A Decision-Making Framework for Assessing the Safety Culture of Maritime Organizations with Commercial Cargo-Carrying Vessels

by

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Declaration

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for the examination, which has led to the award of a degree.

Signed: Chigozie U Odumodu Date: 27th of July 2023

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Glossary

Assessment: The process and result of analyzing systematically and evaluating the hazards associated with sources and practices and associated protection and safety measures (IAEA, 2018).

Criteria Weights: A quantitative value that specifies the relative importance of one criterion over another in decision making. The act of determining the weights of criteria's in a decision-making model is called priority setting.

Decision-Making: The cognitive process of deciding what course of action to follow. It also entails exploring the decision problem or the available opportunity to decide on a course of action to follow (Herbert Simon, 1965).

Priority Setting: Same with Criteria Weights

Safety Climate: A summary of molar perceptions that employees share about their work environment. It is a snapshot of employees' perceptions, attitudes, and beliefs about safety at a certain point in time, usually obtained by a safety culture survey (Zohar, 1980).

Safety Culture:

1. That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, [nuclear plant] safety issues receive the attention warranted by their significance (UNSCEAR, 1988).
2. The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management (ACSNI,1991).

Safety Decision-Making:	A decision-making process or problem-solving process for managing safety-related issues or problems (Hale, A., Hemning, B., Carthey, J., & Kirwan, 1994). It is also called a problem-solving cycle which provides decision-makers with a step-wise procedure for analyzing and making decisions on safety problems caused by potential or actual deviations from desired, expected, or planned achievements (Hale, A., Hemning, B., Carthey, J., & Kirwan, 1994).
Safety Factors:	This refers to important dimensions or aspects of safety culture, such as effective communications or safety awareness, used in the assessment of safety culture. There is no agreed way to segment safety culture, and so no definitive set of safety factors exists. The ABS safety culture survey questionnaire is based on eight safety factors that were derived after an ABS-funded research was conducted with leading clients of the maritime industry (ABS, 2012).
Self-Assessment:	A routine and continuing process conducted by senior management or management to evaluate the effectiveness of performance in all areas of their responsibilities. Self-Assessment provides an overall view of the performance of the organization and the degree of maturity of the management system. It also helps to identify areas of improvement in the organization, to determine priorities, and to set a baseline for further improvement (IAEA, 2018).

Abbreviations

ABS	American Bureau of Shipping
AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
DM	Decision Makers
IAEA	International Atomic Energy Agency
ISM	International Safety Management Code
IMO	International Maritime Organization
MCDM	Multiple-Criteria Decision-Making
MCDA	Multiple-Criteria Decision-Analysis
MADM	Multi-Attribute Decision Making
MODM	Multi-Objective Decision Making
SAW	Simple Additive Weighting
SC	Safety Culture
SMS	Safety Management System
TOPSIS	The Technique for Order of Preference by Similarity to Ideal Solution

Abstract

Maritime safety culture is currently one of the most important aspects of shipping. It enables maritime administrators to assess and manage safety-related issues proactively. However, most maritime organisations have not been able to effectively assess and manage safety-related issues proactively because of the challenges associated with the availability of safety performance data and the suitability of correlational statistical techniques used in safety culture assessments. Hence, researchers and professionals constantly debate which correlational statistical technique would be most suitable for assessing safety culture.

This thesis aims to contribute to safety culture assessment from a methodological perspective of developing a decision-making framework for assessing maritime safety culture. Therefore, this PhD study offers an original contribution to knowledge regarding the application of decision-making techniques in a way that researchers have not previously done in assessing the safety culture of maritime organisations with commercial cargo-carrying vessels.

Consequently, the integrated decision-making methodology adopted for this study entailed: the application of Analytical Hierarchy Process (AHP) in establishing weightage and priority setting of safety factors used in further assessments; the application of Simple Additive Weighting (SAW) in establishing the weighted safety climate performance of both shoreside staff and shipboard staff; the application of Pareto analysis in justifying the findings of the weighted safety climate and gaining insights into issues concerning occupational health and safety, ship safety, and shore-to-ship safety; and the application of Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) in scheduling vessels for safety culture improvement programs.

The established weightage and priority setting of safety factors are: COMMUNICATION (COM) 0.15, EMPOWERMENT (EMP) 0.13, FEEDBACK (FDB) 0.11, MUTUAL TRUST (MTR) 0.11, PROBLEM IDENTIFICATION (PID) 0.13, PROMOTION OF SAFETY (POS) 0.12, RESPONSIVENESS (RSP) 0.11, and SAFETY AWARENESS (SAW) 0.14. Subsequently, the weighted safety climate performance of shoreside staff were: (COM) 0.651, EMPOWERMENT (EMP) 0.528, FEEDBACK (FDB) 0.418, MUTUAL TRUST (MTR) 0.365, PROBLEM IDENTIFICATION (PID) 0.543, PROMOTION OF SAFETY

(POS) 0.451, RESPONSIVENESS (RSP) 0.448, and SAFETY AWARENESS (SAW) 0.515; while those of shipboard staff were: COMMUNICATION (COM) 0.570, EMPOWERMENT (EMP) 0.523, FEEDBACK (FDB) 0.432, MUTUAL TRUST (MTR) 0.419, PROBLEM IDENTIFICATION (PID) 0.517, PROMOTION OF SAFETY (POS) 0.458, RESPONSIVENESS (RSP) 0.441, and SAFETY AWARENESS (SAW) 0.601.

Furthermore, Pareto analysis revealed that amongst all the feedback statements reviewed, MUTUAL TRUST (MTR) represents 30% of the safety factors attributed to feedback statements that are responsible for 70% of the least performing safety factors found in the weighted safety climate of shipboard staff, while PROMOTION OF SAFETY (POS) and PROBLEM IDENTIFICATION (PID) represent 30% of the safety factors attributed to feedback statements that are responsible for 70% of the least performing safety factors found in the weighted safety climate of shipboard staff. Finally, the TOPSIS methodology was applied to provide maritime administrators with a vessel's ranking, from the least performing to the most performing, for safety culture improvement programs as follows: MT DIDI (0.0908), MT SEA ADVENTURER (0.1124), MT SEAS GRACE (0.1726), MT UMBALWA (0.1815), MT SEA PROGRESS (0.2307), MT SEA VOYAGER (0.3816), MT ASHABI (0.4693), MT MOSUNMOLA (0.5365), MT AMIF (0.9243), and MT KINGIS (1.0000).

Conclusively, this thesis adequately demonstrates how decision-making techniques can be simply and successfully applied in assessing the safety culture of maritime organisations without encountering the challenges associated with the availability of safety performance data and the suitability of correlational statistical techniques. It also demonstrated how safety culture could be assessed and managed like other areas of the organisation and business: thereby making safety culture more assessable to continuous improvement programs of maritime organisations with commercial cargo-carrying vessels.

1 Introduction

1.1 Introduction

This chapter provides the background information that sets the agenda for the research presented in this thesis. This chapter also provides a summary of the contents covered in other chapters of this thesis to clarify how this thesis was carried out and presented.

1.2 Background and Importance of the Subject

Shipping is one of the oldest means of transportation; it has also played a significant role in the development of human civilizations for thousands of years by meeting the needs of human travel and the movement of goods from one place to another (Paine, 2015). Shipping provides a cost-effective means for transporting large volumes of goods around the world. It is also vital to international and intercontinental trade, thereby making shipping the lifeblood of the global economy as no country is completely self-sufficient, and every country relies on maritime trade to sell what it has and buy what it needs (UN, 2016; ICS, 2019). Without shipping, intercontinental trade would simply not be possible because much of what is consumed daily in most countries usually needs to be transported by sea in the form of raw materials, components, or finished articles; hence, most countries in the world benefit from shipping as it helps ensure that the benefits of trade and commerce are evenly spread (ICS, 2019). Shipping and seaborne trade have also made the world an integrated global community. Figure 1 below shows the main shipping routes used for intercontinental trade.

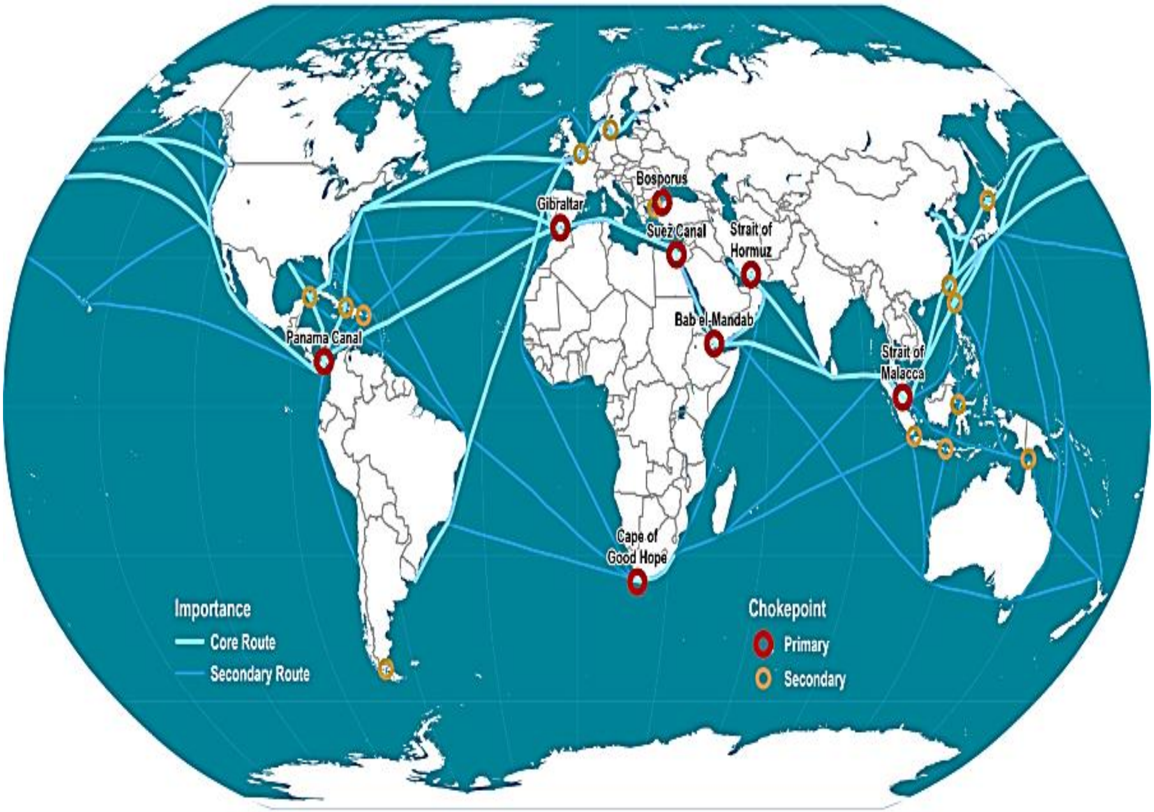

Figure 1: Main maritime shipping routes

(Jean-Paul Rodrigue, 2020)

Shipping is also perhaps the most important type of transportation for goods in the world, as approximately 90% of all goods are transported via the sea (IMO, 2019; Jean-Paul Rodrigue, 2020). It is the most international of the world's great industries and also one of the most dangerous because of the complexities involved in the design, construction, operation, maintenance, and management of ships (IMO, 2019). The industry also has a global fleet size of over 50,000 ships and is principally regulated by the International Maritime Organization (ICS, 2019).

The responsibilities of the International Maritime Organization are "to provide machinery for cooperation among governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, the efficiency of navigation and prevention and control of marine pollution from ships" (IMO, 2019; Rothwell, Elferink, Scott, & Stephens, 2015).

In regulating shipping, the International Maritime Organization (IMO) has also always assumed that the best way to improve safety at sea is by developing international regulations for all shipping nations to follow (IMO, 2019; Fedi, 2021). Hence, the general approaches adopted towards improving safety at sea have generally been reactive as lessons needed to be learned from accidents, disasters, and catastrophes before any regulation on management and technology can be developed or implemented for any type of waterborne transportation (IMO, 2019). However, while many relevant accidents have taken place, it was the capsizing of the MS Herald of Free Enterprise in 1987 that further highlighted the need for a proactive approach towards safety in shipping. The MS Herald of Free Enterprise disaster also further highlighted the contribution of both human and organizational factors to accidents in the maritime industry. Hence, the IMO responded to this need with the adoption of resolution A.647 (16), which later evolved to become the International Safety Management Code (IMO, 1989; Batalden & Sydnes , 2014).

The International Safety Management (ISM) Code provides maritime organizations with an international standard for the safe management of ships and the prevention of pollution at sea. The ISM code also made provisions for the establishment of a Safety Management System (SMS) to ensure that conditions, activities, and tasks that affect safety and the environment are properly planned, organized, executed, and checked to reduce or eliminate the possibility of accidents to be caused by human errors (Goulielmos & Goulielmos, 2005; Karakasnaki, Vlachopoulos, Pantouvakis, & Bouranta , 2018) However, the ISM code has also been perceived as just a paper-based exercise that does not influence the attitude or behaviour of both shipboard and shoreside staff towards safety. Hence, this perception gave rise to an increased interest in human factors from the perspective of safety culture and its influence on the operation and management of vessels (Baatz, 2017; Fedi, 2021).

This perspective was further expanded to cover the unique features needed for describing safety culture within the maritime industry and how maritime safety culture could be assessed, managed, or enhanced to improve the safety performance of vessels. The concept of safety culture was further explored within the shipping industry by the American Bureau of Shipping (ABS) and Lamar University in producing the first guidance notes for the assessment of safety culture in maritime organizations (Pray, McSweeney, & Tomlinson, 2014). The guidance note developed by the American Bureau of Shipping (ABS) also detailed the process of assessing, benchmarking, and improving safety metrics that influences the safety culture and safety performance of maritime organizations with cargo-carrying commercial vessels. Hence, the guidance note for assessing the safety culture of maritime organizations forms the basis of this research study, and the next section highlights areas of concern and motivation for research on the development of a decision-making framework for assessing the safety culture of maritime organizations with commercial cargo-carrying vessels.

1.3 Research Motivation

The safety culture of organizations reflects beliefs, values and attitudes towards safety shared by most people working in an organization or workplace. It is also a reflection of the effectiveness of the safety management system utilized by an organization. The assessment of safety culture allows an organization to understand better how its people perceive safety and the company's approach towards health and safety management. The traditional approach to assessing safety culture is primarily qualitative (e.g., focus groups, interviews) with some quantitative aspects (e.g., experiments, surveys) to ensure the reliability and validity of the results obtained from the qualitative aspect of the assessment (Taylor, 2010; ABS, 2014; Arslan, Turan, Kurt, & Wolff, 2016).

Several studies such as these (Taylor, 2010; Hamid, Suhaimi, & Ismail, 2021; Hon, Hinze, & Chan, 2014; Kouabenan, Ngueutsa , & Mbaye, 2015; Tomlinson, Craig, & McSweeney, 2016; Sparer, Murphy, Taylor, & Dennerlein, 2013; Shea, Cieri, Vu, & Pettit, 2021; Miller & Ng, 2016) show that correlational statistical techniques as Pearson correlation, Spearman correlation and Kendall rank correlation, have mainly been used traditionally in the quantitative aspects of safety culture assessments to measure the strength of the relationship between the performance of safety factors (metrics) derived from survey results and the actual 'safety performance data collected from the assessed organization.

Furthermore, other studies as (Hauke & Kossowski, 2011; Puth, Neuhäuser, & Ruxton, 2015; Xu, Hou, Hung, & Zou, 2013; Fredricks & Nelsen, 2007; Croux & Dehon, 2010) show that different correlational statistical techniques often yield different values and interpretations given the same set of survey data. Hence, this creates substantial disagreements amongst researchers and professionals on the suitability and reliability of correlational statistical techniques in assessing organisations' safety culture.

The different values and interpretations given from different correlational statistical techniques have also made the assessment of safety culture in a maritime organization a complex decision-making issue as maritime administrators find it challenging to interpret and translate findings of safety culture surveys into activities to enhance the safety culture of the assessed organization (Clarke, 2006). Hence, making it is necessary for the assessment of safety culture in maritime organizations to be explored through some decision-making process that would make it less difficult for maritime administrators to interpret and translate the findings of safety culture surveys.

Consequently, the ideal decision-making process for assessing safety culture would not rely on the application of correlational statistical techniques but would rather depend on the elicitation of weights for safety metrics (safety factors) from maritime experts and the perceptions of both shoreside and shipboard staff towards safety to provide maritime administrators with the needed decision making output and insight to easily interpret and translate the findings of safety culture survey into activities to enhance safety culture of the assessed maritime organization.

1.4 Research Questions

Based on the above-mentioned issues and research motivation, the main research question formulated for this study is:

- How can an appropriate decision-making framework be designed to assess and manage the safety culture of maritime organizations?

The additional questions derived to explain the main research questions in depth are:

- How is safety culture assessed in maritime organizations?
- How can decision-making models be integrated to assess and manage the safety culture of maritime organizations?
- How would the weights and priority setting of safety factors that influence the safety culture of maritime organizations across Nigeria be explored and established?
- What are the attitudes amongst shore-side and shipboard staff towards safety in a selected case study maritime organization in Nigeria?
- How would activities be scheduled to improve the performance of safety factors and safety culture?
- How would vessels in the assessed vessel fleet be scheduled for safety culture improvement programs?
- How would decision-making models be integrated to identify, track and schedule improvement activities for safety factors that influence the safety culture of maritime organizations?

1.5 Research Aim

From the above-stated research questions, the main aim of this research is to develop a decision-making framework for assessing the safety culture of maritime organizations.

The decision-making framework would enable decision-makers to assess the safety culture of maritime organizations without the reliance on correlational statistical techniques, learn about the values of safety factors (metrics) used in assessing safety culture, track (benchmark) the performances of safety factors (metrics); and select activities to improve the performances of safety metrics that influence the safety culture of maritime organizations.

1.6 Research Objectives

From the above-stated research aim, the specific objectives of this research are:

- To review the current methodologies for assessing safety culture in maritime organizations.
- To explore decision-making methodologies that can be integrated to assess and manage the safety culture of maritime organizations.
- To establish weights and priority settings for safety factors (metrics) that influence the safety culture of maritime organizations across Nigeria.
- To elicit the attitudes of shore-side and shipboard staff towards safety in a selected case study maritime organization in Nigeria.
- To recommend and justify how improvement activities should be scheduled to enhance the safety culture of a maritime organization.
- To recommend and justify how vessels in the assessed vessel fleet would be scheduled for a safety culture improvement program.
- To validate the different decision-making methodologies that were integrated to assess and manage the safety culture of maritime organizations.
- To make recommendations and suggestions for further studies.

1.7 Scope of Research

Within the boundary of safety culture, the subject areas considered in this thesis are:

- The current methodologies for assessing safety culture in maritime organizations.
- Works of literature on the application of MCDM techniques on issues generally related to safety culture.
- The establishment of weights and priority settings for safety factors (metrics) that influence the safety culture of maritime organizations across Nigeria during the period of the study.
- The attitudes of shore-side and shipboard staff towards safety in a selected case study maritime organization in Nigeria.
- The performances of safety factors that influence safety culture in the selected maritime organization in Nigeria.
- The integration of decision-making techniques to assess and manage the safety culture of an assessed maritime organization.
- The validation of the integrated decision-making framework to assess and manage the safety culture of an assessed maritime organization.

1.8 Thesis Layout

The thesis consists of ten chapters, a list of references and appendices, including this chapter. A description of the contents covered in the eleven chapters, a list of references and appendices are given as follows:

Chapter 1 provides a broad introduction to the research described in this thesis. The chapter also sets the agenda for this thesis; It details the rationale behind the research, the research questions formulated, the research aim, the research objectives, the contribution of the research, and the scope of the research presented in this thesis.

Chapter 2 summarizes the concept of decision-making, safety decision-making and multicriteria decision-making. This chapter also provides a critical review of MCDM techniques and their applications in safety culture assessments. This chapter provides an overview of decision-making techniques such as the Analytical Hierarchy Process (AHP), Analytical Network Process (ANP), Simple Additive Weighting Method (SAW), Technique of Order Preference Similarity to the Ideal Solution (TOPSIS), and Pareto Analysis (PA) explicitly.

Chapter 3 provides a comprehensive overview of the concepts of safety management, safety culture, maritime safety culture, maritime safety culture assessment and gaps in the existing literature on maritime safety culture assessment.

Chapter 4 describes the research design and methodology adopted for this research. This chapter explicitly details all the strategies applied in carrying out this research. This chapter also summarises features of the conceptual decision-making framework developed to demonstrate the assessment of maritime safety culture in Nigeria without the reliance on correlational statistical techniques.

Chapter 5 describes the processes carried out by the researcher in the expert elicitation of weights for safety factors used in assessing and describing the safety culture of maritime organizations in Nigeria. The chapter deals explicitly with the application of the Analytical Hierarchy Process (AHP) in eliciting weights and priority settings of safety factors used in describing the safety culture of maritime organizations.

Chapter 6 details the processes carried out by the researcher in assessing and describing the safety culture of a maritime organization. The chapter deals explicitly with the application of the Simple Additive Weighted (SAW) Model in assessing the safety culture of a maritime organization in Nigeria.

Chapter 7 describes the processes carried out by the researcher in gaining insights into issues concerning occupational health and safety, ship safety, and shore-to-ship safety of the selected case study maritime organization in Nigeria. The chapter also deals with the application of Pareto principles in justifying the ranking and performances of safety factors in the weighted safety climate established from the SAW model used to assess the safety culture of a maritime organization.

Chapter 8 details the processes carried out by the researcher in benchmarking the safety climate of vessels managed by the selected case study maritime organization. This chapter specifically deals with the application of the Technique of Order Preference Similarity to the Ideal Solution (TOPSIS) in scheduling vessels in a vessel fleet for a safety culture improvement program.

Chapter 9 specifically details the processes carried out to validate the conceptual decision-making framework developed and used for this study. The processes carried out entailed a test-retest analysis, sensitivity analysis and a general statement towards the applicability and acceptability of the different decision-making methodologies integrated into the decision-making framework developed and used in this study.

Chapter 10 provides a comprehensive discussion of all the results collected in this thesis. This chapter explicitly summarises the research findings, assumptions of the research study and limitations of the research study.

Chapter 11 summarises all the achievements in this study alongside assumptions, limitations, and recommendations for further study on the application of decision-making techniques in assessing the safety culture of maritime organizations. Table 1 below provides an overview of the thesis structure.

Table 1: Thesis Structure

<table>
<tr><td>Chapter 1</td><td>Introduction</td><td>Research Background, Research Problem, Research Aims, and Research Objectives</td></tr>
<tr><td>Chapter 2</td><td>Theoretical Background of Maritime Safety Culture</td><td rowspan="2">Issues of Concern in Theory and Practice
Gaps in Literature</td></tr>
<tr><td>Chapter 3</td><td>Theoretical Background and Critical Review of Multicriteria Decision-Making Methodologies</td></tr>
<tr><td>Chapter 4</td><td>Research Design and Methodology</td><td>Conceptual Decision-Making Framework for Assessing Safety Culture in Maritime Organization</td></tr>
<tr><td>Chapter 5</td><td>The Application of AHP in Expert Elicitation of Weights for Safety Factors/Metrics</td><td rowspan="4">Testing of Methodology in Real Life Case Study</td></tr>
<tr><td>Chapter 6</td><td>The Application of Simple Additive Weighted Model in Assessing the Safety Culture of a Maritime Organization</td></tr>
<tr><td>Chapter 7</td><td>The Application of Pareto Principle's in the Comparative Analysis of Activities to Enhance the Safety Culture of Maritime Organizations</td></tr>
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<tr><td>Chapter 9</td><td>Validation of Conceptual Decision-Making Framework</td><td>Statistical Testing and Methodology Validation</td></tr>
<tr><td>Chapter 10</td><td>Discussions</td><td>Synthesis and Reporting of Findings</td></tr>
<tr><td>Chapter 11</td><td>Conclusions and Recommendations for Further Studies</td><td>Contribution to Theory and Practice
Recommendations for Future Works</td></tr>
</table>

References provide a formatted list of all sources of information used and cited in this research thesis.

Appendices provide information on the priority setting questionnaire; shoreside and shipboard staff survey questionnaire; vessel responses of the selected case study maritime organization, test re-test analysis for responses from both shore and shipboard staff; sensitivity analysis of the TOPSIS model; a detailed list of activities to improve and enhance different safety factors in the ABS Guidance Notes on Safety Culture and Leading Indicators of Safety; and a summary of feedback statements from both shoreside and shipboard staff on issues concerning occupational health and safety, ship safety and shore to ship safety.

1.9 Chapter Summary

This chapter provides background information on the research carried out in this thesis. The chapter also detailed the importance of a positive safety culture in shipping and the motivation for carrying out this research. This chapter also explicitly highlights the research questions, aim, objectives, the scope of research, and thesis layout to explain the flow of activities carried out to achieve the set aims and objectives of this research study.

2 Theoretical Background of Decision-Making and Critical Review of Multicriteria Decision-Making Methodologies

2.1 Introduction

This chapter introduces the concept of decision-making, safety decision-making, and multicriteria decision analysis (MCDA). This chapter details the strength and limitations of the Analytic Hierarchy Process (AHP) explicitly, the Analytic Network Process (ANP), and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Pareto Analysis (PA). Furthermore, this chapter provides a critical review of the literature on the application of multicriteria decision-making methodologies in the areas of safety (culture) assessment and management.

2.2 Decision Making

Decision-making is something we all do every day, either as individuals or in groups. It entails making a choice about what to do and committing to that course of action. Therefore, a decision is said to have occurred when a course of action is chosen by an individual or group from a number of alternative options after consideration of available options (Hazelrigg, 2012).

Herbert Simon (1960) described decision-making as the cognitive process which results in the selection of a belief or course of action amongst several available alternatives. Hence, decision-making can also be described as the process of identifying and choosing an alternative based on the values, preferences, and beliefs of the decision-maker (See Figure 2 below).

In relation to the cognitive process of humans, Herbert Simon (1960) also summarized the cognitive processes of decision-making as follows;

- Intelligence: The phase entails surveying the environment to identify and collect information about the problem(s). This phase would also entail defining the objectives of making a decision.
- Design: This phase entails the definition of criteria and the development of alternatives to the problem. It would also entail the analysis of the different alternatives to the problem.
- Choice: This phase entails the application of already established criteria in selecting the best possible alternative to the identified problem.

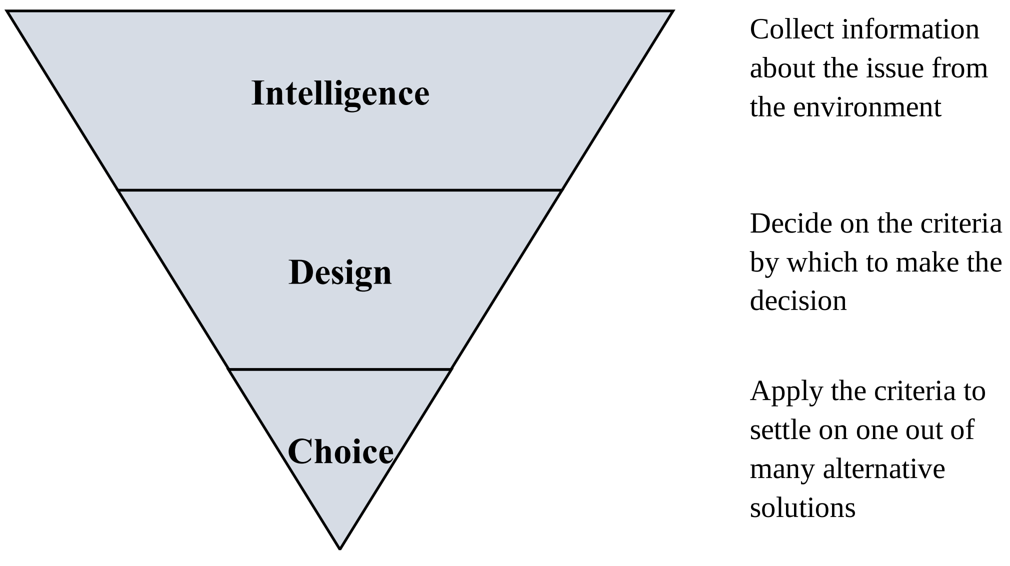

Figure 2: Cognitive Processes of Decision-Making

(Herbert Simon, 1960)

In relation to problems encountered by decision-makers, Clemen and Reilly (2001) described decision-making as a problem-solving activity that terminates when a satisfactory solution is deemed to be found. Clemen and Reilly (2001) went further to describe the process of decision-making in six phases shown below (Figure 3), assuming the decision-maker develops the alternative or solution to the decision problem.

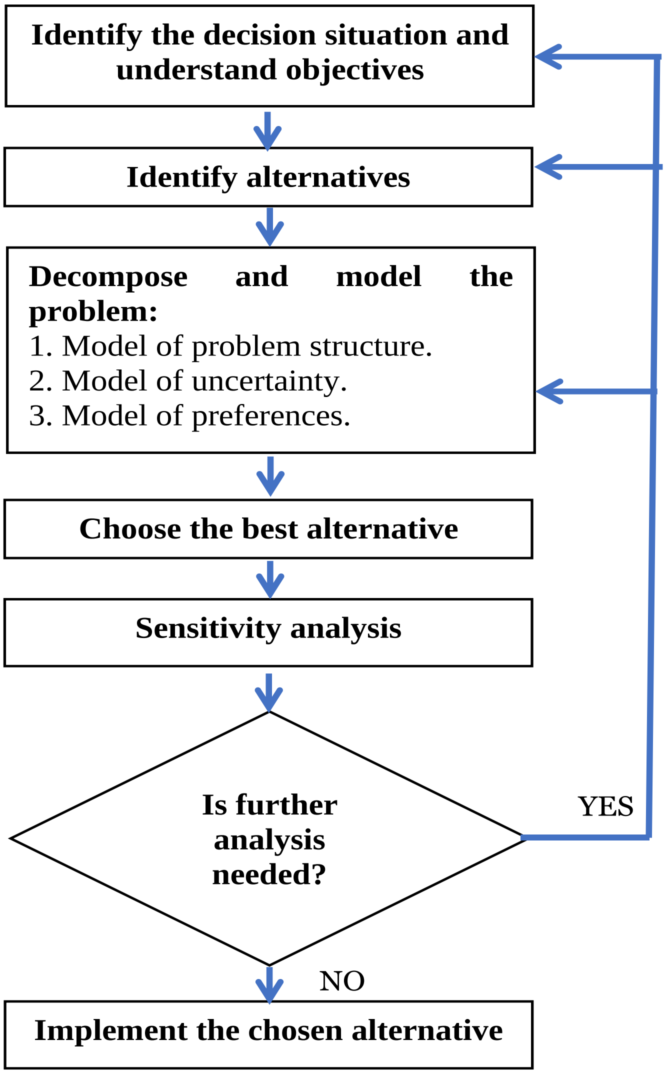

Figure 3: Decision-Making Process

(Clemen & Reilly 2001)

The six phases of decision-making described by Clemen and Reilly (2001) are:

Identification of the decision situation or problem: This first phase of decision-making is to identify the decision situation or problem to understand the objectives of the decision situation or problem. In this phase, the decision-maker would be able to explore the decision situation or problem to establish boundaries for the decision situation or problem. In establishing boundaries, the decision-maker must express the identified objectives in broad terms and also establish the performance to test the effectiveness of later identified alternatives or solutions to the decision situation or problem.

Identification of decision alternatives: The second phase of decision-making is the development of alternatives to the decision situation or problem. In this phase, the decision-maker would explore his or her understanding of the decision situation to identify or develop different alternatives or solutions to the decision problem.

Model the decision problem: The third phase of decision-making is the modelling of the decision situation or problem. In this phase, the decision-maker applies different types of modelling techniques to structure the problem. Most of the models used in decision-making are either analogue or symbolic. This phase provides the decision-maker with a clear representation of the relation between the different identified objectives and performance measures established for the already defined decision problem.

Selection of the best alternative: This phase of decision-making entails the application of a decision model to compare, analyze and select the best alternative or solution to the defined decision problem.

Sensitivity analysis: The fifth phase of decision-making is sensitivity analysis. This phase deals with the consequences of selecting an alternative or solution to the decision problem. This phase answers the 'what if' questions about the alternative or solution to a decision problem. It presents the consequences of selecting an alternative or solution if or when small changes are made to some aspects of the decision model. An alternative or solution to a decision problem is said to be sensitive if small changes in some aspects of the decision models lead to changing the selected alternative or solution. The decision-maker needs to carefully consider the impact of small changes to the selected alternative or solution; hence this phase also allows the decision-maker to return to the first, second, and or the third phase of decision-making to modify aspects of the different phases of decision making until a satisfactory alternative or solution is found for the decision problem.

Implementation of chosen decision: The sixth phase of decision-making deals with the implementation of an alternative or solution to a decision problem. It would also describe how a decision-maker intends to implement his or her alternative or choice for a given decision problem.

In relation to the diverse nature of decision problems, Roy (1981) recognized that the classification of decision problems plays a vital role in decision-making, as decision-makers need first to identify what type of problem he or she has encountered before thinking about what type of decision would yield the desired result or solution to the explored decision problem or situation. Roy (1981) also went further to describe the four types of decision-making problems (See Figure 4).

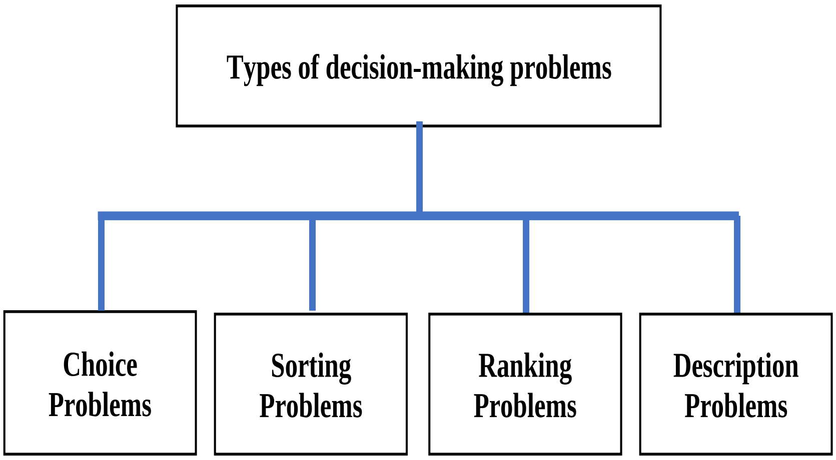

Figure 4: Types of Decision-Making Problems

(Roy, 1981)

The different types of decision-making problems classified by Roy (1981) are:

The choice problem: These are decision-making problems where decision-makers aim to select the single best available option to a decision problem. The best available decision would entail reducing the group of options to a subset of equivalent ‘good’ options.

The sorting problem: This refers to decision-making problems where the primary goal of the decision-maker is to systematically arrange options into ordered or predefined groups (categories). The goal of the decision-maker is to regroup the options with similar behaviours or characteristics for organizational, descriptive, or predictive reasons.

The ranking problem: This refers to decision-making problems where the primary purpose of the decision-maker is to systematically arrange options from best to worst through scores or pairwise comparison. The goal is to arrange options or alternatives in order of decreasing preferences.

The description problem: This refers to decision-making problems where decision-makers aim to characterize the features of options or alternatives to a problem. The goal is to describe the options or alternatives to a problem and its consequences.

2.3 Safety Decision–Making

In relation to safety management and the context of this study, the cognitive process of deciding how best to maintain an acceptable level of safety whilst still working towards fulfilling the set goals and objectives of an organization can be regarded as safety decision-making. Managers in organizations are expected to always consider the implications of decisions made by them, and safety is one of the most important factors considered in taking any decision within the maritime industry. However, the decisions relating to safety-related issues vary in both scope and character depending on the attributes of the safety problem to be managed and the position of the decision-maker in the organization.

Decisions relating to safety-related issues are also not so different from decision-making in other areas of management as there are no simple methods or sets of rules for making good decisions in all situations because of the varying scope and character of problems found within the decision-making environment of safety-related issues. Hale, A., Hemning, B., Carthey, J., & Kirwan, (1994) explored the scope, levels, and cognitive process of deciding how best to maintain an acceptable level of safety over the lifetime of an enterprise/organization.

2.3.1 Scope and Context of Safety Decision-Making

The life cycle of an organization is generally divided into; design; construction; commissioning; operation; maintenance and modification; decomposition, and demolition. Studies from Hale, A., Hemning, B., Carthey, J., & Kirwan, (1994) highlighted the complexity in the scope and context of decision-making on safety-related issues as each element of an organization's life cycle demands decisions on safety-related issues that would not only be specific to that phase alone but may have an impact on other phases in the life cycle of that organization.

Hale (1994) explained that the design, construction, and commissioning phases in the life cycle of an organization would mostly be faced with the decision of how best to develop and realize safety standards and specifications that have been agreed upon by the organization and its stakeholders; while the operation, maintenance and demolition phases in the life cycle of an organization would be faced mainly with task of maintaining and possibly improving the determined level of safety in the organization.

2.3.2 Decision Levels of Safety Management

Decision-making on safety management, as stated earlier, also differ in character depending on the level of the organization. The decision-makers in organizations not only influence the management of safety in an organization but also represent the various decision-making levels for safety management in an organization.

Hale, A., Hemning, B., Carthey, J., & Kirwan, (1994:1997) identified and distinguished three main decision levels for safety management in the organization:

I. The level of execution:

   This level of execution is concerned mainly with the recognition of the hazards, decision-making, and implementation of actions to eliminate, reduce and control the likelihood of exposure to any of the identified hazards. Also, at this level, the decision-makers who directly influence the occurrence and control of hazards or incidents are mainly workers at the front line in the workplace. The decision-makers or workers at the front line are also only given a limited degree of freedom on the scope of safety-related issues they may be allowed to act on; hence feedback and correction loops are frequently employed at this level to correct deviations from established procedures and return or bring workers to practice back to the organizational norm. The next higher level of decision-making on safety management in an organization is activated as soon a situation is identified where the norm agreed upon is no longer thought to be appropriate.

II. The level of planning, organization, and procedures:

   The level of planning, organization, and procedures is mainly concerned with devising and formalizing actions to be taken by workers or decision-makers at the execution level with respect to the entire range of expected hazards covered by the organization's strategy towards safety management. This decision-making level of safety management in an organization also sets out the responsibilities, procedures, and reporting lines found in the safety manuals of the organization; therefore, this level is also responsible for developing and or modifying procedures for hazards that are new to an organization. This level is also responsible for highlighting insights on hazards and possible standards for solutions to the hazard. Specifically, this level translates abstract principles into concrete task allocation and implementation plans and also corresponds with improvement loops required in many quality systems.

III. The level of structure and management:

The level of structure and management is mainly concerned with the overall compliance to principles of safety management in the organization. This level is principally activated whenever the organization observes that the current planning and organizing levels are failing in fundamental areas needed to achieve an acceptable level of safety performance. This level also describes the "normal" functioning of the safety management system; hence it is at this level that safety management is critically and continually monitored, improved, or maintained in the face of changes in the external environment of the organization.

Hale, A., Hemning, B., Carthey, J., & Kirwan, (1997) also highlighted that the three main decision levels for safety management in an organization are abstractions which also correspond to three different kinds of feedback (See Figure 5). The different decision levels of safety management should not be seen as contiguous hierarchical levels of the shop floor, first line, and higher management, as activities specified at each abstract level can be applied in many different ways. Also, the manner in which task allocations are made very often reflects the culture and methods of working in the organization.

Figure 5: Decision Levels of Safety Management

(Hale, A., Hemning, B., Carthey, J., & Kirwan, 1994)

2.3.3 Safety Decision-Making Process

In relation to the cognitive decision-making process of safety management, Hale, A., Hemning, B., Carthey, J., & Kirwan, (1994) proposed the problem-solving cycle model. The proposed problem-solving cycle model provides safety decision-makers with an idealized step-wise procedure for analyzing and making decisions on safety problems caused by potential or actual deviations from desired, expected, or planned achievements. Figure 6 below encapsulates the idealized steps proposed in the problem-cycle model developed by Hale, A., Hemning, B., Carthey, J., & Kirwan, (1994).

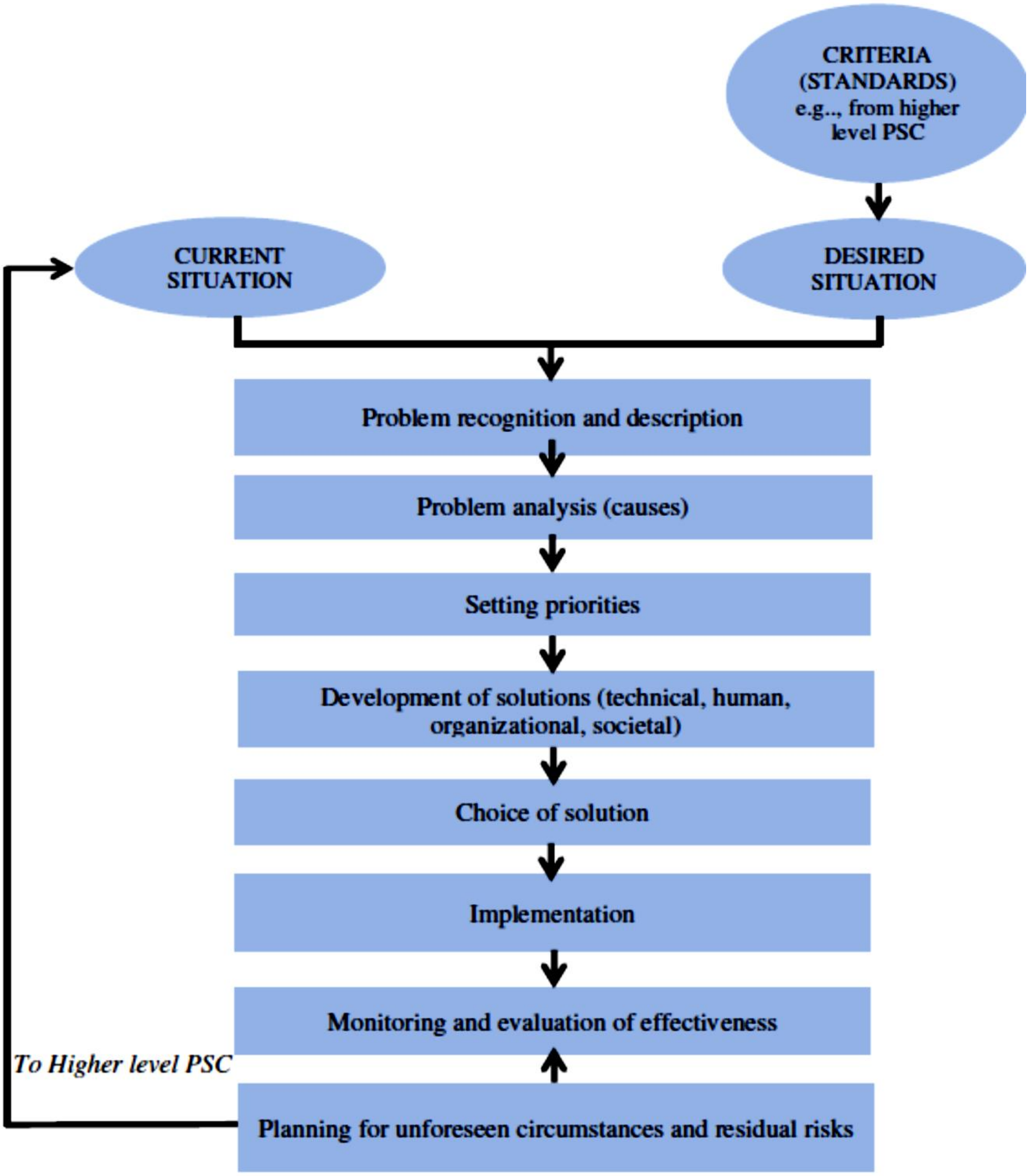

Figure 6:The problem-solving cycle

(Hale, A., Hemning, B., Carthey, J., & Kirwan, 1994)

The idealized steps proposed in the problem cycle model are also the same in principle for all safety management levels; however, the application in practice may differ depending on the nature of the problem treated.

The proposed problem cycle model also indicates that the six main questions covered in safety management are:

- What is an acceptable safety level or standard of the activity/department/company, etcetera?
- What criteria shall be used to assess the safety level?
- What is the current safety level?
- What are the causes of identified deviations between the acceptable and observed levels of safety?
- What means should be chosen to correct the deviations and keep up the safety level?
- How should corrective actions be implemented and followed up?

In practice, the above-mentioned six main questions are usually broken down into other related questions to allow several sub-decisions to be made by a decision-maker. These sub-decisions also form the basis of how decision-making would be made in each of the problem areas and in each of the decision-making levels in the organization. Consequently, the general concept of decision-making in safety management attempts to reduce conflict between workers in safety management as it focuses mainly on providing more clarity on the scope, level, and cognitive process of decision-making on safety-related problems and or issues in an organization.

2.4 Multicriteria Decision Analysis (MCDA)

In the simplest sense, multicriteria decision analysis is a collection of methods or tools which aid a decision-maker in making decisions in the presence of multiple, often conflicting criteria. It is also a structured and justifiable approach to decision problems with two or more often conflicting criteria. According to Valerie Belton (2002), the generalized processes of multicriteria decision analysis (MCDA) are:

- Identifying the problem or issue
- Problem structuring
- Model building
- Challenging thinking
- Developing an action plan.

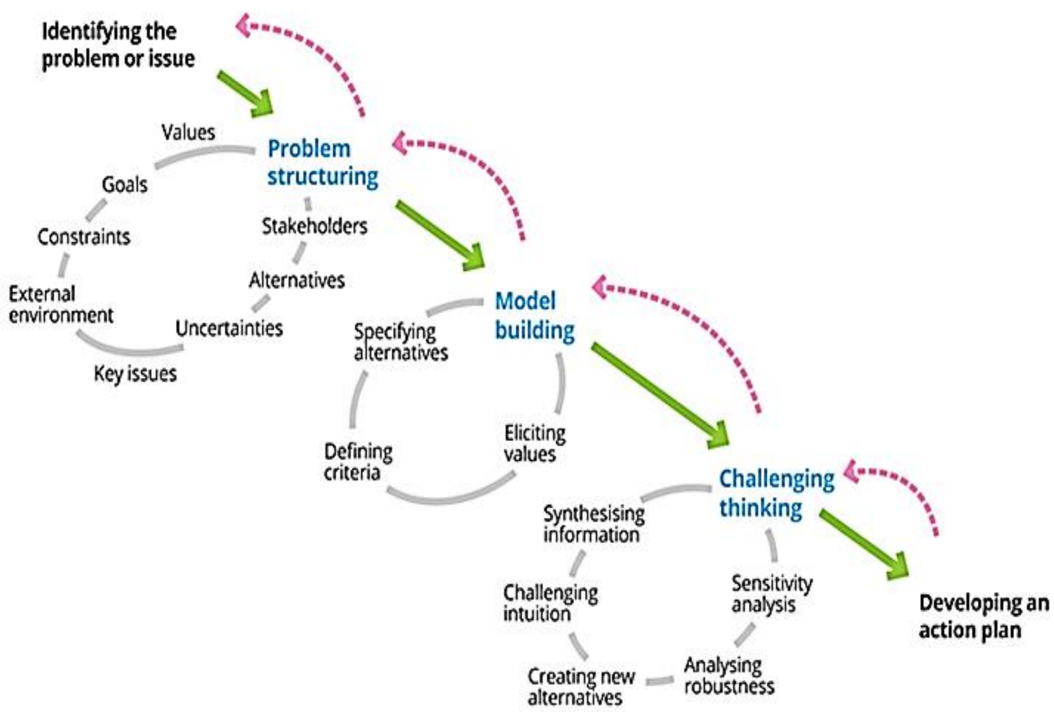

Figure 7:Decision-Making Process

(Valerie & Stewart, 2002)

Figure 7 above summarises the processes of multicriteria decision analysis proposed by Valerie Belton. The above processes of MCDA proposed by Valerie and Stewart (2002) can also be grouped can also be group into three phases: problem identification and structuring, model building and use, and development of an action plan.

- Problem identification and structuring: The goal of the first phase of MCDA is to provide a common understanding of the problem. Hence, this phase entails the identification of stakeholders' interests, the definition of the decision problem or issue, the identification of the decisions to be made, and the criteria by which the decisions would be judged and evaluated.
- Model building and use: The goal of the second phase of the MCDA process is to provide a structured and justifiable approach to evaluating the alternatives of a decision problem or issue. Therefore, this phase entails the development of the model(s) to analyze the alternatives to the decision problem.
- Development of action plans: The third phase entails the implementation of findings from the analysis of alternatives to a decision problem. Hence, the goal of the third phase is to translate results from the analysis of alternatives into specific action plans.

2.5 Classifications of Multicriteria Decision-Making Methods

According to Hwang & Masud (1979), Yoon & Hwang (1995), and Triantaphyllou (2000), Multicriteria Decision Making (MCDM) methods can be classified into Multi-Attribute Decision Making (MADM) and Multi-Objective Decision Making (MODM).

Whilst MADM focuses on the selection of the 'best possible alternative' based on the attributes required in the solution of the problem, MODM focuses on the selection of the best alternative based on the mathematically prescribed objectives (or goals) and constraint functions of the decision-maker(s) (Yoon & Hwang, 1995). Figure 8 below provides a summarized classification of the multicriteria decision-making methodology.

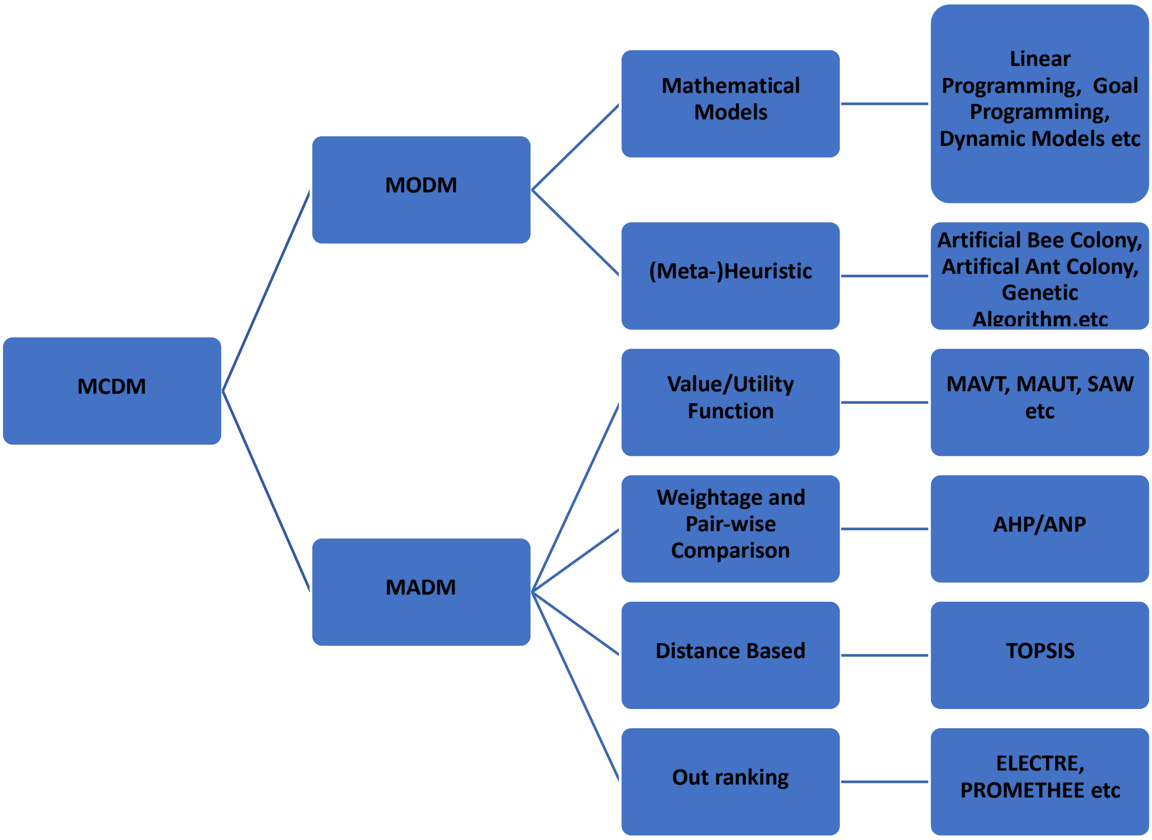

Figure 8: A Summarized Classification of Multicriteria Decision-Making Methodology

(Triantaphyllou, 2000; Valerie & Stewart, 2002)

There is still no universally accepted method for solving decision-making problems; hence a decision analyst is expected to propose a suitable decision-making method in relation to the nature of the decision problem (Triantaphyllou, 2000).

2.6 Critical Review on the Application of MCDM Techniques in Safety Culture Assessments

The application of MCDM in solving complex problems is widely documented; however, there is no systematic literature review of the application of MCDM techniques within the problem domains of safety culture, nor are there attempts to analyze the different MCDM techniques used in the past to assess and or manage the safety culture of organisations. This section seeks to identify works of literature on the application of MCDM techniques within the research domain of safety culture. Hence, this section aims to review the literature on the application of MCDM techniques on issues related to safety culture or highly subjective elements of safety assessment and management with the view of developing a rationale and unique decision-making framework to assess and manage the safety culture of maritime organisations.

The systematic search for the works of literature was carried out using two groups of keywords in Scopus. The first group of keywords represents the words closely associated with the problem domain investigated, while the second group of keywords represent words associated with different types of decision-making methodologies that have been applied previously to investigate different aspects of the problem domain. Table 2 below represents the keywords used for the literature search.

Table 2: List of Keywords Used for Literature Search

Problem Domain	Decision-Making Methodology Applied
Safety Culture, Safety Culture Assessment, Safety Culture Management	Multicriteria Decision Making, Multicriteria Decision Making, MCDM, Multicriteria Decision Analysis, Multicriteria Decision Analysis, MCDA, Analytic Hierarchy Process, AHP, Analytic Network Process, ANP, Simple Multi-Attribute Rating Technique, SMART, Technique for Order Preferences by Similarity to Ideal Solutions, TOPSIS, Data Envelopment Analysis, DEA, Grey Relational Area, GRA, Vise Kriterijumska Optimizacija I Kompromisno Resenje, VIKOR, Preference Ranking Organization Method for Enriching Evaluation, PROMETHEE, Simple Additive Weighting, SAW, Weighted Sum Method, WSM, Weighted Product Method, WPM, Complex Proportional Assessment, COPRAS, Elimination and Choice Transcribing Reality, ELECTRE, Step-Wise Weight Assessment Ratio Analysis, SWARA, Decision-Making Trial and Evaluation Laboratory, DEMATEL Fuzzy Set Theory, and Fuzzy

The final search string formulated was:

(TITLE-ABS-KEY ("Safety Culture" OR "Safety Culture Assessment" OR "Safety Culture Management")) AND ("Multicriteria Decision Making" OR "Multicriteria Decision Making" OR "MCDM" OR "Multicriteria Decision Analysis" OR "Multicriteria Decision Analysis" OR "MCDA" OR "Analytic Hierarchy Process" OR "AHP" OR "Analytic Network Process" OR "ANP" OR "Simple Multi-Attribute Rating Technique" OR "SMART" OR "Technique for Order Preferences by Similarity to Ideal Solutions" OR "TOPSIS" OR "Data Envelopment Analysis" OR "DEA" OR "Grey Relational Area" OR "GRA" OR "Vise Kriterijumska Optimizacija I Kompromisno Resenje" OR "VIKOR" OR "Preference Ranking Organization Method for Enriching Evaluation" OR "PROMETHEE" OR "Simple Additive Weighting" OR "SAW" OR "Weighted Sum Method" OR "WSM" OR "Weighted Product Method" OR "WPM" OR "Complex Proportional Assessment" OR "COPRAS" OR "Elimination and Choice Transcribing Reality" OR "ELECTRE" OR "Step-Wise Weight Assessment Ratio Analysis" OR "SWARA" OR "Fuzzy Set Theory" OR "Fuzzy" OR "Decision-Making Trial and Evaluation Laboratory" OR "DEMATEL") AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Decision Making") OR LIMIT-TO (EXACTKEYWORD , "Analytic Hierarchy Process") OR LIMIT-TO (EXACTKEYWORD , "Hierarchical Systems") OR LIMIT-TO (EXACTKEYWORD , "Fuzzy Sets") OR LIMIT-TO (EXACTKEYWORD , "Analytical Hierarchy Process") OR LIMIT-TO (EXACTKEYWORD , "DEMATEL") OR LIMIT-TO (EXACTKEYWORD , "Fuzzy Logic"))

The search string and strategy above produced an output of 62 papers on the 13th of December, 2022. The quality of the output from the search results was also assessed further to filter the output of the search string above. The quality assessment process ensured that the main problem domain investigated in each paper was focused on safety culture or elements closely associated with safety culture, while the methodology applied in the papers contained and detailed at least one multicriteria decision-making concept. Upon completion of the quality assessment carried out, the final output of the search strategy and filtering was 45 papers. Figure 9 below provides a summary of publications generated from the search string and strategy deployed in this study.

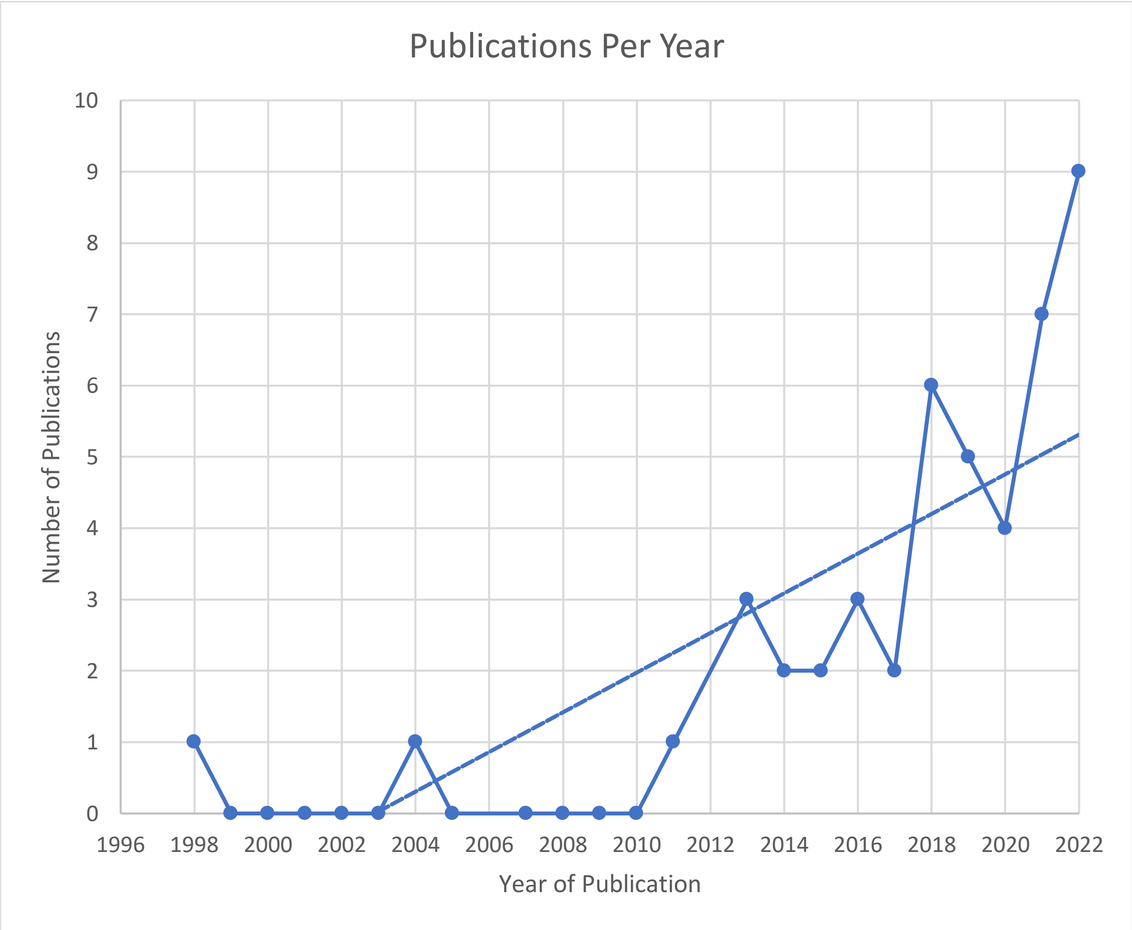

Figure 9: A Summary of Publications Generated from the Search Strategy

The result generated from the search string indicates that works of literature concerning both safety culture and multicriteria decision-making methodologies ranged from 1998 till date. The trendline from the above line graph also shows an upward trend in the number of publications from 2003 till date generally. The graph also shows that most of the publications occurred after 2010. The above graph also indicates that over the years, there has been an increased interest in the application of multicriteria decision-making methodologies within the research domain of safety culture.

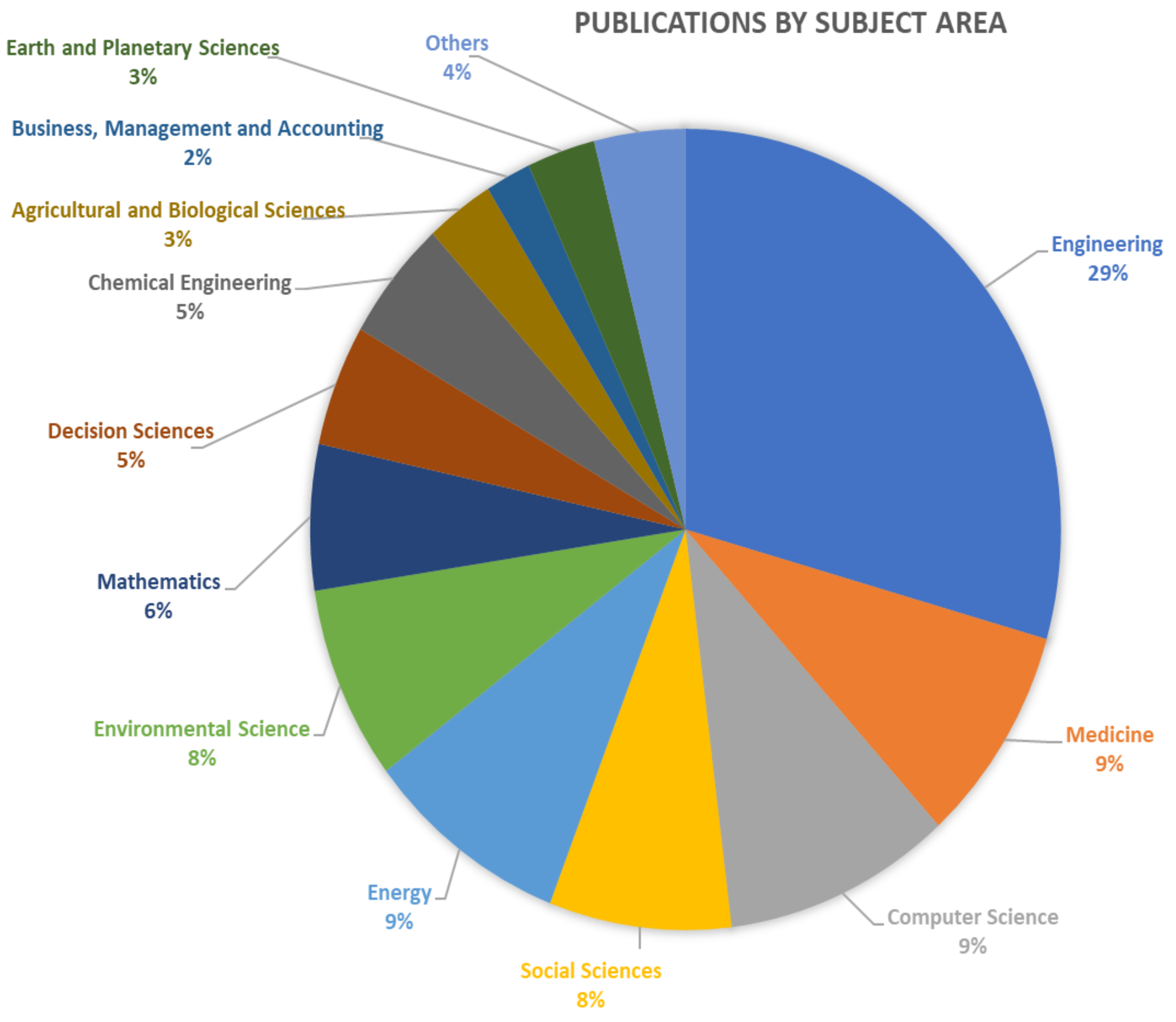

Figure 10: Publications by Subject Area

Figure 10 above summarizes all the subject areas or fields covered by the results of the search string deployed in this study. The result generated from the search string also spreads across different subject areas or fields. The three most highlighted fields covered by the above results are Engineering (29%), Medicine (9%) and Computer Science (9%).

The search string results were also reviewed and analyzed based on the author, year of publication, the focus of the problem, and the methodology applied in the publication so as to better understand the possible trends in the application of multicriteria decision-making methodologies on issues related to safety culture. Table 3 below summarizes all the methodologies found in publications generated from the search for works of literature concerning the application of MCDM techniques on issues related to safety culture assessment and management in organizations.

Table 3: A Summary of Methodologies Found in Publications

S/N	Authors	Year	The Focus of the Problem	Methodology Applied in Publications
	Yorulmaz M., Karabulut K.	2022	The factors determining the effectiveness of the ISM Code on ships.	Fuzzy DEMATEL;
	Bognár F., Benedek P.	2022	Risk evaluation and prioritisation of a nuclear plant using AHP and PRISM	Analytic Hierarchy Process (AHP); Partial risk map (PRISM);
	Ghasemi F., Gholamizadeh K., Farjadnia A., Sedighizadeh A., Kalatpour O.	2022	The contribution of human and organisational factors in industrial accidents (toxic gas leakage)	Bayesian Network (BN); Fuzzy Sets Theory (FST); Human Factor Analysis and Classification System (HFACS):
	Mohandes S.R., Sadeghi H., Fazeli A., Mahdiyar A., Hosseini M.R., Arashpour M., Zayed T.	2022	The causes of accidents on construction sites (identify, map and prioritise critical causes of accidents on construction sites)	Pentagonal Fuzzy Delphi Method (PFDM); and Fuzzy DEMATEL techniques.
	Wang X., Zhang C., Deng J., Su C.,Gao Z.	2022	Factors Influencing Miners’ Unsafe Behaviors in Intelligent Mines	Fuzzy DEMATEL; MICMAC analysis; Interpretive Structural Modelling (ISM)
	Ahn J., Min B.J., Lee S.J.	2022	The frequency and difficulty of safety culture attributes of nuclear power plants in the Republic of Korea.	Analytic Hierarchy Process (AHP); Harmonized Safety Culture model;
	Meng B., Lu N., Lin C., Zhang Y., Si Q., Zhang J.	2022	Factors influencing a Flights crew team situation awareness (TSA) and improvement of flight safety management by priority actions.	Delphi Method; Decision Making Trial and Evaluation (DEMATEL); Interpretive Structure Modelling (ISM) method;

A Summary of Methodologies Found in Publications – Continued from Previous Page				
	Zhang Y.-J., Huang Z.-R., Zhao F.-Y., Wang Y.	2022	Nuclear Safety culture levels for different job positions of operating power plants in China	Fuzzy analytic network process (FANP); Fuzzy decision-making trial and evaluation laboratory (FDEMATE); Fuzzy technique for order performance by similarity to ideal solution (FTOPSIS);
	Yao H.	2022	Factors influencing the resilience safety culture of the construction industry.	Fuzzy Analytic Hierarchy Process (FAHP);
	Ebrahimi H., Sattari F., Lefsrud L., Macciotta R.	2021	Weaknesses in the implementation of Safety Management System (SMS) and causes of railway loss incidents	Analytical Network Process (ANP); Decision-making trial and evaluation laboratory (DEMATEL); Human Factors Analysis and Classification System (HFACS) approach.
	Jabłoński M., Jabłoński A.	2021	A ranking of specific issues responsible for building safety culture and the identification of factors that influence the process of shaping safety culture	Analytic Hierarchy Process (AHP); Vester methods
	Erdem P., Akyuz E.	2021	Failure influencing vulnerabilities and critical human errors in the operational process of marine transportation.	Interval type-2 fuzzy sets; SLIM
	Bayma A., Martins M.R.	2021	Application of HRA (Human Reliability Analysis) as a pedagogical tool to increase the safety culture of students and professionals.	Bayesian Network; Fuzzy Logic
	Iqbal H., Haider H., Waheed B., Tesfamariam S., Sadiq R.	2021	Application of a risk-based benchmarking framework to improve both integrity management programs (IMPs) and safety culture maturity (SCM)	Failure Mode Effects Analysis (FMEA); Risk Management; Pre-emptive goal programming methods.
	Çiftçioğlu G.A., Kadirgan M.A.N., Eşiyok A.	2021	The Assessment of safety culture using a Fuzzy inference system.	Exploratory Factor Analysis (EFA); Fuzzy logic;
	Wu Z., Zhang J., Chen X.	2020	Campus Safety Culture and the Safety Behavior Culture of the University	Fuzzy Analytic Hierarchy Process (FAHP);
	Fan S., Zhang J., Blanco-Davis E., Yang Z., Yan X.	2020	Maritime accident prevention strategy formulation from a human factor perspective.	Multiple Correspondence Analysis (MCA); Hierarchical Clustering (HC); Classification Tree (CT); Bayesian Networks (BN); Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)
	Sudiarno A., Sudarni A.A.C.	2020	Safety Culture Maturity and the production area of steel manufacturers.	Analytical Hierarchy Process(AHP)
	Vianna J., Carvalho P.V.R., Cosenza C.A.N., Grecco C.H.S.	2020	Critical success factors (CSFs) for knowledge management (KM) in Nuclear Organisations.	Fuzzy logic;
	Baldissone G., Comberti L., Bosca S., Murè S.	2019	Accident Precursors Management System used in analysing unsafe act, unsafe conditions and near misses	Fuzzy Logic; HFACS;
	Shieh J.-I., Huang C.-H., Lee Y.-C., Wu H.-H.	2019	The causal relationships of patient's safety culture.	Monte Carlo simulation;
	Machfudiyanto R.A., Latief Y., Robert	2019	Factors that positively influence the safety culture on construction projects.	Factor Analysis; Analytical Hierarchy Process (AHP)
	Yazgan E., Yilmaz A.K.	2019	Factors contributing to human error for corporate-based airworthy strategy	Analytic Network Process (ANP);
	Lee Y.-C., Zeng P.-S., Huang C.-H., Wu C.-F., Yang C.-C., Wu H.-H.	2019	Critical dimensions of the Chinese version of the safety attitudes questionnaire to improve the patient safety culture in Taiwan from experts' viewpoints.	Decision-making trial and evaluation laboratory (DEMATEL);
	Markowski A.S., Siuta D.	2018	Selecting representative accident scenarios (RAS)	Fuzzy logic; HAZOP
	Karakhan A.A., Rajendran S., Gambatese J., Nnaji C.	2018	Evaluating the safety maturity of construction contractors	Choosing By Advantages (CBA);

A Summary of Methodologies Found in Publications – Continued from Previous Page				
	Ardeshir A., Mohajeri M.	2018	Factors influencing the safety culture and ranking of occupations in highrise construction projects and worksites	Fuzzy Decision Trail and Evaluation Laboratory (FDEMATEL); Fuzzy ANP (FANP) method; Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (FTOPSIS)
	Situmorang J., Kuntoro I., Santoso S., Subekti M., Sunaryo G.R.	2018	Responses to the implementation of nuclear installations safety culture	Analytic Hierarchy Process (AHP); Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS); Bivariate Correlation Analysis; Pearson Correlation;
	Wang L., Cao Q., Zhou L.	2018	Factors influencing production safety at coal mines in China	Decision Trail and Evaluation Laboratory (DEMATEL); ISM; Factor analysis; Hierarchical model;
	Lee Y.-C., Zeng P.-S., Huang C.-H., Wu H.-H.	2018	Critical dimensions of Patient Safety Culture in Taiwan	Decision Trail and Evaluation Laboratory (DEMATEL);
	Li H., Di H., Wang X.A.	2017	Factors affecting "zero harm" safety cultural construction performance,	Analytical Hierarchy Process (AHP); Fuzzy Comprehensive Evaluation (FCE)
	Petrillo A., De Felice F., Longo F., Bruzzone A.	2017	Human errors, operator reliability and emergency conditions	Fuzzy Cognitive Map (FCM); Analytic Hierarchy Process (AHP);
	Mu J., Li Q.	2016	Factors that influence the development of Food Safety Culture.	Analytical Hierarchy Process (AHP); Fuzzy Set Theory; Fuzzy Comprehensive Evaluation;
	De Felice F., Petrillo A., Di Salvo B., Zomparelli F.	2016	Safety Management and Safety Culture	Analytical Hierarchy Process (AHP); Performance measurement
	Ma Y.	2016	Evaluation of Safety Culture Construction Level.	Combination weighting; Fuzzy Set Theory; Fuzzy technique for order performance by similarity to ideal solution (FTOPSIS)
	Lee Y.-C., Weng S.-J., Hsieh L.-P., Wu H.-H.	2015	Critical dimensions of the Chinese version of Patient Safety Culture	Decision Trail and Evaluation Laboratory (DEMATEL);
	Supciller A.A., Abali N.	2015	Safety Culture and Risk Analysis	Fuzzy Theory (FT); Proportional Risk Assessment Technique (PRAT); Fuzzy Proportional Risk Assessment Technique (FPRAT);
	Fu Y.-K., Chan T.-L.	2014	Evaluation framework for Airport Safety Culture	Fuzzy Delphi Method (FDM); Fuzzy Analytic Hierarchy Process (FAHP); Analysis of Variance (ANOVA); Scheffe Multiple Comparison Test
	Dos Santos Grecco C.H., Vidal M.C.R., Cosenza C.A.N., Dos Santos I.J.A.L., De Carvalho P.V.R.	2014	Assessment of safety culture in safe-critical organisations.	Fuzzy Set Theory:
	Cao Y.-Q., Li K.-W., Zhu Z.-F.	2013	The impact of aviation maintenance safety culture on group safety behavior,	Fuzzy Set Theory (FST); Intuitionistic Fuzzy Theory (IFT);
	Chen K., Xu L., Yang R., Bi Z.	2013	The safety culture assessment of petroleum enterprises	Fuzzy Set Theory; Analytical Hierarchy Process; SMART assessment model;
	Tong B., Zhang H., Tao G., Zhang L.	2013	Safety culture, AHP and Fuzzy mathematics	Analytic Hierarchy Process (AHP); Fuzzy Clustering; Safety culture assessment
	Xu D.-L., Ruan D., Yang J.-B.	2011	The efficiency, effectiveness, consistency and reliability of nuclear safety culture assessment and Intelligent Decision System (IDS) tool.	Evidential Reasoning Approach; Graphical interface;
	Li H., Li C., Li G., Fu Y.	2004	Quantitative analysis of enterprises safety culture (ESC) construction using Index and systems fuzzy	Fuzzy theory; Index system; Quantitative evaluation
	Hauptmanns U.	1998	Procedure for assessing the quality of safety management during a hazardous installation.	Fuzzy sets;

From the above table, the different methodologies applied in publications generated from the search strategy were either MCDM, Integrated MCDM methods and Integrated MCDM methods with non-MCDM methods. The above table also shows that only thirteen (13) publications reviewed solely used a single MCDM method, while ten (10) publications utilized an integrated MCDM method, and twenty-two (22) publications made use of an integrated MCDM method with a non-MCDM method. The summary of methodologies found in the publications reviewed also shows that MCDM methods can easily be integrated with other non-MCDM methods to provide a structured and justifiable decision-making process to solve complex and often conflicting problems.

Amongst all the MCDM found in Table 4, the three most commonly applied MCDM methodologies were AHP/ANP, DEMATEL and TOPSIS because the adopted fuzzy version of any of the above MCDM methodology only offers a little improvement to the fundamental MCDM method and would not create an entirely new MCDM method far from the principle of the base MCDM technique that has been fuzzed. AHP/ANP appeared nineteen (19) times; DEMATEL appeared eleven (11) times, while TOPSIS appeared five (5) times in all forty-five (45) publications reviewed for this section of the thesis. Furthermore, the most commonly applied MCDM methodologies in the publications reviewed were AHP/ANP, DEMATEL, and TOPSIS. The application of AHP/ANP in the reviewed publications was mainly used for weight elicitation, while the application of DEMATEL and TOPSIS was primarily used in ranking alternatives to a decision problem. DEMATEL and TOPSIS were also the most compensatory MADM methods primarily used in evaluating attributes of a decision-making problem. However, DEMATEL is best suited for evaluating the cause-and-effect relationship of attributes belonging to a system through a visual structural model, while TOPSIS is best suited for evaluating and benchmarking the performances of alternatives to a decision problem through an index system that measures the geometric distance between the best and worst points.

Subsequently, the research tendencies for future application of MCDM in safety culture assessment would most likely see a more robust integration of MCDM methods with non-MCDM methods. Furthermore, the nature or type of non-MCDM methods that could be integrated with the MCDM method in the future is limitless. The future application of MCDM methods in safety culture assessment would also most likely entail the application of weights alongside the possible means of evaluating and benchmarking the performances of attributes to safety culture. The evaluation and benchmarking phase or activity of safety culture assessment would also likely be assessed through some form of cause and effect analysis to gain insights on how best to resolve any identified issues.

Consequently, the MCDM techniques selected for this study are intended to offer decision-makers with solutions to the central decision-making issues outlined in the research questions and scope of this research study. The MCDM techniques selected for this study also needs to allow trade-off amongst each criterias or safety factors because no aspect of safety culture has insignificant consequence. Furthermore, the MCDM techniques selected for this study must be compactible given the computational complexities and specific characteristics associated with each individual MCDM technique needed to explore how safety culture could be assessed and managed like any other business unit of an organization.

2.7 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) was developed by Thomas Saaty (1977, 1980) to model subjective decision-making problems into a hierarchical structure of attributes (Saaty, 1980). It is also a structured MADM technique that has the ability to decompose complex decisions into a series of pairwise comparisons and then synthesize the results to allow a more accurate ordering of priorities for decision-making (Saaty, 2008).

2.7.1 Essential Principles

The Analytic Hierarchy Process (AHP) methodology is based on four principles:

Hierarchical Decompositions – A decision problem suitable for AHP application must be able to be decomposed into a hierarchy of interconnected elements (Saaty, 2008). Where at each level of the hierarchical structure, there will be a collection of a few manageable elements that can be progressively dissected further downwards until all interrelated elements (including goals, criteria, sub-criteria, and alternatives) have been comprehensively addressed. Subsequently, the hierarchical structure serves as the backbone upon which AHP operates, and it entails a series of interconnected levels, each with a specific focus and set of elements. Figure 11 below shows a typical hierarchical structure of a decision problem.

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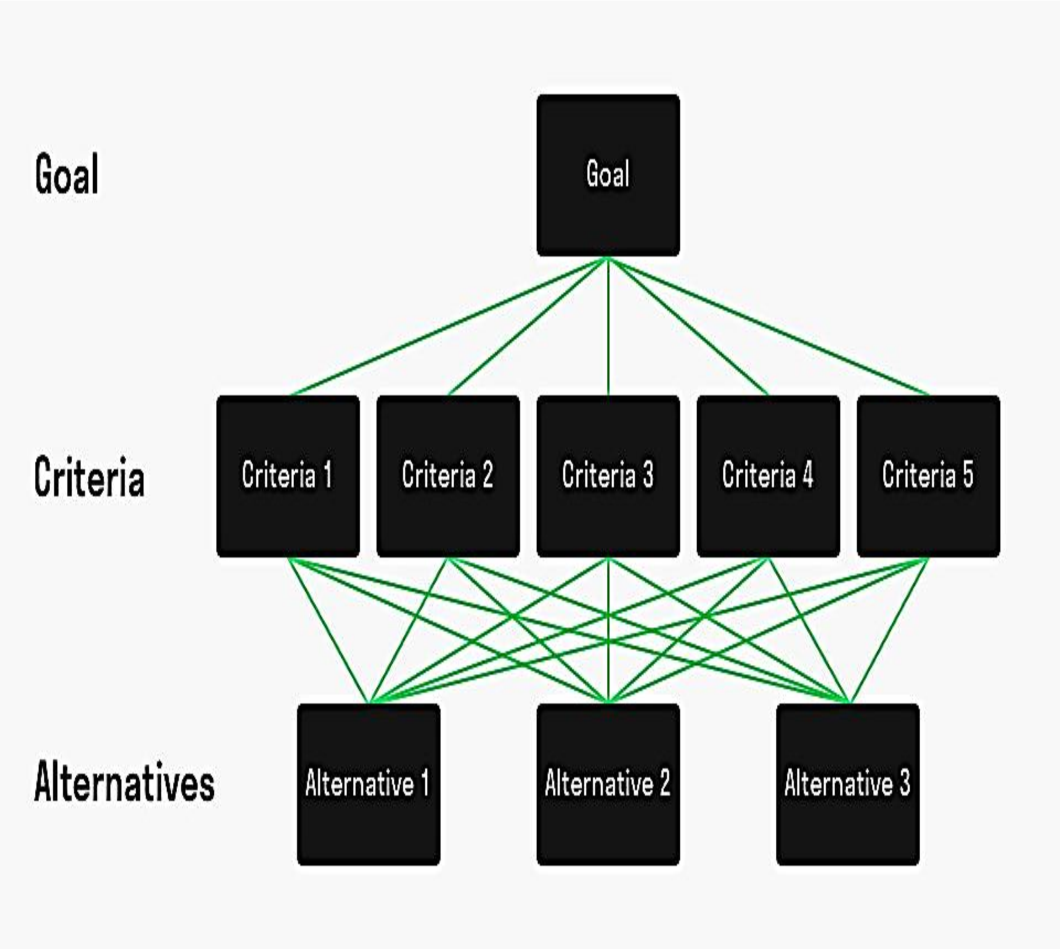

Figure 11: A Typical Two-Level Hierarchical Structure of AHP

(Thomas Saaty, 1980)

- Pairwise Comparison – All interrelated elements of the decomposed decision problem are evaluated through pairwise comparison. Each element on the different levels of the hierarchical structure is assessed through pairwise comparison to obtain the comparative weights of each element (Saaty, 1980; Saaty, 2008). Table 4 below shows Saaty's scale of relative importance used in comparing each element on the different levels of the decomposed decision problem.

Table 4: Saaty's Scale of Relative Importance
(Thomas Saaty, 1980)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective.
3	Moderate importance of one over another.	Experience and judgment slightly favor one activity over another.
5	Strong importance	Experience and judgment strongly favor one activity over another.
7	Very strong or demonstrated Importance	An activity is favored very strongly over another; its dominance is demonstrated in practice.
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order affirmation.
Reciprocals of above	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.	A reasonable assumption.

- Synthesis – All individual subjective judgments are pulled together through the hierarchical decompositions of the decision problem to provide an overall assessment of the available alternatives (Saaty, 2008).
- Sensitivity Analysis – The stability of the optimal solution is assessed to changes in the importance of the criteria by testing the best choice against the "what-if' type of change in the priorities of the criteria (Saaty, 2004; Saaty, 2008).

2.7.2 Implementation

According to Saaty (2008), the steps for implementing the Analytic Hierarchy Process (AHP) are as follows:

- Define the problem and determine the kind of knowledge needed to provide a solution.
- Model the decision problem into a hierarchy structure of interrelated elements

with the goal at the topmost level followed by the criteria on which subsequent elements may depend on the lowest level, which is usually a set of alternatives.

- Establish priorities (weights) from elements of the hierarchy through a series of judgments based on pairwise comparisons amongst the elements of the hierarchy. Each element in an upper level of the hierarchy is used to compare the elements in the level immediately below with respect to it.
- Synthesize all the individual subjective judgments of participants to yield a set of overall priorities for the hierarchy. The priorities obtained from the comparisons are used to weigh the priorities of every element in the level immediately below. Then weighed values are added to each element in the level below to obtain its overall or global priority. Its process is continued until the final priorities of the alternatives at the least level of the hierarchy are obtained.
- Carry out a consistency test of the judgments or sensitivity test of how changes in the weights may affect the optimal solution.
- Make a final decision based on the synthesized results and consistency (sensitivity) test of the process.

2.7.3 Advantages of AHP

- The main advantage of AHP over other multi-criteria methods is its ability to decompose decision problems into a hierarchical structure where the most important element of the decision problem can be further explored (Saaty, 1980; R. Ramanathan, 2001). It also reflects the natural tendency of the human mind to sort elements of a system into different levels and to group like elements in each level (Bayazit, 2005). Hence, AHP provides a more transparent and scientifically sound methodology for dealing with a wide range of decision-making problems.

- AHP has the ability to capture both the subjective and objective criteria (elements) of a decision problem (Ishizaka, 2009; Milosevic, 2003). Hence, its reliance on pairwise comparison allows decision-makers to rank alternatives holistically and directly with respect to the different criteria used in evaluating the decision problem. It also has the ability to deal with the interdependence of elements in a system and does not insist on linear thinking (Saaty, 2004).
- AHP supports group decision-making as it has the ability to combine the input of several people in providing judgment to a decision problem that has been structured in a hierarchical structure (Ishizaka, 2009; Saaty, 1989). Hence, it provides an overall assessment of the available alternatives to a decision problem that can be structured in a hierarchical form. It helps to reduce bias in decision-making (Zahir S., 2016).
- The AHP has the ability to track the logical consistency of judgments used in determining priorities (Madu, 2000; Saaty, 1994). Hence, it enables decision-makers to refine their definition or understanding of a problem so as to improve their judgment about a decision.

2.7.4 Disadvantages of AHP

- The main disadvantage of AHP is that not all decision problems can be decomposed in a hierarchical structure for the element of the decision problem to be further explored (Saaty, 2008). Hence, AHP may not provide a sound methodology for dealing with some complex decision-making problems.
- The AHP approach does not allow participants to explicitly express a true sense of distance in their choices since participants are only asked to provide a pairwise comparison of attributes used in evaluating the decision problem (R.Karthikeyan, K.G.S.Venkatesan, & A.Chandrasekar, 2016).
- The complexity of comparing attributes increases as the number of attributes used in evaluating a decision problem increases, thereby resulting in conflicting choices and a lack of transitivity (Brunelli M., 2017; Brunelli, Critch, & Fedrizzi, 2013). Hence, the complexity of comparing attributes increases as the number of attributes increases, thereby also increasing the risk of inconsistency as the AHP model begins to lack of transitivity in comparing attributes of a decision problem.
- The AHP method adopts an additive aggregation strategy which allows the bad performance in some criteria to be compensated by the good performance of other criteria (Munda, 2008; Zahir S., 1999). Hence, the AHP model allows trade-offs between criteria where detailed and often important information can be lost by this type of additive aggregation strategy.

2.8 Analytic Network Process (ANP)

The Analytic Network Process (ANP) was developed by Thomas Saaty (1996) to model subjective decision-making problems into an influence network of interrelated elements (goal, alternatives, criteria, and sub-criteria). It is a generalized form of AHP which considers the interaction and dependence of higher-level elements on lower-level elements (Saaty, 2004; Saaty, 2001). Hence, the ANP model allows for feedback connections and loops.

It is not a top-to-bottom form of hierarchy but a network of several nodes (elements) and clusters connected by lines or loops. The lines connect different types of nodes to each other, while the loops specifically connect clusters to components of themselves. The different types of nodes found in a network system are source node which acts as an origin of paths of influence (never a destination of paths); sink node, which serves as a destination of paths of influence (never an origin of such paths), an intermediate node which acts as transit nodes or that lies on cycles or falls on paths to a sink node which finally sinks (Saaty, 2004).

2.8.1 Essential Principles

The Analytic Network Process (ANP) methodology is based on five principles:

- Network Decompositions – A decision problem must be able to be decomposed into an influence network of all interrelated elements (clusters and nodes) where the control hierarchy or criteria serve as the basis for pairwise comparisons and are clearly identified (Kadoić1, 2018). The network decomposition would also detail the interaction and dependence between the various interrelated elements (clusters and nodes) of the decision problem. Figure 12 below shows a typical ANP network system with interrelated elements or nodes.

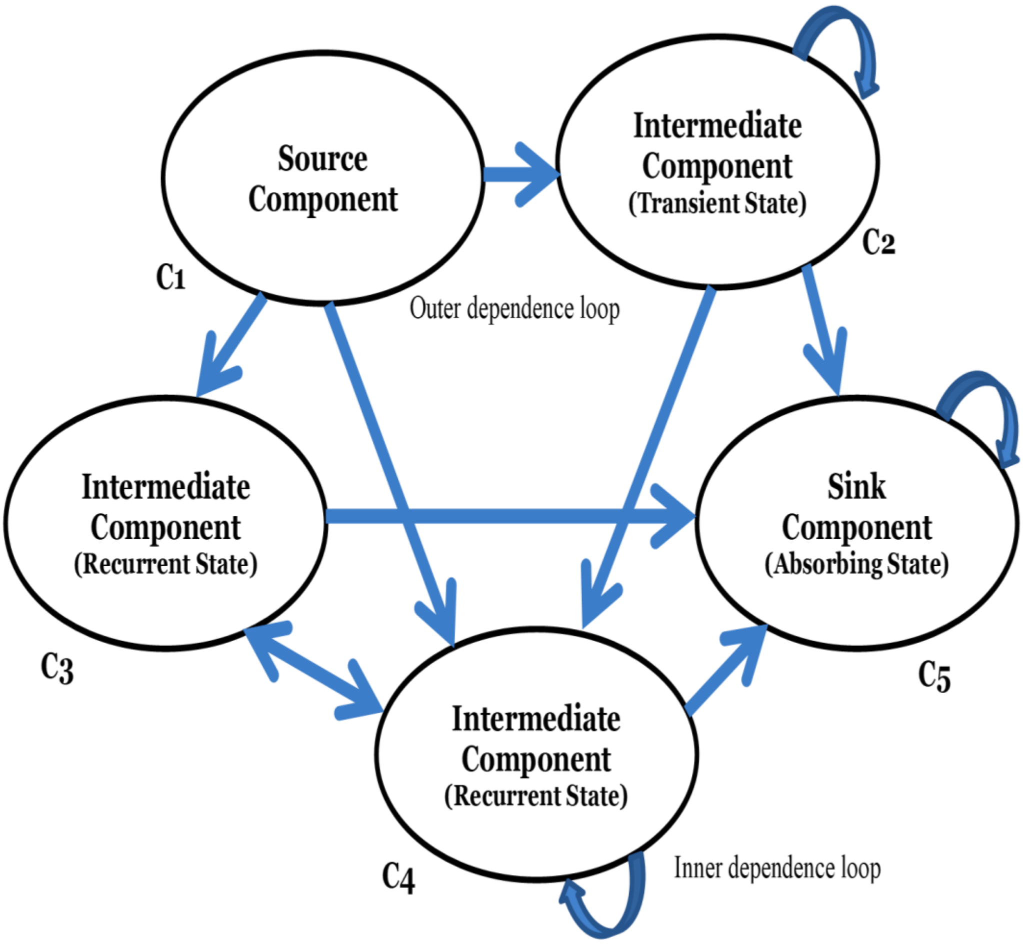

Figure 12: ANP Network System with Interrelated Elements or Nodes

(Saaty, T.L, 2004; Saaty T. L., 2001)

- Super Matrix – A super matrix is needed to measure all the interactions and dependencies between the interrelated elements (goal, alternatives, criteria, and sub-criteria) in an ANP model (Saaty, 2008; Alinezhad & Khalili, 2019). Each subjective judgment on the interrelated elements of the influence network would be used to form a synthesized matrix on the nature of the interactions and dependencies in the ANP model.

- Markov Chain – A Markov chain can be described as a stochastic process where the (probability of) future actions is not dependent upon the steps that led up to the present state (Alinezhad & Khalili, 2019). Hence in the priority calculation of the ANP, subjective judgments are treated as probabilities in a Markov chain process where future actions (nodes in the ANP model) are conditionally independent of the past.
- Synthesis – Here, individual subjective judgments are pulled together through the decomposed network of interrelated elements so as to be able to have an overall assessment of the influences and priorities of the elements making up the decision problem (Saaty, T.L; Vargas, L.G, 2006).
- Sensitivity Analysis – Similar to AHP, the ANP system also considers the stability of the solution in relation to small or large changes in the control criterions of elements to the decision problem (Saaty, 2004).

2.8.2 Implementation

According to Satty (2004), the steps of implementing an Analytic Network Process (ANP) are as follows:

- Define the problem and determine the kind of knowledge needed to provide a solution.

- Model the decision problem into a network of interrelated elements (goal, alternatives, criteria, and sub-criteria). The goal of the decision problem would be further decomposed into clusters and elements, criteria's and alternatives. The relationship between the different elements of the decision problem is explored in terms of interactions and dependence.
- Pairwise comparison is used to assess the subjective judgments of the interrelated elements of the decision before a supermatrix system is applied to obtain the final priority vector or overall rating (priorities) for the interrelated elements of the decision problem.
- A sensitivity test is then carried out to determine how minor changes may affect the final priorities of interrelated elements for the decision problem.
- A final decision can now be made based on the overall rating and consistency (sensitivity) test of the process.

2.8.3 Advantages of ANP

- The main advantage of ANP over other multi-criteria methods is its ability to decompose decision problems into a network of interrelated elements where the interrelationship and dependency of the elements of a decision problem can be further explored (Saaty, 2004). Hence, the ANP model allows feedback connections and loops to be explored for some complex decision-making problems.
- ANP has the ability to capture both the subjective and objective criteria

(elements) of a decision problem. It also relies on the application of a supermatrix for many complex decisions that cannot be handled by AHP to be analyzed (Saaty, T.L; Vargas, L.G, 2006). The supermatrix structure provides the computational space for feedback connections and loops representing decision problems to be assessed.

- ANP also supports group decision-making as it has the ability to combine inputs from several people in providing judgment to a decision problem that can be structured as a network of interrelated elements (Saaty, 2004). Hence, ANP provides the most powerful synthesis methodologies for combining judgment and data to rank options effectively and predict outcomes. It provides a real-world representation of the decision problems by using clusters of elements that represent the decision problem.
- The ANP also has the ability to track the logical consistency of judgments used in determining priorities (Saaty, 2004). Hence, ANP considers the stability of the final judgment (solution) in relation to if small or large changes are made to elements (nodes or clusters or control criterions) to the decision problem.

2.8.4 Disadvantages of ANP

- The main disadvantage of ANP is that this model is that it requires some understanding of the relationship between interrelated elements of the network representing the decision problem. The network structure may also not be as easily comprehensible as the hierarchical structure of AHP (Saaty, 2004).

- The process of deriving weights in ANP also relies heavily on the judgments and experiences of experts; hence the process is often regarded as highly subjective because it is also hard to quantitatively establish the relationship of elements of a network system representing a decision problem (Buede, 2009).
- ANP also relies on a supermatrix system that demands some high level of computing. The application of ANP requires specifically designed software for computing the combined judgments of experts needed to assess the alternatives to a decision problem (Saaty, 2008).
- The ANP method, just like the AHP method, adopts an additive aggregation strategy where bad performance in some criteria can be compensated by the good performance of other criteria (Munda, 2008). Hence, the ANP also allows some trade-offs between criteria where important information can be lost due to this type of additive aggregation strategy.
- The complex nature of the ANP network model makes it very difficult to conduct any form of sensitivity test without the appropriate software; therefore, when it is done by hand, there is no guarantee that it will be successful (Kadoic, 2018).

2.9 Simple Additive Weighting Method (SAW)

The Simple Additive Weighting Method (SAW) was developed by Churchman and Ackoff (1954) to solve and cope with a portfolio selection problem (Gwo-Hshiung & Jih-Jeng, 2011). The Simple Additive Weighting Method (SAW) is also known as the weighted linear combination or scoring method. It is undoubtedly the best-known and widely used method for multiple-attribute decision-making (Gwo-Hshiung & Jih-Jeng, 2011). It calculates the priorities for each alternative by multiplying the scaled value given to the alternative with the weights of relative importance assigned by the decision-makers to the attribute and finally summing up all the products for each criterion (Thakkar, 2021).

2.9.1 Essential Principles

The essential principles in the SAW methodology are:

- Decomposition of Hypothesis – A decision problem must be decomposed into sets of information-processing components where each component would offer some form of utility to the decision-maker that can be categorized as either a benefit or cost (non-benefit) component that makes up the decision problem or task (Gwo-Hshiung & Jih-Jeng, 2011).
- Additive Utility Assumption – Additivity (also called linearity or modularity) means that "the whole is equal to the sum of its parts". The SAW methodology works on the assumption that the utility and preference value of an alternative is made up of the numerical sum of all utilities from each component that make up the decision problem or task (Brandt, Conitzer, Endriss, Lang, & Procaccia, 2016).
- Maximization Principle – The best alternative to a decision problem is one with the highest utility, and if there is more than one alternative with the highest

utility, then any one of those alternatives with the highest utility becomes the best alternative to the decision problem (Bozorg-Haddad, Zolghadr-Asli, & Loáiciga, 2021).

2.9.2 Implementation

According to Churchman and Ackoff (1954), the steps of implementing Simple Additive Weightings (SAW) are as follows:

- Construct a pairwise comparison matrix for criteria, and according to the importance of each criterion assign a score for every criterion.
- Find the weighting sum matrix by multiplying the pairwise comparison matrix and priority vector, the comparison matrix is its column total, and the priority vector is its row averages.
- Find the consistency index by using the formulae:

$$CI = \frac{(k-n)}{(n-1)} \qquad \text{Equation 1}$$

K = average value of all the elements after they are divided by respective priority vector element
n = no. of elements

- Calculate the consistency ratio CR as follows:

$$CR = \frac{CI}{RI} \qquad \text{Equation 2}$$

(Where the value of RI is to be obtained from the standard table proposed by T.L. Saaty).

- Calculate a decision matrix (m * n) and the normalized decision matrix for positive criteria.

- Multiply the normalized weight of each criterion with the respective criteria to obtain the weighted score for each alternative using the normalized decision matrix.
- Obtain the sum total of each row representing various alternatives and from the final scores obtained, rank the alternatives to the decision problem.

2.9.3 Advantages

- The main advantage of this method is the fact that it is a proportional linear transformation of the raw data; hence the relative order of magnitude of the standardized scores would always remain the same or equal (Gwo-Hshiung & Jih-Jeng, 2011; Trise & Punggara, 2018).
- The SAW model can easily be integrated with other approaches or decision-making techniques to find solutions to various problems (Brandt, Conitzer, Endriss, Lang, & Procaccia, 2016). Hence, SAW can easily be integrated with a very large number of decision-making techniques alongside sensitivity analysis.

2.9.4 Disadvantages

- The main disadvantage of the SAW method is that its decision-making process does not account for the fuzziness or quality of experts' judgments being indistinct and without sharp outlines (Bozorg-Haddad, Zolghadr-Asli, & Loáiciga, 2021).

- Its internal validity is also affected by self-assessment bias.
- The SAW method is based on additive utility, and it demands all criteria be of maximizing nature by minimizing criteria within its decision matrix that can be easily converted to maximizing ones. It also demands that all criteria values be positive (Gwo-Hshiung & Jih-Jeng, 2011).
- The SAW method usually becomes more complicated to use when applied to multi-dimensional MCDM problems.

2.10 Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) was developed by Ching-Lai Hwang and Yoon in 1981 to select the shortest geometric distance from the positive ideal solution (PIS) and the longest geometric distance from the negative ideal solution (NIS) (Gwo-Hshiung & Jih-Jeng, 2011). TOPSIS is a compensatory MCDM technique that compares alternatives by identifying weights for each criterion, normalizing scores for each criterion, and calculating the geometric distance between all alternatives before selecting the one with the shortest distance from the ideal solution and the farthest distance from the most negative-ideal solution (Gwo-Hshiung & Jih-Jeng, 2011). Hence, this MCDM method holds the selected alternative that is closest to the most ideal solution and furthest to the least ideal solution as the best alternative to a decision problem.

2.10.1 Essential Principles

The essential principles in the TOPSIS methodology are:

- Decision Matrix – The decision matrix is central to the application of TOPSIS. The Decision matrix is used to define attributes, weigh them, and appropriately sum the weighted attributes to give a relative ranking amongst identified alternatives to the decision problem (Gwo-Hshiung & Jih-Jeng, 2011).
- Euclidean distance – TOPSIS methodology assumes that there is a straight-line distance between the best possible alternative and the worst possible alternative (Chakraborty, 2022). Hence, the alternative closest to the best possible alternative and furthest from the worst possible alternative would be the best attainable solution to a decision problem. Figure 13 below shows a diagrammatic form of Euclidean distance between the best possible alternative (A+) and the worst possible alternative (A).

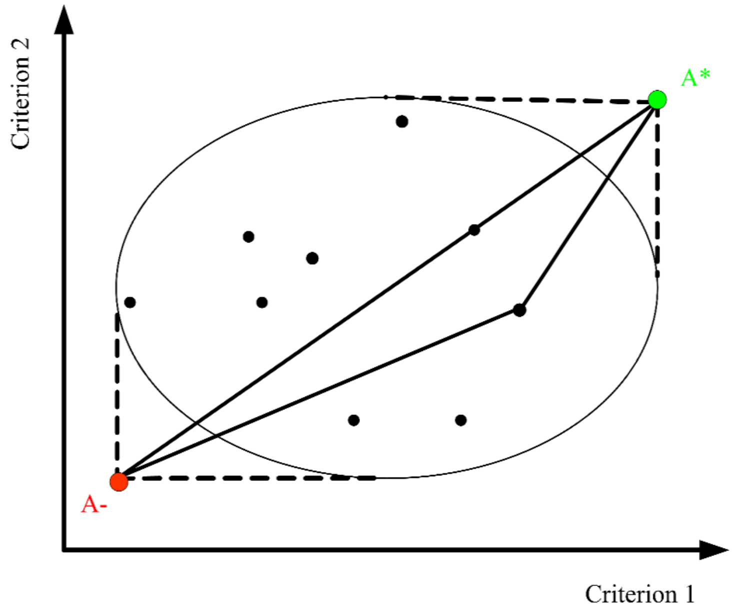

Figure 13: Euclidean Distance between two Alternatives A- and A+
(Gwo-Hshiung & Jih-Jeng, 2011)

2.10.2 Implementation

According to Gwo-Hshiung & Jih-Jeng, (2011), the steps for implementing TOPSIS are as follows:

- Define the overall goal, criteria, and alternatives of the decision-making problem are identified.
- The problem is structured as a decision matrix with m alternatives and n criteria,

Required Attributes (Criteria)

$$\text{Alternatives} \quad \begin{Bmatrix} x_{1,1} & x_{1,2} & x_{1,3} & \cdots & x_{1,n} \\ x_{2,1} & x_{2,2} & x_{2,3} & \cdots & x_{2,n} \\ x_{3,1} & x_{3,2} & x_{3,3} & \cdots & x_{3,n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ Xm,1 & Xm,2 & Xm,3 & & Xm,n \end{Bmatrix}$$

where the intersection of each alternative and criteria is given as xij, to have a matrix (Xij) m × n. for i = 1,2……...m; j = 1,2…......n

- Construct a normalized decision matrix to transform the various attribute dimensions into a non-dimensional attribute for easy comparison across all the attributes of the decision problem.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2 ij}}$$

Equation 3

- Calculate the weighted normalized decision matrix by multiplying the normalized decision matrix by its associated weights.

weighted $r_{ij} = w_j \; r_{ij}$ Equation 4

where i = 1, 2……...m; j = 1, 2….....n

- Calculate the worst alternative (Aw) and best alternative (Ab).

$$A_w = \left\{ \left\langle \max(t_{ij} / i = 1,2,......,m) / j \in J_{-} \right\rangle, \left\langle \min(t_{ij} / i = 1,2,......,m) / j \in J_{+} \right\rangle, \right\} \equiv \left\{ t_{wj} / j = 1,2,...n \right\},$$
$$A_b = \left\{ \left\langle \max(t_{ij} / i = 1,2,......,m) / j \in J_{-} \right\rangle, \left\langle \min(t_{ij} / i = 1,2,......,m) / j \in J_{+} \right\rangle, \right\} \equiv \left\{ t_{bj} / j = 1,2,...n \right\},$$

Where, $J_{+} = \{1,2,...,n / j\}$ is associated with the criteria having a positive impact, and $J_{-} = \{1,2,...,n / j\}$ is associated with the criteria having a negative impact.

- Calculate the L2-distance between the target alternative (i) and the worst condition (Aw) A w

$$d_{iw} = \sqrt{\sum_{i=1}^{n} (t_{ij} - t_{wj})^2}, \quad i = 1,2....,m., \qquad \text{Equation 5}$$

and the L2-distance between the alternative (i) and the best condition (Ab)

$$d_{ib} = \sqrt{\sum_{i=1}^{n} (t_{ij} - t_{bj})^2}, \quad i = 1,2....,m., \qquad \text{Equation 6}$$

and the distance between the alternative (i) and the best condition (Ab) where (d i w) and (d i b) are L2-norm distances from the target alternative (i) to the worst and best conditions, respectively.

- Calculate the similarity to the worst condition:

$$s_{iw} = d_{iw} / (d_{iw} + d_{ib}), \quad 0 \le s_{iw} \le 1, \quad i = 1,2....,m., \qquad \text{Equation 7}$$

Siw = 1 if and only if the alternative solution has the best condition; and

Siw = 0 if and only if the alternative solution has the worst condition.

- Rank the alternatives according to siw $i = 1,2....,m.,$

2.10.3 Advantages of TOPSIS

- The main advantage of TOPSIS is that it provides a simple, rational, and comprehensible approach to comparing the relative performance of each alternative in a mathematical form (Yoon K. , 1987; Hwang, Lai, & Liu, 1993). The TOPSIS method compares alternatives by identifying the weights for each criterion, normalizing the scores of each criterion, and calculating the geometric distance between each alternative to identify the most ideal alternative to a decision problem, which has the overall best aggregate score from each criterion (Hwang, Lai, & Liu, 1993).
- TOPSIS also allows participants to express some sense of distance in their choices of alternatives as its perception of alternatives is given in relation to the shortest geometric distance from the most positive ideal solution (PIS) and the longest geometric distance from the most negative ideal solution (NIS) (Yoon & Hwang, 1995).
- TOPSIS offers a more consistent form of decision-making than other decision-making techniques that rely on the application of pairwise comparison in establishing weights (R.Karthikeyan, K.G.S.Venkatesan, & A.Chandrasekar, 2016). Hence, TOPSIS has the ability to avoid the complexity of comparing attributes or problems of transitivity in selecting an alternative or making a decision.

2.10.4 Disadvantages of TOPSIS

- The main disadvantage of the TOPSIS approach is that it does not provide any means for elicitation of weight and checking the consistency of judgments or solutions produced (Shih, Shyur, & Lee, 2006). Hence, it only reflects the preferences of decision-makers in most cases, and it also lacks the ability to check the consistency of decision-making once weights have been established.
- Compensatory methods such as TOPSIS allow trade-offs between criteria, where a poor result in one criterion can be negated by a good result in another criterion (Valerie & Stewart, 2002; Polatidis, Haralambopoulos, Munda, & Vreeker, 2006; Munda, 2008). Hence, similar to the AHP method, detailed and often important information may also be lost in the evaluation of alternatives using the TOPSIS method.

2.11 Pareto Analysis (PA)

The Pareto Analysis principle was developed by Vilfredo Pareto in 1906. It is also a decision-making technique used in selecting a limited number of tasks that would produce the same significant overall effect if all tasks were included (Powell & Sammut-Bonnici, 2014). The Pareto analysis is based on the 80/20 rule, which states that for most work-related problems, 80 per cent of problems may be caused by as few as 20 per cent of identified causes. Consequently, the phrase "the vital few and the trivial many" was later coined by Dr Joseph Jouran in the 1940s to demonstrate that a small percentage of causes can lead to a higher percentage of issues (Juran & Defeo, 2010). The Pareto analysis is, therefore, also a tool for analyzing both the possible causes of an observed problem and its solutions. For example, 20% of factors considered to avoid collision are responsible for 80% of ship collisions. Then 80% of ship collisions can be addressed by resolving 20% of the most underlined factors considered whilst trying to avoid a collision.

2.11.1 Essential Principles

The essential principles of the Pareto Analysis are:

- Bar Chart – The performance of attributes needs to be displayed in rectangular bars with heights or lengths proportional to the values they represent. It is also used to show comparisons among the attributes investigated (Rahul , 2021).
- Frequency Line Graph – Line graphs are usually used to visualize the value of an attribute over time; hence its contribution in the Pareto analysis is to visualize the percentage contribution of each attribute (each rectangular bar in the Bar chart) to the total distribution of values that represent the observed attributes (Juran & Defeo, 2010). The frequency line used in the Pareto chat is also used to derive the limited number of attributes that would produce the same significant overall effect if all attributes were included. Figure 14 shows a typical Pareto chart showing the vital few that are responsible for 80% of the decision problems and the trivial many responsible for 20% of the decision problem.

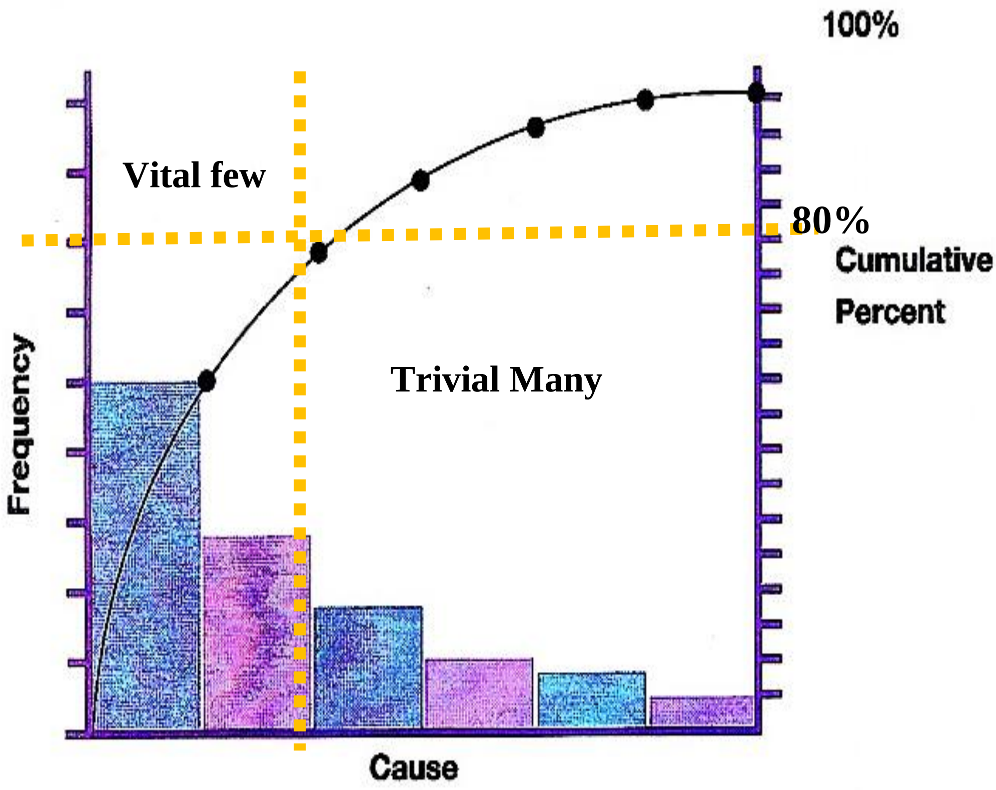

Figure 14: A Typical Pareto Chart

Juran & Defeo (2010)

2.11.2 Implementation

According to Juran & Defeo (2010), the steps of implementing Pareto Analysis are:

- Measurable attributes are identified for data collection to take place.
- Data is collected and represented in the form of a table listing.
- Rank order the attributes with the highest to lowest frequencies.
- A bar chart in ranking order is created (x-axis for the attributes and y-axis for the frequency of the attribute) with the least ranked attribute on the right side of the chart.

- Calculate the cumulative value of the attributes.
- Calculate the cumulative percentage of each attribute.
- Plot on the same a bar graph, a cumulative frequency graph using the cumulative percentages of each attribute.
- Draw the cumulative sum line with the extreme right attribute having a 100% cumulative value for its attribute.
- Draw a straight line on the 80% to where it cuts the cumulative frequency line.
- Identify the vital few attributes responsible for 80% of the observed data and the trivial many other attributes responsible for only 20% of the observed data investigated.

2.11.3 Advantages of the Pareto Analysis

- The main advantage of the Pareto Analysis is that it focuses on the 80:20 rule, which provides a very sound methodology for dealing with a wide range of managerial problems where 20% of identified issues are responsible for 80 % of the problems (Grosfeld-Nir, Ronen, & Kozlovsky, 2007; Powell & Sammut-Bonnici, 2014). Hence, it enables decision-makers to understand the root causes of problems and as well identify the most important causes of the problem needed to resolve a majority of the problem.
- The analysis makes use of bar charts and frequency graphs which gives adequate visualization of the root causes of a problem. It also highlights specific measures needed to provide a solution to a decision problem when resources are scarce

(Powell & Sammut-Bonnici, 2014). Hence, the Pareto analysis is often used as a guide for how to allocate resources in solving a decision problem.

2.11.4 Disadvantages of the Pareto Analysis

- The main disadvantage of the Pareto Analysis is that it focuses on the past, and this might not provide any real significant information on the current situation (Sarkar, Mukhopadhyay, & Ghosh, 2013). Hence, it does not offer any real solution to the problem. It rather only highlights the few significant causes that are responsible for the majority of the problem.
- The Pareto Analysis relies mainly on observed data; hence, it may show the cause of most of the problems but would not be able to show how bad the problem is or how many resources would be needed to completely restore the problem (Sarkar, Mukhopadhyay, & Ghosh, 2013).
- The charts used Pareto Analysis focuses on key causes of decision problems; however, multiple charts may often be needed to understand further the issues responsible for the identified key causes responsible for the majority of the decision problem (Sarkar, Mukhopadhyay, & Ghosh, 2013; Powell & Sammut-Bonnici, 2014). Hence, different levels of problems may require multiple charts of Pareto Analysis.
- Pareto Analysis requires accurate scoring for each element of the problem or causes of the problem; hence any error in the scoring problem would lead to an inaccurate assessment of the problem (Sarkar, Mukhopadhyay, & Ghosh, 2013;

Wilkinson, 2006). This also makes it difficult to troubleshoot any problem arising from inaccurate scoring in a Pareto Analysis.

2.12 Chapter Summary

This chapter provides an overview of the concepts of decision-making, decisions making problems, and the multi-criteria decision analysis (MCDA) process. This chapter also provides a critical review of the application of MCDA methodologies on safety culture. Furthermore, this chapter provides detailed knowledge of selected multi-criteria decision-making methodologies such as the Analytic Hierarchy Process (AHP)/Analytic Network Process (ANP), Simple Additive Weighting Method, Technique for Order of Preference by Similarity to Ideal Solution and Pareto Analysis. It also details explicitly how these MCDA methodologies can be implemented in solving decision-making problems.

3 Theoretical Background of Maritime Safety Culture

3.1 Introduction

This chapter presents the most central perspectives relevant to the concept of safety management and maritime safety culture, as described in the background of this thesis. This chapter details explicitly the development of safety management, safety culture, maritime safety culture, dimensions of maritime safety culture, and the different approaches for assessing the safety culture of maritime organizations.

3.2 Safety Management

The word “safety” means different things to different people, so there are several published definitions of safety. The Merriam-Webster Online Dictionary defines safety as “the condition of being safe from undergoing or causing hurt, injury, or loss” or “safety” (Merriam-Webster, 2021). Safety has also been defined as a state in which hazards and conditions leading to physical, psychological, or material harm are controlled to preserve the health and well-being of individuals and the community (Maurice, Lavoie, Laflamme, Svanström, & Anderson, 2010). Concerning safety management, every organization is required by law to provide measures to ensure people's safety, health, and welfare at work. Hence, safety management can best be described as measures required to ensure that an acceptable level of safety is maintained to help prevent the occurrence of accidents, injuries, or near misses in a workplace.

The earliest records of safety management can be traced to the second millennium, where the Babylonian King Hammurabi set laws to execute masons whose constructed houses fell and killed the owners or occupants. The Hammurabi's Code is also one of the most famous examples of the ancient precept of retaliatory justice. Hence, the Hammurabi code specifically used punishments as a motivational tool to ensure builders created safe homes for their occupants. (ARPANSA, 2020; Wieslaw, 2012). However, Hollnagel (2018) states that the major changes in safety management over the years can best be described in the following four phases: the technological age; the human age; the organizational age; and the systems or holistic age.

The first phase in the evolution of safety management is called the technology age. The technological age started with the first Industrial Revolution between 1750 –1760 and the invention of the steam engine or machines. This era's major causes of accidents were attributed mainly to mechanical and structural failures (Ashton, 1948; ARPANSA, 2020). The general view of safety management in the technological age was that “if the technology is safe, then we will be safe”, hence it was suggested that accidents could be prevented if technical standards and guidelines issued by professional engineers, architects, and designers were followed (ARPANSA, 2020). The technology age also saw an improvement in the ability to identify what part of the technology failed and the development of sophisticated techniques (such as probabilistic risk assessment) for managing risky technology or controlling risk at the source by eliminating, substituting, isolating, or engineering out hazards.

The technology age also witnessed the very obvious contribution of the human factor to accidents; hence, the second age of safety (the human factor age) started after the end of the Second World War. This age of safety management witnessed an increase in the reliability of both hardware and software developed for machines (Hollnagel, 2018; ARPANSA, 2020). It also witnessed the very obvious contribution of the human factor to accidents; hence, the focus of safety management was expanded so that issues of both the human element (the human factor) and technology would be covered so as to prevent or minimize the risk and occurrence of accidents. The general view of safety management during this era was that "if humans are safe, then we would be safe" hence, it was suggested that technology be designed to fit the people and the working environment where that technology is going to be used or used deployed. This approach to safety management also later led to the development of human factors and ergonomics as a professional engineering and design field.

The third age of safety (organizational age) was between the late 1980s and early 2000s. This age is marked by notable accidents such as the Challenger space shuttle accident and Chernobyl reactor meltdown, which brought the realization that humans were rarely the sole cause of accidents or error, and that human performance was based on a complex interaction of the socio-technical system that constitutes an organization (Hollnagel, 2018; ARPANSA, 2020; Swuste, Paul; Groeneweg, Jop; Guldenmund, Frank W; Gulijk, Coen Van; Lemkowitz, Saul; Oostendorp, Yvette, 2021). The scope of safety management was now expanded to cover the contribution of organizational, human, and technological factors in the occurrence of accidents. This view also led to the development of new safety management models and assessment techniques (e.g.

safety culture or climate surveys) to enable safety managers to identify, manage and or remove weaknesses higher up in the organization that could lead to serious accidents in the future. Hence, the general view of the organizational age was that 'if the organization is safe, then we will be safe'.

The fourth age of safety management (system/holistic age) came to birth after investigations on accidents prior to the Columbia Space Shuttle disaster in 2003 highlighted that the causes of several notable accidents were not just isolated events of failures at the organizational level or clear human and technical failures, but rather as a result of complex and interdependent interactions between technology, human and organizational factors present at the time of the accident (ARPANSA, 2020; Hollnagel, 2018; Dekker, 2019). Figure 15 below summarises the different timelines and phases of safety management in organizations.

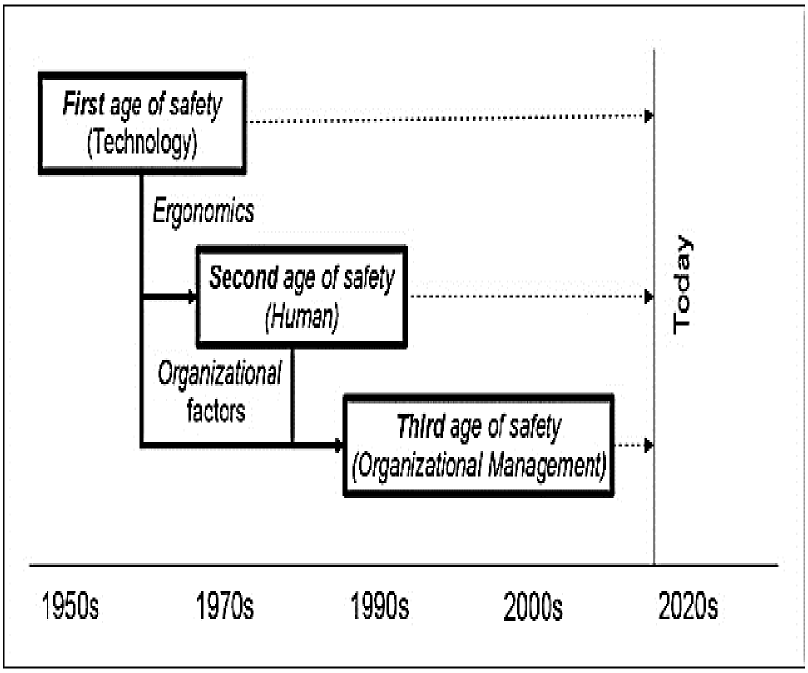

Figure 15: Evolution of Safety Thinking

(Hale A. , 2000b; Schubert, Hüttig, & Lehmann, 2010; Stolzer, Halford, & Goglia, 2008)

The findings of this accident and other similar accidents sparked another paradigm shift in safety management as it became apparent to safety managers that it was no longer enough to only focus on the relationship between technological, human, and organizational factors in isolation but also to explore the complex interrelationships and interdependencies between the technology, human and organization to be able to identify, manage and prevent the occurrence of accidents similar to the Columbia Space Shuttle disaster (ARPANSA, 2020; Hollnagel, 2018; Dekker, 2019). Figure 16 below encapsulates all the different approaches to safety management.

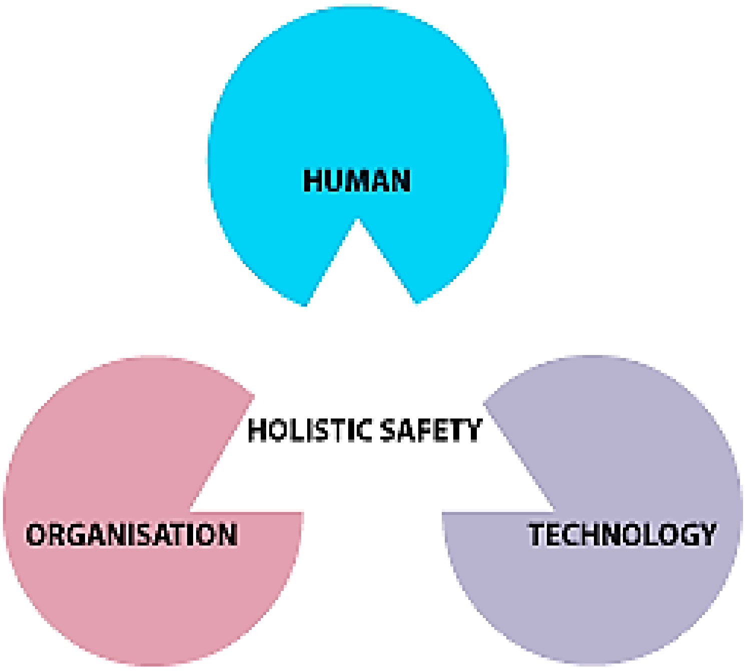

Figure 16: History of Safety

(ARPANSA, 2020)

The system/holistic approach represents current best practices in safety management adopted by many industries (Beard & Santos-Reyes, 2008; Kowalski, 2019; Sgourou, 2014). It encapsulates the previous technological, human and organizational approaches to safety and considers the relative contribution provided by each approach. It also examines the complex inter-relationships and inter-dependences between these approaches, thereby allowing critical aspects of safety that might otherwise be missed to be analyzed (Leveson, 2015; Swuste, Paul; Groeneweg, Jop; Guldenmund, Frank W; Gulijk, Coen Van; Lemkowitz, Saul; Oostendorp, Yvette, 2021). More importantly, it provides a better understanding of crucial factors that can affect the safety performance of an organization and encourage widespread ownership of safety efforts.

3.3 Safety Culture – Origin and Definition

The concept of safety culture was developed as a result of the evolution of safety management and the understanding of accident causation. The concept of safety culture specifically originated during the organizational age of safety management and was first introduced by the International Atomic Energy Agency after the Chernobyl nuclear power plant disaster in 1986 (INSAG, 1986). The International Safety Advisory Group (INSAG), an advisory group to the International Atomic Energy Agency (IAEA), investigated the Chernobyl disaster and identified the root cause of the accident as a human factor. However, the International Safety Advisory Group (INSAG) used the term "poor safety culture" in its report to clearly describe the actions and inactions of people (human factor) that contributed and led up to the Chernobyl disaster (Wiegmann, Zhamng, Von Thaden, & Mitchell, 2002).

The International Safety Advisory Group (INSAG) also went further to define safety culture as; *"That assembly of characteristics and attitudes in organizations and individuals, which establishes that, as an overriding priority, nuclear power plant safety issues receive the attention warranted by their significance."*

Afterwards, several researchers have developed other definitions for safety culture to provide better clarity to the meaning and description of the subject of safety culture and how it fits into the subject of safety management or management of safety. Table 5 below summarizes some of the commonly found definitions seen in different works of literature.

Table 5: Definitions of Safety Culture

Reference	Definition of Safety Culture
Cox & Cox (1991)	Safety culture reflects the attitudes, beliefs, perceptions, and values that employees share in relation to safety (safety culture)
International Safety Advisory Group (1991)	Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance (safety culture)
Pidgeon (1991)	The set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers, and members of the public to conditions considered dangerous or injurious (safety culture)
Ostrom, L., Wilhelmsen, C., & Kaplan, B (1993)	The concept that the organization's beliefs and attitudes manifested in actions, policies, and procedures, affect its safety performance (safety culture)
Geller (1994)	In a total safety culture (TSC), everyone feels responsible for the safety and pursues it on a daily basis (safety culture)
Berends (1996)	The collective mental programming towards the safety of a group of organization members (safety culture)

Lee (1996)	The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, and organization’s health and safety management (safety culture)
Kennedy and Kirwan (1998)	An abstract concept, which is underpinned by the amalgamation of individual and group perceptions, thought processes, feelings, and behaviors, which in turn gives rise to the particular way of doing things in the organization. It is a sub-element of the overall organizational culture (safety culture)
Hale (2000)	This refers to the attitudes, beliefs, and perceptions shared by natural groups as defining norms and values, which determine how they act and react in relation to risks and risk control systems (safety culture)
Glendon and Stanton (2000)	Compromises attitudes, behaviors, norms and values, personal responsibilities as well as human resource features such as training and development (safety culture)
Guldenmund (2000)	Those aspects of the organizational culture which will impact on attitudes and behavior related to increasing or decreasing risk (safety culture)
Cooper (2000)	Culture is the product of multiple goal-directed interactions between people (psychological), jobs (behavioral), and the organizational (situational); while safety culture is that observable degree of effort by which all organizational members direct their attention and actions toward improving safety on a daily basis (safety culture)
Mohamed (2003)	A sub-facet of organizational culture, which affects workers’ attitudes and behavior in relation to an organization’s ongoing safety performance (safety culture)
Richter and Koch (2004)	Shared and learned meanings, experiences, and interpretations of work and safety – expressed partially symbolically- which guide people’s actions toward risk, accidents, and prevention (safety culture)
Fang, D., Chen, Y., & Wong, L. (2006)	A set of prevailing indicators, beliefs, and values that the organization owns in safety (safety culture)
Wu, T.C.; Lin, C.H.; Shiau, S.Y. . (2010)	employees' imaging of safety conditions in the workplace; which images then affect organizational safety activities and safety results

Nuclear Regulatory Commission (2011)	Nuclear Safety Culture is the core values and behaviors resulting from a collective commitment by leaders and individuals to emphasize safety over competing goals to ensure the protection of people and the environment.
BSEE (2013)	The core values and behaviors of all members of an organization that reflect a commitment to conducting business in a safe and environmentally responsible manner.
Morrow, S., Koves, K., & Barnes, V. (2014)	Employees' beliefs about the importance of safety are shaped by the safety culture of the organization, which then influences their attitudes toward safety, perceived norms over safe working behaviours for working safely, and perceptions of control over safe working behavior.

From the table above, most definitions of safety culture are relatively similar from the perspective of belief and the way that people think or behave towards safety-related issues in an organization.

3.3.1 Elements of Safety Culture

According to Reason (1997), safety culture comprises five key elements:

- An informed culture: An organization with a positive safety culture must have current knowledge about the human, technical, organizational, and environmental factors that determines the safety of the system as a whole. Hence, the organization regularly collects and analyses relevant data and actively disseminates safety information across all levels of the organization.
- A reporting culture: An organization with a positive safety culture must also have an atmosphere for people to report safety concerns, errors, and near misses without fear of blame. In an organization with a positive safety culture, managers and operational personnel should freely be able to share critical safety

information without the threat of punitive action. Hence, employees know that the confidentiality of their information will be maintained and that the information provided will be acted upon; otherwise, they may decide that there is no benefit in reporting their safety concerns, errors and near misses.

- A learning culture: An organization with a positive safety culture should be able to learn from its mistakes and make changes. The people working in an organization with a safety culture must understand the SMS processes at a personal level or have the willingness and competence to draw the right conclusions from their safety information system and the will to implement major reforms when the need is indicated.
- A just culture: An organization with a positive safety culture ensures there is some form of shared accountability between the organization and its employees. In such an organization, people would not be held accountable for system failures that they have no control over; however, those who take deliberate and unjustifiable risks would be punished or subjected to disciplinary action. In such an organization, there is also a clear line drawn between acceptable and unacceptable behaviours in the organization.
- A flexible culture: An organization with a positive safety culture should be able to reconfigure itself to face high-tempo operations or certain kinds of danger; hence, organizations should be able to shift from the conventional hierarchical structure to a flatter professional structure if needed to address certain risks or safety issues. Figure 17 below encapsulates all the elements of the safety culture covered above.

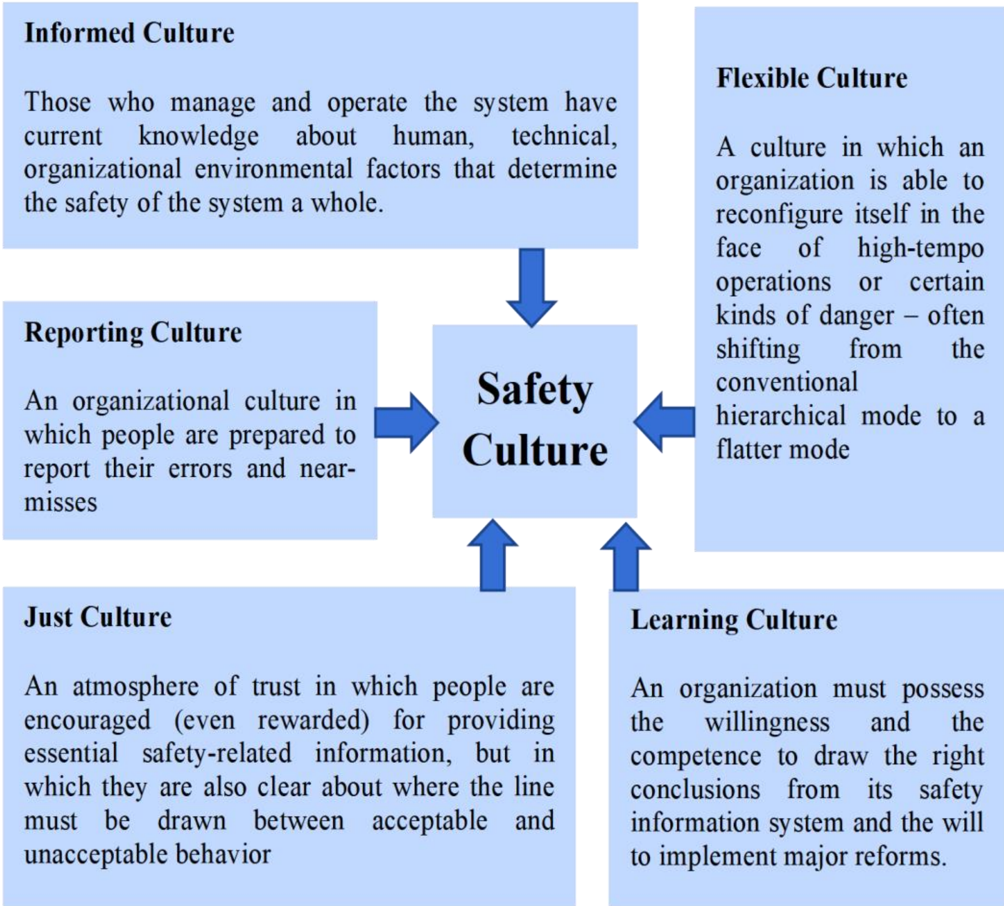

Figure 17: Elements of Safety Culture

(Reason, 1997)

3.3.2 Types of Safety Culture

Several authors as Westrum (1993, 2013), Hudson (2001, 2003) and Fleming (2000), classified safety culture according to different stages of maturity; however, concerning decision-making processes of different actors in an organization regarding safety and safety management. Simard, Daniellou, & Boissières, (2011) classified safety culture according to the weights which actors (management and sharp-end workers) of organizations give to safety in their workplace. The four types of safety culture described by Simard, Daniellou, & Boissières, (2011) are; fatalistic safety culture, workplace work culture, bureaucratic safety culture, and integrated safety culture.

3.3.2.1 Fatalistic Safety Culture

Fatalistic safety culture is developed in an organization where both the management and its sharp-end workers do not place much importance on safety in their decision-making process (Simard, Daniellou, & Boissières, 2011). The actors in these organizations do not believe it is possible to influence the level of safety or accidents. Hence, they believe the occurrences of accidents are just “a stroke of bad luck” or “acts of god”.

3.3.2.2 Shop-Floor Safety Culture

A shop-floor safety culture occurs when the management of an organization does not place much importance on safety while its sharp-end workers develop their own prudent work practices to protect themselves against the risks associated with their occupation (Simard, Daniellou, & Boissières, 2011). Over the years, these practices are later perfected and passed down from one generation to the next. These practices are perfected and get passed down from one generation to the next (for example, it was common for miners to make use of canaries in coal mines to detect the presence of carbon monoxide and other toxic gases before they hurt humans).

3.3.2.3 Bureaucratic Safety Culture

A bureaucratic safety culture develops when an organization and its managers place strong importance on its safety performance level. The managers of the organization and its safety experts usually introduce a formal safety system that takes safety into account in investments and relies on the different echelons of management to pass down orders for other members of staff to follow (Simard, Daniellou, & Boissières, 2011). Furthermore, safety measures developed using this top-down approach easily conflict with the standard work practices within that occupation. Making sharp-end workers more reticent about implementing the requirements of the developed formal safety system or may have trouble following the instructions of the developed formal safety system.

3.3.2.4 Integrated Safety Culture

An integrated safety culture develops in an organization when both management and its employees place a strong emphasis on the impact of safety in its decision-making process. The managers and employees or sharp-end workers of such organizations usually have a shared conviction that no single person holds all of the knowledge necessary for ensuring good safety performance (Simard, Daniellou, & Boissières, 2011). Hence, everyone within the organization works as a team in an attempt to achieve a high level of safety, while the prevention of major accidents or hazards would require the combination of a wide range of skills; it requires information to be circulated and evaluated, and the concern for safety should be reflected in all decisions at all levels as well as in all company processes. In reality, one could easily find a specific combination of all four types of safety culture than just one type in any given organization. Figure 18 below summarizes the different types of safety cultures and possible levels of involvement from both management and employees.

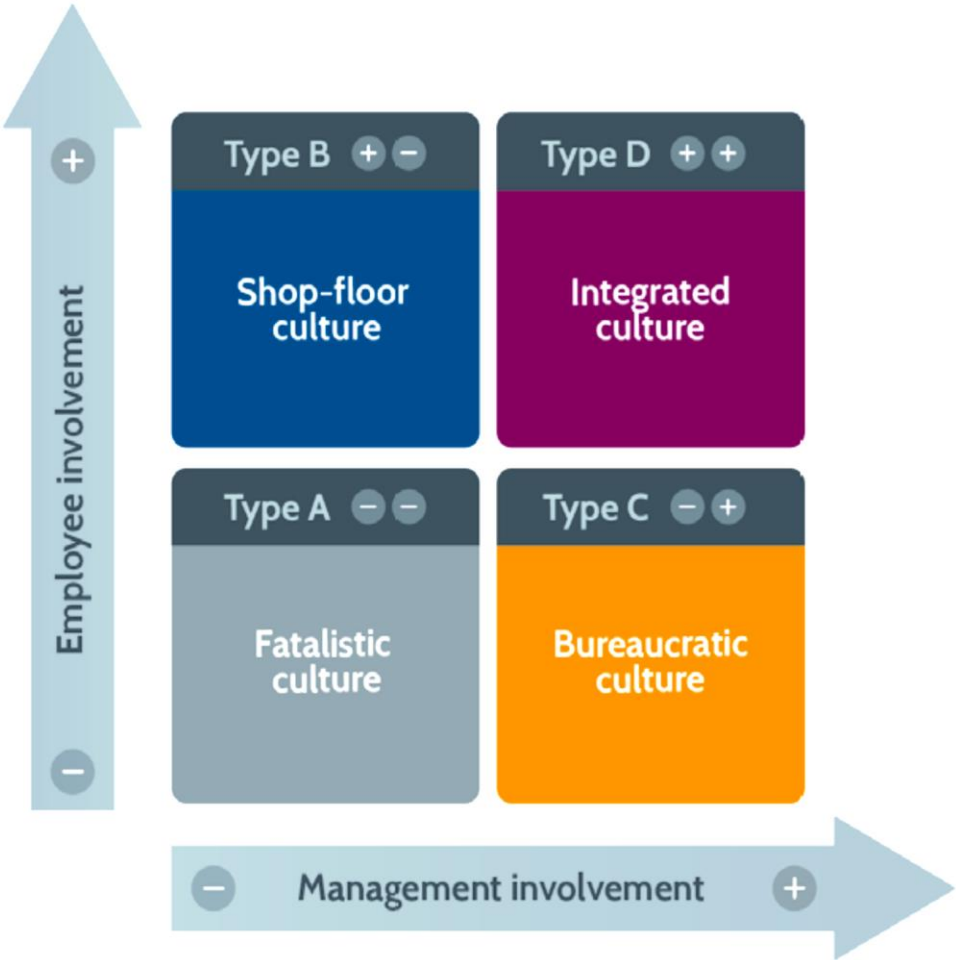

Figure 18: Types of Safety Culture

(Simard, Daniellou, & Boissières, 2011)

3.4 Maritime Safety Culture

The Joint MSC/MEPC Working Group on the role of the human element defines safety culture as a culture in which there is a considerable informed endeavour to reduce risks to the individual, ships, and the marine environment to a level that is .as low as is reasonably practicable (Maritime Safety Committee, 2003). Furthermore, the IMO described "an organization with a safety culture as one that gives appropriate priority to safety and realizes that safety has to be managed like other areas of the business". The IMO also stated that the key to achieving an effective safety culture is "recognizing that accidents are preventable through following correct procedures and established best practice, constantly thinking safety, and seeking continuous improvement of safety with a goal of achieving".

In relation to the context of this study, maritime safety culture can also be described as the attitudes, beliefs, perceptions, and values shared by employees of a maritime organization in relation to safety. It is a product of employees' attitudes, beliefs, perceptions, and values that determine the commitment and robustness of safety management in maritime organizations. In effect, maritime safety culture reflects "the way people think or behave towards safety-related issues when no one is watching".

In relation to the context of shipboard operations, safety culture may be described as doing the right thing at the right time in response to normal and emergency situations. Hence, a good safety culture ensures the safe operation and management of ships. Maritime safety culture is, therefore, of great interest to all senior decision-makers of maritime organizations and not only those involved with the day-to-day technical operation of their organizations' ships because improving safety saves money as well as lives. Maritime safety culture is also of interest to maritime organizations because it enables maritime organizations to maximize the benefits and cost-saving opportunities that could be derived from the implementation of the ISM code. In addition to the above, maritime safety culture aids in reducing loss of employee hours, hospital costs, sick leave, pollution costs, cargo damage, and insurance premiums.

The IMO states that safety culture must take root in the professionalism of seafarers because many accidents still do occur as a result of unsafe acts, errors, or violations of established rules that could easily have been avoided (IMO, 2020). IMO also stated that though the quality and effectiveness of training influence the professionalism of seafarers, it is the culture of maritime organizations or shipping companies that largely shapes the attitude of seafarers in the maritime industry (IMO, 2020). Hence, maritime organizations or shipping companies are encouraged to balance professionalism with a positive organizational culture to achieve s proactive maritime safety culture for the safe operation and management of ships. Furthermore, with an effective safety culture, maritime organizations and their staff will always and automatically think about the implications for safety and pollution prevention in every action taken. Also, everyone employed by the company, whether a manager, Master, or junior rating, would truly believe and understand the purpose of established procedures and continuously seek ways to improve safety and pollution prevention as a matter of course.

3.4.1 Elements for Achieving a Proactive Maritime Safety Culture

According to MSC (2003), the key elements for achieving a proactive maritime safety culture are:

- Stakeholder participation – Stakeholders involved in the identification, assessment, and management of safety-related risks must also play an active role in determining the appropriateness and effectiveness of measures employed to mitigate the risks. Stakeholders usually achieve this through industry representation on international bodies at one level and, at another level, onboard crew safety representatives.
- Commitment and visibility – Individuals responsible for managing risks need to clearly show a strong commitment to the development and support of a safety culture to ensure the environment is safe for work. Although the behaviour of individuals may be influenced by a set of rules, it is their attitude to the rules that really determines the culture. Hence, individuals responsible for managing risks need to be seen as complying with safety regulations because of their understanding and commitment to safety and just because they want to or have to comply. Those responsible for decision-making on safety-related issues would also need to be identifiable to workers in the company, as stated in the ISM code.
- Productivity/Safety Relationship (safety cost v accident cost) – The maritime industry is currently focused on proactive approaches to safety (culture) and has also widely recognized the relationship between improved safety management

and increased ship earnings and productivity. Hence, the economic arguments for not promoting safety management (i.e., it will cost too much) are no longer justified.

- Trust – stakeholders or individuals involved in the assessment and management of safety-related risks must trust in the information received to manage safety-related issues. In other words, stakeholders or individuals involved in the management of safety-related risks must be able to not only receive information but also have the means to judge that information because a crisis of trust cannot be overcome by simply having more regulation and or more auditing, as this may yield a culture of compliance rather than a culture of responsibility.
- Shared perceptions – In the management of safety-related risks, those involved in the management of safety-related risks must have the same perception of risks as those who are exposed to them. Hence, stakeholders are also expected to have a shared perception of how identified risks can be mitigated.
- Communication – Communication ensures that concerns about safety, thoughts, and aspirations are clearly understood by all stakeholders. It is, therefore, not enough to think or have good intentions about what is safe and unsafe but to have concerns and thoughts properly understood by all stakeholders involved.
- Organizational learning – Maritime organizations must have the ability to learn from past mistakes and improve themselves and the systems that support their activity. The potential of real organizational learning can only be fully reached where there is a “No Blame Culture” in the organization. The promotion of such an environment for organizational learning requires visible support from senior

management for seafarers to believe that such an open and honest environment exists for learning to take place from previous mistakes, near misses, or accidents.

- Safety resources – Safety should always be seen to be at the centre of all decisions made in an organization. Hence, sufficient resources should always be made available to support, nurture and develop it.
- Industrial relations and job satisfaction – the maritime industry has also recognized the relationship between job satisfaction and safety performance; hence for a maritime organization to have a positive safety culture, there must also be a good relationship between the employee and the employer. This would yield better job satisfaction among the employee and become more proactive in both understanding and adopting any proposed safety measures. Seafarers who have a negative perception towards their employer would less likely to trust the motives of their employer in wanting to make changes that would be of any benefit to them.
- Training – Training plays a vital role in ensuring a proactive safety culture in a maritime organization; however, training someone does not necessarily mean the person becomes competent automatically. Hence, maritime organizations must recognize the intrinsic relationship between training, competence, and procedures. Very often, procedures are mistakenly viewed as a way of bridging the gap between training and competence; however, laid down procedures for any job task can never replace the understanding and awareness that is innate to competence.

3.4.2 Dimensions of Maritime Safety Culture

The dimensions of safety culture play a significant role in its assessment; however, there are no agreed ways to segment safety culture. The American Bureau of Shipping (ABS) was the first to segment the safety culture of the maritime industry. In 2009, ABS collaborated with Lamar University (Beaumont, Texas) and other maritime industry partners around the world to carry out a Mariner Safety Research Initiative (MSRI) project where over 100,000 injuries and close call records from 31 data sources were analysed and translated into usable context for owners and operators in assessing and describing maritime safety culture (Tomlinson, Craig, & McSweeney, 2016; ABS, 2022).

According to ABS (2014), the identified eight (8) dimensions of maritime safety culture are described as follows.

- Communication: This reflects the extent to which channels of communication within the organization are open and effective. Effective communication plays a vital role in promoting workplace safety (Flin, Crichton, & O'Connor, 2008). Communications up, down, and across maritime organizations must be open and effective; hence the channels of communication must also be monitored for their effectiveness. The managers and masters must be able to speak, listen and understand all the information needed for safe ship operation.
- Empowerment: This refers to the extent to which each member of the workforce feels empowered to fulfil their safety responsibilities successively. The

empowerment of each member of the workforce aids the promotion of positive safety culture by providing workers with the tools and resources needed to address safety-related issues in the workplace. The empowerment of workers would also ensure clear delegation and accountability of safety-related responsibilities (Jung, 2021). This would encourage each member of the workforce to accept and fulfil his/her individual safety responsibilities, while management would expect adequate sharing of safety-related concerns across all levels of the organization.

- Feedback: This refers to the extent of how quickly management responds to safety-related issues and concerns. The feedback system of an organization enables management to respond to workers on safety-related issues and concerns (Schöbel & Szameitat , 2007). It also provides timely communication of incidents, investigations, and audits to the workforce. Feedback also encourages workers to raise safety-related issues and concerns promptly, thereby ensuring mismatches between practices and procedures (or standards) are resolved in time to prevent the normalization of any deviance.
- Mutual Trust: This reflects the extent to which both members of the workforce and management are expected to do the right thing in support of safety. Mutual trust plays a very vital role in safety culture because workers feel more eager to shoulder their share of responsibility towards safety when they trust the managers would also do the right thing towards providing adequate safety in the workplace (Guldenmund F., 2010; Duryan, Smyth, Roberts, Rowlinson, & Sherratt, 2020). It also ensures the workers are productive and keen on reporting

and keen on reporting any potential safety problem, concern, or issue. Mutual trust also gives workers the confidence that honest mistakes can be reported without any fears of reprisals or punishments.

- Problem Identification: This reflects the extent to which potential problems are readily identified. Problem Identification is an important element of safety culture; it enables the workforce to recognize unsafe acts and conditions (Wahlström & Rollenhagen, 2004; Morrow, Koves, & Barnes, 2014). Problem identification encourages positive safety culture when workers have adequate experience and training on how to identify unsafe acts and conditions and how to take steps to avoid or mitigate them. The ability of staff to identify problems within the operation and management of a maritime organization is also a very indicator of the level of safety culture maturity within the organization.
- Promotion of Safety: This reflects the extent to which managers promote safety as a core value in the organization. Safety Promotion refers to any set of activities or processes used to develop, sustain, and improve maritime safety through awareness-raising and changing behaviours. The promotion of safety also yields positive safety culture when managers are seen to be making visible, active, and consistent support towards promoting safety at all levels within the organization (Flin, Crichton, & O'Connor, 2008). The management of maritime organizations should always be seen to be doing what is right, demonstrating their values through their communications, actions, priorities, and provision of resources as these values cascade down through all levels of the organization.
- Responsiveness: This reflects the extent to which each member of the workforce

responds to the demand of the job, including unexpected events and emergencies. The crews of a ship are not only responsible for the task of operating and maintaining the ship, but they are also responsible for managing any form of accidents, unexpected events, and emergencies (Arslan, Turan, Kurt, & Wolff, 2016). All crew members are adequately provided with emergency preparedness training and full personal protection equipment (PPE) for them to be able to respond to emergencies and other safety-related issues. Crew members are also normally encouraged to get adequate rest between shifts to maximize their alertness and readiness to respond to any emergencies during their work periods.

- Safety Awareness: This reflects the extent to which each member of the workforce is aware of his/her responsibilities with regard to the safety of self, co-workers, the organization, and the environment. Workers are expected to be aware of all the possible safety-related issues in their environment (Flin, Crichton, & O'Connor, 2008). A strong sense of safety awareness amongst workers goes a long way in promoting a safety culture because each worker would be aware of his/her responsibility to self, co-workers, the organization, and the environment. A strong sense of safety awareness would also make workers feel more accountable for their own actions and those of their colleagues or crew, thereby creating a strong level of intolerance for violations of established safety performance norms within the workforce. Figure 19 below summarises all the dimensions of maritime safety culture identified by ABS.

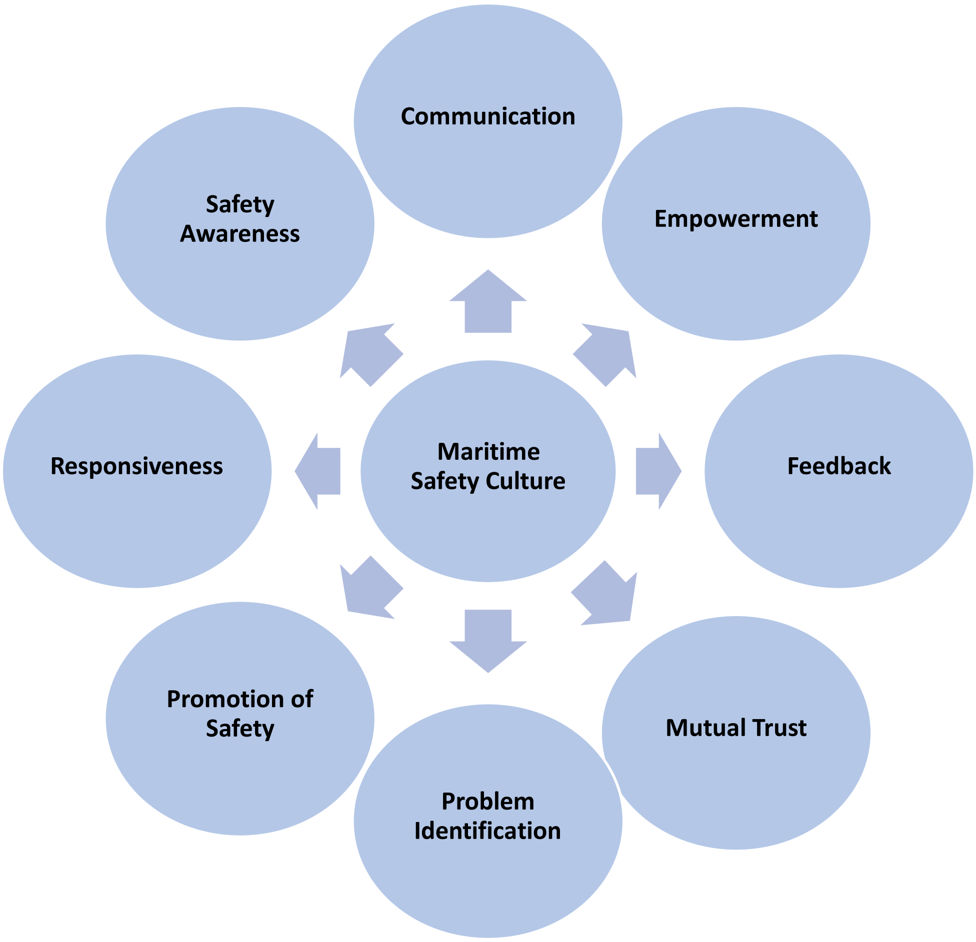

Figure 19:Dimensions of Maritime Safety Culture

(ABS, 2014)

3.5 Maritime Safety Culture Assessment

Safety culture is complex; it combines ways of doing and ways of thinking. It cannot be measured but can be described; hence the purpose of any safety culture assessment is simply to provide a better understanding of how organizational culture (and its different elements) positively or negatively influences safety-related decisions (Simard, Daniellou, & Boissières, 2011; Arslan, Turan, Kurt, & Wolff, 2016; Merry, 1998).

Maritime safety culture assessments are therefore expected to;

- **make visible what people in the organization are thinking:** it looks at beliefs, perceptions, convictions,
- **know what they are doing:** by clearly identifying safety practices and behaviours, the difficulties encountered, deviations from instructions/rules,
- **question the coherence and alignment** between what they are thinking and what they are doing.

3.5.1 Approaches to Maritime Safety Culture Assessment

According to ABS (2014), the two main approaches for assessing maritime safety culture are;

- Objective: This approach entails the identification of objective leading indicators or quantitative safety metrics that are associated with the safety culture and safety performance of a maritime organization. The identification of these objective leading indicators is done by correlating quantitative safety metrics related to safety culture with the safety performance data of a maritime organization for at least five years when done at an organizational level and for at least one year when done at across the fleet or at the business unit level. This is the most preferred approach for maritime organizations because of its objectivity; because it utilizes metrics that have been collected by the organization has collected, and it does not require a survey of the workforce; hence its analysis is relatively straightforward and not time-consuming.

However, the main setbacks of this approach are that it cannot be used to identify new safety culture metrics that could be used to enhance the safety culture and safety performance of a marine organization; this approach is also not suitable for assessing or capturing the quality of the safety management system in place.

- Subjective: This approach entails the identification of subjective leading indicators or qualitative safety metrics from a survey that is associated with the safety culture and safety performance of a maritime organization. The qualitative safety metrics are based on the values, attitudes, and observations of employees. The identification of these subjective leading indicators is made by correlating survey results with the safety performance data of a maritime organization for the last twelve months. This is the most preferred approach when maritime organizations lack sufficient metrics to identify objective leading indicators. This approach also allows potential new safety culture metrics to be collected and tracked by the maritime organization. However, the main setbacks of this approach are that it requires a survey of the workforce and it is time-consuming; this approach is also subjective, which makes them difficult to quantify and include in a continual improvement program.

3.6 Gaps in Literature on Safety Culture Assessments

Safety is one of the most important principles governing the operations and management of ships; however, the application of safety culture as a proactive strategy towards safety management in the maritime industry is still relatively at its early stage of development. Consequently, there are not so many studies on how the safety culture of a maritime organization can be assessed and managed like any functional area of a business. In assessing safety culture, there are still no universally approved lists of safety factors (metrics) that can be used in assessing, describing, and benchmarking the safety culture of a maritime organization (Taylor, 2010). The safety factors (metrics) identified by ABS is still the most recognized set of safety factors (metrics) used in assessing the safety culture of maritime organizations; however, there are no studies that have attempted to evaluate the weightings or (values) of each safety factor (metric) used in assessing the safety culture of the maritime organization. A study exploring the weights or values of safety factors (metrics) used in assessing the safety culture of a maritime organization would provide a better understanding of the value system towards safety factors (metrics) that influences the safety culture of maritime organizations in a country or at a national level.

Furthermore, the conventional methodologies used in assessing the safety culture of maritime organizations have generally been objective, subjective, and a combination of both objective and subjective methods. These conventional methods of assessing safety culture also rely mostly on the application of correlational statistical techniques to ensure the reliability and validity of the results obtained from the assessment process

(ABS, 2014; Taylor, 2010; Arslan, Turan, Kurt, & Wolff, 2016). However, disagreements amongst researchers on which correlational statistical technique is most reliable for assessing safety culture make it difficult to create a universally accepted technique for ensuring the reliability and validity of results obtained from the assessment process. The application of correlational statistical techniques also uses only a few safety factors (metrics) in developing plans for the improvement of safety culture, thereby making it difficult to track and benchmark an organization's performance for each safety factor (metrics). Also, the correlation of historical incident rates against current perceptions in safety culture assessment is scientifically unsound as safety climate scores cannot accurately reflect the safety performance of an organization, and that is why most safety climate surveys hardly predict the actual safety behaviour or ongoing levels of safety performance in an organization (Clarke, 2006). Hence, this is why there are very few industries that use safety climate surveys as a standard, practical ongoing safety performance metric (i.e. a leading indicator).

Most recently, several hybrid techniques have been developed using decision-making techniques to assess the safety culture of organizations without the reliance on correlational statistical techniques; however, every decision-making model is developed to solve one type or category of problem. Some may be useful in exploring the weights or values of safety factors (metrics) used in assessing safety culture; others may be suitable for tracking and benchmarking the performances of each safety factor that influences the safety culture of organizations. Therefore, creating a gap in knowledge on how decision-making techniques can be integrated and combined to enable safety culture to be assessed and managed like any other functional area of a business.

The major gaps identified from the works of literature on the assessment and management of safety culture in organizations are as follows:

- Gap 1: Several works of literature may have explored the preferences of experts on safety factors/safety metrics used in describing the safety culture, but none demonstrates how the preferences of experts on safety factors/safety metrics could be combined with the output of a safety culture survey data to produce a weighted assessment for the safety climate/culture of a maritime organization. The weights or preferences of experts on safety factors/safety metrics are also the most important aspect of applying most decision-making theories in safety culture assessment and management.
- Gap 2: Works of literature provide different methods for assessing safety climate/culture but do not provide a transparent methodology on how the performances of safety factors used in describing the safety culture of vessels can be benchmarked and tracked.
- Gap 3: Works of literature also do not provide a transparent methodology on how feedback received from safety culture surveys can be used to assess and manage safety climate/culture under any known hybrid technique or decision-making technique.
- Gap 4: Several works of literature have explored different means of ensuring the reliability and validity of results obtained from the assessment of safety culture; however, there has not been any transparent methodology for justifying both the sequence of improvement activities to enhance safety culture and the scheduling of vessels for a safety culture improvement plan.

3.7 Chapter Summary

This chapter specifically summarizes the concepts of safety management, safety culture, maritime safety culture, elements for achieving a proactive maritime safety culture, dimensions of maritime safety culture, maritime safety culture assessment, approaches to maritime safety culture assessments and gaps in the literature on the assessment and management of safety culture in maritime organizations.

4 Research Design and Methodology

4.1 Introduction

The previous two chapters reviewed the concepts of safety management, safety culture, decision-making, and multi-criteria decision-making methodologies. This current chapter describes the research design and methodology adopted to achieve the aim and objectives of this research, as outlined in sections 1.5 and 1.6. This chapter also specifically describes various research strategies applied in carrying out this study, with an explanation of the reasons why they were chosen, how they were utilized in this study, and key elements of the proposed conceptual decision-making framework for assessing the safety culture of a selected maritime organization.

4.2 Research Design

A research design is a framework for planning a research study to examine specific testable research questions of interest (O'Leary, 2017). A research design also provides the researcher with an overall strategy to integrate the different components of a study coherently to effectively address a research problem or connect empirical data of a study to a study's initial research question (Yin R. K., 1994; Creswell & Creswell, 2018; Dawson, 2009). Thus, a research design can be said to be the structure, or the blueprint, of research that guides the process of research from the formulation of the research questions and hypotheses to reporting the research findings.

The selection of a research design depends on the nature of the research questions and hypotheses, the variables involved, the settings of the research, the sample of participants, the method of data collection, and the method of data analysis. According to Robson (2002) and Yin (2009), the general principle for applying a research strategy is the appropriateness of that method to answer the research question. Figure 20 below shows the different research strategies based on the different forms of research questions.

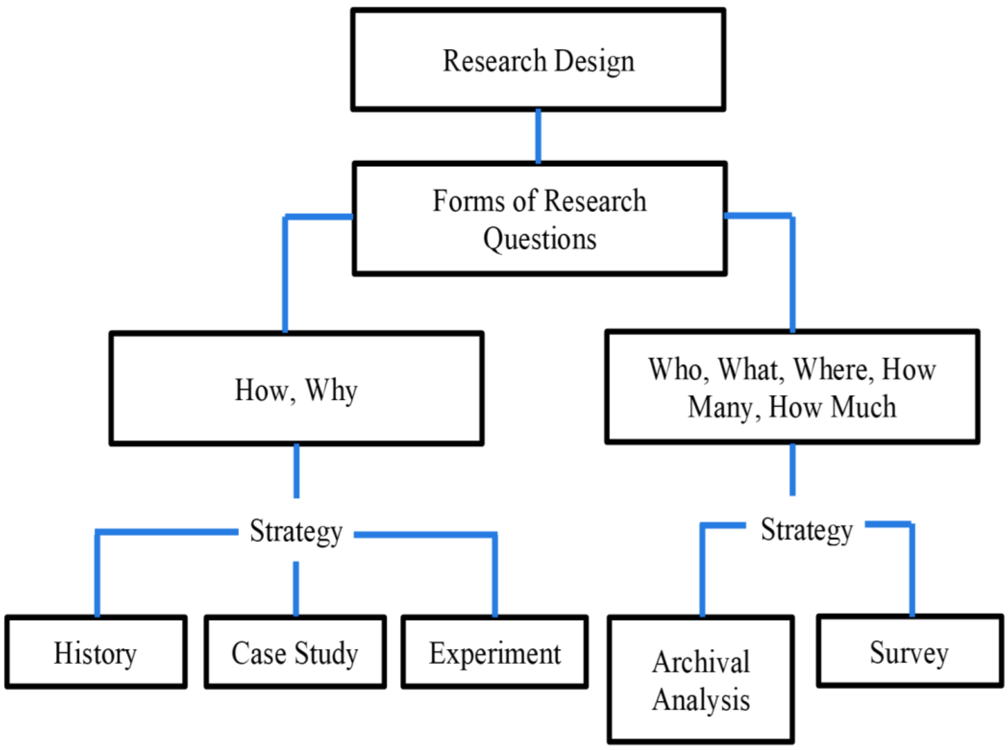

Figure 20: Research Strategies and Different Forms of Research Questions

(Creswell, 2018)

The main purpose of this research study is to develop a decision-making framework for assessing the safety culture of a maritime organization; hence in carrying out this research study, a mixed-method research design was employed to guide the researcher in the collection, measurement, and analysis of data needed to address the research problem or achieve the aims and objectives of the research.

4.2.1 Mixed Research Method

According to Johnson and Onwuegbuzie (2004), mixed methods of research can be defined as a research approach where the researcher mixes or combines both quantitative and qualitative research techniques, methods, approaches, concepts, and language into a single study. The mixed method of research is also an attempt to legitimize the use of multiple approaches in answering research questions rather than restricting or constraining the choices of a researcher in providing answers to research questions (i.e., it rejects dogmatism). It is, therefore, an inclusive, pluralistic, and complementary form of research that allows a researcher to take an expansive and extensive approach towards answering a research question.

Concerning this study, the mixed research method was selected because it allows the purposeful integration of both quantitative (e.g., experiments, surveys) and qualitative (e.g., focus groups, interviews) forms of research in providing answers to the research question of how an appropriate decision-making framework can be designed and implemented to assess the safety culture of maritime organizations. A mixed-method research design was employed because it capitalizes the strengths of both quantitative and qualitative approaches, enhancing the depth and breadth of the study. By combining numerical data with contextual insights, the research would be able to provide a more comprehensive understanding of safety culture assessment and management. The mixed-method research design was also employed in this study because it allows triangulation of findings, validity of findings and exploration into different facets of the research question. The qualitative component of the mixed-method research design particularly enables the capturing of participant perspectives, in-depth exploration and uncovering of nuanced patterns that quantitative data alone might have missed. Additionally, the mixed-method design offered a robust foundation for theory development and testing, and the integration of diverse data sources enriched the interpretation and practical implications of the study's outcomes.

4.2.2 Qualitative Research Method

Nkwi, Nyamongo, and Ryan (2001) define qualitative research as any research that uses data that do not indicate ordinal values. Qualitative research is also described mostly as any research that focuses on obtaining data through open-ended and conversational communication (Guest, Namey, & Mitchell, 2013). Hence, the qualitative research method entails the collection and analysis of non-numerical data (e.g., text, video, or audio) to provide a better understanding or insights into a problem or generate new ideas for research. Also, in this study, the qualitative aspect enables the exploration of research problems that may not be easily quantified. Hence, this aspect of the study would specifically allow the development of insights on variables measured in the quantitative phase as well as developing new variables that could be integrated into future studies on the assessment of safety culture. The data collection method during the qualitative phase of the study employed the use of open-ended survey questions, interviews, and group discussions.

4.2.3 Quantitative Research Method

Creswell (2002) defines the "quantitative research method as the process of collecting, analyzing, interpreting, and writing the results of a study". Also, Watson (2015) defined "quantitative research method as a range of methods concerned with the systematic investigation of a social phenomenon, using statistical or numerical data". It basically entails the use of models to provide a better understanding of trends in data, including describing relationships between variables and identifying inconsistencies.

In relation to this work, the quantitative aspect of this study allows the quantification of research problems by way of generating numerical data or data that can be transformed into usable statistics. The quantitative phase of this study specifically allows the quantification of defined variables used to describe or characterize the attitudes, opinions, and behaviours of staff towards safety in the management and operation of a maritime organization. Hence, this phase of the study uses survey questionnaires to collect and quantify the opinion of both shipboard and shore-side workers of the selected case-study maritime organization in Nigeria.

The quantitative phase of this study specifically utilized three (3) different sets of survey questionnaires in quantifying variables used to characterize the attitudes, opinions, and behaviours of staff towards safety in the management and operation of a maritime organization. The first survey questionnaire was used to elicit weights from safety factors (safety metrics) that influence the safety culture of maritime organizations in Nigeria during the period of the study. The second and third sets of survey questionnaires were used to elicit the attitudes of both shipboard and shore-side staff towards safety, respectively, in the selected case-study maritime organization. The demographic information collected in the three (3) different sets of surveys are; age, gender, nationality, department, job title (position occupied either in the ship or office), years of experience in the maritime industry, years working with their current employer and the number of years working in their present position.

The surveys conducted in this study also make use of traditional survey questionnaire and safety factors (metrics) used by ABS. The traditional survey questionnaire and safety factors (communication, empowerment, feedback, mutual trust, problem identification, promotion of safety, responsiveness, and safety awareness) identified by ABS were adopted in this study because they are still the most recognized set of safety factors used in the maritime industry (Volkan, Rafet , Osman , & Louis , 2016).

Additionally, in comparison to other studies such as Håvold (2004; 2010), Oltedal (2011), Bhattacharya (2015), and Chan (2021), the ABS safety culture questionnaire was also chosen and adopted in this study because it offers a more comprehensive insight into the strengths and areas of improvement regarding safety culture in maritime organizations with commercial carrying vessels. Furthermore, the safety factors (metrics) identified by ABS were also adopted for this study because they are still no recognized studies that explored the preferences of maritime experts on the weights of safety factors (metrics) used in describing the safety culture of maritime organizations.

4.2.4 Case Study

The case study research method aims to analyze specific issues within the boundaries of a specific environment, situation, or organization. The case study research method also allows in-depth, multi-faceted exploration of complex issues in real-life settings. Hence, Nigeria was chosen mainly because it provided the researcher with an opportunity to gain an in-depth appreciation of safety culture as an issue or phenomenon of interest in its natural, real-life context. Nigeria was also chosen because safety culture is still an emerging trend in the country, and the cultural settings of most maritime organizations in Nigeria closely align with the conditions of safety that spurred the exploration of decision-making frameworks for assessing and managing the safety culture of maritime organizations.

Yin (2014) defines a case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and its context are not evident". Goode and Halt (1952) recommend the use of a case study as a tool in research design to simply organize social data so as to preserve the unitary character of the social object being studied. In other words, a case study approach to research design is used to observe, update and refine knowledge about a contemporary phenomenon within its real-life context.

It also provides an in-depth study of a particular research problem rather than a sweeping statistical survey or comprehensive comparative inquiry. Hence, a case study approach to research design was also employed to provide the researcher with a real-life context for the phenomenon or research problem to be explored. A case study approach was also employed in the research design to test whether a specific theory and model applies to a real-life context.

4.2.5 Company Profile: Sea Transport Group Nigeria Limited

The Sea Transport Group Nigeria Limited is an indigenous maritime organization established in 2006 with both tanker operations and ship management services in Nigeria. The Sea Transport Group Nigeria Limited also commenced its inaugural tanker operation in 2008. The Sea Transport Group Nigeria Limited was chosen because it is about the largest indigenous tanker operator in West Africa and would serve as a representative example of the sector's practices, challenges, and trends. The findings of the study would also yield a global impact on the international shipping industry whilst contributing to academic literature. The vessels managed by Sea Transport Group Nigeria Limited consists of ten (10) tankers, namely:

MT AMIF
MT SEA VOYAGER
MT SEA PROGRESS
MT SEA GRACE
MT SEA ADVENTURER
MT DIDDI
MT UM BALWA
MT KINGIS
MT MOSUNMOLA
MT ASHAB

The organizational units involved in the operation and management of tankers in Sea Transport Group Nigeria Limited are:

- Chartering Department
- Manning Department
- Operations Department
- Safety & Certification Department

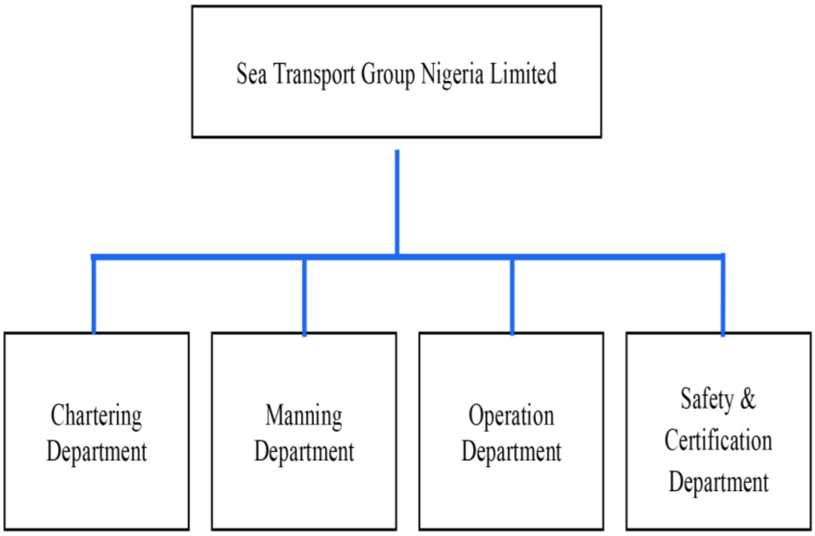

Figure 21: Organizational Units at Sea Transport Group Nigeria Limited

Figure 21 above illustrates the organizational units involved in the operation and management of tankers with Sea Transport Nigeria Limited. Furthermore, details of activities carried out by the above-listed organizational units are:

- **Chartering Department:** The chartering department is the commercial unit of Sea Transport Group Nigeria Limited and is responsible for marketing managed vessels to various clients to secure fleet employment under both short and long-term contracts to ensure a steady and positive cash flow for the company. It is also responsible for negotiating employment contracts after thorough market research and analysis, as well as identifying market trends and opportunities for the company. The chartering department is also responsible for maintaining good working relationships between charterers, brokers, and other market participants.

- **Manning Department:** The manning department is responsible for the recruitment and management of the ship's crew. The manning department is specifically responsible for providing vessels of Sea Transport Group Nigeria Limited with qualified, skilled, certificated and medically fit seafarers in compliance with national and international requirements. The Manning department is also responsible for supporting seafarers on deployment issues, travel arrangements, specialized training, orientation courses, medical emergencies, etcetera.
- **Operations Department:** The Operations Department is responsible for the running of the vessels owned and managed by Sea Transport Group Nigeria Limited. It manages communications and or activities between its fleet, other departments of the company, charterers, and all third parties involved with the ships (ship agents, ship chandlers, bunkering suppliers, shippers, receivers, stevedores, etcetera). The Operations Department is also responsible for monitoring the performance of vessels owned and managed by Sea Transport Group Nigeria Limited during both time and voyage-chartered vessel contracts. Its responsibility also entails the provision of

post-fixture support services, which ensure that its chartered vessels perform in compliance with the charter party agreements and international standards to ensure the safe and efficient carriage of cargoes. Hence, it supervises all activities related to the cargo and voyage of its vessels (pilotage, towage, wharfage, dockage, demurrage collection from charterers, canal transits, bunkering, and cargo operations).

- **Safety & Certification Department:** This department is principally responsible for ensuring vessels owned and managed by Sea Transport Group Nigeria Limited operate within set standards and regulations of the tanker industry. The safety and certification department ensures the effective implementation of Quality, Environmental, Occupational Health & Safety Management Systems in vessels owned and managed by Sea Transport Group Nigeria Limited. The safety and certification department also ensures that all vessels owned and managed by Sea Transport Group Nigeria Limited are suitable for its intended charter. Hence, they are also responsible for arranging all types of inspections, vetting, and safety-related certification and documentation needed for trading.

4.3 Research Methodology

The main purpose of research methodology is to describe the process followed in providing answers to the research questions or fulfilling the objectives of the research. The research methodology specifically details the procedures or techniques used to identify, select, process, and analyze information about a research problem or subject matter, or topic. Such procedures have been developed to increase the likelihood that the information gathered will be relevant to the question as well as reliable and unbiased. Hence, research methodology also constitutes the blueprint for the collection, measurement, and analysis of data used in providing an answer to a research problem. It also enables the researcher to provide answers to questions through the application of scientific procedures followed during the course of this research study.

4.3.1 Research Methods Applied in this Thesis

The works of literature summarized in chapter 2 and chapter 3 of this thesis highlighted key problems and gaps existing in the traditional approaches for assessing and managing the safety culture of maritime organizations. The works of literature summarized in the above chapters also gave insight into how key components and techniques of MCDM can be developed and integrated for the purpose of being applied to this study. Table 6 below shows the different research components and techniques applied in this thesis.

Table 6: Research Components and Techniques used in this Thesis

Research Component	Techniques and Approaches Used	Relevant Chapters
Research Questions	Literature Review	Chapter 1
Conceptual Methodology	Literature Review Conceptual Decision-Making Framework/Model Generation	Chapter 2 Chapter 3 Chapter 4
Sampling, Data Collection and Analysis	Interviews Informal Discussions Online Survey MADM Techniques Statistical Techniques (AHP, SAW, TOPSIS, Pareto Analysis)	Chapter 5 Chapter 6 Chapter 7 Chapter 8 Chapter 9 Chapter 10 Chapter 11

4.4 Decision-Making Framework for Maritime Safety Culture

The problem-solving cycle concept of Hale, A., Hemning, B., Carthey, J., & Kirwan (1994) represents the earliest form of decision-making methodology used for solving safety management-related issues; hence its main stages and phases were further adopted for this thesis (See Figure 22). The main phases of the conceptual decision-making methodology adopted for this study are:

- Problem Recognition
- Application of AHP in the elicitation of weights and priority setting for Safety Factors
- Safety Climate Survey
- Application of SAW in establishing the Weighted Safety Climate
- Application of Pareto Analysis in gaining insights on safety-related issues and justifying the recommendations of the SAW model.
- Application of TOPSIS in scheduling vessels for safety culture improvement programs.
- Validation of decision-making models
- Synthesis and Reporting

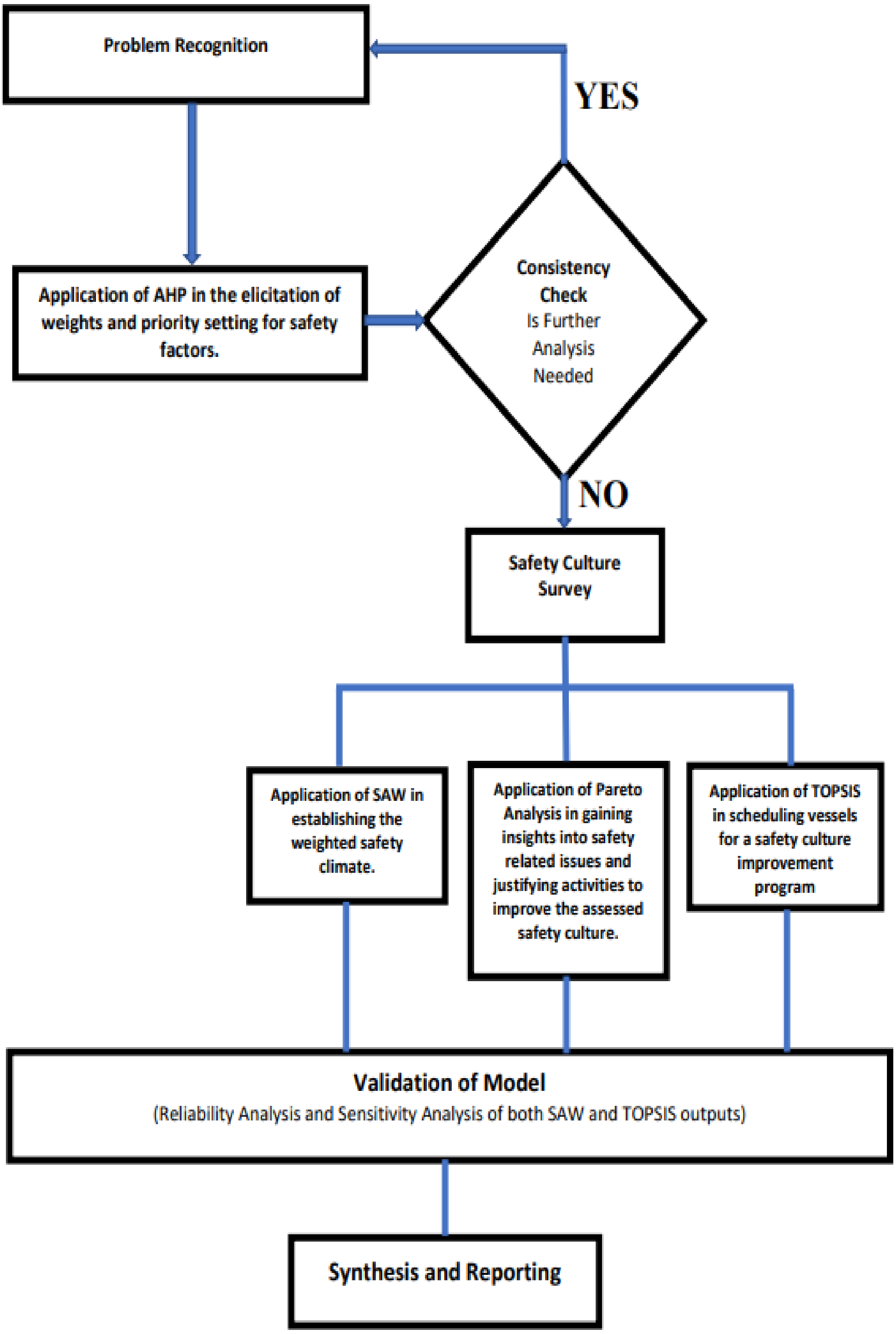

Figure 22: Conceptual Decision-Making Methodology for Safety Culture Assessment

4.4.1 Problem Recognition

The first phase of the conceptual decision-making framework for assessing the safety culture of a maritime organization is problem recognition. A maritime organization would traditionally be recommended to assess its safety culture if it loses money unnecessarily due to safety-related issues. A maritime organization would also be recommended to assess its safety culture if it exhibits features such as poor communication channels between the office and the ship, especially; lack of confidence amongst staff on safety-related issues, lack of feedback to management responses to safety-related issues or concerns; lack of trust between managers and their line staff; poor identification or recognition of unsafe acts; poor management of crew work to rest schedule; and poor sense of safety awareness. These features enable maritime organizations to recognize the need to assess their safety culture as well as the possible decision needed to reduce financial losses due to safety-related issues. Figure 23 below depicts the major components needed to identify and recognize the need to assess safety culture in an organization.

Figure 23: Problem Recognition and the Need to Assess Safety Culture

This phase would also entail the identification and description of safety factors that may influence both the safety performance and financial earnings of the organization.

4.4.2 Application of AHP in the elicitation of Weights and Priority Setting

The second phase of the conceptual decision-making framework for assessing the safety culture of maritime organizations is the application of AHP in the elicitation of weights and priority setting. This phase entails the elicitation of preferences from maritime experts using identified and described safety factors obtained from the first phase of the conceptual decision-making framework for assessing the safety culture of a maritime organization or the problem recognition phase. The selection of maritime experts for this phase should ensure there is an adequate spread of experts with background experiences ranging from both the managerial and operational (safety) aspects of ship (tanker) operations. The main purpose of having this range of experts during this phase of this decision-making framework is to ensure rationality and fairness in the weights that would later be applied in establishing the weighted safety climate of the assessed maritime organization.

4.4.3 Safety Climate Survey

The third phase of the proposed decision-making framework is the sampling of survey questions to both shipboard and shore-based staff of the maritime organization. The survey questionnaires were sampled via Qualtrics software, and their responses were aggregated using MS excel. The output of this phase would be used as input into other phases of the conceptual decision-making models.

4.4.4 Application of SAW in establishing the Weighted Safety Climate

The fourth phase of the proposed decision-making framework is the weighted safety climate. This phase entails the use of aggregated scores from the safety climate survey and the application of weights derived from the priority setting exercise to establish the weighted safety climate of the organization. This phase of the proposed decision-making framework assumes that the combination of the weights established from the priority setting and results of the safety climate survey to provide new measurement metrics that can be used to characterize the safety culture of a maritime organization, especially without the reliance on correlational statistical techniques. These new measurement metrics would also be a more realistic option to characterize the safety culture of an organization if there are no readily available safety performance data to aid any of the traditional approaches for assessing and managing the safety culture of maritime organizations. Figure 24 below depicts the major components needed in establishing the weighted safety climate of an organization.

Figure 24: Weighted Safety Climate Assessment

4.4.5 Application of Pareto Analysis in gaining insights on safety related issues

The fifth phase of the conceptual decision-making methodology is the application of Pareto Analysis in gaining insights on issues concerning occupational health and safety, ship safety, and shore-to-ship safety from feedback statements. This phase would also entail the application of Pareto Analysis in justifying the weighted safety climate established in the previous phase or SAW model. This phase first collects feedback statements from the safety culture survey process and classifies them into different safety factors used in describing the safety culture of the assessed organization. The frequency count of the classified safety factor is then used to create a frequency chart from which the most significant safety factors associated with feedback statements on issues concerning occupational health and safety, ship safety, and shore-to-ship safety are noted on the chart for their Pareto effect and impact on the safety climate of the assessed organization. Hence, the weighted safety climate of the previous phase or SAW model is justified if 70% of the least performing safety factor in the weighted safety climate is matched with 30% of safety factors attributed to feedback statements concerning issues of occupational health and safety, ship safety, and shore-to-ship safety in the assessed maritime organization. For the reason that, the 10% of safety factors attributed to feedback statements on issues concerning occupational health and safety, ship safety, and shore-to-ship safety each gives a cumulative total of 30% of safety factors attributed to feedback statements on issues concerning the safety culture of the assessed organization (See Figure 25).

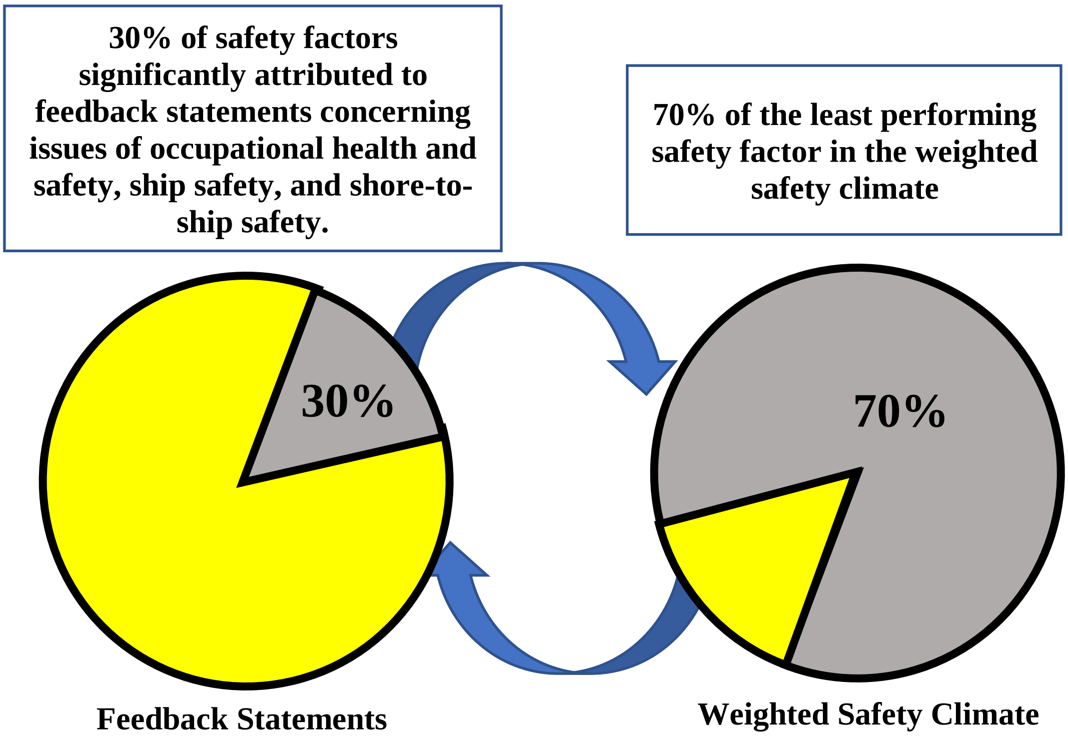

Figure 25:Pareto Principle and Weighted Safety Climate Assessment

4.4.6 Application of TOPSIS in Scheduling Vessels

The sixth phase of the conceptual decision-making methodology for safety culture assessment is the application of TOPSIS in scheduling vessels for safety improvement programs. This phase specifically compares the weighted safety climate of each vessel with both the best and worst possible weighted safety climate measurement obtainable from the safety climate survey carried out earlier. This phase assumes that the best possible weighted safety climate (Most Desired Situation) would be a product of the established weight and the highest possible output obtainable for each safety factor while the least possible weighted climate (Least Desired Situation) is a product of the established weight and least possible output obtainable for each safety factor in the safety culture survey. Hence, this phase would produce a ranking for vessels to be used in scheduling vessels for a safety culture improvement program using the TOPSIS performance score.

4.4.7 Validation of Decision-Making Models

The seventh phase of the conceptual decision-making methodology for safety culture assessment is the validation of the integrated decision-making model. This phase specifically deals with the reliability analysis of responses received during the safety climate survey; and the sensitivity analysis of outs from both SAW and TOPSIS models.

4.4.8 Synthesis and Reporting

The eighth phase of the conceptual decision-making methodology for safety culture assessment is the synthesis and reporting phase. This phase focuses on the combination of all the outputs obtained from the previous second, third, fourth, fifth, sixth and seventh phases of the proposed decision-making framework adopted for this study. The assumption in this phase is that the combination of outputs from the above-mentioned phases could be used both as a guide by administrators in implementing continuous improvement programs for safety culture and for identifying insights into the safety culture of staff in the assessed maritime organization.

4.5 Chapter Summary

The chapter was able to provide a detailed description of the design and methodology adopted in this study. This chapter specifically summaries the various research strategies and steps to be taken in the proposed conceptual decision-making framework for assessing the safety culture of a selected maritime organization. This chapter also described the various departments of the selected company (Sea Transport Group Nigeria Limited) used as a case study in this research.

5 The Application of AHP in Expert Elicitation of Weights/ Priority-Setting for Safety Factors

5.1 Introduction

The previous chapter (Research Design and Methodology) explained the strategies and methodologies adopted in this research. The purpose of this chapter is to elicit the preferences of maritime experts in establishing weights and priority setting of safety factors for maritime organizations in Nigeria. This chapter specifically deals with the application of the AHP methodology in the expert elicitation of weights and priority setting for safety factors used in assessing the safety culture of maritime organizations with tanker operations in Nigeria.

5.2 Analysis of Expert's Preferences (Demographic Analysis)

In the use of expert elicitation in establishing weights or priority settings, there are no rules regarding the number of experts sufficient for an expert survey. Hence, the elicitation process for the establishment of weights for safety factors began with the random selection of maritime experts with extensive knowledge and experience in the managerial and operational aspects of tanker ship operations in Nigeria. A total of nineteen (19) maritime experts were randomly sampled priority-setting questionnaires to elicit the weights of safety factors used in assessing the safety culture of maritime organizations. A copy of the priority-setting questionnaires used in this study can be found in Appendix A. Amongst the maritime experts selected, three (3) have extensive experience in the management of tankers operations, while the remaining sixteen (16) maritime experts have experience working as specialists in the operation of tankers in Nigeria. Amongst these groups of operations specialists, ten (10) were senior ship operators (navigators), while the remaining six (6) were specialists in the repair and maintenance of engines and associated equipment used in tanker ships.

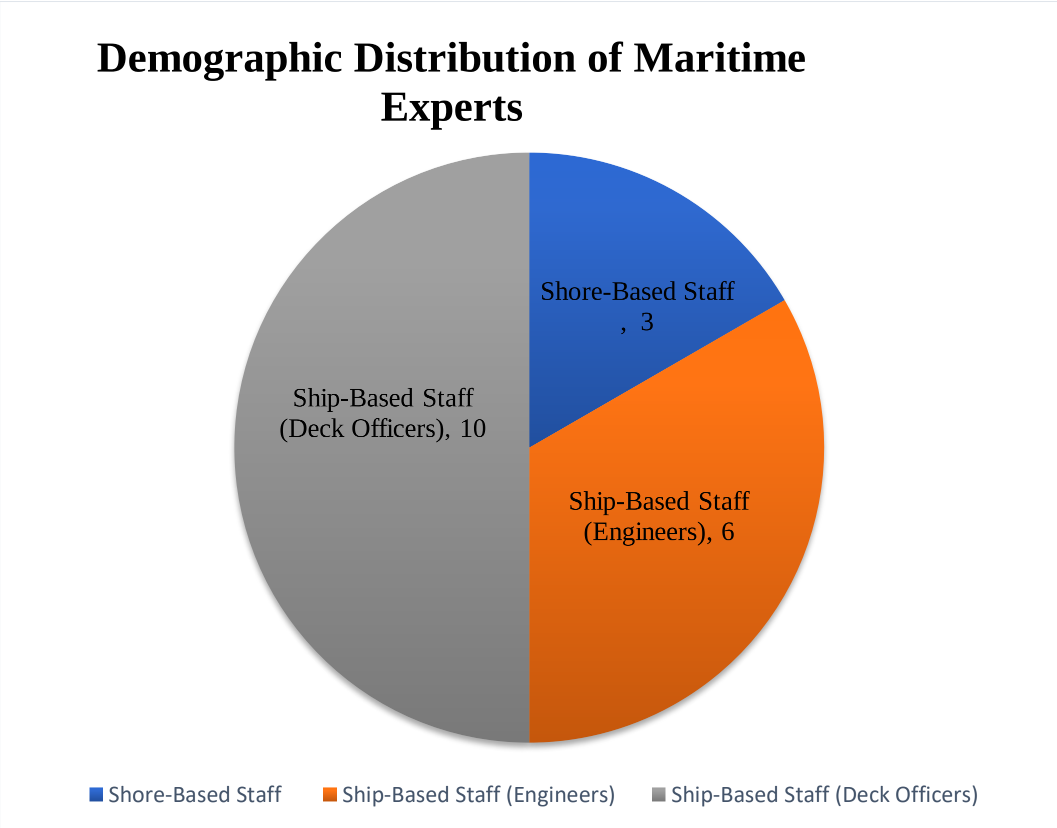

Figure 26: A Pie Chart of Maritime Experts Recruited for Elicitation of Weights

Figure 26 provides a demographic representation of maritime experts recruited to elicit preferences towards establishing weights for safety factors used in assessing safety culture for maritime organizations with tanker operations in Nigeria. The average age amongst the ship-based maritime experts is 37 years, while the average age of shore-based maritime experts is 36 years. The total number of maritime experts recruited for this elicitation exercise brings a combination of over 200 years of experience in the management and operation of tankers in Nigeria. The general average years of experience amongst all maritime experts recruited for the elicitation of weights is ten (10) years, while the average years of experience shared amongst ship-based maritime experts is twelve (12) years, and those of shore-based maritime experts is fourteen (14) years.

5.3 Aggregation of Preferences and Establishment of Weights

Table 8 below summarizes the aggregation of all the preferences collected from the maritime experts used in the establishment of weights and priority-setting for this study. In aggregating the preferences of experts, the values along the diagonals would always be equal to 1 because the diagonals represent the comparison of preferences between similar safety factors found in the pairwise decision comparison matrix. For example, in Table 7 below, the comparison between similar safety factors as COM and COM; EMP and EMP; FDB and FDB; MTR and MTR; PID and PID; POS and POS; RSP and RSP; and SAW with SAW would always be 1.

The values above the diagonals of the pairwise decision comparison matrix would be the average score given by the experts for each comparison between safety factors. For example, the value for the comparison of the safety factor COM and EMP in Table 7 below is given by the summation of scores from experts on their comparison divided by the total nineteen (19) experts surveyed in the priority setting exercise. Hence, the value and score given in the pairwise comparison matrix for COM and EMP (row2 column2) is given by;

$$\frac{(0.3 + 3 + 1+ 1 +1 + 0.3 + 0.2 + 5 + 5 + 5 + 3 + 0.13 + 9 + 5 + 0.11 + 1 + 0.50 + 0.5 + 1)}{19}$$

$$= 2.21$$

Table 7: An Aggregation of Preferences (Ship and Shore-Based Maritime Experts)

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
COM	1.00	2.21	1.81	0.93	0.83	1.19	1.20	0.86
EMP	0.45	1.00	1.76	1.32	1.62	1.20	1.17	0.75
FDB	0.55	0.57	1.00	1.34	1.01	1.26	0.82	0.79
MTR	1.08	0.76	0.75	1.00	1.78	0.99	0.58	0.68
PID	1.21	0.62	0.99	0.56	1.00	1.91	1.22	1.34
POS	0.84	0.83	0.79	1.01	0.52	1.00	2.57	0.84
RSP	0.83	0.85	1.22	1.72	0.82	0.39	1.00	0.57
SAW	1.16	1.33	1.27	0.75	0.75	1.19	1.75	1.00

COM - COMMUNICATION
EMP - EMPOWERMENT
FDB - FEEDBACK
MTR - MUTUAL TRUST
PID - PROBLEM IDENTIFICATION
POS - PROMOTION OF SAFETY
RSP – RESPONSIVENESS
SAW - SAFETY AWARENESS

Furthermore, the values below the diagonals of the pairwise decision comparison matrix would be the inverse of the values above the diagonals because they represent the exact opposite of the comparison of preferences for safety factors already scored and noted above the diagonals of the pairwise decision comparison matrix. For example, given that the value for the pairwise comparison of COM and EMP (row2 column1) is 2.21 in Table 8, the value for comparing the safety factor of EMP and COM (row1 column2) would therefore be given as inverse to the value of COM and EMP or 1 / 2.21 or 0.45.

The values below the diagonals of the pairwise decision comparison matrix would also be the inverse of the values above the diagonals of the pairwise decision comparison matrix for consistency reasons in the decision-making model so that the output of the model would be consistent and reliable. Having developed a complete pairwise comparison matrix, the first step taken towards the establishment of weights is the summation of values for each column of the pairwise comparison matrix (column additions), as shown below in Table 8.

Table 8: Modified Pairwise Comparison Matrix After Column Addition

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
COM	1.00	2.21	1.81	0.93	0.83	1.19	1.20	0.86
EMP	0.45	1.00	1.76	1.32	1.62	1.20	1.17	0.75
FDB	0.55	0.57	1.00	1.34	1.01	1.26	0.82	0.79
MTR	1.08	0.76	0.75	1.00	1.78	0.99	0.58	0.68
PID	1.21	0.62	0.99	0.56	1.00	1.91	1.22	1.34
POS	0.84	0.83	0.79	1.01	0.52	1.00	2.57	0.84
RSP	0.83	0.85	1.22	1.72	0.82	0.39	1.00	0.57
SAW	1.16	1.33	1.27	0.75	0.75	1.19	1.75	1.00
SUM	7.12	8.17	9.59	8.63	8.33	9.13	10.31	6.83

The pairwise comparison matrix is then completely normalized in Table 9 below by dividing the value of each column by the corresponding column sum. For example, the values of each row along the COM column are given as follows;

1.00 / 7.12 = 0.14 (1st row); 0.45 / 7.12 = 0.06 (2st row) ; 0.55 / 7.12 = 0.08 (3rd row); 1.08 / 7.12 = 0.15 (4th row); 1.20 / 7.12 = 0.17 (5th row) ; 0.84 / 7.12 = 0.12 (6th row) ; 0.83 / 7.12 = 0.12 (7th row) and 1.16 / 7.12 = 0.16 (8th row).

Table 9: Normalization of Pairwise Comparison Matrix

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
COM	0.14	0.27	0.19	0.11	0.10	0.13	0.12	0.13
EMP	0.06	0.12	0.18	0.15	0.19	0.13	0.11	0.11
FDB	0.08	0.07	0.10	0.16	0.12	0.14	0.08	0.12
MTR	0.15	0.09	0.08	0.12	0.21	0.11	0.06	0.10
PID	0.17	0.08	0.10	0.07	0.12	0.21	0.12	0.20
POS	0.12	0.10	0.08	0.12	0.06	0.11	0.25	0.12
RSP	0.12	0.10	0.13	0.20	0.10	0.04	0.10	0.08
SAW	0.16	0.16	0.13	0.09	0.09	0.13	0.17	0.15

The priorities are then obtained by simply calculating the average value of each row in the normalized pairwise comparison matrix (For example, the priority or weight for the first row (Communication) is given as; (0.14 + 0.27 + 0.19 + 0.11 + 0.10 + 0.13 + 0.12 + 0.13) / 8 = 0.15). Table 10 below presents the overall priorities derived from the normalized pairwise comparison matrix.

Table 10: Overall Priority for Pairwise Comparison Matrix

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	PRIORITY
COM	0.14	0.27	0.19	0.11	0.1	0.13	0.12	0.13	0.15
EMP	0.06	0.12	0.18	0.15	0.19	0.13	0.11	0.11	0.13
FDB	0.08	0.07	0.1	0.16	0.12	0.14	0.08	0.12	0.11
MTR	0.15	0.09	0.08	0.12	0.21	0.11	0.06	0.1	0.11
PID	0.17	0.08	0.1	0.07	0.12	0.21	0.12	0.2	0.13
POS	0.12	0.1	0.08	0.12	0.06	0.11	0.25	0.12	0.12
RSP	0.12	0.1	0.13	0.2	0.1	0.04	0.1	0.08	0.11
SAW	0.16	0.16	0.13	0.09	0.09	0.13	0.17	0.15	0.14

Having derived the priorities or weights for the entire pairwise comparison matrix, Table 11 below presents the original aggregated preferences of maritime experts and their respective weights and priority setting of safety factors used for this research study.

Table 11: Presentation of Results: Original Aggregated Preferences and Priorities

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	PRIORITY
COM	1.00	2.21	1.81	0.93	0.83	1.19	1.20	0.86	0.15
EMP	0.45	1.00	1.76	1.32	1.62	1.20	1.17	0.75	0.13
FDB	0.55	0.57	1.00	1.34	1.01	1.26	0.82	0.79	0.11
MTR	1.08	0.76	0.75	1.00	1.78	0.99	0.58	0.68	0.11
PID	1.20	0.62	0.99	0.56	1.00	1.91	1.22	1.34	0.13
POS	0.84	0.83	0.79	1.01	0.52	1.00	2.57	0.84	0.12
RSP	0.83	0.85	1.22	1.72	0.82	0.39	1.00	0.57	0.11
SAW	1.16	1.33	1.27	0.75	0.75	1.19	1.75	1.00	0.14

5.4 Consistency Check

The consistency check in the application of AHP is a measure of how logical and non-contradictory the above-elicited results (Aggregated Preferences and Priorities) are in Table 8. The first step entails the multiplication of each column in the aggregated pairwise comparison matrix with their corresponding weights or priority. Hence, the first criterion priority is used to multiply each value of the first column (i.e. 0.15 x 1 = 0.15; 0.15 x 0.45 = 0.07; 0.15 x 0.55 = 0.08; 0.15 x 1.08 = 0.16; 0.15 x 1.20 = 0.18; 0.15 x 0.84 =0.13; 0.15 x 0.83 = 0.13; 0.15 x 1.16 = 0.17) while the second criterion priority would be used to multiply each value of the second column until all the columns and or criterion priority have been completed.

Table 12 below presents a weighted or modified pairwise comparison matrix where each column of the aggregated pairwise comparison matrix has been multiplied with its corresponding weight or priority.

Table 12: Weighted Aggregated Pairwise Comparison Matrix

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
COM	0.15	0.29	0.2	0.1	0.11	0.14	0.13	0.12
EMP	0.07	0.13	0.19	0.15	0.21	0.14	0.13	0.11
FDB	0.08	0.07	0.11	0.15	0.13	0.15	0.09	0.11
MTR	0.16	0.1	0.08	0.11	0.23	0.12	0.06	0.1
PID	0.18	0.08	0.11	0.06	0.13	0.23	0.13	0.19
POS	0.13	0.11	0.09	0.11	0.07	0.12	0.28	0.12
RSP	0.13	0.11	0.13	0.19	0.11	0.05	0.11	0.08
SAW	0.17	0.17	0.14	0.08	0.1	0.14	0.19	0.14

Having applied weights on the aggregated pairwise comparison matrix, the next step to be taken is the summation of values across each row in the comparison matrix. For example, the summation of values across the first row (COM) would be (0.15 + 0.29 + 0.20 + 0.10 + 0.11 + 0.14 + 0.13 + 0.12 = 1.24). Table 13 below presents a summary of all weighted sums across the different rows of the earlier modified pairwise comparison matrix.

Table 13: Weighted Sum for Modified Comparison Matrix

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Weighted Sum
COM	0.15	0.29	0.20	0.10	0.11	0.14	0.13	0.12	1.24
EMP	0.07	0.13	0.19	0.15	0.21	0.14	0.13	0.11	1.12
FDB	0.08	0.07	0.11	0.15	0.13	0.15	0.09	0.11	0.90
MTR	0.16	0.10	0.08	0.11	0.23	0.12	0.06	0.10	0.96
PID	0.18	0.08	0.11	0.06	0.13	0.23	0.13	0.19	1.11
POS	0.13	0.11	0.09	0.11	0.07	0.12	0.28	0.12	1.02
RSP	0.13	0.11	0.13	0.19	0.11	0.05	0.11	0.08	0.90
SAW	0.17	0.17	0.14	0.08	0.10	0.14	0.19	0.14	1.14

After the calculation of the weighted sums across the different roles, as shown in Table 14, a new table is created where the weighted sum of each criterion is divided by the priority of each corresponding criterion. Lambda can now be determined by calculating the average of the values derived from the summation of ratios between the weighted sum and priority of each criterion. Table 14 below presents the calculation of Lambda max or the average of the ratio between the weighted sum and priority of each criterion.

Table 14: Calculation of Lambda Max

Weighted Sum	Priority	
1.24	0.15	8.266667
1.12	0.13	8.615385
0.9	0.11	8.181818
0.96	0.11	8.727273
1.11	0.13	8.538462
1.02	0.12	8.5
0.9	0.11	8.181818
1.14	0.14	8.142857
	Total	67.15428
	Divide Total by 8	8.394285

From Table 14 above Lambda Max is 8.394285; therefore, the Consistency Index (CI) can be calculated as follows:

$$\text{Consistency Index (CI)} = \frac{(\lambda Max - n)}{(n-1)} \qquad \text{Equation 1}$$

where n is the number of compared elements is 8

$$\text{Consistency Index (CI)} = \frac{(8.394285 - 8)}{(8-1)}$$

Consistency Index (CI) = 0.056

And the Consistency Ratio (CR) is given as follows:

$$\text{Consistency Ratio (CR)} = \frac{\text{Consistency Index (CI)}}{\text{Ratio Index (RI)}} \qquad \text{Equation 2}$$

The Ratio Index (RI) for a randomly generated matrix with eight (8) elements is 1.41 (Saaty , 1980).

$$\text{Consistency Ratio (CR)} = \frac{0.056}{1.41}$$

Consistency Ratio (CR) = 0.0397

Since the value of CR is 0.0397 and it is less than the 0.10 threshold recommended by Thomas Saaty, (1980) for using the derived weights in decision making. The 0.1 threshold also means that a 10% level of inconsistency is the maximum acceptable level permitted in the application of AHP in making a decision. In summary, the resulting priority setting to be used for this study can be summarized as follows in Table 15 below:

Table 15: Safety Factor/Metrics and Priority Setting

Safety Factors/Metrics	Priority Setting
COM	0.15
EMP	0.13
FDB	0.11
MTR	0.11
PID	0.13
POS	0.12
RSP	0.11
SAW	0.14

5.5 Chapter Summary

This chapter clearly illustrated the research strategies adopted for establishing weights and priority settings for safety factors used in assessing the safety culture of the selected case study maritime organization. This chapter also captured the demographic analysis of the maritime experts recruited for the establishment of weights used in assessing the safety factors/metrics of maritime organizations. The preferences of both ship-based and shore-based maritime experts are collated and aggregated before the weights and priority setting of safety factors can be established and used in other aspects of decision-making and assessment of the assessment of safety culture in the research study. This chapter also specifically detailed the application of AHP methodology in establishing weights and priority setting for exploring the application of decision-making methods on safety culture for this research study.

6 The Application of the Simple Additive Weighted (SAW) Model in Assessing the Safety Climate of a Maritime Organization

6.1 Introduction

The previous chapter dealt with the application of the AHP methodology in the expert elicitation of weights and priority-setting for safety factors used in assessing the safety culture of maritime organizations with tanker operations in Nigeria. This chapter aims to establish the weighted safety climate of both shoreside and shipboard staff in the selected case study maritime organization. This chapter specifically deals with the application of SAW methodology in establishing the weighted safety climate performance of the selected case study-maritime organization in Nigeria.

6.2 Demographic Analysis

The safety climate survey of the selected case study maritime organization was conducted using an online survey software called Qualtrics. The online survey software (Qualtrics) was chosen by the researcher mainly because it is very user-friendly. Qualtrics also allows its users to build surveys, send surveys and analyze all responses from one convenient online location. A copy of both the shoreside and shipboard safety culture survey questionnaire used for this study can be found in Appendix B and C, respectively. A total of two hundred and fifty-eight (258) individuals participated in this survey. Of these, two hundred and thirteen (218) completed the survey thoughtfully, while the remaining forty (40) individuals were primarily screened out for not responding thoughtfully to the survey. Hence, the responses of forty (40) individuals were excluded by the researcher in analyzing this study. Amongst the selected two hundred and thirteen (218) responses used in the analysis of this study, five (5) of the responses were from shore-based staff tasked with the management of tanker operations, while the remaining two hundred and thirteen (213) individuals were from shipboard staff tasked with the daily operation of tankers owned by the selected case study maritime organization. Figure 27 below presents a demographic profile of respondents used in the analysis of this survey study.

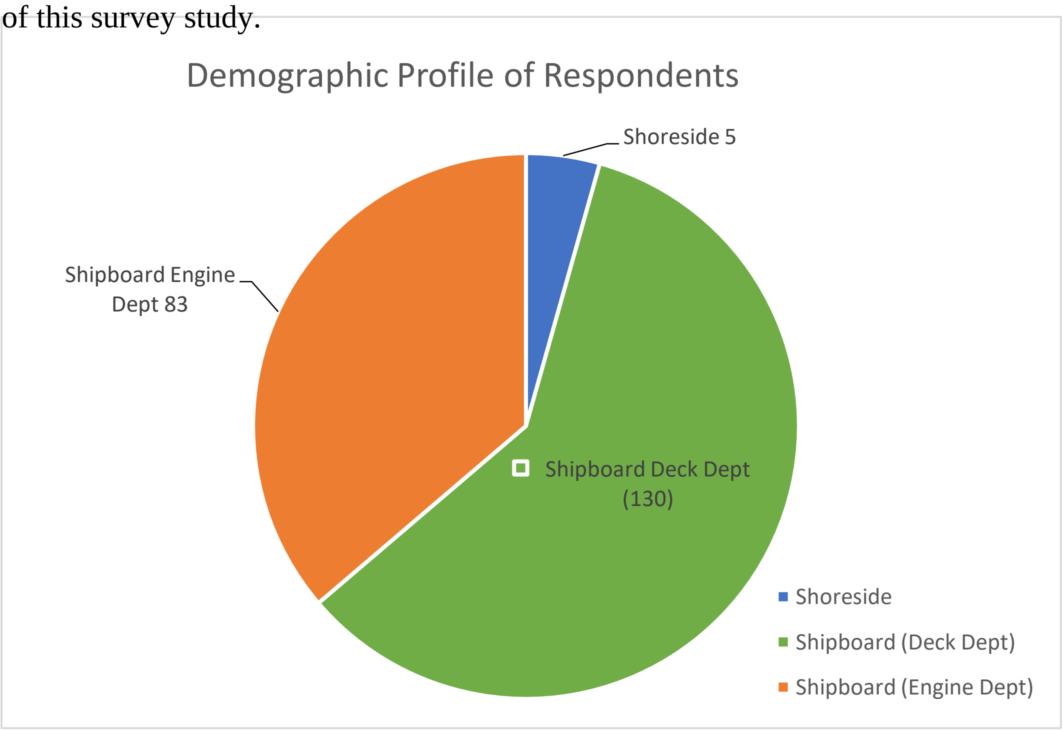

Figure 27: Demographic Profile of Respondents (Shipboard and Shore-based)

Also, amongst the responses from shipboard staff, 38.07 per cent (n = 83 people) were from the engine department, while 59.63 per cent (n = 130 people) were from the deck department onboard tanker ships owned and managed by the selected case study maritime organization used for this study. A summary of other demographic details captured by the safety climate survey can be found below in Table 16.

Table 16: Demographic Summary of Respondents

Demographic Variable	Categories		n	%	Cumulative %
Age Group	20 - 30		73	33.49	33.49
	31 - 40		108	49.54	83.03
	41 - 50		37	16.97	100.00
	>60		-	-	-
	Total		218	100.0	-
Job Position	Shoreside		5	2.29	2.29
	Shipboard	Deck Dept	130	59.63	61.93
		Engine Dept	83	38.07	100
	Total		218	100	-
Years worked with the company	< 1		6	2.75	2.75
	1 - 5		129	59.17	61.93
	6 - 10		70	32.11	94.04
	>10		13	5.96	100
	Total		218	100	-
Years worked in the maritime industry	< 1		1	0.46	0.46
	1 - 5		69	31.65	32.11
	6 - 10		79	36.24	68.35
	>10		69	31.65	100
	Total		218	100	-
Years worked at current position	< 1		6	2.75	2.75
	1 - 5		136	62.39	65.14
	6 - 10		68	31.19	96.33
	>10		8	3.67	100
	Total		218	100	-

From the above table, the largest number of responses received for this survey exercise was from the age group of 31 to 40 years (n = 108), followed closely by those within the age group of 21 to 30 (n = 73). With regards to the job positions, the deck department recorded the most significant number of people that responded to the survey questionnaires were 130 (59.63%), next to the engine department (38.07%, n = 83), while the remaining (2.29%, n = 5) were from the shoreside staff of the sampled case study maritime organization.

Concerning the number of years respondents have worked with the company; 59.17% (129) of the respondents have worked with the company for between one to five years while 2.75% (6) of the respondents have worked with the case study company for less than a year.

Amongst the participants working with the selected case study maritime organization, (36.24%, n = 79) had worked in the maritime industry for between six and ten years; while 31.65% (n = 69) had also worked in the maritime industry between one to five years. Also, 0.46% (n = 1) and another 31.65% (n = 69) of respondents had worked in the maritime industry for less than a year and more than ten years, respectively.

Regarding years worked at the current position, 62.39% (n = 136) of respondents had worked between one and five years, while 31.19% (n = 68) had also worked between six to ten years in their current position. Also, 3.67% (n = 8) of respondents had worked in their current positions for more than ten years, while 2.7% (n = 6) had worked in their current position for less than a year.

6.3 Shoreside Analysis of Safety Climate

In assessing the safety climate of the selected case study maritime organization, the responses of shoreside staff to survey questions were summarized and scored according to the various safety factors/safety metrics used in subjectively assessing the safety culture of the selected case study maritime organization. The arithmetic average of scores assigned to the responses of shoreside staff is calculated for each group or set of survey questions/statements to establish the corresponding performance of safety factors/safety metrics that reflects the overall safety culture of the selected case study maritime organization. Table 17 below summarizes the responses of shoreside staff towards the Communication aspects of safety culture in the assessed case study maritime organization.

Table 17: Responses of Shoreside Staff towards Communication

COMMUNICATION – COM								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
11.	There is good ship-to-shore communication about safety issues.	1	0	0	2	2	0	
34.	There is good ship-to-shore communication about safety issues.	1	0	0	0	3	1	3.5
9.	Language differences in multi-cultural crews are not a threat to safety.	0	0	0	2	3	0	4.6
25.	An effective anonymous reporting system exists in this company.	1	0	0	2	2	0	3.8
43.	I always give proper instructions when I initiate any work.	0	0	0	0	5	0	5
44.	I always ask questions if I do not understand the instructions given to me, or I am unsure of the relevant safety precautions.	0	0	0	1	4	0	4.8
	TOTAL							21.7

Also, the responses captured for this analysis ranged between 3.5 and 5. The respondents mostly agreed that proper instructions were always given when any work was initiated in the company, while the nature of communication between ship to shore on safety-related issues received the least agreed responses.

Table 18: Responses of Shoreside Staff towards Empowerment

EMPOWERMENT - EMP								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG Score
5.	Employees are actively encouraged to improve safety.	1	0	0	0	4	0	
35.	Employees are actively encouraged to improve safety.	1	0	0	0	3	1	3.7
27.	Suggestions to improve health and safety are welcomed.	1	0	0	1	3	0	4
38.	I have good control over the safety outcomes of my job.	0	0	3	0	2	0	3.8
39.	I am usually consulted on matters that affect how I do my job.	0	0	0	3	2	0	4.4
41.	I am comfortable asking for help when unsure how to do a task.	0	0	1	1	3	0	4.4
	TOTAL							20.3

Table 18 above summarizes the responses of shoreside staff towards Empowerment. The average score observed ranges between 3.7 and 4.4. The respondents mostly agreed that they were both consulted on matters that affected how they did their jobs and were also comfortable asking for help when unsure of how to do a task. However, the respondents least agreed that they were actively encouraged to improve safety.

Table 19: Responses of Shoreside Staff towards Feedback

FEEDBACK - FDB								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
21.	This company has good follow-up measures after accidents, incidents, and near misses.	1	0	0	1	3	0	
48.	This company has good follow-up measures after accidents, incidents, and near misses.	1	0	0	3	1	0	3.8
12.	Our seafarers are always informed about the outcome of shipboard meetings that address safety.	0	0	0	3	2	0	4.4
23.	Our seafarers are always given feedback on accidents, incidents, or near misses that occur on board ships.	1	0	2	0	2	0	3.4
29.	Our crews are always given feedback on injuries that occur on board their ship.	1	0	0	2	2	0	3.8
31.	I am always informed about the outcome of shore meetings that address health and safety.	1	0	0	3	1	0	3.6
	TOTAL							19

Table 19 above outlines the responses of shoreside staff towards Feedback. Also, the responses of shoreside staff towards Feedback ranged between 3.4 and 4.4. The respondents mostly agreed that their seafarers are always informed about the outcomes of shipboard meetings aimed address safety, while the least responses from respondents were on the nature of feedback given about accidents, incidents, or near misses that occur onboard ships.

Table 20: Responses of Shoreside Staff towards Mutual Trust

MUTUAL TRUST - MTR								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
8.	People are hired for their ability and willingness to work safely.	0	0	2	0	3	0	
47.	People are hired for their ability and willingness to work safely.	1	0	0	2	2	0	4
10.	There are no differences in the performance of seafarers from different cultures.	1	0	1	2	1	0	3.4
22.	Mistakes are corrected without punishment and treated as a learning opportunity.	1	0	2	0	2	0	3.4
26.	This company cares about my health and safety.	1	0	0	1	3	0	4
28.	I fully understand my line responsibilities for shipboard health and safety.	0	0	0	1	4	0	4.8
	TOTAL							19.6

Table 20 above provides a summary of responses from shoreside staff towards Mutual Trust. Table 20 also indicated that the average scores ranged from 3.4 to 4.8 where most respondents mostly understood their line responsibilities for shipboard health and safety; Nevertheless, these respondents also least agreed that mistakes should be treated as a learning opportunity in the organization and or should be corrected without punishments. The respondents also least agreed that there is no difference in the performance of seafarers from different cultures.

Table 21: Responses of Shoreside Staff towards Problem Identification

PROBLEM IDENTIFICATION - PID								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
20.	Our seafarers are competent to operate their automated equipment.	0	0	0	2	3	0	
45.	Our seafarers are competent to operate their automated equipment.	1	0	0	0	3	1	3.9
16.	All violations of safety regulations are reported.	1	0	2	1	1	0	3.2
24.	Our seafarers are encouraged to conduct risk assessments and report near misses.	1	0	0	0	4	0	4.2
36.	If I am interrupted whilst carrying out a task, I carefully check what I did, or start	0	0	0	1	4	0	4.8
42.	Pre-job assessments are completed for all jobs that need them.	0	0	0	1	4	0	4.8
	TOTAL							20.9

Table 21 above summarizes the responses of shoreside staff towards Problem Identification. The average scores received ranged from 3.2 to 4.8 where the least score was received on the nature of reporting for violations of safety regulations; while most of the respondents agreed on the completion of pre-job assessments for all jobs that need them and checks to be made before commencing on a task if interrupted.

Table 22: Responses of Shoreside Staff towards Promotion of Safety

PROMOTION OF SAFETY - POS								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
1.	When line safety managers are told about accidents, incidents, or near misses, corrective action is taken promptly.	0	0	0	2	3	0	
32.	When line safety managers are told about accidents, incidents, or near misses, corrective action is taken promptly.	2	0	0	0	3	0	4
2.	Shoreside managers never put schedule or costs above safety.	1	0	2	0	2	0	3.4
3.	Senior management is personally involved in safety activities on a routine basis.	0	1	2	0	2	0	3.6
4.	Ship Management places a high priority on safety training.	1	0	0	1	3	0	4
6.	This company has excellent maintenance standards.	1	0	0	2	2	0	3.8
	TOTAL							18.8

Table 22 above summarizes the responses of shoreside staff towards the Promotion of Safety. The average scores received ranged from 3.4 to 4 where the least score received was about if shoreside managers put schedule or cost above safety, while the most score received was on if ship management places a high priority on safety training and if line safety managers were told about accidents, incidents, near misses or if corrective action is taken promptly after an incident.

Table 23: Responses of Shoreside Staff towards Responsiveness

RESPONSIVENESS - RSP								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
7.	Our seafarers have adequate training in emergency procedures.	0	0	0	2	3	0	
33.	Our seafarers have adequate training in emergency procedures.	0	0	1	0	4	0	4.6
17.	Our seafarers are expected to adhere to their work/rest cycle.	0	0	0	2	3	0	4.6
18.	There is a system in place for observing seafarers' time off-duty.	1	0	0	0	4	0	4.2
19.	Our seafarers get adequate rest on their work/rest cycle.	0	2	0	1	2	0	3.6
30.	I have all the right equipment to do my job safely.	1	0	1	2	1	0	3.4
	TOTAL							20.4

Table 23 above summarizes the responses of shoreside staff towards Responsiveness. Also, the responses received from statements (questions) related to Responsiveness ranged from 3.4 to 4.6; where the most agreed response was about if seafarers had received adequate training on emergency procedures and also if seafarers adhered to their work/rest cycle. The least agreed response by shoreside staff on Responsiveness was that its staff (shoreside staff) had the right equipment to do their jobs.

Table 24: Responses of Shoreside Staff towards Safety Awareness

SAFETY AWARENESS - SAW								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
15.	Safety is the top priority for seafarers onboard our ships.	1	0	0	0	4	0	
46.	Safety is the top priority for seafarers on board our ships.	1	0	2	2	0	0	3.6
13.	Watch hand-overs are thorough and not hurried.	1	0	0	2	2	0	3.8
14.	When joining a ship our seafarers receive a proper hand-over, including familiarization with any new tasks.	1	0	1	0	3	0	3.8
37.	Safety briefings and training are never overlooked.	0	0	1	2	2	0	4.2
40.	Our seafarers are not encouraged to break the rules to achieve a target.	1	0	2	2	0	0	3
	TOTAL							18.4

Table 24 above summarizes the responses of shoreside staff towards Safety Awareness. Also, the average score from responses received from statements on Safety Awareness ranged from 3.4 to 4.6; where the most agreed responses on safety awareness were about if safety briefings and training were never overlooked, while the least agreed response was on if seafarers were encouraged to break the rules to achieve any needed target.

Having established the average score of each safety factor from the shoreside staff, there is need to calculate the score of each safety factor in an equivalent 5-point rating scale for ease of application and interpretation in any decision-making environment. Given that the maximum average score achievable for each safety factor is 25, the score for any safety factor in an equivalent 5-point rating scale is therefore given by:

$$\frac{\text{AVG score of a safety factor}}{25} \times 5 \qquad \text{Equation 8}$$

Table 25: A Summary of Responses from Shoreside Staff of Sea Transport Group

SAFETY FACTORS /SAFETY METRICS	AVG SCORE	SCORE (5 POINT SCALE)
COMMUNICATION - COM	21.7	4.34
EMPOWERMENT - EMP	20.3	4.06
FEEDBACK - FDB	19.0	3.80
MUTUAL TRUST - MTR	19.6	3.32
PROBLEM IDENTIFICATION - PID	20.9	4.18
PROMOTION OF SAFETY - POS	18.8	3.76
RESPONSIVENESS - RSP	20.4	4.08
SAFETY AWARENESS - SAW	18.4	3.68

Table 25 above summarizes the average scores collated from the responses of shoreside staff on safety factors that influence the safety culture of Sea Transport Group Nigeria Limited. The table also summarizes the average scores of safety factors in an equivalent 5-point rating scale using Equation 8.

6.4 Shipboard Analysis of Safety Climate

The responses of shipboard staff to the safety climate survey were also summarized and scored according to the various safety factors/safety metrics used in subjectively assessing the safety culture of the selected case study maritime organization. And just like in Section 6.3, both the average score of each safety factor and their equivalent 5-point rating scale would be calculated using Equation 8 above.

Table 26: Responses of Shipboard Staff towards Communication

COMMUNICATION - COM								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
11.	There is good communication on this ship about safety issues.	1	9	22	82	94	5	
34.	There is good communication on this ship about safety issues.	1	11	18	10 1	79	3	4.13
9.	Language differences in multi-cultural crews are not a threat to safety.	21	39	78	17	49	9	3.03
25.	An effective anonymous reporting system exists in this company.	7	14	61	48	75	8	3.69
43.	I always give proper instructions when I initiate any work.	5	28	37	38	98	7	3.82
44.	I always ask questions if I do not understand the instructions given to me, or I am unsure of the relevant safety precautions.	0	2	29	81	10 1	0	4.32
	TOTAL							18.99

Table 26 above summarizes the responses of shipboard staff towards Communication as a safety factor that influences the overall safety culture of the selected case study maritime organization. The average scores derived from the questions or statements on Communication ranged from 3.03 to 4.32. Amongst the statements on Communication received, most shipboard staff agreed that they ask questions if they did not understand instructions given or were unsure of relevant safety precautions. However, the least agreed responses received on

Communication were on if language differences in multi-cultural crews are not a threat to safety.

Table 27: Responses of Shipboard Staff towards Empowerment

EMPOWERMENT - EMP								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
5.	Employees are actively encouraged to improve safety.	0	4	50	67	88	4	
35.	Employees are actively encouraged to improve safety.	0	3	29	82	92	7	4.10
27.	Suggestions to improve health and safety are welcomed.	1	25	44	67	73	3	3.83
38.	I have good control over the safety outcomes of my job.	0	7	44	54	105	3	4.16
39.	I am usually consulted on matters that affect how I do my job.	3	40	32	52	86	0	3.84
41.	I am comfortable asking for help when unsure how to do a task.	0	21	22	69	101	0	4.17
	TOTAL							20.11

Table 27 above provides a summary of responses from shipboard staff on Empowerment as an element of safety culture in the selected maritime organization. The average score from responses received from statements on Empowerment ranged from 3.83 to 4.17. Also, the responses received from the statements above were primarily positive. However, the most agreed statement related to Empowerment was that shipboard staff were comfortable asking for help when unsure of how to do a task. Also, it is worth noting that the statement "suggestions to improve health and safety are welcomed" received the least average scores from responses to statements about Empowerment.

Table 28: Responses of Shipboard Staff towards Feedback

FEEDBACK - FDB								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
21.	I am very satisfied with the follow-up measures taken after accidents, incidents, and near misses.	0	7	38	41	12 4	3	
48.	I am very satisfied with the follow-up measures taken after accidents, incidents, and near misses.	4	46	36	51	76	0	3.99
12.	I am always informed about the outcome of shipboard meetings that address safety.	0	8	49	79	75	2	4.01
23.	The crew is always given feedback on accidents, incidents, or near misses that occur on board this ship.	4	29	59	54	60	7	3.54
29.	The crew is always given feedback on injuries that occur onboard this ship.	3	4	47	75	82	2	4.05
31.	I am always informed about the outcome of shipboard meetings that address health and safety.	5	3	44	73	86	2	4.06
	TOTAL							19.65

Table 28 above provides a summary of responses from shipboard staff towards Feedback as an element of safety culture in the selected maritime organization. The average score received ranged from 3.54 and 4.06. Furthermore, the most agreed responses received were on the outcomes of shipboard meetings that address health and safety-related issues, while the least agreed response was on the statement, “The crew is always given feedback on accidents, incidents, or near misses that occur on board this ship”.

Table 29: Responses of Shipboard Staff towards Mutual Trust

MUTUAL TRUST - MTR								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
8.	People are hired for their ability and willingness to work safely.	1	28	34	65	76	9	
47.	People are hired for their ability and willingness to work safely.	1	27	33	49	96	7	3.82
10.	There are no differences in the performance of crew members from different cultures.	23	36	68	28	48	10	3.06
22.	Mistakes are corrected without punishment and treated as a learning opportunity.	3	42	50	69	47	2	3.51
26.	This company cares about my health and safety.	1	6	41	78	87	0	4.15
28.	I fully understand my responsibilities for health and safety.	0	0	13	66	132	2	4.52
	TOTAL							19.06

Table 29 above summarizes the responses from shipboard staff towards Mutual Trust in the safety culture survey of the selected case study maritime organization. From the above table, shipboard staff mostly agreed that they understood their responsibilities for health and safety. However, they also least agreed that there were no differences in the performance of crew members from different cultures.

Table 30: Responses of Shipboard Staff towards Problem Identification

PROBLEM IDENTIFICATION - PID								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
20.	I am confident that I can operate the automated equipment within my area of responsibility.	0	7	38	41	124	3	
45.	I am confident that I can operate the automated equipment within my area of responsibility.	0	8	17	66	122	0	4.35
16.	Whenever I see safety regulations being broken, I report it.	0	9	45	65	92	2	4.10
24.	I am encouraged to conduct risk assessments and report near misses.	24	55	32	26	73	3	3.28
36.	If I am interrupted whilst carrying out a task, I carefully check what I did, or start again, before resuming the task.	0	11	14	62	125	1	4.40
42.	Pre-job assessments are completed for all jobs that need them.	3	18	36	61	82	13	3.76
	TOTAL							19.89

Table 30 above provides a summary of responses from shipboard staff on Problem Identification. The average score from responses received ranged from 3.28 to 4.40. The most positively scored statement was about if seafarers checked what they did or started again after they were interrupted whilst carrying out a task, while the least positively scored statement was on the level of encouragement to conduct risk assessments and report near misses.

Table 31: Responses of Shipboard Staff towards Promotion of Safety

PROMOTION OF SAFETY - POS								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
1.	When ship management is told about accidents, incidents, or near misses, corrective action is taken promptly.	12	26	13	59	100	3	
32.	When ship management is told about accidents, incidents, or near misses, corrective action is taken promptly.	6	31	46	60	64	6	3.77
2.	Shoreside managers never put schedule or costs above safety.	6	19	44	47	79	18	3.56
3.	Ship management is personally involved in safety activities on a routine basis.	6	14	41	67	83	2	3.94
4.	Management places a high priority on safety training.	2	9	51	64	80	7	3.89
6.	This company has excellent maintenance standards.	1	26	30	78	75	3	3.90
	TOTAL							19.06

Table 31 above summarizes the average scores collated from the responses of shipboard staff on the Promotion of Safety. The average scores received ranged from 3.56 to 3.94. Hence, most of the responses were generally positive towards the Promotion of Safety as a safety factor. The most positive response was to the statement, “Ship management is personally involved in safety activities on a routine basis.” while the least positive response received was to the statement “, Shoreside managers never put schedule or costs above safety”.

Table 32: Responses of Shipboard Staff towards Responsiveness

RESPONSIVENESS - RSP								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
7.	Our crew has adequate training in emergency procedures.	0	0	23	81	108	1	
33.	Our crew has adequate training in emergency procedures.	0	1	24	69	117	2	4.38
17.	The crew is expected to adhere to the work/rest cycle.	2	8	18	90	91	4	4.16
18.	There is a system in place for observing my time off-duty.	3	31	77	31	61	10	3.40
19.	I get adequate rest on the work/rest cycle that I work.	8	34	54	57	57	3	3.53
30.	The crew has access to all necessary personal protective equipment (PPE).	1	1	6	70	135	0	4.58
	TOTAL							20.06

Table 32 summarizes the responses of shipboard staff towards Responsiveness in the safety climate survey. The average score received ranged from 3.53 and 4.58. Also, the most agreed responses were about the crew's access to all necessary personal protective equipment (PPE), while the least agreed responses were received on if the crew gets adequate rest on their work/rest cycle.

Table 33: Responses of Shipboard Staff towards Safety Awareness

SAFETY AWARENESS - SAW								
S/N	Statement/Survey Questions	D (1)	SD (2)	N (3)	SA (4)	A (5)	DK (0)	AVG score
15.	Safety is the top priority for crew on board this ship.	1	1	19	54	134	4	
46.	Safety is the top priority for crew on board this ship.	0	6	32	62	108	5	4.32
13.	Watch hand-overs are thorough and not hurried.	0	7	20	77	108	1	4.33
14.	When I joined this ship I received a proper hand-over, including familiarization with any new tasks.	1	1	27	85	99	0	4.31
37.	Safety briefings and training are never overlooked.	1	12	24	94	82	0	4.15
40.	The crew is not encouraged to break the rules to achieve a target.	3	1	33	59	116	1	4.32
	TOTAL							21.43

Table 33 above summarizes the average scores collated from the responses of shipboard staff towards Safety Awareness as a safety factor in the safety culture survey of the selected case study maritime organization. The average scores received from shipboard staff towards the Promotion of Safety ranged from 4.15 to 4.33. Concerning the statements attached to Safety Awareness, most of the responses received were generally positive; the most positive response was about if watch hand-overs are thorough and not hurried, while the least positive response was about if safety briefings and training were ever overlooked.

Table 34: A Summary of Responses from Shipboard Staff of Sea Transport Group

SAFETY FACTORS /SAFETY METRICS	AVG SCORE	SCORE (5 POINT SCALE)
COMMUNICATION - COM	18.99	3.80
EMPOWERMENT - EMP	20.11	4.02
FEEDBACK - FDB	19.65	3.93
MUTUAL TRUST - MTR	19.06	3.812
PROBLEM IDENTIFICATION - PID	19.89	3.98
PROMOTION OF SAFETY - POS	19.06	3.813
RESPONSIVENESS - RSP	20.06	4.01
SAFETY AWARENESS - SAW	21.43	4.29

Also, having now established the average score of each safety factor from the shipboard staff, its score on an equivalent 5-point rating scale was also established using Equation 8. Table 34 above summarizes the average scores of each safety factor from the responses of shipboard staff and their score on an equivalent 5-point rating scale.

6.5 Weighted Safety Climate (Shoreside and Shipboard Staff)

It should be remembered that this phase in the decision-making framework aims to establish the weighted safety climate of the selected case study maritime organization in Nigeria. Mathematically, this is achieved by multiplying the Likert scores of each safety factor with its corresponding weights derived from maritime experts in the previous chapter. The established weighted safety climate derived from both the shoreside and shipboard staff of the selected case study maritime organization in Nigeria is shown in Table 35 below.

Table 35: Weighted Safety Factors and Ranking (Shoreside and Shipboard Staff)

			SHORESIDE STAFF			SHIPBOARD STAFF		
S/N	SAFETY FACTOR	WEIGHTS	LIKERT SCORE	WEIGHTED SAFETY CLIMATE	RANK	LIKERT SCORE	WEIGHTED SAFETY CLIMATE	RANK
		(w)	(v)	(w) x (v)		(v)	(w) x (v)	
1	COMMUNICATION - COM	0.15	4.34	0.651	1	3.80	0.570	2
2	EMPOWERMENT - EMP	0.13	4.06	0.528	3	4.02	0.523	3
3	FEEDBACK - FDB	0.11	3.80	0.418	7	3.93	0.432	7
4	MUTUAL TRUST - MTR	0.11	3.32	0.365	8	3.812	0.419	8
5	PROBLEM IDENTIFICATION – PID	0.13	4.18	0.543	2	3.98	0.517	4
6	PROMOTION OF SAFETY - POS	0.12	3.76	0.451	5	3.813	0.458	5
7	RESPONSIVENESS - RSP	0.11	4.08	0.448	6	4.01	0.441	6
8	SAFETY AWARENESS - SAW	0.14	3.68	0.515	4	4.29	0.601	1

From the above table, the ranking of safety factors in the established weighted safety climate of shoreside staff are COMMUNICATION, PROBLEM IDENTIFICATION, EMPOWERMENT, SAFETY AWARENESS, PROMOTION OF SAFETY, RESPONSIVENESS, FEEDBACK, and MUTUAL TRUST, respectively. While, the ranking of safety factors in the established weighted safety climate of shipboard staff are; SAFETY AWARENESS, EMPOWERMENT, RESPONSIVENESS, PROBLEM IDENTIFICATION, FEEDBACK, PROMOTION OF SAFETY, MUTUAL TRUST, and COMMUNICATION, respectively.

6.6 Analysis of Results

The weighted safety climate of both shoreside and shipboard staff in Table 36 represents the actual perception towards safety in the assessed maritime organization. The ranking of weighted safety factors also reflects a positive linear relationship between safety factors and the perception of staff towards safety; hence safety factors that are high reflect areas where the perception towards safety is also high or the competency and knowledge of the staff is also high on dealing with safety related issues. The recommendations to administrators from the rankings in Table 36 are to implement improvement activities associated with safety factors that are ranked low before those that are ranked higher in the weighted safety climate. Therefore, the recommendations for administrators towards improving the safety climate of shoreside staff are the implementation of safety programs with improvement activities associated with safety factors in the following sequence: MTR, FDB, RSP, POS, SAW, EMP, PID and COM. While the recommendations for administrators towards improving the safety climate of shipboard staff are the implementation of improvement activities associated with safety factors in the following sequence: MTR, FDB, RSP, POS, PID, EMP, COM and SAW (See Appendix G for a detailed description of activities recommended to improve and enhance the safety culture in a maritime organization).

6.7 Chapter Summary

This Chapter analyzed the safety climate survey data collected from both the shoreside and shipboard staff of the selected case study maritime organization in Nigeria (Sea Group Transport Limited). The analysis began with a demographic analysis of the respondents, then the analysis responses from both the shoreside and shipboard staff using a 5-point Likert scale before the establishment of the weighted safety climate of both shoreside and shipboard staff using weights (priority settings) derived from maritime experts in the previous Chapter. This Chapter also provided interpretation and insights into how improvement activities can be implemented to enhance the safety culture of the assessed maritime organization.

7 The Application of Pareto Principles in Gaining Insights into Safety-Related Issues

7.1 Introduction

The previous chapter dealt with the application of SAW methodology in establishing the weighted safety climate of the selected case study-maritime organization in Nigeria, while this chapter deals with the application of Pareto principles in gaining insights into issues concerning occupational health and safety, ship safety, and shore-to-ship safety. This chapter also deals with the use of feedback statements and insights gained to justify the weighted safety climate established in Chapter 6.

7.2 Reasoning Behind the Application of Pareto Principles

The Pareto principle is basically an observational tool in research studies to primarily analyse the relationship between naturally occurring events or phenomena. The general concept behind the Pareto principle is that 80% of the desired outcome will come from 20% of the effort. However, the inverse is also true, where 80% of problems (undesired outcomes) will come from 20% of your circumstances (Grosfeld-Nir. A; Boaz. R; Kozlovsky. N, 2007; Ivančić, 2014). Hence, its application in safety culture is to gain insight into safety culture through highlighted safety-related issues on occupational health and safety, ship safety, and shore-to-ship safety.

Hola & Sawicki (2018) used Pareto analysis to classify the causes of accidents into different elements of safety culture (Technical, Organizational and Human); Obolewicz and Dabrowski (2018) identified areas to improve the safety of an organisation using the perception of workers towards safety; and Karanikas (2016) identified the different elements to improve in a safety program. Therefore, the application of Pareto analysis on feedback statements concerning issues of occupational health and safety, ship safety, and shore-to-ship safety would provide insights into what aspects of safety culture needs improvement, while the application of Pareto analysis on the weighted safety climate would provide insight into what and how improvement activities would be carried out.

In carrying out Pareto analysis on feedback statements and weighted safety climate, the classification process would entail using safety factors. The ranking of safety factors from both Pareto charts would have similar findings. The Pareto Chart of feedback statements would rank safety factors as aspects of safety culture to be improved from the most important to the least important, while the Pareto Chart of the weighted safety climate would rank safety factors as performance indicators in the weighted safety climate from the best to worst. Hence, creating a distribution ratio based on Pareto principles to justify the observed relationship between the assessed safety culture (weighted safety climate) and feedback statement on issues concerning occupational health and safety, ship safety, and shore-to-ship safety.

As a guide to decision-makers, the least important safety factor attributed to aspects of safety culture that needs to be improved from the Pareto chart of feedback statements is as important as the least performing safety factor attributed to the Pareto chart of the weighted safety climate. Hence, the proposed Pareto principle for this study is that 30% of safety factors attributed to feedback statements on occupational health and safety, ship safety, and shore-to-ship safety are responsible for 70% of the least performing safety factors attributed to the weighted safety climate of the assessed maritime organisation. Alternatively, the most significant safety factor attributed to occupational health and safety, ship safety, and shore-to-ship safety is responsible for 70% of the least performing safety factors attributed to the weighted safety climate of the assessed maritime organisation. Hence, it also provides decision-makers with a means for using Pareto analysis to justify the ranking and performances of safety factors in the weighted safety climate established with a SAW model from Chapter 6.

7.3 Pareto Analysis of Feedback Statements

In the application of Pareto principles for analyzing activities to enhance safety culture, the feedbacks statements of respondents concerning issues of occupational health and safety, ship safety, and shore-to-ship safety are analyzed and classified into safety factors that may be associated with feedback statements received about the above-mentioned issues. A summary of feedback statements from both shoreside and shipboard staff can be found in Appendix H. The frequency count of safety factors associated with all the assessed feedback statements is then noted.

Table 36: Frequency Counts of Safety Factors from Feedback Statements of Shoreside Staff

Occupational Health and Safety									
Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Total
Frequency Count	0	0	0	0	1	3	1	1	6
Percent (%)	0%	0%	0%	0%	17%	50%	17%	17%	
Cum Pct (%)	0%	0%	0%	0%	17%	67%	83%	100%	
Ship Safety									
Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Total
Frequency Count	0	0	1	1	4	1	0	2	9
Percent (%)	0%	0%	11%	11%	44%	11%	0%	22%	
Cum Pct (%)	0%	0%	11%	22%	67%	78%	78%	100%	
Shore to Ship Safety									
Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Total
Frequency Count	4	0	0	0	0	0	2	0	6
Percent (%)	67%	0%	0%	0%	0%	0%	33%	0%	
Cum Pct (%)	67%	67%	67%	67%	67%	67%	100%	100%	

Table 36 and Table 37 provide a summary of the frequency count of safety factors associated with feedback statements from both shoreside and shipboard staff on issues concerning occupational health and safety, ship safety, and shore-to-ship safety. The total frequency count of safety factors associated with feedback statements from the shoreside staff ranged from six (6) to nine (9). On issues concerning occupational health and safety, the total frequency count is six (6) with only PID, POS, RSP & SAW safety factors attributed to its received feedback statements while on issues concerning ship safety the total frequency count is nine (9) with the safety factors of FDB, MTR, PID, POS & SAW attributed to its received feedback statements. Additionally, on issues concerning shore-to-ship safety, the total frequency count is six (6) with safety factors of only COM and RSP attributed to the feedback statements received.

Table 37: Frequency Counts of Safety Factors from Feedback Statements of Shipboard Staff

Occupational Health and Safety									
Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Total
Frequency Count	20	3	33	60	34	23	28	15	216
Percent (%)	9.3%	1.4%	15.3%	27.8%	15.7%	10.6%	13.0%	6.9%	
Cum Pct (%)	9.3%	10.6%	25.9%	53.7%	69.4%	80.1%	93.1%	100%	
Ship Safety									
Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Total
Frequency Count	8	2	17	74	31	48	54	12	246
Percent (%)	3.3%	0.8%	6.9%	30.1%	12.6%	19.5%	22.0%	4.9%	
Cum Pct (%)	3.3%	4.1%	11.0%	41.1%	53.7%	73.2%	95.1%	100%	
Shore to Ship Safety									
Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Total
Frequency Count	84	1	8	46	41	10	3	3	196
Percent (%)	42.9%	0.5%	4.1%	23.5%	20.9%	5.1%	1.5%	1.5%	
Cum Pct (%)	42.9%	43.4%	47.4%	70.9%	91.8%	96.9%	98.5%	100%	

The total frequency count of safety factors associated with feedback statements from the shipboard staff is much larger than those received from the shoreside staff. The total frequency count of safety factors associated with feedback statements from shipboard staff ranged from one hundred and ninety-six (196) to two hundred and forty-six (246). On issues concerning occupational health and safety, the total frequency count on safety factors attributed to feedback statements received is two hundred and sixteen (216) while the total frequency count of safety factors attributed to feedback statements concerning Ship safety issues is two hundred and forty-six (246). Additionally, the total frequency count of safety factors attributed to feedback statements of Ship-to-Shore issues is one hundred and ninety-six (196). Having noted the total frequency counts of safety factors associated with all the assessed feedback statements, a Pareto chart is developed from which the ship manager (decision-makers) would be able to gain insights into possible safety factors attributed to feedback statements that could be traced to 70% of the least performing safety factors found in the weighted safety climate of the assessed maritime organization (See Figure 28 below).

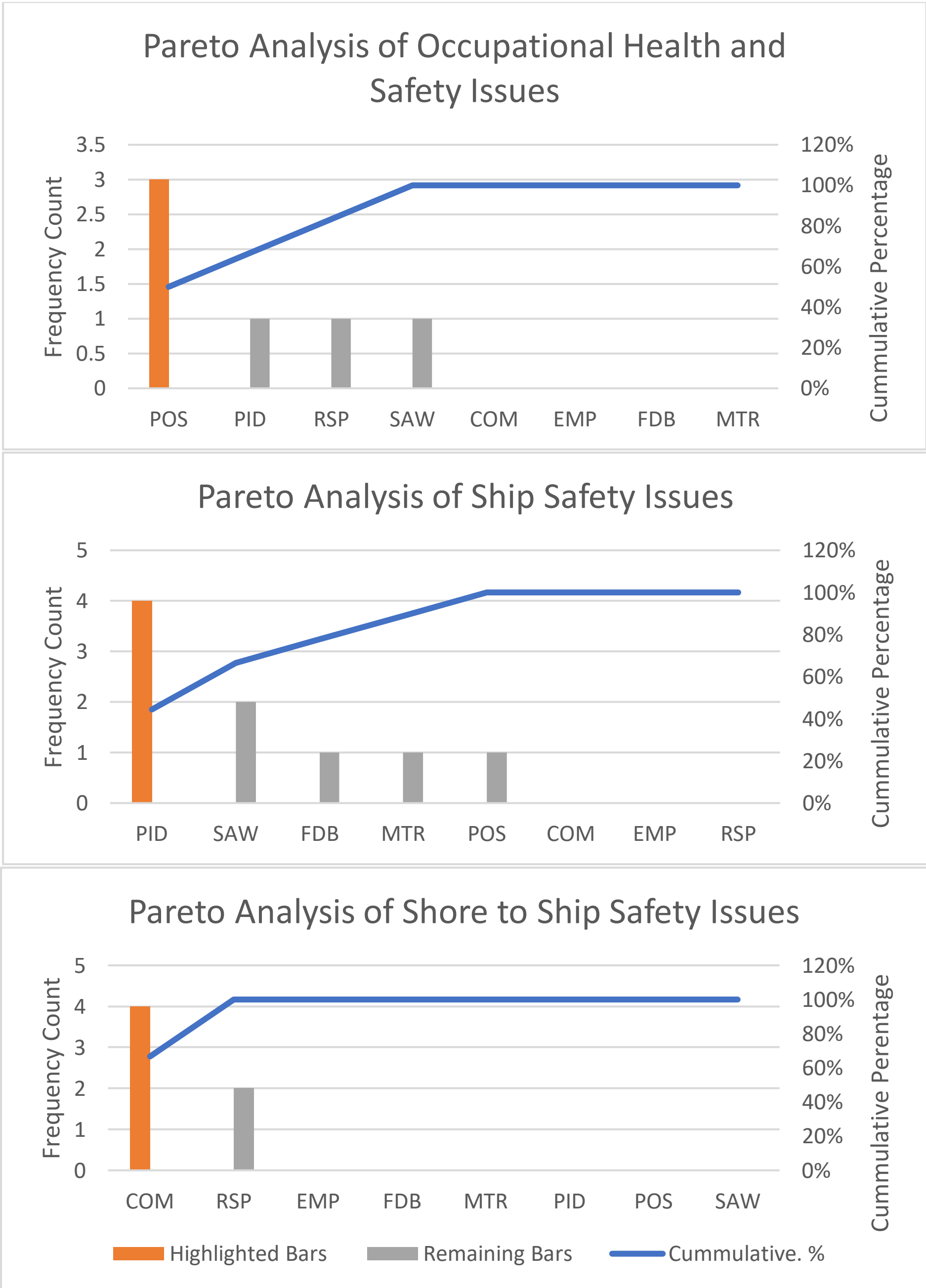

Figure 28: Pareto Analysis of Feedback Statements from Shoreside Staff on Issues Concerning Occupational Health and Safety, Ship Safety and Shore to Ship Safety

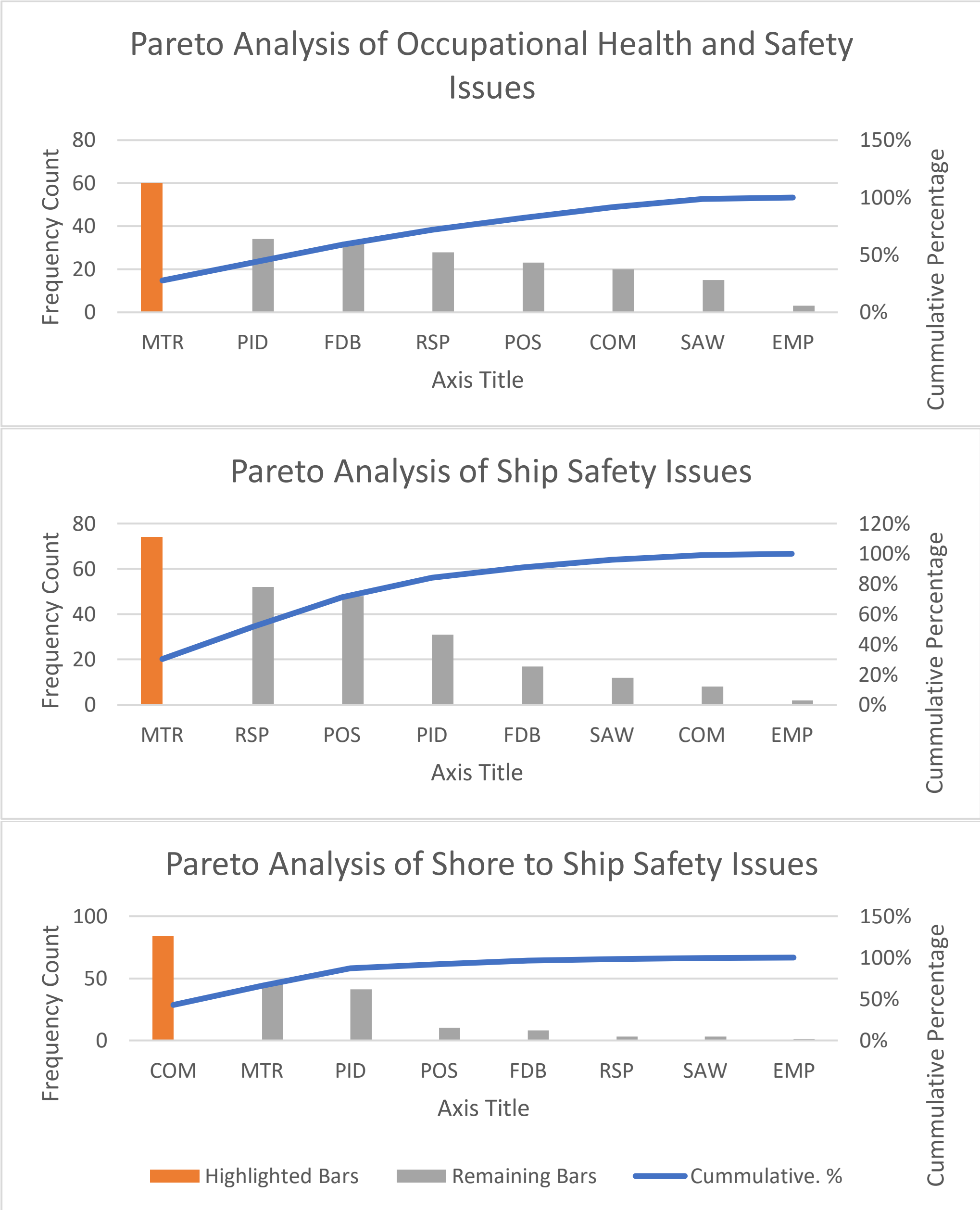

Figure 29: Pareto Analysis of Feedback Statements from Shipboard Staff on Issues Concerning Occupational Health and Safety, Ship Safety, and Shore-to-Ship Safety

Figures 28 and 29 above present Pareto charts of feedback statements from the shoreside staff on issues concerning Occupational Health and Safety; Ship Safety and Shore-to-Ship Safety that could be used to enhance the safety culture of the assessed maritime organization.

From Figure 28, the most significant safety factor attributed to feedback statements from shoreside staff on issues concerning Occupational Health and Safety, Ship Safety, and Shore to Ship Safety is POS, PID, and COM respectively. While from Figure 29, it can be seen that the most significant safety factors highlighted from the Pareto analysis of feedback statements from shipboard staff on issues concerning Occupational Health and Safety, Ship Safety, and Shore to Ship Safety was MTR, MTR (followed by RSP), and COM respectively.

7.4 Pareto Analysis of Safety Factors in the Weighted Safety Climate and Justification of Performance Scores from SAW Model

Given the performance scores and ranking of safety factors in a weighted safety climate obtained using the Simple Additive Weighting Method (SAW), the Pareto chart in Figures 30 and 31 below provide insights into 70% of least performing safety factors found in the weighted safety climate of both shipboard and shoreside staff. The Pareto chart below also provides insight into 30% of the most performing safety factors found in the weighted safety climate of both shoreside and shipboard staff of the assessed maritime organization.

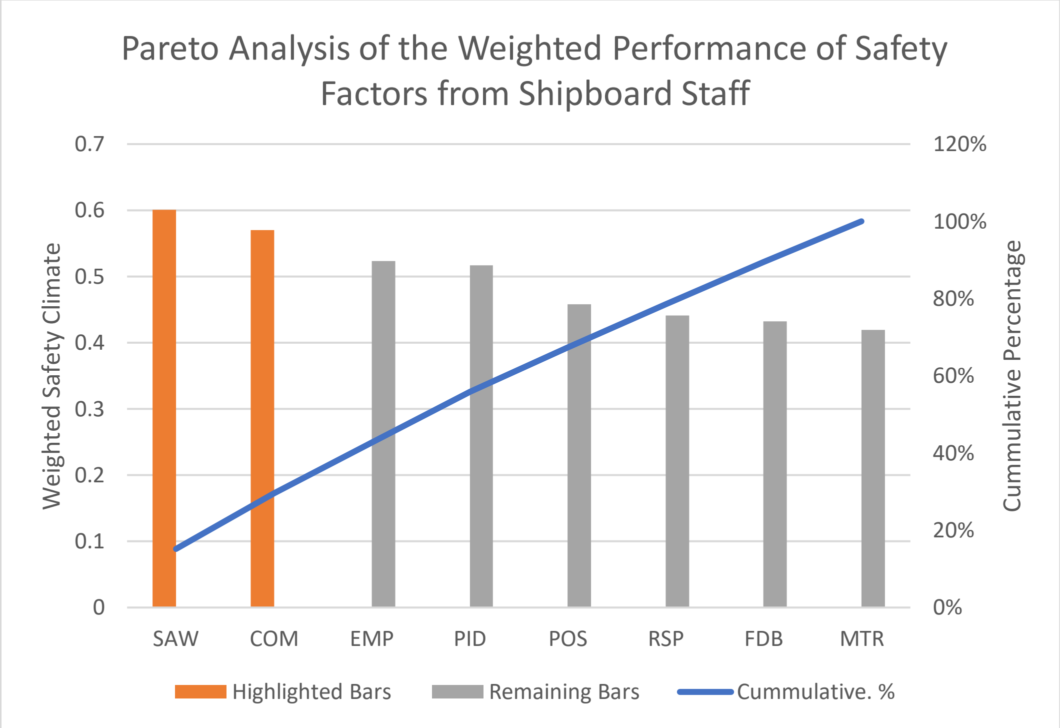

Figure 30: Pareto Analysis of Safety Factors in the Weighted Safety Climate of Shipboard Staff

From the above charts in Figure 30, the highlighted bars represent 30% of the most performing safety factors found in the weighted safety climate of the shipboard staff (SAW and COM) while the remaining bars represent 70% of the least performing safety factors (undesired outcomes) found in the weighted safety climate of shipboard staff. (EMP, PID, POS, RSP, FDB and MTR).

Amongst the most significant safety factors highlighted by shipboard staff on issues concerning Occupational Health and Safety, Ship Safety, and Shore to Ship Safety in Figure 29; only MTR could be traced to 70% of the least performing safety factors (undesired outcomes) found in the weighted safety climate of shipboard staff (See Figure 30). Therefore, the ranking and performances of safety factors or recommended activities to enhance the safety culture of shipboard staff in the assessed maritime organization is justified because MTR was highlighted on issues concerning both ship safety and the occupational health and safety of the assessed maritime organization.

Also, from the Pareto Analysis of feedback statements on issues concerning ship safety in Figure 29, the next most significant safety factor to MTR was RSP and PID (above a 55% cumulative target mark). Hence, the ranking and performances of safety factors or recommended activities to enhance the safety culture of shipboard staff in the assessed maritime organization is justified because most of the highlighted safety factors found on issues concerning occupational health and safety, ship safety, and shore-to-ship safety (observed/reported circumstances) could also be matched with safety factors found in 70% of the least performing safety factors of the weighted safety climate of shipboard staff (See Figure 30). Table 38 below summarises the comparison of Pareto Charts from both the weighted safety climate and feedback statements of shipboard staff from the assessed maritime organization.

Table 38: Comparative Analysis of Highlighted Safety Factors within the Weighted Safety Climate and Feedback Statements of Shipboard Staff

70% of Least Performing Safety Factors found in the Weighted Safety Climate of Shipboard Staff	30% of Safety Factors Attributed to Feedback Statements Concerning Issues of Occupational Health and Safety, Ship Safety, and Shore-to-Ship Safety in the assessed maritime organization.
EMP, PID, POS, FDB, RSP and MTR	MTR and COM
Match: MTR	

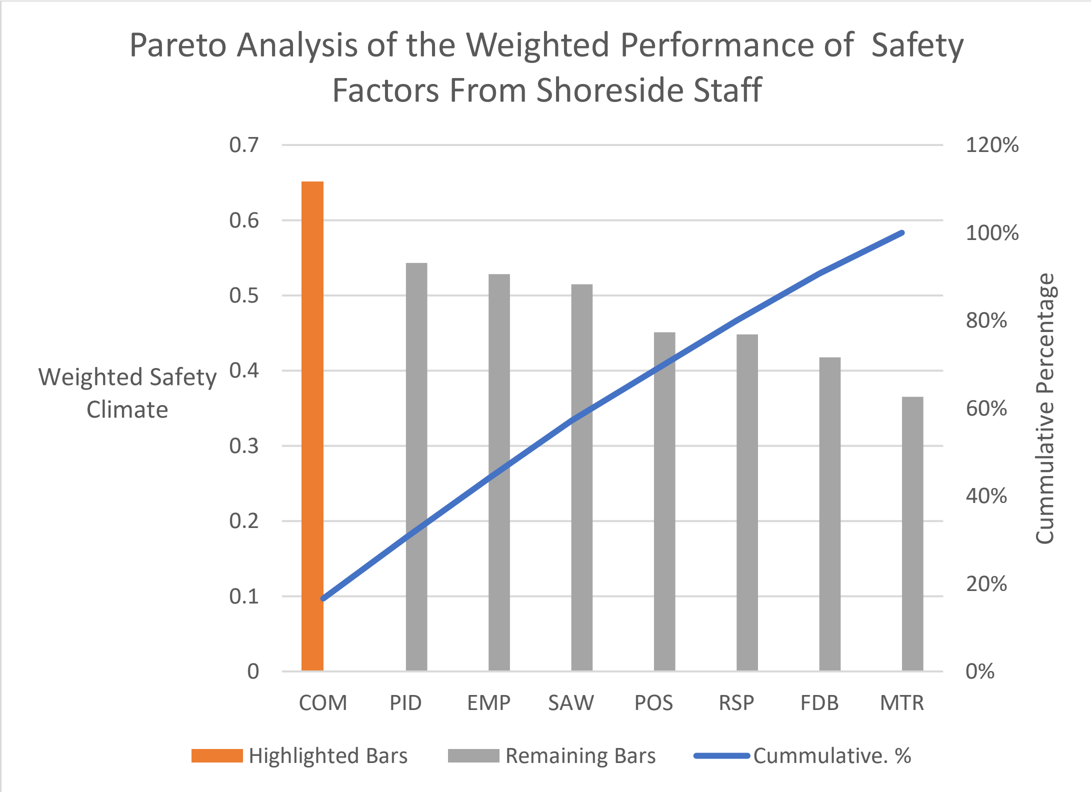

Figure 31: Pareto Analysis of Safety Factors in the Weighted Safety Climate of Shoreside Staff

From the above charts in Figure 31, 30% of the most performing safety factors found in the weighted safety climate of the shoreside staff is COM, while the remaining bars represent 70% of the least performing safety factors (undesired outcomes) found in the weighted safety climate of shipboard staff (PID, EMP, SAW, POS, RSP, FDB, and MTR.).

Also, POS, PID, and COM were highlighted on issues concerning Occupational Health and Safety, Ship Safety, and Shore to Ship Safety in Figure 28. Hence, only POS and PID were found amongst 70% of the least performing safety factors in the weighted safety climate of shoreside staff (Figure 31). Therefore, the ranking and performances of safety factors or recommended activities to enhance the safety culture of shipboard staff in the assessed maritime organization is justified because two out of three safety factors (POS and PID) highlighted in the Pareto analysis of the feedback statements matched 70% of the least performing safety factor identified from the SAW model.

Table 39: Comparative Analysis of Highlighted Safety Factors within the Weighted Safety Climate and Feedback Statements of Shoreside Staff

70% of Least Performing Safety Factors found in the Weighted Safety Climate of Shoreside Staff	30% of Safety Factors Attributed to Feedback Statements Concerning Issues of Occupational Health and Safety, Ship Safety, and Shore-to-Ship Safety in the assessed maritime organization.
PID, EMP, SAW, POS, RSP, FDB, and MTR.	POS, PID and COM
Match: POS and PID	

Table 39 above summarizes the comparison of Pareto Charts from both the weighted safety climate and feedback statements of shoreside staff from the assessed maritime organization.

7.5 Analysis of Results

The application of Pareto Analysis is used to provide insights into issues concerning occupational health and safety, ship safety, and shore-to-ship safety using feedback statements from both shoreside and shipboard staff. The Pareto Analysis is also used to justify the weighted safety climate of both shoreside and shipboard staff using safety factors attributed to feedback statements received during the safety climate survey. The Pareto model used for this study proposes that the (10%) of the most vital safety factors on issues concerning occupational health and safety, ship safety, and shore-to-ship safety are responsible for 70% of the least performing safety factors found in the weighted safety climate of the assessed maritime organization. Hence, 70% of the least performing safety factors highlighted within the weighted safety climate and 30% of safety factors classified from feedback statements matched with POS and PID for shoreside, while those of shipboard staff matched with MTR to justify the result outputs of the weighted safety climate established in Chapter 6.

7.6 Chapter Summary

The chapter details the application of Pareto analysis in gaining insights into issues concerning occupational health and safety, ship safety, and the shore-to-ship safety of the assessed maritime organization. This chapter also details the application of Pareto analysis in justifying the output and recommendations of the weighted climate assessment established in Chapter 6.

8 The Application of TOPSIS in Scheduling Vessels for Safety Culture Improvement Programs

8.1 Introduction

The previous chapter focused on the application of Pareto analysis in gaining insights into issues concerning occupational health and safety, ship safety, and shore-to-ship safety. The previous chapter dealt with the use of feedback statements and insights gained in justifying the weighted safety climate established in Chapter 6 and activities recommended to enhance the safety culture of the assessed maritime organization. This current chapter explicitly deals with the logical treatment of values on the TOPSIS framework and the generation of ranks for the scheduling of vessels in safety culture improvement programs.

8.2 Benchmarking of Weighted Safety Climate

As part of the processes carried out by maritime administrators in the assessment and management of safety culture, the safety climate performance of each vessel may need to be assessed and benchmarked. With respect to this research study and the application of a decision-making framework for assessing and managing the safety culture of a maritime organization, the survey responses of shipboard staff are re-structured and analyzed with respect to the vessels so as to derive the average score of each safety factor used in describing the safety climate of each vessel managed by the selected case study maritime organization.

The re-structured and analyzed responses from each vessel to the sampled safety culture/climate survey and the average score for each safety factor can be found in Appendix D. The output from the survey responses of shipboard staff also serves as input for the application of TOPSIS in benchmarking the average score of safety factors used in describing the safety culture/climate of each vessel managed by the selected case study company. Hence, the safety culture/climate of vessels can be benchmarked using the subjective performance scores of safety factors derived from the survey responses of shipboard staff in vessels and an established weights/priority setting for safety.

The mathematical algorithm of TOPSIS generally allows the comparison of the combined performances of safety factors for each vessel with those of the possible best (ideal) or worst combined performances of safety factors in the different vessels managed by the selected case study maritime organization. Hence, the application of TOPSIS in this phase of the decision-making framework provides a justifiable means by which maritime administrators would be able to score, compare, benchmark, and track the average score of each safety factor in a fleet managed by a maritime organization. The application of TOPSIS would also aid the provision of insights on the influence of safety factors on the safety climate of different vessels managed by a maritime organization.

8.3 TOPSIS Implementation

In the application of TOPSIS in benchmarking the subjective performance scores of safety factors derived from the survey responses of shipboard staff in different vessels managed by the selected case study maritime organization, the first step taken is the development of a scored matrix to represent the responses for each vessel surveyed in the selected case study maritime organization. Table 40 below shows a scored matrix representing the responses of each vessel in the fleet managed by the selected case study maritime organization.

Table 40: Scored Matrix of Safety Factors in Vessels

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	4.5	4.6	4.5	4.5	4.5	4.5	4.6	4.7
	MT SEA VOYAGER	3.8	3.9	3.8	3.8	4.0	3.8	4.0	4.3
	MT SEA PROGRESS	3.5	3.9	3.6	3.5	3.8	3.6	4.0	4.1
	MT SEA GRACE	3.5	3.7	3.6	3.6	3.7	3.5	3.8	4.0
	MT SEA ADVENTURER	3.3	3.8	3.6	3.3	3.8	3.2	3.6	4.1
	MT DIDDI	3.4	3.5	3.4	3.4	3.7	3.4	3.8	4.0
	MT UMBALWA	3.4	3.9	3.7	3.4	3.7	3.4	3.8	4.2
	MT KINGIS	4.6	4.6	4.5	4.6	4.6	4.6	4.7	4.8
	MT MOSUNMOLA	4.2	4.0	3.8	4.2	3.9	4.2	3.9	4.3
	MT ASHABI	4.0	4.0	3.7	3.7	3.8	4.3	3.9	4.5

The second step taken is the normalization of the score matrix to ensure the integrity and compatibility of the data throughout the methodology. The scores in the matrix are normalized using;

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x^2 ij}} \qquad \text{.................Equation 3}$$

The normalization process is shown in Table 41 and 42 below, where the first element is calculated as: MT AMIF (COM) / SQUARE ROOT (MT AMIF (COM)2 + MT SEA VOYAGER(COM)2 + MT SEA PROGRESS (COM)2 + MT GRACE (COM)2 + MT SEA ADVENTURER (COM)2 + MT DIDDI (COM)2 + MT UMBALWA (COM)2 + MT KINGIS (COM)2 + MT MOSUNMOLA (COM)2 + MT ASHAB(COM)2)

Table 41: Normalized of Scores for Safety Factors in Vessels

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.370	0.363	0.371	0.372	0.359	0.367	0.361	0.345
	MT SEA VOYAGER	0.312	0.308	0.313	0.314	0.319	0.310	0.314	0.316
	MT SEA PROGRESS	0.288	0.308	0.297	0.289	0.303	0.293	0.314	0.301
	MT SEA GRACE	0.288	0.292	0.297	0.298	0.295	0.285	0.299	0.294
	MT SEA ADVENTURER	0.271	0.300	0.297	0.273	0.303	0.261	0.283	0.301
	MT DIDDI	0.279	0.276	0.280	0.281	0.295	0.277	0.299	0.294
	MT UMBALWA	0.279	0.308	0.305	0.281	0.295	0.277	0.299	0.308
	MT KINGIS	0.378	0.363	0.371	0.380	0.367	0.375	0.369	0.352
	MT MOSUNMOLA	0.345	0.316	0.313	0.347	0.311	0.342	0.306	0.316
	MT ASHABI	0.329	0.316	0.305	0.306	0.303	0.350	0.306	0.330
	Weights of Safety Factors	0.15	0.13	0.11	0.11	0.13	0.12	0.11	0.14

The third step taken in TOPSIS implementation is the application of weights on the normalized scored matrix, hence the weights of safety factors established in Chapter 5 are applied on the normalized score to produce a weighted normalized scored matrix for the subjective performance of safety factors in vessels.

The weights of safety factors are applied to the normalized scores using;

Weighted $\mathbf{r}_{ij} = w_j \mathbf{r}_{ij}$ $i = 1, 2....m; j = 1, 2....n$ ………..Equation 4

For example, the weighted normalized scores of MT ASHABI were calculated as follows:0.15x0.329=0.0493(COM);0.13x0.316=0.0411(EMP);0.11x0.305=0.0335 (FDB);0.11x0.306=0.0336(MTR);0.13x0.303=0.0394(PID);0.12x0.350=0.0421 (POS); 0.11x0.306=0.0337(RSP); 0.14x0.330=0.0462(SAW)

Table 42 below shows the weighted normalized scores, with the first element calculated as; $\mathbf{r}_{ij}$ = weight of first element x normalized scores of the first element.

Table 42: Weighted Normalized Scores for Safety Factors in Vessels

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.0555	0.0472	0.0408	0.0409	0.0467	0.0440	0.0398	0.0483
	MT SEA VOYAGER	0.0469	0.0400	0.0345	0.0345	0.0415	0.0372	0.0346	0.0442
	MT SEA PROGRESS	0.0432	0.0400	0.0326	0.0318	0.0394	0.0352	0.0346	0.0421
	MT SEA GRACE	0.0432	0.0380	0.0326	0.0327	0.0384	0.0342	0.0328	0.0411
	MT SEA ADVENTURER	0.0407	0.0390	0.0326	0.0300	0.0394	0.0313	0.0311	0.0421
	MT DIDDI	0.0419	0.0359	0.0308	0.0309	0.0384	0.0333	0.0328	0.0411
	MT UMBALWA	0.0419	0.0400	0.0335	0.0309	0.0384	0.0333	0.0328	0.0432
	MT KINGIS	0.0567	0.0472	0.0408	0.0418	0.0477	0.0450	0.0406	0.0493
	MT MOSUNMOLA	0.0518	0.0411	0.0345	0.0382	0.0405	0.0411	0.0337	0.0442
	MT ASHABI	0.0493	0.0411	0.0335	0.0336	0.0394	0.0421	0.0337	0.0462

The fourth step taken is the determination of both the best and worst possible ideal solutions in the weighted normalized matrix above. The best possible solution would be a combination of the most beneficial value of safety factors found across the vessels surveyed while the worst possible solution refers to a combination of the least beneficial value of safety factors found across the vessels surveyed. Table 43 below shows the weighted normalized matrix alongside the possible best and worst combination of safety factors obtainable from the vessels surveyed in the case study maritime organization.

Table 43:Best and Worst Ideal Solutions for Safety Factors in Vessels

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.0555	0.0472	0.0408	0.0409	0.0467	0.0440	0.0398	0.0483
	MT SEA VOYAGER	0.0469	0.0400	0.0345	0.0345	0.0415	0.0372	0.0346	0.0442
	MT SEA PROGRESS	0.0432	0.0400	0.0326	0.0318	0.0394	0.0352	0.0346	0.0421
	MT SEA GRACE	0.0432	0.0380	0.0326	0.0327	0.0384	0.0342	0.0328	0.0411
	MT SEA ADVENTURER	0.0407	0.0390	0.0326	0.0300	0.0394	0.0313	0.0311	0.0421
	MT DIDDI	0.0419	0.0359	0.0308	0.0309	0.0384	0.0333	0.0328	0.0411
	MT UMBALWA	0.0419	0.0400	0.0335	0.0309	0.0384	0.0333	0.0328	0.0432
	MT KINGIS	0.0567	0.0472	0.0408	0.0418	0.0477	0.0450	0.0406	0.0493
	MT MOSUNMOLA	0.0518	0.0411	0.0345	0.0382	0.0405	0.0411	0.0337	0.0442
	MT ASHABI	0.0493	0.0411	0.0335	0.0336	0.0394	0.0421	0.0337	0.0462
Max	Ideal (Best) Value	0.0567	0.0472	0.0408	0.0418	0.0477	0.0450	0.0406	0.0493
Min	Ideal (Worst) Value	0.0407	0.0359	0.0308	0.0300	0.0384	0.0313	0.0311	0.0411

The fifth step taken in TOPSIS implementation is the determination of the Euclidean distance for the ideal best and ideal worst solutions. The Euclidean distance from the ideal best is calculated given;

$$d_{iw} = \sqrt{\sum_{i=1}^{n}(t_{ij} - t_{wj})^2}, \qquad i = 1, 2...., m., \qquad \text{Equation 5}$$

and the L2-distance between the alternative (i) and the best condition (Ab)

$$d_{ib} = \sqrt{\sum_{i=1}^{n}(t_{ij} - t_{bj})^2}, \qquad i = 1, 2...., m., \qquad \text{Equation 6}$$

Table 44 below shows the Euclidean distance for both the ideal best and worst solution.

Table 44: Euclidean Distance for both Ideal Best and Worst Solution

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Eud Dist From Ideal Best	Eud Dist From Ideal Wors t
VESSEL NAMES	MT AMIF	0.0555	0.0472	0.0408	0.0409	0.0467	0.0440	0.0398	0.0483	0.0025	0.0304
	MT SEA VOYAGER	0.0469	0.0400	0.0345	0.0345	0.0415	0.0372	0.0346	0.0442	0.0201	0.0124
	MT SEA PROGRESS	0.0432	0.0400	0.0326	0.0318	0.0394	0.0352	0.0346	0.0421	0.0256	0.0077
	MT SEA GRACE	0.0432	0.0380	0.0326	0.0327	0.0384	0.0342	0.0328	0.0411	0.0274	0.0057
	MT SEA ADVENTURER	0.0407	0.0390	0.0326	0.0300	0.0394	0.0313	0.0311	0.0421	0.0305	0.0039
	MT DIDDI	0.0419	0.0359	0.0308	0.0309	0.0384	0.0333	0.0328	0.0411	0.0303	0.0030
	MT UMBALWA	0.0419	0.0400	0.0335	0.0309	0.0384	0.0333	0.0328	0.0432	0.0277	0.0061
	MT KINGIS	0.0567	0.0472	0.0408	0.0418	0.0477	0.0450	0.0406	0.0493	0.0000	0.0325
	MT MOSUNMOLA	0.0518	0.0411	0.0345	0.0382	0.0405	0.0411	0.0337	0.0442	0.0161	0.0186
	MT ASHABI	0.0493	0.0411	0.0335	0.0336	0.0394	0.0421	0.0337	0.0462	0.0186	0.0165

Max	Ideal (Best) Value	0.0567	0.0472	0.0408	0.0418	0.0477	0.0450	0.0406	0.0493
Min	Ideal (Worst) Value	0.0407	0.0359	0.0308	0.0300	0.0384	0.0313	0.0311	0.0411

For example, the Euclidean distance from the Ideal Best Solution in MT AMIF was determined as follows: (0.0555-0.0567)^2+(0.0472-0.0472)^2+(0.0408-0.0408)^2 +(0.0409-0.0418)^2+(0.0037-0.0467)^2+(0.0036-0.0440)^2+(0.0031-0.0398)

^2+(0.0035-0.0483) ^2) ^0.5 = 0.0025; while the Euclidean distance from the Ideal Worst Solution was determined as: (0.0555-0.0407)^2+(0.0472-0.0359)^2+(0.0408-0.0308)^2+(0.0409-0.0300)^2+(0.0037-0.0384)^2+(0.0036-0.0313)^2+(0.0031-0.0311) ^2+(0.0035-0.0411) ^2) ^0.5 = 0.0304

The sixth step taken in TOPSIS implementation is the calculation of the TOPSIS performance score (Pi) for each of the vessels. The TOPSIS Performance Score is calculated using:

$$s_{iw} = d_{iw} / (d_{iw} + d_{ib}),$$

$$0 \le s_{iw} \le 1, \qquad i = 1, 2...., m., \qquad \text{Equation 7}$$

The calculated performance score of the vessels surveyed can be shown in Table 45 below.

Table 45: TOPSIS Performance Score and Ranking of Vessels Surveyed

	Safety Factors	Eud Dist From Ideal Best	Eud Dist From Ideal Worst	Sum (Ideal Best & Ideal Worst)	Peformance Score	Ranking	
VESSEL NAMES	MT AMIF	0.0025	0.0304	0.0328	0.9243	92%	2nd
	MT SEA VOYAGER	0.0201	0.0124	0.0325	0.3816	38%	5th
	MT SEA PROGRESS	0.0256	0.0077	0.0333	0.2307	23%	6th
	MT SEA GRACE	0.0274	0.0057	0.0331	0.1726	17%	8th
	MT SEA ADVENTURER	0.0305	0.0039	0.0343	0.1124	11%	9th
	MT DIDDI	0.0303	0.0030	0.0333	0.0908	9%	10th
	MT UMBALWA	0.0277	0.0061	0.0338	0.1815	18%	7th
	MT KINGIS	0.0000	0.0325	0.0325	1.0000	100%	1st
	MT MOSUNMOLA	0.0161	0.0186	0.0347	0.5365	54%	3rd
	MT ASHABI	0.0186	0.0165	0.0351	0.4693	47%	4th

Using MT ASHABI as an example, the Performance Score of MT ASHABI was calculated as follows: Ideal Worst / (Sum of Both Ideal Best and Ideal Worst)

0.0165 / 0.0351= 0.4693 (Approx. 47%)

This above performance score can therefore be used as a means to track subsequent performances of MT ASHABI's safety climate/culture.

8.4 Analysis of Results

The weighted safety climate of shipboard staff and sequence of activities to improve the safety culture of the assessed maritime organization has already been established in Chapter 6, while the application of TOPSIS in this Chapter is to benchmark the performance of vessels in the vessel fleet and determine how vessels in the vessel fleet would be scheduled for safety culture improvement as recommended in Chapter 6. Therefore, the recommendations to administrators from the TOPSIS rankings of Table 46 are to schedule vessels in the vessel fleet assessed as follows: MT DIDI, MT SEA ADVENTURER, MT SEAS GRACE, MT UMBALWA, MT SEA PROGRESS, MT SEA VOYAGER, MT ASHABI, MT MOSUNMOLA, MT AMIF, and MT KINGIS.

8.5 Chapter Summary

This current chapter dealt with the application of TOPSIS in benchmarking the safety climate performance of a vessel fleet. It specifically deals with the logical treatment of values on the TOPSIS framework in comparing the combined performance of safety factors for each vessel with those of the most ideal (positive) and negative solutions. This chapter precisely demonstrated how the TOPSIS framework could be used in benchmarking the performances of safety factors across a vessel fleet and scheduling vessels for safety climate improvements already established in Chapter 6.

9 Validation of Conceptual Decision-Making Framework

9.1 Introduction

This Chapter details the different processes carried out to validate the conceptual decision-making framework developed and used for this study. This Chapter provides readers with a test-retest analysis, sensitivity analysis and a general statement towards the applicability and acceptability of the different decision-making methodologies integrated in the decision-making framework developed and used in this study.

9.2 Test-Retest Analysis

This study used questionnaires to generate the primary data concerning the attitudes of both shore-side and shipboard staff towards safety. Hence, the reliability of responses received plays a vital role in validating the conceptual decision-making framework developed and used for this study. In sampling the questionnaire, the researcher made sure one question associated with each of the safety factors assessed was repeated randomly to provide the data set needed to carry out a Test-retest reliability analysis. The needed Test-retest reliability analysis was done using MS Excel (See details of the analysis in Appendix E and Appendix F).

The results from the responses of shipboard staff ranged from 0.8125 to 0.9900, indicating strong consistency in the responses received (See Appendix E). In contrast, the responses of shoreside staff ranged from -0.4021 to 0.9432, indicating a very weak consistency in responses received from questionnaires on SAW, MTR, FDB and COM (See Appendix F).

The responses with weak consistency also indicate a wide range of perceptions and understanding of safety culture shared by the shoreside staff. Hence, the results of such a test-retest could also be used as insights into exploring shoreside staff's knowledge level towards safety culture. Decisively, the responses of shoreside staff were still considered fit for use because both the sample size and responses affected are small; Hence have no severe influence on the general expectations of the decision-making framework developed.

9.3 Sensitivity Analysis

Sensitivity analysis is an assessment used by researchers and decision makers to understand how variations in the input factors or parameters of a model affect the model outputs. The goal of sensitivity analysis is to identify which input parameters have the greatest impact on the model's results and to quantify the degree of that impact (Triantaphyllou & Sánchez, 1997; Peiyue , Hui, Jianhua , & Jie , 2013). Hence, sensitivity analysis is a powerful tool in the development of models because it enables decision makers to understand the level of accuracy needed for an input factor to make the model sufficiently useful and valid.

In relation to this study, the outputs generated from the SAW and TOPIS methodology are the only source of information needed to guide decision-makers on both activities to enhance the safety culture and the scheduling of vessels for a safety culture improvement program. The SAW methodology generated the weighted safety climate performance across shoreside and shipboard staff, while the TOPSIS methodology ranked how vessels would be scheduled for a safety culture improvement program. Hence, a sensitivity analysis of the weighted safety climate and the ranking of vessels is needed to validate the developed decision-making framework used in this study. The sensitivity analysis would also measure the extent to which these two main outputs are affected by assumptions or values of variables (weights).

9.3.1 Sensitivity Analysis of Output from the AHP methodology

The outputs of the AHP methodology in Chapter 5 provide administrators with the weights and priority setting needed as input into other decision-making techniques used in this study to assess and manage the safety culture of the selected case study maritime organization. Therefore, the sensitivity analysis of the output from the AHP methodology would focus on the relationship between the distribution of maritime experts and the ranking of the weights established for each safety factor. In this analysis, two groups of maritime experts were used. One group comprised of maritime experts evenly distributed across the backgrounds of Navigation, Engineering and Shoreside operation and management of tankers while the other group comprised of the entire maritime experts sampled in this study. Table 46 below presents the outputs and priorities established from nine maritime experts, each selected evenly across the Navigation, Engineering, and Shoreside disciplines.

Table 46: Aggregation of Preferences and Priorities derived from evenly distributed maritime expert.

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	PRIORITY
COM	1.00	2.51	2.14	0.86	0.83	1.60	1.63	1.04	0.16
EMP	0.40	1.00	1.33	1.20	2.21	1.52	1.61	0.62	0.14
FDB	0.47	0.75	1.00	1.49	1.21	1.53	0.87	0.65	0.11
MTR	1.16	0.83	0.67	1.00	1.81	1.21	0.62	0.86	0.12
PID	1.20	0.45	0.83	0.55	1.00	2.36	1.83	2.02	0.14
POS	0.63	0.66	0.65	0.83	0.42	1.00	2.70	0.85	0.10
RSP	0.61	0.62	1.15	1.60	0.55	0.37	1.00	0.63	0.10
SAW	0.96	1.62	1.54	0.50	0.50	1.18	1.59	1.00	0.13

The consistency check of the above outputs was also tested for consistency. The consistency ratio derived from the above table is 0.063, which is within the range and threshold recommended by Thomas Saaty (1980). From the above table, the most highlighted safety factor amongst the above-described group of maritime experts is COM with a value of 0.16, while the least highlighted safety factor is POS and RSP with a value of 0.10.

Table 47 below presents a comparative analysis and ranking of safety factors derived from both maritime experts evenly distributed across disciplines (Navigation, Engineering, and Shoreside) and the entire maritime experts sampled for this study.

Table 47: Comparative analysis of safety factor rankings between maritime experts evenly distributed across disciplines and the entire sample of maritime experts.

MARITIME EXPERTS (Evenly distributed across disciplines)			MARITIME EXPERTS (Across entire sample collected)		
	PRIORITY	**RANKING**		**PRIORITY**	**RANKING**
COM	0.16	1	COM	0.15	1
EMP	0.14	3/2	EMP	0.13	4/3
FDB	0.11	6	FDB	0.11	7/8/6
MTR	0.12	5	MTR	0.11	8/7/6
PID	0.14	2/3	PID	0.13	3/4
POS	0.10	7/8	POS	0.12	5
RSP	0.10	8/7	RSP	0.11	6/7/8
SAW	0.13	4	SAW	0.14	2

From the above Table 47, the established values of safety factors were often consistent in both groups of maritime experts hence creating additional conditions for the ranking of safety factors. The ranking of safety factors that shared similar value therefore shared similar range of ranking and position. For example, under maritime experts that were evenly distributed across disciplines (Navigation, Engineering, and Shoreside), POS and RSP share a similar value of 0.10 hence both safety factors of POS and RSP jointly occupied the 7th and 8th position. Similarly, under the other group consisting of the entire maritime experts, FDB, MTR and RSP shared a consistent value of 0.11, hence they occupied the 6th, 7th and 8th positions on the priority setting.

Upon comparative analysis of both groups of maritime experts, the most highlighted safety factor across both groups of maritime experts is COM. Similarly, across both groups of maritime experts both EMP and PID exhibited consistent values (0.14 for maritime experts evenly distributed across disciplines and 0.13 for maritime experts across the entire sample collected). Additionally, the three least highlighted safety factors across both groups of maritime experts are also RSP, MTR and FDB.

In conclusion, the ranking of safety factors within both groups of maritime experts varied primarily. However, the additional conditions used in ranking also revealed that most safety factors shared similar rankings and positions in the priority setting of both groups of maritime experts used for the sensitivity analysis.

9.3.2 Sensitivity Analysis of Outputs from the SAW methodology

The outputs of the SAW methodology in Chapter 6 provide administrators with the established weighted safety climate and sequence of activities to enhance safety culture in the assessed maritime organization. Therefore, the sensitivity analysis of output from the SAW methodology would focus on the relationship between the weights of each safety factor and the performance score of each safety factor (Memariani, Amini, & Alinezha, 2009). Table 46 summarizes the ranking of Likert scores derived from the responses of shoreside and shipboard staff used for this study prior to the application of weights.

Table 48: Ranking of Likert Scores (Shoreside and Shipboard Staff)

		SHORESIDE STAFF		SHIPBOARD STAFF	
S/N	SAFETY FACTOR	LIKERT SCORE	RANK	LIKERT SCORE	RANK
		(v)		(v)	
1	COMMUNICATION - COM	4.34	1	3.80	8
2	EMPOWERMENT - EMP	4.06	4	4.02	2
3	FEEDBACK - FDB	3.80	5	3.93	5
4	MUTUAL TRUST - MTR	3.32	8	3.812	7
5	PROBLEM IDENTIFICATION – PID	4.18	2	3.98	4
6	PROMOTION OF SAFETY - POS	3.76	6	3.813	6
7	RESPONSIVENESS - RSP	4.08	3	4.01	3
8	SAFETY AWARENESS - SAW	3.68	7	4.29	1
Shoreside Staff: COM>PID>RSP>EMP>FDB>POS>SAW>MTR Shipboard Staff: SAW>EMP>RSP>PID>FDB>POS>MTR>COM					

The ranking of safety factors using the Likert scores derived from the responses of shoreside staff are; Communication, Problem Identification, Responsiveness, Empowerment, Feedback, Promotion of Safety, Safety Awareness, and Mutual Trust respectively; while the ranking of safety factors using the Likert scores derived from the responses of shipboard staff are; Safety awareness, Empowerment, Responsiveness, Problem Identification, Feedback, Promotion of Safety, Mutual Trust, and Communication respectively. Upon application of weights, the comparative ranking of safety factors for both shoreside and shipboard staff is summarized in tables 47 below.

Table 49: Comparative Ranking of Safety Factors (Likert vs Original Weighted Assessment)

		SHORESIDE STAFF				SHIPBOARD STAFF			
S/N	SAFETY FACTOR	LIKERT SCORE	RANK	Weighted Safety Factors (WSF)	RANK (WSF)	LIKERT SCORE	RANK	Weighted Safety Climate (WSF)	RANK (WSF)
		(v)				(v)			
1	COMMUNICATION - COM	4.34	1	0.651	1	3.80	8	0.570	2
2	EMPOWERMENT - EMP	4.06	4	0.528	3	4.02	2	0.523	3
3	FEEDBACK - FDB	3.80	5	0.418	7	3.93	5	0.432	7
4	MUTUAL TRUST - MTR	3.32	8	0.365	8	3.812	7	0.419	8
5	PROBLEM IDENTIFICATION – PID	4.18	2	0.543	2	3.98	4	0.517	4
6	PROMOTION OF SAFETY - POS	3.76	6	0.451	5	3.813	6	0.458	5
7	RESPONSIVENESS - RSP	4.08	3	0.448	6	4.01	3	0.441	6
8	SAFETY AWARENESS - SAW	3.68	7	0.515	4	4.29	1	0.601	1
Shoreside Staff: Likert Score Ranking: WSF Ranking:		COM>PID>RSP>EMP>FDB>POS>SAW>MTR COM>PID>EMP>SAW>POS>RSP>FDB>MTR							
Shipboard Staff: Likert Score Ranking: WSF Ranking:		SAW>EMP>RSP>PID>FDB>POS>MTR>COM SAW>COM>EMP>PID>POS>RSP>FDB>MTR							

The ranking of safety factors varied in five (5) safety factors out of eight (8) for shoreside staff while those of shipboard staff varied in six (6) out of eight (8) hence the application of weights can be said to have influenced the ranking of safety factors used to describe the safety climate of the assessed maritime organization.

The relationship between the weights of each safety factor and the performance score of each safety factor was also examined from the perspective of percentage change in weight is needed to change the ranking of safety factors in the original weighted safety climate that describes the safety climate of the assessed maritime organization (See Table 48 below)

Table 50: Percentage Change in Weight Needed to Change Ranking

S/N	SAFETY FACTOR	Weights	Rank of Weights	Likert Score	Weighted Safety Climate	Ranking of Weighted Safety Climate	New Weight Needed to Change to Next Level	% change in Weight to Change to Next Level
SHORESIDE STAFF								
		(w)		(v)	(w) x (v)		NEXT LEVEL (w)x(v) / (w)	new (w) - old (w) / old (w) x 100
1	COMMUNICATION - COM	0.15	1	4.34	0.651	1	(-)0.125	(-) 16.67%
2	EMPOWERMENT - EMP	0.13	3	4.06	0.528	3	0.134	0.4%
3	FEEDBACK - FDB	0.11	8	3.80	0.418	7	0.118	7%
4	MUTUAL TRUST - MTR	0.11	7	3.32	0.365	8	0.126	14.5%
5	PROBLEM IDENTIFICATION – PID	0.13	4	4.18	0.543	2	0.156	20%
6	PROMOTION OF SAFETY - POS	0.12	5	3.76	0.451	5	0.137	14.17%
7	RESPONSIVENESS - RSP	0.11	6	4.08	0.448	6	0.111	0%
8	SAFETY AWARENESS - SAW	0.14	2	3.68	0.515	4	0.143	2.14%
SHIPBOARD STAFF								
S/N	SAFETY FACTOR	Weights	Rank of Weights	Likert Score	Weighted Safety Climate	Ranking of Weighted Safety Climate	New Weight Needed to Change to Next Level	% change in Weight to Change to Next Level
		(w)		(v)	(w) x (v)		NEXT LEVEL (w)x(v) / (w)	new (w) - old (w) / old (w) x 100
1	COMMUNICATION - COM	0.15	1	3.80	0.570	2	0.158	5.3%
2	EMPOWERMENT - EMP	0.13	3	4.02	0.523	3	0.142	1.2%
3	FEEDBACK - FDB	0.11	8	3.93	0.432	7	0.112	0.2%
4	MUTUAL TRUST - MTR	0.11	7	3.812	0.419	8	0.113	0.3%
5	PROBLEM IDENTIFICATION – PID	0.13	4	3.98	0.517	4	0.131	0.1%
6	PROMOTION OF SAFETY - POS	0.12	5	3.813	0.458	5	0.136	1.6%
7	RESPONSIVENESS - RSP	0.11	6	4.01	0.441	6	0.114	0.4%
8	SAFETY AWARENESS - SAW	0.14	2	4.29	0.601	1	(-)0.133	0.7%

From Table 48 above, the percentage change in weights needed for each safety factor to change to the next desirable rank varied from 0.4% to 16.67% for shoreside staff while those of the shipboard staff varied from 0.7% to 5.3% showing how stable and robust the SAW model performed.

The relationship between the weights of each safety factor and the performance score of each safety factor was also examined from the perspective of uniform weights. Upon the application of uniform weights, the ranking of safety factors for both shoreside and shipboard staff is summarized in tables 49 below.

Table 51: Comparative Ranking of Safety Factors (Uniform Weight Assessment)

		SHORESIDE STAFF				SHIPBOARD STAFF			
S/N	SAFETY FACTOR	Weighted Safety Factors	RANK for WSF	Uniformly Weighted Safety Factors	RANK for Uniformly WSF	Weighted Safety Climate	RANK for WSF	Uniformly Weighted Safety Factors	RANK for Uniformly WSF
1	COMMUNICATION - COM	0.651	1	0.5425	1	0.570	2	0.475	8
2	EMPOWERMENT - EMP	0.528	3	0.5075	4	0.523	3	0.503	2
3	FEEDBACK - FDB	0.418	7	0.475	5	0.432	7	0.491	5
4	MUTUAL TRUST - MTR	0.365	8	0.415	8	0.419	8	0.477	7
5	PROBLEM IDENTIFICATION – PID	0.543	2	0.523	2	0.517	4	0.498	4
6	PROMOTION OF SAFETY - POS	0.451	5	0.470	6	0.458	5	0.477	6
7	RESPONSIVENESS - RSP	0.448	6	0.510	3	0.441	6	0.501	3
8	SAFETY AWARENESS - SAW	0.515	4	0.460	7	0.601	1	0.536	1
Shoreside Staff: WSF Ranking: Uniformly WSF Ranking:		COM>PID>EMP>SAW>POS>RSP>FDB>MTR COM>PID>RSP>EMP>FDB>POS>SAW>MTR							
Shipboard Staff: WSF Ranking: Uniformly WSF Ranking:		SAW>COM>EMP>PID>POS>RSP>FDB>MTR SAW>EMP>RSP>PID>FDB>POS>MTR>COM							

From table 50 above, the ranking of the uniformly weighted safety factor varied from the original weighted safety factor used to describe the safety climate of the assessed maritime organization. Amongst the ranking of shoreside staff only COM, PID and MTR did not alter ranks, while amongst shipboard staff only SAW and PID were unchanged after the application of uniform weights on established Likert scores used for the study.

9.3.3 Sensitivity Analysis of Outputs from the TOPSIS methodology

The outputs of the TOPSIS methodology in Chapter 8 provide administrators with the ranking of vessels according to their TOPSIS performance score across the vessel fleet of the assessed organization. The outputs of Chapter 8, therefore, serve as guidance to administrators on how activities to improve safety culture and safety performance may be implemented on a vessel-by-vessel basis. The sensitivity analysis of output from the TOPSIS methodology also focuses on the relationship between the weights of each safety factor used in the decision-making framework and the ranking of vessels based on the TOPSIS performance score from each vessel of the vessel fleet. Hence, this section focuses on five "What if's" scenarios starting with what would happen if the highest weight was replaced with the lowest weight to what would happen if five of the highest weights were replaced with the four lowest weights (Alinezhad & Amini, 2011; Peiyue , Hui, Jianhua , & Jie , 2013; Moradi, 2022).

Table 50 below summarizes the different scenarios and adjusted weights used in analyzing the sensitivity of the TOPSIS model.

Table 52:Scenarios and Adjusted Weights for Analysis of TOPSIS model

				Scenarios and Adjusted Weights				
S/N	SAFETY FACTOR	Weights	Rank of Weights	S1	S2	S3	S4	S5
1	COMMUNICATION - COM	0.15	1	0.125	0.11	0.11	0.11	0.11
2	SAFETY AWARENESS - SAW	0.14	2	0.125	0.14	0.11	0.11	0.11
3	EMPOWERMENT - EMP	0.13	3	0.125	0.13	0.13	0.11	0.11
4	PROBLEM IDENTIFICATION – PID	0.13	4	0.125	0.13	0.13	0.13	0.12
5	PROMOTION OF SAFETY - POS	0.12	5	0.125	0.12	0.12	0.12	0.13
6	RESPONSIVENESS - RSP	0.11	6	0.125	0.11	0.11	0.13	0.13
7	MUTUAL TRUST - MTR	0.11	7	0.125	0.11	0.14	0.14	0.14
8	FEEDBACK - FDB	0.11	8	0.125	0.15	0.15	0.15	0.15

S1 - Uniform Weights
S2 – What if we replace the highest weight with the lowest weight.
S3- What if we replace the two highest weight with the two lowest weights.
S4 – What if we replace the three highest weight with the three lowest weights.
S5 – What if we replace the four highest weights with the four lowest weights.

Details of the computational process for the sensitivity analysis of the TOPSIS model using the scenarios and adjusted weights shown in Table 51 above can be found in Appendix H. Furthermore, the TOPSIS outputs and ranking of vessels from the different scenarios were summarized to determine how robust the TOPSIS model performed. It was also done to identify if there would be any incident of rank reversal.

Table 51 below summaries the performance scores and ranking of vessel for all Scenarios and those from the Original TOPSIS result.

Table 53: Performance Scores and Ranking of Vessel (Scenarios vs Original TOPSIS result)

	Original TOPSIS Result		Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
VESSEL NAMES	P-Score	Rank	P-Score	Rank	P-Score	Rank	P-Score	Rank	P-Score	Rank	P-Score	Rank
MT AMIF	0.9243	**2nd**	0.9258	**2nd**	0.9278	**2nd**	0.9291	**2nd**	0.9272	**2nd**	0.9278	**2nd**
MT SEA VOYAGER	0.3816	**5th**	0.3818	**5th**	0.3798	**5th**	0.3803	**5th**	0.3803	**5th**	0.3823	**5th**
MT SEA PROGRESS	0.2307	**6th**	0.2367	**6th**	0.2346	**6th**	0.2313	**6th**	0.2312	**6th**	0.2340	**6th**
MT SEA GRACE	0.1726	**8th**	0.1792	**8th**	0.1754	**8th**	0.1825	**8th**	0.1825	**8th**	0.1848	**8th**
MT SEA ADVENTURER	0.1124	**9th**	0.1121	**9th**	0.1251	**9th**	0.1199	**9th**	0.1104	**9th**	0.1087	**9th**
MT DIDDI	0.0908	**10th**	0.0953	**10th**	0.0883	**10th**	0.0886	**10th**	0.0943	**10th**	0.0965	**10th**
MT UMBALWA	0.1815	**7th**	0.1840	**7th**	0.1981	**7th**	0.1898	**7th**	0.1821	**7th**	0.1824	**7th**
MT KINGIS	1.0000	**1st**	1.0000	**1st**	1.0000	**1st**	1.0000	**1st**	1.0000	**1st**	1.0000	**1st**
MT MOSUNMOLA	0.5365	**3rd**	0.5282	**3rd**	0.5081	**3rd**	0.5237	**3rd**	0.5183	**3rd**	0.5264	**3rd**
MT ASHABI	0.4693	**4th**	0.4556	**4th**	0.4488	**4th**	0.4357	**4th**	0.4308	**4th**	0.4434	**4th**

From the above table, the performance scores continued to vary with changes to the weights, but their outputs never led to any reversal of ranks amongst the vessels assessed. The vessels maintained the same ranks as the original TOPSIS results validating the use of the TOPSIS model in ranking vessels to be scheduled for a safety culture improvement program.

9.4 Validation of the Conceptual Decision-Making Framework

The determination of a model's acceptability or the endorsement of its suitability for use depends on its validation. The validation process helps confirm that the developed model or methodology effectively operates as intended, addressing targeted problems, and delivering the intended results. However, Collis and Hussey (2003) emphasize that methodologies or mathematical models are very similar to theories that inherently resist complete verification or falsification. Consequently, a model or methodology should always be accepted for as long as it delivers plausible outcomes, particularly when there is no insufficient evidence to reject it.

The complexity inherent in validating intricate models or methodologies often poses challenges to achieving comprehensive validation. Consequently, a strategy involving partial validation was adopted, aiming to partition the validation process into manageable phases. This approach facilitates a more comprehensive assessment of the reliability and validity of the specific elements constituting the model or methodology. The division of the validation process also facilitates the attainment of a more targeted and structured validation process for the individual components forming the model or methodology. Furthermore, this division serves as a means to mitigate research risks by promptly identifying and rectifying potential issues early in the research process.

This study executed partial validation through test-retest analysis to confirm the questionnaire's reliability and sensitivity analysis for both the SAW and TOPSIS aspects of the framework. This approach bolsters the credibility of the research findings and enhances confidence in the reliability of the developed framework.

9.5 Applicability of Integrated MCDM Methodologies

The different MCDM/MCDA methodologies integrated in the decision-making framework used in this thesis are well-known methodologies that have been used for many years by academicians and governments in solving complex decision-making problems (See Chapter 2).

AHP was the first method used in the study to establish the weights and priority setting of safety factors used in this study. The AHP method was selected because it is the only subjective method capable of translating the preferences of described safety factors into weights and priority settings that can be used in other decision-making techniques. The option of using ANP was also not selected because it would be extremely difficult to assess the inter-relationship between the different safety factors used in describing the safety culture of a maritime organization. Hence, the hierarchical decomposition of AHP provides the best option for establishing weights and priority setting for safety factors used in this study.

The experts selected in the elicitation process ranged from individuals working onboard to administrators with many years of experience the tanker shipping industry in Nigeria. The output generated from the AHP process also passed the consistency test given by Saaty (1980) hence was seen fit for use in other decision-making methodologies integrated into the study and decision-making framework.

SAW was the second method used in this study, and it built on the output of the AHP process to produce a weighted safety climate performance for both shoreside and shipboard staff. The SAW methodology was selected at this phase of the decision-making framework because it offered the easiest, transparent and flexible means of applying the outputs of AHP for further decision-making. The output of the SAW process gave administrators a guide on how activities to improve safety culture can be scheduled at the organizational level or across shoreside and shipboard staff (entire vessel fleet).

The third methodology used in this study is the Pareto analysis. It is not just a decision-making tool for problem solving but a tool for gaining insights to a problem, hence Pareto analysis was used here in this study for both insight development and to justify the output of the SAW methodology further. The Pareto analysis does not directly build on any decision-making methodology but rather from originates the feedback statements of the safety culture survey before other activities were carried out that gave the pareto chart given (See Chapter 8). The Pareto analysis was selected at this phase of the conceptual decision framework because if offers the best possible means of using feedbacks from the survey exercise in gaining into issues concerning occupational health and safety, ship safety, and shore-to-ship safety for both shoreside and shipboard staff.

The last methodology used in this study and in the decision-making framework is the TOPSIS methodology. The TOPSIS methodology was selected in the conceptual decision-making framework because it provides decision-makers with a simplified, rational, and comprehensible approach to mathematically compare how well each alternative performs. TOPSIS, like the SAW methodology, also builds on the output of the AHP process to produce a ranking of vessels in accordance with its TOPSIS performance scores. The output from the TOPSIS process provided a ranking of vessels to guide administrators on the possible sequence vessel in the fleet were to be nominated for a safety culture improvement program to improve the safety culture and performance of the fleet. Therefore, from a methodological point of view the decision-making framework behaved and performed as expected in providing support to administrators on assessing and managing safety culture.

9.6 Chapter Summary

This Chapter covered procedures carried out to ensure it acceptability and applicability. This chapter specifically detailed findings from additional analysis and assessments carried out to validate the developed conceptual decision-making framework used in this study.

10 Discussions

10.1 Introduction

This Chapter compares the outcomes of previous chapters with the general aims and objectives of this PhD title and study. This Chapter explicitly outlines the research’s contribution to knowledge and practice, assumptions of the research study and limitations that influenced the nature and scope of this research study.

10.2 Contributions of the Research to Knowledge and Practice

This section summarises this study’s contribution to knowledge and practice. It also specifically highlights vital points within the aim of this study and how the application of an integrated decision-making framework in assessing the safety culture of a selected maritime organization aligns with the PhD study's objectives.

In Chapter 2 of this thesis, the cognitive decision-making processes of safety management or problem-solving cycle was first outlined before critically reviewing MCDM methodologies that could be integrated and adopted as part of the cognitive decision-making processes of safety management. Specifically, several MCDM methodologies were highlighted to demonstrate their potential for use in assessing the safety culture of maritime organizations. The chapter not only establishes a theoretical foundation for the integration of MCDM methodologies but also provides practical guidance on how the different MCDM methodologies can be implemented.

Chapter 3 explores the concepts of safety management, safety culture, maritime safety culture and gaps in literature concerning the application of both conventional and modern decision-making techniques in safety culture assessment. This chapter serves as a significant contribution to the theoretical underpinnings of the study, shedding light on both the present and potential future directions of Multi-Criteria Decision Making (MCDM) techniques employed in the evaluation of safety culture.

Chapter 4 highlights both the research design and research methodology adopted in carrying out this study. Chapter 4 also highlighted the reasoning behind the selection of the case study organization and provided in-depth details about the selected case study maritime organization. This Chapter not only contributes to the theoretical framework of this study but to the practical processes adopted in carrying out this study. This Chapter specifically details how the conceptual decision-making framework would be used to assess the safety culture of a maritime organization with commercial cargo carrying vessels.

Chapter 5 details the processes carried out in establishing weights and priority settings for safety factors (metrics) that influence the safety culture of maritime organizations with tanker shipping operations across Nigeria. Chapter 5 contributes to knowledge by demonstrating how AHP can be used in establishing weights or priority setting of safety factors (metrics) that could influence the safety culture of maritime organizations in Nigeria as at the time of the study. The weights established ranged from 0.11 to 0.15, with the highest priority setting (weight) being COM and the lowest of 0.11 being shared by FDB, MTR, and RSP. The AHP out also yielded a consistency ratio of 0.0397, making it reasonable consistent because it fell below the standard 0.1 margin. This Chapter clearly explores the values of safety factors used in assessing the safety culture of a maritime organization in Nigeria.

Chapter 6 details and demonstrates the application of SAW in establishing the weighted safety climate of both shoreside and shipboard staff. This Chapter specifically contributes to knowledge by providing readers with a demonstration of how safety culture could be assessed at an organizational level (across shoreside and shipboard staff) using SAW. It also generally contributes to the body of knowledge by demonstrating how established priority setting can be used input for assessing the safety culture of a maritime organization in Nigeria using the SAW decision-making technique. The ranking also provides guidance on how improvement programs would be implemented, the ranking of safety factors in the established weighted safety climate of shoreside staff are COM, PID, EMP, SAW, POS, RSP, FDB, and MTR, respectively; while, the ranking of safety factors in the established weighted safety climate of shipboard staff are; SAW, EMP, RSP, PID, FDB, POS, MTR, and COM respectively.

Chapter 7 specifically contribute to knowledge by providing readers with a demonstration of how Pareto Principle can be used to gain insights into issues concerning occupational health and safety, ship safety, and shore-to-ship safety using feedback statements from both shoreside and shipboard staff. This Chapter also demonstrated how Pareto Analysis can be used to justify the weighted safety climate of both shoreside and shipboard staff given the assumption that 30% of safety factors associated to feedback statements received during the safety climate survey is responsible for 70% of the least performing safety factors highlighted in the weighted safety climate established by the SAW process of the conceptual decision-making framework.

Chapter 8 explicitly contributes to knowledge and practice by demonstrating how TOPSIS can be used in scheduling vessels in the vessel fleet for a safety culture improvement program. The Chapter provides a practical demonstration of how the safety climate survey data and established priority setting of safety factors can be used in a TOPSIS framework to rank vessels based on their overall safety factor performances, ranging from the least performing to the best performing. The ranking and scheduling of vessels for a safety culture improvement program using the adopted TOPSIS framework are: MT DIDI, MT SEA ADVENTURER, MT SEAS GRACE, MT UMBALWA, MT SEA PROGRESS, MT SEA VOYAGER, MT ASHABI, MT MOSUNMOLA, MT AMIF, and MT KINGIS.

Chapter 9 explicitly contributes to knowledge and practice by demonstrating how both the reliability and validation of this study was carried out. The reliability assessment of the responses to the survey questionnaires were reasonable, consistent with only a few exceptions in responses from the surveyed shoreside staff. However, the responses of the shoreside staff were still considered fit for use because both the sample size and responses affected are small. The responses of shoreside staff also had no severe influence on the general expectations of the decision-making framework developed. The sensitivity analysis of the SAW model was considered valid because the ranking of safety factors moderately varied in cases where no weights were applied to when uniform weights were applied. The output of the SAW model was also validated given the moderate percentage changes needed to change rank to the next desirable rank. The sensitivity analysis of the TOPSIS model was also considered valid because the model did not suffer any rank reversal after varying most of the weights with the lowest weights. Conclusively, Chapter 9 contributes to knowledge by demonstrating how both sensitivity and validity of this study was carried out. It also highlighted conditions necessary for the acceptance of outputs from different aspects of the conceptual decision-making framework.

10.3 Assumptions of the Research Study

Every research work makes use of some assumptions in conceptualizing its subject matter (research problem), research method, and process to be adopted for the research. Given that the above study focused on the assessment and management of safety culture using decision-making techniques, the assumptions made by the researcher are:

- The safety factors/metrics identified by ABS could also be used as suitable criteria's in the conceptual decision-making framework for assessing and managing the safety culture of a maritime organization as the safety factors/metrics identified by ABS are still the most recognized piece of literature used by both academicians and professionals in assessing the safety culture of maritime organizations (Volkan, Rafet , Osman , & Louis

, 2016).

- The experience of maritime experts with tanker operations and management in Nigeria could be used as valuable inputs in the subjective assessment of safety culture. The weights derived from the preferences elicitation of maritime experts would yield a more structured and justifiable framework for assessing the safety culture of maritime organizations without the reliance on safety-related quantitative data and correlational statistical techniques.
- The AHP methodology would be best suited to explore the preferences of maritime experts. The weights derived from the AHP methodology would also be realistically applied to the outputs of the safety culture survey to yield the weighted safety climate as a means for describing the safety culture of the maritime organization.
- The respondents of the safety culture survey questionnaires administered were still employees (shoreside and shipboard staff) of the selected case study maritime organization. It is also assumed that the respondents were honest in all their responses regardless of their perception and attitude towards safety in their place of work.
- The TOPSIS methodology would be a suitable MCDM technique to rank and schedule vessels for a safety culture improvement program since it is also one of the most MCDM methods used to aid decision makers in safety related issues. The TOPSIS methodology would be able to provide a realistic ranking for vessels using weight established from AHP

methodology and values derived from the responses to safety climate survey questionnaires.

- Pareto analysis would be able to provide a more structured and justifiable means for developing and scheduling needed activities to improve the safety culture and safety performance of the surveyed maritime organization.

10.4 Limitations of the Research Study

The development of a decision-making framework for assessing the safety culture of a maritime organization without the reliance on correlational statistical techniques focused mainly on the establishment of priority setting (weightings), assessment of the current safety climate survey, the establishment of the weighted safety climate, development of insights on issues concerning safety and justification of recommendations from the weighted safety climate assessment, and the ranking of vessels to be scheduled for a safety culture continual improvement program in the assessed maritime organization. Given the unique nature of the research problem as described in Chapter 1 and the sensitive nature of safety culture, the researcher thought it wise to collaborate with a maritime organization in Nigeria with tanker operations because it provides the researcher with the most realistic option for testing the conceptual decision-making framework in real life.

In managing and organizing this research study, the main limitations experienced were maintaining communications with stakeholders of this research study based in Nigeria. The researcher had to rely entirely on phone calls, video calls, and emails during the data collection phase of this research. However, there were still difficulties in receiving feedback because some groups of respondents (maritime experts) wanted to hear directly from me to clarify some aspects of the research study, while others (shipboard staff) had difficulties having access to the internet or computers needed to participate in the survey.

In order to address the issues of communications and feedback, the human resources management of the selected case study maritime organization was kind enough to nominate several trainees (cadet) who facilitated the collection of data by providing the respondents on board with a dedicated computer with internet access to respond to the survey questions. These trainees (cadets) were also moved across different tanker ships owned and managed by the selected case study maritime organization so as to improve communications and feedback between the researcher and respondents during the data collection phase of the research study. The data collection process was also impacted by the outbreak of COVID-19 also negatively impacted the communication and feedback process during the data collection process as it made it more difficult for the maritime organization to carry out crew change hence it took much longer to make logistics arrangements for the transfer of the nominated cadets to board and assist respondents on board with access to internet and computers to respond to the survey questions.

In establishing the priority setting or weights for the safety factors used in the conceptual decision-making framework, the analytical hierarchy process methodology was selected in eliciting preferences from the maritime experts because it became apparent that the maritime experts would not be able to produce a rational output or judgment to justify the inter-relationships and interactions amongst the safety factors used to assess and describe the safety culture of the selected case study maritime organizations used for this research study.

The analytical hierarchy process methodology was also selected because it provides a valuable means of obtaining the linear approximation of an unexpressed utility for decision making. However, the analytical hierarchy process methodology is prone to consistency issues as the number of attributes compared increases. This means that as the number of attributes increases it becomes more challenging to be able to achieve a rational and consistent output from the pairwise comparison of attributes used in decision making. This also means that the standard consistency test used in the AHP process was just used as a tool to ensure the linearity of the judgments taken when attributes were compared than a measure of the final judgment taken for the decision-making problem been addressed.

In establishing the weighted safety climate, the simple additive weighted methodology was used because of its simplicity and adaptability to other MCDM methodology. However, its use depends highly on the quality of its respondents hence the reliability and responses received was also considered as a input in the decision making framework to provide decision makers with insight on how reliable the established weighted safety climate would in enhancing the safety culture of the assessed maritime organization. The application of simple additive weighted method was only used to establish a weighted performance of each safety factor used in describing the safety culture of a maritime organization hence a weighted safety climate of the assessed maritime organization.

In gaining insights into issues concerning occupational health and safety, ship safety, and shore-to-ship safety, a Pareto analysis system was integrated into the conceptual decision-making framework because it offers a very realistic means of observing the natural distribution of events or human activity. The application of Pareto was also used as a tool for justifying the weighted safety climate established with the SAW model. However, the effectiveness of its use depends solely on the performance scoring of safety factors such that any error in the scoring process would lead to inaccurate assessment of insights concerning issues of occupational health and safety, ship safety, and shore-to-ship safety. Also, leading to a greater possibility of not being able to justify the weighted safety climate established by the SAW model. In this research study, the Pareto analysis system was used primarily to visualize insights gained and justification for the weighted safety climate established by the SAW model.

In scheduling vessels for safety culture improvement programs, the TOPSIS methodology was adopted because is its simplicity, rationality, comprehensibility, good computational efficiency, and ability to measure the relative performance of alternatives assessed in a simple mathematical form. The TOPSIS methodology was also adopted because it has the ability to avoid the complexity of comparing attributes or problems of transitivity in making decisions. However, the adopted TOPSIS methodology used in the benchmarking phase of this research study allows trade-offs hence poor performances in any of the safety factors were overlooked in the final report. The TOPSIS methodology was only used to produce a ranking for scheduling vessels in a vessel fleet for a safety culture improvement program.

10.5 Chapter Summary

This chapter summarized all the research findings, assumptions and limitations that influenced the nature and scope of this research study. This chapter also provides a foundation to the conclusion of this thesis and recommendations to possible areas of research and work that could be carried out in the future to further contribute to the body of knowledge concerning safety culture assessment of maritime organizations.

11 Conclusions and Recommendations for Further Studies

11.1 Introduction

This chapter summarizes all the information presented in this research study with a list of concluding statements and recommendations for further studies. This chapter also outlines how the research questions formulated in Chapter 1 of this research study were addressed.

11.2 Research Conclusions

The main conclusion of this PhD research is summarized as follows:

- The different methodologies for assessing safety culture in maritime organizations were covered mainly in Chapters 1, 2 and 3. Chapter 1 mainly highlighted issues with the current methodologies for assessing safety culture in maritime organizations. Chapter 2 critically explored the application of MCDM techniques on safety culture assessments while Chapter 3 mainly provided background information on the origin and concept of safety culture alongside the different conventional approaches for assessing the safety culture of maritime organizations. These Chapters therefore provided answers to the research question of "how is safety culture assessed in maritime organizations" and

- Chapters 2 and 4 answer the question on "how can decision-making models be integrated to assess and manage the safety culture of maritime organizations". Chapter 2 partially provided a theoretical concept on how decision-making models may be integrated while Chapter 4 demonstrated with a flow chart on how the different decision-making techniques would interact as a network structure to assess and manage the safety culture of a maritime organization. Hence Chapters 2 and 4 specifically provided information on how decision-making models could be integrated to identify, track and schedule improvement activities for safety factors that influence the safety culture of maritime organizations.
- Chapters 2 and 5 provide answer to the research question of "how the weights and priority setting of safety factors that influence the safety culture of maritime organizations across Nigeria would be explored" Chapter 2 contains background information on the concept and implementation of AHP while Chapter 5 provides practical demonstrations of how weights and priority setting of safety factors that influence the safety culture of maritime organizations across Nigeria were explored and established using AHP framework.
- Chapters 6 provides answers to the questions of both "how the attitudes of shore-side and shipboard staff towards safety were elicited within the selected case study maritime organization in Nigeria" and "how would activities be scheduled to improve the performance of safety factors and

safety culture". Chapter 6 described how the attitudes of shore-side and shipboard staff towards safety were elicited alongside how the SAW framework was used in establishing the weighted safety climate assessment of a maritime organization. The ranking of performances from the least to the best for each weighted safety factor is therefore used to schedule how improvements would be carried out to enhance the safety culture of the assessed maritime organization.

- Chapters 7 and 9 provide information on how the Pareto analysis was used to justify the outputs of the SAW framework. Chapters 7 and 9 also answered the research question "how activities could be scheduled to improve the performance of safety factors and safety culture". The reasoning behind the application of pareto analysis is that 30% of safety factors attributed to feedback statements on occupational health and safety, ship safety, and shore-to-ship safety are responsible for 70% of the least performing safety factors attributed to the weighted safety climate of the assessed maritime organization. Hence these conditions were met for both shoreside and shipboard staff to justify how activities would be scheduled to improve the performance of safety factors and safety culture in the assessed maritime organization. Consequently, Chapter 7 demonstrated how associated feedback statements from the safety climate survey met the estimated outputs of the SAW framework while Sections 9.3.1 of Chapter 9 demonstrated how sensitivity analysis can be used to further justify the findings of the SAW framework. Sections 9.3.1 of Chapter 9 also provides insights into how the weights and priority setting of each safety factor influences both the output of the SAW framework and activities that could enhance the safety culture of the assessed maritime organization.

- Chapters 8 and 9 provide answers to the research question of "how vessels in the assessed vessel fleet can be scheduled for a safety culture improvement program". Chapter 8 provides a practical demonstration of how the TOPSIS framework was used to rank vessels according to their overall safety factor performance. The ranking from least performing vessel to best performing vessel was used to schedule vessels in a vessel fleet for a safety culture improvement program. Section 9.3.2 of Chapter 9 demonstrated how sensitivity analysis could be used to justify the findings of the TOPSIS framework, hence providing a means of justifying how vessels scheduled for a safety culture improvement program. Consequently, Chapter 9 specifically demonstrates the entire validation process carried out both for this study and the different decision-making methodologies that were integrated to assess and manage the safety culture of maritime organizations.

11.3 Recommendations for Further Studies

The work presented in this thesis represents a decision-making framework for assessing the safety culture of a maritime organization without the reliance on correlational statistical techniques. The work in this thesis also emphasizes on the integration of several decision-making methodologies to provide a more structured and justifiable approach for the subjective assessment of safety culture in a maritime organization. Nevertheless, given the above-stated limitations and challenges experienced whilst carrying out this research study, the recommendations for further studies are:

- Integration of Delphi Technique: This study relied on safety factors identified by ABS in assessing and describing the safety culture of the selected case study maritime organization. However, the safety factors developed by ABS were not designed as performance indicators or sub-elements to the traditional components of safety culture (human, organizational and technical) hence, the inter-relationships and interactions between the safety factors identified by ABS cannot rationally be compared and explored. Therefore, the integration of a Delphi system in future studies would enable researchers to identify and develop safety factors as performance indicators that can easily be associated with the traditional components/elements (human, organizational and technical) of safety culture. The safety factors developed from the Delphi system would also be designed such that the inter-relationships and interactions between the safety factors identified can rationally be compared and explored.
- Integration of Analytical Network Process (ANP): The process of decision-making entails the elicitation of preferences, weightings, or priority setting at one point in time of the decision-making process. This study made use of the analytical hierarchy process (AHP) in establishing the priority setting or

weightage, as the safety factors adopted for this study made it difficult to explore the inter-relationships and interactions between them. Hence, the researcher recommends the integration of the analytical network process (ANP) to explore the inter-relationships and interactions between safety factors that have been designed as performance indicators that are easily associated with the traditional components/elements (human, organizational and technical) of safety culture. The application of ANP would also yield a more realistic and rational output or judgment in establishing the weightage or priority setting for assessing safety culture using a decision-making technique. It would also yield a more rational output to justify the inter-relationships and interactions amongst the safety factors used to assess and describe the safety culture of maritime organizations in future studies. The application of ANP would also enable researchers to overcome issues of consistency that may be experienced in using AHP as ANP has the ability to track the logical consistency of judgments used in determining priorities to a decision-making problem.

- Use of Survey Facilitators: The safety climate survey of shipboard staff entailed the use of facilitators who were equipped with computers and internet access to ensure that respondents attended to the survey questions timely. However, delays in the survey process were experienced because there were only a few facilitators who were nominated for the survey exercise. The survey facilitators were also routinely moved from one vessel to the other to provide support for respondents of the survey. Hence, the survey facilitators acted as a point of contact for the researcher onboard the vessel for resolving any issues encountered onboard regarding the survey in a timely manner. For further studies, the researcher recommends the use of survey facilitators on board each vessel to ensure that planned survey exercises are completed under the time scale set for the survey exercise. Also, for future research on the impact of improvement activities on safety factors, the use of safety facilitators onboard each vessel of the maritime organization would ensure the continuous monitoring of safety factors after improvement activities have been carried out by the maritime organization. The nature of this type of research study may entail the repetition of safety climate survey over a fixed period of time, hence, having a nominated facilitator would go a long way in ensuring the consistency of the survey process, it would also go a long way in ensuring that planned survey exercises are completed under the time scale set for the survey exercise.

- Exploration of alternatives to TOPSIS: The final scoring and evaluation of the weighted safety climate performance was done using the TOPSIS methodology in this current thesis. However, other MCDM techniques as COPRAS, PROMETHEE, and SMART remain yet to be explored as decision-making techniques for assessing the safety culture of maritime organizations. Hence, the researcher recommends the use of any of the above MCDM techniques on the final scoring and evaluation of the weighted safety climate performance depending on the understanding and capacity of the researcher and future decision-maker.

- Customizations of Pareto Analysis System and Application of Data Analytics Techniques: In future researches on the application of Pareto systems in gaining insights on safety culture, the researcher recommends that the application of a Pareto system be further customized to view the contribution of each safety factor on the safety climate (weighted safety climate) performance of vessels assessed in the selected case study maritime organization while the application of data analytical techniques could be used to gain insights into the contribution of the different units (deck or engine) onboard on the weighted safety climate performance of vessel assessed by the researcher. The application of data analytical techniques is also valuable in future research to gain insights into the impact of different categories of workers (ratings or officers) on the safety climate performance of each vessel in a marine organization.
- Validation of MCDM methodology: This study adopted a partial validation strategy which focused on key components within the conceptual decision-making framework. However, it is important to note that the output and findings of the conceptual decision-making were not contrasted or compared with other established methods that are already in use for assessing and managing safety culture. Hence, the researcher recommends a thorough comparison between the outcomes derived from the decision-making techniques implemented in this study and the results typically obtained from the outputs or findings of conventional approaches commonly utilized in the assessment of safety culture. This comparative analysis will not only

illuminate the strengths and weaknesses of each approach but will also provide invaluable insights into the potential benefits and innovative perspectives introduced by the decision-making technique. Furthermore, it would facilitate a holistic comprehension of how effectively the newly employed decision-making technique aligns with, or diverges from, established practices. Therefore, this comparison will empower researchers to evaluate and measure the efficiency and distinctiveness of the decision-making process within the broader framework of safety culture assessment and management.

11.4 Chapter Summary

In conclusion, this chapter summarized all the information presented in this thesis using several closing statements to justify the application of AHP, SAW, TOPSIS, and Pareto Analysis in assessing and managing the safety culture of a maritime organization. This chapter also provided recommendations for further studies and details of possible areas of research and work that could be carried out in the future to improve the performance of a decision-making framework for assessing the safety culture of a maritime organization without relying on any correlational statistical technique.

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Appendix A - Priority Setting Questionnaire

SURVEY STUDY ON PRIORITY SETTING FOR THE SELF-ASSESSMENT OF SAFETY CULTURE ACROSS MARITIME ORGANISATIONS IN NIGERIA

Dear Sir/Madam,

I am a Ph.D. student from the Department of NAOME, University of Strathclyde, Glasgow. My research focuses on the development of a decision-making framework for the self-assessment of safety culture across maritime organizations in Nigeria.

This survey study forms the first part of my research, and it aims to elicit the preferences of experts for priority setting in the self-assessment of safety culture across maritime organizations in Nigeria. The survey study would focus mainly on the preferences and priorities of experts on the safety factors used in assessing the safety culture of cargo-carrying commercial vessels (tankers).

Your opinions are extremely important to this research, and there are no right or wrong answers. Your participation in this survey is entirely voluntary and the information gathered would also be treated in the strictest confidence. This survey will only be used for academic research purposes, and you are entitled to withdraw your answer at any time.

This survey will take approximately 20 minutes to complete. If you consent to participate in this survey, please provide your opinions to the questions of the survey. If you would also like to have a copy of the final research result, please e-mail me, and I will be happy to send you a copy of the research summary when the research is complete.

If you have any queries regarding the survey, please do not hesitate to contact me. Thanks for your anticipated co-operation.

Yours Sincerely,

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PARTICIPANT INFORMATION SHEET

Name of department: Naval Architecture, Ocean & Marine Engineering

Title of the study: Priority Setting for the Self-Assessment of Safety Culture across Maritime Organisations in Nigeria

Introduction
My name is Odumodu Chigozie and I am a Ph.D. student at the University of Strathclyde, under the supervision of Prof Peilin Zhou and Dr. Qing Xiao. As part of my studies, I am conducting a study on Priority Setting for the Self-Assessment of Safety Culture in Maritime Organisations across Nigeria.

What is the purpose of this investigation?
As part of my doctoral research for a Ph.D. thesis, I am trying to elicit the preferences of experts for setting priority in the self-assessment of safety culture across maritime organizations in Nigeria.
The doctoral research would entail the use of questionnaires to elicit preferences needed to develop a decision-making framework to assess the safety culture of maritime organizations.

Do you have to take part?
Your participation is very important to us. However, participation in this study is voluntary and you have the right to withdraw your participation at any point. If you feel uncomfortable answering any of the questions, please let the interviewer know and the question can be missed or the discussion stopped. Also, note that ALL information that you provide will be kept anonymous by the researchers. Therefore, you CANNOT be identified through the information you provided.

What will you do in the project?
Participants would be requested to be read the background/rationale of the study and the description of safety factors used in assessing the safety culture in maritime organizations. Participants would also be expected to confirm their understanding of the attached background/rationale of the study before answering the questionnaire to the best of their knowledge.

Why have you been invited to take part?
The doctoral research focuses on the development of a decision-making framework for assessing and managing the safety culture of maritime organizations in Nigeria. Therefore participants required to take part in this study are either shipboard or shore-based staff of maritime organizations.

Inclusive Criteria for Participants

Deck Department	Engine Department	Shore-based Staff
Captains	Chief Engineer	Designated Person Ashore
Chief Officer	Second Engineer	HSEQ/Safety Officer
Second Officer	Third Engineer	Marine Superintendent/ Port Captain
Third Officer	Fourth Engineer	Technical Superintendent

Exclusive Criteria for Participants
Individuals not covered in the inclusive criteria (or not involved in any safety-related roles of a maritime organization involved in tanker operation and management)

What are the potential risks to you in taking part?
There is no risk in participants taking part in this study as the data collected will in no way reveal any case-sensitive matter that may be harmful to any organization.

What happens to the information in the project?
Your participation is anonymous: we will not include any names or other personally identifying information in any subsequent reports or publications. Thus, you CANNOT be identified through the information you provided.
The University of Strathclyde is registered with the Information Commissioner's Office who implements the Data Protection Act 1998. All personal data on participants will be processed in accordance with the provisions of the Data Protection Act 1998. This means that the data will be obtained and processed fairly for the purpose of Chigozie Odumodu's doctoral thesis and all the information collected will be in line and relevant for that purpose. The information will be accurate and kept up to date, will not be kept any longer than necessary and will be processed in accordance with the data subject's rights. The data will be kept safe from unauthorised access, accidental loss or destruction.

What happens next?
Thank you for taking time to read the above information. If you are happy to participate, please sign the attached consent form and we will begin the discussion. If you have any questions, please do not hesitate to contact me, using the contact details provided below.

Researcher contact details:

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Dr Qing Xiao

This project has been supported by: :

This investigation was granted ethical approval by the University of Strathclyde Ethics Committee.
If you have any questions/concerns, during or after the investigation, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:
Secretary to the University Ethics Committee
Research & Knowledge Exchange Services
University of Strathclyde
Graham Hills Building
50 George Street
Glasgow
G1 1QE
Telephone: 0141 548 3707
Email: ethics@strath.ac.uk

PARTICIPANT CONSENT FORM

Name of department: Naval Architecture, Ocean & Marine Engineering Department, University of Strathclyde
Title of the study: Priority Setting for the Self-Assessment of Safety Culture in Maritime Organisation

- I confirm that I have read and understood the information sheet for the above project and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, up to the point of completion, without having to give a reason and without any consequences. If I exercise my right to withdraw and I don't want my data to be used, any data which have been collected from me will be destroyed.
- I understand that I can withdraw from the study any personal data (i.e. data which identifies me personally) at any time.
- I understand that anonymized data (i.e. .data which do not identify me personally) cannot be withdrawn once they have been included in the study.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project.
- I consent to being audio and/or video recorded as part of the project.

For investigations where it has been decided that "no fault compensation" cover will be provided the following wording needs to be included: In agreeing to participate in this investigation I am aware that I may be entitled to compensation for accidental bodily injury, including death or disease, arising out of the investigation without the need to prove fault. However, such compensation is subject to acceptance of the Conditions of Compensation, a copy of which is available on request.

(PRINT SURNAME)	(PRINT OTHER NAMES)
Signature of Participant:	Date:
Mobile Network Provider / Mobile Number:	

DESCRIPTION OF SAFETY FACTORS

Safety factors are important elements used in the self-assessment of safety culture across maritime organizations. In this survey, you will be asked to compare the safety factors used in the self-assessment of safety culture across Maritime organizations. Hence, the description of the safety factors used in the self-assessment of safety culture are as follows;

- Communication – This reflects the extent to which channels of communications within the organization are open and effective.
- Empowerment – This refers to the extent to which each member of the workforce feels empowered to successively fulfill their safety responsibilities.
- Feedback – This refers to the extent of how quickly management responds to safety-related issues and concerns.
- Mutual Trust – This reflects the extent to which both members of the workforce and management are expected to do the right thing in support of safety.
- Problem Identification – This reflects the extent to which potential problems are readily identified.
- Promotion of Safety – This reflects the extent to which managers promote safety as a core value in the organization.
- Responsiveness – This reflects the extent to which each member of the workforce responds to the demand of the job, including unexpected events and emergencies.
- Safety Awareness – This reflects the extent to which each member of the workforce is aware of his/her responsibilities with regards to the safety of self, co-workers, the organization, and the environment.

HOW TO COMPLETE THE QUESTIONNAIRE

Compare each safety factor used in the self-assessment of safety culture using the reciprocal numerical scale found below.

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the aim fulfilment
3	Moderate importance	The experience and the judgement favour slightly to an activity
5	Strong importance	The experience and the judgement favour strongly to an activity
7	Very strong importance	An activity is more favoured that other one; its predominance was demonstrated in the practice
9	Extreme importance	The evidence favours an activity absolutely and clearly
2, 4, 6, 8	Intermediate values between adjacent scale values	When the parts need a commitment between adjacent values
Reciprocals	If the activity i has a number that is different of zero when this is compared with the activity j, then j has a reciprocal value when it is compared with (aij = 1/aji)	

Tick the most appropriate box according to your opinion on how important one safety factor is over another when you are assessing the safety culture of a maritime organization in Nigeria. For example;

If you think that Communication is equally important to Empowerment, you score a 1.

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Communication									x									Empowerment

If you think that, Communication is moderately more important than Empowerment, you score a 3 on the side of context of the Communication.

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Communication							x											Empowerment

If your preference is between two levels of importance, e.g If you think Communication is between equally important and moderately more important than Empowerment, you score a 2 on the side of context of the Communication.

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Communication								x										Empowerment

Then, compare all the safety factors used in assessing safety culture using a reciprocal numerical scale from 1 to 9. Use the same method as in step 1.

PRIORITY SETTING QUESTIONNAIRE

SECTION A – SURVEY OF SAFETY FACTORS

Comparison of the relative importance for each of the safety factors used in the self-assessment of safety across maritime organisations: Communication

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Communication																		Empowerment
																		Feedback
																		Mutual Trust
																		Problem Identification
																		Promotion of Safety
																		Responsiveness
																		Safety Awareness

Comparison of the relative importance for each of the safety factors used in the self-assessment of safety across maritime organisations: Empowerment

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Empowerment																		Feedback
																		Mutual Trust
																		Problem Identification
																		Promotion of Safety
																		Responsiveness
																		Safety Awareness

Comparison of the relative importance for each of the safety factors used in the self-assessment of safety across maritime organisations: Feedback

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Feedback																		Mutual Trust
																		Problem Identification
																		Promotion of Safety
																		Responsiveness
																		Safety Awareness

Comparison of the relative importance for each of the safety factors used in the self-assessment of safety across maritime organisations: Mutual Trust

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Mutual Trust																		Problem Identification
																		Promotion of Safety
																		Responsiveness
																		Safety Awareness

Comparison of the relative importance for each of the safety factors used in the self-assessment of safety across maritime organisations: Problem Identification

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Problem Identification																		Promotion of Safety
																		Responsiveness
																		Safety Awareness

Comparison of the relative importance for each of the safety factors used in the self-assessment of safety across maritime organisations: Promotion of Safety

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Promotion of Safety																		Responsiveness
																		Safety Awareness

Comparison of the relative importance for each of the safety factors used in the self-assessment of safety across maritime organisations: Responsiveness

Safety Factor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Safety Factor
Responsiveness																		Safety Awareness

Any other additional comments

SECTION B – PERSONAL INFORMATION

What is your age

What is your gender?

What is your nationality?

Which department are you in?

What is your position abroad this ship or the organization?

How many years have you been working in the maritime (tanker) industry?

How many years have you worked for your current employer?

How many years have you been in your present position?

THANK YOU FOR YOUR HELP

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Appendix B - Shoreside Staff Questionnaire

HOW TO COMPLETE THE QUESTIONNAIRE

- Please read each statement carefully
- Indicate the extent to which you agree with the following statements by choosing a number from the scale below. If you don't know please choose '0'.

Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know
1	2	3	4	5	0

When ship management is told about accidents, incidents, or near misses, corrective action is taken promptly.

- If you disagree with the above statement, you score 1.
- If you slightly disagree with the above statement, you score 2.
- If you are neutral about the above statement, you score 3.
- If you slightly agree with the above statement, you score 4.
- If you agree with the above statement, you score 5.
- If you don't know, you 0.

SHORESIDE SAFETY CULTURE QUESTIONNAIRE

Please indicate the extent to which you agree with the following statements by choosing a number from the scale below. If you don't know please choose '0'.

Please indicate the extent to which you agree with the following statements by choosing a number from the scale below. If you don't know please choose '0'.

Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know
1	2	3	4	5	0

SECTION A

This section is about ship safety (i.e., the policies, procedures, attitudes, and actions that are taken to mitigate risk and prevent collisions, groundings, loss of life, or major injuries). It asks for YOUR views, from the perspective of a shoreside employee.

1. When line safety managers are told about accidents, incidents, or near misses, corrective action is taken promptly.
2. Shoreside managers never put schedule or costs above safety.
3. Senior management is personally involved in safety activities on a routine basis.
4. Management places a high priority on safety training.
5. Employees are actively encouraged to improve safety.
6. This company has excellent maintenance standards.

7. Our seafarers have adequate training in emergency procedures.
8. People are hired for their ability and willingness to work safety.
9. Language differences in multi-cultural crews are not a threat to safety.
10. There are no differences in the performance of seafarers from different cultures.
11. There is good ship-to-shore communication about safety issues.
12. Our seafarers are always informed about the outcome of shipboard meetings that address safety.
13. Watch hand-overs are thorough and not hurried.
14. When joining a ship our seafarers receive a proper hand-over, including familiarization with any new tasks.
15. Safety is the top priority for seafarers on board our ships.
16. All violations of safety regulations are reported.
17. Our seafarers are expected to adhere to their work/rest cycle.
18. There is a system in place for observing seafarers' time off-duty.
19. Our seafarers get adequate rest on their work/rest cycle.
20. Our seafarers are competent to operate their automated equipment.
21. This company has good follow-up measures after accidents, incidents, and near misses.
22. Mistakes are corrected without punishment and treated as a learning opportunity.
23. Our seafarers are always given feedback on accidents, incidents, or near misses that occur on board ships.
24. Our seafarers are encouraged to conduct risk assessments and report near misses.
25. An effective anonymous reporting system exists in this company.

SECTION B

This section asks about YOUR understanding of this company's health and safety responsibilities.

26. This company cares about health and safety.
27. Suggestions to improve health and safety are welcomed.
28. I fully understand my line responsibilities for shipboard health and safety.
29. Our crews are always given feedback on injuries that occur on board their ship.
30. I have the right equipment to do my job safely.
31. I am always informed about the outcome of shore meetings that address health and safety.

SECTION C

This section asks about your own shoreside job.

32. If I am interrupted whilst carrying out a task, I carefully check what I did, or start again, before resuming the task.
33. Safety briefings and training are never overlooked.
34. I have good control over the safety outcomes of my job.
35. I am usually consulted on matters that affect how I do my job.

36. Our seafarers are not encouraged to break the rules to achieve a target.
37. I am comfortable asking for help when unsure how to do a task.
38. Pre-job assessments are completed for all jobs that need them.
39. I always give proper instructions when I initiate any work.
40. I always ask questions if I do not understand the instructions given to me, or I am unsure of the relevant safety precautions.

SECTION D

This section collects personal information so that differences in responses can be analyzed.

1. What is your age?
2. What is your gender?
3. What is your nationality?
4. Which department are you in?
5. What is your job title?
6. Which office do you work in?
7. How many years have you been working in the maritime industry?
8. How many years have you worked for your current employer?
9. How many years have you been in your present position?

SECTION E

And finally, please take a moment to answer the following questions before submitting your questionnaire.
1. What could this company do to improve occupational health and safety?
2. What could this company do to improve ship safety?
3. What could this company do to improve shore-to-ship safety?
4. What questions were not asked in this survey, but should have been?

THANK YOU FOR YOUR HELP

Appendix C - Shipboard Staff Questionnaire

University of Strathclyde Glasgow

HOW TO COMPLETE THE QUESTIONNAIRE
Please read each statement carefully
Indicate the extent to which you agree with the following statements by choosing a number from the scale below. If you don't know please choose '0'.

Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know
1	2	3	4	5	0

When ship management is told about accidents, incidents, or near misses, corrective action is taken promptly.

- If you disagree with the above statement, you score 1.
- If you slightly disagree with the above statement, you score 2.
- If you are neutral about the above statement, you score 3.
- If you slightly agree with the above statement, you score 4.
- If you agree with the above statement, you score 5.
- If you don't know, you 0.

SHIPBOARD SAFETY CULTURE QUESTIONNAIRE

Please indicate the extent to which you agree with the following statements by choosing a number from the scale below. If you don't know please choose '0'.

Please indicate the extent to which you agree with the following statements by choosing a number from the scale below. If you don't know please choose '0'.

Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know
1	2	3	4	5	0

SECTION A
This section is about ship safety (i.e., the policies, procedures, attitudes and actions that are taken to mitigate risk and prevent collisions, groundings, loss of life, or major injuries).

1. When ship management is told about accidents, incidents, or near misses, corrective action is taken promptly.
2. Shoreside managers never put schedule or costs above safety.
3. Ship management is personally involved in safety activities on a routine basis.
4. Management places a high priority on safety training.
5. Crew members are actively encouraged to improve safety.
6. This company has excellent maintenance standards.
7. Our crew has adequate training in emergency procedures.

8. People are hired for their ability and willingness to work safely.
9. Language differences in multi-cultural crews are not a threat to safety.
10. There are no differences in the performance of crew members from different cultures.
11. There is good communication on this ship about safety issues.
12. I am always informed about the outcome of shipboard meetings that address safety.
13. Watch hand-overs are thorough and not hurried.
14. When I joined this ship I received a proper hand-over, including familiarization with any new tasks.
15. Safety is the top priority for crew on board this ship.
16. Whenever I see safety regulations being broken, I report it.
17. The crew is expected to adhere to the work/rest cycle.
18. There is a system in place for observing my time off-duty.
19. I get adequate rest on the work/rest cycle that I work.
20. I am confident that I can operate the automated equipment within my area of responsibility.
21. I am very satisfied with the follow-up measures taken after accidents, incidents, and near misses.
22. Mistakes are corrected without punishment and treated as a learning opportunity.
23. The crew is always given feedback on accidents, incidents, or near misses that occur on board this ship.
24. I am encouraged to conduct risk assessments and report near misses.
25. An effective anonymous reporting system exists in this company.

SECTION B
This section is about occupational health and safety (i.e., about protecting your physical and mental health and welfare in the workplace).

26. This company cares about my health and safety.
27. Suggestions to improve health and safety are welcomed.
28. I fully understand my responsibilities for health and safety.
29. The crew is always given feedback on injuries that occur on board this ship.
30. The crew has access to all necessary personal protective equipment (PPE).
31. I am always informed about the outcome of shipboard meetings that address health and safety.

SECTION C
This section is about your job.

32. If I am interrupted whilst carrying out a task, I carefully check what I did, or start again, before resuming the task.
33. Safety briefings and training are never overlooked.
34. I have good control over the safety outcomes of my job.
35. I am usually consulted on matters that affect how I do my job.
36. The crew is not encouraged to break the rules to achieve a target.
37. I am comfortable asking for help when unsure how to do a task.
38. Pre-job assessments are completed for all jobs that need them.
39. I always give proper instructions when I initiate any work.

40. I always ask questions if I do not understand the instructions given to me, or I am unsure of the relevant safety precautions.

SECTION D
This section collects personal information so that differences in responses can be analyzed.

1. What is your age?
2. What is your gender?
3. What is your nationality?
4. Which department are you in?
5. What is your position aboard this ship?
6. What is the email address of your ship?
7. How many years have you been working in the maritime industry?
8. How many years have you worked for your current employer?
9. How many years have you been in your present position?

SECTION E
And finally, please take a moment to answer the following questions before submitting your questionnaire.

1. What could this company do to improve occupational health and safety?
2. What could this company do to improve ship safety?
3. What could this company do to improve shore-to-ship safety?
4. What questions were not asked in this survey, but should have been?

THANK YOU FOR YOUR HELP

Appendix D - Vessel Responses

VESSEL RESPONSES OF SEA TRANSPORT GROUP TO SAFETY CULTURE/CLIMATE SURVEY

S/NO	VESSEL NAME	OBSERVATION (CREW SAMPLED)
	MT AMIF	23
	MT ASHABI	21
	MT DIDDI	38
	MT KINGIS	23
	MT MOSUNMOLA	24
	MT SEA ADVENTURER	15
	MT SEA GRACE	25
	MT SEA PROGRESS	27
	MT SEA VOYAGER	10
	MT UMBALWA	7

MT AMIF (23 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	0	1	2	2	18	0	
QUESTION 34	0	0	2	3	18	0	4.7
QUESTION 9	1	1	4	1	16	0	4.3
QUESTION 25	1	0	3	2	17	0	4.5
QUESTION 43	0	0	2	1	19	1	4.6
QUESTION 44	0	0	1	4	18	0	4.7
							22.7
							4.5
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	0	5	0	18	0	
QUESTION 35	0	0	2	2	19	0	4.7
QUESTION 27	0	0	3	2	18	0	4.7
QUESTION 38	0	0	1	4	18	0	4.7
QUESTION 39	0	1	4	1	17	0	4.5
QUESTION 41	0	1	1	3	18	0	4.7
							23.2
							4.6
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	0	0	1	2	20	0	
QUESTION 48	0	2	3	1	17	0	4.6
QUESTION 12	0	1	2	3	17	0	4.6
QUESTION 23	0	3	2	0	17	1	4.2
QUESTION 29	0	0	3	2	18	0	4.7
QUESTION 31	1	0	0	4	18	0	4.7
							22.7
							4.5

MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	0	1	2	4	16	0	
QUESTION 47	0	1	2	2	18	0	4.6
QUESTION 10	0	2	4	1	16	0	4.3
QUESTION 22	0	2	4	1	16	0	4.3
QUESTION 26	0	1	3	3	16	0	4.5
QUESTION 28	0	0	0	4	19	0	4.8
							22.6
							4.5
PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	0	1	2	20	0	
QUESTION 45	0	0	0	2	21	0	4.9
QUESTION 16	0	1	3	2	17	0	4.5
QUESTION 24	2	3	0	1	17	0	4.2
QUESTION 36	0	1	1	2	19	0	4.7
QUESTION 42	0	0	0	3	18	2	4.4
							22.7
							4.5
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	1	1	0	2	19	0	
QUESTION 32	1	1	1	3	17	0	4.5
QUESTION 2	0	2	1	3	17	0	4.5
QUESTION 3	1	0	3	3	16	0	4.4
QUESTION 4	0	1	2	1	19	0	4.7
QUESTION 6	0	2	1	3	17	0	4.5
							22.7
							4.5
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	4	5	14	0	4.5
QUESTION 17	0	0	2	3	18	0	4.7
QUESTION 33	0	0	3	4	16	0	
QUESTION 18	0	1	4	0	17	1	4.3
QUESTION 19	0	2	2	1	18	0	4.5
QUESTION 30	0	0	1	3	19	0	4.8
							22.8
							4.6
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	0	1	0	2	20	0	
QUESTION 46	0	1	0	3	19	0	4.8
QUESTION 13	0	1	0	3	19	0	4.7
QUESTION 14	0	0	2	3	18	0	4.7
QUESTION 37	0	0	1	3	19	0	4.8
QUESTION 40	1	0	0	2	20	0	4.7
							23.7
							4.7

MT ASHABI (7 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	0	1	0	4	2	0	
QUESTION 34	0	0	0	2	5	0	4.4
QUESTION 9	0	3	1	0	3	0	3.4
QUESTION 25	0	0	1	3	2	1	3.6
QUESTION 43	0	0	1	1	5	0	4.6
QUESTION 44	0	0	2	1	4	0	4.3
0							20.2
0							4.0
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	0	2	3	2	0	
QUESTION 35	0	0	0	3	4	0	4.3
QUESTION 27	0	0	1	1	5	0	4.6
QUESTION 38	0	0	3	0	4	0	4.1
QUESTION 39	0	0	2	4	1	0	3.9
QUESTION 41	0	3	2	0	2	0	3.1
0							20.0
0							4.0
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	0	0	6	0	1	0	
QUESTION 48	0	3	3	0	1	0	3.1
QUESTION 12	0	1	4	0	2	0	3.4
QUESTION 23	0	0	4	1	2	0	3.7
QUESTION 29	0	0	1	4	2	0	4.1
QUESTION 31	0	0	3	1	3	0	4.0
0							18.4
0							3.7
MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	0	1	1	3	2	0	
QUESTION 47	0	0	2	2	3	0	4.0
QUESTION 10	0	1	3	2	1	0	3.4
QUESTION 22	0	1	3	0	3	0	3.7
QUESTION 26	0	0	5	2	0	0	3.3
QUESTION 28	0	0	1	0	5	1	4.0
0							18.4
0							3.7

PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	0	0	2	5	0	
QUESTION 45	0	0	0	3	4	0	4.6
QUESTION 16	0	0	4	2	1	0	3.6
QUESTION 24	2	0	2	1	1	1	2.4
QUESTION 36	0	0	0	0	7	0	5.0
QUESTION 42	0	0	5	1	1	0	3.4
0							19.1
0							3.8
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	0	0	1	3	3	0	
QUESTION 32	0	0	1	1	5	0	4.4
QUESTION 2	0	1	0	3	3	0	4.1
QUESTION 3	0	0	1	1	5	0	4.6
QUESTION 4	0	0	3	0	4	0	4.1
QUESTION 6	0	0	1	3	3	0	4.3
0							21.6
0							4.3
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	2	4	1	0	4.1
QUESTION 17	0	0	2	2	3	0	4.1
QUESTION 33	0	0	1	2	4	0	
QUESTION 18	0	1	3	2	1	0	3.4
QUESTION 19	0	1	4	2	0	0	3.1
QUESTION 30	0	0	1	1	5	0	4.6
0							19.4
0							3.9
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	0	0	1	0	6	0	
QUESTION 46	0	0	2	3	2	0	4.4
QUESTION 13	0	0	0	0	7	0	5.0
QUESTION 14	0	0	1	2	4	0	4.4
QUESTION 37	0	0	2	3	2	0	4.0
QUESTION 40	0	0	1	1	5	0	4.6
							22.4
							4.5

MT DIDDI (15 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	0	3	3	3	6	0	
QUESTION 34	1	5	0	4	5	0	3.6
QUESTION 9	4	2	6	1	2	0	2.7
QUESTION 25	3	3	2	4	3	0	3.1
QUESTION 43	1	1	2	4	6	1	3.7
QUESTION 44	0	2	1	5	7	0	4.1
0							17.2
0							3.4
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	1	5	2	7	0	
QUESTION 35	0	1	2	5	4	3	3.6
QUESTION 27	1	2	3	6	3	0	3.5
QUESTION 38	0	3	3	4	4	1	3.4
QUESTION 39	2	4	3	3	3	0	3.1
QUESTION 41	0	0	5	3	7	0	4.1
0							17.7
0							3.5
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	1	6	3	3	2	0	
QUESTION 48	2	5	3	4	1	0	2.9
QUESTION 12	0	0	4	7	4	0	4.0
QUESTION 23	0	0	7	3	4	1	3.5
QUESTION 29	1	2	4	5	3	0	3.5
QUESTION 31	2	3	3	4	3	0	3.2
0							17.1
0							3.4
MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	1	4	2	5	3	0	
QUESTION 47	1	1	2	7	4	0	3.6
QUESTION 10	1	2	3	6	3	0	3.5
QUESTION 22	5	4	1	4	0	1	2.1
QUESTION 26	1	4	2	4	4	0	3.4
QUESTION 28	0	0	1	5	9	0	4.5
0							17.2
0							3.4

PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	0	3	4	8	0	
QUESTION 45	0	0	3	3	9	0	4.4
QUESTION 16	0	4	2	5	4	0	3.6
QUESTION 24	1	5	1	4	4	0	3.3
QUESTION 36	0	2	3	3	7	0	4.0
QUESTION 42	1	2	0	5	5	2	3.3
0							18.6
0							3.7
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	4	2	0	5	4	0	
QUESTION 32	0	7	1	4	3	0	3.2
QUESTION 2	2	2	3	1	7	0	3.6
QUESTION 3	1	1	4	3	6	0	3.8
QUESTION 4	2	1	3	6	3	0	3.5
QUESTION 6	1	7	1	3	3	0	3.0
0							17.1
0							3.4
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	4	7	4	0	4.0
QUESTION 17	0	0	2	6	7	0	4.3
QUESTION 33	0	1	2	7	5	0	
QUESTION 18	0	1	6	4	3	1	3.4
QUESTION 19	0	4	2	6	3	0	3.5
QUESTION 30	1	1	1	8	4	0	3.9
0							19.2
0							3.8
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	1	0	4	3	7	0	
QUESTION 46	0	1	4	3	7	0	4.0
QUESTION 13	0	1	3	6	4	1	3.7
QUESTION 14	1	1	1	9	3	0	3.8
QUESTION 37	0	0	2	7	6	0	4.3
QUESTION 40	1	1	0	4	9	0	4.3
							20.0
							4.0

MT KINGIS (27 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	0	0	2	4	21	0	
QUESTION 34	0	0	1	7	19	0	4.7
QUESTION 9	0	4	6	3	14	0	4.0
QUESTION 25	1	1	0	3	22	0	4.6
QUESTION 43	0	0	2	6	19	0	4.6
QUESTION 44	0	0	2	0	25	0	4.9
0							22.8
0							4.6
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	0	8	0	19	0	
QUESTION 35	0	0	1	7	19	0	4.5
QUESTION 27	0	0	0	5	22	0	4.8
QUESTION 38	0	0	0	3	24	0	4.9
QUESTION 39	0	1	0	6	20	0	4.7
QUESTION 41	0	4	3	1	19	0	4.3
0							23.2
0							4.6
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	0	0	3	6	18	0	
QUESTION 48	0	0	3	3	21	0	4.6
QUESTION 12	0	0	5	3	19	0	4.5
QUESTION 23	0	7	1	1	18	0	4.1
QUESTION 29	0	0	0	7	20	0	4.7
QUESTION 31	0	0	6	1	20	0	4.5
0							22.5
0							4.5
MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	0	0	4	4	19	0	
QUESTION 47	0	0	0	4	23	0	4.7
QUESTION 10	0	0	9	1	17	0	4.3
QUESTION 22	0	0	5	5	17	0	4.4
QUESTION 26	0	0	1	7	19	0	4.7
QUESTION 28	0	0	0	1	26	0	5.0
0							23.1
0							4.6

PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	0	1	1	25	0	
QUESTION 45	0	0	0	7	20	0	4.8
QUESTION 16	0	0	2	5	20	0	4.7
QUESTION 24	1	3	2	2	19	0	4.3
QUESTION 36	0	0	1	1	25	0	4.9
QUESTION 42	1	0	5	6	15	0	4.3
0							22.9
0							4.6
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	0	0	2	4	21	0	
QUESTION 32	0	0	8	4	15	0	4.5
QUESTION 2	0	1	4	4	18	0	4.4
QUESTION 3	0	0	3	0	24	0	4.8
QUESTION 4	0	0	7	2	18	0	4.4
QUESTION 6	0	0	1	5	21	0	4.7
0							22.9
0							4.6
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	1	2	24	0	4.7
QUESTION 17	0	1	0	1	25	0	4.9
QUESTION 33	0	0	2	5	19	1	
QUESTION 18	0	0	3	8	16	0	4.5
QUESTION 19	0	1	3	4	19	0	4.5
QUESTION 30	0	0	0	3	24	0	4.9
0							23.4
0							4.7
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	0	0	0	1	26	0	
QUESTION 46	0	0	1	6	20	0	4.8
QUESTION 13	0	0	0	3	24	0	4.9
QUESTION 14	0	0	1	8	18	0	4.6
QUESTION 37	0	0	1	7	19	0	4.7
QUESTION 40	0	0	1	0	26	0	4.9
							23.9
							4.8

MT MOSUNMOLA (10 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	0	0	1	4	5	0	
QUESTION 34	0	0	1	2	7	0	4.5
QUESTION 9	2	3	3	1	1	0	2.6
QUESTION 25	0	0	1	3	6	0	4.5
QUESTION 43	0	0	1	3	6	0	4.5
QUESTION 44	0	0	1	1	8	0	4.7
0							20.8
0							4.2
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	0	6	1	3	0	
QUESTION 35	0	0	0	7	3	0	4.0
QUESTION 27	0	0	2	3	5	0	4.3
QUESTION 38	0	0	3	1	6	0	4.3
QUESTION 39	0	0	1	4	5	0	4.4
QUESTION 41	0	6	0	0	4	0	3.2
0							20.2
0							4.0
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	0	3	2	2	3	0	
QUESTION 48	0	1	3	2	4	0	3.7
QUESTION 12	0	0	6	1	3	0	3.7
QUESTION 23	0	4	1	2	3	0	3.4
QUESTION 29	0	0	1	5	4	0	4.3
QUESTION 31	0	0	6	0	4	0	3.8
0							18.9
0							3.8
MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	0	0	4	2	4	0	
QUESTION 47	0	0	0	5	5	0	4.3
QUESTION 10	0	0	6	1	3	0	3.7
QUESTION 22	0	0	3	2	5	0	4.2
QUESTION 26	0	0	2	2	6	0	4.4
QUESTION 28	0	0	2	2	6	0	4.4
0							21.0
0							4.2

PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	1	1	1	7	0	
QUESTION 45	0	0	0	6	4	0	4.4
QUESTION 16	0	1	3	3	3	0	3.8
QUESTION 24	5	0	1	1	3	0	2.7
QUESTION 36	0	0	2	2	6	0	4.4
QUESTION 42	0	0	4	2	4	0	4.0
0							19.3
0							3.9
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	0	1	2	1	6	0	
QUESTION 32	0	0	3	2	5	0	4.2
QUESTION 2	0	1	3	1	5	0	4.0
QUESTION 3	0	0	2	2	6	0	4.4
QUESTION 4	0	0	3	2	5	0	4.2
QUESTION 6	0	1	0	5	4	0	4.2
0							21.0
0							4.2
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	4	3	3	0	4.1
QUESTION 17	0	1	1	3	5	0	4.2
QUESTION 33	0	0	1	6	3	0	
QUESTION 18	0	0	5	2	3	0	3.8
QUESTION 19	0	2	4	1	2	1	3.0
QUESTION 30	0	0	1	4	5	0	4.4
0							19.5
0							3.9
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	0	0	1	3	6	0	
QUESTION 46	0	0	1	2	7	0	4.6
QUESTION 13	0	1	4	1	4	0	3.8
QUESTION 14	0	0	2	4	4	0	4.2
QUESTION 37	0	0	0	7	3	0	4.3
QUESTION 40	0	0	2	1	7	0	4.5
							21.4
							4.3

MT SEA ADVENTURER (24 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	0	0	4	14	4	2	
QUESTION 34	0	3	1	15	4	1	3.7
QUESTION 9	7	4	8	1	2	2	2.2
QUESTION 25	0	4	6	6	5	3	3.1
QUESTION 43	1	7	2	3	10	1	3.5
QUESTION 44	0	0	3	13	8	0	4.2
0							16.7
0							3.3
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	2	3	6	12	1	
QUESTION 35	0	0	6	4	12	2	4.0
QUESTION 27	0	8	2	7	5	2	3.1
QUESTION 38	0	0	6	6	12	0	4.3
QUESTION 39	0	10	3	4	7	0	3.3
QUESTION 41	0	0	1	12	11	0	4.4
0							19.1
0							3.8
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	0	7	4	10	2	1	
QUESTION 48	1	5	3	6	9	0	3.4
QUESTION 12	0	4	4	8	7	1	3.6
QUESTION 23	1	0	7	10	4	2	3.4
QUESTION 29	0	0	5	10	8	1	4.0
QUESTION 31	1	0	5	11	6	1	3.8
0							18.2
0							3.6
MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	0	5	0	11	5	3	
QUESTION 47	0	5	6	2	9	2	3.3
QUESTION 10	5	10	2	4	1	2	2.2
QUESTION 22	2	8	3	2	7	2	2.9
QUESTION 26	0	1	8	7	8	0	3.9
QUESTION 28	0	0	3	11	10	0	4.3
0							16.6
0							3.3

PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	1	2	9	10	2	
QUESTION 45	0	1	1	8	14	0	4.2
QUESTION 16	0	0	5	11	7	1	3.9
QUESTION 24	2	8	4	2	8	0	3.3
QUESTION 36	0	1	2	10	11	0	4.3
QUESTION 42	1	4	1	7	8	3	3.3
0							19.0
0							3.8
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	1	3	3	7	9	1	
QUESTION 32	3	3	3	7	6	2	3.4
QUESTION 2	2	2	3	7	3	7	2.4
QUESTION 3	0	2	6	8	7	1	3.7
QUESTION 4	0	4	4	8	5	3	3.2
QUESTION 6	0	5	2	8	7	2	3.5
0							16.2
0							3.2
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	3	9	11	1	4.3
QUESTION 17	1	4	2	11	4	2	3.3
QUESTION 33	0	0	3	8	13	0	
QUESTION 18	1	8	4	2	6	3	2.8
QUESTION 19	2	4	8	7	2	1	3.0
QUESTION 30	0	0	0	12	12	0	4.5
0							17.9
0							3.6
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	0	0	4	8	11	1	
QUESTION 46	0	1	4	11	7	1	4.0
QUESTION 13	0	1	1	12	10	0	4.3
QUESTION 14	0	0	4	8	12	0	4.3
QUESTION 37	0	4	2	8	10	0	4.0
QUESTION 40	0	0	6	11	7	0	4.0
							20.7
							4.1

MT SEA GRACE (23 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	0	1	5	9	7	1	
QUESTION 34	0	1	3	15	3	1	3.8
QUESTION 9	0	4	12	3	2	2	2.9
QUESTION 25	0	2	12	6	3	0	3.4
QUESTION 43	1	5	6	5	6	0	3.4
QUESTION 44	0	0	7	10	6	0	4.0
0							17.5
0							3.5
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	1	3	14	4	1	
QUESTION 35	0	1	5	10	7	0	3.9
QUESTION 27	0	6	7	8	2	0	3.3
QUESTION 38	0	2	7	6	7	1	3.7
QUESTION 39	1	7	4	5	6	0	3.3
QUESTION 41	0	0	5	9	9	0	4.2
0							18.3
0							3.7
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	1	6	7	8	1	0	
QUESTION 48	0	7	6	5	5	0	3.2
QUESTION 12	0	1	5	14	3	0	3.8
QUESTION 23	0	3	8	7	4	1	3.4
QUESTION 29	0	1	8	8	6	0	3.8
QUESTION 31	0	0	8	8	7	0	4.0
0							18.2
0							3.6
MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	0	6	3	6	7	1	
QUESTION 47	0	4	6	6	7	0	3.6
QUESTION 10	3	4	8	4	2	2	2.7
QUESTION 22	3	6	5	4	5	0	3.1
QUESTION 26	0	0	2	15	6	0	4.2
QUESTION 28	0	0	3	10	10	0	4.3
0							17.8
0							3.6

PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	1	7	6	9	0	
QUESTION 45	0	3	4	7	9	0	4.0
QUESTION 16	0	1	6	8	8	0	4.0
QUESTION 24	1	7	7	3	4	1	3.0
QUESTION 36	0	2	3	8	10	0	4.1
QUESTION 42	0	5	5	6	7	0	3.7
0							18.7
0							3.7
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	2	6	1	5	9	0	
QUESTION 32	0	7	4	8	3	1	3.4
QUESTION 2	0	3	10	4	5	1	3.3
QUESTION 3	0	3	7	9	3	1	3.4
QUESTION 4	0	0	11	7	5	0	3.7
QUESTION 6	0	4	5	11	3	0	3.6
0							17.4
0							3.5
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	1	11	11	0	4.3
QUESTION 17	0	0	0	15	7	1	4.1
QUESTION 33	0	0	6	6	11	0	
QUESTION 18	1	5	11	3	2	1	2.9
QUESTION 19	1	6	7	8	1	0	3.1
QUESTION 30	0	0	1	12	10	0	4.4
0							18.8
0							3.8
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	0	0	1	8	13	1	
QUESTION 46	0	2	4	6	10	1	4.1
QUESTION 13	0	0	6	10	7	0	4.0
QUESTION 14	0	0	6	9	8	0	4.1
QUESTION 37	0	1	5	14	3	0	3.8
QUESTION 40	1	0	6	9	7	0	3.9
							20.0
							4.0

MT SEA PROGRESS (38 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	0	1	2	20	14	1	
QUESTION 34	0	1	6	22	8	1	4.0
QUESTION 9	1	6	18	2	7	4	2.9
QUESTION 25	1	1	21	10	3	2	3.2
QUESTION 43	1	8	8	9	11	1	3.5
QUESTION 44	0	0	7	19	12	0	4.1
0							17.7
0							3.5
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	0	8	18	10	2	
QUESTION 35	0	0	8	19	11	0	4.0
QUESTION 27	0	5	15	13	5	0	3.5
QUESTION 38	0	0	12	12	13	1	3.9
QUESTION 39	0	8	5	11	14	0	3.8
QUESTION 41	0	0	1	19	18	0	4.4
0							19.6
0							3.9
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	0	10	10	16	1	1	
QUESTION 48	0	14	6	14	4	0	3.2
QUESTION 12	0	0	7	18	12	1	4.0
QUESTION 23	2	5	13	14	3	1	3.2
QUESTION 29	2	1	16	12	7	0	3.6
QUESTION 31	0	0	7	18	13	0	4.2
0							18.1
0							3.6
MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	0	5	7	12	11	3	
QUESTION 47	0	9	9	7	11	2	3.4
QUESTION 10	10	5	14	4	1	4	2.2
QUESTION 22	0	13	13	6	6	0	3.1
QUESTION 26	0	0	7	19	12	0	4.1
QUESTION 28	0	0	0	17	21	0	4.6
0							17.4
0							3.5

PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	2	10	6	19	1	
QUESTION 45	0	2	4	13	19	0	4.2
QUESTION 16	0	2	10	14	12	0	3.9
QUESTION 24	5	14	7	4	7	1	2.8
QUESTION 36	0	2	2	16	18	0	4.3
QUESTION 42	0	4	10	15	8	1	3.6
0							18.8
0							3.8
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	3	7	3	12	12	1	
QUESTION 32	1	7	11	15	3	1	3.4
QUESTION 2	1	2	10	12	10	3	3.5
QUESTION 3	3	6	6	16	7	0	3.5
QUESTION 4	0	2	4	21	9	2	3.8
QUESTION 6	0	2	11	19	6	0	3.8
0							17.9
0							3.6
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	2	14	22	0	4.4
QUESTION 17	0	1	2	22	12	1	4.1
QUESTION 33	0	0	3	16	18	1	
QUESTION 18	1	6	17	5	7	2	3.1
QUESTION 19	2	7	8	14	7	0	3.4
QUESTION 30	0	0	0	13	25	0	4.7
0							19.8
0							4.0
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	0	0	4	12	21	1	
QUESTION 46	0	1	7	10	18	2	4.2
QUESTION 13	0	0	4	23	11	0	4.2
QUESTION 14	0	0	6	17	15	0	4.2
QUESTION 37	1	5	5	19	8	0	3.7
QUESTION 40	0	0	11	14	12	1	3.9
							20.3
							4.1

MT SEA VOYAGER (21 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	0	0	2	12	7	0	
QUESTION 34	0	0	3	13	5	0	4.2
QUESTION 9	0	3	14	3	1	0	3.1
QUESTION 25	0	0	9	6	6	0	3.9
QUESTION 43	0	3	8	3	7	0	3.7
QUESTION 44	0	0	4	9	8	0	4.2
0							19.0
0							3.8
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	0	6	11	4	0	
QUESTION 35	0	0	4	12	5	0	4.0
QUESTION 27	0	1	6	10	4	0	3.8
QUESTION 38	0	0	6	8	7	0	4.0
QUESTION 39	0	4	4	6	7	0	3.8
QUESTION 41	0	4	1	12	4	0	3.8
0							19.4
0							3.9
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	0	2	6	11	2	0	
QUESTION 48	0	3	4	9	5	0	3.7
QUESTION 12	0	0	7	11	3	0	3.8
QUESTION 23	0	3	9	8	1	0	3.3
QUESTION 29	0	0	5	9	7	0	4.1
QUESTION 31	0	0	2	13	6	0	4.2
0							19.1
0							3.8
MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	0	3	7	7	4	0	
QUESTION 47	0	3	4	6	8	0	3.7
QUESTION 10	0	1	15	3	2	0	3.3
QUESTION 22	0	5	10	3	3	0	3.2
QUESTION 26	0	0	6	7	8	0	4.1
QUESTION 28	0	0	0	8	13	0	4.6
0							18.9
0							3.8

PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	1	5	5	10	0	
QUESTION 45	0	1	2	5	13	0	4.3
QUESTION 16	0	0	5	8	8	0	4.1
QUESTION 24	2	7	3	5	4	0	3.1
QUESTION 36	0	1	0	9	11	0	4.4
QUESTION 42	0	1	5	7	8	0	4.0
0							20.0
0							4.0
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	0	3	0	10	7	1	
QUESTION 32	0	1	9	8	3	0	3.7
QUESTION 2	0	0	9	5	7	0	3.9
QUESTION 3	0	1	4	14	2	0	3.8
QUESTION 4	0	0	8	7	6	0	3.9
QUESTION 6	0	1	6	10	4	0	3.8
0							19.2
0							3.8
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	0	13	8	0	4.5
QUESTION 17	0	0	5	12	4	0	4.0
QUESTION 33	0	0	1	8	12	0	
QUESTION 18	0	2	13	4	2	0	3.3
QUESTION 19	1	2	8	7	3	0	3.4
QUESTION 30	0	0	0	6	15	0	4.7
0							19.8
0							4.0
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	0	0	2	8	11	0	
QUESTION 46	0	0	5	5	11	0	4.4
QUESTION 13	0	0	1	8	12	0	4.5
QUESTION 14	0	0	2	11	8	0	4.3
QUESTION 37	0	1	3	11	6	0	4.0
QUESTION 40	0	0	4	6	11	0	4.3
							21.5
							4.3

MT UMBALWA (25 CREW SAMPLED)

COM	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	Scores
QUESTION 11	1	2	1	10	10	1	
QUESTION 34	0	1	1	18	5	0	4.0
QUESTION 9	6	9	6	2	1	1	2.2
QUESTION 25	1	3	6	5	8	2	3.4
QUESTION 43	1	4	5	3	9	3	3.2
QUESTION 44	0	0	1	19	5	0	4.2
0							17.0
0							3.4
EMP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 5	0	0	4	12	9	0	
QUESTION 35	0	1	1	13	8	2	4.0
QUESTION 27	0	3	5	12	4	1	3.6
QUESTION 38	0	2	3	10	10	0	4.1
QUESTION 39	0	5	6	8	6	0	3.6
QUESTION 41	0	3	3	10	9	0	4.0
0							19.3
0							3.9
FDB	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 21	1	6	5	12	1	0	
QUESTION 48	1	6	2	7	9	0	3.5
QUESTION 12	0	1	5	14	5	0	3.9
QUESTION 23	1	4	7	8	4	1	3.3
QUESTION 29	0	0	4	13	7	1	4.0
QUESTION 31	1	0	4	13	6	1	3.8
0							18.4
0							3.7
MTR	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 8	0	3	4	11	5	2	
QUESTION 47	0	4	2	8	8	3	3.5
QUESTION 10	4	11	4	2	2	2	2.2
QUESTION 22	2	6	12	3	2	0	2.9
QUESTION 26	0	0	5	12	8	0	4.1
QUESTION 28	0	0	3	8	13	1	4.2
0							16.9
0							3.4

PID	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 20	0	1	8	5	11	0	
QUESTION 45	0	1	3	12	9	0	4.1
QUESTION 16	0	0	5	7	12	1	4.1
QUESTION 24	3	8	5	3	6	0	3.0
QUESTION 36	0	2	0	11	11	1	4.1
QUESTION 42	0	2	1	9	8	5	3.3
0							18.7
0							3.7
POS	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 1	1	3	1	10	10	0	
QUESTION 32	1	5	5	8	4	2	3.6
QUESTION 2	1	5	1	7	4	7	2.5
QUESTION 3	1	1	5	11	7	0	3.9
QUESTION 4	0	1	6	10	6	2	3.6
QUESTION 6	0	4	2	11	7	1	3.7
0							17.2
0							3.4
RSP	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 7	0	0	2	13	10	0	4.4
QUESTION 17	1	1	2	15	6	0	4.0
QUESTION 33	0	0	2	7	16	0	
QUESTION 18	0	7	11	1	4	2	2.8
QUESTION 19	2	5	8	7	2	1	3.0
QUESTION 30	0	0	1	8	16	0	4.6
0							18.8
0							3.8
SAW	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Don't Know	
QUESTION 15	0	0	2	9	13	1	
QUESTION 46	0	0	4	13	7	1	4.1
QUESTION 13	0	3	1	11	10	0	4.1
QUESTION 14	0	0	2	14	9	0	4.3
QUESTION 37	0	1	3	15	6	0	4.0
QUESTION 40	0	0	2	11	12	0	4.4
							21.0
							4.2

Appendix E - Test Re-test Analysis of Shipboard Staff

Shipboard Analysis of Safety Climate - Communication								
		x	y	x2	y2	xy		
1	D	1	1	1	1	1		
2	SD	9	11	81	121	99	N	6
3	N	22	18	484	324	396	Sum of X	213
4	SA	82	101	6724	10201	8282	Sum of Y	213
5	A	94	79	8836	6241	7426	$\sum x2$	16151
6	DK	5	3	25	9	15	$\sum y2$	16897
		213	213	16151	16897	16219	$\sum xy$	16219
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	51945
							Denominator	53728.409
							r (test 1)	0.966807
							r (test 2)	0.966807

Shipboard Analysis of Safety Climate - Empowerment								
		x	y	x2	y2	xy		
1	D	0	0	0	0	0		
2	SD	4	3	16	9	12	N	6
3	N	50	29	2500	841	1450	Sum of X	213
4	SA	67	82	4489	6724	5494	Sum of Y	213
5	A	88	92	7744	8464	8096	$\sum x2$	14765
6	DK	4	7	16	49	28	$\sum y2$	16087
		213	213	14765	16087	15080	$\sum xy$	15080
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	45111
							Denominator	47020.036
							r (test 1)	0.959400
							r (test 2)	0.959400

Shipboard Analysis of Safety Climate - Feedback								
		x	y	x2	y2	xy		
1	D	0	4	0	16	0		
2	SD	7	46	49	2116	322	N	6
3	N	38	36	1444	1296	1368	Sum of X	213
4	SA	41	51	1681	2601	2091	Sum of Y	213
5	A	124	76	15376	5776	9424	$\sum x2$	18559
6	DK	3	0	9	0	0	$\sum y2$	11805
		213	213	18559	11805	13205	$\sum xy$	13205
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	33861
							Denominator	40988.341
							r (test 1)	0.826113
							r (test 2)	0.826113

Shipboard Analysis of Safety Climate – Mutual Trust								
		x	y	x2	y2	xy		
1	D	1	1	1	1	1		
2	SD	28	27	784	729	756	N	6
3	N	34	33	1156	1089	1122	Sum of X	213
4	SA	65	49	4225	2401	3185	Sum of Y	213
5	A	76	96	5776	9216	7296	$\sum x2$	12023
6	DK	9	7	81	49	63	$\sum y2$	13485
		213	213	12023	13485	12423	$\sum xy$	12423
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	29169
							Denominator	30844.724
							r (test 1)	0.945672
							r (test 2)	0.945672

Shipboard Analysis of Safety Climate – Problem Identification								
		x	y	x2	y2	xy		
1	D	0	0	0	0	0		
2	SD	7	8	49	64	56	N	6
3	N	38	17	1444	289	646	Sum of X	213
4	SA	41	66	1681	4356	2706	Sum of Y	213
5	A	124	122	15376	14884	15128	$\sum x2$	18559
6	DK	3	0	9	0	0	$\sum y2$	19593
		213	213	18559	19593	18536	$\sum xy$	18536
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][\, n\sum y^2 - (\sum y)^2]}}$							Numerator	65847
							Denominator	69017.325
							r (test 1)	0.954065
							r (test 2)	0.954065

Shipboard Analysis of Safety Climate – Promotion of Safety								
		x	y	x2	y2	xy		
1	D	12	6	144	36	72		
2	SD	26	31	676	961	806	N	6
3	N	13	46	169	2116	598	Sum of X	213
4	SA	59	60	3481	3600	3540	Sum of Y	213
5	A	100	64	10000	4096	6400	$\sum x2$	14479
6	DK	3	6	9	36	18	$\sum y2$	10845
		213	213	14479	10845	11434	$\sum xy$	11434
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][\, n\sum y^2 - (\sum y)^2]}}$							Numerator	23235
							Denominator	28595.279
							r (test 1)	0.812547
							r (test 2)	0.812547

Shipboard Analysis of Safety Climate - Responsiveness								
		x	y	x2	y2	xy		
1	D	0	0	0	0	0		
2	SD	0	1	0	1	0	N	6
3	N	23	24	529	576	552	Sum of X	213
4	SA	81	69	6561	4761	5589	Sum of Y	213
5	A	108	117	11664	13689	12636	$\sum x2$	18755
6	DK	1	2	1	4	2	$\sum y2$	19031
		213	213	18755	19031	18779	$\sum xy$	18779
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	67305
							Denominator	67983.958
							r (test 1)	0.9900130
							r (test 2)	0.9900130

Shipboard Analysis of Safety Climate – Safety Awareness								
		x	y	x2	y2	xy		
1	D	1	0	1	0	0		
2	SD	1	6	1	36	6	N	6
3	N	19	32	361	1024	608	Sum of X	213
4	SA	54	62	2916	3844	3348	Sum of Y	213
5	A	134	108	17956	11664	14472	$\sum x2$	21251
6	DK	4	5	16	25	20	$\sum y2$	16593
		213	213	21251	16593	18454	$\sum xy$	18454
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	65355
							Denominator	66715.230
							r (test 1)	0.979611
							r (test 2)	0.979611

Appendix F - Test Re-test Analysis of Shoreside

Shoreside Analysis of Safety Climate - Communication								
		x	y	x2	y2	xy		
1	D	1	1	1	1	1		
2	SD	0	0	0	0	0	N	6
3	N	0	0	0	0	0	Sum of X	5
4	SA	2	0	4	0	0	Sum of Y	5
5	A	2	3	4	9	6	$\sum x2$	9
6	DK	0	1	0	1	0	$\sum y2$	11
		5	5	9	11	7	$\sum xy$	7
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][\, n\sum y^2 - (\sum y)^2]}}$							Numerator	17
							Denominator	34.48188
							r (test 1)	0.493013
							r (test 2)	0.493013

Shoreside Analysis of Safety Climate - Empowerment								
		x	y	x2	y2	xy		
1	D	1	1	1	1	1		
2	SD	0	0	0	0	0	N	6
3	N	0	0	0	0	0	Sum of X	5
4	SA	0	0	0	0	0	Sum of Y	5
5	A	4	3	16	9	12	$\sum x2$	17
6	DK	0	1	0	1	0	$\sum y2$	11
		5	5	17	11	13	$\sum xy$	13
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][\, n\sum y^2 - (\sum y)^2]}}$							Numerator	53
							Denominator	56.187187
							r (test 1)	0.943276
							r (test 2)	0.943276

Shoreside Analysis of Safety Climate - Feedback								
		x	y	x2	y2	xy		
1	D	1	1	1	1	1		
2	SD	0	0	0	0	0	N	6
3	N	0	0	0	0	0	Sum of X	5
4	SA	1	3	1	9	3	Sum of Y	5
5	A	3	1	9	1	3	$\sum x2$	11
6	DK	0	0	0	0	0	$\sum y2$	11
		5	5	11	11	7	$\sum xy$	7
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	17
							Denominator	41
							r (test 1)	0.414634
							r (test 2)	0.414634

Shoreside Analysis of Safety Climate – Mutual Trust								
		x	y	x2	y2	xy		
1	D	0	1	0	1	0		
2	SD	0	0	0	0	0	N	6
3	N	2	0	4	0	0	Sum of X	5
4	SA	0	2	0	4	0	Sum of Y	5
5	A	3	2	9	4	6	$\sum x2$	13
6	DK	0	0	0	0	0	$\sum y2$	9
		5	5	13	9	6	$\sum xy$	6
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	11
							Denominator	39.204592
							r (test 1)	0.280579
							r (test 2)	0.280579

Shoreside Analysis of Safety Climate – Problem Identification								
		x	y	x2	y2	xy		
1	D	0	1	0	1	0		
2	SD	0	0	0	0	0	N	6
3	N	0	0	0	0	0	Sum of X	5
4	SA	2	0	4	0	0	Sum of Y	5
5	A	3	3	9	9	9	$\sum x2$	13
6	DK	0	1	0	1	0	$\sum y2$	11
		5	5	13	11	9	$\sum xy$	9
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][\,n\sum y^2 - (\sum y)^2]}}$							Numerator	29
							Denominator	46.615448
							r (test 1)	0.622111
							r (test 2)	0.622111

Shoreside Analysis of Safety Climate – Promotion of Safety								
		x	y	x2	y2	xy		
1	D	0	2	0	4	0		
2	SD	0	0	0	0	0	N	6
3	N	0	0	0	0	0	Sum of X	5
4	SA	2	0	4	0	0	Sum of Y	5
5	A	3	3	9	9	9	$\sum x2$	13
6	DK	0	0	0	0	0	$\sum y2$	13
		5	5	13	13	9	$\sum xy$	9
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][\,n\sum y^2 - (\sum y)^2]}}$							Numerator	29
							Denominator	53
							r (test 1)	0.547170
							r (test 2)	0.547170

Shoreside Analysis of Safety Climate - Responsiveness								
		x	y	x2	y2	xy		
1	D	0	0	0	0	0		
2	SD	0	0	0	0	0	N	6
3	N	0	1	0	1	0	Sum of X	5
4	SA	2	0	4	0	0	Sum of Y	5
5	A	3	4	9	16	12	$\sum x2$	13
6	DK	0	0	0	0	0	$\sum y2$	17
		5	5	13	17	12	$\sum xy$	12
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	47
							Denominator	63.882705
							r (test 1)	0.735723
							r (test 2)	0.735723

Shoreside Analysis of Safety Climate – Safety Awareness								
		x	y	x2	y2	xy		
1	D	1	1	1	1	1		
2	SD	0	0	0	0	0	N	6
3	N	0	2	0	4	0	Sum of X	5
4	SA	0	2	0	4	0	Sum of Y	5
5	A	4	0	16	0	0	$\sum x2$	17
6	DK	0	0	0	0	0	$\sum y2$	9
		5	5	17	9	1	$\sum xy$	1
$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$							Numerator	-19
							Denominator	47.254629
							r (test 1)	-0.402077
							r (test 2)	-0.402077

Appendix G – Sensitivity Analysis of TOPSIS

Scenario 1 (What would the ranking of vessels be with uniform weight)

Normalization Process

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	4.50	4.60	4.50	4.50	4.50	4.50	4.60	4.70
	MT SEA VOYAGER	3.80	3.90	3.80	3.80	4.00	3.80	4.00	4.30
	MT SEA PROGRESS	3.50	3.90	3.60	3.50	3.80	3.60	4.00	4.10
	MT SEA GRACE	3.50	3.70	3.60	3.60	3.70	3.50	3.80	4.00
	MT SEA ADVENTURER	3.30	3.80	3.60	3.30	3.80	3.20	3.60	4.10
	MT DIDDI	3.40	3.50	3.40	3.40	3.70	3.40	3.80	4.00
	MT UMBALWA	3.40	3.90	3.70	3.40	3.70	3.40	3.80	4.20
	MT KINGIS	4.60	4.60	4.50	4.60	4.60	4.60	4.70	4.80
	MT MOSUNMOLA	4.20	4.00	3.80	4.20	3.90	4.20	3.90	4.30
	MT ASHABI	4.00	4.00	3.70	3.70	3.80	4.30	3.90	4.50
		12.17	12.66	12.13	12.10	12.53	12.27	12.73	13.62

Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.370	0.363	0.371	0.372	0.359	0.367	0.361	0.345
	MT SEA VOYAGER	0.312	0.308	0.313	0.314	0.319	0.310	0.314	0.316
	MT SEA PROGRESS	0.288	0.308	0.297	0.289	0.303	0.293	0.314	0.301
	MT SEA GRACE	0.288	0.292	0.297	0.298	0.295	0.285	0.299	0.294
	MT SEA ADVENTURER	0.271	0.300	0.297	0.273	0.303	0.261	0.283	0.301
	MT DIDDI	0.279	0.276	0.280	0.281	0.295	0.277	0.299	0.294
	MT UMBALWA	0.279	0.308	0.305	0.281	0.295	0.277	0.299	0.308
	MT KINGIS	0.378	0.363	0.371	0.380	0.367	0.375	0.369	0.352
	MT MOSUNMOLA	0.345	0.316	0.313	0.347	0.311	0.342	0.306	0.316
	MT ASHABI	0.329	0.316	0.305	0.306	0.303	0.350	0.306	0.330
	Weights of Safety Factors	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125

Weighted Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.0462	0.0454	0.0464	0.0465	0.0449	0.0458	0.0452	0.0431
	MT SEA VOYAGER	0.0390	0.0385	0.0392	0.0393	0.0399	0.0387	0.0393	0.0395
	MT SEA PROGRESS	0.0360	0.0385	0.0371	0.0362	0.0379	0.0367	0.0393	0.0376
	MT SEA GRACE	0.0360	0.0365	0.0371	0.0372	0.0369	0.0357	0.0373	0.0367
	MT SEA ADVENTURER	0.0339	0.0375	0.0371	0.0341	0.0379	0.0326	0.0354	0.0376
	MT DIDDI	0.0349	0.0346	0.0350	0.0351	0.0369	0.0346	0.0373	0.0367
	MT UMBALWA	0.0349	0.0385	0.0381	0.0351	0.0369	0.0346	0.0373	0.0385
	MT KINGIS	0.0473	0.0454	0.0464	0.0475	0.0459	0.0469	0.0462	0.0440
	MT MOSUNMOLA	0.0432	0.0395	0.0392	0.0434	0.0389	0.0428	0.0383	0.0395
	MT ASHABI	0.0411	0.0395	0.0381	0.0382	0.0379	0.0438	0.0383	0.0413
Max	Ideal (Best) Value	0.0473	0.0454	0.0464	0.0475	0.0459	0.0469	0.0462	0.0440
Min	Ideal (Worst) Value	0.0339	0.0346	0.0350	0.0341	0.0369	0.0326	0.0354	0.0367

Euclidean Distance for both Ideal Best and Worst Solution

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Eud Dist From Ideal Best	Eud Dist From Ideal Worst
VESSEL NAMES	MT AMIF	0.0462	0.0454	0.0464	0.0465	0.0449	0.0458	0.0452	0.0431	0.0024	0.0305
	MT SEA VOYAGER	0.0390	0.0385	0.0392	0.0393	0.0399	0.0387	0.0393	0.0395	0.0202	0.0124
	MT SEA PROGRESS	0.0360	0.0385	0.0371	0.0362	0.0379	0.0367	0.0393	0.0376	0.0254	0.0079
	MT SEA GRACE	0.0360	0.0365	0.0371	0.0372	0.0369	0.0357	0.0373	0.0367	0.0272	0.0059
	MT SEA ADVENTURER	0.0339	0.0375	0.0371	0.0341	0.0379	0.0326	0.0354	0.0376	0.0305	0.0039
	MT DIDDI	0.0349	0.0346	0.0350	0.0351	0.0369	0.0346	0.0373	0.0367	0.0302	0.0032
	MT UMBALWA	0.0349	0.0385	0.0381	0.0351	0.0369	0.0346	0.0373	0.0385	0.0276	0.0062
	MT KINGIS	0.0473	0.0454	0.0464	0.0475	0.0459	0.0469	0.0462	0.0440	0.0000	0.0326
	MT MOSUNMOLA	0.0432	0.0395	0.0392	0.0434	0.0389	0.0428	0.0383	0.0395	0.0164	0.0184
	MT ASHABI	0.0411	0.0395	0.0381	0.0382	0.0379	0.0438	0.0383	0.0413	0.0192	0.0161
Max	Ideal (Best) Value	0.0473	0.0454	0.0464	0.0475	0.0459	0.0469	0.0462	0.0440		
Min	Ideal (Worst) Value	0.0339	0.0346	0.0350	0.0341	0.0369	0.0326	0.0354	0.0367		

TOPSIS Performance Score and Ranking of Vessels Surveyed

	Safety Factors	Eud Dist From Ideal Best	Eud Dist From Ideal Worst	Sum (Ideal Best & Ideal Worst)	Peformance Score	Ranking	
VESSEL NAMES	MT AMIF	0.0024	0.0305	0.0329	0.9258	93%	2nd
	MT SEA VOYAGER	0.0202	0.0124	0.0326	0.3818	38%	5th
	MT SEA PROGRESS	0.0254	0.0079	0.0333	0.2367	24%	6th
	MT SEA GRACE	0.0272	0.0059	0.0331	0.1792	18%	8th
	MT SEA ADVENTURER	0.0305	0.0039	0.0344	0.1121	11%	9th
	MT DIDDI	0.0302	0.0032	0.0334	0.0953	10%	10th
	MT UMBALWA	0.0276	0.0062	0.0338	0.1840	18%	7th
	MT KINGIS	0.0000	0.0326	0.0326	1.0000	100%	1st
	MT MOSUNMOLA	0.0164	0.0184	0.0348	0.5282	53%	3rd
	MT ASHABI	0.0192	0.0161	0.0353	0.4556	46%	4th

Scenario 2 (What if we replace the highest weights with the lowest weights)

Normalization Process

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	4.50	4.60	4.50	4.50	4.50	4.50	4.60	4.70
	MT SEA VOYAGER	3.80	3.90	3.80	3.80	4.00	3.80	4.00	4.30
	MT SEA PROGRESS	3.50	3.90	3.60	3.50	3.80	3.60	4.00	4.10
	MT SEA GRACE	3.50	3.70	3.60	3.60	3.70	3.50	3.80	4.00
	MT SEA ADVENTURER	3.30	3.80	3.60	3.30	3.80	3.20	3.60	4.10
	MT DIDDI	3.40	3.50	3.40	3.40	3.70	3.40	3.80	4.00
	MT UMBALWA	3.40	3.90	3.70	3.40	3.70	3.40	3.80	4.20
	MT KINGIS	4.60	4.60	4.50	4.60	4.60	4.60	4.70	4.80
	MT MOSUNMOLA	4.20	4.00	3.80	4.20	3.90	4.20	3.90	4.30
	MT ASHABI	4.00	4.00	3.70	3.70	3.80	4.30	3.90	4.50
		12.17	12.66	12.13	12.10	12.53	12.27	12.73	13.62

Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.370	0.363	0.371	0.372	0.359	0.367	0.361	0.345
	MT SEA VOYAGER	0.312	0.308	0.313	0.314	0.319	0.310	0.314	0.316
	MT SEA PROGRESS	0.288	0.308	0.297	0.289	0.303	0.293	0.314	0.301
	MT SEA GRACE	0.288	0.292	0.297	0.298	0.295	0.285	0.299	0.294
	MT SEA ADVENTURER	0.271	0.300	0.297	0.273	0.303	0.261	0.283	0.301
	MT DIDDI	0.279	0.276	0.280	0.281	0.295	0.277	0.299	0.294
	MT UMBALWA	0.279	0.308	0.305	0.281	0.295	0.277	0.299	0.308
	MT KINGIS	0.378	0.363	0.371	0.380	0.367	0.375	0.369	0.352
	MT MOSUNMOLA	0.345	0.316	0.313	0.347	0.311	0.342	0.306	0.316
	MT ASHABI	0.329	0.316	0.305	0.306	0.303	0.350	0.306	0.330
	Weights of Safety Factors	0.11	0.13	0.15	0.11	0.13	0.12	0.11	0.14

Weighted Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.0407	0.0472	0.0556	0.0409	0.0467	0.0440	0.0398	0.0483
	MT SEA VOYAGER	0.0344	0.0400	0.0470	0.0345	0.0415	0.0372	0.0346	0.0442
	MT SEA PROGRESS	0.0316	0.0400	0.0445	0.0318	0.0394	0.0352	0.0346	0.0421
	MT SEA GRACE	0.0316	0.0380	0.0445	0.0327	0.0384	0.0342	0.0328	0.0411
	MT SEA ADVENTURER	0.0298	0.0390	0.0445	0.0300	0.0394	0.0313	0.0311	0.0421
	MT DIDDI	0.0307	0.0359	0.0420	0.0309	0.0384	0.0333	0.0328	0.0411
	MT UMBALWA	0.0307	0.0400	0.0457	0.0309	0.0384	0.0333	0.0328	0.0432
	MT KINGIS	0.0416	0.0472	0.0556	0.0418	0.0477	0.0450	0.0406	0.0493
	MT MOSUNMOLA	0.0380	0.0411	0.0470	0.0382	0.0405	0.0411	0.0337	0.0442
	MT ASHABI	0.0362	0.0411	0.0457	0.0336	0.0394	0.0421	0.0337	0.0462
Max	Ideal (Best) Value	0.0416	0.0472	0.0556	0.0418	0.0477	0.0450	0.0406	0.0493
Min	Ideal (Worst) Value	0.0298	0.0359	0.0420	0.0300	0.0384	0.0313	0.0311	0.0411

Euclidean Distance for both Ideal Best and Worst Solution

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Eud Dist From Ideal Best	Eud Dist From Ideal Worst
VESSEL NAMES	MT AMIF	0.0407	0.0472	0.0556	0.0409	0.0467	0.0440	0.0398	0.0483	0.0023	0.0301
	MT SEA VOYAGER	0.0344	0.0400	0.0470	0.0345	0.0415	0.0372	0.0346	0.0442	0.0199	0.0122
	MT SEA PROGRESS	0.0316	0.0400	0.0445	0.0318	0.0394	0.0352	0.0346	0.0421	0.0250	0.0077
	MT SEA GRACE	0.0316	0.0380	0.0445	0.0327	0.0384	0.0342	0.0328	0.0411	0.0269	0.0057
	MT SEA ADVENTURER	0.0298	0.0390	0.0445	0.0300	0.0394	0.0313	0.0311	0.0421	0.0295	0.0042
	MT DIDDI	0.0307	0.0359	0.0420	0.0309	0.0384	0.0333	0.0328	0.0411	0.0300	0.0029
	MT UMBALWA	0.0307	0.0400	0.0457	0.0309	0.0384	0.0333	0.0328	0.0432	0.0266	0.0066
	MT KINGIS	0.0416	0.0472	0.0556	0.0418	0.0477	0.0450	0.0406	0.0493	0.0000	0.0320
	MT MOSUNMOLA	0.0380	0.0411	0.0470	0.0382	0.0405	0.0411	0.0337	0.0442	0.0168	0.0173
	MT ASHABI	0.0362	0.0411	0.0457	0.0336	0.0394	0.0421	0.0337	0.0462	0.0192	0.0156
Max	Ideal (Best) Value	0.0416	0.0472	0.0556	0.0418	0.0477	0.0450	0.0406	0.0493		
Min	Ideal (Worst) Value	0.0298	0.0359	0.0420	0.0300	0.0384	0.0313	0.0311	0.0411		

TOPSIS Performance Score and Ranking of Vessels Surveyed

	Safety Factors	Eud Dist From Ideal Best	Eud Dist From Ideal Worst	Sum (Ideal Best & Ideal Worst)	Peformance Score	Ranking	
VESSEL NAMES	MT AMIF	0.0023	0.0301	0.0324	0.9278	93%	2nd
	MT SEA VOYAGER	0.0199	0.0122	0.0320	0.3798	38%	5th
	MT SEA PROGRESS	0.0250	0.0077	0.0327	0.2346	23%	6th
	MT SEA GRACE	0.0269	0.0057	0.0326	0.1754	18%	8th
	MT SEA ADVENTURER	0.0295	0.0042	0.0337	0.1251	13%	9th
	MT DIDDI	0.0300	0.0029	0.0329	0.0883	9%	10th
	MT UMBALWA	0.0266	0.0066	0.0332	0.1981	20%	7th
	MT KINGIS	0.0000	0.0320	0.0320	1.0000	100%	1st
	MT MOSUNMOLA	0.0168	0.0173	0.0341	0.5081	51%	3rd
	MT ASHABI	0.0192	0.0156	0.0348	0.4488	45%	4th

Scenario 3 (What if we replace the two highest weights with the two lowest weights)

Normalization Process

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	4.50	4.60	4.50	4.50	4.50	4.50	4.60	4.70
	MT SEA VOYAGER	3.80	3.90	3.80	3.80	4.00	3.80	4.00	4.30
	MT SEA PROGRESS	3.50	3.90	3.60	3.50	3.80	3.60	4.00	4.10
	MT SEA GRACE	3.50	3.70	3.60	3.60	3.70	3.50	3.80	4.00
	MT SEA ADVENTURER	3.30	3.80	3.60	3.30	3.80	3.20	3.60	4.10
	MT DIDDI	3.40	3.50	3.40	3.40	3.70	3.40	3.80	4.00
	MT UMBALWA	3.40	3.90	3.70	3.40	3.70	3.40	3.80	4.20
	MT KINGIS	4.60	4.60	4.50	4.60	4.60	4.60	4.70	4.80
	MT MOSUNMOLA	4.20	4.00	3.80	4.20	3.90	4.20	3.90	4.30
	MT ASHABI	4.00	4.00	3.70	3.70	3.80	4.30	3.90	4.50
		12.17	12.66	12.13	12.10	12.53	12.27	12.73	13.62

Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.370	0.363	0.371	0.372	0.359	0.367	0.361	0.345
	MT SEA VOYAGER	0.312	0.308	0.313	0.314	0.319	0.310	0.314	0.316
	MT SEA PROGRESS	0.288	0.308	0.297	0.289	0.303	0.293	0.314	0.301
	MT SEA GRACE	0.288	0.292	0.297	0.298	0.295	0.285	0.299	0.294
	MT SEA ADVENTURER	0.271	0.300	0.297	0.273	0.303	0.261	0.283	0.301
	MT DIDDI	0.279	0.276	0.280	0.281	0.295	0.277	0.299	0.294
	MT UMBALWA	0.279	0.308	0.305	0.281	0.295	0.277	0.299	0.308
	MT KINGIS	0.378	0.363	0.371	0.380	0.367	0.375	0.369	0.352
	MT MOSUNMOLA	0.345	0.316	0.313	0.347	0.311	0.342	0.306	0.316
	MT ASHABI	0.329	0.316	0.305	0.306	0.303	0.350	0.306	0.330
	Weights of Safety Factors	0.11	0.13	0.15	0.14	0.13	0.12	0.11	0.11

Weighted Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.0407	0.0472	0.0556	0.0521	0.0467	0.0440	0.0398	0.0379
	MT SEA VOYAGER	0.0344	0.0400	0.0470	0.0440	0.0415	0.0372	0.0346	0.0347
	MT SEA PROGRESS	0.0316	0.0400	0.0445	0.0405	0.0394	0.0352	0.0346	0.0331
	MT SEA GRACE	0.0316	0.0380	0.0445	0.0417	0.0384	0.0342	0.0328	0.0323
	MT SEA ADVENTURER	0.0298	0.0390	0.0445	0.0382	0.0394	0.0313	0.0311	0.0331
	MT DIDDI	0.0307	0.0359	0.0420	0.0393	0.0384	0.0333	0.0328	0.0323
	MT UMBALWA	0.0307	0.0400	0.0457	0.0393	0.0384	0.0333	0.0328	0.0339
	MT KINGIS	0.0416	0.0472	0.0556	0.0532	0.0477	0.0450	0.0406	0.0388
	MT MOSUNMOLA	0.0380	0.0411	0.0470	0.0486	0.0405	0.0411	0.0337	0.0347
	MT ASHABI	0.0362	0.0411	0.0457	0.0428	0.0394	0.0421	0.0337	0.0363
Max	Ideal (Best) Value	0.0416	0.0472	0.0556	0.0532	0.0477	0.0450	0.0406	0.0388
Min	Ideal (Worst) Value	0.0298	0.0359	0.0420	0.0382	0.0384	0.0313	0.0311	0.0323

Euclidean Distance for both Ideal Best and Worst Solution

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Eud Dist From Ideal Best	Eud Dist From Ideal Worst
VESSEL NAMES	MT AMIF	0.0407	0.0472	0.0556	0.0521	0.0467	0.0440	0.0398	0.0379	0.0024	0.0310
	MT SEA VOYAGER	0.0344	0.0400	0.0470	0.0440	0.0415	0.0372	0.0346	0.0347	0.0204	0.0125
	MT SEA PROGRESS	0.0316	0.0400	0.0445	0.0405	0.0394	0.0352	0.0346	0.0331	0.0259	0.0078
	MT SEA GRACE	0.0316	0.0380	0.0445	0.0417	0.0384	0.0342	0.0328	0.0323	0.0273	0.0061
	MT SEA ADVENTURER	0.0298	0.0390	0.0445	0.0382	0.0394	0.0313	0.0311	0.0331	0.0306	0.0042
	MT DIDDI	0.0307	0.0359	0.0420	0.0393	0.0384	0.0333	0.0328	0.0323	0.0308	0.0030
	MT UMBALWA	0.0307	0.0400	0.0457	0.0393	0.0384	0.0333	0.0328	0.0339	0.0277	0.0065
	MT KINGIS	0.0416	0.0472	0.0556	0.0532	0.0477	0.0450	0.0406	0.0388	0.0000	0.0329
	MT MOSUNMOLA	0.0380	0.0411	0.0470	0.0486	0.0405	0.0411	0.0337	0.0347	0.0167	0.0184
	MT ASHABI	0.0362	0.0411	0.0457	0.0428	0.0394	0.0421	0.0337	0.0363	0.0201	0.0155
Max	Ideal (Best) Value	0.0416	0.0472	0.0556	0.0532	0.0477	0.0450	0.0406	0.0388		
Min	Ideal (Worst) Value	0.0298	0.0359	0.0420	0.0382	0.0384	0.0313	0.0311	0.0323		

TOPSIS Performance Score and Ranking of Vessels Surveyed

	Safety Factors	Eud Dist From Ideal Best	Eud Dist From Ideal Worst	Sum (Ideal Best & Ideal Worst)	Peformance Score	Ranking	
VESSEL NAMES	MT AMIF	0.0024	0.0310	0.0334	0.9291	93%	2nd
	MT SEA VOYAGER	0.0204	0.0125	0.0330	0.3803	38%	5th
	MT SEA PROGRESS	0.0259	0.0078	0.0337	0.2313	23%	6th
	MT SEA GRACE	0.0273	0.0061	0.0334	0.1825	18%	8th
	MT SEA ADVENTURER	0.0306	0.0042	0.0347	0.1199	12%	9th
	MT DIDDI	0.0308	0.0030	0.0338	0.0886	9%	10th
	MT UMBALWA	0.0277	0.0065	0.0342	0.1898	19%	7th
	MT KINGIS	0.0000	0.0329	0.0329	1.0000	100%	1st
	MT MOSUNMOLA	0.0167	0.0184	0.0351	0.5237	52%	3rd
	MT ASHABI	0.0201	0.0155	0.0357	0.4357	44%	4th

Scenario 4 (What if we replace the three highest weights with the three lowest weights)

Normalization Process

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	4.50	4.60	4.50	4.50	4.50	4.50	4.60	4.70
	MT SEA VOYAGER	3.80	3.90	3.80	3.80	4.00	3.80	4.00	4.30
	MT SEA PROGRESS	3.50	3.90	3.60	3.50	3.80	3.60	4.00	4.10
	MT SEA GRACE	3.50	3.70	3.60	3.60	3.70	3.50	3.80	4.00
	MT SEA ADVENTURER	3.30	3.80	3.60	3.30	3.80	3.20	3.60	4.10
	MT DIDDI	3.40	3.50	3.40	3.40	3.70	3.40	3.80	4.00
	MT UMBALWA	3.40	3.90	3.70	3.40	3.70	3.40	3.80	4.20
	MT KINGIS	4.60	4.60	4.50	4.60	4.60	4.60	4.70	4.80
	MT MOSUNMOLA	4.20	4.00	3.80	4.20	3.90	4.20	3.90	4.30
	MT ASHABI	4.00	4.00	3.70	3.70	3.80	4.30	3.90	4.50
		12.17	12.66	12.13	12.10	12.53	12.27	12.73	13.62

Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.370	0.363	0.371	0.372	0.359	0.367	0.361	0.345
	MT SEA VOYAGER	0.312	0.308	0.313	0.314	0.319	0.310	0.314	0.316
	MT SEA PROGRESS	0.288	0.308	0.297	0.289	0.303	0.293	0.314	0.301
	MT SEA GRACE	0.288	0.292	0.297	0.298	0.295	0.285	0.299	0.294
	MT SEA ADVENTURER	0.271	0.300	0.297	0.273	0.303	0.261	0.283	0.301
	MT DIDDI	0.279	0.276	0.280	0.281	0.295	0.277	0.299	0.294
	MT UMBALWA	0.279	0.308	0.305	0.281	0.295	0.277	0.299	0.308
	MT KINGIS	0.378	0.363	0.371	0.380	0.367	0.375	0.369	0.352
	MT MOSUNMOLA	0.345	0.316	0.313	0.347	0.311	0.342	0.306	0.316
	MT ASHABI	0.329	0.316	0.305	0.306	0.303	0.350	0.306	0.330
	Weights of Safety Factors	0.11	0.11	0.15	0.14	0.13	0.12	0.13	0.11

Weighted Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.0407	0.0400	0.0556	0.0521	0.0467	0.0440	0.0470	0.0379
	MT SEA VOYAGER	0.0344	0.0339	0.0470	0.0440	0.0415	0.0372	0.0409	0.0347
	MT SEA PROGRESS	0.0316	0.0339	0.0445	0.0405	0.0394	0.0352	0.0409	0.0331
	MT SEA GRACE	0.0316	0.0321	0.0445	0.0417	0.0384	0.0342	0.0388	0.0323
	MT SEA ADVENTURER	0.0298	0.0330	0.0445	0.0382	0.0394	0.0313	0.0368	0.0331
	MT DIDDI	0.0307	0.0304	0.0420	0.0393	0.0384	0.0333	0.0388	0.0323
	MT UMBALWA	0.0307	0.0339	0.0457	0.0393	0.0384	0.0333	0.0388	0.0339
	MT KINGIS	0.0416	0.0400	0.0556	0.0532	0.0477	0.0450	0.0480	0.0388
	MT MOSUNMOLA	0.0380	0.0347	0.0470	0.0486	0.0405	0.0411	0.0398	0.0347
	MT ASHABI	0.0362	0.0347	0.0457	0.0428	0.0394	0.0421	0.0398	0.0363
Max	Ideal (Best) Value	0.0416	0.0400	0.0556	0.0532	0.0477	0.0450	0.0480	0.0388
Min	Ideal (Worst) Value	0.0298	0.0304	0.0420	0.0382	0.0384	0.0313	0.0368	0.0323

Euclidean Distance for both Ideal Best and Worst Solution

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Eud Dist From Ideal Best	Eud Dist From Ideal Worst
VESSEL NAMES	MT AMIF	0.0407	0.0400	0.0556	0.0521	0.0467	0.0440	0.0470	0.0379	0.0024	0.0309
	MT SEA VOYAGER	0.0344	0.0339	0.0470	0.0440	0.0415	0.0372	0.0409	0.0347	0.0204	0.0125
	MT SEA PROGRESS	0.0316	0.0339	0.0445	0.0405	0.0394	0.0352	0.0409	0.0331	0.0259	0.0078
	MT SEA GRACE	0.0316	0.0321	0.0445	0.0417	0.0384	0.0342	0.0388	0.0323	0.0273	0.0061
	MT SEA ADVENTURER	0.0298	0.0330	0.0445	0.0382	0.0394	0.0313	0.0368	0.0331	0.0308	0.0038
	MT DIDDI	0.0307	0.0304	0.0420	0.0393	0.0384	0.0333	0.0388	0.0323	0.0306	0.0032
	MT UMBALWA	0.0307	0.0339	0.0457	0.0393	0.0384	0.0333	0.0388	0.0339	0.0279	0.0062
	MT KINGIS	0.0416	0.0400	0.0556	0.0532	0.0477	0.0450	0.0480	0.0388	0.0000	0.0329
	MT MOSUNMOLA	0.0380	0.0347	0.0470	0.0486	0.0405	0.0411	0.0398	0.0347	0.0170	0.0183
	MT ASHABI	0.0362	0.0347	0.0457	0.0428	0.0394	0.0421	0.0398	0.0363	0.0203	0.0154
Max	Ideal (Best) Value	0.0416	0.0400	0.0556	0.0532	0.0477	0.0450	0.0480	0.0388		
Min	Ideal (Worst) Value	0.0298	0.0304	0.0420	0.0382	0.0384	0.0313	0.0368	0.0323		

TOPSIS Performance Score and Ranking of Vessels Surveyed

	Safety Factors	Eud Dist From Ideal Best	Eud Dist From Ideal Worst	Sum (Ideal Best & Ideal Worst)	Peformance Score	Ranking	
VESSEL NAMES	MT AMIF	0.0024	0.0309	0.0333	0.9272	93%	2nd
	MT SEA VOYAGER	0.0204	0.0125	0.0330	0.3803	38%	5th
	MT SEA PROGRESS	0.0259	0.0078	0.0337	0.2312	23%	6th
	MT SEA GRACE	0.0273	0.0061	0.0334	0.1825	18%	8th
	MT SEA ADVENTURER	0.0308	0.0038	0.0347	0.1104	11%	9th
	MT DIDDI	0.0306	0.0032	0.0338	0.0943	9%	10th
	MT UMBALWA	0.0279	0.0062	0.0341	0.1821	18%	7th
	MT KINGIS	0.0000	0.0329	0.0329	1.0000	100%	1st
	MT MOSUNMOLA	0.0170	0.0183	0.0352	0.5183	52%	3rd
	MT ASHABI	0.0203	0.0154	0.0357	0.4308	43%	4th

Scenario 5 (What if we replace the four highest weights with the four lowest weights)

Normalization Process

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	4.50	4.60	4.50	4.50	4.50	4.50	4.60	4.70
	MT SEA VOYAGER	3.80	3.90	3.80	3.80	4.00	3.80	4.00	4.30
	MT SEA PROGRESS	3.50	3.90	3.60	3.50	3.80	3.60	4.00	4.10
	MT SEA GRACE	3.50	3.70	3.60	3.60	3.70	3.50	3.80	4.00
	MT SEA ADVENTURER	3.30	3.80	3.60	3.30	3.80	3.20	3.60	4.10
	MT DIDDI	3.40	3.50	3.40	3.40	3.70	3.40	3.80	4.00
	MT UMBALWA	3.40	3.90	3.70	3.40	3.70	3.40	3.80	4.20
	MT KINGIS	4.60	4.60	4.50	4.60	4.60	4.60	4.70	4.80
	MT MOSUNMOLA	4.20	4.00	3.80	4.20	3.90	4.20	3.90	4.30
	MT ASHABI	4.00	4.00	3.70	3.70	3.80	4.30	3.90	4.50
		12.17	12.66	12.13	12.10	12.53	12.27	12.73	13.62

Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.370	0.363	0.371	0.372	0.359	0.367	0.361	0.345
	MT SEA VOYAGER	0.312	0.308	0.313	0.314	0.319	0.310	0.314	0.316
	MT SEA PROGRESS	0.288	0.308	0.297	0.289	0.303	0.293	0.314	0.301
	MT SEA GRACE	0.288	0.292	0.297	0.298	0.295	0.285	0.299	0.294
	MT SEA ADVENTURER	0.271	0.300	0.297	0.273	0.303	0.261	0.283	0.301
	MT DIDDI	0.279	0.276	0.280	0.281	0.295	0.277	0.299	0.294
	MT UMBALWA	0.279	0.308	0.305	0.281	0.295	0.277	0.299	0.308
	MT KINGIS	0.378	0.363	0.371	0.380	0.367	0.375	0.369	0.352
	MT MOSUNMOLA	0.345	0.316	0.313	0.347	0.311	0.342	0.306	0.316
	MT ASHABI	0.329	0.316	0.305	0.306	0.303	0.350	0.306	0.330
	Weights of Safety Factors	0.11	0.11	0.15	0.14	0.12	0.13	0.13	0.11

Weighted Normalized Decision Matrix

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
VESSEL NAMES	MT AMIF	0.0407	0.0400	0.0556	0.0521	0.0431	0.0477	0.0470	0.0379
	MT SEA VOYAGER	0.0344	0.0339	0.0470	0.0440	0.0383	0.0403	0.0409	0.0347
	MT SEA PROGRESS	0.0316	0.0339	0.0445	0.0405	0.0364	0.0381	0.0409	0.0331
	MT SEA GRACE	0.0316	0.0321	0.0445	0.0417	0.0354	0.0371	0.0388	0.0323
	MT SEA ADVENTURER	0.0298	0.0330	0.0445	0.0382	0.0364	0.0339	0.0368	0.0331
	MT DIDDI	0.0307	0.0304	0.0420	0.0393	0.0354	0.0360	0.0388	0.0323
	MT UMBALWA	0.0307	0.0339	0.0457	0.0393	0.0354	0.0360	0.0388	0.0339
	MT KINGIS	0.0416	0.0400	0.0556	0.0532	0.0441	0.0487	0.0480	0.0388
	MT MOSUNMOLA	0.0380	0.0347	0.0470	0.0486	0.0373	0.0445	0.0398	0.0347
	MT ASHABI	0.0362	0.0347	0.0457	0.0428	0.0364	0.0456	0.0398	0.0363
Max	Ideal (Best) Value	0.0416	0.0400	0.0556	0.0532	0.0441	0.0487	0.0480	0.0388
Min	Ideal (Worst) Value	0.0298	0.0304	0.0420	0.0382	0.0354	0.0339	0.0368	0.0323

Euclidean Distance for both Ideal Best and Worst Solution

	Safety Factors	COM	EMP	FDB	MTR	PID	POS	RSP	SAW	Eud Dist From Ideal Best	Eud Dist From Ideal Worst
VESSEL NAMES	MT AMIF	0.0407	0.0400	0.0556	0.0521	0.0431	0.0477	0.0470	0.0379	0.0024	0.0312
	MT SEA VOYAGER	0.0344	0.0339	0.0470	0.0440	0.0383	0.0403	0.0409	0.0347	0.0205	0.0127
	MT SEA PROGRESS	0.0316	0.0339	0.0445	0.0405	0.0364	0.0381	0.0409	0.0331	0.0260	0.0079
	MT SEA GRACE	0.0316	0.0321	0.0445	0.0417	0.0354	0.0371	0.0388	0.0323	0.0275	0.0062
	MT SEA ADVENTURER	0.0298	0.0330	0.0445	0.0382	0.0364	0.0339	0.0368	0.0331	0.0312	0.0038
	MT DIDDI	0.0307	0.0304	0.0420	0.0393	0.0354	0.0360	0.0388	0.0323	0.0308	0.0033
	MT UMBALWA	0.0307	0.0339	0.0457	0.0393	0.0354	0.0360	0.0388	0.0339	0.0281	0.0063
	MT KINGIS	0.0416	0.0400	0.0556	0.0532	0.0441	0.0487	0.0480	0.0388	0.0000	0.0332
	MT MOSUNMOLA	0.0380	0.0347	0.0470	0.0486	0.0373	0.0445	0.0398	0.0347	0.0168	0.0187
	MT ASHABI	0.0362	0.0347	0.0457	0.0428	0.0364	0.0456	0.0398	0.0363	0.0201	0.0160
Max	Ideal (Best) Value	0.0416	0.0400	0.0556	0.0532	0.0441	0.0487	0.0480	0.0388		
Min	Ideal (Worst) Value	0.0298	0.0304	0.0420	0.0382	0.0354	0.0339	0.0368	0.0323		

TOPSIS Performance Score and Ranking of Vessels Surveyed

	Safety Factors	Eud Dist From Ideal Best	Eud Dist From Ideal Worst	Sum (Ideal Best & Ideal Worst)	Peformance Score	Ranking	
VESSEL NAMES	MT AMIF	0.0024	0.0312	0.0336	0.9278	93%	2nd
	MT SEA VOYAGER	0.0205	0.0127	0.0333	0.3823	38%	5th
	MT SEA PROGRESS	0.0260	0.0079	0.0339	0.2340	23%	6th
	MT SEA GRACE	0.0275	0.0062	0.0337	0.1848	18%	8th
	MT SEA ADVENTURER	0.0312	0.0038	0.0350	0.1087	11%	9th
	MT DIDDI	0.0308	0.0033	0.0341	0.0965	10%	10th
	MT UMBALWA	0.0281	0.0063	0.0344	0.1824	18%	7th
	MT KINGIS	0.0000	0.0332	0.0332	1.0000	100%	1st
	MT MOSUNMOLA	0.0168	0.0187	0.0355	0.5264	53%	3rd
	MT ASHABI	0.0201	0.0160	0.0361	0.4434	44%	4th

Appendix H - List of Activities to Improve and Enhance Safety Culture

A detailed list of activities to improve and enhance different safety factors in the ABS Guidance Notes on Safety Culture and Leading Indicators of Safety.

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1 Communication

1.1 Desired Activities, Attitudes, and Behaviors

i) Managers and masters listen as well as speak.

ii) All of the workforce (both crew and shoreside staff) are provided with all necessary information to do their jobs safely.

1.2 Possible Activities for Improvement

- Increase the number of mechanisms for communicating safety to employees (e.g., newsletters, toolbox talks, meetings, training, incident findings).
- Increase safety training (including printed formats) in native languages.
- Provide a mechanism for anonymous input to management so that those fearful of reprisal have an alternate communication pathway.
- Emphasize the importance of, and management's expectations for, timely and effective communication throughout the chain of command.
- Provide positive public reinforcement of communications – even the "bad news". Do not shoot the messenger.
- Provide communications training to everyone.
- Create newsletters and other modes of management communication.
- Include safety messages in periodic newsletters or other communications.
- Provide access to internet sites that have regulatory activity that affects the organization.
- Disseminate relevant information from Masters' and management reviews which indicate continuance or change of direction in policies and/or procedures.
- Increase safety and/or information meeting frequency and effectiveness.
- Distribute summaries of external incidents and communicate how the lessons learned from them might apply locally.
- Disseminate organizational policies for quality, health, safety, and environment (QHSE).
- Disseminate bulletins throughout the organization regarding lessons learned or alerts regarding incidents that could have fleet-wide application.

2 Empowerment

2.1 Desired Activities, Attitudes, and Behaviors

i) Every employee has the authority and responsibility to terminate a task or activity if there are legitimate safety concerns.

ii) All crew feel able to voice concerns and to make suggestions to improve safety.

iii) Every employee tries to improve safety.

2.2 Possible Activities for Improvement

- Check that all employees know how to voice concerns, whether proactively as an opportunity for
- improvement or reactively as notice of deficiency.
- Solicit workforce opinions on effective communication means and frequency.
- Check that employees have the resources necessary to satisfy safety responsibilities.
- Clearly define accountability for safety systems.
- Celebrate employee safety decision/action successes.
- Institute an off-the-job safety program.
- Promote highlighting of employee safety concerns through formal and non-traditional means.
- See that employee safety concerns and suggestions are resolved in a credible, timely fashion.
- Establish safety committees that include a vertical slice of the organization.
- Establish clear, documented accountabilities for safety.
- Create an anonymous safety issue reporting system.

3 Feedback

3.1 Desired Activities, Attitudes, and Behaviors

i) The workforce is informed of outcomes of incident investigations, audits, etc., in a timely manner.

ii) Mismatches between practices and procedures (or standards) are quickly resolved to prevent normalization of deviance.

iii) Employee concerns are resolved quickly.

3.2 Possible Activities for Improvement

- Implement an employee suggestion/feedback program.
- Increase the number of mechanisms by which safety is communicated to employees and encourage their usage.
- Increase the percentage of employees who have their performance appraised annually.
- Establish a feedback system to crews on safety audits, issues, and concerns.

- Encourage suggestions from employees for improvements through the corrective/preventative action system, with corresponding follow-up for effectiveness once decisions are made and plans implemented.
- Establish and communicate a policy from the top management to all levels of the organization that it is acceptable and encouraged that people appropriately question safety issues.
- Discuss QHSE policies, objectives, and progress made during QHSE meetings.
- Communicate lessons learned from internal and external audits.
- Provide frequent status updates on lengthy projects that are important to employees, so they are aware of progress.
- Implement periodic employee opinion/attitude surveys to identify any concerns not making their way through normal channels.

4 Mutual Trust

4.1 Desired Activities, Attitudes, and Behaviors

i) There is a good understanding of individual and crew responsibility for safety.
ii) Relationships are characterized by respect.
iii) Employees trust managers to "do the right thing" in support of safety.
iv) Managers trust employees to shoulder their share of responsibility for performance, and to report potential problems and concerns.
v) Peers trust the motivations and behaviors of peers.
vi) Employees have confidence that a just system exists where honest errors can be reported without fear of reprisals.

4.2 Possible Activities for Improvement

- Document policies that prevent unethical behavior throughout the organization.
- Establish a training program and targets for ethics training.
- Communicate the need/expectation for reporting all incidents and near misses.
- Institute a blameless system for incident investigation, unless willful policy or procedure violations occurred.
- Establish a system that provides fair, consistent treatment of parties involved in incidents.
- Enforce the expectation that the workforce will be dealt with even-handedly.
- Document hiring policy and procedures, and implement them.
- Institute an internship training program.
- Initiate an interviewer training program.
- Provide attractive terms and conditions.

- Provide training matrices to persons involved in new-hires or in transfers of crew between ships to show adequate competency.
- Adopt an employee-driven behavior-based safety program including peer observations.
- Provide appropriate accommodation for different faiths and customs.
- Provide all procedures in native language of the crew members (as well as English).
- See that management response to acceptable and unacceptable safety performance is timely, consistent, and fair.

5 Problem Identification

5.1 Desired Activities, Attitudes, and Behaviors

i) All parts of the organization are vigilant for indications of weakness in the system that could lead to significant safety events.

ii) Avoidance of complacency – there are constant efforts to avoid the complacency that could accompany good safety records.

iii) The organization always places the burden of proof on determining that activities are safe rather than unsafe.

5.2 Possible Activities for Improvement

- Provide safety checklists for all jobs.
- Provide safety procedures, instructions or rules for all jobs.
- Provide policy/procedures for reporting unsafe conditions – and encourage their usage.
- Set targets for the number of jobs with hazard assessments.
- Set targets for the number of hazard analysis techniques utilized.
- Set targets for the number of safety inspections.
- Set targets for the number of corrective action reports originating from audits.
- Set targets for the percentage of incident reports which have causal analysis.
- Investigate and communicate lessons learned from recent accidents and incidents.
- Provide hazard/risk awareness training.
- Provide causal factor training to all employees.
- Modify the incident investigation system to more fully address “what could have happened” (potential consequences) instead of only the actual incident consequences.

6 Promotion of Safety

6.1 Desired Activities, Attitudes, and Behaviors

i) Develop a vision statement for safety culture.

ii) Establish a continual improvement program as a core value, and a campaign to communicate it to all levels of the organization.

iii) Visible, active, consistent support for safety programs from all levels of management through communications, actions, priorities, provision of resources, etc.
iv) Management commitment to doing what is right is demonstrated through decisions and actions.
v) Openness, honesty, firmness, and flexibility are qualities of the management team.

6.2 Possible Activities for Improvement

- Increase the annual safety budget so that there are sufficient resources for safety systems.
- Provide onboard or in-service training for all employees.
- Set new targets and controls for prompt closure of corrective action reports.
- Set new targets and controls for the number of safety audit recommendations closed out in time.
- Increase number of safety meetings senior management must attend.
- Increase targets for the frequency of safety management meetings.
- Set new targets for time to implement action on complaints or suggestions.
- Set new targets for employee attendance at safety meetings.
- Set new targets for increasing the percentage of new hires put through an induction training program that meets the requirements of the STCW code.
- Set good quality safety goals that are measurable.
- Improve the method of how incident investigation findings are made available to employees.
- Establish procedures to identify and impart any training required in support of safety management systems.
- Institute periodic safety culture evaluations.
- Highlight safety culture as an evaluation area in audits, incident investigations, etc. Look for and correct causal factors of incidents and safety performance problems.
- Hold regular safety management reviews.
- Establish annual safety objectives/goals throughout the organization.
- Implement a policy of zero tolerance for willful violation of safety policies and procedures.
- Effectively communicate expectations by training employees in safety policies and procedures.
- Make safety performance and safety culture a part of every worker's performance evaluation.

7 Responsiveness

7.1 Desired Activities, Attitudes, and Behaviors

i) Adequate and timely actions are taken in response to unexpected situations in order to prevent potential hazard consequences and to preserve safety.

7.2 Possible Activities for Improvement

- Check that all crew have PPE.
- Improve training for emergency procedures.
- Establish a system for ensuring that crew's time off-duty is observed.
- Determine a performance standard on action item completion.
- Do a survey of all safety-related action items to determine their status and due dates.
- Create metrics to measure the organization's performance regarding the resolution of safety concerns, recommendations, lessons learned, and audit findings. Monitor these metrics during regular management reviews.

8 Safety Awareness

8.1 Desired Activities, Attitudes and Behaviors

i) All members of the workforce exhibit a high standard of safety performance.

ii) The workforce will not tolerate willful violation of safety standards, rules or procedures.

iii) Watch-handovers are careful and unhurried.

8.2 Possible Activities for Improvement

- Establish effective and efficient procedures for ship and watch hand-overs.
- Establish a training program for safety awareness.
- Establish a training program and targets for safety investigation.
- Provide training matrices to persons involved in new-hires or in transfers of personnel between ships to show adequate competency.
- Provide training in analysis of job tasks and associated hazards, including hazards affecting quality, (e.g., using cranes with wires that are beyond their useful life for cargo movements wherein a load could be dropped and cargo subsequently damaged or destroyed).
- Provide awareness training on workplace hazards/risks and accident statistics.
- Set targets for number of near misses reported per employee.

Appendix H -Feedback Statements

A summary of Feedback Statements from both Shoreside and Shipboard Staff on Issues Concerning Occupational Health and Safety, Ship Safety and Shore to Ship Safety

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Feedback Statements from Shoreside Staff on Issues Concerning Occupational Health and Safety

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
What could this company do to improve occupational health and safety?								
Give more attention to HSE department						1		
Provide all safety apparatus and equipment for workers							1	
Engage in more awareness programs on health and safety								1
Safety training of staff and taken risk assessment before carrying out any job by the staff					1	1		
Better cascading of safety information						1		
Total Count	0	0	0	0	1	3	1	1
Percentage	0%	0%	0%	0%	17%	50%	17%	17%
Cum Percentage	0%	0%	0%	0%	17%	67%	83%	100%

Feedback Statements from Shoreside Staff on Issues Concerning Ship Safety

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
What could this company do to improve ship safety?								
To indulge in training and retraining of seafarers					1			1
Conduct risk assessment before carrying out any duty and also encourage periodic safety feedbacks and safety meetings			1		1	1		
Necessary they ensure everyone complies with the safety regulations								1
Improving vessel maintenanceactivities onboard the vessel by the crew, adequate supply of spare parts and carrying survey on the vessel when due by class surveyors				1	1			
Acquisition of more modern safety alert system					1			
Total Count	**0**	**0**	**1**	**1**	**4**	**1**	**0**	**2**
Percentage	**0%**	**0%**	**11%**	**11%**	**44%**	**11%**	**0%**	**22%**
Cum Percentage	**0%**	**0%**	**11%**	**22%**	**67%**	**78%**	**78%**	**100%**

Feedback Statements from Shoreside Staff on Issues Concerning Shore-to-Ship Safety

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
What could this company do to improve shore-to-ship safety?								
To improve on means of communication	1							
Improvement ship to shore communication among workers	1							
Ensure adequate safety equipments and training for staff							1	
Frequent communication with the ship by shore operators and arrangement of key meeting between the ship and shore before vessel commence operation while alongside jetty, and strict compliance for the usage of PPE (personal protective equipment) , and effective communication links	1						1	
improved communication	1							
Total Count	**4**	**0**	**0**	**0**	**0**	**0**	**2**	**0**
Percentage	**67%**	**0%**	**0%**	**0%**	**0%**	**0%**	**33%**	**0%**
Cum Percentage	**67%**	**67%**	**67%**	**67%**	**67%**	**67%**	**100%**	**100%**

Feedback Statements from Shipboard Staff on Issues Concerning Occupational Health and Safety

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
What could this company do to improve occupational health and safety?								
To priorititise crew health and welfare,and to prioritise proffesionalism on God fatherism to maintain goid sea standard				1				
BY MAINTAINING THE SOLAS REGULATIONS						1		
more funds should be put in place and more training should be taken at all time.						1		
More of shore base training for seamen						1		
Satisfactory								
By improving and maintaining a good communication with the crew onboard and have routine medical check up of all the crew before joining vessel and while onboard	1							
Providing adequate Safety Equipment (PPE) onboard ship							1	
To supply more safty equipment							1	
Always answer when needed			1					
Maintaining with experince crew				1				
Regular shifting of company crews				1				
adopt advance training skills						1		
Training and retraining						1		
More safety campaigns and safety trainings should be encouraged						1		
Frequent safety trainings and safety meetings			1			1		
Quick response and periodic safety training onboard						1		
More training for crew members						1		
To follow the Safety policies and always take precautions					1			

Carryout regular maintenance always				1				
Carryout proper maintenance procedures					1			
They should should make sure that maintenances is their first priority.					1			
Set a good maintenances standard.					1			
Safety briefings not be overlooked on frequent carried out jobs								1
Lamguage diffrrencies can cause missunderstanding about safety	1							
Crew should aways be consulted on matters that affect how they do their jobs		1						
Not to overlook pre job assesment when carrying out some jobs					1			
Supply of adequate PPE							1	
Language differencea cause communication gap	1							
Aupply of adequate and proper PPE at all times							1	
Culture and ethnicity sometimes affects communication	1							
Culture and nationality affects crew working performance in some cases				1				
The importance of training can not be over emphasised hence there is need to ensure trainings on safety are up to date and regular to ensure the crew are compliant with international standards and set rules on safety regulations. There is also strong need to encourage staff to participate in risk assessments as it relates to their job task so as to improve the safety of operations onboard the ship.						1		
Improved communication between the shore and ship staff Safety should be given the main priority in discussions between the shore and ship staff. Improved managements participation in the training and retraining of staff	1							
Seafarers should be encouraged to participate in risk assessments They should also be encouraged to provide suggestions towards improving the occupational health and safety onboard the ship					1			
Improved means of monitoring of routine safety activities carried out on-board the ship. Improved means of observing time off-duty and work to rest cycle. Improved feedback communication and follow-up measures taken after accidents, incidents, and near misses					1		1	
Improved empowerment of staff to ensure better occupational health and safety onboard the ship Improved training of staff on risk assessment towards improvement of occupational health and safety onboard the ship		1						1
Better supervision of the work to rest system Improved supervision of safety drills							1	
Improved feedback on accidents Improved recruitment of workers willing to work more safely			1	1				
Improvement in the supply of PPE. Improved risk assessment both at ship and at shore.					1		1	
Improved Risk assessment training and supervision. Better recruitment of Staff that are willing to work more safely				1	1			

Improved risk assessment and safety awareness					1			1
Improved training on automated equipment. Improvement in maintenance standard, Improvement in the standard of PPE					1			
Improved communication with ship management. Improved feedback on accidents and corrective measures.	1		1		1			
Follow up measures after accidents. Proper risk assessment			1		1			
Better recruitment of workers who are experienced and would work safety. Better inclusion of line workers assessment of risk. Better follow-ups after an accident or an incident has occurred				1	1			
carrying out routine safety drills onboard						1		1
making sure adequate drugs and periodic drills are carried out onboard						1		
fast response to injuries onboard			1				1	
There is need to give support and monitoring during staff off work							1	
Make effective monitoring of worker especially when they are off-duty							1	
Safety should be given the main priority in discussions between the shore and ship staff. Improved managements participation in the training and retraining of staff		1		1				
There is immediate need for staff training on effective communication between both shore and ship staff. More so, Safety should remain paramount.	1					1		
Training on Safety awareness and practices remain important for staff.						1		1
Promote Training on health and health hazards						1		
Cadet should be adequately trained on health and safety				1				
The Company should maintain all status quo on occupational health and safety at present				1				
Better motivation of staff on working more safely				1				
Safety recruitment skills should be part of qualities for selection				1				
Include safety skills in recruitment process								1
There is need to give support and monitoring during staff off work							1	
There is need to increase the supply of PPE for safety purpose							1	
Improved communication on safety related issues	1							
Improved training plans and assessments for cadets				1				
There is need for the company to improve on risk assessment and safety awareness					1			1
Improved collaboration between ship and shore staff				1				
More Training on work health and safety for middle level and management staff						1		
Better motivation of staff on working more safely. Improved feedback system on injuries that occur on-board the ship. Improved training on risk and pre job assessment			1	1				
Provide sufficient PPE supply. Promote constant risk assessment both at ship and at shore					1		1	

Improved communications on safety related issues. Better learning opportunity in using automated systems related to jobs	1				1			
Increased communication with ship management	1							
Improved collaboration in developing follow-up measures after accidents occurs			1	1				
There is need to recruit workers who are experienced and would work safely				1				
Improved training for staff/cadets				1				
Improved collaboration between ship and shore staff. Improved communication during operations. Improved recruitment standard to ensure staff are willing to work safely	1			1				
Provide off worksupport and monitoring			1					
There is immediate need for staff training on effective communication between both shore and ship staff. More so, safety should remain paramount and put in high priority.	1					1		
Provide adequate training for staff on safety awareness and practices								1
Promote training om health and health hazards						1		
Provide adequate training for cadets				1				
I think the company is maintaining all status quo on occupational health and safety at present								
Better motivation of staff on working more safely. Improved feedback system on injuries that occur on-board the ship			1	1				
There is need to increase the supply of PPE for safety purpose. Improved risk assessment both at ship and at shore							1	
Language differences between nationalities affects communication onboard the ship	1							
Work / rest hours is overlooked in some cases							1	
I think the company is maintaining all status quo on occupational health and safety at present								
Improved communications on safety related issues. Better learning opportunity in using automated systems related to jobs	1				1			
There is need for the company to improve on risk assessment and safety awareness					1			1
Improved collaboration between ship and shore staff				1				
Improved communication with ship management	1							
Improved collaboration in developing follow-up measures after accidents occurs. To make provision of standard PPE				1			1	
Better recruitment of workers who are experienced and would work safety. Better inclusion of line workers assessment of risk				1				
There is need for the company to improve on risk assessment and safety awareness				1			1	
There is need to increase the supply of PPE for safety purpose. Improved risk assessment both at ship and at shore				1	1		1	
Better motivation of staff on working more safely. Improved feedback system on injuries that occur on board the ship			1	1				
Improved collaboration in developing			1				1	

follow-up measures after accidents occurs. Provide adequate PPE supply and training.								
Better recruitment of workers who are experienced and would work safely				1				
Make effective monitoring of worker especially when they are off-duty							1	
Safety should be given the main priority in discussions between the shore and ship staff. Improved managements participation in the training and retraining of staff.				1		1	1	
Safety recruitment skills should be part of qualities for selection				1				
Include safety skills in recruitment process				1				
Improved training plans and assessment for cadets				1				
Better motivation of staff on working more safely. Improved feedback system on injuries that occur on board the ship. Improved training on risk and pre-job assessment			1	1	1			
Provide Sufficient PPE supply. Promote constant risk assessment both at ship and at shore				1	1			
Improved communication on safety related issues. Better learning opportunity in using automated systems related to jobs	1				1			
Improved communication during operations	1							
There is need for more strict observation during off duty							1	
There is need for more strict observation during off duty							1	
Communication is essential between the shore and ship staff. Increased the number of management staff participating in the training and retraining of staff	1					1		
Increased recruitment of experienced staff that are more willing to work more safely				1				
They can by improving on the quality of drugs and providing the necessary things need for safety such as improving on the expired PPE onboard in which some are expired				1			1	
improved PPE and quality drugs							1	
Improved means of monitoring of routine safety activities carried out onboard the ship.						1		
Expedite plans on the assessment of cadets				1				
Improved collaboration between ship and shore staff. Improved communication during operations. Improved recruitment standard to ensure staff are willing to work safely	1			1				
Improved feedback on accidents and corrective measures. Improved Safety training and method of safety briefing.			1			1		
Improved collaboration in developing follow-up measures after accidents occurs. Provide adequate PPE supply and training			1	1				
Better recruitment of workers who are experienced and would work safely				1				
Improved collaboration in developing follow-up measures after accidents occurs. To make provision of standard PPE				1			1	
Better motivation of staff on working more safely				1				
Improved collaboration in developing follow-up measures after accidents occurs. To make provision of standard PPE			1	1				

Motivate staff to work more safely				1				
Improved collaboration between staff on safety discussions				1				
Improved response from management on safety related issues. Improved feedback on accidents and safety related issues			1					
Improved feedback on accident and corrective measures			1					
Improved training on occupational health and safety related issues						1		1
Improved feedback on accidents and corrective measures			1					
nil								
Need for improved feedback system on injuries that occur on-board of the ship			1					
There is need to increase the supply of PPE. There is need for provision of risk assessment both on the ship and at shore					1		1	
Provide learning opportunity in adopting automated systems related to jobs					1			
Recruitment of experienced workers who will be more wiling to work safely				1				
Better recruitment process. Better follow up measures to be followed by the company			1	1				
Improved collaboration in developing follow-up measures after accidents occur			1	1				
Better motivation of staff on working more safely				1				
Improved training for risk assessment and safety awareness for staff					1			1
Better motivation of staff on working more safely				1				
Improved feedback system on injuries that occur on board the ship			1					
Improved feedback system on injuries that occur on-board the ship			1					
Improved feedback on accidents and other safety related issues			1					
Better training on safety and risk assessment					1			1
Better motivation of staff on working more safely. Improved feedback system on injuries that occur on board the ship			1	1				
Better motivation of staff on working more safely. Improved feedback system on injuries that occur on board the ship.			1	1				
Risk assessment and safety awareness are essential					1			1
Improved collaboration betwen ship and shore staff. Better risk assessment and pre job assessment				1	1			
Training on automated equipment. Improvement in maintenance standard					1			
Improved training on automated equipment's. Improvement in maintenance standard. Improvement in the standard of PPE					1		1	
Improved feedback on accidents and corrective measures			1					
Improved feedback on accidents and corrective measures			1					
Improved feedback about accidents and safety related issues. Improved collaborations amongst staff and better follow ups on safety related issues			1	1				
Improved communication and collaboration amongst staff. Improved maintenance	1			1				

standard								
Improved collaboration between ship and shore staff				1				
There is need for the company to improve on risk assessment and safety awareness					1			
Better recruitment of more experienced workers who are willing to work more safely				1				
Improved collaboration between ship and shore staff				1				
Improved feedback on safety related issues			1					
There is need for the company to improve on risk assessment and safety awareness					1			1
improved feedback on accidents and corrective measures			1					
Improved risk assessment in carrying out operational task					1			
Feedback system on injuries that occur onboard the ship			1					
Motivation for staff working safely. More trainings				1				1
Total count	**20**	**3**	**33**	**60**	**34**	**23**	**28**	**15**
Percentage	**9.3%**	**1.4%**	**15.3%**	**27.8%**	**15.7%**	**10.6%**	**13.0%**	**6.9%**
Cum Percentage	**9.3%**	**10.6%**	**25.9%**	**53.7%**	**69.4%**	**80.1%**	**93.1%**	**100.0 %**

Feedback Statements from Shipboard Staff on Issues Concerning Ship Safety

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
What could this company do to improve ship safety?								
Set safety rules,adhere to it strictly and ensure enforcement from top officer,and as well punish accirdingly any defaulter with no fear or favour					1			
regular inspection of all safty equipments which is very important.					1			
More measures of compliance of safety					1			
By employing staff with safety conscience				1				
The ship should be taking to dry dock when necessary and there should be sufficient and manufacturer recommended spare parts on board					1			
Adequate Training of crew members on Safety and maintainance For the Ship to be Seaworthy						1		
To supply us more equipment				1				
Teach them what is safety								1
Maintaining a regular drill						1		
Regular drill						1		
Provide conducive working environment as well as appropriate working tools/equipment.				1	1			
Routine maintenance					1			
Incentive scheme for good safety conduct onboard		1						
Regular and compulsory safety rounds				1				
Taking the vessel to dock regularly				1				
Sponsor crew members for safty courses						1		
Adequate safety training in a standard Institutions						1		
Preach safety always and provide proper PPE for crew						1	1	
Preach safety regularly to crews						1		
They should make sure that that safety is their first priority.								1
Make safety first priority.								1
Always not to overlook safety breefing								1
By not practicing reported incidents near miss report for a limited period of time								
Adequate and proper drill						1		

Better adherence of Work/Rest Cycle and observation of the crew during their off-time. There is also need to improve the process of recruitment so as to ensure that people are employed for their ability and willingness to work safely							1	
The management should play a more active role safety activities carried out onboard their vessels		1						
Safety issues should be taken more seriously that issues of cutting cost or meeting deadlines The standard of maintenance should be improved Safety briefings and training should be taken equally as issues of cost and or meeting deadlines					1	1		
Improved means of monitoring of routine safety activities carried out on-board the ship. Improved means of observing time off-duty and work to rest cycle. Improved feedback communication and follow-up measures taken after accidents, incidents, and near misses.						1	1	
Improved training of staff on onboard equipment's Engagement of onboard trainer to improve the training of cadets				1		1		
Better supervision of the work to rest system Improved supervision of safety drills						1	1	
Improved feedback on accidents Follow up measures after an accident Better supervision of safety drills						1	1	
Recruitment of people that are safety conscious . Improved supervision of safety drills. Proper description of job task.				1		1		1
A strict adherence to work to rest cycle. Better recruitment of Staff that are willing to work more safely				1			1	
Improved training for staff/cadets				1				
Improvement of risk assessment and planning . Improved system for observing time of workers off-duty.					1		1	
Better recruitment of staff and Improved supervision of safety drills. Improved safety training and method of safety briefing. Better supervision of work to rest schedule				1		1		1
Better recruitment. Better supervision of work to rest schedules. Better supervision of safety drills and training schedules of staff				1		1	1	1
Improved communication between the ship and shore. Ability for staff to learn from mistakes	1			1				
taking the ship to dock periodically					1			
making sure all PPE are available to every crew member onboard							1	
carrying out constant orientation to report any harmful situation that can put the crew in danger such as smokes,fire etc								1
The rest cycle of worker should be given high priority. Encourage staff to put safety procedure first						1	1	
Management should revisit the workers work to rest cycle period. Characteristics of staff recruitment should include staff that are more willing to work safely				1			1	
The role of management in safety activities especially safety carried out on-board of vessels				1				
Conduct of Safety investigation should be enforced on all vessel					1			
There is need for improve risk assessment					1			
improve means of monitoring of routine safety activities carried out on-board the ship.						1	1	1
Improved system for observing and supervising works (both while on duty and off duty)							1	
improved supervision of safety drills						1		
Better collaboration between management and ship staff on both commercial and safety related issues				1				
Promote risk assessment practices					1			
Improved means of monitoring of routine safety activities carried out on-board the ship. Improved means of observing time off-duty and work to rest cycle. Improved feedback communication and follow-up measures taken after accidents, incidents, and near misses.					1		1	
The rest cycle of worker should be given high priority. Encourage staff to put safety procedure first						1	1	
recruitment of people that are safety cautious. Improved supervision of safety drills.				1		1		
Seafearers can be more encouraged to work more safely. Recruitment of staff more willing to work more safely at sea						1		1
Improved supervision of staff trainings				1		1		
Increase the trainng of staff specifically cadet staff				1				
Better observation of time off-duty. Better collaboration on follow-up measures given after an accident occurs			1				1	

Better supervision of the work to rest system. Promote supervision of safety drills						1	1	
Better collaboration between management and ship staff on both commercial and safety related issues. Improved communications amongst staff during operations. Better observation of staff off-duty while onboard. Better observation of work/rest cycle amongst staff. Improved learning opportunities for staff	1			1				
Recruitment of people that are safety cautious. Improved supervision of safety drills. Proper description of job task				1		1		1
Seafarers can be more encouraged to work more safely. Better observation of the work to rest/cycle				1			1	
Better recruitment of staff and improved supervision of safety drills				1		1		
Need to observe the activities of staff while off-duty. Strict observation of work/rest cycle.							1	
Ability for staff to learn from mistakes				1				
Improved training for staff/cadets				1				
Improvement of maintenance standards. Better observation of time off-duty. Better collaboration on follow-up measures given after an accident occurs			1	1	1		1	
Place high importance on rest cycle of workers. Improved recruitment of staff that are more willing to work safely				1			1	
Safety activities and conduct of safetry investigation should be enforced on all vessel								
There is need for improve risk assessment					1			
Improved means of monitoring of routine safety activities carried out on-board the ship					1	1		
Improved System for observing and supervising works (both while on duty and off duty)							1	
Better supervision of the work to rest system. Improved supervision of safety drills						1	1	
Better collaboration between management and ship staff on both commercial and safety related issues. Improved learning opportunities for staff				1		1		
Recruitment of people that are safety cautious. Improved supervision of safety drills.				1		1		
Better supervision of the work to rest system. Improved supervision of safety drills				1			1	
Seafarers can be more encouraged to work more safely. Recruitment of staff more willing to work more safely at sea. Better observation of the work to rest/cycle				1				
Increase the training of staff specifically cadet staff				1				
Better observation of time off-duty. Better collaboration on follow-up measures given after an accident occurs								
Better recruitment of staff and improved supervision of safety drills. Better supervision of work to rest schedule				1		1	1	
Need to observe the activities of staff while off duty. Strict observation of work/rest cycle							1	
Ability for staff to learn from mistake				1				
Increase the training of staff specifically cadet staff				1				
Recruitment of people that are safety cautious. Improved supervision of safety drills				1		1		
Better collaboration between management and ship staff on both commercial and safety related issues. Better observation of work/rest cycle amongst staff. Improved learning opportunities for stuff.				1		1	1	
Improved feedback on accidents. Motivation of workers to conduct risk assessments.			1		1			
Improved communication between the ship and shore	1							
Management should revisit the workers work to rest cycle period. Characteristics of staff recruitment should include staff that are more willing to work safely.							1	
The role of management in safety activities especially safety carried out on-board of vessels				1		1		
promote risk assessments practices					1			
Improved means of monitoring of routine safety activities carried out on board the ship. Improved means of observing time off duty and work to rest cycle. Improved feedback communication and follow-up measures taken after accidents, incidents and near misses			1			1	1	
Improved supervision staff's training						1		
Better collaboration between management and ship staff on both commercial and safety related issues. Improved communications amongst staff during operations. Better observation of staff off-duty while onboard. Better observation of work/rest cycle amongst staff. Improved learning opportunities for staff	1			1				
Recruitment of people that are safety cautious. Improved supervision of safety drills. Proper description of job task				1	1	1		

Seafarers can be more encouraged to work more safely. Better observation of the work to rest/cycle				1			1	
Improved training for staff/cadets				1				
Strict observation of workers work to rest cycle							1	
Strict observation of workers work to rest cycle							1	
The management should play a more active role safety activities carried out on board their vessels				1				
Focus on risk assessment					1			
taking it to dock periodically					1	1		
periodic training and re training						1		1
Improved feedback communication and follow-up measures taken after accidents, incidents and near misses			1	1				
Improved system for observing and supervising works (both while on duty and off duty)							1	
Improvement of maintenance standards. Better observation of time off-duty. Better collaboration on follow-up measure given after an accident occurs				1	1		1	
Better recruitment of staff and improved supervision of safety drills. Better supervision of work to rest schedule				1		1	1	
Improved feedback on accidents. Motivation of workers to conduct risk assessments			1	1				
Improved communication between the ship and shore								
Need to observe the activities of staff while off-duty. Strict observation of work/rest cycle								
Better observation of work/rest cycle amongst staff. Improved training on risk assessment and safety related issues.					1		1	
Improve observance of staff while-off duty. Improve observance of work/rest cycle							1	
Better collaboration between management and ship staff on both commercial and safety related issues. Better communication amongst staff related issues	1			1				
Better observation of time off-duty. Improved follow-up measures on accidents and safety related issues				1			1	
Better observance of time off work. Better supervision of work to rest schedule of staff							1	
recruitment of staff and improved supervision of safety drills. Supervise work to rest schedule				1			1	
Better feedback and follow ups on safety related issues			1					
Recruitment of staff and Improved supervision of safety drills. Supervise work to rest schedule				1		1		
Improved supervision of safety drills						1		
Better collaboration between management and ship staff on both commercial and safety related issues. Improved learning opportunities for staff				1		1		
Recruitment of safety cautious people. Proper job description				1				
Seafarers can be more encouraged to work more safely. Better observation of the work to rest cycle				1			1	
Improved communication between staffs on safety related issues (feedbacks and follow ups)	1		1					
Ability for staff to learn from mistakes				1				
Better observation of work/rest cycle and also staff while off-duty							1	
Better observation of work/rest cycle amongst staff							1	
Increase the training on automated equipments					1			
Better collaboration amongst ship staff on both commercial and safety related issues. Better work/rest cycle observation amongst staff				1			1	
Improved feedback on accidents and other safety related issues			1					
Improved feedback system on injuries that occur on board the ship			1					
Better collaboration amongst shipboard staff on commercial and safety related issues				1				
Adequate feedback on accidents and safety related issues			1					
Better collaboration between management and ship staff on both commercial and safety related issues. Better observation of work/rest cycle amongst staff. Improved learning opportunities for staff				1			1	
Better collaboration between management and ship staff on both commercial and safety related issues. Improved learning opportunities for staff				1		1		
Increase training for staff/cadets				1				
Improvement of maintenance standards. Improved recruitment standard to ensure staff are willing to work safely				1	1			

Improved recruitment systems where workers would be more willing to work safely. Better observation of workers time off-duty				8			1	
Improved collaboration between staffs (ship and shore staff). Improved system for observing time of workers off duty.				1			1	
Recruitment of staff and improved supervision of safety drills. supervise work to rest schedule				1		1		
Improved training of staff on safety related issues. Improved supervision of work to rest schedule						1	1	
Recruitment of staff and improved supervision of safety drills. Supervise work to rest schedule				1			1	
Improvement of risk assessment and planning. Better observation of workers time off-duty					1		1	
Better observation of time off duty. Better observation of work to rest cycle. Better collaboration on follow up measure given after an accident occurs			1				1	
Improvement of maintenance standard. Follow up measure on safety or accident related issues			1		1			
Ability for staff to learn from mistakes. Better follow up measures on safety related issues			1	1				
Better training on automated equipment. Better collaboration on follow-up measures given after an accident occurs			1		1			
Increase the training on safety and risk assessment					1	1		
Better feedback on safety related issues. Improved communications between staffs	1		1					
Improved supervision of safety drills. Recruitment of staff. Supervision of work-to-rest schedule					1	1	1	
Better feedback on accidents, Motivation of workers to conduct risk assessments. Improved observation of work/rest cycle			1		1		1	
Forum for staff to learn from mistakes				1				
Better communication between management and ship staff on safety issues	1							
Improved observation of work/rest cycle. Better collaboration on safety and commercial issues between management and staffy				1			1	
Total Count	**8**	**2**	**17**	**74**	**31**	**48**	**54**	**12**
Percentage	**3.3%**	**0.8%**	**6.9%**	**30.1%**	**12.6%**	**19.5%**	**22.0%**	**4.9%**
Cum Percentage								
	3.3%	**4.1%**	**11.0%**	**41.1%**	**53.7%**	**73.2%**	**95.1%**	**100.0%**

Feedback Statements from Shipboard Staff on Issues Concerning Shore-to-Ship Safety

	COM	EMP	FDB	MTR	PID	POS	RSP	SAW
What could this company do to improve shore-to-ship safety?								
To make communications clear and for crew to be well unformed of the decision of the management	1							
always employ professionals in the field of marine and provide good means of transports and communication.				1				
Continuous Briefing	1		1					
To employ dedicated,honest staff.				1				
By ensuring the mooring ropes meet manilla convention standard								
The company should provide enough Provision to the Crew members and Send Company Security Officer (CSO) At Terminals and to always apply ISPS code Security Level 1				1				
To give more safety materials						1		
Provide all safety equipment for safety							1	
Always following the ship-shore safety checklist					1			
Holding a meeting before any operation at ports and sea						1		
Send more crew go training, improve their salary structure so that they can steadily re at a in their staffs.						1		
Proper logistic support				1				
Adequate safety procedures should be followed and improvement encouraged at all times					1			
Constant and frequent safety evaluations and communication	1				1			

Quick response			1					
Train crew members on shore operations to ship						1		
Adhere to safety instructions					1			
Improve their communication system on safety..	1							
Improve on their communications system	1							
They should improve on their reporting systems.. communication.	1		1					
Good communication system.	1							
By not overlooking the shipshore safety checklist when carrying out the job					1			
Adhere to the level of security they are operating					1			
Sticking to all the level of security accordingly						1		1
Improved planning and communications from shore-to-ship ship	1			1				
Mistakes should be used more as a learning opportunity than punishments.Improved reporting whenever safety rules and regulations are broken Better implementation of work/rest policy				1				
Improved training for risk assessments					1			
Communication Planning, risk assessment and communication	1			1	1			
Improved Communication	1							
Improved communication Employment of experienced staff at shore	1			1				
Improved communication systems between ship and shore staff. Improved risk assessment from shore staff for emergency operations.	1				1			
Improved communication. Improved risk assessment.	1				1			
Better communication on safety related issues. Improved follow up measures after the occurrence of accidents etc	1		1					
Improved communications regarding operations and safety issues from shore to ship	1							
Improved communication of job task and risk assessment	1				1			
Improved communications, recruitment of staff that are willing to work more safety	1							
Improved communication and employment of better experienced staff in shore positions	1			1				
Improved communication between the ship and Shore. Improved follow up of events from ship to shore. Recruitment of more experienced staff	1		1	1				
proper follow up feedbacks and adequete communication	1		1					
making sure ship management do proper follow up on cases of accident on a crew member					1			
quick response to the needs of the crew onboard			1					
Place high importance to risk assessment and communicate between shore to ship staff	1				1			
Risk assessment and communication between shore to ship staff are important	1				1			
Improved reporting whenever safety rules and regulations are broken Better implementation of work/rest policy					1			
Mistakes should be used more as a learning opportunity than punishments				1				
Manage effective communication between the shore and ship staff	1							
The Company should seriously invest in communication and planning training.	1				1			
Improved communication with shore staff	1							
There is need for recruitment of more experience staff at shore				1				
Better observation of work/rest cycle amongst staff. improved learning opportunities for staff						1	1	
Safety training should be encouraged. Enhance communication between the shore and ship staff						1		1
Communication. Planning and risk assessment	1			1	1			
Place high importance to risk assessment and communication between shore to ship staff	1				1			
Communication and risk assessment needed to be improved. Improved risk assessment both at ship and at shore	1				1			
Better learning opportunity in using automated system related to jobs. Better collaboration between ship and shore staff on discussing safety related issues and suggesting follow up measures	1							
Improved communication with shore staff	1							
Communication	1							
Better communication between shore and ship staff carrying out operational task	1							

Improved communication. Employment of experienced staff at shore	1			1				
nil								
Communication and risk assessment	1				1			
Improved communication on safety related issues. Better collaboration between ship and shore staff on discussing safety related issues and suggesting follow up measures	1			1				
There is need for effective communications, and recruitment of staff that are willing to work more safety	1			1				
Better pre job assessment and communication				1	1			
Experienced staff should be employed. There is need to include line workers assessment of risk				1	1			
Improved communications regarding operations and safety issues from shore to ship	1							
Better collaborations in developing follow up measures to safety related issues. Better communications between shore and ship staff in carrying out operational task	1			1				
Place high importance to risk assessment and communication between shore to ship staff	1				1			
Mistake should be used more as a learning opportunity than punishments				1				
Manage effectivecommunication between the shore and ship staff	1							
Communication and Planning	1				1			
Improved communications with off shore staff	1							
There is need for recruitment of more experience staff at shore				1				
Nil								
Communication and risk assessment needed to be improved	1				1			
There is need for recruitment of more experience staff at shore				1				
Improved communication on safety related issues. Better collaboration between ship and shore staff on discussing safety related issues and suggesting follow up measures	1							
Communications	1							
Better communications between shore and ship staff in carrying out operational task	1							
There is need for effective communications and recruitment of staff that are willing to work more safety	1			1				
Better pre job assessment and communication				1	1			
Recruitment of more experienced staff				1				
Communication	1							
Communication and risk assessment needed to be improved	1				1			
NIL								
Better pre job assessment. Better communications	1				1			
Improved communication between the ship and shore. Recruitment of more experienced staff	1			1				
Risk assessment and communication between shore to ship staff are important	1				1			
Improved reporting whenever safety rules and regulations are broken. Better implementation of work/rest policy					1		1	
Safety training should be encouraged. Enhance communication between the shore and ship staff	1					1		
Communication. Planning and risk assessment	1							
Improved communications with shore staff	1							
Communication and risk assessment	1				1			
Improved communication on safety related issues. Better collaboration between ship and shore staff on discussing safety related issues and suggesting follow up measures	1			1				
Improved communications regarding operations and safety issues from shore to ship	1							
Improved risk assessment and communication between shore to ship staff	1				1			
Improved risk assessment and communication between shore to ship staff	1				1			
The management should convert mistakes to learning opportunities as against punishments				1				
More safety training						1		
ensuringnthe ropes used for STS are very strong and do away with the weak ones in order to avoid accidents to crew working onboard					1			
application of safety pre caution at all levels onboard the ship						1		1
Communication, Planning, and Risk Assessment	1			1	1			
Need for effective communications with shore staff	1							

Better collaboration in developing follow up measures to safety related issues. Better communications between shore and ship staff in carrying out operational task	1		1	1				
Improved communications, recruitment of staff that are willing to work more safely	1			1				
Better pre job assessment. Better communications				1	1			
Improved communication between the ship and shore. Recruitment of more experienced staff	1			1				
Better job assessment and communication	1				1			
Better pre job assessment and communication	1				1			
Better communications between shore and ship staff in carrying out operational task	1							
Improved communications, recruitment of staff that intend to work with safety precautions	1			1				
Improved communications, recruitment of staff that intend to work with safewty precautions	1			1				
Better communication	1							
Improved recruitment and communications amongst staff	1			1				
Recruitment of experienced staff at shore				1				
Improved communication and risk assessment	1				1			
Better collaboration between ship and shore staff on discussing safety related issues and suggesting follow up measures				1				
Improved follow up of events from ship to shore		1						
Employment of more experienced staff				1				
Better communication amongst staff	1							
communication	1							
Improved communications regarding operations and safety issues from shore to ship	1							
Better collaboration in developing follow upmeasures to safety related issues. Better communications between shore and ship staff in carrying out operational task	1			1				
Improved communication of job task and risk assessment	1				1			
Improved communication about safety related issues and risk assessment	1							
Improved communications, recruitment of staff that intend to work with safety precautions	1			1				
Improved communications, recruitment of staff that intend to work with safety precautions	1			1				
Training on risk assessment					1			
Better communication between shore ship staff in carrying out operational task	1							
Improved communications amongst staffs	1							
Recruitment of more experienced staff				1				
Improved communications. Recruitment of safety conscious staff	1			1				
Better recruitment for both ship and shore staff				1				
Recruitment of more experienced staff				1				
Total Count	**84**	**1**	**8**	**46**	**41**	**10**	**3**	**3**
Percentage	**42.9%**	**0.5%**	**4.1%**	**23.5%**	**20.9%**	**5.1%**	**1.5%**	**1.5%**
Cum Percentage	**42.9%**	**43.4%**	**47.4%**	**70.9%**	**91.8%**	**96.9%**	**98.5%**	**100.0%**