 'Leadership' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork									x								

B. Goal: To Select the most important element of teamwork

Teambuilding and maintaining

How important is 'Team Building and maintaining' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Considering others									x								
Supporting others									x								
Communication									x								
Information sharing									x								

Considering others

How important is 'Considering Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Supporting others								x									
Communication										x							
Information sharing								x									

Supporting others

How important is 'Supporting Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Communication										x							
Information sharing									x								

Communication

How important is 'Communication' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Information sharing										x							

C. Goal: To Select the most important element of Leadership and Managerial Skillls

Use of authority and assertiveness

How important is 'Use of authority and assertiveness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Providing and maintaining standards											x						
Planning and co-ordination									x								
Work load management									x								
Prioritisation								x									
Task delegation									x								
Initial Crisis Management									x								

Providing and maintaining standards

How important is 'Providing and maintaining standards' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Planning and co-ordination								x									
Work load management								x									
Prioritisation							x										
Task Delegation							x										
Initial Crisis Management							x										

Planning and co-ordination

How important is 'Planning and Co-ordination' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Work load management									x								
Prioritisation								x									
Task Delegation								x									
Initial Crisis Management								x									

Work load management

How important is 'Workload management' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Prioritisation								x									
Task Delegation										x							
Initial Crisis Management								x									

Prioritisation

How important is 'Prioritisation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Task Delegation									x								
Initial Crisis Management								x									

Task Delegation

How important is 'Task delegation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Initial Crisis Management								x									

D. Goal: To Select the most important element of Situation awareness

Awareness of bridge systems

How important is ‘Awareness of bridge systems’ compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of external environment									x								
Awareness of time								x									
Situation assessment									x								

Awareness of external environment

How important is ‘Awareness of external environment’ compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of time								x									
Situation assessment									x								

Awareness of time

How important is 'Awareness of time' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Situation assessment								x									

E. Goal: To Select the most important element of Decision Making

Problem definition and diagnosis

How important is 'Problem definition and diagnosis' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Option generation								x									
Risk assessment and option selection										x							
Outcome review								x									

Option Generation

How important is 'Option generation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Risk assessment and option selection									x								
Outcome review									x								

Risk assessment and option review

How important is 'Risk assessment and option review' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Outcome review									x								

Table A11.7: Expert weights - Participant 07

Taxonomy of the Non-technical Skills for Deck Officers in Crisis Situations

A. Goal: To Select the most important non-technical skills for deck Officers

Situation Awareness

How important is 'Situation Awareness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making											x						
Leadership									x								
Teamwork									x								

Decision Making

How important is 'Decision Making' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership									x								
Teamwork							x										

Leadership

How important is 'Leadership' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork						x											

B. Goal: To Select the most important element of teamwork

Teambuilding and maintaining

How important is 'Team Building and maintaining' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Considering others									x								
Supporting others											x						
Communication											x						
Information sharing									x								

Considering others

How important is 'Considering Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Supporting others									x								
Communication											x						
Information sharing											x						

Supporting others

How important is 'Supporting Others' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Communication									x								
Information sharing									x								

Communication

How important is 'Communication' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Information sharing									x								

C. Goal: To Select the most important element of Leadership and Managerial Skillls

Use of authority and assertiveness

How important is 'Use of authority and assertiveness' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Providing and maintaining standards											x						
Planning and co-ordination														x			
Work load management											x						
Prioritisation											x						
Task delegation									x								
Initial Crisis Management									x								

Providing and maintaining standards

How important is 'Providing and maintaining standards' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Planning and co-ordination					x												
Work load management									x								
Prioritisation									x								
Task Delegation									x								
Initial Crisis Management						x											

Planning and co-ordination

How important is 'Planning and Co-ordination' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Work load management							x										
Prioritisation							x										
Task Delegation							x										
Initial Crisis Management								x									

Work load management

How important is 'Workload management' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Prioritisation							x										
Task Delegation							x										
Initial Crisis Management					x												

Prioritisation

How important is 'Prioritisation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Task Delegation							x										
Initial Crisis Management					x												

Task Delegation

How important is 'Task delegation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Initial Crisis Management					x												

D. Goal: To Select the most important element of Situation awareness

Awareness of bridge systems

How important is 'Awareness of bridge systems' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of external environment							x										
Awareness of time									x								
Situation assessment									x								

Awareness of external environment

How important is 'Awareness of external environment' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of time									x								
Situation assessment								x									

Awareness of time

How important is 'Awareness of time' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Situation assessment									x								

E. Goal: To Select the most important element of Decision Making

Problem definition and diagnosis

How important is 'Problem definition and diagnosis' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Option generation							x										
Risk assessment and option selection							x										
Outcome review									x								

Option Generation

How important is 'Option generation' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Risk assessment and option selection									x								
Outcome review										x							

Risk assessment and option review

How important is 'Risk assessment and option review' compared to ..	Less important								Equally Important	More important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Outcome review									x								

Table A11.8: Expert weights - Participant 08

Taxonomy of the Non-technical Skills for Deck Officers in Crisis Situations

A. Goal: To Select the most important non-technical skills for deck Officers

Situation Awareness

How important is 'Situation Awareness' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Decision Making									x								
Leadership							x										
Teamwork										x							

Decision Making

How important is 'Decision Making' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Leadership									x								
Teamwork											x						

Leadership

How important is	Unimportant								Equally	Important							

‘Leadership’ compared to ..									Important								
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Teamwork											x						

B. Goal: To Select the most important element of teamwork

Teambuilding and maintaining

How important is 'Team Building and maintaining' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Considering others										x							
Supporting others												x					
Communication								x									
Information sharing											x						

Considering others

How important is 'Considering Others' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Supporting others								x									
Communication					x												
Information sharing							x										

Supporting others

How important is ‘Supporting Others’ compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Communication						x											
Information sharing								x									

Communication

How important is ‘Communication’ compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Information sharing								x									

C. Goal: To Select the most important element of Leadership and Managerial Skillls

Use of authority and assertiveness

How important is 'Use of authority and assertiveness' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Providing and maintaining standards															x		
Planning and co-ordination									x								
Work load management												x					
Prioritisation											x						
Task delegation										x							
Initial Crisis Management								x									

Providing and maintaining standards

How important is 'Providing and maintaining standards' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Planning and co-ordination					x												
Work load management						x											
Prioritisation							x										
Task Delegation					x												
Initial Crisis Management			x														

Planning and co-ordination

How important is ‘Planning and Co-ordination’ compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Work load management										x							
Prioritisation											x						
Task Delegation								x									
Initial Crisis Management					x												

Work load management

How important is ‘Workload management’ compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Prioritisation										x							
Task Delegation									x								
Initial Crisis Management					x												

Prioritisation

How important is 'Prioritisation' compared to ..	Unimportant								Equally Important	Important								
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Task Delegation										x								
Initial Crisis Management					x													

Task Delegation

How important is 'Task delegation' compared to ..	Unimportant								Equally Important	Important								
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Initial Crisis Management				x														

D. Goal: To Select the most important element of Situation awareness

Awareness of bridge systems

How important is ‘Awareness of bridge systems’ compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of external environment									x								
Awareness of time											x						
Situation assessment							x										

Awareness of external environment

How important is ‘Awareness of external environment’ compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Awareness of time											x						
Situation assessment								x									

Awareness of time

How important is	Unimportant	Equally	Important

‘Awareness of time’ compared to ..									Important								
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Situation assessment					x												

E. Goal: To Select the most important element of Decision Making

Problem definition and diagnosis

How important is 'Problem definition and diagnosis' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Option generation									x								
Risk assessment and option selection									x								
Outcome review									x								

Option Generation

How important is 'Option generation' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Risk assessment and option selection									x								
Outcome review									x								

Risk assessment and option review

How important is 'Risk assessment and option review' compared to ..	Unimportant								Equally Important	Important							
	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1	2	3	4	5	6	7	8	9
Outcome review									x								

Appendix 12: Group 1 - 17th April 2013 – AM (NO HELM)

Table A12.1: Teamworking (Group 1)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others			x			Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members		x				Ignores suggestions of other team members
	Considers condition of other team members into account				x		Does not take account of the condition of other team members
	Provide detailed personal feedback				x		Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation			x			Do not help other team members in demanding situation
	Offers very good assistance			x			Does not offer assistance
Communication	Establish total atmosphere for open communication				x		Blocks open communication
	Communicates very effectively				x		Ineffective communication
Information sharing	Shares information among all team members			x			Does not share information properly among all team members

Table A12.2: Leadership and Managerial Skills (Group 1)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion				x		Hinders or withholds crew involvement.
	Takes full control if situation requires					x	Does not show initiative for decision
	Totally reflects on suggestions of others			x			Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance			x			Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x			Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed				x		Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion				x		Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue				x		Ignores signs of fatigue
	Allots good time to complete tasks					x	Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks				x		Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly					x	Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly					x	Does not identify initial crisis situation

Table A12.3: Situation Awareness (Group 1)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states			x			Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)				x		Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members			x			Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members				x		Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation					x	Does not make an assessment of changing situation

Table A12.4: Decision making (Group 1)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem		x				Failure to diagnose the problem
	Review all casual factors with other crew members				x		No discussion of probable cause
Option generation	States all alternative option					x	Does not search for information
	Asks crew members for all options				x		Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options				x		No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action			x			Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan					x	Fails to check selected outcome against plan

Appendix 13: Group 2 - 18th April 2013 – AM (NO HELM)

Table A13.1: Teamworking (Group 2)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others			x			Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members				x		Ignores suggestions of other team members
	Considers condition of other team members into account			x			Does not take account of the condition of other team members
	Provide detailed personal feedback					x	Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation				x		Do not help other team members in demanding situation
	Offers very good assistance				x		Does not offer assistance
Communication	Establish total atmosphere for open communication			x			Blocks open communication
	Communicates very effectively			x			Ineffective communication
Information sharing	Shares information among all team members			x			Does not share information properly among all team members

Table A13.2: Leadership and Managerial Skills (Group 2)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion			x			Hinders or withholds crew involvement.
	Takes full control if situation requires			x			Does not show initiative for decision
	Totally reflects on suggestions of others				x		Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance				x		Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x			Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed			x			Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion			x			Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue					x	Ignores signs of fatigue
	Allots good time to complete tasks				x		Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks				x		Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly				x		Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly				x		Does not identify initial crisis situation

Table A13.3: Situation Awareness (Group 2)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states				x		Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)				x		Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members			x			Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members					x	Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation				x		Does not make an assessment of changing situation

Table A13.4: Decision making (Group 2)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem				x		Failure to diagnose the problem
	Review all casual factors with other crew members				x		No discussion of probable cause
Option generation	States all alternative option				x		Does not search for information
	Asks crew members for all options				x		Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options				x		No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action				x		Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan					x	Fails to check selected outcome against plan

Appendix 14: Group 3 - 19th April 2013 – All Day (NO HELM)

Table A14.1: Teamworking (Group 3)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others				x		Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members			x			Ignores suggestions of other team members
	Considers condition of other team members into account				x		Does not take account of the condition of other team members
	Provide detailed personal feedback				x		Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation			x			Do not help other team members in demanding situation
	Offers very good assistance			x			Does not offer assistance
Communication	Establish total atmosphere for open communication			x			Blocks open communication
	Communicates very effectively			x			Ineffective communication
Information sharing	Shares information among all team members				x		Does not share information properly among all team members

Table A14.2: Leadership and Managerial Skills (Group 3)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion			x			Hinders or withholds crew involvement.
	Takes full control if situation requires				x		Does not show initiative for decision
	Totally reflects on suggestions of others			x			Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance				x		Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x			Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed				x		Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion			x			Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue				x		Ignores signs of fatigue
	Allots good time to complete tasks					x	Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks			x			Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly					x	Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly				x		Does not identify initial crisis situation

Table A14.3: Situation Awareness (Group 3)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states			x			Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)				x		Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members				x		Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members			x			Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation			x			Does not make an assessment of changing situation

Table A14.4: Decision making (Group 3)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem				x		Failure to diagnose the problem
	Review all casual factors with other crew members				x		No discussion of probable cause
Option generation	States all alternative option			x			Does not search for information
	Asks crew members for all options			x			Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options				x		No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action			x			Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan			x			Fails to check selected outcome against plan

Appendix 15: Group 4 - 07th May 2013 – AM (NO HELM)

Table A15.1: Teamworking (Group 4)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others			x			Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members			x			Ignores suggestions of other team members
	Considers condition of other team members into account				x		Does not take account of the condition of other team members
	Provide detailed personal feedback					x	Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation				x		Do not help other team members in demanding situation
	Offers very good assistance				x		Does not offer assistance
Communication	Establish total atmosphere for open communication				x		Blocks open communication
	Communicates very effectively					x	Ineffective communication
Information sharing	Shares information among all team members					x	Does not share information properly among all team members

Table A15.2: Leadership and Managerial Skills (Group 4)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion					x	Hinders or withholds crew involvement.
	Takes full control if situation requires				x		Does not show initiative for decision
	Totally reflects on suggestions of others				x		Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance				x		Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x			Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed			x			Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion				x		Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue					x	Ignores signs of fatigue
	Allots good time to complete tasks				x		Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks				x		Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly				x		Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly					x	Does not identify initial crisis situation

Table A15.3: Situation Awareness (Group 4)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states				x		Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)					x	Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members				x		Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members				x		Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation					x	Does not make an assessment of changing situation

Table A15.4: Decision making (Group 4)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem					x	Failure to diagnose the problem
	Review all casual factors with other crew members				x		No discussion of probable cause
Option generation	States all alternative option				x		Does not search for information
	Asks crew members for all options			x			Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options					x	No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action					x	Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan					x	Fails to check selected outcome against plan

Appendix 16: Group 5 - 08th May 2013 – PM (NO HELM)

Table A16.1: Teamworking (Group 5)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others			x			Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members		x				Ignores suggestions of other team members
	Considers condition of other team members into account				x		Does not take account of the condition of other team members
	Provide detailed personal feedback				x		Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation			x			Do not help other team members in demanding situation
	Offers very good assistance			x			Does not offer assistance
Communication	Establish total atmosphere for open communication			x			Blocks open communication
	Communicates very effectively			x			Ineffective communication
Information sharing	Shares information among all team members			x			Does not share information properly among all team members

Table A16.2: Leadership and Managerial Skills (Group 5)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion			x			Hinders or withholds crew involvement.
	Takes full control if situation requires			x			Does not show initiative for decision
	Totally reflects on suggestions of others			x			Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance				x		Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x			Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed				x		Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion				x		Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue				x		Ignores signs of fatigue
	Allots good time to complete tasks				x		Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks				x		Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly				x		Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly				x		Does not identify initial crisis situation

Table A16.3: Situation Awareness (Group 5)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states			x			Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)				x		Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members			x			Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members					x	Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation			x			Does not make an assessment of changing situation

Table A16.4: Decision making (Group 5)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem			x			Failure to diagnose the problem
	Review all casual factors with other crew members				x		No discussion of probable cause
Option generation	States all alternative option					x	Does not search for information
	Asks crew members for all options				x		Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options					x	No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action				x		Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan				x		Fails to check selected outcome against plan

Appendix 17: Group 6 - 09th May 2013 – All Day (NO HELM)

Table A17.1: Teamworking (Group 6)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others			x			Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members			x			Ignores suggestions of other team members
	Considers condition of other team members into account	x					Does not take account of the condition of other team members
	Provide detailed personal feedback				x		Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation		x				Do not help other team members in demanding situation
	Offers very good assistance			x			Does not offer assistance
Communication	Establish total atmosphere for open communication		x				Blocks open communication
	Communicates very effectively		x				Ineffective communication
Information sharing	Shares information among all team members		x				Does not share information properly among all team members

Table A17.2: Leadership and Managerial Skills (Group 6)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion			x			Hinders or withholds crew involvement.
	Takes full control if situation requires		x				Does not show initiative for decision
	Totally reflects on suggestions of others			x			Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance		x				Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x			Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed		x				Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion		x				Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue			x			Ignores signs of fatigue
	Allots good time to complete tasks			x			Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks			x			Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly	x					Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly			x			Does not identify initial crisis situation

Table A17.3: Situation Awareness (Group 6)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states				x		Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)		x				Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members		x				Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members				x		Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation		x				Does not make an assessment of changing situation

Table A17.4: Decision making (Group 6)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem		x				Failure to diagnose the problem
	Review all casual factors with other crew members			x			No discussion of probable cause
Option generation	States all alternative option			x			Does not search for information
	Asks crew members for all options				x		Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options				x		No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action				x		Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan				x		Fails to check selected outcome against plan

Appendix 18: Group 7 - 05th August 2013 – AM (WITH HELM)

Table A18.1: Teamworking (Group 7)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others			x			Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members		x				Ignores suggestions of other team members
	Considers condition of other team members into account		x	x			Does not take account of the condition of other team members
	Provide detailed personal feedback				x		Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation		x	x			Do not help other team members in demanding situation
	Offers very good assistance		x	x			Does not offer assistance
Communication	Establish total atmosphere for open communication			x			Blocks open communication
	Communicates very effectively				x		Ineffective communication
Information sharing	Shares information among all team members			x	x		Does not share information properly among all team members

Table A18.2: Leadership and Managerial Skills (Group 7)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion			x			Hinders or withholds crew involvement.
	Takes full control if situation requires			x			Does not show initiative for decision
	Totally reflects on suggestions of others			x			Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance			x	x		Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x	x		Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed			x	x		Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion				x		Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue				x		Ignores signs of fatigue
	Allots good time to complete tasks			x			Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks			x			Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly			x	x		Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly			x			Does not identify initial crisis situation

Table A18.3: Situation Awareness (Group 7)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states		x				Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)		x				Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members		x	x			Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members			x			Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation			x			Does not make an assessment of changing situation

Table A18.4: Decision making (Group 7)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem		x	x			Failure to diagnose the problem
	Review all casual factors with other crew members			x	x		No discussion of probable cause
Option generation	States all alternative option			x			Does not search for information
	Asks crew members for all options					x	Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options				x		No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action			x			Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan				x		Fails to check selected outcome against plan

Appendix 19: Group 8 - 05th August 2013 – PM (WITH HELM)

Table A19.1: Teamworking (Group 8)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others				x		Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members				x		Ignores suggestions of other team members
	Considers condition of other team members into account				x		Does not take account of the condition of other team members
	Provide detailed personal feedback					x	Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation					x	Do not help other team members in demanding situation
	Offers very good assistance				x	x	Does not offer assistance
Communication	Establish total atmosphere for open communication				x		Blocks open communication
	Communicates very effectively				x		Ineffective communication
Information sharing	Shares information among all team members				x		Does not share information properly among all team members

Table A19.2: Leadership and Managerial Skills (Group 8)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion				x		Hinders or withholds crew involvement.
	Takes full control if situation requires					x	Does not show initiative for decision
	Totally reflects on suggestions of others			x			Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance				x	x	Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion				x	x	Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed				x		Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion				x	x	Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue					x	Ignores signs of fatigue
	Allots good time to complete tasks				x		Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks				x		Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly			x	x		Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly					x	Does not identify initial crisis situation

Table A19.3: Situation Awareness (Group 8)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states			x	x		Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)			x	x		Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members				x	x	Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members				x	x	Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation					x	Does not make an assessment of changing situation

Table A19.4: Decision making (Group 8)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem				x	x	Failure to diagnose the problem
	Review all casual factors with other crew members				x	x	No discussion of probable cause
Option generation	States all alternative option					x	Does not search for information
	Asks crew members for all options				x	x	Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options				x	x	No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action					x	Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan				x	x	Fails to check selected outcome against plan

Appendix 20: Group 9 - 07th August 2013 – All Day (WITH HELM)

Table A20.1: Teamworking (Group 9)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others			x			Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members			x	x		Ignores suggestions of other team members
	Considers condition of other team members into account			x			Does not take account of the condition of other team members
	Provide detailed personal feedback					x	Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation				x		Do not help other team members in demanding situation
	Offers very good assistance				x	x	Does not offer assistance
Communication	Establish total atmosphere for open communication			x	x		Blocks open communication
	Communicates very effectively				x		Ineffective communication
Information sharing	Shares information among all team members				x	x	Does not share information properly among all team members

Table A20.2: Leadership and Managerial Skills (Group 9)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion				x		Hinders or withholds crew involvement.
	Takes full control if situation requires				x	x	Does not show initiative for decision
	Totally reflects on suggestions of others			x	x		Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance				x		Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x	x		Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed				x	x	Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion			x	x		Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue				x		Ignores signs of fatigue
	Allots good time to complete tasks			x			Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks				x		Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly			x		x	Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly				x		Does not identify initial crisis situation

Table A20.3: Situation Awareness (Group 9)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states			x			Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)				x		Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members				x		Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members				x		Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation				x		Does not make an assessment of changing situation

Table A20.4: Decision making (Group 9)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem				x	x	Failure to diagnose the problem
	Review all casual factors with other crew members			x	x		No discussion of probable cause
Option generation	States all alternative option				x		Does not search for information
	Asks crew members for all options			x			Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options				x		No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action			x	x		Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan				x		Fails to check selected outcome against plan

Appendix 21: Group 10 - 27th November 2013 – (WITH HELM)

Table A21.1: Teamworking (Group 10)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others			x			Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members			x			Ignores suggestions of other team members
	Considers condition of other team members into account						Does not take account of the condition of other team members
	Provide detailed personal feedback				x		Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation		x	x			Do not help other team members in demanding situation
	Offers very good assistance			x			Does not offer assistance
Communication	Establish total atmosphere for open communication		x	x			Blocks open communication
	Communicates very effectively			x			Ineffective communication
Information sharing	Shares information among all team members			x			Does not share information properly among all team members

Table A21.2: Leadership and Managerial Skills (Group 10)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion			x			Hinders or withholds crew involvement.
	Takes full control if situation requires				x		Does not show initiative for decision
	Totally reflects on suggestions of others			x	x		Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance			x	x		Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x			Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed			x			Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion		x	x			Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue						Ignores signs of fatigue
	Allots good time to complete tasks			x			Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks			x			Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly				x	x	Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly				x		Does not identify initial crisis situation

Table A21.3: Situation Awareness (Group 10)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states			x	x		Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)		x	x	x		Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members		x	x			Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members				x		Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation			x	x		Does not make an assessment of changing situation

Table A21.4: Decision making (Group 10)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem			x	x		Failure to diagnose the problem
	Review all casual factors with other crew members			x	x		No discussion of probable cause
Option generation	States all alternative option			x	x		Does not search for information
	Asks crew members for all options			x	x		Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options				x		No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action			x			Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan				x		Fails to check selected outcome against plan

Appendix 22: Group 11 – 28th November AM (WITH HELM)

Table A22.1: Teamworking (Group 11)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others		x				Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members		x				Ignores suggestions of other team members
	Considers condition of other team members into account						Does not take account of the condition of other team members
	Provide detailed personal feedback						Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation			x			Do not help other team members in demanding situation
	Offers very good assistance			x			Does not offer assistance
Communication	Establish total atmosphere for open communication			x			Blocks open communication
	Communicates very effectively			x			Ineffective communication
Information sharing	Shares information among all team members		x	x			Does not share information properly among all team members

Table A22.2: Leadership and Managerial Skills (Group 11)

Element	**Very Good Practice**	**5**	**4**	**3**	**2**	**1**	**Very Poor Practice**
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion			x			Hinders or withholds crew involvement.
	Takes full control if situation requires			x	x		Does not show initiative for decision
	Totally reflects on suggestions of others		x	x			Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance			x			Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion						Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed						Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion			x			Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue						Ignores signs of fatigue
	Allots good time to complete tasks			x			Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks			x			Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly				x		Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly				x		Does not identify initial crisis situation

Table A22.3: Situation Awareness (Group 11)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states		x		x		Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)			x	x		Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members		x		x		Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members			x	x		Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation			x	x		Does not make an assessment of changing situation

Table A22.4: Decision making (Group 11)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem		x				Failure to diagnose the problem
	Review all casual factors with other crew members			x			No discussion of probable cause
Option generation	States all alternative option				x		Does not search for information
	Asks crew members for all options				x		Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options				x		No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action			x			Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan			x			Fails to check selected outcome against plan

Appendix 23: Group 12 – 28th November 2013 – PM (WITH HELM)

Table A23.1: Teamworking (Group 12)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Team building and maintaining	Fully encourages input and feedback from others			x	x		Keeps barriers between team members
Considering others	Take notice of the suggestions of other team members			x	x		Ignores suggestions of other team members
	Considers condition of other team members into account						Does not take account of the condition of other team members
	Provide detailed personal feedback						Show no reaction to other team members
Supporting others	Provide ample help to other team members in demanding situation			x			Do not help other team members in demanding situation
	Offers very good assistance			x			Does not offer assistance
Communication	Establish total atmosphere for open communication		x	x			Blocks open communication
	Communicates very effectively		x	x			Ineffective communication
Information sharing	Shares information among all team members			x	x		Does not share information properly among all team members

Table A23.2: Leadership and Managerial Skills (Group 12)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Use of Authority and assertiveness	Takes full initiative to ensure crew involvement and task completion			x			Hinders or withholds crew involvement.
	Takes full control if situation requires				x		Does not show initiative for decision
	Totally reflects on suggestions of others			x	x		Ignores suggestions of others
Providing and Maintaining standards	Demonstrates complete will to achieve top performance			x	x		Does not care for performance effectiveness.
Planning and Co-ordination	Completely encourages crew participation in planning and task completion			x			Does not encourage crew participation in planning and task completion
	Plan is well clearly stated and confirmed						Plan is not clearly stated and confirmed
	Well clearly states goals and boundaries for task completion			x	x		Goals and boundaries remain unclear
Workload Management	Completely notifies signs of stress and fatigue						Ignores signs of fatigue
	Allots good time to complete tasks			x			Allots very little time to complete tasks
Prioritisation	Demonstrate very good prioritisation of tasks			x			Demonstrate no prioritisation of tasks
Task Delegation	Delegates all tasks properly				x		Does not delegate tasks
Initial crisis management	Identifies initial crisis situation very quickly and respond accordingly				x	x	Does not identify initial crisis situation

Table A23.3: Situation Awareness (Group 12)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Awareness of bridge systems	Fully monitors and report changes in systems' states				x	x	Do not monitors changes in systems' states
Awareness of external environment	Collects full information about environment (own ship's position, traffic and weather)			x	x		Does not collect information about environment (own ship's position, traffic and weather)
	Shares complete key information about environment with team members			x	x		Does not share key information about environment with crew
Awareness of time	Fully discuss time constraints with other team members				x		Does not discuss time constraints with other CM
Situation Assessment	Makes full assessment of changing situation					x	Does not make an assessment of changing situation

Table A23.4: Decision making (Group 12)

Element	Very Good Practice	5	4	3	2	1	Very Poor Practice
Problem definition and diagnosis	Gather all information to identify problem				x	x	Failure to diagnose the problem
	Review all casual factors with other crew members				x		No discussion of probable cause
Option generation	States all alternative option				x		Does not search for information
	Asks crew members for all options				x	x	Does not ask crew for alternatives
Risk Assessment and option selection	Considers and shares all estimated risk of alternative options					x	No discussion of limiting factors with crew
	Confirms and states all selected options/agreed action					x	Does not inform crew of decision path being taken
Outcome review	Complete checking of outcome against plan				x	x	Fails to check selected outcome against plan

Appendix 24: PUBLISHED WORK AS A RESULT OF THIS RESEARCH

The following work has been published as a result of this research;

SAEED, F. and RIAHI, R. (2014) "Development of taxonomy for deck officers' non-technical skills (NTS) and analysing training needs for human element, leadership and management (HELM) course", International Association of Maritime Universities (IAMU) funded project (FY2013-2), ISBN 978-4-907408-60-0

SAEED, F. (2014) "Enhancement of non-technical skills training for deck officers" International Association of Maritime Universities (IAMU) 15th Annual general assembly, 27-29 October, Australian Maritime College, Launceston, Tasmania, Australia.

SAAED, F. (2013) "An analysis of Human Element Leadership and Management (HELM) training course" (2013), International Maritime Lecturers Association (IMLA) Conference 9/13 October 2013, St. Johns, Canada.

SAEED, F. (2010) "Importance of the non-technical skills in the maritime education" (2010), International Association of Maritime Universities (IAMU) Conference 14-18 October 2010, Busan, South Korea.