A NEW METHODOLOGY ON HUMAN RELIABILITY ANALYSIS FOR SHIP SAFETY Maritime Accident Analysis and Reduction Technique (MAART)

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A NEW METHODOLOGY ON HUMAN RELIABILITY ANALYSIS FOR SHIP SAFETY

Maritime Accident Analysis and Reduction Technique (MAART)

(船舶安全のための人間信頼性分析に関する新しい方法論

海難分析に基づく削減技術（MAART））

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EXECUTIVE SUMMARY

Although many developments of HEART methods to overcome the limitations and shortcomings, most of these developments lack consideration to the relation among EPC. In the maritime working environment, machinery, environment, and management can also influence the human condition to judge and control the situation. Furthermore, these factors have a strong relationship with human factors. This condition has been described in the HEART -4M method, where the EPC is categorized into four factors, man, machine, media, and management. However, the relation among factors and the HEP calculations process are still the issues. This study proposes an approach of the HEART – 4M method by combining it with Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to evaluate the HEP in maritime accidents. The TOPSIS is introduced to handle the determination of the Assessed Proportion Effect (APE) and the relation among factors. This proposed methodology also eases the decision-maker to create the mitigation process to overcome the accident in the future.

In this study, there are three kinds of maritime accidents analyzed, collision, grounding, and sinking accidents. Generic tasks available in this study, there are nine types of generic tasks, which are sorted according to the level of working type when the accidents occurred. The generic tasks A, B, and C are classified as challenging working types because they require a high skill level and more knowledge to do the task. Moreover, if the weather condition is becoming challenging, a convenient task will become a challenging task. Furthermore, besides the generic task in a challenging task, the rest is classified as a convenient task. It is because the seafarer has familiarized well with the job due to its routine practice and do the job according to the procedures. From all maritime accidents analyzed, it turns out that many accidents occurred in a convenient task rather than in a challenging task.

Furthermore, it supported the result of the poor environment in media factors, which only affected about 20% of all analyzed accidents. It means that most of the accidents occurred in the fine weather and condition of the sea's voyage. This condition has to be given more concern. Many seafarers will feel more relaxed and lack focus and concentration when in fine weather and situation because they thought everything is under control. At the same time, the possibility of the accident's occurrence always exists.

Management factors dominated the causal of the collision, grounding, and sinking accidents. Where the monitoring and communication subfactors are the most found causal factors. The lack of checking and progress tracking lack is causing more accidents rather than a poor environment. HEP's result shows a decreasing trend, which means that improvements designed to decrease human error in maritime accidents were quite effective.

Finally, a hybrid method of HEART–4M - TOPSIS is proposed, called MAART (Maritime Accident Analysis and Reduction Technique), which was applied to evaluate the HEP in maritime accidents. At least seven advantages can be obtained from the proposed method:

1. It can reveal the causality among the different factors in terms of EPC–4M classification, focusing on the causal factors' origins. For example, if the report stated that the bridge team's coordination was defective, we could study this in more detail by looking to EPC–4M in the coordination subfactor.
2. It provides information for identifying human factors and other factors that affect human behavior.
3. It provides accident assessors with the knowledge of which factors have the highest impact on accidents because of the EPC series' performance. Moreover, it is easy for assessors to determine mitigation actions to reduce the value of errors that have occurred or occur in the future.
4. Minimize the subjectivity calculation of Human Error Probability (HEP).
5. The proposed method can be applied to evaluate the human influence in a particular condition on-board operation to minimize error occurrences.
6. The proposed method can be considered to make a mitigation strategy by reducing the error probability based on which factors cause some accidents.
7. The proposed method can assess occupational accidents and other maritime accidents, such as collision, grounding, fire, and explosion, sinking. It is not limited to maritime accidents. Furthermore, it also can be applied to the maintenance operations and other different operations to diagnose the error probability.

Published Journal

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iii. **Bowo, L.P.,** Furusho, M. & Mutmainnah W. (2020). A New HEART − 4M Method for Human Error Assessment in Maritime Collision Accidents. *Transactions of Navigation,* Vol 5 (2), pp 39 – 46. DOI: 10.18949/jintransnavi.5.2_39.
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ABBREVIATIONS

APE	: Assessed Proportion Effect
ATHEANA	: A Technique for Human Error Analysis
CARA	: Controller Action Reliability Assessment
CR	: Consistency Ratio
EPC	: Error Producing Conditions are the causal factors of the accidents.
GT	: Generic Task is the working condition description prior to accidents.
HEART	: Human Error Assessment and Reduction Technique
HFACS	: Human Factor Analysis and Classification System
HEP	: Human Error Probability
HRA	: Human Reliability Analysis
ILO	: International Labor Organization
IMO	: International Maritime Organization
MCDM	: Multi-criteria Decision Making
NARA	: Nuclear Action Reliability Assessment
NHU	: Nominal Human Unreliability
RARA	: Railway action reliability assessment
RI	**:** Random Index
SOLAS	**:** International Convention for the Safety of Life at Sea
TOPSIS	**:** Technique for Order Preference by Similarity to Ideal Solution

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CHAPTER 1
INTRODUCTION

1.1 Background

The maritime industry is an essential mode of international trade. Over 90% of cargo shipping occurs through the sea (Zhang, Teixeira, Guedes Soares, & Yan, 2018). International organizations with maritime interests, especially those that serve as authorities, such as the International Maritime Organization (IMO), the International Labour Organization (ILO), and Ship Classification Societies (IACS), have shown increasing interest regarding the human error, mainly when accidents have occurred (Akyuz, Celik, & Cebi, 2016; Bowo, Mutmainnah, & Furusho, 2017). Maritime technology development costs a tremendous amount of money because it is one of the most capital-intensive industries (Ashmawy, 2012). Despite the implementation of international safety at sea rules, new technologies, safety measures, maritime accidents due to human factors continue to occur (Celik & Cebi, 2009; Schröder-Hinrichs, Hollnagel, & Baldauf, 2012; Yildirim, Başar, & Uğurlu, 2017) — Moreover, 71% of maritime accidents caused by human errors in onboard operation (EMSA, 2017). Considering the fatalities due to maritime accidents from 2011–2016, 38% of the fatalities occurred during collision accidents; 479 seafarers lost their lives, and 5607 persons were injured (EMSA, 2017).

Besides, human error is not only recognized as a predominant cause in maritime accidents but also in many other domains, such as railway transportation (Gibson, Mills, Smith, & Kirwan, 2013; Wang, Liu, & Qin, 2018a), nuclear power plant (Park, Arigi, & Kim, 2019), aviation (B Kirwan & Gibson, 2009), and healthcare services (Francesco Castiglia, Giardina, & Tomarchio, 2015). Thus, numerous researchers and practitioners create alternative and develop models and theories related to Human Reliability Analysis (HRA) (Akyuz et al., 2016; Bowo et al., 2017; Dsouza & Lu, 2017; Wang et al., 2018a). HRA has three purposes: first, identifying human errors, predicting future risk probability, and reducing probability (B Kirwan, 1996). The development of HRA is differed to be three generations (Wang, Liu, & Qin, 2018b). The first generation in the 1980s, HRA, was developed to predict and calculate the probability of human error, and it focuses on the skill and rule base level of human action. The methodologies which are included in the first generation are as follows: THERP (Technique for Human Error Rate Prediction), ASEP (Accident Sequence Evaluation Program), HEART (Human Error Assessment and Reduction Technique), and SPAR-H (Simplified Plant Analysis Risk Human Reliability Assessment). The second-generation methodologies consider the influence of internal and external context on the error and the cognitive context that may influence the system operation. ATHEANA (A Technique for Human Event Analysis) and CREAM (Cognitive Reliability and Error Analysis Method) are included in the second generation. Furthermore, the third generation utilizes the present method and the development from the previous generations to be more suitable in the particular industry.

HEART methodology is a simple, flexible, and effective method to determine the human error involved in the accidents. Therefore, it has been used in various industries with a complex system, such as nuclear power plant, railway transportation, aviation, off-shore platform, maritime industry (Akyuz et al., 2016; Bowo & Furusho, 2019b; Francesco Castiglia et al., 2015; Deacon, Amyotte, Khan, & Mackinnon, 2013; Gibson et al., 2013; Wang et al., 2018b). The HEART method has some developments to handle its limitation, especially for calculating the value of Human Error Probability (HEP). Fault tree analysis and fuzzy set theory were hybrid to the HEART method to determine the HEP in irradiation plants (Casamirra, Castiglia, Giardina, & Tomarchio, 2009; F. Castiglia & Giardina, 2011). The fuzzy set theory was also employed to assess HEP in hydrogen refueling stations (F. Castiglia & Giardina, 2013). In the maritime industry, the HEART method has been integrated by the Analytic Hierarchy Process (AHP) method to determine EPC's specific value (Akyuz & Celik, 2015a). In the railway industry, the combination of the Fuzzy Analytic Network Process (FANP) and HEART method are utilized to determine the weight of the Assess Proportion Effect (APE) for HEP calculation (Wang et al., 2018b). The fuzzy logic theory is combined with the HEART method to solve expert elicitations' linguistic expressions to determine the appropriate weight to EPC (Maniram Kumar, Rajakarunakaran, & Arumuga Prabhu, 2017).

In spite of many developments of HEART methods to overcome the limitations and shortcomings, most of these developments lack consideration to the relation among EPC. In the maritime working environment, machinery, environment, and management can also influence the human condition to judge and control the situation. Furthermore, these factors have a strong relationship with human factors. This condition has been described in the HEART -4M method, where the EPC is categorized into four factors, man, machine, media, and management. However, the relation among factors and the HEP calculations process are still the issues. This study proposes an approach of the HEART – 4M method by combining it with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to evaluate the HEP in maritime accidents. The TOPSIS is introduced to handle the determination of the Assessed Proportion Effect (APE) and the relation among factors. This proposed methodology also eases the decision-maker to create the mitigation process to overcome the accident in the future.

1.2 Purposes of the Research

The purposes of this study are as follows:

(1). To investigate the potential navigational likelihood of maritime accidents.
(2). To propose a hybrid maritime accident analysis to enhance safety at sea.

1.3 Methodologies

The steps of this study are as follows:

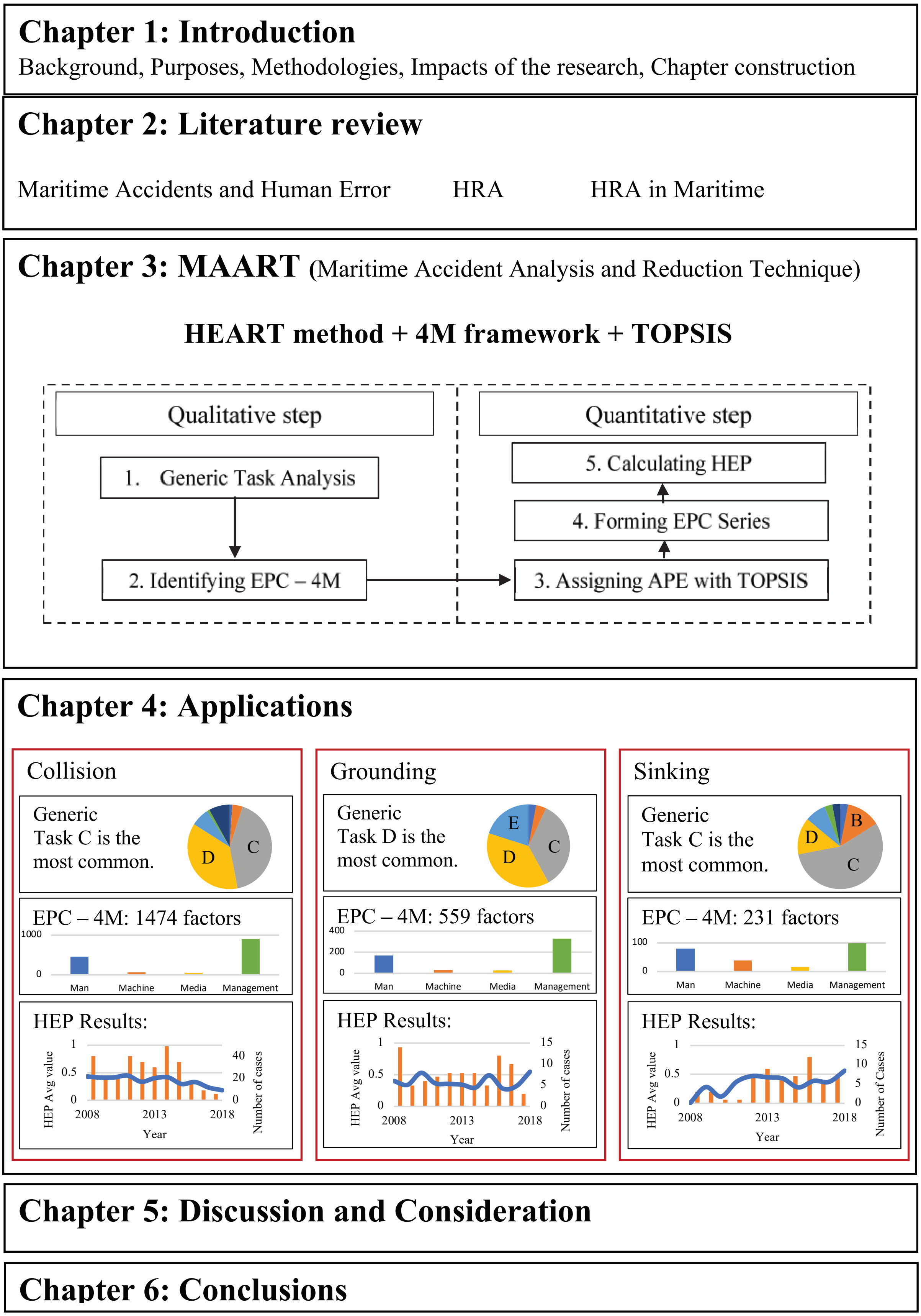
(1). Literature review.
(2). Collect the maritime accident data report from the national authority organization from 12 countries.
(3). List all of the generic tasks of each maritime accident.
(4). Obtaining all of the error-producing conditions and categorize EPC to 4M framework.
(5). Calculate the Assessed Proportion Effect (APE) weight by TOPSIS.
(6). Calculate the Human Error Probability (HEP).
(7). Analyze the trend of human error in maritime accidents.

1.4 Impacts of the Research

Human reliability assessment (HRA) has become essential in the industry and is a growing field of concern for the public and regulators (Deacon et al., 2013). HRA describes how reliable the operator conducts the task successfully with no error in the period. This study is expected to contribute to maritime industry sectors, such as ship management companies, ship operators, safety engineers, ship safety management system practices, maritime accident researchers, to analyze the human reliability onboard ship operations. The following subjects of the thesis can be highlighted as a contribution;

(1). The proposed approach can utilize both qualitative and quantitative data in maritime safety and human reliability analysis.
(2). It would be a significant advantage for literature in establishing a maritime accident-specific methodology to evaluate human reliability.
(3). The research provides a set of parameters for the maritime industry to improve HRA calculation consistency.
(4). This research contributes to evaluating human reliability on-board ships.
(5). The method can assist ship management companies, safety engineers, and reliability researchers in giving their full attention to the most critical human error factor.

Dissertation Structure



CHAPTER 2
LITERATURE REVIEW

2.1 Maritime Accidents and Human Error

The IMO has defined the difference between maritime accidents and maritime incidents, where the former is an event or a sequence of events that causes the death of or serious injury to a person, loss of people from a ship, abandonment of a ship, material damage to the ship and maritime infrastructure, and also severe damage to the environment. On the other hand, a maritime incident is an event or a sequence of events directly connected with the operation of a ship that presents a threat (IMO, 2008).

Maritime accidents have quite a long and extensive list, and the number of casualties is very high. The most well-known maritime accidents in the 1900s are the Titanic sinking, which sank in the Atlantic Ocean and lost thousands of lives. Two years after this accident occurred, the international society cooperated to make safety regulations on the sea, known as the International Convention for the Safety Life at Sea (SOLAS) in 1914. Some accidents caused pollutions because of the impact of accidents, such as oil spills in Torrey Canyon, Amoco Cadiz, Exxon Valdez, Erika, and Prestige. It motivates the international society to make new rules to protect the environment from the same kind of accidents by creating rules and recommendations in MARPOL, port state control, and US oil pollution act because this accident had a terrible impact. In recent times, several accidents in passenger ships have attention from the world community. The accident of MV Costa

Concordia, which occurred in 2012, had thirty-two fatalities because of the ship listed after striking an underwater rock obstruction off Isola del Giglio, Italy. Moreover, the most current big accident of MV Sewol in 2014, which carried 466 passengers, and mostly the passengers were secondary school students. The Social and political aspects in South Korea reacted to this accident and the world (Awal & Hasegawa, 2017).

Figure 2.1 shows the timeline of navigational accident rates, consisting of collision and grounding accidents, from 1978 to 2003, and the international maritime regulations, safety guidelines, and codes introduced to mitigate the same kind of accidents in the future. The rates of maritime accidents in Figure 2.1 has fluctuated; however, it shows the decreasing trendline over the years. The highest peak for collision and grounding was in 1979. Thus, every year (1980 – 1982), the international organization introduces new regulations to support safe navigation to suppress the navigational accident rate. Moreover, it has been proven by a significant decrease in the number of years after that.

Although the rules and recommendations, and improvements have been made, intend to reduce and prevent the same kind of accidents throughout a century, but the number of maritime accidents has not been reduced yet.

According to the annual reports of EMSA (European Maritime Safety Agency) in 2019, 66% of accidents onboard ship operation causes from 2011 to 2018 are human factors (EMSA, 2019). The contributing factors related to human factors onboard operation that causes accidents are safety awareness, inadequate work methods, lack of knowledge, planning, and coordination. Therefore, the International Maritime Organization (IMO), through its Resolution A.947(23) – *Human Element Vision, Principles and Goals for the Organization* – recognizes "the need for increased focus on human-related activities in the safe operation of ships, and the need to achieve and maintain high standards of safety, security and environmental protection to significantly reduce maritime casualties."

Reason explained the nature of human errors; there are two actions done by human, which lead to accidents, intended actions and unintended actions (Reason, 2000). Intended actions mismatch between the prior intention and the intended consequences; this term is called mistakes. Meanwhile, the violations in intended actions are from the motivational factor of the human, attitude, and culture. The unintended actions are different from intended actions. These errors are caused by humans' acts when doing the task, loss of focus, and absent-mindedness, so not aware of the situation, which is a potential danger.

Major accidents with many fatalities attract public attention and receive significant effort to prevent them in the future did not occur randomly. There are many contributing factors and causes, and the most critical factor is operational practices (Chengi, 2007). In the operational practices, the probability of primary error type occurrences is high if the safety procedure of operation is absent or neglected by the operator. The fatal accident can occur because of the negligence of near misses, which can cause damages and small injuries, leading to fatalities, as shown in **Figure 2.2.**

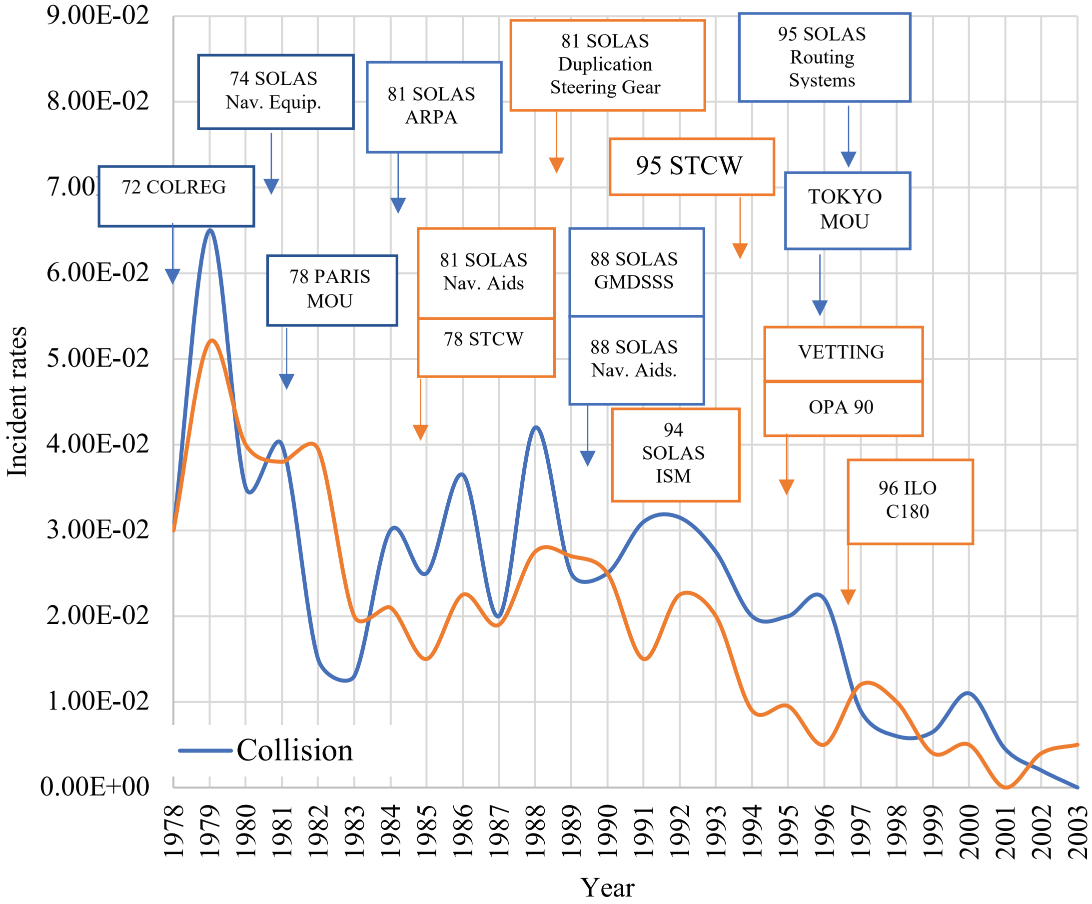


Figure 2. 1 Timeline of navigational accident rates and introduced international maritime regulations, safety guidelines, and codes (Eliopoulou & Papanikolaou, 2007)

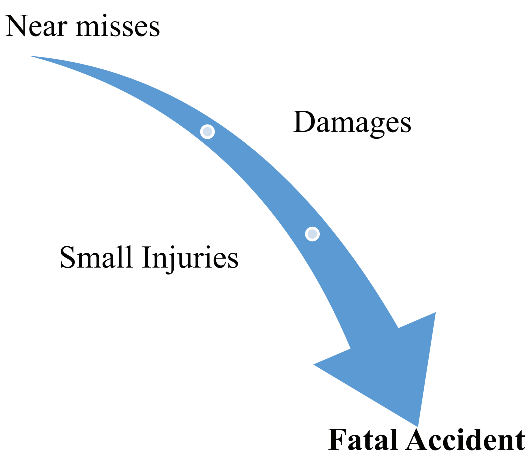


Figure 2. 2 A typical accident occurrence

2.2 Human Reliability Assessment

Since the 1970s, many researchers have been developing Human Reliability Assessment (HRA) for identifying influenced factors, such as human errors and machinery factors. It is predicting the likelihood and reducing their likelihood of nuclear power plants (Kirwan, 1996).

Hollnagel summarized HRA development from 1975–2005, as shown in Figure 2.3. In the 1980s, the development of HRAs had the most significant growth than in previous years, in this period represents the first generation of HRA. There are about twenty-five HRA methods in 1988 had been developed. The number of developing HRA was slightly increasing since the 1980s. The HRA that developed in the period 1990 and more represents HRA's launch second-generation (Erik Hollnagel, 2005).

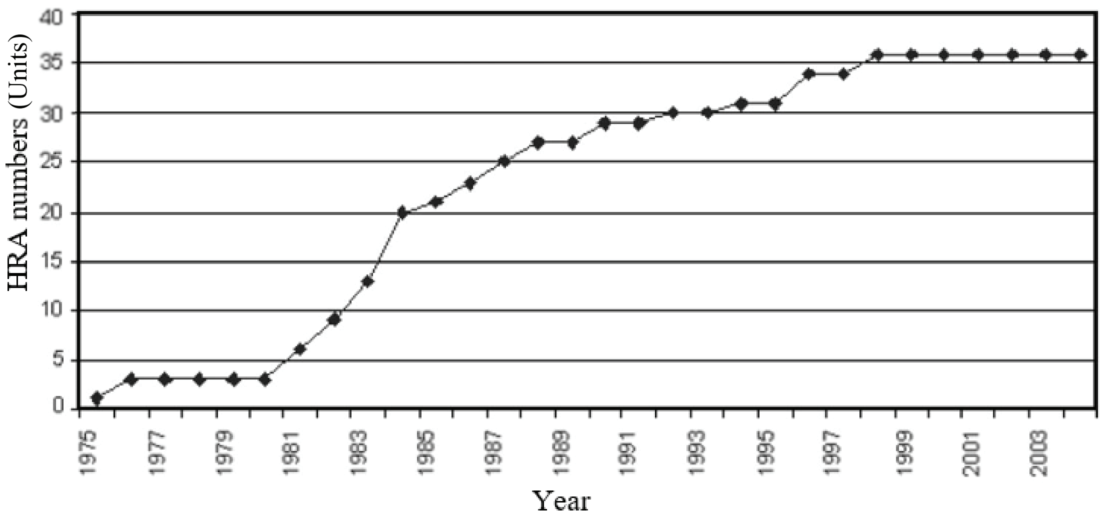


Figure 2. 3 Cumulated number of new HRA methods published by the researchers start from 1975 until 2005 (Erik Hollnagel, 2005).

However, as of recent, many industrial sectors such as the railway, airplane, medical, and maritime sectors, apply HRA to identify the errors after the accidents and arrange the mitigation process to prevent the same accidents occur in the future or making a scene of an accident to prepare the preventive actions to avoid such scenario. Therefore the development of HRA is still ongoing.

First Generation

The first generation of HRA was first developed in the 1970s. The objectives are helping risk assessors predict and calculating the likelihood of human error. Furthermore, the first-generation methods focus on the skill and rule base level of human action and are often criticized for failing to consider aspects such as the impact of context, organizational factors, and errors of commission (Bell & Holroyd, 2009). The methodologies which are included in the first generation are as follows: THERP (Technique for Human Error Rate Prediction), ASEP (Accident Sequence Evaluation Program), HEART (Human Error Assessment and Reduction Technique), and SPAR-H (Simplified Plant Analysis Risk Human Reliability Assessment).

Second Generation

This generation is carefully considered and models the influence of context on the error. Moreover, it utilizes findings and insights from the then developed cognitive movement (Boring, 2012). The development of this second generation began in the 1990s and is going to be developed even further. ATHEANA (A Technique for Human Event Analysis) and CREAM (Cognitive Reliability and Error Analysis Method) are included in the second generation.

Third Generation

The third generation is the development of the first and the second generation to some particulars industry. The previous methods were changed by adjusting the conditions in a particular industry and adding other methods to encounter their inadequacy. Many of the previous methods were developed to solve the human error in the nuclear field, while recently, many other industries are also developing rapidly and have different working conditions than the nuclear industry. The methodologies that consider to the third generation are NARA (Nuclear Action Reliability Assessment), CARA (Controller Action Reliability Assessment), RARA (Railway Action Reliability Assessment). Those methodologies are developed by modifying the HEART method in the first generation to be applied in aviation, railway and renew it to the nuclear field.

Table 2.1 shows the list of HRA that was used in practice from the 1960s to 2013. Mostly the application of these HRA is for assessing the error likelihood of Nuclear Power Plant operators since NPP is one of the complex systems and might have a high impact on the society, environment, and social economy if there is an accident occurred. However, other industries also develop rapidly in recent years, such as aviation, railway, medical health, and the maritime industry. Therefore the development of HRA is widely applied in those new sectors.

In Table 2.1, the highlighted HRA, HEART method, is one example of the development for application in other sectors. HEART method has been utilized to solve the HRA problem in NPP and develop suitable in other sectors. The examples of HEART developments are NARA (Nuclear action reliability assessment) for assessing the nuclear power plant in more detail, CARA (Controller action reliability assessment) for assessing the human error in the aviation industry, RARA (Railway action reliability assessment) for assessing the human error in the railway industry and MAHRA (Maritime Human Reliability Analysis) for assessing the human error which occurred in the port area.

Table 2. 1 Human Reliability Assessment (HRA) used in practice.

Abbreviation	Methodology	Created by
AIPA	Accident initiation and progression analysis	(Raabe, 1976)
TESEO	The empirical technique for estimating operator errors	(Bello & Colombari, 1980)
OATS	Operator action tree system	(Hall, Fragola, & Wreathall, 1982)
OHPRA	Operational human performance reliability analysis	
COGENT	Cognitive event tree	(Swain & Guttmann, 1983)
THERP	The technique for human error rate prediction	(Swain & Guttmann, 1983)
HCR	Human cognitive reliability	(Hannaman, Spurgin, & Lukic, 1984)
MAPPS	Maintenance personnel performance simulation	(Knee et al., 1984)
SHARP	Systematic human action reliability procedure	(Nus Corporation, 1984)
SLIM	Success likelihood index methodology	(Embrey, Humphreys, Rosa, Kirwan, & Rea, 1984)
STAHR	Socio-Technical assessment of human reliability	(Phillips, Humphreys, Embrey, & Selby, 1985)
ASEP	Accident sequence evaluation programme	(Swain, 1987)
CES	Cognitive environmental simulation	(Woods & Roth, 1987)
HEART	**Human error assessment and reduction technique**	**(Williams, 1988)**
BN	Bayesian network	(Almond, 1992)
COSIMO	Cognitive simulation model	(Cacciabue, Decortis, Drozdowicz, Masson, & Nordvik, 1992)
DREAMS	Dynamic reliability technique for error assessment in man-machine system	(Cacciabue, Carpignano, & Vivalda, 1993)
ATHEANA	A Technique for human error analysis	(Cooper, Ramey-Smith, & Wreathall, 1996)
CREAM	Cognitive reliability and error analysis method	(E. Hollnagel, 1998)
FACE	Framework for analyzing commission error	(Pyy, 2000)
HRMS	Human reliability management system	(Reason, 2000)
NARA	**Nuclear action reliability assessment**	(Barry Kirwan et al., 2005)
SPAR-H	Simplified plant analysis risk human reliability assessment	(Gertman, Blackman, Marble, Byers, & Smith, 2005)
CARA	**Controller action reliability assessment**	(B Kirwan & Gibson, 2009)
RARA	**Railway action reliability assessment**	(Gibson et al., 2013)
MAHRA	**Maritime Human Reliability Analysis**	(Akyuz et al., 2016)

2.3 HRA in the Maritime Industry

Maritime accidents have been a topic for many researchers to research how to reduce the number and take preventive actions because maritime accidents threaten the safety of life at sea and the shipping industry's economic performance and the environment. Therefore, assessing the situation that can lead to a collision accident is essential to be a consideration for seafarers because the human factor is the main factor leading the situation into the accident. In 80% of maritime accidents were found that human factors have been implicated in it (Soares & Teixeira, 2001). Moreover, several studies have identified human factors' contribution to maritime accidents (Graziano, Teixeira, & Guedes Soares, 2016; Sotiralis, Ventikos, Hamann, Golyshev, & Teixeira, 2016).

Table 2.2 shows the elaborative list of researches that analyzed human reliability in the maritime industry. The study upon human reliability analysis is increasing by the year since it has gained more importance in the maritime industry.

Trucco, et al. (Trucco, Cagno, Ruggeri, & Grande, 2008) used the BBN as a risk model of socio-technical systems, mainly which are related to Human and Organizational Factors (HOF) is crucial. It identified the correlation probability between a collision accident's basic events and the BBN model of the operational and organizational conditions.

Celik, et al. (Celik & Cebi, 2009) analyzed the maritime accidents by using HFACS for the qualitative analysis and integrating with Fuzzy AHP (FAHP) to quantify human contributions. In this study, an illustrative case of a boiler explosion is analyzed.

El-Ladan, et al.(El-Ladan & Turan, 2012) utilized human entropy because it characterizes and classifies all forms of human disorderliness into errors, bounded rationalities, and extraneous human endeavors. In this study, the nine most common human influencing factors in maritime and offshore accidents were identified: crew quality, training, procedure, logistics, supervision, communication, welfare, stress, and environmental conditions.

Chauvin, et al. (Chauvin, Lardjane, Morel, Clostermann, & Langard, 2013) utilized the HFACS frameworks to analyze the collision accidents reported by MAIB UK and TSB Canada. This study concludes that decision errors are the most common error in collision accidents. The error that occurred at every level is different. At the preconditioning level, operators' environmental factors, conditions, and personnel factors are the most common occurrences. At the leadership level, the most common occurrences are inappropriate operations and non-compliance with the Safety Management System (SMS).

Chen, et al. (Chen et al., 2013) also utilized the HFACS frameworks to analyze maritime accidents in relation to human and organizational factors. A case study is the Herald of Free Enterprise accident. In this study, the authors proposed HFACS – Maritime Accidents with a Why-Because Graph for analysis, providing a complement measure using HFACS. It concluded that there is an indication of the causation amongst factors and adverse influences between different levels.

Table 2. 2 Elaborative list for HRA in maritime industry.

Authors	Methodology	Topic	Publisher (Journal or Conference)
Trucco, Cagno, Ruggeri, & Grande, 2008	Bayesian Belief Network (BBN)	Maritime accident: a collision in the open sea	Reliability Engineering and System Safety
Celik & Cebi, 2009	HFACS & FAHP	Maritime accident	Accident Analysis and Prevention
El-Ladan & Turan, 2012	Human Entropy (HENT)	Maritime and offshore accidents	Reliability Engineering and System Safety
Chauvin, Lardjane, Morel, Clostermann, & Langard, 2013	HFACS	Maritime accident: collision	Accident Analysis and Prevention
Chen et al., 2013	HFACS – Maritime Accidents	Maritime accident	Safety Science
Yang, Bonsall, Wall, Wang, & Usman, 2013	CREAM & Fuzzy Bayesian	Marine engineering	Ocean Engineering
Ung, 2015	CREAM & Fuzzy CREAM	Oil Tanker	Safety Science
Akyuz & Celik, 2015	CREAM	LPG cargo loading process	Journal of Loss Prevention in the Process Industries
Akyuz, 2016	SLIM	Evacuation procedures	Ocean Engineering
Akyuz et al., 2016	HFACS, HEART & AHP	Shipboard operation	Safety Science
Xi, Yang, Fang, Chen, & Wang, 2017	CREAM & Evidential Reasoning (ER)	Collision	Ocean Engineering
Islam, Abbassi, Garaniya, & Khan, 2017	HEART	Maintenance procedures	Journal of Loss Prevention in the Process Industries
De Maya & Kurt, 2018	Fuzzy Cognitive Maps (FCMs)	Maritime accidents: grounding	The Royal Institution of Naval Architects
Lee & Chung, 2018	HSI network (based on FRAM)	Maritime accident: a capsizing and a collision	Safety Science
Zhou, Wong, Loh, & Yuen, 2018	CREAM & BN	Tanker shipping	Safety science
Uğurlu, Yildiz, Loughney, & Wang, 2018	HFACS	Passenger vessel	Ocean Engineering
Adhita & Furusho, 2019	FRAM	Maritime accident: collision	Conference
Bowo & Furusho, 2019	HEART	Maritime accident: Collision	International Journal of e-Navigation and Maritime Economy
Bowo, Prilana, & Furusho, 2019	HEART & 4M	Maritime accident: Collision	Conference
Bowo & Furusho, 2019	HEART & 4M	Maritime accident: Grounding	Journal of ETA Maritime Science

Yang, et al. (Yang, Bonsall, Wall, Wang, & Usman, 2013) combined the traditional CREAM method with a fuzzy Bayesian to quantify human error probabilities. The study's point is using the evidential reasoning to establish fuzzy IF–THEN rule bases with belief structures and employing a Bayesian inference mechanism to aggregate all the rules associated with a marine engineer’s task for estimating its failure probability.

Akyuz, et al. (Akyuz & Celik, 2015b) applied the Cognitive Reliability and Error Analysis Methods (CREAM) method to analyze the human reliability in the LPG cargo loading and discharging operations. The focus of the study was to systemically predict human error potential and determine the required safety control.

Ung (Ung, 2015) proposed a new fuzzy CREAM methodology to resolve the shortcomings of the original CREAM method. In this proposed method, the author considers every Common Performance Conditions (CPC) weight, logical improvement between the CPC and Contextual Control Mode (COCOM), and useful information deliberations.

Emre Akyuz (Akyuz, 2016) utilized the HRA method named Success Likelihood Index Method (SLIM), which combines with fuzzy sets to reduce the vagueness of expert judgments in decision-making to determine the weight of each performance shaping factors (PSF). The evacuation procedures to prevent the loss of life at sea was the object of this study.

Akyuz, et al. (Akyuz et al., 2016) utilized HFACS, HEART, and AHP to generate new multiply factors for every EPC. First, the author identifies the HFACS – EPC relationships and applying the majority rules. The EPC’s interpolation is based on expert judgment and also by analyzing 100 maritime accidents. AHP is used to determine the weight of every HFACS – EPC relationship to calculate HEP's value.

Xi, et al. (Xi, Yang, Fang, Chen, & Wang, 2017) developed the traditional CREAM with Evidential Reasoning (ER) approach and a Decision Making Trial and Evaluation Laboratory (DEMATEL) technique to overcome the limitation of CREAM in quantifying the human error probability value. The study used a case investigating the collision avoidance scenario in Shanghai coastal waters. It focuses on how seafarers’ actions were unsuccessful and concern the human element in the reliability analysis.

Islam, et al. (Islam, Abbassi, Garaniya, & Khan, 2017) used the case study of maintenance procedures of a marine engine exhaust turbocharger and condensate pump on an offshore oil and gas facilities. The authors applied the HEART method to analyze and quantify the HEP value. To determine the weight of the Assessed Proportion Effect, the authors used questionnaires to the seafarers to determine the rating of each activity. In conclusion, extreme weather, extreme workplace temperature, high ship motion, high level of noise and vibration, and work overload and stress increase the probability of human error and potential accidents.

Lee, et al. (Lee & Chung, 2018) proposed a methodology based on the FRAM method named Human-System Interaction (HSI). This method aims to improve the interaction with crew network level by defining the relation between the system function with FRAM and the crew network as the link type. The author applied this proposed method to analyze the capsizing case of MV Herald of free enterprise and the collision case of MT Hebei spirit. The authors found that the system and the human network for supporting the work are insufficient. This method is a semi-quantification method.

Maya, et al. (De Maya & Kurt, 2018) proposed a new modeling and simulation approach on Fuzzy Cognitive Maps (FCMs) to assess the factors that cause grounding accidents. The FMCs calculates and evaluates the individual weight of human and technical factors.

Zhou, et al. (Zhou, Wong, Loh, & Yuen, 2018) applied the fuzzy and Bayesian CREAM model for HRA. The objective is to evaluate human reliability in the shipping operation. The authors combined the CREAM, BN, and fuzzy logic theory to overcome the limitations of the data imprecision and subjectivity of the analysis. The tanker shipping industry is chosen as the object of this study.

Uğurlu, et al. (Uğurlu, Yildiz, Loughney, & Wang, 2018) utilized HFACS for passenger vessel accidents and developed the methods, HFACS-PV. The proposed method facilitates analyzing the human factors in passenger vessel accidents, and the operational condition level has been defined as well.

Adhita, et al. (Adhita & Furusho, 2019) analyzed the collision of the ship in Japan and Indonesia by utilizing the FRAM model. In the collision cases, it was concluded that watchkeeping and bridge to bridge communication has to be improved. This research was only conducted in the qualitative method.

Bowo, et al. (Bowo & Furusho, 2019a) applied the HEART method, which is a scarce method to apply in the maritime industry, to analyze the maritime collision in Japan and Hong Kong. The authors compared the human reliability in collision accidents according to the most common generic task, error producing condition (EPC), and the human error probability (HEP) value. The most common generic task in Japan and Hong Kong is different, and there was more EPC in the Hong Kong case, which was less than in Japan. However, there was a limitation in this study, the EPC is still general, and the HEP calculation needs an additional method to overcome the subjectivity. Furthermore, Bowo, et al. (Bowo & Furusho, 2019c; Bowo, Prilana, & Furusho, 2019) developed more the HEART method by combining it with the 4M (Man, Machine, Media and Management) framework. This hybrid method made a categorization of the 38 EPC that has been established into each factor. The aim of this categorization is to focus on human-related other factors that are commonly causing accidents. This categorization is helpful in understanding how mitigation action should be performed first to overcome it.

In light of the above explanation of the development of HRA in the ten years period, 2008 to 2018, particularly in the maritime transportation industry, the following significant aspects are revealed:

1. HRA development in the maritime transportation industry is still scarce.
2. The quantification process of human error probability in the current HRA does not provide a consistent approach.

3. There is no explanation of the interdependencies among the factors, whereas, in the maritime transportation industry, every factor is related to one another.
4. Apparently, it is a limited number of HRA that focus on human error in navigation operation since the seafarers in navigation bridge are the important people to take judgment for the ship safety.
5. The data that was used in most research of HRA in maritime transportation was segmented in a certain area only.
6. It would be a significant advantage for maritime stakeholders to analyze human reliability in the maritime transportation industry.

Therefore, it is necessary to develop a new approach to assess human reliability in maritime transportation, particularly focus on the seafarers in bridge navigation. The objectives of this study are to investigate the potential navigational likelihood of maritime accidents across countries and to propose a hybrid maritime accident analysis to enhance safety at sea. The next chapter introduces the concept of the new approach of HRA in maritime transportation, named MAART (Maritime Accident Analysis and Reduction Technique).

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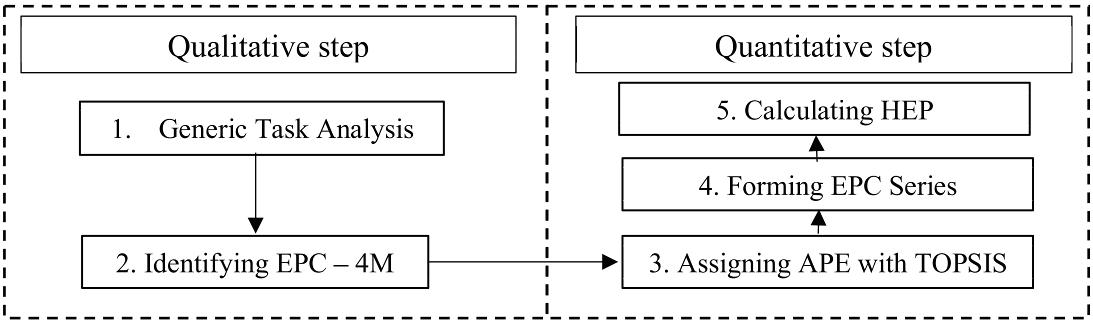
CHAPTER 3
MARITIME ACCIDENT ANALYSIS AND REDUCTION TECHNIQUE (MAART)

3.1 Conceptual Framework

Maritime Accident Analysis and Reduction Technique or in the abbreviation is MAART, which is a new proposal of maritime accident analysis that focuses on human factors and their relation with other factors such as management, machinery, and environment. The influence of management, machinery condition, and environment situation can impact how human behavior and making the judgment, which might be different on every occasion. Therefore, it is essential to consider the role of management, machinery, and the maritime human reliability assessment environment.

In the MAART method, there are two steps of processing the data. The first one is a qualitative step and followed by a quantitative step. In the qualitative step, the data which can be formed accident data report from the maritime agency or direct interview with the ship crews first has to be determined the generic task analysis. After that, the assessor has to identify the EPC – 4M that occurred in the series of misconduct or misjudgment situations that can lead the situation to more dangerous and the accident occurred. EPC – 4M is a categorization of 38 EPC into man, machine, media, and management.

After obtaining the qualitative step's information, the next step is calculating the Human Error Probability (HEP) in the quantitative step. To obtain the HEP, first, all the EPC obtained have to weigh the Assessed Proportion Effect (APE) by utilizing TOPSIS. Then, the EPC series will be formed to know which EPC and 4M factors have the weightiest impact on the accident. It can help the assessors or maritime researchers determine the mitigation action by knowing the worst cause of the accidents. Furthermore, finally, HEP can be calculated. More explanation about the methodologies used to develop the MAART method will be explained in the following sections.



Remarks:
EPC: Error Producing Conditions
APE: Assessed Proportion Effect
TOPSIS: Technique for Order Preference by Similarity to Ideal Solution
HEP: Human Error Probability

Figure 3. 1 MAART Conceptual Framework.

3.2 Methodological Background

(1)HEART

Human Error Assessment and Reductive Technique (HEART) methodology is the first generation of Human Reliability Assessment (HRA), which developed in the 1980s and focused on the skill and rule base level of human action (Bell & Holroyd, 2009). The HEART methodology was first developed to assess the accidents in the nuclear power plant by William (Williams, 1988). Besides nuclear power plant (Barry Kirwan et al., 2005), HEART methodology has been developed to analyze the various type of industry such as the railway industry (Gibson et al., 2013), aviation (B Kirwan & Gibson, 2009), and maritime operation (Akyuz et al., 2016). In this study, the author utilized the HEART methodology for assessing various kinds of maritime accidents.

HEART methodology is a versatile, quick, and simple human reliability methodology (Bell & Holroyd, 2009). Therefore, this methodology is easy to understand. There are two stages of HEART methodology, the first stage is the qualitative method, and the second stage is the quantitative method. The qualitative method comprises obtaining the Generic Task (GT) and obtaining the details of accidents to Error-Producing Conditions (EPC). Then followed by the quantitative method to calculate the Human Error Probability (HEP).

In the light above, the calculation formula to determine the value of HEP is shown below;

$$HEP_{value} = NHU \times \left\{ \prod_{i} (EPC_i - 1)APE_i + 1 \right\} \quad (1)$$

Where NHU is the error probability value of relevant GT, and EPC_i is the ith (i = 1,2,3, ···n) error producing condition, Assessed Proportion Effect (APE) is a weight that corresponds to the importance of every EPC. More important, the EPC influence in the case, the value of APE will be higher.

HEART application overview

Besides the HEART method, thereafter, numerous HRA methodologies started to propose in order to analyze human error and reliability, such as Technique for Human Error Rate Prediction (THERP) proposed by Swain (Swain, 1963). This methodology aims to analyze human reliability dealing with task analysis, failure definition, and quantification of HEP values. Standardized Plant Analysis Risk-Human reliability (SPAR-H) was introduced by the US Nuclear Regulatory Commission (NRC) in 1994 and developed by Jensen et al. (Jensen & Nielsen, 2007). The developed methodology is unlike the traditional HRA approach because this methodology contains the dependency between the different Performance Shaping Factors (PSF) and cohesive actions in a direct way.

Since HEART methodology has successfully been modified in various types of industries, applications in the maritime industry are still few. For instance, Deacon et al. (Deacon et al., 2013) applied the HEART methodology to enhance offshore evacuation procedures. In the paper, the author the HEP values for critical steps in three conditions, emergency escape, evacuation, and rescue process in the offshore platform. A similar methodological approach has been applied to analyze and determine the HEP values of a condenser pump installed in single buoy moorings (SBM) in the offshore platform during the maintenance process (Noroozi, Khan, Mackinnon, Amyotte, & Deacon, 2012). Furthermore, Akyuz et al. (Akyuz & Celik, 2015a) provide the methodological extension through the integration of the Analytic Hierarchy Process (AHP) technique into the HEART methodology to analyze the cargo tank cleaning operation onboard chemical tanker ships. Besides, Akyuz et al. also produced marine-specific EPC values (m-EPC) following an advanced methodological framework by combining the HEART methodology with Human Factors Analysis and Classification System (HFACS) and AHP (Akyuz et al., 2016). However, Bridge Resource Management (BRM) analysis by utilizing HEART methodology in the accident situation is still scarce.

(2) 4M framework

4M factors are one method for finding the causal factors of accidents. The 4M factors consist of Man, Machine, Media, and Management. 4M was first introduced by the

National Transportation Safety Board (NTSB) of the United States of America. The 4M factors method has been utilized to analyze various kinds of accidents in different industries, such as railway (Chiba, Aonuma, & Kusugami, 2003), aviation (Miller, 1991), and maritime industry (Mutmainnah & Furusho, 2016). Those implementations are using modified 4M factors since the basic concept of 4M factors is very widely adaptable. 4M factors provide a basic framework to assess the accident case causes and determine the relationships among the factors that create such a condition, which can lead to an accident.

Related to these 4M factors, some modifications that have been introduced are as follows; Chiba et al., introduced the 4M4E analysis to address the contributing factors related to the human factors in a multifaced manner and perspective in the railway's accident (Chiba et al., 2003). 4M4E consists of 4M, man, machine, media, management, and 4E, education, engineering, environment, and enforcement. In the aviation industry, instead of 4M, the 5M model is applied to analyze accidents. The 5M consists of man, machine, media, management, and mission. This model was proposed by NTSB (Miller, 1991).

There are also developments in the 4M model in the maritime industry. IM-Model focuses on the relationship between 4M to I as an individual (Furusho, 2013). In addition, IM-Model's concept is divided into three concepts, subjective concept, intermediate concept, and external concept. The most recent development of the 4M factor methodology is the 4M overturned pyramid (MOP) model. In this model, 4M factors are described as an overturned pyramid, where the factor 'man' is placed at the bottom as a stabilizer for other factors (Bowo et al., 2017; Mutmainnah, 2014, 2017; Mutmainnah & Furusho, 2016). This model's basic idea is that man (human) is a decision-maker and represents the most critical factor that can influence other factors. The definition of 4M factors used in this study shows in Table 3.1.

Table 3. 1 4M Factors definition (Mutmainnah & Furusho, 2016).

Factor	Definition
Man	All human elements affect human performance while performing their tasks.
Machine	All technology helps humans to perform their tasks correctly and satisfactorily.
Media	The environment and social conditions that affect the system and human.
Management	All elements control the system and human, such as rules, procedures.

4M application overview

A 4M Overturned Pyramid (MOP) model consists of the Man, Machine, Media, and Management (4M) factors arranged into a 3-sided inverted pyramid, as seen in Figure 3.2. The pyramid has four corners that represent each 4M Factor. The man should always be at the bottom because it is the core of the system. Between 2 factors, there is a line that connects to other factors, as the edge of an inverted pyramid, showing the relationship between 2 factors. In the MOP model, the stability of the overturned-pyramid has to be maintained among factors to keep the system safe.

This model is applied to a Maritime Transportation System (MTS) by defining each Factor, as outlined in Table 3.1. Control is needed in order to reduce the number of accidents. The MOP model can be utilized using two steps, using Corner Analysis (CA) and then applying Linear Relationship Analysis (LRA). In CA, all failures that caused accidents are listed and classified into 4M based on each corner of the MOP model's definitions. We then count the number of failures after all reports are analyzed. The failures listed are the causative factors (CFs), which are the outcome of this step. In the next step, the relationship among all the CFs listed in the corners of the MOP model is explored because CFs listed in the CA results do not only belong in one corner. By performing LRA, we can know which linear relationship is the most vulnerable to failure.

The outcome of the LRA step is Causative Chains (CCs). CA identifies which CF caused the accident, which CFs were repeated, how many times those CFs occurred, and which CF was the leading cause of the accident. LRA provides the connections, identifies what the CFs lead to, as well as the subsequent CF(s), the repeated and significant CF, what CFs form CC, and how many CCs occurred. Research has also found that CCs have heads, a core, and tails (Mutmainnah, 2017).

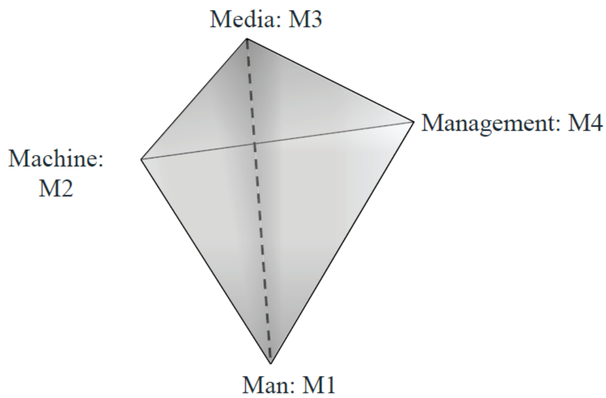


Figure 3. 2. MOP Model Pyramid.

(3)TOPSIS methodology

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision-making tool. TOPSIS was introduced in 1981 by (Hwang & Yoon, 1981), and it has been used widely for complex decision-making problems in various domains. TOPSIS aims to calculate the importance-weight of alternatives through the similarity with the ideal solution (Krohling & Pacheco, 2015; Olson, 2004). TOPSIS comprises a set of processes.

TOPSIS application overview

The first process is to construct the pair-wise comparison matrix. The Saaty's 1 – 9 linguistic relative importance scale is used (Saaty, 1985).

Table 3. 2 Saaty's pair-wise comparison scale.

Importance scale	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	Extreme importance
9	Absolute extreme importance
2, 4, 6, 8	Intermediate values

1. A pair-wise comparison matrix (D) can be established in accordance with formula (2). In the formula, x_{ij} (i= 1, 2, …, m, j = 1, 2, …, n) has the relative importance of *i*th elements compared to the *j*th. In this study, every selected EPC will be compared to other selected EPC, to determine the interdependencies of every EPC. By comparing this EPC, it can be known that every EPC is related to each other, and there will be a tendency for an EPC to be a major factor in an accident.

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} x_{ii} = 1, \quad x_{ij} = 1/x_{ji},\ x_{ji} \neq 0 \quad (2)$$

2. Construct the normalized decision matrix and weighted.

   a. Normalized decision matrix

   To construct the normalized decision matrix, first, the attribute weight (w_i) for each EPCi has to be obtained by utilizing formula (3).

$$w_i = \sqrt{\sum_{i=1}^{m} x_{ij}^2} \quad (3)$$

   After obtaining the attribute weight, then construct the normalized decision matrix (r_{ij}) by dividing the value from the pair-wise comparison matrix to the attributes weight, as shown in the formula (4).

$$r_{ij} = \frac{x_{ij}}{w_i} \quad (4)$$

b. Weighted normalized decision matrix

$$p_{ij} = r_{ij} \times x_{ij} \quad (5)$$

3. Determine the ideal and negative ideal solution.

   a. Ideal solution

$$d_{ij}^{+} = (p_{ij} - p_{i\,max})^2 \quad (6)$$

   b. Negative ideal solution

$$d_{ij}^{-} = (p_{ij} - p_{i\,min})^2 \quad (7)$$

4. Determine separation from the ideal solution.

$$d_i^{+} = \sqrt{\sum_{j=1}^{n}(d_{ij}^{+})^2} \quad (8)$$

5. Determine separation from the negative ideal solution.

$$d_i^{-} = \sqrt{\sum_{j=1}^{n}(d_{ij}^{-})^2} \quad (9)$$

6. Relative closeness to ideal solution.

$$\xi_i = \frac{d_i^{-}}{d_i^{+} + d_i^{-}} \quad (10)$$

7. Normalization.

   Because the summation of all the EPC ideal solution value is not one and often more than one and even less than 1, so it needs to be normalized before using this value in the HEP calculation, the last value that is used in the HEP calculation is the normalization value (N) to be the weight in the Assessed Proportion Effect (APE). This value shows which EPC has the highest values of weight, which implicate the main factors of the accident because its particular EPC is the essential EPC compared with other EPC. If the weight is approved, then it can be used for the HEP calculation. Therefore, in this study, the highest value of EPC is named Top of EPC series. Formula (11) shows the calculation formula for the Normalization value.

$$\mathrm{N} = \frac{\xi_i}{\Sigma\,\xi} \quad (11)$$

8. Consistency check

The next step is to prove consistent data. This step is to check whether the comparison pair-wise matrix is consistent or not. The following formula can calculate the consistency index (CI).

$$\sum_{j=1}^{n} x_{ij} N = \lambda_{max} N_i \quad (12)$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (13)$$

A consistency check calculation is needed to specify reasonable consistency. The CR value will be ≤ 0.10. Otherwise, the expert judges will be revised to get a consistent result.

$$CR = \frac{CI}{RI} \quad (14)$$

In the equation, RI stands for random index (RI). It is subjected to the number of items that are compared in the matrix. The RI value table is provided in Table 3.3.

Table 3. 3 Random index value (Saaty, 1994).

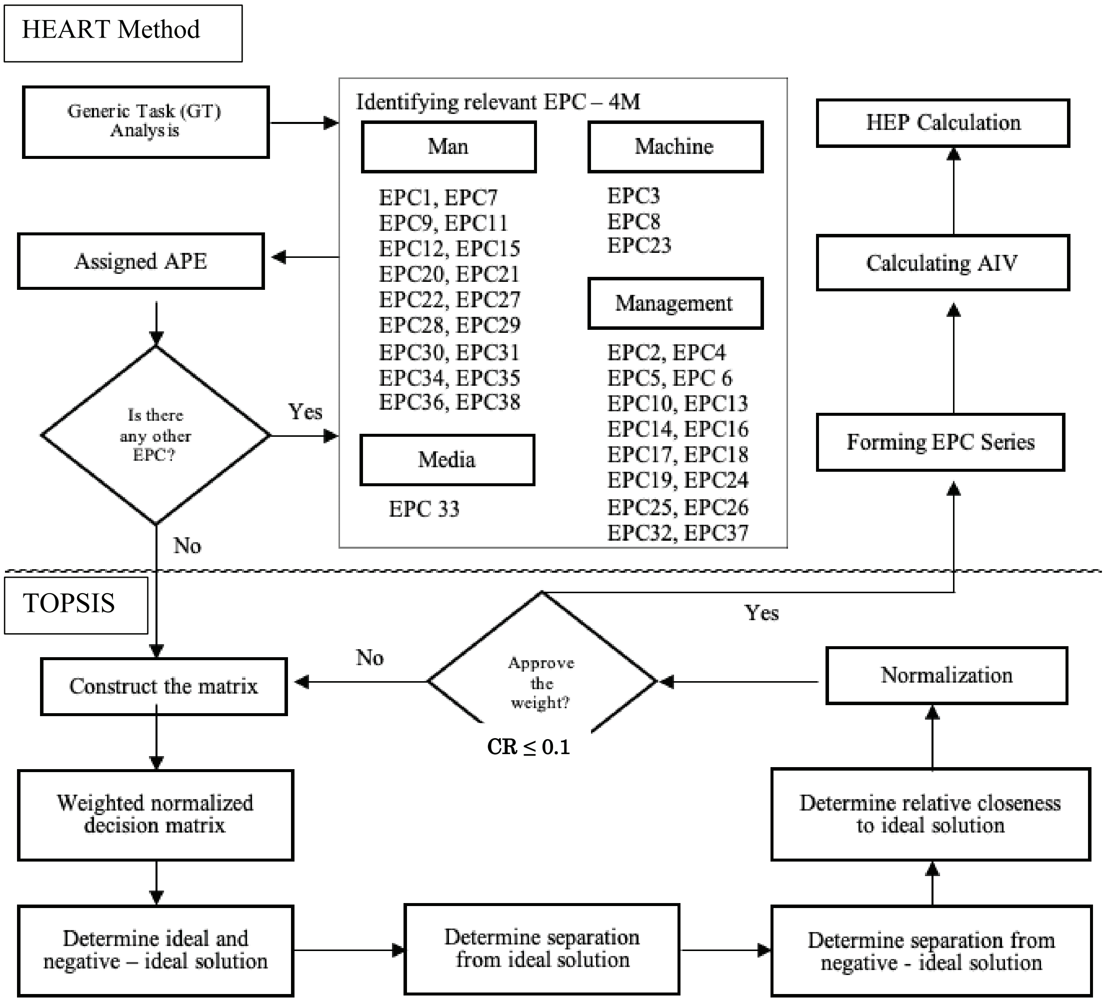
n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

3.3 System Application

Figure 3.3 shows all processes to utilize the MAART methodology from a qualitative step to a quantitative step. All detailed information will be explained in the following paragraphs.

(1)Evidence-based data and information

A systematic accident database was generated in Microsoft Excel by tabulating the accident data into a textual format. The information in the database included the following information: Accident date and year, time of the accident, accident location, name of the ship involved, type of ship, technical specifications of the ship (gross tonnage, deadweight total), weather and environmental information at the time of occurrence, accident severity, as well as the number of fatalities/injuries, environmental damage, ship damage, accident causes.



Remarks:
EPC: Error Producing Conditions
APE: Assessed Proportion Effect
AIV: Assessed Impact Value
HEART: Human Error Assessment and Reduction Technique
TOPSIS: Technique for Order Preference by Similarity to Ideal Solution
HEP: Human Error Probability

Figure 3. 3 The process of the proposed Maritime Accident Analysis and Reduction Technique (MAART).

(2)Generic task classification

After extracting the data information from the maritime accident reports, then applied the HEART–4M method. The first stage was the qualitative stage, in which the generic task was obtained, and a Nominal Human Unreliability (NHU) value was assigned. By assigning the generic task, the researcher can determine whether the accident occurred due to a difficult task that needs a lot of concentration and specialized skill to do or whether it occurred as a result of daily routine activities that the seafarer is already familiar. The more numerous and more accessible the work carried on by the seafarers, the lower the NHU. Because the tasks are not typically the same, the researcher had to decide how to define the task and classify it accordingly (B Kirwan, 1996).

Nine generic tasks were used in this study. Each generic task had an NHU between the 5th and 95th percentiles as lower and upper probability boundaries, respectively (B Kirwan, 1996). The applicability of the proposed NHU is based on the researchers' experience, but Williams (Williams, 1986) provided a mean number to use if the assessor is unable to determine the exact number of the proposed NHU to analyze the task. The average NHU number is used in the Human Error Probability (HEP) calculation. The influence of weather and traffic conditions on the working situation onboard is also considered. Table 3.4 shows the Generic Tasks and NHU that applied in this study.

Table 3. 4 Generic Tasks (GT).

Generic Tasks (GT)			
Code	**Type of work**	**Condition**	**NHU**
A	Totally unfamiliar	Works performed at speed with no real idea of likely consequences.	0.55000
B	Restore the system to an original state on a single attempt	Doing it without supervision or procedures.	0.26000
C	Complex task	Task requires a high level of comprehension and skill.	0.16000
D	A fairly simple task	Works performed rapidly or given scant attention.	0.09000
E	The routine, highly practiced, rapid task	Works involving a relatively low level of skill.	0.02000
F	Restore a system to original	An error occurred even though following procedures with some checking.	0.00300
G	Entirely familiar, highly practiced, routine task occurring several times per hour, performed to highest possible standards by a highly motivated, highly trained, and experienced person, totally aware of implications of failure, with time to correct the potential error	However, without the benefit of significant job aids.	0.00040
H	Respond correctly to the system command	Even when there is an augmented or automated supervisory system providing an accurate interpretation of the system stage.	0.00002
M	The miscellaneous task for which no description can be found.		0.03000

If the weather and ship traffic conditions deteriorate, a simple routine task could become a complicated task because of the unfamiliar conditions. The generic task information in Table 3.4 consists of generic task code, type of work, working conditions, and the NHU used in the HEP calculation. Here, generic tasks' descriptions are different from generic tasks in general because there is a lengthy explanation of the generic task, divided into the type of work and the working conditions. This division can make it easier to determine which generic task is most suitable for the investigated situation.

(3)Identifying relevant EPC – 4M

There are 38 EPC that has been established by William (B Kirwan, 1996; Williams, 1988), which are formed by human factors that are commonly found as the cause of Nuclear Power Plant accidents. However, due to the differences in the working environment, it is necessary to categorize it to be more detailed according to 4M factors, man, machine, media, and management. This categorization aims to make it easily understandable from which perspective the cause has commonly occurred because it might be essential to determine the mitigation action based on which factor.

The tables below consist of the 4M categorization, the EPC that is categorized in the factors, the multiplier that belongs to every EPC, and the explanation of the EPC.

Man factors

Human error is a significant factor in maritime accidents (Uğurlu et al., 2018). Human fatigue and task omission are closely related to situational awareness (Bowo & Furusho, 2018). Man factors are defined as all human elements that affect human behavior and performance while performing tasks. There are 18 EPC that categorized in the man factors, as shown in Table 3.5. furthermore, the man factors have five subfactors: experience, skill, and knowledge, phycological, physical, and health.

The experience subfactors show the ability and familiarity that the seafarers already have due to frequent practice of the tasks. There are 3 EPC that categorized into this subfactor, EPC 1, EPC 12, and EPC 22.

Skill and knowledge subfactors describe the information had by the seafarers from their training and education to encounter particular dangerous conditions on board. Five EPC are categorized in skill and knowledge subfactors, EPC 7, EPC 9, EPC 11, EPC 15, and EPC 20.

It is essential to consider the psychological condition of the seafarers' onboard operation. Due to a long time of sailing, the environmental condition, far from family, and workload, it can affect seafarer psychological condition and influence their performance at work. There are five EPC for this subfactor, EPC 21, EPC 28, EPC 29, EPC 31, and EPC34.

The seafarer requires good physical ability to work safely and effectively onboard. Because working beyond physical capabilities can lead to a dangerous situation. Therefore, the onboard workload operation has to be measured well to keep the voyage safe. The EPC in these subfactors is EPC 27, EPC 36, and EPC 38.

Before working on board, the seafarer has to make sure that they are in a healthy condition for working. However, the sailing condition might affect seafarer health conditions, such as sleep cycle disruption and other ill-health conditions. This bad health condition can lead the seafarer to misjudge the situation and take the wrong action in a critical situation. The consumption of medicine also can affect the seafarer's behavior.

Table 3. 5 EPC – 4M, Man Factors.

Man factors			
1. Experience			
EPC 1	Unfamiliarity	17	Unfamiliarity with a situation that is potentially significant but occurs infrequently or which is novel
EPC 12	Misperception of risk	4	Misperception of an object, threat, or situation creates an unsafe situation
EPC 22	Lack of experience	1.8	Little opportunity to carry out the work and to train
2. Skill and Knowledge			
EPC 7	Irreversibility	8	No means of doing an unintended action
EPC 9	Technique unlearning	6	A need to learn a technique to support work
EPC 11	Performance ambiguity	5	Ambiguity in the required performance standards
EPC 15	Operator inexperience	3	A newly qualified seafarer
EPC 20	Educational mismatch	2	A mismatch between the educational achievement level and the requirements of the task
3. Psychological			
EPC 21	Dangerous incentives	1.8	An incentive to use dangerous procedures
EPC 28	Low meaning	1.4	Individual shows little or no intrinsic meaning in the work
EPC 29	Emotional stress	1.3	High level of emotional stress
EPC 31	Low morale	1.2	Individual shows low workforce morale
EPC 34	Low mental workload	1.1	Prolonged inactivity or highly repetitious cycling
4. Physical			
EPC 27	Physical capabilities	1.4	Working beyond physical capabilities that may cause danger
EPC 36	Task pacing	1.06	Unfocused and ineffective working situation due to lack of human resources and intervention of others
EPC 38	Age	1.02	Age of personnel performing perceptual works
5. Health			
EPC 30	Ill-health	1.2	Evidence of ill-health, fever, stomachache
EPC 35	Sleep cycle disruption	1.1	Disruption of normal work-sleep cycles

Machine factors

Machine factors include the equipment, machinery, instruments, and facilities that support humans to perform their tasks correctly and satisfactorily. Table 3.6 shows the EPC that include in the machine factors.

Table 3. 6 EPC – 4M, Machine Factors.

Machine factors			
EPC 3	Low signal-noise ratio	10	A low signal to noise ratio
EPC 8	Channel overload	6	A channel capacity overload, particularly one caused by simultaneous presentation of non-redundant information
EPC 23	Unreliable instruments	1.6	The unreliable instrument, machinery, and technology to support the work

Management factors

Working on the ship on board is not an individual task, but it needs good teamwork to safely and effectively achieve sailing. The International Safety Management (ISM) Code has addressed management's influence in maritime accidents (IMO, 1993). In the early 1990s, Bridge Resource Management (BRM) was adopted in the maritime industry as a safety and error management tool, according to the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (the STCW Convention) in 2010, Reg. A-II/1. BRM regulates good coordination and communication flow on the bridge among seafarers in order to conduct safe sailing. Ineffective coordination and communication might cause much misunderstanding in the bridge. Therefore it is essential to keep the good BRM. The details of EPC in the management factors are shown in Table 3.7 below.

Table 3. 7 EPC – 4M, Management Factors.

Management factors			
1. Coordination			
EPC 2	Time shortage	11	A shortage of time available for error detection and correction
EPC 6	Model mismatch	8	A mismatch between a seafarer's model and that imagined by the designer
EPC 24	Absolute judgments required	1.6	A necessity for absolute judgments, which are beyond the capabilities or experience of an operator
EPC 25	Unclear allocation of function	1.6	Obscurity in allocating function and responsibility
EPC 37	Supernumeraries/ lack of human resources	1.03	Additional team members over or lack of team member, those necessary to perform the task regularly and satisfactorily
2. Rules and procedures			
EPC 4	Features over-ride allowed	9	A means of overriding information or features
EPC 5	Spatial and functional incompatibility	8	No means of conveying spatial and functional information to seafarer in a form which they can readily assimilate
EPC 32	Inconsistency of displays	1.2	Inconsistency meaning of procedures
3. Communication			
EPC 10	Knowledge transfer	5.5	The need to transfer specific or essential information from task to task without loss
EPC 13	Poor feedback	4	Ambiguous system feedback, the language barrier
EPC 14	Delayed/incomplete feedback	3	No explicit direct and timely confirmation of an intended action from the portion of the system over which control is to be exerted
EPC 16	Impoverished information	3	Inadequate quality of information conveyed by procedures and person-person interaction
EPC 18	Objectives conflict	2.5	A conflict between immediate and long-term objectives
EPC 19	No diversity of information	2.5	No diversity of information input for veracity checks
4. Monitoring			
EPC 17	Inadequate checking	3	Little or no independent checking of output
EPC 26	Progress tracking lack	1.4	No effort to keep track of progress during the work

There are 16 EPC categorized in the management factor, which then differed again into four subfactors, coordination, rules and procedures, communication, and monitoring. In the coordination subfactor, five EPC are categorized it. These subfactors define seafarers' ability to manage the time and human to do the task optimally and safely. EPC 2, EPC 6, EPC 24, EPC 25, and EPC 37 are categorized in the coordination subfactor. Working on a ship onboard, which has a limited working area and complex system operation, needs many rules and procedures for every task and condition in order to be able to conduct the task safely. Besides, those rules and procedures have to be familiarized to all seafarers on board. There are three EPC categorized into this subfactor, EPC 4, EPC 5, and EPC32.

Keeping good communication on the bridge is essential. The communication that conducts onboard has to be straightforward and easy to understand for all the crews. Therefore English is an international language to use in maritime navigation. Communication on the bridge is between the master and the officer, but it also includes ship to ship communication, ship to VTS, master and pilot communication. There are six EPC that relate to the communication problems, EPC 10, EPC 13, EPC 14, EPC 16, EPC 18, and EPC 19.

Keeping the seafarer's focus and attention to maintain the watchkeeping is a must to do during the voyage. Therefore, monitoring the ship’s condition is essential. Checking the ship’s status and always maintaining the ship’s progress is essential to keep the ship’s safe. EPC 17 and EPC 26 are including in the monitoring subfactor.

Media factors

Environmental conditions can be a significant factor in an accident (Reinach & Viale, 2006). The natural environment is the natural condition faced by the ship during her voyages, such as weather, wind, fog, tide, and all-natural conditions that can significantly affect ship stability and maneuverability and the bridge team's ability to control the ship. The EPC included in media factors is EPC 33 poor environment, as shown in Table 3.8.

Table 3. 8 EPC – 4M, Media Factors.

Media factors			
EPC 33	Poor environment	1.15	Bad weather, poor visibility, high-traffic density, poor working space condition

(4)Assigned APE

In this section, the authors take one of the cases to be the calculation example of this proposed method. The following calculation description is from case number one, with details as follows; this accident occurred on May 22nd, 2009, at 17:28 in Madura Strait, Surabaya. At that time, the weather condition was fine weather, calm winds, and currents of 1.8 knots from the West. This accident involved two ships, container ships with 5,283 Gross Tonnage and general cargo with 8,639 Gross Tonnage. However, the accident report on NTSC only reported about the container ship condition. Therefore, the analysis of case number one only assessed one ship.

In case one, there are five EPC selected to consist of EPC 11, EPC 21, EPC 12, EPC 29, and EPC 1. From this EPC to know the APE weight of every EPC, these data are processed using TOPSIS, as follow;

1. A pair-wise comparison matrix (D)
   After selecting the EPC that causes accidents in the accident report, the next step to calculate the APE wight value is to construct the pair-wise comparison matrix, as shown in Table 3.9. The matrix is comparing every EPC that is selected by putting the importance scale and using formula (2) for calculating the proportion. The attribute weight (w_i) also calculated in this table by using formula (3). The attribute weight value will be used in the next step to construct the normalized decision matrix.

Table 3. 9 Pair-wise comparison matrix and attributes weight (w_i).

	EPC11	EPC21	EPC12	EPC29	EPC1	w_i
EPC11	1	0.3333	3	3	0.5000	4.4000
EPC21	3	1	0.2000	0.3333	0.2500	3.2000
EPC12	0.3333	5	1	0.2000	0.3300	5.1200
EPC29	0.3333	3	5	1	0.2500	5.9300
EPC1	2	4	3	4	1	6.7800

2. Construct the normalized decision matrix and weighted.

a. Normalized decision matrix
   After calculating the attribute weight (w_i), then constructing the normalized decision matrix, Table 3.10, by utilizing the formula (4).

Table 3. 10 Normalized decision matrix.

	EPC11	EPC21	EPC12	EPC29	EPC1
EPC11	0.2300	0.0800	0.6800	0.6800	0.1100
EPC21	0.9400	0.3100	0.0600	0.1000	0.0800
EPC12	0.0700	0.9800	0.2000	0.0400	0.0700
EPC29	0.0600	0.5100	0.8400	0.1700	0.0400
EPC1	0.2900	0.5900	0.4400	0.5900	0.1500

b. Weighted normalized decision matrix
   In the weighted normalized decision matrix, in Table 3.11, it is determined the maximum weight ($p_{i\,max}$) and the minimum weight ($p_{i\,min}$) for every EPC. The maximum weight will be used to calculate the ideal solution matrix, and the minimum weight will be used for the negative – ideal solution matrix.

Table 3. 11 Weighted normalized decision matrix.

	EPC11	EPC21	EPC12	EPC29	EPC1	MAX	MIN
EPC11	0.2300	0.0300	2.0500	2.0500	0.0600	2.0500	0.0300
EPC21	2.8200	0.3100	0.0100	0.0300	0.0200	2.8200	0.0100
EPC12	0.0200	4.8800	0.2000	0.0100	0.0200	4.8800	0.0100
EPC29	0.0200	1.5200	4.2200	0.1700	0.0100	4.2200	0.0100
EPC1	0.5900	2.3600	1.3300	2.3600	0.1500	2.3600	0.5900

3. Determine the ideal and negative ideal solution.

a. Ideal solution matrix and separation from the ideal solution d_i^+.
The ideal solution is the maximum limit that can be reached for every EPC from the calculation, as shown in Table 3.12.

Table 3. 12 Ideal solution matrix and separation from the ideal solution d_i^+.

	EPC11	EPC21	EPC12	EPC29	EPC1
EPC11	3.3100	4.0800	0.0000	0.0000	3.9500
EPC21	0.0000	6.2700	7.8600	7.7400	7.8200
EPC12	23.5900	0.0000	21.9300	23.7200	23.5900
EPC29	17.6100	7.2800	0.0000	16.3800	17.6800
EPC1	3.1300	0.0000	1.0600	0.0000	4.8900
d_i^+	23.8200	8.8100	15.4300	23.9200	28.9700

b. Negative ideal solution matrix and separation from the negative ideal solution d_i^-.
The negative ideal solution is the minimum value that can be reached for every EPC from the calculation, as shown in Table 3.13.

Table 3. 13 Negative ideal solution matrix and separation from the negative ideal solution d_i^-.

	EPC11	EPC21	EPC12	EPC29	EPC1
EPC11	0.0400	0.0000	4.0800	4.0800	0.0009
EPC21	7.8600	0.0900	0.0000	0.0000	0.0000
EPC12	0.0000	23.7200	0.0400	0.0000	0.0000
EPC29	0.0000	2.2700	17.6800	0.0200	0.0000
EPC1	0.0000	3.1300	0.5400	3.1300	0.2000
d_i^-	3.9500	14.6100	11.1700	3.6200	0.1000

4. Relative closeness to ideal solution and Normalization
After getting the result of the ideal and negative ideal solution, the relative closeness to the ideal solution must be calculated using formula (10). Because the summation of all the relative closeness to the ideal solution is more than 1 in this example, it needs to be normalized in order for the total of the weight will be one. Table 3.14 shows the value f relative closeness to the ideal solution and its normalization value.

Table 3. 14 Relative closeness to ideal solution and Normalization.

	EPC11	EPC21	EPC12	EPC29	EPC1	Total
ξ_i	0.1400	0.6200	0.4200	0.1300	0.0034	1.3200
N	0.1100	0.4700	0.3200	0.1000	0.0026	1.0000

5. Consistency check
Before using the normalization value to the HEP calculation, the consistency of the value given in the pair-wise comparison matrix has to be checked. The consistency

index (CI) can be calculated by the formula (12), as shown in Table 3.15. Random Index (RI) value has been established by Saaty because in this case, the number of EPC found was five; the RI assigned for calculating the CR is 1.1086. The parameter is if CR ≤ 0.1, the normalization can be accepted and used in the HEP calculation.

Table 3. 15 Consistency check.

CI	RI	CR
0.0700	1.1086	0.0610

(5)Forming EPC series

After calculating APE's value with the TOPSIS method, it generates the sequence of EPC series by the highest value of APE. Table 3.16 shows the new sequence of the EPC series, from the highest impact to the accidents until the least impact.

Table 3. 16 EPC series.

TOP		BODY							
EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE
21	0.4700	12	0.3200	11	0.1100	29	0.1000	1	0.0026

(6)HEP Calculation

At last, the HEP value can be calculated by applying the formula (1). The NHU of GT assigned for the case, in this example, is C GT has NHU value is 0.16 will be calculated with EPC multiplier and APE value. The value of HEP has to be between 0 to 1. Table 3.17 shows the HEP calculation simulation.

Table 3. 17 HEP Calculation.

GT	NHU	TOP		BODY								HEP
		EPC 21		EPC 12		EPC 11		EPC 29		EPC 1		
		×	APE	×	APE	×	APE	×	APE	×	APE	
C	0.1600	2	0.4700	4	0.3200	5	0.1100	1.3	0.0900	17	0.0030	0.7100

Remarks:
EPC: Error Producing Conditions
APE: Assessed Proportion Effect
GT: Generic Task
NHU: Nominal Human Unreliability
HEP: Human Error Probability

However, there is a limitation of APE value calculation if the EPC discovered in the case is only one or two EPC. The CR value cannot be calculated because there is no random index for that number.

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CHAPTER 4
APPLICATIONS

4.1 Maritime accidents data

Accident reports are commonly used as data sources for several types of research involving maritime accident analysis. Accident reports are designated as secondary data sources because they are created from primary data sources by interviewing the operators and analyzing first-hand information obtained by the accident investigator after the accident (A Mazaheri, Montewka, & Kujala, 2013; Arsham Mazaheri, Montewka, Nisula, & Kujala, 2015). Official maritime accident reports are prepared by national investigation boards and provide valuable information regarding the accident's occurrence. The period of investigated maritime accidents is from 2008 to 2018. The accident reports investigated in the current study were retrieved from the national investigation boards, as shown in Table 4.1.

Most of the countries on the list above have the main language, which not English; therefore, the reports analyzed in this study written in English and Indonesian, and the number is limited. The sections of accident reports that were thoroughly reviewed for this study were the synopses, analysis sections, and the conclusions. All the information from the accident report has to be derived before it can be used. However, derivation of the information typically requires human effort; thus, the risk of human subjectivity exists

(Arsham Mazaheri et al., 2015). To minimize human subjectivity, the accident reports' reviewers extracted the embedded information based only on the words that were written in the reports, avoiding further investigation and assumptions that could create subjective opinions. The reports were all reviewed by researchers who are experts in human factors and risk analysis.

Table 4. 1 National Investigation Boards Lists.

No.	Countries	Abbreviation	
Asia			
1.	Indonesia	NTSC	National Transportation Safety Committee
2.	Japan	JTSB	Japan Transport Safety Board
3.	Hong Kong	MarDep	Marine Department, The Government of the Hong Kong Special Administrative Region
Australia			
4.	Australia	ATSB	Australian Transport Safety Bureau
5.	New Zealand	TAIC	Transport Accident Investigation Commission
America			
6.	United States of America	NTSB	National Transportation Safety Board
7.	Canada	TSB	Transportation Safety Board of Canada
Europe			
8.	Norway	AIBN	Accident Investigation Board Norway
9.	Germany	BSU	Federal Bureau of Maritime Casualty Investigation
10.	Denmark	DMAIB	Danish Maritime Accident Investigation Board
11.	United Kingdom	MAIB	Marine Accident Investigation Branch
12.	Finland	SIA	Safety Investigation Authority

A systematic accident database was generated in Microsoft Excel by tabulating the accident data into a textual format. The information in the database included the following information: Accident date and year, time of the accident, accident location, name of the ship involved, type of ship, technical specifications of the ship (gross tonnage, deadweight total), weather and environmental information at the time of occurrence, accident severity, as well as the number of fatalities/injuries, environmental damage, ship damage, accident causes.

4.2 Collision

Collision is the physical impact between two ships or more, or between ships and a still structure like an offshore drilling platform or even a port. For collision accidents, the data were collected from twelve countries. There are differences in the total data and total ships because, in some reports, two or three ships are being reported and analyzed, so those ships being analyzed separately in this study. From 213 reports data collected, there are 332 ships involved in the collision accidents. The data distribution is shown in Table 4.2.

The data that available in every country is different. This is also related to the language restriction. In the country where the main language is not English, the available data using English is less than their main language data reports. The most collision data obtained from the MAIB, UK, there are 42 data reports and 65 ships that were written and analyzed in the reports.

Table 4. 2 Collision data reports.

No.	Countries	Total Data	Total Ships
1.	Indonesia	14	24
2.	Japan	28	49
3.	Hong Kong	21	21
4.	Australia	13	23
5.	New Zealand	6	7
6.	United States of America	31	50
7.	Canada	6	11
8.	Norway	3	4
9.	Germany	32	47
10.	Denmark	9	17
11.	United Kingdom	42	65
12.	Finland	8	14
	Total	213	332

(1)Generic Task

For the generic task results, every country has different generic tasks that are obtained and has similarities. All countries, except New Zealand, have the C generic task in their collision accidents working type. However, in New Zealand, all the collisions occurred in a convenient situation; it stated in the D and E generic task. Due to the limited number of the collision accident report from New Zealand that are available on their website, it could have occurred so that the analysis results' diversities are limited. Moreover, in North America, both the United States of America and Canada have the G generic task obtained in their collision accidents report. G generic task is an entirely familiar, highly practiced, routine task occurring several times per hour, performed to highest possible standards by a highly motivated, highly trained, and experienced person, totally aware of implications of failure, with time to correct the potential error, however, without the benefit of significant job aids has 26 cases.

From 332 ships analyzed, 141 collisions occurred when the task categorizes as a complex task that requires a high level of comprehension and skill (C generic task). It is the most common generic task for collision accidents. D generic task, for the fairly simple task but performed rapidly or given scant attention in 123 cases.

Table 4. 3 Collision Generic Task.

Collision	Generic Task (%)								
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(M)
Indonesia	-	-	4	2	18	-	-	-	-
Japan	1	-	21	25	-	2	-	-	-
Hong Kong	-	-	11	10	-	-	-	-	-
Australia	-	1	6	15	1	-	-	-	-
New Zealand	-	-	-	4	3	-	-	-	-
United States of America	1	2	22	4	-	-	21	-	-
Canada	-	-	5	1	-	-	5	-	-
Norway	-	1	1	2	-	-	-	-	-
Germany	-	1	25	18	3	-	-	-	-
Denmark	-	1	6	8	2	-	-	-	-
United Kingdom	1	-	30	34	-	-	-	-	-
Finland	-	7	6	1	-	-	-	-	-
Collision Total	**3 (1%)**	**13 (4%)**	**141 (42%)**	**123 (37%)**	**24 (7%)**	**2 (1%)**	**26 (8%)**	**0**	**0**

Twenty-four cases of collision accidents occurred during the routine; highly practiced, rapid task works involving a relatively low level of skill (E generic task). B generic task for restoring the system to an original state on a single attempt doing the task without supervision or procedures has 13 cases that occurred during it. The most laborious generic task, A generic task known as totally unfamiliar work but performed at speed with no real idea of likely consequences, has 2 cases. Two generic tasks have no cases at all, H generic task and M generic task. Table 4.3 shows the generic task of collision accidents.

(2)EPC – 4M

There are 1474 EPC – 4M selected for 332 analyzed ships in the collision accidents, as shown in Table 4.4. From 38 EPC – 4M that established, only EPC 31 for low morale and EPC 38 for ages factor that has no cause in the collision accidents. 899 of EPC in management factors has been found out. It is the highest factor that causes collision accidents. The most common EPC - 4M in management factors that occurred as the cause of collision accidents is EPC in monitoring subfactors, EPC 17, and EPC 26. That two EPC is related to the seafarers' not good watchkeeping in the bridge during the voyage process—furthermore, 338 EPC – 4M related in the communication subfactors found in the collision accidents.

In addition, 455 EPC in man factors were selected. In the man factors, the misperception of assessing the dangerous situation's risk is the most common EPC – 4M that occurred. Furthermore, task pacing also influenced 77 cases of collision accidents. Focus and concentration are importantly needed during working on the bridge in order to be able to maintain the ship safely.

Table 4. 4 Collision EPC - 4M.

EPC – 4M		Total
Man factors		
• ***Experience***		
EPC 1	Unfamiliarity	**8**
EPC 12	Misperception of risk	**115**
EPC 22	Lack of experience	**23**
• ***Skill and Knowledge***		
EPC 7	Irreversibility	**19**
EPC 9	Technique unlearning	**8**
EPC 11	Performance ambiguity	**56**
EPC 15	Operator inexperience	**26**
EPC 20	Educational mismatch	**6**
• ***Psychological***		
EPC 21	Dangerous incentives	**56**
EPC 28	Low meaning	**8**
EPC 29	Emotional stress	**5**
EPC 31	Low morale	**0**
EPC 34	Low mental workload	**25**
• ***Physical***		
EPC 27	Physical capabilities	**4**
EPC 36	Task pacing	**77**
EPC 38	Age	**0**
• ***Health***		
EPC 30	Ill-health	**2**
EPC 35	Sleep cycle disruption	**17**
Machine factors		
EPC 3	Low signal-noise ratio	**3**
EPC 8	Channel overload	**6**
EPC 23	Unreliable instruments	**55**
Management factors		
• ***Coordination***		
EPC 2	Time shortage	**85**
EPC 6	Model mismatch	**2**
EPC 24	Absolute judgments required	**30**
EPC 25	Unclear allocation of function	**17**
EPC 37	Supernumeraries/ lack of human resources	**31**
• ***Rules and procedures***		
EPC 4	Features over-ride allowed	**1**
EPC 5	Spatial and functional incompatibility	**11**
EPC 32	Inconsistency of displays	**2**
• ***Communication***		
EPC 10	Knowledge transfer	**37**
EPC 13	Poor feedback	**75**
EPC 14	Delayed/incomplete feedback	**57**
EPC 16	Impoverished information	**96**
EPC 18	Objectives conflict	**9**
EPC 19	No diversity of information	**64**
• ***Monitoring***		
EPC 17	Inadequate checking	**189**
EPC 26	Progress tracking lack	**193**

Media factors		
EPC 33	Poor environment	**56**
	EPC – 4M Total	**1474**

There are 64 EPC – 4M in machine factors found in the 332 collision cases that were analyzed. Mostly it is due to the unreliable instrument or equipment installed in the ship. In some cases, the equipment is broken and waiting for maintenance. It is essential to check the condition of every instrument on the ship before departure for the voyage.

Fifty-six cases of collision accidents are influenced by the poor environmental situation at the time of collision occurred. It is about 20% of collision accidents. 80% of the collision accidents occurred when the situation was good, calm sea, and no dangerous warning issued by authorities.

(3)Top of EPC series

The EPC series is formed due to the calculation process of APE weight. The most common EPC that is becoming the TOP of the EPC series is EPC 26, 57 cases have EPC 26 as the leading cause of collision accidents. There are 29 EPC selected as the TOP of EPC series, where 14 of the EPC belong to man factors, and 13 of the EPC belong to management factors. Although the number of EPC's type in man factors is the most common, the total cases of collision accidents with management factors as the TOP of EPC series are higher than any other factors. In total, 210 cases have management factors as the leading cause of the accidents, followed by 107case s main cause by man factors, 13 cases by machine factors, and 2 cases by media factors. Table 4.5 shows the frequency of EPC as TOP of EPC series.

Table 4. 5 TOP of EPC series in the collision accident.

No.	4M categorizations	EPC	Total	No.	4M categorizations	EPC	Total
1	Management	EPC26	57	16	Management	EPC37	5
2	Management	EPC17	52	17	Man	EPC25	4
3	Management	EPC16	31	18	Man	EPC22	3
4	Man	EPC12	26	19	Man	EPC34	3
5	Man	EPC36	24	20	Man	EPC35	3
6	Management	EPC13	18	21	Man	EPC9	2
7	Management	EPC19	17	22	Management	EPC18	2
8	Machine	EPC23	13	23	Man	EPC29	2
9	Man	EPC11	12	24	Media	EPC33	2
10	Management	EPC14	11	25	Management	EPC2	1
11	Man	EPC21	11	26	Management	EPC6	1
12	Man	EPC15	8	27	Man	EPC20	1
13	Management	EPC10	8	28	Man	EPC28	1
14	Man	EPC7	7	29	Management	EPC32	1
15	Management	EPC24	6				

The EPC series formed in the 310 ships analyzed shows variations of series and variations of the number of EPC found in one case. It is due to the differences in condition and the causes that affected the collision.

(4)HEP Calculation

Figure 4.1 shows the HEP value that is categorized according to year, from 2008 to 2018. The red line shows the trendline in the collision accidents reducing every year.

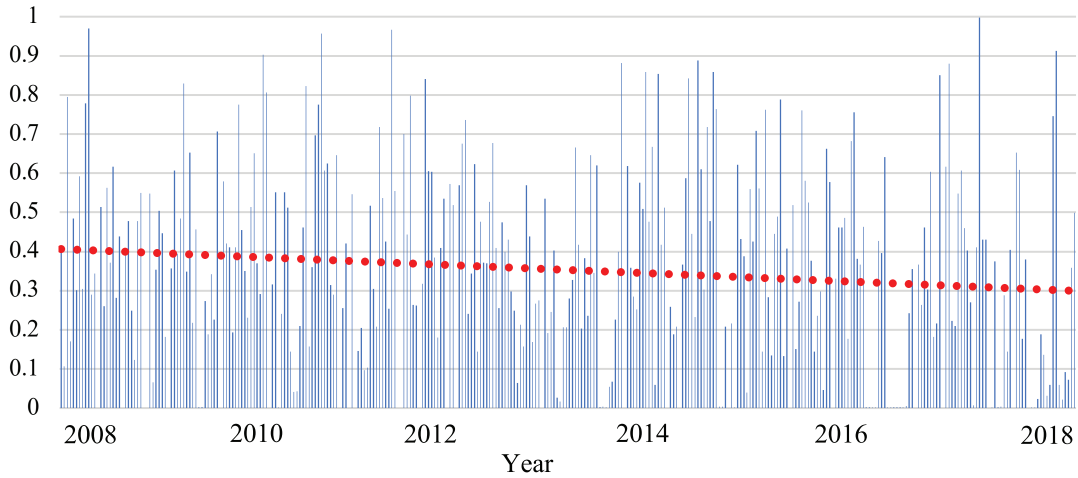

Figure 4. 1 Collision HEP rates per year from 2008 to 2018.

Figure 4.2 shows the average of HEP value every year. The number of cases that are analyzed every year is varied. Therefore, if the number of cases in 2017 and 2018 is as many as the previous year, the graph will be changed accordingly.

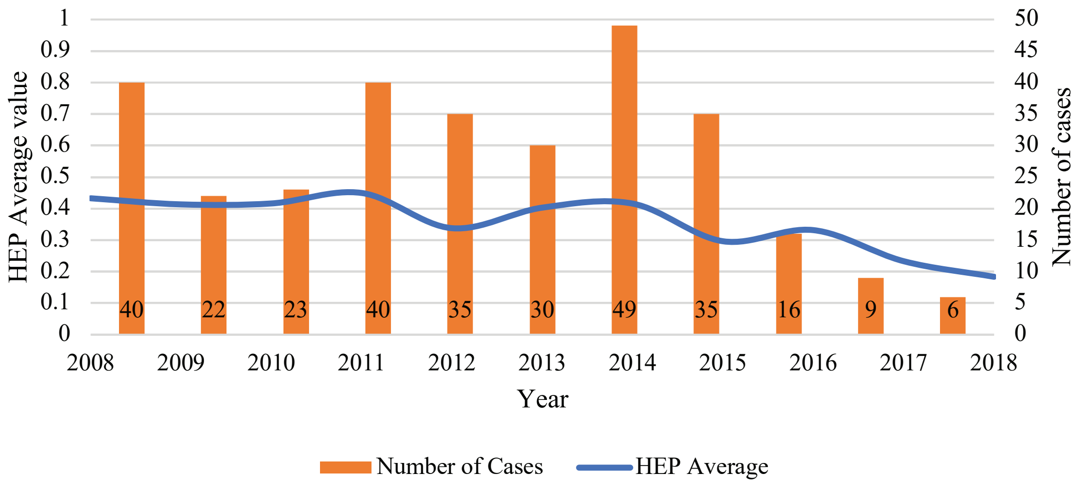

Figure 4. 2 Collision average of HEP rates per year.

4.3 Grounding

Grounding is the accident when the bottom of the ship struck the sea bed and stuck for some period that might cause the loss of power, ship, and environmental damage. In this study, in total, 105 grounding accident data collected from twelve countries (see Table 4.6 below) from 2008 to 2018 are analyzed. The most significant number of data provided by Germany, followed by Canada and Finland. The ships' gross tonnage in the grounding accident is bigger than in the collision accidents. The gross tonnage for the grounding accidents in these cases is between 100 up to 190,000 GT.

Table 4. 6 Grounding data reports.

No.	Countries	Total Data	No.	Countries	Total Data
1.	Indonesia	4	7.	Canada	10
2.	Japan	6	8.	Norway	4
3.	Hong Kong	2	9.	Germany	11
4.	Australia	16	10.	Denmark	6
5.	New Zealand	6	11.	United Kingdom	28
6.	United States of America	3	12.	Finland	9

(1)Generic Task

The generic task results in grounding accidents show the same results as a collision accident for the most common generic task. The complex task that requires a high level of comprehension and skill (C generic task) has 36% of all the generic tasks. Followed by D generic task for a fairly simple task but given scant attention while doing the work.

Table 4. 7 Grounding Generic Task.

Grounding	Generic Task (%)								
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(M)
Indonesia	1	-	1	1	1	-	-	-	-
Japan	-	-	4	1	1	-	-	-	-
Hong Kong	-	-	-	2	-	-	-	-	-
Australia	-	-	6	7	3	-	-	-	-
New Zealand	-	1	1	2	2	-	-	-	-
United States of America	-	-	1	-	2	-	-	-	-
Canada	-	-	5	2	3	-	-	-	-
Norway	-	-	1	2	1	-	-	-	-
Germany	-	-	3	4	4	-	-	-	-
Denmark	1	1	2	1	1	-	-	-	-
United Kingdom	1	2	9	14	2	-	-	-	-
Finland	-	-	4	4	1	-	-	-	-
Grounding Total	**3 (3%)**	**4 (4%)**	**37 (35%)**	**40 (38%)**	**21 (20%)**	**0**	**0**	**0**	**0**

E generic task value only has a slightly different value with C and D generic tasks. About 27% of grounding accidents occurred in the E generic task classification, as shown in Table 4.7. In the grounding accidents, only five types of generic tasks that discovered among 105 cases that were analyzed. It is different from collision accidents, where it has six types of generic tasks discovered. Generic tasks F, G, H, and M have no cases.

(2)EPC – 4M

There are 382 EPC – 4M that discovered the 105 cases of grounding accidents. Where from 38 EPC – 4M that established, only 32 types of EPC – 4M that assigned. It is different from the collision accidents, where there are 37 types of EPC – 4M discovered. In the grounding cases, EPC – 4M that does not cause the accidents are EPC 20, EPC 38, EPC 30, EPC 3, EPC 8, and EPC 6.

The most common causal factor of the grounding accidents is management factors; there are 229 out of 382 EPC – 4M found in total. Where mostly the problem occurred in the communication subfactor, followed by the monitoring subfactor. There are 107 EPC – 4M in the communication subfactors, where the most common is impoverished information performed onboard, followed by knowledge transfer of important tasks and information. Managing good communication onboard operation is essential for ship safety. Therefore the BRM training is established to minimize the number of accidents caused by the communication problem and make communication effective and efficient. Good watchkeeping by maintaining all the available means to maintain ship safety is also essential, and the main job of the bridge crew. However, in the grounding accidents, more than half of all cases analyzed were caused by inadequate monitoring (EPC 17) and progress tracking lack (EPC 26).

Man factor has 105 EPC – 4M selected in these 105 grounding cases. The experience subfactor has the highest number that causes the accident. Among all EPC – 4M in man factors, misperception of risk has the most common occurrence, about half of all grounding cases analyzed. The seafarer misjudges the situation that high potentially dangerous and given no attention to that matter.

Twenty-six cases have problems with the machines, which unreliable to use when needed. In percentage, the environmental factor causes more grounding accident cases rather than in collision accidents. Strong wind causes difficulty for the ship's maneuver and worsens by combining unreliable machinery systems that cannot support the maneuver. Table 4.8 shows the frequency of EPC appears to be the cause of accidents in grounding cases.

Table 4. 8 Grounding EPC - 4M.

EPC – 4M		Total
Man factors		
• ***Experience***		
EPC 1	Unfamiliarity	**4**
EPC 12	Misperception of risk	**41**
EPC 22	Lack of experience	**17**
• ***Skill and Knowledge***		
EPC 7	Irreversibility	**3**
EPC 9	Technique unlearning	**3**
EPC 11	Performance ambiguity	**14**
EPC 15	Operator inexperience	**5**
EPC 20	Educational mismatch	**0**
• ***Psychological***		
EPC 21	Dangerous incentives	**17**
EPC 28	Low meaning	**11**
EPC 29	Emotional stress	**1**
EPC 31	Low morale	**8**
EPC 34	Low mental workload	**12**
• ***Physical***		
EPC 27	Physical capabilities	**2**
EPC 36	Task pacing	**15**
EPC 38	Age	**0**
• ***Health***		
EPC 30	Ill-health	**1**
EPC 35	Sleep cycle disruption	**14**
Machine factors		
EPC 3	Low signal-noise ratio	**0**
EPC 8	Channel overload	**0**
EPC 23	Unreliable instruments	**32**
Management factors		
• ***Coordination***		
EPC 2	Time shortage	**8**
EPC 6	Model mismatch	**3**
EPC 24	Absolute judgments required	**8**
EPC 25	Unclear allocation of function	**10**
EPC 37	Supernumeraries/ lack of human resources	**12**
• ***Rules and procedures***		
EPC 4	Features over-ride allowed	**2**
EPC 5	Spatial and functional incompatibility	**17**
EPC 32	Inconsistency of displays	**6**
• ***Communication***		
EPC 10	Knowledge transfer	**42**
EPC 13	Poor feedback	**15**
EPC 14	Delayed/incomplete feedback	**10**
EPC 16	Impoverished information	**43**
EPC 18	Objectives conflict	**4**
EPC 19	No diversity of information	**26**
• ***Monitoring***		
EPC 17	Inadequate checking	**64**
EPC 26	Progress tracking lack	**60**
Media factors		
EPC 33	Poor environment	**29**
	EPC – 4M Total	**559**

(3)Top of EPC series

In the grounding accidents, there are 22 EPC that are assigned as the TOP of the EPC series. There are twelve EPC that categorized in the management factors assigned as the TOP of EPC series, as follows EPC 17, EPC 10, EPC 26, EPC 16, EPC 13, EPC 19, EPC 37, EPC 2, EPC 5, EPC 14, EPC 24, and EPC 25—followed by seven EPC in man factors assigned as TOP of EPC series. The machine factor was also assigned in 5 cases as the TOP of the series. The detailed information is stated in Table 4.9.

The most common EPC assigned as TOP of EPC series is EPC 17, which relates to inadequate checking, followed by EPC 10 for knowledge transfer, and EPC 26 for progress tracking. EPC 17 and EPC 26 consist of the monitoring subfactors, which are also assigned as the most common EPC selected in the EPC – 4M. It means that the monitoring problem is the major problem in most grounding accidents, besides communication problems.

Misperception of risk is the most common assigned EPC – 4M in man factors, and become the most common selected as TOP of EPC series among other man factors. The other EPC – 4M in man factors are EPC 31, EPC 35, EPC 11, EPC 22, EPC 7, and EPC 28.

Table 4. 9 TOP of EPC series in the grounding accident.

No.	4M categorizations	EPC	Total	No.	4M categorizations	EPC	Total
1	Management	EPC 17	20	12	Man	EPC 11	2
2	Management	EPC 26	15	13	Management	EPC 37	2
3	Management	EPC 10	14	14	Management	EPC 2	1
4	Management	EPC 16	10	15	Management	EPC 5	1
5	Man	EPC 12	9	16	Man	EPC 7	1
6	Machine	EPC 23	7	17	Management	EPC 14	1
7	Management	EPC 13	4	18	Management	EPC 24	1
8	Management	EPC 19	4	19	Management	EPC 25	1
9	Man	EPC 21	3	20	Man	EPC 28	1
10	Man	EPC 22	3	21	Man	EPC 31	1
11	Man	EPC 35	3	22	Man	EPC 36	1

(4) HEP Calculation

Figure 4.3 shows the HEP value from 105 grounding cases, which is grouped according to the occurrence year from 2008 to 2018. As it shows, the value of HEP is fluctuated every year due to differences in value for every case. However, the HEP value graph's trendline shows the projection of decreasing trendline of HEP value every year.

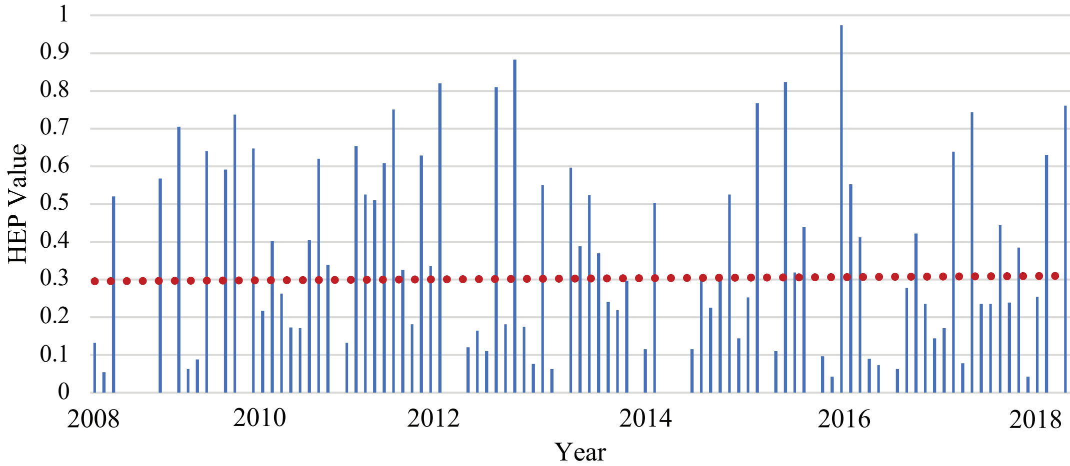

Figure 4. 3 Grounding HEP rates per year from 2008 to 2018.

In contrast, the average value of HEP every year shows a fluctuated chart. The trend shows that if the previous year's value is high, next year's value might be increasing, so the average value is not stable to decreasing every year. However, this occurs due to the imbalance of the case number analyzed every year. The value will be increased if the number of cases is lesser than the previous year.

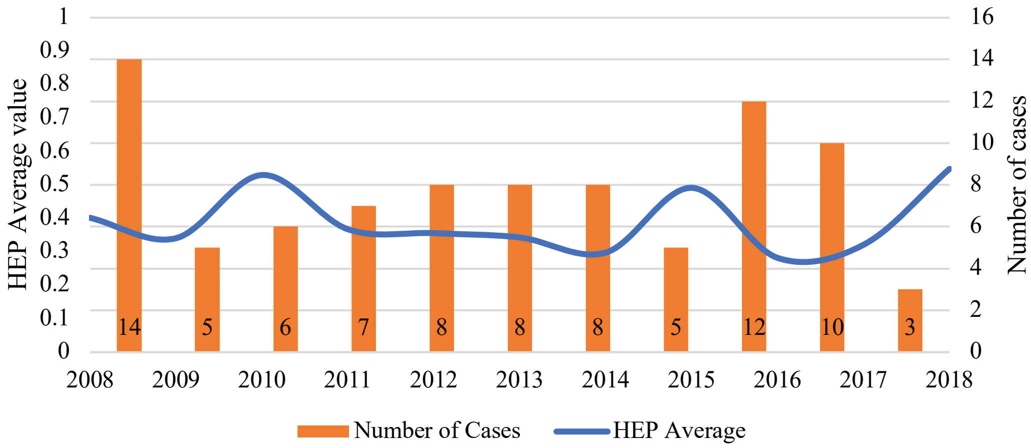

Figure 4. 4 Grounding average of HEP rates per year.

4.4 Sinking

Sinking is when the water ingresses the ship and causes the ship to lose its buoyancy and submerge into the water. The availability of sinking accident data is limited, comparing with collision and grounding accidents. From twelve countries analyzed, only seven countries have the sinking accident data that can be accessed on their available authorize website. Moreover, the size of the ship is smaller than collision and grounding accidents.

The sinking accidents occurred in the small ships in the range of below 500 gross tonnages on average. The vessel which has GT below 100 GT is not analyzed in this study. There is 63 sinking accident data report that can be retrieved from Indonesia, Hong Kong, and the United States of America, as shown in Table 4.10.

Table 4. 10 Sinking data reports.

No.	Countries	Total Data
1.	Indonesia	19
2.	Hong Kong	3
3.	United States of America	41

(1)Generic Task

In sinking accidents, only H and M generic task that have no cases categorized in it. The most common working type situation in the sinking accidents is C generic task, which is known as a complex task that required a high level of skill, has more than 50% of all the cases have it. As shown in Table 4.11, all Hong Kong working types during accidents are categorized in the C generic task. Moreover, it is similar to USA sinking accidents, which has a C generic task as the most common generic task. Indonesia also has C generic task in their sinking accidents accompanied by the D generic task. Furthermore, only Indonesia sinking accidents has A generic task in their cases, and only the USA has an F and G generic task.

Table 4. 11 Sinking Generic Task.

	Generic Task (%)								
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(M)
Indonesia	2	2	6	6	3	-	-	-	-
Hong Kong	-	-	3	-	-	-	-	-	-
United States of America	-	6	26	3	2	2	2	-	-
Sinking Total	2 (3%)	8 (13%)	35 (56%)	9 (14%)	5 (8%)	2 (3%)	2 (3%)	-	-

(2)EPC – 4M

From sixty-three sinking accident cases in the three countries, there are 231 EPC – 4M found. There are eight EPC – 4M that have no cases, consist of EPC 29, EPC 27, EPC 36, EPC 38, EPC 30, EPC 3, EPC 37, and EPC 4. EPC – 4M, which is included in the management factors, has the highest number among other factors, 98 EPC – 4M. Moreover, man factors have 80 EPC – 4M. However, if we breakdown the total for every EPC, machine factors for unreliable instrument EPC 23 has the highest number found in sinking cases, there are 37 of sinking cases that have problems in their types of machinery before sinking accidents occurred.

Table 4. 12 Sinking EPC - 4M.

EPC – 4M		Total
Man factors		
• ***Experience***		
EPC 1	Unfamiliarity	**2**
EPC 12	Misperception of risk	**16**
EPC 22	Lack of experience	**7**
• ***Skill and Knowledge***		
EPC 7	Irreversibility	**1**
EPC 9	Technique unlearning	**7**
EPC 11	Performance ambiguity	**9**
EPC 15	Operator inexperience	**10**
EPC 20	Educational mismatch	**4**
• ***Psychological***		
EPC 21	Dangerous incentives	**19**
EPC 28	Low meaning	**2**
EPC 29	Emotional stress	**0**
EPC 31	Low morale	**1**
EPC 34	Low mental workload	**1**
• ***Physical***		
EPC 27	Physical capabilities	**0**
EPC 36	Task pacing	**0**
EPC 38	Age	**0**
• ***Health***		
EPC 30	Ill-health	**0**
EPC 35	Sleep cycle disruption	**1**
Machine factors		
EPC 3	Low signal-noise ratio	**0**
EPC 8	Channel overload	**1**
EPC 23	Unreliable instruments	**37**
Management factors		
• ***Coordination***		
EPC 2	Time shortage	**3**
EPC 6	Model mismatch	**8**
EPC 24	Absolute judgments required	**4**
EPC 25	Unclear allocation of function	**3**
EPC 37	Supernumeraries/ lack of human resources	**0**
• ***Rules and procedures***		
EPC 4	Features over-ride allowed	**0**
EPC 5	Spatial and functional incompatibility	**9**
EPC 32	Inconsistency of displays	**2**
• ***Communication***		
EPC 10	Knowledge transfer	**1**
EPC 13	Poor feedback	**2**
EPC 14	Delayed/incomplete feedback	**5**
EPC 16	Impoverished information	**6**
EPC 18	Objectives conflict	**10**
EPC 19	No diversity of information	**4**
• ***Monitoring***		
EPC 17	Inadequate checking	**23**
EPC 26	Progress tracking lack	**18**
Media factors		
EPC 33	Poor environment	**15**
	EPC – 4M Total	**231**

(3)EPC series and APE weight

In the sinking accidents, there are 18 EPC – 4M out of 38 EPC – 4M, stated as the Top of EPC series. The EPC that is mainly causing the accidents are EPC in management factor, EPC 17, and machine factor, EPC 23. This result is different from collision and grounding accidents, whereas, in sinking accidents, the unreliable instrument is the most common main factor. Table 4.13 shows the result of Top of the EPC series in the sinking accident.

Table 4. 13 TOP of EPC series in the grounding accident.

No.	4M categorizations	EPC	Total	No.	4M categorizations	EPC	Total
1	Management	EPC 17	14	10	Management	EPC 18	2
2	Machine	EPC 23	14	11	Management	EPC 6	1
3	Management	EPC 26	7	12	Machine	EPC 8	1
4	Man	EPC 21	5	13	Management	EPC 13	1
5	Man	EPC 22	4	14	Man	EPC 15	1
6	Man	EPC 9	3	15	Management	EPC 19	1
7	Man	EPC 11	2	16	Management	EPC 25	1
8	Man	EPC 12	2	17	Man	EPC 28	1
9	Management	EPC 16	2	18	Media	EPC 33	1

(4)HEP Calculation

Figure 4.5 shows the HEP rates for sinking accidents in Indonesia, Hong Kong, and the USA, which are sorted according to the year of occurrence from 2008 to 2018. The red line sated the linear forecast of the HEP in the sinking accidents. It shows the increasing number of HEP from 2008 to 2018.

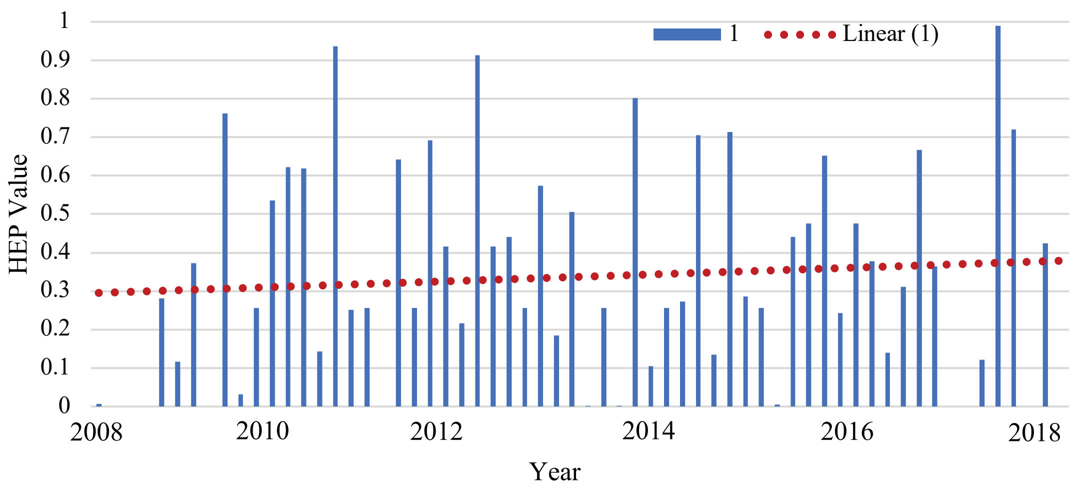

Figure 4. 5 Sinking HEP rates per year from 2008 to 2018.

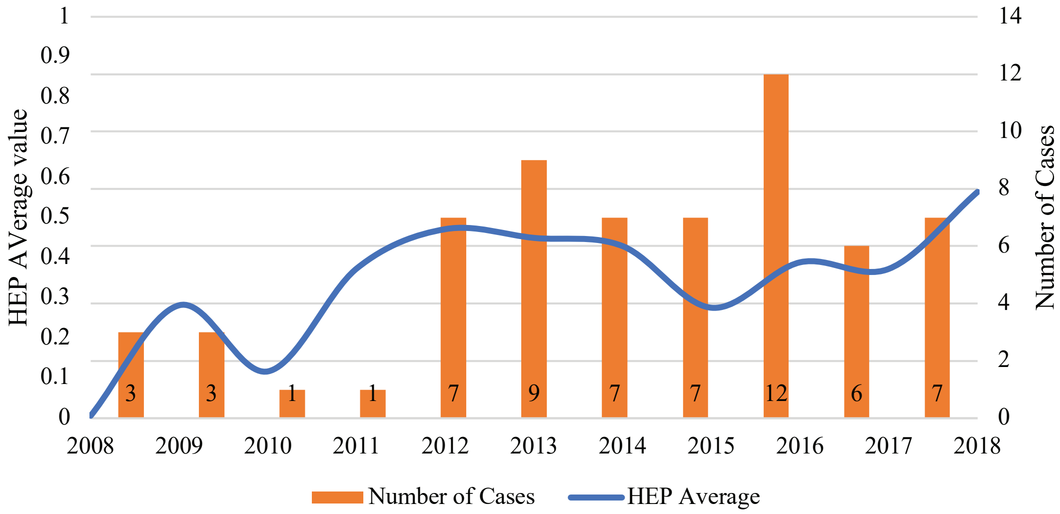

Figure 4. 6 Sinking average of HEP rates per year.

4.5 All results

In this chapter, the summary of all the results will be discussed. Table 4.14 shows the total maritime accident data in this study. Three hundred eighty-one reports cases were obtained, and consist of 500 ships that have been analyzed. Ninety-seven data reports obtained in the Asia continent consist of Indonesia, Japan, and Hong Kong.

Table 4. 14 Total cases analyzed.

No.	Countries		Total Data	Total Ships
Asia				
1.	Indonesia	NTSC	37	47
2.	Japan	JTSB	34	55
3.	Hong Kong	MarDep	26	26
Australia				
4.	Australia	ATSB	29	39
5.	New Zealand	TAIC	12	13
America				
6.	United States of America	NTSB	75	94
7.	Canada	TSB	16	21
Europe				
8.	Norway	AIBN	7	8
9.	Germany	BSU	43	58
10.	Denmark	DMAIB	15	23
11.	United Kingdom	MAIB	70	93
12.	Finland	SIA	17	23
			381	**500**

In Australia and New Zealand, there are 41 report cases, which Australia has more data accessible than New Zealand. In the American continent, the availability of maritime accident data can be obtained only in the North American countries, Canada, and the USA, and the total data is 91 maritime accident data. Moreover, most data obtained from the European continent. There are 152 data, and the UK has the most data of maritime accidents that are accessible.

(1)Generic Task

Table 4.15 shows the results of the generic task in every maritime accident analyzed. The H and M generic task has no case for those 500 maritime accident cases. The generic task can differ into two parts, the first part is a challenging task that needs high skill and knowledge and more effort to do the task, and the generic task included in this part is generic task A, B, and C.

Furthermore, the second part is a convenient task, which already familiar task, because it has been done routinely, and doing the job according to the procedures, in this parts consist of generic task D, E, F, G, and H. M generic task is a miscellaneous task, and not suitable for both parts.

The most common occurrence of the accidents occurred during C generic task, a complex task that required high skill and knowledge of the seafarers—following by D generic task that has 172 cases. However, the total of the challenging generic task (generic tasks A, B, and C) is 246 cases, and the total for the convenient generic task (generic tasks D, E, F, G) is 254. It shows that most maritime accidents occurred in the situation that convenient for the seafarers rather than the challenging one.

Table 4. 15 The summary of all generic tasks.

	Generic Task								
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(M)
Collision	3	13	141	123	24	2	26	-	-
Grounding	3	4	37	40	21	-	-	-	-
Sinking	2	8	35	9	5	2	2	-	-
Total	**8**	**25**	**213**	**172**	**50**	**4**	**28**	**0**	**0**

(2)EPC – 4M

Table 4.17 shows the total result of every EPC – 4M selected in this study. In total, there are 2,264 EPC – 4M from all three maritime accidents. In contrast, it is still dominated by EPC – 4M in the management factors.

Table 4. 16 EPC – 4M for all maritime accidents analyzed.

EPC – 4M		Collision	Grounding	Sinking	Total
Man factors					
• ***Experience***					
EPC 1	Unfamiliarity	**8**	**4**	**2**	**14**
EPC 12	Misperception of risk	**115**	**41**	**16**	**172**
EPC 22	Lack of experience	**23**	**17**	**7**	**47**
• ***Skill and Knowledge***					
EPC 7	Irreversibility	**19**	**3**	**1**	**23**
EPC 9	Technique unlearning	**8**	**3**	**7**	**18**
EPC 11	Performance ambiguity	**56**	**14**	**9**	**79**
EPC 15	Operator inexperience	**26**	**5**	**10**	**41**
EPC 20	Educational mismatch	**6**	**0**	**4**	**10**
• ***Psychological***					
EPC 21	Dangerous incentives	**56**	**17**	**19**	**92**
EPC 28	Low meaning	**8**	**11**	**2**	**21**
EPC 29	Emotional stress	**5**	**1**	**0**	**6**
EPC 31	Low morale	**0**	**8**	**1**	**9**
EPC 34	Low mental workload	**25**	**12**	**1**	**38**
• ***Physical***					
EPC 27	Physical capabilities	**4**	**2**	**0**	**6**
EPC 36	Task pacing	**77**	**15**	**0**	**92**
EPC 38	Age	**0**	**0**	**0**	**0**
• ***Health***					
EPC 30	Ill-health	**2**	**1**	**0**	**3**
EPC 35	Sleep cycle disruption	**17**	**14**	**1**	**32**
Machine factors					
EPC 3	Low signal-noise ratio	**3**	**0**	**0**	**3**
EPC 8	Channel overload	**6**	**0**	**1**	**7**
EPC 23	Unreliable instruments	**55**	**32**	**37**	**124**
Management factors					
• ***Coordination***					
EPC 2	Time shortage	**85**	**8**	**3**	**96**
EPC 6	Model mismatch	**2**	**3**	**8**	**13**
EPC 24	Absolute judgments required	**30**	**8**	**4**	**42**
EPC 25	Unclear allocation of function	**17**	**10**	**3**	**30**
EPC 37	Supernumeraries/ lack of human resources	**31**	**12**	**0**	**43**
• ***Rules and procedures***					
EPC 4	Features over-ride allowed	**1**	**2**	**0**	**3**
EPC 5	Spatial and functional incompatibility	**11**	**17**	**9**	**37**
EPC 32	Inconsistency of displays	**2**	**6**	**2**	**10**
• ***Communication***					
EPC 10	Knowledge transfer	**37**	**42**	**1**	**80**
EPC 13	Poor feedback	**75**	**15**	**2**	**92**
EPC 14	Delayed/incomplete feedback	**57**	**10**	**5**	**72**
EPC 16	Impoverished information	**96**	**43**	**6**	**145**
EPC 18	Objectives conflict	**9**	**4**	**10**	**23**
EPC 19	No diversity of information	**64**	**26**	**4**	**94**
• ***Monitoring***					
EPC 17	Inadequate checking	**189**	**64**	**23**	**276**
EPC 26	Progress tracking lack	**193**	**60**	**18**	**271**
Media factors					
EPC 33	Poor environment	**56**	**29**	**15**	**100**
	EPC – 4M Total	**1,474**	**559**	**231**	**2,264**

(3)Human Error Probability

Figure 4.7 shows the graphic of all HEP in this study's maritime accidents and the linear trendline of the graphic. It shows that the HEP is in the decreasing trendline by the years.

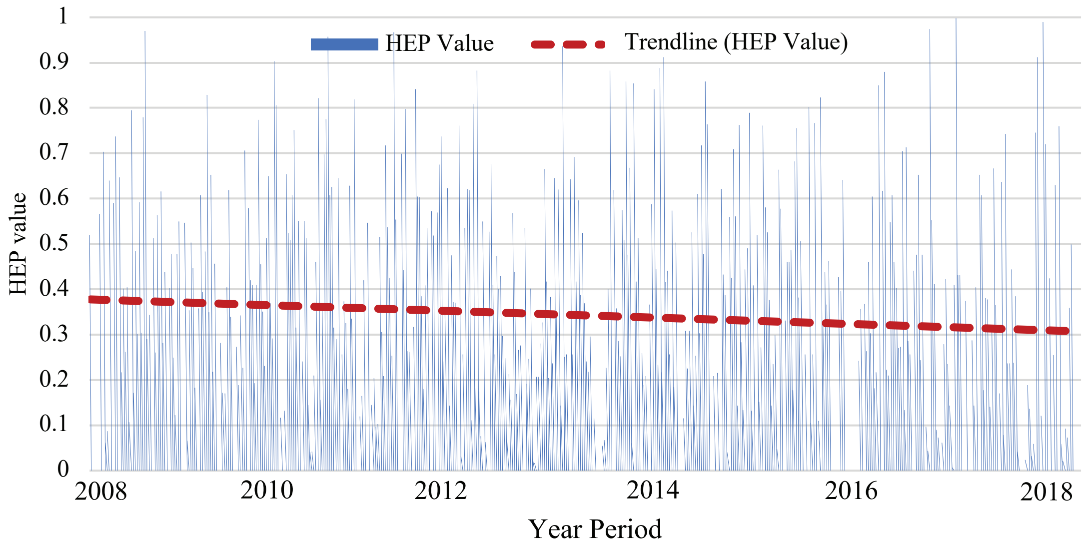

Figure 4. 7 HEP of collision, grounding accidents period 2008 - 2018

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CHAPTER 5 DISCUSSION AND CONSIDERATION

5.1 Maritime accidents

In this study, there are three kinds of maritime accidents analyzed, collision, grounding, and sinking accidents. These three accidents have similarities in the cause of the accident, which mostly caused by the lack of focus of seafarers while doing the task on the bridge. The distribution data from every country analyzed is different. This is because the availability of the maritime accident reports data is different. Furthermore, the language limitation is also contributing to the report's availability because in the country, which the primary language is not English, the maritime report's data that available has two versions, and the English one is less than the primary language reports. Regardless, there are 381 maritime accidents collected from 2008 to 2018, and there are 500 ships involved in those accidents.

As mention in the previous section, for the generic task available in this study, there are nine types of generic tasks, which are sorted according to the level of working type when the accidents occurred. The generic task A, B, and C are classified as the challenging working type because it required a high skill level and more knowledge to do the task. Moreover, if the weather condition is becoming challenging as well, the convenient task will become a challenging task too. Furthermore, the rest of the generic task is classified as the convenient task because the seafarer has familiarized well with the job due to the routine practice of it and do the job in accordance with the procedures. From all maritime accidents analyzed, it turns out that many accidents occurred in a convenient task rather than in a challenging task.

Furthermore, it is supported by the result of the poor environment in media factors, which only affected about 20% of all analyzed accidents. It means that most of the accidents occurred in the fine weather and condition of the voyage at sea. This condition has to be given more concern. Many seafarers will feel more relax and becoming a lack focus and concentration when in fine weather and situation because they thought everything is under control. Whereas the possibility of the accident's occurrence always exists.

Management factors dominated the causal of the collision, grounding, and sinking accidents. Where the monitoring and communication subfactors are the most found causal factors. The lack of checking and progress tracking lack is causing more accidents rather than a poor environment.

The result of HEP is showing a decreasing trend, which means that improvements designed to decrease human error in maritime accidents were quite effective. This is in line with the post period of ISM code implementation, resulting in a significant reduction of human-induced factors in maritime accidents. Improvement of the maritime technology, technology in shipbuilding and ship management, and also better crew training induces the improvement of maritime society. The results for HEP were varied and depended on the selected GT, i.e., at the time of the accidents, what kind of situation existed, and which task was being performed. The more complex and challenging the task, the higher the NHU will be. Also, the number of EPC selected in a case can influence the HEP results. A detailed explanation of every accident's kind will be explained in the next sections.

(1)Collision

The definition of collision in several accidents' reports is different. However, in this study, the definition of collision is explained as follows; collision is the physical impact between two ships or more, or between ships and a still structure like an offshore drilling platform or even a port. From the twelve countries in four continents that were analyzed in this study, in total, there are 332 ships data from 213 data reports. There are accident reports that only report from only one side view of the analysis because the other vessel cannot available for giving the statements.

In the navigation bridge, the functions and responsibilities of seafarers are delivering cargo or passengers on time by conducting safe navigation. According to COLREG, Rule 5, the definition of look-out is maintaining a proper look-out by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision (Ventura, 2009)It means that seafarers have to pay attention to everything during sailing and have to use all of that information continuously to assess the situation and the risk of collision. All of the information during sailing is obtained by using navigational equipment as well, such as ECDIS, ARPA, radio.

The collision accidents occurred when the seafarers' inconvenient working type occurred at D, E, F, and G generic tasks rather than a challenging task. However, the result of every country is different for the generic task. The detailed information can be found in Chapter 4. This might be happened due to the social, cultural condition of the seafarer who is residing and voyaging in that country. Because, there are cultural differences in every country that can shape the behavior of the seafarer, such as how they communicate and solving the problem, whether the communicate directly or subtlety. Further research is needed to know deeper about the differences of nationality to handle crisis situation on board.

The management factors are leading as the causal factors in collision accidents. The monitoring sub-factors are the most common causes that occurred in collision accidents. Inadequate checking and progress tracking lack are EPC – 4M in the monitoring subfactor. Moreover, communication also has big problems with seafarers.

The situation that mostly occurred in the collision accidents is the seafarers sailed in good condition, where the visibility is not restricted, and the traffic is not high dense. In this situation, the seafarers are overconfident to maneuver the vessel alone, supported by the finding of EPC 37 for lack of human resources onboard operation. Besides, the collision accidents mostly occurred when there were two people keeping watch on the bridge deck. However, the seafarers did not give their best performance on keeping watch by lack of checking the situation prior to the hazard situation and the progress of the situation. The seafarers were late to notice that their ship was heading to the accidents because of improper look-out, it is shown as EPC 17, EPC 26, EPC 23, therefore the seafarers were a shortage of time (EPC 2) to avoid the collision.

Lack of information in hazardous situations leads the seafarers to have a misperception of the risk of the upcoming dangerous situation that might be occurred so that it influences the seafarer’s judgment to do the required action to mitigate the risk. The communication among seafarers in the navigational bridge is essential to prevent accidents. It is shown by the EPC 13, EPC 14, EPC 16, and EPC 19. Poor communication can influence the master to take a wrong judgment because of misunderstanding the situation (Mutmainnah & Furusho, 2016). In these cases, some seafarers maintain the look-out without the supervision of the Master. Meanwhile, the seafarer himself was not confident with their ability due to a lack of experience and knowledge. This condition has to be informed to the Master well (EPC 15). Moreover, seafarers have to give excellent and precise feedback. Communication is essential to prevent to choose the wrong judgments to avoid the collision (EPC 11, EPC 12, EPC 18, EPC 19, and EPC 24).

It is in line with Chauvin in 2013, who applied the HFACS framework to analyze 27 recent collision cases involving 39 vessels. He found that the collisions occurred because of decision errors, which are supported by the poor visibility and misuses of the instrument, loss of situation awareness or poor attention, and poor communication among seafarers in bridge Resources Management (Chauvin et al., 2013).

(2)Grounding

The analysis of the reviewed accident reports shows that the usability of maritime accident reports is reliable for extracting critical factors that influence accidents. The GT results show that convenient tasks involving a relatively low level of skill were the task conditions when the accidents occurred, meaning that the seafarer had previously experienced this situation several times. However, they became overconfident and tended to underestimate the task because they thought they were familiar with the situation. This condition is similar to fairly simple tasks, in which seafarers perform the task rapidly or give it scant attention. Environmental conditions affected the human ability to address the situation in order to avoid an accident, but because of several other influential factors, the accident still occurred. This situation is similar to collision accidents.

Based on the top-most EPC series, this study found that most causes recognized by investigators are management factors in terms of monitoring (EPC 17, EPC 26), improper communication (EPC 10, EPC 16, EPC 13), and lack of guideline procedures on the bridge, such as the bridge team being reluctant to provide information to the master because they felt they had less experience and knowledge than the master. Established incorrect practices such as categorizing piloting as a one-person duty were also a factor. Because of overconfidence in their knowledge and maneuvering skills, seafarers did not fully pay attention to watchkeeping beyond that displayed by the bridge team. This condition might lead the seafarer to have a misperception of the upcoming situation that might be dangerous. The lack of information because of the lack of monitoring and communication among seafarers is the main problem that encounters the seafarers, and this is the leading cause of most of the grounding accidents. The lack of procedural information from companies regarding cooperation and communication in different conditions and a lack of knowledge transfer between the bridge team and the engine control room about engine failure conditions were other factors.

In the future, since the application of automation ship will be done, the probability of man and management factors as the leading cause of the maritime accidents might be decreased, due to the less human power needed in the ship operation. However, it might increase EPC in machine factors.

(3)Sinking

The availability of sinking accident reports is more limited than other maritime accidents. This is because the ship's size is mostly smaller than the other maritime accidents, so that the class does not cover that type of ship, and it is more challenging to gather the data due to the loss of ship and fatalities. The ship's characteristics in the sinking accidents are different from collision and grounding accidents. In the USA and Hong Kong, the sinking accidents occurred to the ship that has smaller GT than the other casualties. However, in the Indonesian sinking accidents, the ship's GT is not entirely different from other maritime accidents.

The generic task that occurred in the sinking accidents was mostly a challenging task. This because the situation faced by the seafarers is a complicated situation that is not supported as well by the machinery and instrument to prevent accidents.

Most of the sinking accidents occurred in the fine weather, which in the calm sea and good visibility. Therefore, the environmental condition is not a significant threat to sinking accidents. However, the seafarer also has to give concern for the environmental state well, so the seafarer can do some mitigation procedures to encounter the bad weather condition, such as preparing the types of machinery condition.

Unlike other maritime accidents, the machine factors are leading as a primary causal factor in the sinking accidents. The unreliable instrument on the vessel is mostly due to the ignorance of the maintenance schedule of the machinery. Compare with other maritime accidents, the ship's size in the sinking accidents was smaller, and mostly it was owned by individuals. It is probably the cause of lack of machine maintenance because they tend to do the corrective maintenance with their vessel. The operational procedure of small ships is not as good as the big vessel as well.

5.2 MAART method applications

Other factors related to humans can also influence human performance and judgment while performing their tasks, especially in terms of BRM. Machine factors, media factors, and management factors also strongly affect the human condition and performance (Chen et al., 2013; Mutmainnah, Bowo, Sulistiyono, & Furusho, 2018; Uğurlu et al., 2018). The EPC factors established by William (Williams, 1986) also include some that are related to 4M (man, machine, media, and management) factors; yet, this method is still general. This study combines the HEART method, which was developed for assessing nuclear power plants, with 4M factors in order to understand the relation of 4M within the context of EPC, particularly BRM. Previously, the conventional HEART method has been utilized to assess HEPs in maritime accident cases; yet, this method may have some weaknesses when selecting the EPC and determining the mitigation process because it is still general. There are no classification details however in the HEART method EPC. Nevertheless, in the BRM, machinery, environment, and management factors can strongly influence human performance. Therefore, in this study, EPC was classified into 4M to clarify the role of these other factors.

The results of the study reinforce the idea that the interaction between the man and management factors, namely the coordination between the person on the bridge and related stakeholders onshore, that is, the operator/owner, VTS, or PSC (Port State Control) (Mutmainnah, 2014, 2017; Mutmainnah et al., 2018; Mutmainnah & Furusho, 2016), (Chauvin et al., 2013) is the interaction during which the most errors occur, leading to accidents. Some key causative factors are traffic density and unfavorable weather conditions, such as heavy rain, high waves, and fast currents in terms of media. Given the variety of environmental conditions and stakeholders involved in the operation of sea transportation, technological requirements that can support the transportation process's safety become essential. The causative factors described above are not entirely covered in the EPC list contained in the current HEART. Therefore, the authors developed a special HEART for maritime accidents by incorporating the 4M framework concept. Of the four factors in the 4M framework, man is an intrinsic element prone to making mistakes.

In this study, the authors developed the MAART method, by combining HEART method by adding the EPC – 4M series, categorized the EPC to the 4M framework in the qualitative process, and adding the quantification process to minimize the subjectivity. The results of this development identify the main issues that need focus. Because the top factor in the EPC – 4M series is the one with the highest APE weight, the highest APE is considered the leading cause of the accident. In previous maritime accidents that were analyzed using the HEART method, the most common EPC – 4M was the one with the most significant number of EPC – 4M identified, but it did not consider whether this EPC – 4M had the highest or lowest weights. The main problem was not well clarified.

Furthermore, the management, environment, and technology factors need to be considered in maritime accidents because they are related to the actual human involved in the situation. Therefore, these factors cannot be excluded when assessing maritime accidents. In the quantification process, adding the MCDM (Multi-Criteria Decision Making) tools to determine the weight of every Assessed Proportion Effects (APE) that belong to EPC – 4M is reducing the subjectivity. So, the results of the HEP can be more reliable.

The HEART method is a robust tool for analyzing human error probability. However, this method has some limitations to connect each EPC that has an attachment to other factors and to calculate the HEP value in the maritime industry. To overcome these limitations, first, the HEART method has been combined with the 4M factors to categorize the EPC into man, machine, media, and management factors (Bowo, Prilana, and Furusho 2019). This categorization can define all the 38 EPC established by William in 1986 into the 4M factors, which are related to the maritime industry's working environment. These 4M factors are related to each other because each factor can also influence other factors. Second, TOPSIS is used to determine the APE's weight for every selected EPC in the case by considering the relation of every EPC.

Finally, a hybrid method that integrates HEART – 4M and TOPSIS to calculate Indonesia's maritime accidents was proposed. The integration of these methods suggests the relation between the EPC and the 4M method and the dependencies among them. The relationship between factors and the involvement of other factors in maritime accidents is now well addressed. The TOPSIS method also helps the assessor to determine the weight of the APE for every selected EPC.

CHAPTER 6
CONCLUSIONS

6.1 Conclusion

HRA is considered as a tool to determine the probability of human error and help the decision-maker to develop a mitigation process to avoid the same situation in the future. However, other factors related to humans can also influence human performance and judgment while performing their tasks, especially in terms of BRM. Machine factors, media factors, and management factors also strongly affect the human condition and performance (Chen et al., 2013; Mutmainnah et al., 2018; Uğurlu et al., 2018). The EPC factors established by William (Williams, 1986) also include some that are related to 4M (man, machine, media, and management) factors; yet, this method is still general. This study combines the HEART method, which was developed for assessing nuclear power plants, with 4M factors in order to understand the relation of 4M within the context of EPC, particularly BRM and TOPSIS method, to calculate the APE weight objectively. Previously, the conventional HEART method has been utilized to assess HEPs in maritime accident cases; yet, this method may have some weaknesses when selecting the EPC and determining the mitigation process because it is still general. There are no classification details yet in the HEART method EPC. Nevertheless, in the BRM, machinery, environment, and management factors can strongly influence human performance. Therefore, in this study, EPC were classified into 4M to clarify these other factors' role.

Furthermore, the purpose of this study is to introduce a new method for quantifying the HEP in maritime accidents, in this case, collision accidents. Owing to some limitations of the HEART method, a number of developments of this method have been conducted. In this study, the HEART – 4M method, based on the TOPSIS method, is proposed to overcome the limitation of the HEART method for analyzing maritime accident cases. The TOPSIS method can be used to obtain the uncertainty of weight for every EPC and determine the dependencies among EPC to determine the most influential EPC in a particular maritime accident. Furthermore, the result of the analysis of Indonesian maritime collision accidents shows that the most common GT is a fairly simple task that is rapidly performed and receives scant attention. Further, the EPC of management factors are the most common causal factors found in these accidents. In conclusion, the hybrid method proposed in this study provides a practical tool to determine the value of HEP in maritime accidents.

6.2 Contributions to Academic Literature

In this study, the categorization of EPC to 4M factors clarifies which factors need to be given more concern. It can be contended that by using the integrated method presented in this study as a complement to a HEART method, the question about the relationships between factors and the involvement of other factors in maritime accidents is now well addressed. At least two benefits can be obtained from the proposed method:

1. A new robust tool to analyze the maritime accidents is provided, named MAART.
2. Although some previous researches (Akyuz et al., 2016; Maniram Kumar, Rajakarunakaran, & Arumuga Prabhu, 2017; Wang, Liu, & Qin, 2018b) in HEART development method have been conducted before, it focused on the calculation process to provide the weight of APE. This study offers a new approach to analyze the maritime accidents, not limited to occupational accidents, by utilizing the HEART – 4M methods due to its flexibility and convenience to apply. Furthermore, the results from the HEART – 4M methods can provide academic researchers with highlight results of which factors are given the most impact in the accidents and more comfortable to determine the mitigation strategy to reduce the value of errors. This study also contributed to the maritime literature for the categorization of the EPC to 4M factors, that suitable conditions for the maritime industry.
3. To the best of authors' knowledge, the categorization of EPC to 4M factors to assess the human error probability firstly conducted by the author to evaluate the maritime accidents (Bowo & Furusho, 2019b) and this is the first time to utilize it to determine the occupational accidents in the maritime industry.

6.3 Contribution to Maritime Industry

Finally, a hybrid method of HEART–4M - TOPSIS is proposed, called MAART (Maritime Accident Analysis and Reduction Technique), which was applied to evaluate the HEP in maritime accidents. The integration of the frameworks suggests each factor's relation and which EPC should belong in the 4M factors. It can be argued that by using the integrated method presented in this paper as a complement to a HEART method, the problem about the relationships between factors and the involvement of other factors in maritime accidents is now well addressed. At least seven advantages can be obtained from the proposed method:

1. It can reveal the causality among the different factors in terms of EPC–4M classification, focusing on the origins of the causal factors. For example, if the report stated that the bridge team's coordination was defective, we could study this in more detail by looking to EPC–4M in the coordination subfactor.
2. It provides information for identifying human factors and other factors that affect human behavior.
3. It provides accident assessors with the knowledge of which factors have the highest impact on accidents because of the EPC series' performance. Moreover, it is easy for assessors to determine mitigation actions to reduce the value of errors that have occurred or occur in the future.
4. Minimize the subjectivity calculation of Human Error Probability (HEP).
5. The proposed method can be applied to evaluate the human influence in a particular condition on-board operation to minimize error occurrences.
6. The proposed method can be considered to make a mitigation strategy by reducing the error probability based on which factors cause some accidents.
7. The proposed method can assess occupational accidents and other maritime accidents, such as collision, grounding, fire, and explosion, sinking. It is not limited to maritime accidents. Furthermore, it also can be applied to the maintenance operations and other different operations to diagnose the error probability.

6.3 Research Limitations

There are some limitations for conducting this research during the process. One of the fundamental rules is the availability of maritime accidents data reports. This study aim is to find the causal factors of the maritime accidents by utilizing the MAART method and utilizing the maritime accidents report as the data source. However, the maritime accidents data report that available in the open source website that belongs to a country official institution is limited. In the countries that the main language is not English, most of the reports will be written in their primary language, and the English reports will be less. It becomes troublesome for international researchers to collect the information needed in cross-country. Therefore, due to the availability of the accident reports in the official website, the data distribution is not even for every country and every kind of the accidents.

Furthermore, the contents of the maritime accident data reports for every country is different from one another. And the explanation style of the reports is also different. There are countries that explain the occurrence of the accident clearly but there are some countries that give the information subtlety. The further development of MAART method is designing the knowledge-based program so that the maritime data reports can be extracted automatically into meaningful information.

The followings further research proposals are made with respect of this study:

1. Design knowledge-based programming to extract the maritime data reports and MAART method.
2. Apply proposed method for forecasting the accidents that might be happened and create the mitigation action.
3. Apply proposed method into different case application.
4. Extend proposed method into other similar sectors in maritime industry, such as offshore, vessel traffic system, port and terminal operation, and so on.

6.4 Recommendations

The recommendations to improve safety on-board operations are explained below:

Lack of monitoring
Adequate checking and maintaining progress tracking while doing the task on-board have a strong relationship with good communication and coordination.

Lack of communication and coordination
Lack of communication is the most common factors that occurred. Effective and efficient communication while working on deck is essential to keep. Effective and efficient communication between seafarers and Master to seafarers increase the safety level. By making the instructions as straightforward as possible before doing the task may decrease the probability of accidents. Those clear instructions are both for oral and procedural instructions. This is also to overcome language problem due to multinational crew which their native languages are not English. Working on-board ship is all about team-work to achieve the objectives. Keeping good communication and coordination while working onboard operation is essential for crew and ship's safety. Briefing for every task and safety induction that has to do on-board every day is vital to do and maintain.

Violation of rules and procedures
Maintaining and monitoring good safety behavior in the ship is essential to prevent the violation of rules and procedures. This commitment of doing the safety behavior has to be had from the top management to the crew on-board operation.

Inadequate skill and knowledge
The education level to be a ship's seafarers is very important for improving the working safety culture on-board and preventing accidents. The adequate skill and knowledge have to be learned and trained before working onboard, especially for safe working conditions. Therefore, the management has to be more selective for recruiting the seafarers.

Lack of Experience

The need for practices all the skill and knowledge, whether it is refreshing the understanding or learning new experiences, is essential for the ship's crew to keep updating their abilities. It is the management task to conduct such training for the ship's crew who has working on-board in a certain period.

Psychological Problem
Stress may induce a higher risk of occupational accidents. Furthermore, stress has been identified as a contributory factor to the crew's productivity and welfare (Hetherington, Flin, & Mearns, 2006). Good management of working schedule, both for the break and rest time on-board and holiday schedule for the ship's crew, is vital to managing the ship's seafarer's mental health.

Unreliable Instrument
It is crucial to maintain all instruments on the ships can work well while sailing. The ship's crew has to support the maintenance schedule and the instruments' physical conditions to keep the ship's crew safe while working with instruments and tools.

Poor Environment
Poor environments such as strong wind and rough seas conditions are associated with increased occupational accidents on-board operation. Therefore, extra precautions and good communications about weather forecast situation is needed.

Health and physical condition
Being tired and sleepy while doing the task may increase the probability of occupational accidents (Barlas & Izci, 2018). Therefore, the management has to grant the ship's seafarers sufficient time to break and rest times.

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APPENDICES

The appendices consist of:

A. **Excel Spreadsheet Calculation.**
   To give the reader better understanding with the calculation process of the Human Error Probability.

B. **Collision.**
C. **Grounding.**
D. **Sinking.**
   In these sections, all the results analysis will be breakdown in detail for every case in collision, grounding, and sinking accidents.

A. Excel Spreadsheet Calculation

Table A. 1 Vessel information and EPC - 4M.

No.	Year	Date	Time	Place	Name	Type			GT	NHU

EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE

Table A. 2 New EPC – 4M Series.

New EPC – 4M Series

TOP		BODY																
EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE	EPC	APE	HEP
																		0
1		**1**		**1**		**1**		**1**		**1**		**1**		**1**		**1**		

Table A. 3 Pair-Wise Comparison Matrix and CR value.

POINTS FROM ASSESSOR – PAIR WISE COMPARISON MATRIX

Attribute

Criteria

	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	Attributes Weight	Consistency measure	Data total (n)	9
EPC X	1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#VALUE!	lmax	#VALUE!
EPC X		1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	CI	#VALUE!
EPC X			1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	RI	1.4499
EPC X				1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	CR	#VALUE!
EPC X					1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
EPC X						1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
EPC X							1	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
EPC X								1	#DIV/0!	#DIV/0!	#DIV/0!		
EPC X									1	1.00	#DIV/0!		

Table A. 4 Standardize Decision Matrix.

Attribute

Criteria

	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

Table A. 5 Weighted Standardized Decision Matrix.

Attribute

Criteria

	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	MAX	MIN
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00

Table A. 6 Ideal Solution Matrix.

Attribute

Criteria

	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	1	1	1	1	1	1	1	1	0
Si*	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Table A. 7 Negative Ideal Solution.

NEGATIVE IDEAL SOLUTION

Attribute

Criteria

	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
EPC X	0	0	0	0	0	0	0	0	1
Si'	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Table A. 8 APE Value.

Criteria

	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X	EPC X
Si*	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Si'	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Si* + Si'	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Si'/(Si* + Si')	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Normalization	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

B. Collision

I. Indonesia

Table B. 1 Indonesia's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2009	22-May	17:28	Tanto Niaga	Container Ship	5,283	0.061	C	0.16
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.4722	1.4722	29	Emotional stress		0.0995	1.0298
2	Time shortage		0.318	1.9539	1	Unfamiliarity		0.0026	1.0410
11	Performance ambiguity		0.1077	1.4309					
HEP		0.7061							
2a	2010	19-May	22:50	Soechi Chemical XIX	Kapal Tangki Kimia	2,904	0.025	E	0.02
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.3602	2.0805	2	Time shortage		0.0639	1.6389
17	Inadequate checking		0.3255	1.6509	11	Performance ambiguity		0.0530	1.2118
26	Progress tracking lack		0.1473	1.0589	37	Lack of human resources		0.0502	1.0015
HEP		0.1447							
2b	2010	19-May	22:50	KM. Dian No.1	General Cargo	1,079	0.074	E	0.02
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.3978	2.1934	17	Inadequate checking		0.1572	1.3144
20	Educational mismatch		0.3595	1.3595	2	Time shortage		0.0855	1.8551
HEP		0.1454							
3	2010	2-Jun	4:30	BOSOWA VI	Kapal General Cargo	3,241	0.038	E	0.02
EPC			APE	AIV	EPC			APE	AIV
29	Emotional stress		0.3549	1.1065	24	Absolute judgments required		0.0402	1.0241
17	Inadequate checking		0.3041	1.6082	28	Low meaning		0.0400	1.0160
26	Progress tracking lack		0.2609	1.1044					
HEP		0.0409							
3	2010	2-Jun	4:30	SHINPO 18	Kapal Barang	1,075	0.025	E	0.02
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.3602	2.0805	2	Time shortage		0.0639	1.6389
10	Knowledge transfer		0.3255	2.4646	17	Inadequate checking		0.0530	1.1059
26	Progress tracking lack		0.1473	1.0589	22	Lack of experience		0.0502	1.0401
HEP		0.2047							
4	2010	4-Aug	1:45	KM. INDIMATAM V	General Cargo	702		E	0.02
EPC			APE	AIV	EPC			APE	AIV
20	Educational mismatch		0.6711	1.6711	22	Lack of experience		0.3289	1.2632
HEP		0.0422							
4	2010	4-Aug	1:45	KM. TRISAL PRATAMA	General Cargo	1,252	0.098	E	0.02
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.2701	1.8103	11	Performance ambiguity		0.0890	1.3558
17	Inadequate checking		0.2302	1.4603	18	Objectives conflict		0.0759	1.1138
28	Low meaning		0.1450	1.0580	26	Progress tracking lack		0.0760	1.0304
20	Educational mismatch		0.1127	1.1127	34	Low mental workload		0.0013	1.0001
HEP		0.0969							
5	2011	18-Mar	4:10	MT. Gloria Sentosa	Asphalt Tanker	955	0.076	E	0.02
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.5417	2.0833	12	Misperception of risk		0.0248	1.0743
13	Poor feedback		0.4336	2.3007					
HEP		0.1030							
5	2011	18-Mar	4:10	Kapal Jukung Irpansya	Kapal Pedalaman	-	0.057	E	0.02
EPC			APE	AIV	EPC			APE	AIV
22	Lack of experience		0.2335	1.1868	37	Lack of human resources		0.1411	1.0042

17	Inadequate checking		0.2048	1.4095	34	Low mental workload		0.0814	1.0081
12	Misperception of risk		0.1706	1.5118	11	Performance ambiguity		0.0193	1.0771
20	Educational mismatch		0.1488	1.1488	2	Time shortage		0.0005	1.0048
HEP		0.0637							
6	2011	26-Sep	6:45	KM. MARINA NUSANTARA	Ferry Ro-Ro Pax	5,272	0.074	D	0.09
EPC			APE	AIV	EPC			APE	AIV
9	Technique unlearning		0.3978	2.9889	12	Misperception of risk		0.1572	1.4716
22	Lack of experience		0.3595	1.2876	33	Poor environment		0.0855	1.0128
HEP		0.5163							
6	2011	26-Sep	6:45	KT. BOMAS SEGARA	(tug boat	177	0.038	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3549	1.7097	37	Lack of human resources		0.0402	1.0040
22	Lack of experience		0.3041	1.2433	34	Low mental workload		0.0400	1.0000
26	Progress tracking lack		0.2609	1.1044					
HEP		0.2121							
7	2012	26-Sep	5:30	Bahuga Jaya	Ro-Ro Passenger Ferry	765	0.076	E	0.02
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.5417	3.1667	12	Misperception of risk		0.0248	1.0743
13	Poor feedback		0.4336	2.3007					
HEP		0.1565							
7	2012	26-Sep	5:30	Norgas Cathinka	gas carrier	14,781	0.012	E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6178	1.2471	10	Knowledge transfer		0.0227	1.1021
13	Poor feedback		0.2237	1.6712	11	Performance ambiguity		0.0182	1.0726
21	Dangerous incentives		0.1176	1.1176					
HEP		0.0551							
8	2012	11-Dec	22:30	KM. ALKEN PESAT	Cargo ship	1,303	0.074	C	0.16
EPC			APE	AIV	EPC			APE	AIV
34	Low mental workload		0.3978	1.0398	21	Dangerous incentives		0.1572	1.1572
10	Knowledge transfer		0.3595	2.6178	19	No diversity of information		0.0855	1.1283
HEP		0.5686							
9	2013	31-May	21:15	KM. Lintas Bahari Utama	General Cargo	1,654	0.074	E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3978	1.1591	16	Impoverished information		0.1572	1.3144
12	Misperception of risk		0.3595	2.0785	23	Unreliable instruments		0.0855	1.0513
HEP		0.0666							
9	2013	31-May	21:15	KM. Lintas Bengkulu	Container ship	2,670	0.074	E	0.02
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.3978	1.0239	12	Misperception of risk		0.1572	1.4716
26	Progress tracking lack		0.3595	1.1438	17	Inadequate checking		0.0855	1.1710
HEP		0.0404							
10	2014	1-Apr	2:13	KM. Journey	Container ship	2,772	0.096	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2645	1.5290	23	Unreliable instruments		0.1180	1.0708
18	Objectives conflict		0.2327	1.3490	10	Knowledge transfer		0.0398	1.1792
21	Dangerous incentives		0.2029	1.2029	16	Impoverished information		0.0009	1.0017
22	Lack of experience		0.1413	1.1130					
HEP		0.5588							
11	2016	19-Nov	19:45	Victory Prima	kapal tangki minyak	3,570	0.031	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6187	1.2475	23	Unreliable instruments		0.0180	1.0108
17	Inadequate checking		0.2056	1.4112	37	Lack of human resources		0.0082	1.0002
36	Task pacing		0.1494	1.0090					
HEP		0.2874							
11	2016	19-Nov	19:45	Jaya-II	Fishing vessel	-	0.076	E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5417	1.2167	17	Inadequate checking		0.0248	1.0495
23	Unreliable instruments		0.4336	1.2601					
HEP		0.0322							
12	2017	7-Apr	1:30	Elisabet	Oil Tanker	833	0.076	E	0.02
EPC			APE	AIV	EPC			APE	AIV

26	Progress tracking lack		0.5417	1.2167	17	Inadequate checking		0.0248	1.0495
13	Poor feedback		0.4336	2.3007					
HEP		0.0588							
12	2017	7-Apr	1:30	Bhaita Jaya Samudra	cargo ship	675	0.076	E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5417	1.2167	17	Inadequate checking		0.0248	1.0495
13	Poor feedback		0.4336	2.3007					
HEP		0.0588							
13	2018	22-May	14:30	Harapan Baru Express VII	passenger ship	6	0.076	E	0.02
EPC			APE	AIV	EPC			APE	AIV
37	Lack of human resources		0.5417	1.0163	34	Low mental workload		0.0248	1.0025
35	Sleep cycles disruption		0.4336	1.0434					
HEP		0.0213							
14	2018	19-Jul	21:50	Bunga Melati 79	cargo ship	1,471		E	0.02
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6786	2.3571	13	Poor feedback		0.3214	1.9643
HEP		0.0926							
14	2018	19-Jul	21:50	Tk. Golden Way 3310	barge	3,395		E	0.02
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		3.0357	2.3571	23	Unreliable instruments		0.3214	1.1929
HEP		0.0724							

II. Japan

Table B. 2 Japan's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	22-Jul	7:42	Nord Power	Cargo ship	88,594	0.074	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3480	1.6961	26	Progress tracking lack		0.1447	1.0579
10	Knowledge transfer		0.2485	2.1182	19	No diversity of information		0.0039	1.0059
12	Misperception of risk		0.2548	1.7645					
HEP		0.6071							
1	2008	22-Jul	7:42	Hai Ying	Cargo ship	1,312	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
18	Objectives conflict		0.5417	1.8125	14	Delayed/incomplete feedback		0.0248	1.0495
12	Misperception of risk		0.4336	2.3007					
HEP		0.3939							
2	2009	20-Feb	6:15	Marine Star	Cargo ship	7,382	0.090	D	0.09
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.4586	1.0275	26	Progress tracking lack		0.2620	1.1048
10	Knowledge transfer		0.2688	2.2098	14	Delayed/incomplete feedback		0.0106	1.0212
HEP		0.2306							
2	2009	20-Feb	6:15	Takasago	Container ship	499	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
13	Task pacing		0.5145	2.5435	12	Misperception of risk		0.0211	1.0632
26	Progress tracking lack		0.4644	1.1858					
HEP		0.5131							
3	2009	10-Mar	2:13	CYGNUS ACE	Vehicles carrier	10,833	0.030	D	0.09
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.2355	1.7065	26	Progress tracking lack		0.1207	1.0483
12	Misperception of risk		0.2156	1.6467	22	Lack of experience		0.1151	1.0921
10	Knowledge transfer		0.1598	1.7192	19	No diversity of information		0.0020	1.0031
17	Inadequate checking		0.1512	1.3025					
HEP		0.6503							
4	2009	27-Oct	19:56	Carina Star	Container ship	7,401	0.089	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4665	1.1866	21	Dangerous incentives		0.0355	1.0355
36	Task pacing		0.2487	1.0149	13	Poor feedback		0.0126	1.0377
12	Misperception of risk		0.2283	1.6850	5	Spatial and functional incompatibility		0.0084	1.0588
HEP		0.3694							
4	2009	27-Oct	19:56	Kurama	Destroyer	5,200	0.053	D	0.09
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.5500	1.5500	12	Misperception of risk		0.1447	1.4340
19	No diversity of information		0.3019	1.4528	22	Lack of experience		0.0034	1.0027
HEP		0.2914							
5	2010	28-Mar	0:11	Outsailing 9	Cargo ship	2,926	0.095	C	0.16
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.2323	1.4646	21	Dangerous incentives		0.1534	1.1534
19	No diversity of information		0.2196	1.3293	13	Poor feedback		0.0449	1.1346
26	Progress tracking lack		0.2042	1.0817	17	Inadequate checking		0.0013	1.0025
12	Misperception of risk		0.1534	1.4602					
HEP		0.6455							
5	2010	28-Mar	0:11	Nisshinmaru	Cargo ship	199	0.090	C	0.16
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.4586	2.3757	14	Delayed/incomplete feedback		0.2620	1.5240
12	Misperception of risk		0.2688	1.8065	26	Progress tracking lack		0.0106	1.0042
HEP		1							
6	2011	6-Jul	6:14	Aquamarine	Cargo ship	4,095	0.030	C	0.16
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.2355	1.9420	26	Progress tracking lack		0.1207	1.0483

12	Misperception of risk		0.2156	1.6467	19	No diversity of information		0.1151	1.1727
14	Delayed/incomplete feedback		0.1598	1.3197	22	Lack of experience		0.0020	1.0016
17	Inadequate checking		0.1512	1.3025					
HEP		1							
6	2011	6-Jul	6:14	Hirashin maru	Fishing vessel	4.9	0.024	C	0.16
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.4047	1.8093	21	Dangerous incentives		0.0655	1.0655
12	Misperception of risk		0.2617	1.7850	17	Inadequate checking		0.0086	1.0172
36	Task pacing		0.2585	1.0155	26	Progress tracking lack		0.0010	1.0004
HEP		0.5690							
7	2011	19-Aug	4:39	flevodijk	Container ship	9,994	0.014	A	0.55
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4898	1.1959	34	Low mental workload		0.119	1.012
37	Lack of human resources		0.3514	1.0105	35	Sleep cycles disruption		0.040	1.004
HEP		0.6753							
8	2011	11-Sep	4:40	Song Lin Wan	Oil Tanker	56,358	0.064	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3133	1.6266	13	Poor feedback		0.1301	1.3903
26	Progress tracking lack		0.2692	1.1077	19	No diversity of information		0.0535	1.0802
12	Misperception of risk		0.2340	1.7020					
HEP		0.7368							
8	2011	11-Sep	4:40	BBC Texas	Cargo ship	9,611	0.098	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6565	1.2626	19	No diversity of information		0.0761	1.1141
13	Poor feedback		0.2197	1.6592	12	Misperception of risk		0.0477	1.1430
HEP		0.2401							
9	2011	27-Nov	4:58	Maruka	Cargo ship	1,416	0.090	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4586	1.9171	26	Progress tracking lack		0.2620	1.1048
12	Misperception of risk		0.2688	1.8065	37	Lack of human resources		0.0106	1.0003
HEP		0.3445							
9	2011	27-Nov	4:58	Kairyo maru no.18	Fishing vessel	16	0.095	C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.3762	2.1287	13	Poor feedback		0.0689	1.2067
26	Progress tracking lack		0.3326	1.1331	2	Time shortage		0.0324	1.3240
36	Task pacing		0.1898	1.0114					
HEP		0.6236							
10	2012	7-Feb	16:22	Kota Duta	Container ship	6,245	0.065	F	0.003
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3790	1.7581	11	Performance ambiguity		0.0407	1.1627
12	Misperception of risk		0.3489	2.0467	2	Time shortage		0.0443	1.4428
13	Poor feedback		0.1543	1.4629	37	Lack of human resources		0.0328	1.0010
HEP		0.0265							
10	2012	7-Feb	16:22	Tanya Karpinskaya	Cargo ship	2,163	0.090	F	0.003
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4586	1.9171	19	No diversity of information		0.2620	1.3930
13	Poor feedback		0.2688	1.8065	2	Time shortage		0.0106	1.1060
HEP		0.0160							
11	2012	8-Mar	11:01	JNS-2	Cargo ship	1,500	0.026	D	0.09
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.3349	1.0201	30	Ill-health		0.0957	1.0191
12	Misperception of risk		0.3338	2.0013	21	Dangerous incentives		0.1018	1.1018
37	Lack of human resources		0.1339	1.0040					
HEP		0.2071							
11	2012	8-Mar	11:01	Choho Maru	Fishing vessel	4.92	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5145	1.2058	17	Inadequate checking		0.0211	1.0421
36	Task pacing		0.4644	1.0279					
HEP		0.2067							
12	2012	15-Apr	20:15	Yong Cai	Container ship	9,810	0.047	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3265	1.6531	12	Misperception of risk		0.0421	1.1264

19	No diversity of information		0.3247	1.4870	25	Unclear allocation of function		0.0017	1.0010
26	Progress tracking lack		0.3049	1.1220					
HEP	0.2799								
13	2012	3-Jul	7:15	Tian Fu	Container ship	5,070	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.5145	1.7717	12	Misperception of risk		0.0211	1.0632
17	Inadequate checking		0.4644	1.9289					
HEP	0.3270								
13	2012	3-Jul	7:15	Sentaimaru	Chemical tanker	498	0.099	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4492	1.8983	12	Misperception of risk		0.0956	1.2868
10	Knowledge transfer		0.2657	2.1954	19	No diversity of information		0.0077	1.0115
16	Impoverished information		0.1819	1.3639					
HEP	0.6658								
14	2012	16-Jul	4:03	No. 317 ORYONG	Fishing Vessel	380		D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6786	2.3571	12	Misperception of risk		0.3214	1.9643
HEP	0.4167								
14	2012	16-Jul	4:03	Shoki Maru	Fishing Vessel	11	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.5417	1.0325	17	Inadequate checking		0.0248	1.0495
26	Progress tracking lack		0.4336	1.1734					
HEP	0.2034								
15	2012	24-Sep	1:56	Nikkei Tiger	Bulk Carrier	25,074	0.004	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.3876	2.1628	26	Progress tracking lack		0.1506	1.0602
19	No diversity of information		0.3587	1.5381	17	Inadequate checking		0.1031	1.2061
HEP	0.3829								
15	2012	24-Sep	1:56	Horiei maru	Fishing Vessel	119		C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.6786	1.4071	33	Poor environment		0.3214	1.0482
HEP	0.2360								
16	2013	10-Jan	12:19	Putri Nilam Satu	LNG tanker	94,446	0.038	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3549	1.7097	13	Poor feedback		0.0402	1.1205
10	Knowledge transfer		0.3041	2.3685	2	Time shortage		0.0400	1.3996
12	Misperception of risk		0.2609	1.7827					
HEP	1								
16	2013	10-Jan	12:19	Sakura Harmony	LPG tanker	2,997	0.019	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4684	1.1874	12	Misperception of risk		0.0822	1.2466
17	Inadequate checking		0.3813	1.7627	19	No diversity of information		0.0681	1.1021
HEP	0.2588								
17	2013	23-Jan	23:12	BAI CHAY BRIDGE	Container ship	44,234	0.051	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3855	1.7710	28	Low meaning		0.141057368	1.0564
36	Task pacing		0.2745	1.0165	11	Performance ambiguity		0.004695349	1.0187
26	Progress tracking lack		0.1943	1.0777					
HEP	0.1879								
17	2013	23-Jan	23:12	SEIHOU MARU No. 18	Fishing vessel	18	0.043	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6404	1.2562	12	Misperception of risk		0.0511	1.1532
17	Inadequate checking		0.1530	1.3060	21	Dangerous incentives		0.0414	1.0414
19	No diversity of information		0.1141	1.1712					
HEP	0.2077								
18	2013	25-Feb	5:59	WAN HAI 162	Container ship	13,246	0.074	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3480	1.6961	18	Objectives conflict		0.1447	1.2171
12	Misperception of risk		0.2548	1.7645	24	Absolute judgments required		0.0039	1.0024
10	Knowledge transfer		0.2485	2.1182					
HEP	1								

18	2013	25-Feb	5:59	SEINAN MARU No.7	Fishing vessel	9.7	0.098	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4064	1.1626	13	Poor feedback		0.1062	1.3186
36	Task pacing		0.2510	1.0151	19	No diversity of information		0.0053	1.0080
17	Inadequate checking		0.2311	1.4622					
HEP		0.3669							
19	2013	15-Jun	2:04	Fukukawa	Cargo ship	1,451	0.070	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2489	1.0996	25	Unclear allocation of function		0.2026	1.1216
11	Performance ambiguity		0.2114	1.8454	12	Misperception of risk		0.1103	1.3309
21	Dangerous incentives		0.2078	1.2078	33	Poor environment		0.0191	1.0029
HEP		0.5870							
20	2013	23-Jun	9:44	NOCC OCEANIC	Car Carrier	58,250	0.040	C	0.16
EPC			APE	AIV	EPC			APE	AIV
24	Absolute judgments required		0.2358	1.1415	8	Channel overload		0.1046	1.5231
19	No diversity of information		0.2308	1.3462	33	Poor environment		0.0108	1.0016
21	Dangerous incentives		0.2118	1.2118	3	Low signal-noise ratio		0.0022	1.0200
11	Performance ambiguity		0.2040	1.8159					
HEP		0.8419							
20	2013	23-Jun	9:44	YUJIN MARU No. 7	Fishing Vessel	19	0.036	C	0.16
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.2619	1.3929	24	Absolute judgments required		0.1022	1.0613
26	Progress tracking lack		0.2317	1.0927	11	Performance ambiguity		0.0106	1.0423
21	Dangerous incentives		0.2073	1.2073	33	Poor environment		0.0022	1.0003
17	Inadequate checking		0.1841	1.3683					
HEP		0.4451							
21	2013	27-Sep	1:22	JIA HUI	Cargo ship	2,962	0.090	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4586	1.1834	19	No diversity of information		0.2620	1.3930
17	Inadequate checking		0.2688	1.5377	14	Delayed/incomplete feedback		0.0106	1.0212
HEP		0.2330							
22	2014	18-Mar	3:10	BEAGLE III	Cargo ship	12,630	0.044	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3495	1.1398	14	Delayed/incomplete feedback		0.0841	1.1682
19	No diversity of information		0.3341	1.5011	24	Absolute judgments required		0.0191	1.0115
17	Inadequate checking		0.2133	1.4265					
HEP		0.4614							
22	2014	18-Mar	3:10	PEGASUS PRIME	Container ship	7,406	0.044	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3495	1.1398	14	Delayed/incomplete feedback		0.0841	1.1682
19	No diversity of information		0.3341	1.5011	24	Absolute judgments required		0.0191	1.0115
17	Inadequate checking		0.2133	1.4265					
HEP		0.4614							
23	2014	15-Nov	19:19	YONG SHENG VII	Cargo ship	2,982	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.5417	2.6250	2	Time shortage		0.0248	1.2476
19	No diversity of information		0.4336	1.6504					
HEP		0.4864							
23	2014	15-Nov	19:19	HOKUEI No.18	Dredger carrier	960	0.003	D	0.09
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.3267	1.0196	21	Dangerous incentives		0.0924	1.0924
26	Progress tracking lack		0.2934	1.1174	18	Objectives conflict		0.0740	1.1109
17	Inadequate checking		0.2031	1.4062	19	No diversity of information		0.0104	1.0156
HEP		0.1777							
24	2015	17-Oct	3:26	SULPHUR GARLAND	Chemical Tanker	3,498	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.5145	2.5435	17	Inadequate checking		0.0211	1.0421
14	Delayed/incomplete feedback		0.4644	1.9289					
HEP		0.4602							
24	2015	17-Oct	3:26	WAKOMARU NO. 2	Oil Tanker	2,018	0.009	C	0.16
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.3456	1.0207	17	Inadequate checking		0.1000	1.2001

26	Progress tracking lack		0.3081	1.1232	22	Lack of experience		0.0582	1.0465
9	Technique unlearning		0.1401	1.7006	25	Unclear allocation of function		0.0480	1.0288
HEP		0.4031							
25	2015	2-Nov	21:09	RYOHOMARU No.8,	Fishing vessel	7	0.037	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5500	1.2200	12	Misperception of risk		0.0773	1.2319
36	Task pacing		0.3201	1.0192	17	Inadequate checking		0.0526	1.1051
HEP		0.2708							
26	2016	8-Jan	9:54	"BEETLE"	Passenger Ship	164	0.006	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.3747	2.1241	36	Task pacing		0.1389	1.0083
17	Inadequate checking		0.3704	1.7409	5	Spatial and functional incompatibility		0.1159	1.8116
HEP		0.6079							
27	2016	19-Feb	23:56	SINOKOR INCHEON	Container Ship	3,489	0.055	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4679	1.1872	21	Dangerous incentives		0.1286	1.1286
17	Inadequate checking		0.2181	1.4362	12	Misperception of risk		0.0053	1.0158
37	Lack of human resources		0.1802	1.0054					
HEP		0.1769							
27	2016	19-Feb	23:56	TOSHIMARU	Fishing Vessel	5	0.079	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4605	1.9210	2	Time shortage		0.0899	1.8988
26	Progress tracking lack		0.3727	1.1491	34	Low mental workload		0.0770	1.0077
HEP		0.3801							
28	2018	4-May	7:02	NYK VENUS	Container vessel	97,825	0.098	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2715	1.1086	17	Inadequate checking		0.1256	1.2512
16	Impoverished information		0.2679	1.5358	36	Task pacing		0.0430	1.0026
12	Misperception of risk		0.1507	1.4520	10	Knowledge transfer		0.0009	1.0041
14	Delayed/incomplete feedback		0.1405	1.2810					
HEP		0.3590							
28	2018	4-May	7:02	SITC OSAKA	Container vessel	9,566	0.080	D	0.09
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.3922	1.7845	17	Inadequate checking		0.1890	1.3781
12	Misperception of risk		0.3255	1.9766	19	No diversity of information		0.0932	1.1398
HEP		0.4986							

III. HongKong

Table B. 3 Hong Kong's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	1-Jul	20:17	The Cotai Strip Expo	Passenger ship	1,510	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3762	1.7524	7	Irreversibility		0.0689	1.4824
27	Physical capabilities		0.3326	1.1331	2	Time shortage		0.0324	1.3240
17	Inadequate checking		0.1898	1.3796					
HEP		0.4839							
2	2008	2-Sep	11:42	THE VENETIAN	Passenger ship	700	0.07	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.2711	1.5422	13	Poor feedback		0.0225	1.0675
17	Inadequate checking		0.2643	1.5286	7	Irreversibility		0.0099	1.0690
26	Progress tracking lack		0.1841	1.0736	5	Spatial and functional incompatibility		0.0060	1.0421
14	Delayed/incomplete feedback		0.1688	1.3375	23	Unreliable instruments		0.0022	1.0013
11	Performance ambiguity		0.0711	1.2845					
HEP		0.8285							
3	2008	5-Mar	21:01	CSCL HAMBURG	Bulk carrier	39,894	0.1	D	0.09
EPC			APE	AIV	EPC			APE	AIV
18	Objectives conflict		0.2645	1.3967	24	Absolute judgments required		0.1180	1.0708
15	Operator inexperience		0.2327	1.4653	22	Lack of experience		0.0398	1.0319
13	Poor feedback		0.2029	1.6088	2	Time shortage		0.0009	1.0085
26	Progress tracking lack		0.1413	1.0565					
HEP		0.3489							
4	2008	11-Jan	20:28	Funchal	Passenger ship	267	0.06	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4722	1.9445	14	Delayed/incomplete feedback		0.0995	1.1990
16	Impoverished information		0.3180	1.6359	2	Time shortage		0.0026	1.0256
26	Progress tracking lack		0.1077	1.0431					
HEP		0.6529							
5	2008	21-Oct	5:43	OOCL Europe	Container ship	89,097	0.03	D	0.09
EPC			APE	AIV	EPC			APE	AIV
35	Sleep cycles disruption		0.2355	1.0236	13	Poor feedback		0.1207	1.3621
20	Educational mismatch		0.2156	1.2156	15	Operator inexperience		0.1151	1.2302
22	Lack of experience		0.1598	1.1279	2	Time shortage		0.0020	1.0204
36	Task pacing		0.1512	1.0091					
HEP		0.2179							
6	2008	22-Mar	21:13	Yao Hai	Bulk Carrier	36,544	0.06	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2670	1.1068	11	Performance ambiguity		0.1510	1.6039
14	Delayed/incomplete feedback		0.2478	1.4955	13	Poor feedback		0.0870	1.2611
17	Inadequate checking		0.2456	1.4911	2	Time shortage		0.0017	1.0167
HEP		0.4568							
7	2009	20-Mar	5:27	*XIN HUI JI 9*	Container vessel	673	0.09	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3762	1.7524	2	Time shortage		0.0689	1.6891
14	Delayed/incomplete feedback		0.3326	1.6653	15	Operator inexperience		0.0324	1.0648
26	Progress tracking lack		0.1898	1.0759					
HEP		0.9036							
8	2009	20-Mar	3:44	COTAI STRIP COTAIGOLD	Passenger ship	700	0.08	C	0.16
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.3922	1.7845	17	Inadequate checking		0.1890	1.3781
12	Misperception of risk		0.3255	1.9766	26	Progress tracking lack		0.0932	1.0373
HEP		0.8067							

9	2009	14-Nov	21:47	Joshu Maru	General cargo ship	3,843	0.1	C	0.16
EPC			APE	AIV	EPC			APE	AIV
15	Operator inexperience		0.2645	1.5290	17	Inadequate checking		0.1180	1.2360
10	Knowledge transfer		0.2327	2.0470	16	Impoverished information		0.0398	1.0796
14	Delayed/incomplete feedback		0.2029	1.4059	2	Time shortage		0.0009	1.0085
26	Progress tracking lack		0.1413	1.0565					
HEP		1							
10	2010	7-Dec	3:05	Hui Jin Qiao 07	Container ship	995	0.06	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2670	1.1068	14	Delayed/incomplete feedback		0.1510	1.3020
20	Educational mismatch		0.2478	1.2478	23	Unreliable instruments		0.0870	1.0522
15	Operator inexperience		0.2456	1.4911	11	Performance ambiguity		0.0017	1.0067
HEP		0.2556							
11	2011	1-Sep	4:47	HADIS	Container ship	27, 681		D	0.09
EPC			APE	AIV	EPC			APE	AIV
24	Absolute judgments required		1	1.6					
HEP		0.144							
12	2011	9-Mar	21:45	Hoi Lung No.87	Dumb Lighter	476	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4586	1.9171	16	Impoverished information		0.2620	1.5240
13	Poor feedback		0.2688	1.8065	35	Sleep cycles disruption		0.0106	1.0011
HEP		0.4755							
13	2011	13-Feb	22:37	New Fe rry LXXXVI	Passenger ship	695	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3762	1.7524	14	Delayed/incomplete feedback		0.0689	1.1378
26	Progress tracking lack		0.3326	1.1331	2	Time shortage		0.0324	1.3240
17	Inadequate checking		0.1898	1.3796					
HEP		0.3714							
14	2011	26-Jun	9:35	NEW FERRY VI	Passenger ship	489	0.1	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2701	1.5402	14	Delayed/incomplete feedback		0.0890	1.1779
16	Impoverished information		0.2302	1.4603	15	Operator inexperience		0.0759	1.1518
30	Ill-health		0.1450	1.0290	13	Poor feedback		0.0760	1.2279
23	Unreliable instruments		0.1127	1.0676	36	Task pacing		0.0013	1.0001
HEP		0.3705							
15	2012	8-May	13:25	LILAU	Passenger ship	267	0.09	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3762	1.7524	13	Poor feedback		0.0689	1.2067
17	Inadequate checking		0.3326	1.6653	15	Operator inexperience		0.0324	1.0648
26	Progress tracking lack		0.1898	1.0759					
HEP		0.6455							
16	2012	13-May	4:18	Wealth Great	Bulk Carrier	40,913	0.06	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2670	1.1068	14	Delayed/incomplete feedback		0.1510	1.3020
16	Impoverished information		0.2478	1.4955	15	Operator inexperience		0.0870	1.1741
17	Inadequate checking		0.2456	1.4911	2	Time shortage		0.0017	1.0167
HEP		0.3452							
17	2012	9-Apr	17:39	Josco Lily	Container ship	9,590	0.1	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.2645	1.5290	24	Absolute judgments required		0.1180	1.0708
15	Operator inexperience		0.2327	1.4653	14	Delayed/incomplete feedback		0.0398	1.0796
17	Inadequate checking		0.2029	1.4059	2	Time shortage		0.0009	1.0085
26	Progress tracking lack		0.1413	1.0565					
HEP		0.6208							
18	2013	5-Nov	0:51	OOCL Southampton	Container ship	89,097	0.09	C	0.16
EPC			APE	AIV	EPC			APE	AIV
15	Operator inexperience		0.3762	1.7524	24	Absolute judgments required		0.0689	1.0413
14	Delayed/incomplete feedback		0.3326	1.6653	2	Time shortage		0.0324	1.3240
17	Inadequate checking		0.1898	1.3796					
HEP		0.8882							

19	2014	29-Oct	23:40	Silver Phoenix	Bulk Carrier	40,489	0.09	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3762	1.7524	11	Performance ambiguity		0.0689	1.2756
14	Delayed/incomplete feedback		0.3326	1.6653	15	Operator inexperience		0.0324	1.0648
26	Progress tracking lack		0.1898	1.0759					
HEP		0.6824							
20	2014	24-Aug	18:53	SAFMARINE NOMAZWE	Container ship	50,657	0.06	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2670	1.1068	11	Performance ambiguity		0.1510	1.6039
15	Operator inexperience		0.2478	1.4955	14	Delayed/incomplete feedback		0.0870	1.1741
17	Inadequate checking		0.2456	1.4911	2	Time shortage		0.0017	1.0167
HEP		0.7561							
21	2014	25-Dec	21:17	RBD Jutlandia	Container ship	7,464	0.08	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5417	1.2167	14	Delayed/incomplete feedback		0.0248	1.0495
17	Inadequate checking		0.4336	1.8671					
HEP		0.3815							

IV. Australia

Table B. 4 Australia's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2007	23-Apr	11:50	Bulk Carrier	Bulk Carrier	45,665	0.08	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3921	1.7843	26	Progress tracking lack		0.1890	1.0756
17	Inadequate checking		0.3255	1.6509	10	Knowledge transfer		0.0932	1.4194
HEP		0.4047							
1	2007	24-Apr	12:50	Fishing vessel	Fishing vessel	48.1	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
37	Lack of human resources		0.5238	1.0157	36	Task pacing		0.0239	1.0014
26	Progress tracking lack		0.4193	1.1677					
HEP		0.1069							
2	2007	30-Nov	0:36	LPG Tanker	LPG Tanker	3,676	0.025	D	0.09
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.3601	2.6206	11	Performance ambiguity		0.0639	1.2555
16	Impoverished information		0.3254	1.6509	17	Inadequate checking		0.0530	1.1059
13	Poor feedback		0.1473	1.4420	26	Progress tracking lack		0.0502	1.0201
HEP		0.7953							
2	2007	30-Nov	0:36	Fishing vessel	Fishing vessel	48	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.5238	1.3143	2	Time shortage		0.0239	1.2394
26	Progress tracking lack		0.4193	1.1677					
HEP		0.1712							
3	2008	21-Jan	21:02	Fishing vessel	Fishing vessel	20.22	0.074	C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.3976	1.2386	24	Absolute judgments required		0.1571	1.0943
26	Progress tracking lack		0.3594	1.1438	16	Impoverished information		0.0855	1.1710
HEP		0.2904							
3	2008	22-Jan	22:02	Container Ship	Container Ship	30,509	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.4219	1.6328	10	Knowledge transfer		0.2411	2.0848
26	Progress tracking lack		0.2473	1.0989	16	Impoverished information		0.0098	1.0195
HEP		0.3432							
4	2009	16-Apr	1:00	Bulk Carrier	Bulk Carrier	32,942	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4219	1.1688	12	Misperception of risk		0.2411	1.7232
19	No diversity of information		0.2473	1.3710	2	Time shortage		0.0098	1.0975
HEP		0.2727							
4	2009	17-Apr	2:00	Fishing vessel	Fishing vessel	20.22		D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6786	1.2714	17	Inadequate checking		0.3214	1.6429
HEP		0.1880							
5	2009	9-Sep	1:50	Ella's pink lady	yacht	6.2	0.095	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3762	1.7524	35	Sleep cycles disruption		0.0689	1.0069
13	Poor feedback		0.3326	1.9979	36	Task pacing		0.0324	1.0019
26	Progress tracking lack		0.1898	1.0759					
HEP		0.3420							
5	2009	10-Sep	2:50	Silver Yang	Bulk Carrier	63,800	0.056	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2647	1.1059	36	Task pacing		0.1497	1.0090
13	Poor feedback		0.2456	1.7369	19	No diversity of information		0.0863	1.1294
24	Absolute judgments required		0.2434	1.1461	14	Delayed/incomplete feedback		0.0017	1.0033
HEP		0.2265							
6	2010	6-Oct	19:44	Offshore sup.ves	Offshore sup. vess	3,750	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.4296	2.2888	24	Absolute judgments required		0.0176	1.0106

26	Progress tracking lack		0.3878	1.1551					
HEP		0.2405							
6	2010	7-Oct	20:44	barge	barge	1,360	0.09	C	0.16
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.4219	2.6876	23	Unreliable instruments		0.2411	1.1446
26	Progress tracking lack		0.2473	1.0989	15	Operator inexperience		0.0098	1.0195
HEP		0.5515							
7	2010	8-Oct	14:50	Bulk Carrier	Bulk Carrier	68,788	0.068	D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.2711	1.1627	5	Spatial and functional incompatibility		0.0225	1.1576
17	Inadequate checking		0.2643	1.5286	19	No diversity of information		0.0099	1.0148
10	Knowledge transfer		0.1841	1.8283	13	Poor feedback		0.0060	1.0181
16	Impoverished information		0.1688	1.3375	2	Time shortage		0.0022	1.0224
21	Dangerous incentives		0.0711	1.0711					
HEP		0.5123							
8	2012	26-May	21:56	Bulk Carrier	Bulk Carrier	32,387	0.08	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.3921	1.5882	16	Impoverished information		0.1890	1.3780
26	Progress tracking lack		0.3255	1.1302	2	Time shortage		0.0932	1.9320
HEP		0.4301							
8	2012	27-May	22:56	yacht	yacht	-	0.012	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.5840	2.1680	16	Impoverished information		0.0214	1.0429
26	Progress tracking lack		0.2115	1.0846	23	Unreliable instruments		0.0172	1.0103
12	Misperception of risk		0.1112	1.3336					
HEP		0.2974							
9	2014	8-May	5:48	Bulk Carrier	Bulk Carrier	11,246	0.061	B	0.26
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.4640	1.2784	28	Low meaning		0.0978	1.0391
17	Inadequate checking		0.3124	1.6248	33	Poor environment		0.0025	1.0004
21	Dangerous incentives		0.1058	1.1058					
HEP		0.6208							
10	2014	6-Jul	4:19	Container ship	Container ship	16,772	0.075	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6283	2.2565	26	Progress tracking lack		0.0969	1.0388
23	Unreliable instruments		0.2522	1.1513	34	Low mental workload		0.0023	1.0002
HEP		0.4319							
10	2014	7-Jul	5:19	yacht	yacht	-	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.5238	2.0476	23	Unreliable instruments		0.0239	1.0144
26	Progress tracking lack		0.4193	1.1677					
HEP		0.3880							
11	2015	23-Jun	19:00	Jag Arnav	bulk carrier	43,007		C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6786	1.2714	23	Unreliable instruments		0.3214	1.1929
HEP		0.2427							
11	2015	24-Jun	20:00	Total Response	utility vessel	69	0.025	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3601	1.1441	11	Performance ambiguity		0.0639	1.2555
27	Physical capabilities		0.3254	1.1302	21	Dangerous incentives		0.0530	1.0530
15	Operator inexperience		0.1473	1.2947	34	Low mental workload		0.0502	1.0050
HEP		0.3559							
12	2017	24-Jun	7:35	Arafura Sea Delta	Tug	212		E	0.02
EPC			APE	AIV	EPC			APE	AIV
33	Poor environment		1	1.15					
HEP		0.0230							
13	2017	12-Aug	20:00	Glasgow Express	container ship	46,009		D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6786	1.2714	17	Inadequate checking		0.3214	1.6429
HEP		0.1880							
13	2017	13-Aug	21:00	Mako	fishing vessel			D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6786	1.2714	23	Unreliable instruments		0.3214	1.1929
HEP		0.1365							

V. New Zealand

Table B. 5 New Zealand's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2007	22-Feb	22:00	Cruise Cat	passenger vessel	27	0.03	C	0.16
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.2355	1.0141	9	Technique unlearning		0.1207	1.6035
12	Misperception of risk		0.2156	1.6467	37	Lack of human resources		0.1151	1.0035
24	Absolute judgments required		0.1598	1.0959	5	Spatial and functional incompatibility		0.0020	1.0143
35	Sleep cycles disruption		0.1512	1.0151					
	HEP	0.4851							
2	2008	28-Apr	6:33	Anatoki	bulk carrier	550	0.03	C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.2355	1.7065	10	Knowledge transfer		0.1207	1.5431
17	Inadequate checking		0.2156	1.4311	5	Spatial and functional incompatibility		0.1151	1.8058
13	Poor feedback		0.1598	1.4795	33	Poor environment		0.0020	1.0003
16	Impoverished information		0.1512	1.3025					
	HEP	1							
2	2008	29-Apr	7:33	Lodestar Forest	bulk carrier	19,789	0.051	C	0.16
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.3455	1.0207	26	Progress tracking lack		0.1060	1.0424
17	Inadequate checking		0.1664	1.3328	33	Poor environment		0.1006	1.0151
13	Poor feedback		0.1459	1.4377	34	Low mental workload		0.0137	1.0014
10	Knowledge transfer		0.1216	1.5470	16	Impoverished information		0.0003	1.0007
	HEP	0.5133							
3	2008	20-Jun	15:55	Shikari	work boat	NA	0.019	D	0.09
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.3651	1.0219	17	Inadequate checking		0.2279	1.4557
21	Dangerous incentives		0.2751	1.2751	11	Performance ambiguity		0.1319	1.5277
	HEP	0.2608							
4	2008	9-Aug		Monte Stello	Passenger ferry	11,630	0.026	C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.2781	1.8342	23	Unreliable instruments		0.1065	1.0639
24	Absolute judgments required		0.2459	1.1475	36	Task pacing		0.0402	1.0024
17	Inadequate checking		0.2076	1.4152	2	Time shortage		0.0010	1.0103
22	Lack of experience		0.1208	1.0966					
	HEP	0.5631							
5	2012	24-Aug	12:30	Torea	fishing vessel	45		D	0.09
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.6786	1.6786	17	Inadequate checking		0.3214	1.6429
	HEP	0.2482							
6	2015	17-Feb	12:35	Kea	Passenger ferry	105	0.031	D	0.09
EPC			APE	AIV	EPC			APE	AIV
9	Technique unlearning		0.6187	4.0935	12	Misperception of risk		0.0180	1.0541
22	Lack of experience		0.2056	1.1645	2	Time shortage		0.0082	1.0824
7	Irreversibility		0.1494	2.0459					
	HEP	1							

VI. United States of America

Table B. 6 United States of America's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2010	23-Jan	13:00	Eagle Otome	Oil tankship	53,504	0.074	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3389	1.6779	36	Task pacing		0.1409	1.0085
35	Sleep cycles disruption		0.2482	1.0248	2	Time shortage		0.0038	1.0381
26	Progress tracking lack		0.2420	1.0968					
HEP		0.3159							
2	2010	7-Jul	14:25	Caribbean Seo	Towing vessel	NA	0.075	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6283	2.2565	11	Performance ambiguity		0.0969	1.3877
26	Progress tracking lack		0.2522	1.1009	36	Task pacing		0.0023	1.0001
HEP		0.5516							
2	2010	8-Jul	15:25	DUKW 34	Passenger Vehicle	NA	0.069	G	0.0004
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.4296	1.0258	23	Unreliable instruments		0.0176	1.0106
26	Progress tracking lack		0.3878	1.1551					
HEP		0.0005							
3	2011	29-Oct	9:05	Elka Apollon	Chemical tankship	59,486	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.4296	1.2578	2	Time shortage		0.0176	1.1760
16	Impoverished information		0.3878	1.7756					
HEP		0.4202							
3	2011	29-Oct	9:05	MSC netherland	Container ship	37,071		C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.6786	2.3571	2	Time shortage		0.3214	4.2143
HEP		1							
4	2011	5-Dec	2:13	Maersk Wisconsin	Container Ship	50,698	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
22	Lack of experience		0.4296	1.3437	2	Time shortage		0.0176	1.1760
13	Poor feedback		0.3878	2.1634					
HEP		0.5469							
4	2011	5-Dec	2:13	Ruth M Reinaver	Towing vessel	191		C	0.16
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.6786	3.0357	2	Time shortage		0.3214	4.2143
HEP		1							
5	2012	1-Feb	16:30	Natures Way	Towing vessel	140	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4296	1.1718	23	Unreliable instruments		0.0176	1.0106
13	Poor feedback		0.3878	2.1634					
HEP		0.4099							
6	2012	2-May	7:18	FR 8 Pride	Oil tanker	42,010		C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1	1.6					
HEP		0.2560							
7	2012	6-Jun	5:30	Mary ann	Bulk Carrier	21,734		C	0.16
EPC			APE	AIV	EPC			APE	AIV
15	Operator inexperience		0.6786	2.3571	22	Lack of experience		0.3214	1.2571
HEP		0.4741							
8	2012	3-Oct	19:12	John D. Leitch	Bulk Carrier	22,031		C	0.16
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		1	2.5					
HEP		0.4000							
9	2013	23-Apr	8:17	American Dinasty	Fishing vessel	3,659	0.069	G	0.0004
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.4296	2.2888	23	Unreliable instruments		0.0176	1.0106
16	Impoverished information		0.3878	1.7756					
HEP		0.0016							
10	2014	5-Jan	10:42	Mesabi Miner	Bulk Carrier	34,728	0.075	C	0.16

EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.6283	2.2565	12	Misperception of risk		0.0969	1.2908
14	Delayed/incomplete feedback		0.2522	1.5045	2	Time shortage		0.0023	1.0234
HEP		0.7175							
10	2014	6-Jan	11:42	Hollyhock	US Coast Guard Cutter	2,000	0.051	C	0.16
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.3736	1.7473	26	Progress tracking lack		0.1367	1.0547
16	Impoverished information		0.2660	1.5320	2	Time shortage		0.0046	1.0455
36	Task pacing		0.1883	1.0113					
HEP		0.4776							
11	2014	22-Mar	13:00	Summer wind	Bulk Carrier	25,503	0.08	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3921	1.7843	14	Delayed/incomplete feedback		0.1890	1.3780
26	Progress tracking lack		0.3255	1.1302	2	Time shortage		0.0932	1.9320
HEP		0.8590							
11	2014	22-Mar	13:00	The miss susan	Towing vessel	131	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.4296	2.2888	2	Time shortage		0.0176	1.1760
16	Impoverished information		0.3878	1.7756					
HEP		0.7646							
12	2014	18-Jul	3:55	Riley Elizabeth	Towing vessel	514		G	0.0004
EPC			APE	AIV	EPC			APE	AIV
16			0.6786	2.3571	2			0.3214	4.2143
HEP		0.0040							
12	2014	18-Jul	3:55	Barge plant	Barge plant	NA		G	0.0004
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.6786	2.3571	5	Spatial and functional incompatibility		0.3214	3.2500
HEP		0.0031							
13	2014	24-Aug	22:40	Gloria May	Offshore supply vessel	88	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5238	1.2095	17	Inadequate checking		0.0239	1.0479
36	Task pacing		0.4193	1.0252					
HEP		0.2079							
13	2014	24-Aug	22:40	Capt Lee	Fishing vessel	134		A	0.55
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6786	2.3571	26	Progress tracking lack		0.3214	1.1286
HEP		1							
14	2014	23-Sep	6:35	Key Largo	US Coast Guard Cutter	155	0.012	C	0.16
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.5840	1.0350	26	Progress tracking lack		0.0214	1.0086
35	Sleep cycles disruption		0.2115	1.0211	16	Impoverished information		0.0172	1.0343
17	Inadequate checking		0.1112	1.2224					
HEP		0.2157							
14	2014	23-Sep	6:35	Sea Shepperd	Fishing Vessel	NA		G	0.0004
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		1	3					
HEP		0.0012							
15	2015	22-Feb	5:49	St. Louis Express	Container Ship	40,146	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.5238	1.7857	2	Time shortage		0.0239	1.2394
16	Impoverished information		0.4193	1.8385					
HEP		0.3662							
15	2015	22-Feb	5:49	Hammersmith Bridge	Container Ship	98,747	0.074	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.3978	1.5967	36	Task pacing		0.1572	1.0094
16	Impoverished information		0.3595	1.7190	2	Time shortage		0.0855	1.8551
HEP		0.4626							
16	2015	2-Mar	10:27	Diamond Edge	Passenger Vessel	98	0.076	G	0.0004
EPC			APE	AIV	EPC			APE	AIV

19	No diversity of information		0.5417	1.8125	23	Unreliable instruments		0.0248	1.0149
21	Dangerous incentives		0.4336	1.4336					
	HEP	0.0011							
16	2015	2-Mar	10:27	B.W. Haley	Liftboat	98		G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
23	Unreliable instruments		0.6786	1.4071	19	No diversity of information		0.3214	1.4821
	HEP	0.0008							
17	2015	5-Mar	13:34	Chembulk Houston	Tanker	9,230	0.069	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.5145	2.0290	26	Progress tracking lack		0.0211	1.0084
16	Impoverished information		0.4644	1.9289					
	HEP	0.0016							
17	2015	6-Mar	14:34	Monte Alegre	Container Ship	69,132	0.08	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
24	Absolute judgments required		0.3922	1.2353	17	Inadequate checking		0.1890	1.3781
16	Impoverished information		0.3255	1.6510	26	Progress tracking lack		0.0932	1.0373
	HEP	0.0012							
18	2015	9-Mar	12:30	Conti Peridot	Bulk Carrier	33,036	0.095	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.3762	1.1505	36	Task pacing		0.0689	1.0041
17	Inadequate checking		0.3326	1.6653	33	Poor environment		0.0324	1.0049
16	Impoverished information		0.1898	1.3796					
	HEP	0.4267							
18	2015	10-Mar	13:30	Carla Maersk	Tanker	29,289		C	0.16
	EPC		APE	AIV		EPC		APE	AIV
16	Impoverished information		0.6786	2.3571	33	Poor environment		0.3214	1.0482
	HEP	0.3953							
19	2015	30-May	7:55	Miss Natalie	Towing vessel	143		C	0.16
	EPC		APE	AIV		EPC		APE	AIV
12	Misperception of risk		0.6786	3.0357	21	Dangerous incentives		0.3214	1.3214
	HEP	0.6418							
19	2015	31-May	8:55	George W Banta	Towing vessel	267		G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
13	Poor feedback		1	4					
	HEP	0.0016							
20	2015	20-Jul	1:02	Capt. Shorty C	Towing ves.	199	0.09	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
16	Impoverished information		0.4586	1.9171	13	Poor feedback		0.2620	1.7860
21	Dangerous incentives		0.2688	1.2688	23	Unreliable instruments		0.0106	1.0064
	HEP	0.0017							
20	2015	21-Jul	2:02	Jackie	Towing ves.	136	0.069	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
13	Poor feedback		0.5145	2.5435	16	Impoverished information		0.0211	1.0421
21	Dangerous incentives		0.4644	1.4644					
	HEP	0.0016							
21	2015	2-Sep	19:59	Dewey R	Towing Vessel	587	0.069	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.5145	2.0290	26	Progress tracking lack		0.0211	1.0084
21	Dangerous incentives		0.4644	1.4644					
	HEP	0.0012							
21	2015	2-Sep	19:59	P. B. Shah tow	Towing Vessel	754	0.069	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.5145	2.0290	26	Progress tracking lack		0.0211	1.0084
36	Task pacing		0.4644	1.0279					
	HEP	0.0008							
22	2015	29-Oct	22:26	Ocean Freedom	Multipurpose heavy-lift cargo	12,810	0.09	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
16	Impoverished information		0.4586	1.9171	36	Task pacing		0.2620	1.0157
7	Irreversibility		0.2688	2.8819	26	Progress tracking lack		0.0106	1.0042
	HEP	0.0023							
23	2015	14-Dec	11:22	William E Strait	Towing vessel	1,103		G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
7	Irreversibility		0.6786	5.7500	11	Performance ambiguity		0.3214	2.2857

HEP		0.0053							
24	2016	15-Jan	0:20	Tug and Barge, Lucia	Tug and Barge	254	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.5417	2.0833	17	Inadequate checking		0.0248	1.0495
26	Progress tracking lack		0.4336	1.1734					
HEP		0.4105							
24	2016	16-Jan	1:20	William S &Caribbean	Tugboat	195		B	0.26
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.6786	1.6786	11	Performance ambiguity		0.3214	2.2857
HEP		0.9976							
25	2016	17-Jan	16:31	Manizales	Cargo Vessel	4,951	0.087	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4203	1.8407	8	Channel overload		0.1903	1.9516
26	Progress tracking lack		0.3734	1.1494	2	Time shortage		0.0160	1.1595
HEP		0.4309							
25	2016	18-Jan	17:31	Zen-noh GP	Bulk Carrier	30,619	0.087	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4203	1.8407	8	Channel overload		0.1903	1.9516
26	Progress tracking lack		0.3734	1.1494	2	Time shortage		0.0160	1.1595
HEP		0.430877066							
26	2016	28-Jan	4:30	Crimson Gem	Towing Vessel	1,166	0.069	B	0.26
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.5145	1.5145	12	Misperception of risk		0.0211	1.0632
7	Irreversibility		0.4644	4.2511					
HEP		1							
27	2016	31-Jan	19:53	Aris T	Bulk carrier	49,973	0.08	G	0.0004
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4432	1.8863	12	Misperception of risk		0.0311	1.0933
36	Task pacing		0.2564	1.0154	11	Performance ambiguity		0.0152	1.0608
26	Progress tracking lack		0.2489	1.0995	2	Time shortage		0.0082	1.0817
HEP		0.0011							
28	2016	12-Mar	5:00	Specialist	Towing Vessel	131	0.085	C	0.16
EPC			APE	AIV	EPC			APE	AIV
15	Operator inexperience		0.4311	1.8622	22	Lack of experience		0.1131	1.0905
35	Sleep cycles disruption		0.2495	1.0250	23	Unreliable instruments		0.0036	1.0022
24	Absolute judgments required		0.2027	1.1216					
HEP		0.3743							
29	2016	2-Jun	1:11	Matachin	Towing Vessel	489	0.005	G	0.0004
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.5419	1.0325	12	Misperception of risk		0.0874	1.2622
26	Progress tracking lack		0.3521	1.1408	17	Inadequate checking		0.0187	1.0374
HEP		0.0006							
29	2016	3-Jun	2:11	Thetis	US Coast Guard	1800	0.095	G	0.0004
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.3762	2.6930	2	Time shortage		0.0689	1.6891
17	Inadequate checking		0.3326	1.6653	23	Unreliable instruments		0.0324	1.0194
26	Progress tracking lack		0.1898	1.0759					
HEP		0.0033							
30	2017	17-Apr	15:30	Towing Vessel	Towing Vessel	189		C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.6786	3.0357	5	Spatial and functional incompatibility		0.3214	3.2500
HEP		1							
31	2017	18-Apr	0:29	Cerro Santiago	Tugboat	484		G	0.0004
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		1	3					
HEP		0.0012							
31	2017	19-Apr	1:29	Tampa	US Coast Guard	1,829	0.08	G	0.0004
EPC			APE	AIV	EPC			APE	AIV
29	Emotional stress		0.3922	1.1177	17	Inadequate checking		0.1890	1.3781
35	Sleep cycles disruption		0.3255	1.0326	2	Time shortage		0.0932	1.9322
HEP		0.0012							

VII. Canada

Table B. 7 Canada's Collision Accidents.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	17-Dec	4:31	Capt. Henry Jackman	Bulk Carrier	19,643	0.095	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
12	Misperception of risk		0.3579	2.0736	21	Dangerous incentives		0.0918	1.0918
13	Poor feedback		0.3300	1.9900	3	Low signal-noise ratio		0.0052	1.0469
33	Poor environment		0.2151	1.0323					
	HEP	0.7790							
1	2008	18-Dec	5:31	Québecois	Bulk Carrier	17,646	0.076	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
12	Misperception of risk		0.5417	2.6250	33	Poor environment		0.0248	1.0037
13	Poor feedback		0.4336	2.3007					
	HEP	0.9699							
2	2009	8-Apr	1:11	VELERO IV	Research vessel	198	0.051	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
35	Sleep cycles disruption		0.3961	1.0396	19	No diversity of information		0.2435	1.3653
17	Inadequate checking		0.3539	1.7078	2	Time shortage		0.0065	1.0649
	HEP	0.0010							
2	2009	9-Apr	2:11	SILVER CHALLENGER II	Fishing vessel	38	0.077	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
15	Operator inexperience		0.5720	2.1441	19	No diversity of information		0.0380	1.0569
17	Inadequate checking		0.1974	1.3949	2	Time shortage		0.0052	1.0516
12	Misperception of risk		0.1874	1.5622					
	HEP	0.0021							
3	2012	28-Sep	4:30	Viking storm	Fishing vessel	246	0.048	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.4882	1.9765	19	No diversity of information		0.1346	1.2020
16	Impoverished information		0.1739	1.3479	23	Unreliable instruments		0.0298	1.0179
36	Task pacing		0.1638	1.0098	34	Low mental workload		0.0095	1.0010
	HEP	0.5271							
3	2012	29-Sep	5:30	maverick	Fishing vessel	27	0.066	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.5521	2.1042	24	Absolute judgments required		0.0403	1.0242
16	Impoverished information		0.3466	1.6931	5	Spatial and functional incompatibility		0.0112	1.0786
19	No diversity of information		0.0498	1.0748					
	HEP	0.6767							
4	2013	3-Aug	20:59	Heloise	Bulk Carrier	19,865	0.095	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
19	No diversity of information		0.3762	1.5643	5	Spatial and functional incompatibility		0.0689	1.4824
17	Inadequate checking		0.3326	1.6653	34	Low mental workload		0.0324	1.0032
16	Impoverished information		0.1898	1.3796					
	HEP	0.0021							
4	2013	4-Aug	21:59	Ocean Georgie Bain	Tug Boat	204		G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
16	Impoverished information		0.6786	2.3571	4	Features over-ride allowed		0.3214	3.5714
	HEP	0.0034							
5	2014	1-Aug	20:52	CAPTAIN A.G. SOPPITT	Pilot boat	47	0.044	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.6822	2.3643	23	Unreliable instruments		0.0229	1.0138
16	Impoverished information		0.2561	1.5123	33	Poor environment		0.0052	1.0008
19	No diversity of information		0.0335	1.0503					
	HEP	0.6096							
5	2014	2-Aug	21:52	BAYLINER	Passenger/work boat	40	0.031	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.4964	1.9929	24	Absolute judgments required		0.0096	1.0057
16	Impoverished information		0.2746	1.5493	33	Poor environment		0.0081	1.0012
26	Progress tracking lack		0.2112	1.0845					
	HEP	0.3035							
6	2016	24-May	17:30	Albern	Tug Boat	9	0.085	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
7	Irreversibility		0.4586	4.2105	5	Spatial and functional incompatibility		0.1563	2.0943
15	Operator inexperience		0.3683	1.7365	23	Unreliable instruments		0.0168	1.0101
	HEP	0.0062							

VIII. Norway

Table B. 8 Norway's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2009	3-Jul	13:16	SUNDSTRAUM	Chemical tanker	3,205	0.03	D	0.09
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.2355	1.9420	37	Lack of human resources		0.1207	1.0036
25	Unclear allocation of function		0.2156	1.1293	12	Misperception of risk		0.1151	1.3453
21	Dangerous incentives		0.1598	1.1598	9	Technique unlearning		0.0020	1.0102
22	Lack of experience		0.1512	1.1210					
HEP		0.3501							
2	2014	27-Nov	22:20	STAR KVARVEN LAJK7	Mixed cargo/bulk/container	49,856	0.074	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3480	1.1392	11	Performance ambiguity		0.1447	1.5789
24	Absolute judgments required		0.2485	1.1491	16	Impoverished information		0.0039	1.0078
12	Misperception of risk		0.2548	1.7645					
HEP		0.3308							
3	2015	12-Oct	19:57	CLIPPER QUITO LAPW7	Very Large Gas Carrier (VLGC)	48,051	0.074	C	0.16
EPC			APE	AIV	EPC			APE	AIV
24	Absolute judgments required		0.3978	1.2387	16	Impoverished information		0.1572	1.3144
12	Misperception of risk		0.3595	2.0785	33	Poor environment		0.0855	1.0128
HEP		0.5484							
3	2015	12-Oct	19:57	Lurongyu 71108	fishing vessel	78	0.074	B	0.26
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3978	1.1591	21	Dangerous incentives		0.1572	1.1572
17	Inadequate checking		0.3595	1.7190	33	Poor environment		0.0855	1.0128
HEP		0.6072							

IX. Germany

Table B. 9 Germany's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	31-Jan	17:42	Train/car ferry	Train/car ferry	15,187	0.061	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2534	1.1014	13	Poor feedback		0.0979	1.2937
25	Unclear allocation of function		0.2025	1.1215	17	Inadequate checking		0.0930	1.1860
19	No diversity of information		0.1749	1.2623	12	Misperception of risk		0.0455	1.1365
36	Task pacing		0.1319	1.0079	33	Poor environment		0.0008	1.0001
	HEP	0.4385							
2	2008	12-Mar	22:49	HOPE BAY	Reefer Vessel	8,896	0.09	C	0.16
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.4586	3.0635	23	Unreliable instruments		0.2620	1.1572
12	Misperception of risk		0.2688	1.8065	33	Poor environment		0.0106	1.0016
	HEP	1							
2	2008	13-Mar	23:49	OCEANIA	Tug Boat	2,294	0.047	C	0.16
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.3265	1.0196	33	Poor environment		0.0421	1.0063
34	Low mental workload		0.3247	1.0325	16	Impoverished information		0.0017	1.0034
10	Knowledge transfer		0.3049	2.3722					
	HEP	0.4035							
3	2008	14-Mar	20:57	JOSEF MOBIUS	Suction Dredger	5,939	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4586	1.9171	16	Impoverished information		0.2620	1.5240
13	Poor feedback		0.2688	1.8065	26	Progress tracking lack		0.0106	1.0042
	HEP	0.4770							
3	2008	15-Mar	21:57	OCEANIA	Tug Boat	2,294	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
25	Unclear allocation of function		0.5145	1.3087	33	Poor environment		0.0211	1.0032
26	Progress tracking lack		0.4644	1.1858					
	HEP	0.2491							
4	2008	16-May	19:52	FINNLADY	RoPax Ferry	45,923	0.04	E	0.02
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.2623	2.1802	23	Unreliable instruments		0.1089	1.0653
17	Inadequate checking		0.2437	1.4873	2	Time shortage		0.0112	1.1116
16	Impoverished information		0.2244	1.4487	1	Unfamiliarity		0.0023	1.0371
26	Progress tracking lack		0.1473	1.0589					
	HEP	0.1222							
5	2008	1-Jun	6:45	ARTUR BECKER	Special craft	331	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4586	1.9171	16	Impoverished information		0.2620	1.5240
13	Poor feedback		0.2688	1.8065	26	Progress tracking lack		0.0106	1.0042
	HEP	0.4770							
6	2008	1-Jun	7:45	RABA	BULK CARIER	2,325	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.5145	2.5435	34	Low mental workload		0.0211	1.0021
13	Poor feedback		0.4644	2.3933					
	HEP	0.5490							
6	2008	26-Oct	6:00	BELUGA SENSATION	Container Vessel	7,660	0.015	C	0.16
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.6274	2.8823	36	Task pacing		0.1189	1.0071
7	Irreversibility		0.2507	2.7550	2	Time shortage		0.0029	1.0290
	HEP	1							
7	2008	12-Dec	9:46	RMS SAIMAA	multi-purpose freighter	2,069	0.095	C	0.16
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.3762	2.6930	26	Progress tracking lack		0.0689	1.0276
13	Poor feedback		0.3326	1.9979	2	Time shortage		0.0324	1.3240
33	Poor environment		0.1898	1.0285					
	HEP	1							
7	2008	13-Dec	10:46	NORDIC DIANA	multi-purpose freighter	2,774	0.024	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4047	1.1619	37	Lack of human resources		0.0655	1.0020
17	Inadequate checking		0.2617	1.5233	2	Time shortage		0.0086	1.0862
13	Poor feedback		0.2585	1.7756	33	Poor environment		0.0010	1.0001
	HEP	0.5473							
8	2008	16-Dec	22:16	FREYA	Cargo Ship	5,067		E	0.02
EPC			APE	AIV	EPC			APE	AIV

19	No diversity of information		0.6786	2.0179	17	Inadequate checking		0.3214	1.6429
	HEP	0.0663							
9	2009	27-Jun	22:10	MARTI PRINCESS	general cargo ship	6,019	0.056	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.2670	1.1068	17	Inadequate checking		0.1510	1.3020
36	Task pacing		0.2478	1.0149	12	Misperception of risk		0.0870	1.2611
19	No diversity of information		0.2456	1.3683	2	Time shortage		0.0017	1.0167
	HEP	0.4105							
9	2009	28-Jun	23:10	RENATE SCHULTE	Container Vessel	14,619	0.074	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
36	Task pacing		0.3480	1.0209	19	No diversity of information		0.1447	1.2171
17	Inadequate checking		0.2548	1.5097	2	Time shortage		0.0039	1.0392
26	Progress tracking lack		0.2485	1.0994					
	HEP	0.1929							
10	2010	18-Apr	4:05	SONORO	Mini bulker	3,244	0.042	B	0.26
	EPC		APE	AIV		EPC		APE	AIV
19	No diversity of information		0.2607	1.3910	25	Unclear allocation of function		0.1157	1.0694
17	Inadequate checking		0.1710	1.3419	11	Performance ambiguity		0.0861	1.3446
23	Unreliable instruments		0.1604	1.0963	13	Poor feedback		0.0606	1.1817
26	Progress tracking lack		0.1453	1.0581	33	Poor environment		0.0002	1.0000
	HEP	0.9566							
10	2010	19-Apr	5:05	SULLBERG	Tanker	1,969	0.08	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.3922	1.1569	33	Poor environment		0.1890	1.0284
17	Inadequate checking		0.3255	1.6510	2	Time shortage		0.0932	1.9322
	HEP	0.6072							
11	2011	5-Apr	8:04	ZAPADNYY	Tanker	1,896	0.051	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
7	Irreversibility		0.3855	3.6986	13	Poor feedback		0.1411	1.4232
12	Misperception of risk		0.2745	1.8234	21	Dangerous incentives		0.0047	1.0047
33	Poor environment		0.1943	1.0291					
	HEP	1							
13	2011	21-Jun	11:53	CMV CCNI RIMAC	Container Vessel	25,703	0.061	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
32	Inconsistency of displays		0.4722	1.0944	18	Objectives conflict		0.0995	1.1492
25	Unclear allocation of function		0.3180	1.1908	33	Poor environment		0.0026	1.0004
13	Poor feedback		0.1077	1.3232					
	HEP	0.3172							
13	2011	22-Jun	12:53	CMV CSAV PETORCA	Container Vessel	74,373	0.075	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
12	Misperception of risk		0.6412	2.9237	13	Poor feedback		0.0989	1.2968
18	Objectives conflict		0.2574	1.3862	33	Poor environment		0.0024	1.0004
	HEP	0.8412							
14	2013	31-Jan		CORAL ACE	Bulk carrier	25,942	0.03	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
21	Dangerous incentives		0.2355	1.2355	13	Poor feedback		0.1207	1.3621
17	Inadequate checking		0.2156	1.4311	12	Misperception of risk		0.1151	1.3453
26	Progress tracking lack		0.1598	1.0639	2	Time shortage		0.0020	1.0204
33	Poor environment		0.1512	1.0227					
	HEP	0.5756							
14	2013	1-Feb		LISA SCHULTE	Container Vessel	35,975		C	0.16
	EPC		APE	AIV		EPC		APE	AIV
13	Poor feedback		0.6786	3.0357	33	Poor environment		0.3214	1.0482
	HEP	0.5091							
15	2013	2-Mar	10:49	HERM KIEPE	Container Vessel	9,991	0.091	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.3732	1.7464	1	Unfamiliarity		0.0822	2.3149
26	Progress tracking lack		0.2713	1.1085	29	Emotional stress		0.0625	1.0187
33	Poor environment		0.1228	1.0184	7	Irreversibility		0.0096	1.0671
21	Dangerous incentives		0.0762	1.0762	14	Delayed/incomplete feedback		0.0023	1.0045
	HEP	0.8582							
15	2013	3-Mar	11:49	EMPIRE	Container Vessel	15,924	0.074	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.3978	1.1591	14	Delayed/incomplete feedback		0.1572	1.3144
33	Poor environment		0.3595	1.0539	2	Time shortage		0.0855	1.8551
	HEP	0.4766							
16	2013	7-May	15:55	CONMAR AVENUE	Container Vessel	10,585	0.038	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
21	Dangerous incentives		0.3549	1.3549	16	Impoverished information		0.0400	1.0799
7	Irreversibility		0.3041	3.1289	2	Time shortage		0.0402	1.4016
23	Unreliable instruments		0.2609	1.1565					
	HEP	0.6679							

16	2013	8-May	16:55	MAERSK KALMAR	Container Vessel	80,942		E	0.02
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		1	3	Low signal-noise ratio				
	HEP	0.0600							
17	2013	28-Oct	2:56	CORAL IVORY	LPG Tanker	5,831	0.025	D	0.09
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.3602	1.3602	11	Performance ambiguity		0.0639	1.2555
10	Knowledge transfer		0.3255	2.4646	13	Poor feedback		0.0530	1.1589
16	Impoverished information		0.1473	1.2947	2	Time shortage		0.0502	1.5018
	HEP	0.8535							
17	2013	29-Oct	3:56	SIDERFLY	dry bulk cargo ship	2,882		D	0.09
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.6786	2.3571	12	Misperception of risk		0.3214	1.9643
	HEP	0.4167							
18	2013	12-Dec	15:30	MERWEBORG	general cargo ship	6,540	0.098	C	0.16
EPC			APE	AIV	EPC			APE	AIV
24	Absolute judgments required		0.2701	1.1621	12	Misperception of risk		0.0890	1.2669
17	Inadequate checking		0.2302	1.4603	16	Impoverished information		0.0759	1.1518
25	Unclear allocation of function		0.1450	1.0870	18	Objectives conflict		0.0760	1.1139
23	Unreliable instruments		0.1127	1.0676	33	Poor environment		0.0013	1.0002
	HEP	0.5122							
19	2014	16-Jan	5:18	WES JANINE	Container Vessel	10,585	0.057	C	0.16
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.2335	1.0140	26	Progress tracking lack		0.1411	1.0565
16	Impoverished information		0.2048	1.4095	13	Poor feedback		0.0814	1.2443
17	Inadequate checking		0.1706	1.3412	33	Poor environment		0.0193	1.0029
37	Lack of human resources		0.1488	1.0045	2	Time shortage		0.0005	1.0048
	HEP	0.408096							
19	2014	17-Jan	6:18	STENBERG	Chemical Tanker	11,935	0.012	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6178	1.2471	17	Inadequate checking		0.0182	1.0363
36	Task pacing		0.2237	1.0134	2	Time shortage		0.0227	1.2269
33	Poor environment		0.1176	1.0800					
	HEP	1							
20	2014	17-Jan	2:24	PACIFIC ORCA	wind farm inst.vessel	24,586	0.096	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2645	1.1058	12	Misperception of risk		0.1180	1.3540
17	Inadequate checking		0.2327	1.4653	25	Unclear allocation of function		0.0398	1.0239
16	Impoverished information		0.2029	1.4059	1	Unfamiliarity		0.0009	1.0136
34	Low mental workload		0.1413	1.0141					
	HEP	0.5194							
20	2014	18-Jan	3:24	JURIE VAN DEN BERG	fishing vessel	269	0.019	D	0.09
EPC			APE	AIV	EPC			APE	AIV
35	Sleep cycles disruption		0.3651	1.0365	17	Inadequate checking		0.2279	1.4557
26	Progress tracking lack		0.2751	1.1100	37	Lack of human resources		0.1319	1.0040
	HEP	0.1513							
21	2014	1-Mar	6:36	BIMI	general cargo vessel	2,373	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
33	Poor environment		0.5417	1.0813	2	Time shortage		0.0248	1.2476
23	Unreliable instruments		0.4336	1.2601					
	HEP	0.2720							
22	2014	5-Mar	8:02	WILSON FEDJE	general cargo vessel	3,561	0.026	C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.2781	1.8342	33	Poor environment		0.1065	1.0160
26	Progress tracking lack		0.2459	1.0983	19	No diversity of information		0.0402	1.0603
14	Delayed/incomplete feedback		0.2076	1.4152	13	Poor feedback		0.0010	1.0031
10	Knowledge transfer		0.1208	1.5434					
	HEP	0.76078							
22	2014	6-Mar	9:02	JADE	motor cargo vessel	1,408	0.025	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3602	1.7203	21	Dangerous incentives		0.0639	1.0639
19	No diversity of information		0.3255	1.4882	33	Poor environment		0.0530	1.0079
14	Delayed/incomplete feedback		0.1473	1.2947	26	Progress tracking lack		0.0502	1.0201
	HEP	0.5801							
23	2014	30-May	14:25	NOBILE	gaff cutter	72	0.031	D	0.09
EPC			APE	AIV	EPC			APE	AIV

10	Knowledge transfer		0.6187	3.7842	11	Performance ambiguity		0.0180	1.0721
26	Progress tracking lack		0.2056	1.0822	12	Misperception of risk		0.0082	1.0247
17	Inadequate checking		0.1494	1.2988					
HEP		0.5259							
23	2014	31-May	15:25	WERKER	worksite craft	234	0.074	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3978	1.7956	12	Misperception of risk		0.1572	1.4716
26	Progress tracking lack		0.3595	1.1438	10	Knowledge transfer		0.0855	1.3848
HEP		0.3767							
24	2014	4-Jun	10:52	ADLER EXPRESS	passenger ship	334		D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1	1.6					
HEP		0.1440							
25	2014	5-Sep	2:11	FRANSISCA	general cargo	2,377	0.012	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6178	2.2356	19	No diversity of information		0.0182	1.0272
23	Unreliable instruments		0.2237	1.1342	36	Task pacing		0.0227	1.0014
37	Lack of human resources		0.1176	1.0035					
HEP		0.2356							
25	2014	6-Sep	3:11	BREMEN	dry cargo vessel	2,589		D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.6786	2.0179	17	Inadequate checking		0.3214	1.6429
HEP		0.2984							
26	2015	17-Jan	9:42	RED7 ALLIANCE	Supply ship	3,700	0.08	D	0.09
EPC			APE	AIV	EPC			APE	AIV
7	Irreversibility		0.3922	3.7456	26	Progress tracking lack		0.1890	1.0756
12	Misperception of risk		0.3255	1.9766	17	Inadequate checking		0.0932	1.1864
HEP		0.8503							
27	2015	20-Mar	midday	SAINT GEORGE	Cargo Ship	6,680	0.096	D	0.09
EPC			APE	AIV	EPC			APE	AIV
6	Model mismatch		0.2645	2.8513	21	Dangerous incentives		0.1180	1.1180
26	Progress tracking lack		0.2327	1.0931	16	Impoverished information		0.0398	1.0796
11	Performance ambiguity		0.2029	1.8117	17	Inadequate checking		0.0009	1.0017
7	Irreversibility		0.1413	1.9889					
HEP		1							
28	2015	16-Jun	13:59	FRISIA V	passenger ship	1,007		D	0.09
EPC			APE	AIV	EPC			APE	AIV
7	Irreversibility		0.6786	5.7500	23	Unreliable instruments		0.3214	1.1929
HEP		0.6173							
30	2015	3-Dec	18:23	EMSMOON	general cargo vessel	4,563	0.005	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.2729	1.5459	11	Performance ambiguity		0.0226	1.0903
13	Poor feedback		0.2360	1.7079	17	Inadequate checking		0.0056	1.0111
10	Knowledge transfer		0.1875	1.8437	36	Task pacing		0.0089	1.0005
12	Misperception of risk		0.1855	1.5566	26	Progress tracking lack		0.0025	1.0010
14	Delayed/incomplete feedback		0.0773	1.1547	3	Low signal-noise ratio		0.0013	1.0114
HEP		0.8793							
31	2016	20-Nov	1:53	MERIDIAN	multi-purp. carrier	1,251	0.012	C	0.16
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.6178	3.7800	26	Progress tracking lack		0.0227	1.0091
34	Low mental workload		0.2237	1.0224	23	Unreliable instruments		0.0182	1.0109
29	Emotional stress		0.1176	1.0353					
HEP		0.6530							
32	2017	12-Aug	9:55	MV FINNSKY	Ro-ro ferry	28,002	0.012	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6178	2.2356	13	Poor feedback		0.0227	1.0681
21	Dangerous incentives		0.2237	1.2237	1	Unfamiliarity		0.0182	1.2905
14	Delayed/incomplete feedback		0.1176	1.2353					
HEP		0.7452							
32	2017	13-Aug	10:55	STETTIN	traditional ship	783	0.07	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2594	1.1037	36	Task pacing		0.1228	1.0074
13	Poor feedback		0.2147	1.6440	1	Unfamiliarity		0.0309	1.4943
7	Irreversibility		0.2086	2.4603	11	Performance ambiguity		0.0060	1.0239
12	Misperception of risk		0.1576	1.4729					
HEP		0.9121							

X. Denmark

Table B. 10 Denmark's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	21-May		RUDOKOP	tug-vessel	201	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.5145	2.0290	21	Dangerous incentives		0.0211	1.0211
12	Misperception of risk		0.4644	2.3933					
	HEP	0.4462							
1	2008	21-May		ATLANTIC	fishing vessel	13	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4586	1.1834	17	Inadequate checking		0.2620	1.5240
36	Task pacing		0.2688	1.0161	2	Time shortage		0.0106	1.1060
	HEP	0.1824							
2	2008	1-Dec	20:49	BLUE BIRD	General cargo vessel	1,115	0.08	C	0.16
EPC			APE	AIV	EPC			APE	AIV
7	Irreversibility		0.3922	3.7456	17	Inadequate checking		0.1890	1.3781
19	No diversity of information		0.3255	1.4883	33	Poor environment		0.0932	1.0140
	HEP	1.0000							
2	2008	1-Dec	20:49	HAGLAND BONA	General cargo vessel	2,456	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.5417	1.8125	17	Inadequate checking		0.0248	1.0495
26	Progress tracking lack		0.4336	1.1734					
	HEP	0.3571							
3	2010	6-Jul	18:41	NINANITU	Fishing vessel	27	0.081	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2875	1.5749	26	Progress tracking lack		0.1396	1.0558
12	Misperception of risk		0.2479	1.7438	36	Task pacing		0.1344	1.0081
21	Dangerous incentives		0.1890	1.1890	11	Performance ambiguity		0.0017	1.0067
	HEP	0.3149							
3	2010	6-Jul	18:41	AFRICAN ZEBRA	Bulk carrier	23,207	0.095	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.3762	1.5643	11	Performance ambiguity		0.0689	1.2756
26	Progress tracking lack		0.3326	1.1331	21	Dangerous incentives		0.0324	1.0324
17	Inadequate checking		0.1898	1.3796					
	HEP	0.2898							
4	2011	26-Jun	7:38	FRANK W	General cargo	2,528	0.024	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4385	1.1754	16	Impoverished information		0.1162	1.2324
17	Inadequate checking		0.2499	1.4997	13	Poor feedback		0.0428	1.1283
12	Misperception of risk		0.1526	1.4579					
	HEP	0.5718							
4	2011	26-Jun	7:38	LILLY	Trawler	36	0.085	C	0.16
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.5906	2.7718	36	Task pacing		0.1795	1.0108
26	Progress tracking lack		0.1932	1.0773	17	Inadequate checking		0.0367	1.0734
	HEP	0.5184							
5	2012	28-Mar	22:26	RAMONA	Cargo ship	1,297	0.08	E	0.02
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.3922	2.1767	14	Delayed/incomplete feedback		0.1890	1.3781
16	Impoverished information		0.3255	1.6510	2	Time shortage		0.0932	1.9322
	HEP	0.1914							
6	2012	5-Jun	22:34	SPRING GLORY	Bulk carrier	51,265	0.096	D	0.09
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.2645	1.0159	17	Inadequate checking		0.1180	1.2360

24	Absolute judgments required		0.2327	1.1396	12	Misperception of risk		0.0398	1.1195
13	Poor feedback		0.2029	1.6088	8	Channel overload		0.0009	1.0043
26	Progress tracking lack		0.1413	1.0565					
HEP		0.2461							
6	2012	5-Jun	22:34	JOSEPHINE MÆRSK	Container ship	30,166	0.098	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.2701	1.5402	36	Task pacing		0.0890	1.0053
12	Misperception of risk		0.2302	1.6905	26	Progress tracking lack		0.0759	1.0304
24	Absolute judgments required		0.1450	1.0870	13	Poor feedback		0.0760	1.2279
17	Inadequate checking		0.1127	1.2253	2	Time shortage		0.0013	1.0131
HEP		0.4022							
7	2014	10-Jul	6:07	RIG	General cargo	2,351	0.049	E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3158	1.1263	12	Misperception of risk		0.0840	1.2520
36	Task pacing		0.2911	1.0175	19	No diversity of information		0.0707	1.1061
17	Inadequate checking		0.2383	1.4767					
HEP		0.0469							
7	2014	10-Jul	6:07	INGER MARIE	Fishing vessel – stern trawler	9	0.075	B	0.26
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6412	2.2825	36	Task pacing		0.0989	1.0059
26	Progress tracking lack		0.2574	1.1030	12	Misperception of risk		0.0024	1.0072
HEP		0.6632							
8	2014	1-Nov	13:19	KRASLAVA	Chemical/products tanker	23,315	0.075	C	0.16
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.6412	1.9619	33	Poor environment		0.0989	1.0148
12	Misperception of risk		0.2574	1.7723	2	Time shortage		0.0024	1.0239
HEP		0.5781							
8	2014	1-Nov	13:19	ATLANTIC LADY	Refrigerated cargo ship	8,864	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
2	Time shortage		0.5145	6.1449	33	Poor environment		0.0211	1.0032
12	Misperception of risk		0.4644	2.3933					
HEP		1.0000							
9	2015	1-Jul	23:27	NECKAR HIGHWAY	Vehicle carrier	9,233	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5145	1.2058	12	Misperception of risk		0.0211	1.0632
17	Inadequate checking		0.4644	1.9289					
HEP		0.2226							
9	2015	1-Jul	23:27	ORION	Fishing vessel, gillnetter	6	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5145	1.2058	37	Lack of human resources		0.0211	1.0006
17	Inadequate checking		0.4644	1.9289					
HEP		0.2095							

XI. United Kingdom

Table B. 11 United Kingdom's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2007	3-Feb	11:38	Sea Express 1	Passenger Ferry	3,003	0.012	C	0.16
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.6178	1.0371	23	Unreliable instruments		0.0227	1.0136
14	Delayed/incomplete feedback		0.2237	1.4475	33	Poor environment		0.0182	1.0027
17	Inadequate checking		0.1176	1.2353					
HEP		0.301549							
1	2007	4-Feb	12:38	Alaska Rainbow	Bulk Carrier	13,898	0.025	C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.3602	2.0805	33	Poor environment		0.0639	1.0096
26	Progress tracking lack		0.3255	1.1302	10	Knowledge transfer		0.0530	1.2383
19	No diversity of information		0.1473	1.2210	25	Unclear allocation of function		0.0502	1.0301
HEP		0.5916							
1	2007	5-Feb	13:38	VTS			0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
37	Lack of human resources		0.5417	1.0163	36	Task pacing		0.0248	1.0015
14	Delayed/incomplete feedback		0.4336	1.8671					
HEP		0.3040							
2	2008	25-Feb	20:20	Sichem Melbourne	Product carrier	8,455	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.4296	1.8592	19	No diversity of information		0.0176	1.0264
13	Poor feedback		0.3878	2.1634					
HEP		0.3715							
3	2008	29-Oct	4:49	Scot Isles	General cargo vessel	2,595	0.098	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.2701	1.8103	11	Performance ambiguity		0.0890	1.3558
10	Knowledge transfer		0.2302	2.0357	17	Inadequate checking		0.0759	1.1518
26	Progress tracking lack		0.1450	1.0580	21	Dangerous incentives		0.0760	1.0760
28	Low meaning		0.1127	1.0451	35	Sleep cycles disruption		0.0013	1.0001
HEP		0.6162							
3	2008	29-Oct	4:49	Wadi Halfa	general cargo vessel	22,895	0.074	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.3978	2.1934	26	Progress tracking lack		0.1572	1.0629
28	Low meaning		0.3595	1.1438	17	Inadequate checking		0.0855	1.1710
HEP		0.2810							
4	2009	25-Feb		Vallermosa	Product tanker		0.015	C	0.16
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.6124	3.4494	10	Knowledge transfer		0.1161	1.5224
16	Impoverished information		0.2447	1.4894	34	Low mental workload		0.0028	1.0003
HEP		1.0000							
5	2009	20-Dec	18:51	Alam Pintar	Bulk carrier	46,982	0.074	D	0.09
EPC			APE	AIV	EPC			APE	AIV
24	Absolute judgments required		0.3978	1.2387	11	Performance ambiguity		0.1572	1.6288
15	Operator inexperience		0.3595	1.7190	2	Time shortage		0.0855	1.8551
HEP		0.5790							
5	2009	20-Dec	18:51	Etoile des Ondes	fishing vessel	40	0.031	D	0.09
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.6187	3.4748	21	Dangerous incentives		0.0180	1.0180
36	Task pacing		0.2056	1.0123	26	Progress tracking lack		0.0082	1.0033
17	Inadequate checking		0.1494	1.2988					
HEP		0.4200							
6	2010	6-Feb		Isle of Arran	Ro-ro, vehicle passenger ferry	3296	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5238	1.2095	17	Inadequate checking		0.0239	1.0479
16	Impoverished information		0.4193	1.8385					
HEP		0.2097							
7	2010	31-Mar	16:19	NORMAN ARROW	High Speed Craft		0.025	C	0.16

EPC			APE	AIV	EPC			APE	AIV
15	Operator inexperience		0.3601	1.7203	17	Inadequate checking		0.0639	1.1278
34	Low mental workload		0.3254	1.0325	19	No diversity of information		0.0530	1.0794
16	Impoverished information		0.1473	1.2947	23	Unreliable instruments		0.0502	1.0301
HEP		0.4614							
8	2010	29-May	8:32	SKANDI FOULA	platform supply vessel	3252	0.095	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3762	1.7524	35	Sleep cycles disruption		0.0689	1.0069
15	Operator inexperience		0.3326	1.6653	1	Unfamiliarity		0.0324	1.5185
22	Lack of experience		0.1898	1.1519					
HEP		0.8223							
9	2010	5-Aug	19:46	Homeland	fishing vessel	23	0.031	D	0.09
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.6187	1.0371	15	Operator inexperience		0.0180	1.0360
17	Inadequate checking		0.2056	1.4112	2	Time shortage		0.0082	1.0824
26	Progress tracking lack		0.1494	1.0598					
HEP		0.1565							
9	2010	5-Aug	19:46	Scottish Viking	ro-ro passenger vessel	26,904	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.5417	3.166676	12	Misperception of risk		0.0248	1.074272
26	Progress tracking lack		0.4336	1.173429					
HEP		0.3593							
10	2010	29-Aug	11:26	NORMAN ARROW	High Speed Craft	10503	0.061	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.4640	1.928048	19	No diversity of information		0.0978	1.146649
17	Inadequate checking		0.3124	1.624849	23	Unreliable instruments		0.0025	1.001512
15	Operator inexperience		0.1058	1.211697					
HEP		0.6975							
11	2010	11-Dec	1:20	Antonis	Bulk Carrier	25935	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.5238	2.047557	16	Impoverished information		0.0239	1.047879
12	Misperception of risk		0.4193	2.257759					
HEP		0.7751							
12	2011	11-Feb	18:39	Admiral Blake	Twin beam trawler	136	0.025	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.3602	2.080509	35	Sleep cycles disruption		0.0639	1.006389
26	Progress tracking lack		0.3255	1.130183	17	Inadequate checking		0.0502	1.100355
16	Impoverished information		0.1473	1.294698	34	Low mental workload		0.0530	1.005296
HEP		0.3050							
12	2011	11-Feb	18:39	Boxford	Container ship	25,624		D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.6786	1.407143	17	Inadequate checking		0.3214	1.642857
HEP		0.2081							
13	2011	6-Mar	2:18	Cosco Hong Kong	container ship	65,531	0.074	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3480	1.696088	14	Delayed/incomplete feedback		0.1447	1.289446
36	Task pacing		0.2485	1.014909	33	Poor environment		0.0039	1.000588
11	Performance ambiguity		0.2548	2.019324					
HEP		0.7176							
14	2011	9-Apr	4:53	PHILIPP	container vessel	8,971	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.5417	3.166676	26	Progress tracking lack		0.0248	1.009903
17	Inadequate checking		0.4336	1.867147					
HEP		0.5374							
14	2011	9-Apr	4:53	LYNN MARIE	fishing vessel	65		C	0.16
EPC			APE	AIV	EPC			APE	AIV
15	Operator inexperience		0.6786	2.357143	26	Progress tracking lack		0.3214	1.128571
HEP		0.4256							
15	2011	14-Apr	7:00	Tyumen-2	cargo ship	3,086	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.5417	1.325001	8	Channel overload		0.0248	1.123787
33	Poor environment		0.4336	1.065036					
HEP		0.2537							
15	2011	14-Apr	7:00	OOCL Finland	Container vessel	13,720	0.025	C	0.16
EPC			APE	AIV	EPC			APE	AIV

26	Progress tracking lack		0.3602	1.144068	13	Poor feedback		0.0639	1.191661
11	Performance ambiguity		0.3255	2.301833	16	Impoverished information		0.0502	1.100355
8	Channel overload		0.1473	1.736746	33	Poor environment		0.0530	1.007944
	HEP	0.9672							
16	2011	26-Feb		SBS Typhoon	Platform Supply Vessel		0.08	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.3921	1.784276	23	Unreliable instruments		0.1890	1.113394
16	Impoverished information		0.3255	1.650903	25	Unclear allocation of function		0.0932	1.055918
	HEP	0.5541							
17	2011	15-May	10:04	CMA CGM Platon	Container vessel	17594	0.042	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
21	Dangerous incentives		0.2606	1.260646	19	No diversity of information		0.1157	1.173509
16	Impoverished information		0.1709	1.341885	17	Inadequate checking		0.0861	1.172283
13	Poor feedback		0.1604	1.481234	2	Time shortage		0.060564	1.605643
15	Operator inexperience		0.1453	1.290665	23	Unreliable instruments		0.000196	1.000118
	HEP	1							
18	2011	24-May	5:16	Clipper Point	Ro-ro cargo ship	14759	0.051	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
13	Poor feedback		0.3736	2.120882	24	Absolute judgments required		0.1367	1.082023
16	Impoverished information		0.2660	1.53199	32	Inconsistency of displays		0.0046	1.00091
9	Technique unlearning		0.1883	1.941349					
	HEP	1							
19	2011	11-Dec	7:56	ACX Hibiscus	Container ship	18,502	0.026	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
34	Low mental workload		0.2781	1.027806	17	Inadequate checking		0.1065	1.212931
11	Performance ambiguity		0.2459	1.983487	26	Progress tracking lack		0.0402	1.016085
13	Poor feedback		0.2076	1.622821	33	Poor environment		0.001027	1.000154
23	Unreliable instruments		0.1208	1.072456					
	HEP	0.6998							
19	2011	11-Dec	7:56	Hyundai Discovery	Container ship	64,054	0.076	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
14	Delayed/incomplete feedback		0.5417	2.083338	2	Time shortage		0.0248	1.247573
33	Poor environment		0.4336	1.065036					
	HEP	0.4429							
20	2011	18-Dec	23:00	Johanna	container ship	6,363		c	0.16
	EPC		APE	AIV		EPC		APE	AIV
13	Poor feedback		0.6786	3.035714	16	Impoverished information		0.3214	1.642857
	HEP	0.7980							
21	2011	19-Dec	8:35	Alex D	general cargo ship	31,649	0.031	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
21	Dangerous incentives		0.6187	1.618708	2	Time shortage		0.0180	1.180205
17	Inadequate checking		0.2056	1.411247	12	Misperception of risk		0.0082	1.02471
26	Progress tracking lack		0.1494	1.059765					
	HEP	0.2635							
21	2011	19-Dec	8:35	Jacoba	fishing vessel	270	0.076	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
21	Dangerous incentives		0.5417	1.541669	26	Progress tracking lack		0.0248	1.009903
17	Inadequate checking		0.4336	1.867147					
	HEP	0.2616							
22	2012	10-Mar	5:40	Seagate	Geared bulk carrier	17,590	0.056	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
12	Misperception of risk		0.2670	1.801006	26	Progress tracking lack		0.1510	1.060391
17	Inadequate checking		0.2478	1.495514	11	Performance ambiguity		0.0870	1.348157
21	Dangerous incentives		0.2456	1.24555	2	Time shortage		0.0017	1.01674
	HEP	0.4389							
22	2012	10-Mar	5:40	Timor Stream	Refrigerated-cargo	9,307	0.024	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
36	Task pacing		0.4047	1.02428	37	Lack of human resources		0.0655	1.001966
17	Inadequate checking		0.2617	1.523329	2	Time shortage		0.0086	1.086174
26	Progress tracking lack		0.2585	1.103411	11	Performance ambiguity		0.0010	1.003983
	HEP	0.1693							
23	2012	24-Mar	10:14	Spring Bok	Refrigerated cargo ship	12,113	0.08	D	0.09

EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.3922	2.568902	36	Task pacing		0.1890	1.011342
26	Progress tracking lack		0.3255	1.13021	34	Low mental workload		0.0932	1.009322
HEP		0.2667							
23	2012	24-Mar	10:14	Gas Arctic	LPG Tanker	2,985	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.7299	1.291972	2	Time shortage		0.0404	1.40412
12	Misperception of risk		0.2297	1.688973					
HEP		0.2758							
24	2012	1-Aug	13:37	Alexander Tvardovski	cargo vessel	2,319	0.024	C	0.16
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.4047	2.820993	7	Irreversibility		0.0655	1.458707
21	Dangerous incentives		0.2617	1.261665	11	Performance ambiguity		0.0086	1.034469
16	Impoverished information		0.2585	1.517055	17	Inadequate checking		0.0010	1.001992
HEP		1							
25	2013	13-Jan	20:58	CHRISTOS XXII	tug	545	0.095	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.3762	2.128653	37	Lack of human resources		0.0689	1.002067
36	Task pacing		0.3326	1.019959	33	Poor environment		0.0324	1.004861
22	Lack of experience		0.1898	1.151857					
HEP		0.2266							
26	2013	16-Feb		Finnarrow	Passenger/ro-ro cargo vessel		0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
22	Lack of experience		0.4219	1.337517	17	Inadequate checking		0.2411	1.482117
9	Technique unlearning		0.2473	2.236744	35	Sleep cycles disruption		0.0098	1.000975
HEP		0.3995							
27	2013	19-Mar	0:33	CMA CGM Florida	Container vessel	54,309	0.095	C	0.16
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.3762	2.128653	26	Progress tracking lack		0.0689	1.027564
16	Impoverished information		0.3326	1.665293	12	Misperception of risk		0.0324	1.097214
14	Delayed/incomplete feedback		0.1898	1.379642					
HEP		0.8822							
27	2013	19-Mar	0:33	Chou Shan	Bulk carrier	91,166	0.08	D	0.09
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.3922	2.568902	12	Misperception of risk		0.1890	1.567097
6	Model mismatch		0.3255	3.278669	2	Time shortage		0.0932	1.932179
HEP		1							
28	2013	22-Jun	12:54	SIRENA SEAWAYS	passenger and vehicle ferry		0.056	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2647	1.105886	7	Irreversibility		0.1497	2.047789
14	Delayed/incomplete feedback		0.2456	1.491268	11	Performance ambiguity		0.0863	1.345174
16	Impoverished information		0.2434	1.486892	2	Time shortage		0.0017	1.016596
HEP		0.6180							
29	2013	25-Jul	2:20	Apollo	chemical tanker	16914	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
25	Unclear allocation of function		0.4296	1.257752	36	Task pacing		0.0176	1.001056
16	Impoverished information		0.3878	1.775589					
HEP		0.3577							
30	2013	11-Dec	0:27	Paula C	general cargo ship	2,998	0.03	C	0.16
EPC			APE	AIV	EPC			APE	AIV
37	Lack of human resources		0.2355	1.007065	36	Task pacing		0.1151	1.006907
22	Lack of experience		0.2156	1.172453	26	Progress tracking lack		0.1207	1.048278
24	Absolute judgments required		0.1598	1.095896	21	Dangerous incentives		0.002042	1.002042
17	Inadequate checking		0.1512	1.302493					
HEP		0.2852							
30	2013	11-Dec	0:27	Darya Gayatri	bulk carrier	44,325	0.075	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6412	2.282478	26	Progress tracking lack		0.0989	1.039572
24	Absolute judgments required		0.2574	1.154467	2	Time shortage		0.0024	1.023863
HEP		0.2524							
31	2014	11-Jan	1:54	Rickmers	cargo vessel	15,377	0.061	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4722	1.944499	12	Misperception of risk		0.0995	1.298497
37	Lack of human resources		0.3180	1.009539	28	Low meaning		0.0026	1.001026

26	Progress tracking lack		0.1077	1.04309					
	HEP	0.4259							
31	2014	11-Jan	1:54	Walcon Wizard	crane barge	106		C	0.16
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.6786	3.714286	23	Unreliable instruments		0.3214	1.192857
	HEP	0.7089							
31	2014	11-Jan	1:54	VTS			0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.5145	3.057954	10	Knowledge transfer		0.0211	1.094837
34	Low mental workload		0.4644	1.046444					
	HEP	0.5606							
32	2014	30-Apr	21:27	Shalimar	Stern trawler	168		D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1.0000	1.6					
	HEP	0.1440							
33	2014	8-Jun	13:31	dredger, Shoreway	dredger	5,005	0.096	C	0.16
EPC			APE	AIV	EPC			APE	AIV
28	Low meaning		0.2645	1.10579	17	Inadequate checking		0.1180	1.235997
10	Knowledge transfer		0.2327	2.046971	36	Task pacing		0.039817	1.002389
12	Misperception of risk		0.2029	1.608795	37	Lack of human resources		0.00085	1.000026
26	Progress tracking lack		0.1413	1.056507					
	HEP	0.7627							
33	2014	8-Jun	13:31	yacht, Orca	yacht	-	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.5145	2.543465	17	Inadequate checking		0.0211	1.04215
26	Progress tracking lack		0.4644	1.185775					
	HEP	0.2829							
34	2014	4-Jun	11:53	Millennium Diamond	passenger vessel	458	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.4219	1.168758	23	Unreliable instruments		0.2411	1.144635
36	Task pacing		0.2473	1.014841	2	Time shortage		0.0098	1.097508
	HEP	0.1341							
35	2014	16-Jul	6:26	Barfleur	RoPax	20,133	0.047	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3259	1.651716	10	Knowledge transfer		0.0421	1.189274
26	Progress tracking lack		0.3240	1.12959	17	Inadequate checking		0.0017	1.00344
11	Performance ambiguity		0.3043	2.217213					
	HEP	0.4443							
36	2014	9-Nov	7:59	Dover Seaways	cross-channel ferry	35923	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
7	Irreversibility		0.4296	4.007107	2	Time shortage		0.0176	1.175971
26	Progress tracking lack		0.3878	1.155118					
	HEP	0.4899							
37	2014	21-Dec	5:33	Margriet	Twin beam trawler	441	0.075	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6412	2.282478	26	Progress tracking lack		0.0989	1.039572
11	Performance ambiguity		0.2574	2.029782	2	Time shortage		0.0024	1.023863
	HEP	0.7890							
37	2014	21-Dec	5:33	Orakai	Chemical/product tanker	3,953	0.061	D	0.09
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.4722	1.028335	24	Absolute judgments required		0.0995	1.059699
25	Unclear allocation of function		0.3180	1.190777	2	Time shortage		0.0026	1.025645
21	Dangerous incentives		0.1077	1.107725					
	HEP	0.1327							
38	2015	11-Feb	19:42	Ever Smart	container ship	75,246	0.03	D	0.09
EPC			APE	AIV	EPC			APE	AIV
25	Unclear allocation of function		0.2355	1.141304	12	Misperception of risk		0.1207	1.362087
16	Impoverished information		0.2156	1.431133	26	Progress tracking lack		0.115116	1.046047
17	Inadequate checking		0.1598	1.319654	2	Time shortage		0.002042	1.020419
14	Delayed/incomplete feedback		0.1512	1.302493					
	HEP	0.3674							
38	2015	11-Feb	19:42	Alexandra 1	oil tanker	79,779	0.07	D	0.09
EPC			APE	AIV	EPC			APE	AIV

25	Unclear allocation of function		0.3476	1.208575	12	Misperception of risk		0.1082	1.324661
14	Delayed/incomplete feedback		0.2752	1.550424	16	Impoverished information		0.0403	1.080517
26	Progress tracking lack		0.2287	1.091474					
HEP		0.2635							
38	2015	11-Feb	19:42	VTS			0.074	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3978	1.795575	19	No diversity of information		0.1572	1.235803
14	Delayed/incomplete feedback		0.3595	1.719008	11	Performance ambiguity		0.0855	1.342026
HEP		0.4607							
39	2015	29-Aug	16:58	Daroja	general cargo ship	3,266	0.07	C	0.16
EPC			APE	AIV	EPC			APE	AIV
34	Low mental workload		0.3476	1.034762	26	Progress tracking lack		0.1082	1.043288
17	Inadequate checking		0.2752	1.550424	12	Misperception of risk		0.0403	1.120776
37	Lack of human resources		0.2287	1.006861					
HEP		0.3022							
39	2015	29-Aug	16:58	Erin Wood	oil bunker bsrge	70	0.07	C	0.16
EPC			APE	AIV	EPC			APE	AIV
15	Operator inexperience		0.3476	1.69525	26	Progress tracking lack		0.1082	1.043288
17	Inadequate checking		0.2752	1.550424	12	Misperception of risk		0.0403	1.120776
21	Dangerous incentives		0.2287	1.228684					
HEP		0.6042							
40	2015	3-Dec	20:40	City of Rotterdam	car carrier	21,143	0.07	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.3476	1.521437	27	Physical capabilities		0.1082	1.043288
33	Poor environment		0.2752	1.041282	12	Misperception of risk		0.0403	1.120776
26	Progress tracking lack		0.2287	1.091474					
HEP		0.1820							
40	2015	3-Dec	20:40	Primula Seaways	ro-ro freight ferry	32,289	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.5417	1.812504	2	Time shortage		0.0248	1.247573
33	Poor environment		0.4336	1.065036					
HEP		0.2167							
41	2016	13-May	21:10	Uriah Heep	passenger ferry	13.57		D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1.0000	1.6					
HEP		0.1440							
42	2016	19-May	4:50	Petunia Seaways	Ro-Ro Cargo	32,289	0.074	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3978	1.795575	26	Progress tracking lack		0.1572	1.062881
33	Poor environment		0.3595	1.0539	12	Misperception of risk		0.0855	1.25652
HEP		0.4044							
42	2016	19-May	4:50	Peggotty	Motor launch	23	0.076	A	0.55
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.5417	2.6250	27	Physical capabilities		0.0248	1.009903
33	Poor environment		0.4336	1.065					
HEP		1							

XII. Finland

Table B. 12 Finland's Collision Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	8-Dec	5:29	BIRKA EXPORTER	Ro-Ro vessel	6,620	0.06	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
37	Lack of human resources		0.2670	1.0080	14	Delayed/incomplete feedback		0.1510	1.3020
17	Inadequate checking		0.2478	1.4955	34	Low mental workload		0.0870	1.0087
26	Progress tracking lack		0.2456	1.0982	2	Time shortage		0.0017	1.0167
HEP		0.353699							
1	2008	8-Dec	5:29	HENDRIK SENIOR	Beam trawler	428	0.09	B	0.26
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.3542	1.1417	21	Dangerous incentives		0.0533	1.0533
17	Inadequate checking		0.2877	1.5753	34	Low mental workload		0.0237	1.0024
37	Lack of human resources		0.2755	1.0083	14	Delayed/incomplete feedback		0.0056	1.0113
HEP		0.503383							
2	2009	5-Apr	16:16	Vega	Tug boat	144	0.08	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
16	Impoverished information		0.5417	2.0833	17	Inadequate checking		0.0248	1.0495
26	Progress tracking lack		0.4336	1.1734					
HEP		0.410511							
3	2009	13-Sep	6:00	MS LAIMA	Dry cargo carrier	3,020	0.08	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.5417	2.0833	26	Progress tracking lack		0.0248	1.0099
12	Misperception of risk		0.4336	2.3007					
HEP		0.774503							
3	2009	13-Sep	6:00	MS SILVA	Dry cargo ship	5,021	0.04	B	0.26
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.6338	1.2535	12	Misperception of risk		0.1057	1.3170
36	Task pacing		0.2381	1.0143	17	Inadequate checking		0.0225	1.0450
HEP		0.454918							
4	2010	27-Feb		GLOBAL CARRIER	Cargo ship, RoRo	13,117	0.1	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
12	Misperception of risk		0.2645	1.7934	26	Progress tracking lack		0.1180	1.0472
14	Delayed/incomplete feedback		0.2327	1.4653	37	Lack of human resources		0.0398	1.0012
17	Inadequate checking		0.2029	1.4059	21	Dangerous incentives		0.0009	1.0009
36	Task pacing		0.1413	1.0085					
HEP		0.62555							
5	2011	14-Feb	4:00	BIRKA TRANSPORTER	Ro-Ro vessel	6,620	0.07	B	0.26
	EPC		APE	AIV		EPC		APE	AIV
36	Task pacing		0.2711	1.0163	14	Delayed/incomplete feedback		0.0225	1.0450
12	Misperception of risk		0.2643	1.7930	17	Inadequate checking		0.0099	1.0197
26	Progress tracking lack		0.1841	1.0736	35	Sleep cycles disruption		0.0060	1.0006
25	Unclear allocation of function		0.1688	1.1013	9	Technique unlearning		0.0022	1.0112
37	Lack of human resources		0.0711	1.0021					
HEP		0.605221							
5	2011	14-Feb	4:00	WILLEMPJE HOEKSTRA	Beam trawler	426	0.08	B	0.26
	EPC		APE	AIV		EPC		APE	AIV
14	Delayed/incomplete feedback		0.3922	1.7845	26	Progress tracking lack		0.1890	1.0756
36	Task pacing		0.3255	1.0195	17	Inadequate checking		0.0932	1.1864
HEP		0.603641							
6	2011	17-May	15:47	BIRKA CARRIER	RoRo vessel	12,251	0.08	B	0.26
	EPC		APE	AIV		EPC		APE	AIV
36	Task pacing		0.3922	1.0235	17	Inadequate checking		0.1890	1.3781
37	Lack of human resources		0.3255	1.0098	26	Progress tracking lack		0.0932	1.0373
HEP		0.384118							
6	2011	17-May	15:47	LED ZEPPELIN	Pleasure craft	-	0.07	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
36	Task pacing		0.5145	1.0309	26	Progress tracking lack		0.0211	1.0084

17	Inadequate checking		0.4644	1.9289					
HEP		0.180466							
7	2011	23-Oct	5:00	FLORENCE	Fishing vessel	105	0.1	C	0.16
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.2701	1.5402	33	Poor environment		0.0890	1.0133
26	Progress tracking lack		0.2302	1.0921	19	No diversity of information		0.0759	1.1138
36	Task pacing		0.1450	1.0087	21	Dangerous incentives		0.0760	1.0760
17	Inadequate checking		0.1127	1.2253	2	Time shortage		0.0013	1.0131
HEP		0.409246							
7	2011	23-Oct	5:00	MENHADEN	Fishing vessel	229	0.1	C	0.16
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.2701	1.5402	21	Dangerous incentives		0.0890	1.0890
36	Task pacing		0.2302	1.0138	17	Inadequate checking		0.0759	1.1518
19	No diversity of information		0.1450	1.2175	10	Knowledge transfer		0.0760	1.3418
26	Progress tracking lack		0.1127	1.0451	33	Poor environment		0.0013	1.0002
HEP		0.535067							
7	2011	23-Oct	5:00	AMAZON	General cargo	16,405	0.09	B	0.26
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2500	1.4999	22	Lack of experience		0.0038	1.0030
16	Impoverished information		0.2230	1.4460	33	Poor environment		0.0269	1.0040
14	Delayed/incomplete feedback		0.1675	1.3350	11	Performance ambiguity		0.0090	1.0360
12	Misperception of risk		0.1680	1.5041	24	Absolute judgments required		0.0019	1.0012
26	Progress tracking lack		0.1499	1.0600	1	Unfamiliarity		0.0001	1.0010
HEP		1							
8	2012	10-Jan		BARENTSZDIEP	Cargo Ship	4,102	0.06	B	0.26
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.2670	1.0160	17	Inadequate checking		0.1510	1.3020
16	Impoverished information		0.2456	1.4911	26	Progress tracking lack		0.0870	1.0348
37	Lack of human resources		0.2478	1.0074	21	Dangerous incentives		0.0017	1.0017
HEP		0.53553							

C. Grounding

I. Indonesia

Table C. 1 Indonesia's Grounding Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2016	22-Dec	18:50	SINABUNG	Passenger ship	14,665	0.08	E	0.02
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.5238	1.7857	10	Knowledge transfer		0.0239	1.1077
16	Impoverished information		0.4193	1.8385					
HEP		0.072733							
2	2017	12-Jun	19:15	Kutai Raya Dua	General cargo	4,255	0.07	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3978	1.7956	5	Spatial and functional incompatibility		0.1572	2.1004
23	Unreliable instruments		0.3595	1.2157	33	Poor environment		0.0855	1.0128
HEP		0.743003							
3	2018	20-Feb	21:00	Kayong Utara	Passenger ship	NA	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
24	Absolute judgments required		0.2336	1.1401	10	Knowledge transfer		0.0991	1.4458
5	Spatial and functional incompatibility		0.2081	2.4570	17	Inadequate checking		0.0994	1.1988
36	Task pacing		0.1587	1.0095	22	Lack of experience		0.0899	1.0719
12	Misperception of risk		0.1103	1.3309	23	Unreliable instruments		0.0009	1.0005
HEP		0.629663							
4	2018	10-Aug		Altaf	Tradiitional ship	NA	0.06	A	0.55
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.4147	1.4147	33	Poor environment		0.0323	1.0048
15	Operator inexperience		0.3133	1.6266	23	Unreliable instruments		0.0207	1.0124
9	Technique unlearning		0.2191	2.0953					
HEP		1							

II. Japan

Table C. 2 Japan's Grounding Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2011	30-Jan	0:34	BOHAI CHALLENGE	Cargo ship	8,708	0.07	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.5145	2.0290	33	Poor environment		0.0211	1.0032
14	Delayed/incomplete feedback		0.4644	1.9289					
HEP		0.6282							
2	2014	14-Jul	22:08	Amakusa Island	Cargo ship	44,547		E	0.02
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.6784	2.3567	10	Knowledge transfer		0.3216	2.4473
HEP		0.1154							
3	2014	20-Dec	22:29	Mighty Royal	Cargo ship	22,046		D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.6786	3.0357	26	Progress tracking lack		0.3214	1.1286
HEP		0.3083							
4	2016	10-Jan	5:09	city	Cargo ship	4,359	0.02	C	0.16
EPC			APE	AIV	EPC			APE	AIV
5	Spatial and functional incompatibility		0.4967	4.4767	16	Impoverished information		0.1291	1.2583
12	Misperception of risk		0.3711	2.1132	2	Time shortage		0.0031	1.0312
HEP		1							
5	2017	11-Feb	6:00	SAGAN	Oil tanker	5,404		C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.6786	1.4071	33	Poor environment		0.3214	1.0482
HEP		0.2360							
6	2017	23-Oct	0:15	REAL	Cargo ship	1,798		C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.6786	1.4071	33	Poor environment		0.3214	1.0482
HEP		0.2360							

III. HongKong

Table C. 3 Hong Kong's Grounding Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2011	8-May	0:32	Zhong Fu Fa Zhan	cargo vessel	2,765	0.05	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.3374	2.0122	36	Task pacing		0.1317	1.0079
17	Inadequate checking		0.2871	1.5743	22	Lack of experience		0.0628	1.0502
23	Unreliable instruments		0.1810	1.1086					
HEP		0.3346							
2	2014	21-Feb	10:10	Sunrise Orient	cargo vessel	2,580	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.4586	1.4586	26	Progress tracking lack		0.2620	1.1048
17	Inadequate checking		0.2688	1.5377	22	Lack of experience		0.0106	1.0085
HEP		0.2249							

IV. Australia

Table C. 4 Australia's Grounding Results

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	9th May	6:09	Francoise Gilot	Container Ship	16,162	0.05	E	0.02
	EPC		APE	AIV		EPC		APE	AIV
35	Sleep cycles disruption		0.3855	1.0386	26	Progress tracking lack		0.1411	1.0564
36	Task pacing		0.2745	1.0165	10	Knowledge transfer		0.0047	1.0211
7	Irreversibility		0.1943	2.3598					
	HEP	0.0537							
2	2008	15th July	8:56	Atlantic Eagle	Bulk Carrier	39,973	0.1	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
28	Low meaning		0.2637	1.1055	32	Inconsistency of displays		0.1177	1.0235
11	Performance ambiguity		0.2320	1.9279	34	Low mental workload		0.0397	1.0040
17	Inadequate checking		0.2023	1.4047	33	Poor environment		0.0008	1.0001
26	Progress tracking lack		0.1409	1.0563					
	HEP	0.5200							
3	2008	31th July	22:25	Iron King	Bulk Carrier	81,155	0.02	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
10	Knowledge transfer		0.3651	2.6428	23	Unreliable instruments		0.2278	1.1367
12	Misperception of risk		0.2751	1.8252	5	Spatial and functional incompatibility		0.1319	1.9234
	HEP	1							
4	2009	7th Febr	3:12	Atlantic Blue	Oil Tanker	29,266	0.09	E	0.02
	EPC		APE	AIV		EPC		APE	AIV
16	Impoverished information		0.3732	1.7463	17	Inadequate checking		0.0822	1.1643
12	Misperception of risk		0.2712	1.8137	5	Spatial and functional incompatibility		0.0625	1.4372
10	Knowledge transfer		0.1228	1.5525	32	Inconsistency of displays		0.0096	1.0019
26	Progress tracking lack		0.0762	1.0305	23	Unreliable instruments		0.0023	1.0014
	HEP	0.1701							
5	2010	3rd Apr	17:05	Shen Neng 1	Bulk Carrier	36,575	0.06	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
10	Knowledge transfer		0.3976	2.7894	16	Impoverished information		0.1571	1.3143
17	Inadequate checking		0.3594	1.7188	23	Unreliable instruments		0.0855	1.0513
	HEP	1							
6	2010	1st Nov	9:37	MSC Basel	Container Ship		0.07	E	0.02
	EPC		APE	AIV		EPC		APE	AIV
10	Knowledge transfer		0.4640	3.0881	12	Misperception of risk		0.0978	1.2933
16	Impoverished information		0.3124	1.6248	11	Performance ambiguity		0.0025	1.0101
35	Sleep cycles disruption		0.1058	1.0106					
	HEP	0.1325							
7	2011	29th Apr	17:09	Dumun	Bulk Carrier	32,315		D	0.09
	EPC		APE	AIV		EPC		APE	AIV
13	Poor feedback		0.6711	3.0132	23	Unreliable instruments		0.3289	1.1974
	HEP	0.3247							
8	2015	28th Feb	4:40	Maersk Garonne	Container Ship		0.02	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
11	Performance ambiguity		0.3601	2.4406	26	Progress tracking lack		0.0639	1.0256
5	Spatial and functional incompatibility		0.3254	3.2780	16	Impoverished information		0.0502	1.1003
17	Inadequate checking		0.1473	1.2947	13	Poor feedback		0.0530	1.1589
	HEP	1							
9	2008	12-Feb	15:45	Breakthrough	products tanker	4,393	0.043	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
23	Unreliable instruments		0.2620	1.1572	5	Spatial and functional incompatibility		0.0650	1.4548
9	Technique unlearning		0.2002	2.0011	4	Features over-ride allowed		0.0529	1.4233
22	Lack of experience		0.1653	1.1323	33	Poor environment		0.0356	1.0053
32	Inconsistency of displays		0.1366	1.0273	1	Unfamiliarity		0.0009	1.0146
10	Knowledge transfer		0.0815	1.3666					
	HEP	1							
10	2008	23-Feb	18:17	Van gogh	passenger ship	15,402	0.096	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
16	Impoverished information		0.2645	1.5290	14	Delayed/incomplete feedback		0.1180	1.2360
19	No diversity of information		0.2327	1.3490	36	Task pacing		0.0398	1.0024
10	Knowledge transfer		0.2029	1.9132	11	Performance ambiguity		0.0009	1.0034

13	Poor feedback		0.1413	1.4238					
HEP		1							
11	2013	29-Oct	17:55	Bosphorus	general cargo	8,407	0.082	D	0.09
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.2467	2.1100	25	Unclear allocation of function		0.1197	1.0718
17	Inadequate checking		0.2125	1.4250	16	Impoverished information		0.0937	1.1874
26	Progress tracking lack		0.1587	1.0635	19	No diversity of information		0.0310	1.0465
36	Task pacing		0.1263	1.0076	32	Inconsistency of displays		0.0114	1.0023
HEP		0.3871							
12	2016	30-Oct	16:09	Searoad Mersey	general cargo	7,928	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.5417	2.0833	33	Poor environment		0.0248	1.0037
19	No diversity of information		0.4336	1.6504					
HEP		0.5522							
13	2016	19-Aug	14:50	Bow Singapore	products tanker	6,219		D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.6786	1.4071	5	Spatial and functional incompatibility		0.3214	3.2500
HEP		0.4116							
14	2017	6-Nov	11:20	Orient Centaur	Bulk Carrier	63,993	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
22	Lack of experience		0.5417	1.4333	17	Inadequate checking		0.0248	1.0495
23	Unreliable instruments		0.4336	1.2601					
HEP		0.1706							
15	2017	30-Sep	0:25	Roebuck Bay	Patrol vessel	240	0.097	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.2396	1.7189	6	Model mismatch		0.1527	2.0690
17	Inadequate checking		0.2170	1.4340	26	Progress tracking lack		0.0488	1.0195
23	Unreliable instruments		0.1948	1.1169	22	Lack of experience		0.0012	1.0009
19	No diversity of information		0.1459	1.2189					
HEP		0.6376							
16	2018	11-Apr	2:30	Lauren Hansen	Landing craft	490	0.078	D	0.09
EPC			APE	AIV	EPC			APE	AIV
36	Task pacing		0.4662	1.0280	21	Dangerous incentives		0.0310	1.0310
11	Performance ambiguity		0.3669	2.4676	34	Low mental workload		0.0026	1.0003
23	Unreliable instruments		0.1332	1.0799					
HEP		0.2543							

V. New Zealand

Table C. 5 New Zealand's Grounding Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2010	6-May	5:05	M.V. Anatoki	bulk carrier	561	0.1	B	0.26
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2701	1.1080	17	Inadequate checking		0.0890	1.1779
16	Impoverished information		0.2302	1.4603	37	Lack of human resources		0.0759	1.0023
15	Operator inexperience		0.1450	1.2899	35	Sleep cycles disruption		0.0760	1.0076
34	Low mental workload		0.1127	1.0113	25	Unclear allocation of function		0.0013	1.0008
HEP		0.6533							
2	2010	21-Jun	20:06	Hanjin Bombay	Bulk carrier	16,252	0.08	D	0.09
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.3921	2.7646	16	Impoverished information		0.1890	1.3780
23	Unreliable instruments		0.3255	1.1953	13	Poor feedback		0.0932	1.2796
HEP		0.5244							
3	2010	18-Sep	8:30	Spirit of Resolution	container ship	3,850		C	0.16
EPC			APE	AIV	EPC			APE	AIV
12			0.6786	3.0357	33			0.3214	1.0482
HEP		0.5091							
4	2011	5-Oct	2:14	MV Rena	Container ship	37,209	0.07	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2711	1.1084	16	Impoverished information		0.0225	1.0450
31	Low morale		0.2643	1.0529	14	Delayed/incomplete feedback		0.0099	1.0197
21	Dangerous incentives		0.1841	1.1841	5	Spatial and functional incompatibility		0.0060	1.0421
34	Low mental workload		0.1688	1.0169	35	Sleep cycles disruption		0.0022	1.0002
11	Performance ambiguity		0.0711	1.2845					
HEP		0.1804							
5	2016	19-Aug	7:35	Molly Manx	Bulk carrier	32,296	0.06	E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2647	1.1059	10	Knowledge transfer		0.1497	1.6736
19	No diversity of information		0.2456	1.3685	16	Impoverished information		0.0863	1.1726
17	Inadequate checking		0.2434	1.4869	5	Spatial and functional incompatibility		0.0017	1.0116
HEP		0.0893							
6	2017	9-Feb	5:55	L'Austral	Passenger ship	10,944	0.02	E	0.02
EPC			APE	AIV	EPC			APE	AIV
22	Lack of experience		0.3601	1.2881	33	Poor environment		0.0639	1.0096
16	Impoverished information		0.3254	1.6509	19	No diversity of information		0.0530	1.0794
10	Knowledge transfer		0.1473	1.6630	26	Progress tracking lack		0.0502	1.0201
HEP		0.0786							

VI. United States of America

Table C. 6 United States of America Grounding Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2016	20-Mar	23:38	Sparna	Bulk Carrier	31,385	0.09	E	0.02
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4586	1.9171	26	Progress tracking lack		0.2620	1.1048
10	Knowledge transfer		0.2688	2.2098	12	Misperception of risk		0.0106	1.0318
HEP		0.0966							
2	2016	27-May	13:12	Roger Blough	Bulk Carrier	22,041		E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.6500	1.2600	17	Inadequate checking		0.3500	1.7000
HEP		0.0428							
3	2016	19-Nov	2:46	Nenita	Bulk Carrier	40,042	0.08	C	0.16
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.3921	2.1764	26	Progress tracking lack		0.1890	1.0756
10	Knowledge transfer		0.3255	2.4645	23	Unreliable instruments		0.0932	1.0559
HEP		0.9747							

VII. Canada

Table C. 7 Canada's Grounding Results

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	28-May	5:49	Algomarine	Bulk Carrier	18,338	0.05	E	0.02
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.3259	1.6517	35	Sleep cycles disruption		0.0421	1.0042
10	Knowledge transfer		0.3240	2.4579	26	Progress tracking lack		0.0017	1.0007
16	Impoverished information		0.3043	1.6086					
HEP		0.13125							
2	2009	5-Oct	19:45	Federal Agno	Bulk Carrier	17,821	0.09	E	0.02
	EPC		APE	AIV		EPC		APE	AIV
10	Knowledge transfer		0.4586	3.0635	12	Misperception of risk		0.2620	1.7860
17	Inadequate checking		0.2688	1.5377	16	Impoverished information		0.0106	1.0212
HEP		0.1718							
3	2012	28-Nov	21:48	Tundra	Bulk Carrier	19,814	0.09	E	0.02
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.3762	1.7524	35	Sleep cycles disruption		0.0689	1.0069
16	Impoverished information		0.3326	1.6653	26	Progress tracking lack		0.0324	1.0130
10	Knowledge transfer		0.1898	1.8542					
HEP		0.1104							
4	2013	7-Nov	12:00	Princess of Acadia	Roll-on/roll-off passenger ferry	10,050	0.06	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
10	Knowledge transfer		0.2670	2.2015	23	Unreliable instruments		0.1510	1.0906
24	Absolute judgments required		0.2478	1.1487	5	Spatial and functional incompatibility		0.0870	1.6093
16	Impoverished information		0.2456	1.4911	33	Poor environment		0.0017	1.0003
HEP		0.5957							
5	2014	25-Jan	21:56	Cap Blanche	Container	28,372	0.04	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
10	Knowledge transfer		0.2622	2.1800	26	Progress tracking lack		0.1089	1.0435
23	Unreliable instruments		0.2436	1.1462	2	Time shortage		0.0112	1.1116
19	No diversity of information		0.2243	1.3365	33	Poor environment		0.0023	1.0003
12	Misperception of risk		0.1473	1.4419					
HEP		0.5029							
6	2014	24-Apr	4:16	Halit Bey	Chemical/Products Tanker	12,619	0.05	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.3762	1.7524	27	Physical capabilities		0.0689	1.0276
11	Performance ambiguity		0.3326	2.3306	23	Unreliable instruments		0.0324	1.0194
10	Knowledge transfer		0.1898	1.8542					
HEP		1							
7	2014	12-Jun	10:20	Atlantic Erie	Bulk Carrier	24,300	0.02	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
10	Knowledge transfer		0.4047	2.8210	2	Time shortage		0.0655	1.6553
19	No diversity of information		0.2617	1.3925	26	Progress tracking lack		0.0086	1.0034
12	Misperception of risk		0.2585	1.7756	23	Unreliable instruments		0.0010	1.0006
HEP		1							
8	2014	14-Jul	22:09	Amakusa Island	Bulk Carrier	44,547	0.09	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
22	Lack of experience		0.3855	1.3084	1	Unfamiliarity		0.1411	3.2569
9	Technique unlearning		0.2745	2.3723	2	Time shortage		0.0047	1.0470
23	Unreliable instruments		0.1943	1.1166					
HEP		1							
9	2015	11-Jan	13:29	Atlantic Erie	Bulk Carrier	24,300	0.06	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.4722	1.1889	5	Spatial and functional incompatibility		0.0995	1.6965
12	Misperception of risk		0.3180	1.9539	33	Poor environment		0.0026	1.0004
17	Inadequate checking		0.1077	1.2154					
HEP		0.7667							
10	2016	22-Jan	8:02	MSC Monica	Container	37,398	0.06	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
7	Irreversibility		0.2670	2.8690	13	Poor feedback		0.1510	1.4529
17	Inadequate checking		0.2478	1.4955	22	Lack of experience		0.0870	1.0696
12	Misperception of risk		0.2456	1.7367	23	Unreliable instruments		0.0017	1.0010
HEP		1							

VIII. Norway

Table C. 8 Norway's Grounding Results

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	6-Oct	5:10	FEDERAL KIVALINA	Bulk carrier	20,659	0.1	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2695	1.5390	26	Progress tracking lack		0.0888	1.0355
19	No diversity of information		0.2296	1.3445	10	Knowledge transfer		0.0757	1.3407
36	Task pacing		0.1447	1.0087	16	Impoverished information		0.0758	1.1516
13	Poor feedback		0.1124	1.3372	33	Poor environment		0.0013	1.0002
HEP		0.4017							
2	2008	19-Nov	7:00	CRETE CEMENT	Cargo ship	4,075	0.02	C	0.16
EPC			APE	AIV	EPC			APE	AIV
37	Lack of human resources		0.3602	1.0108	35	Sleep cycles disruption		0.0639	1.0064
19	No diversity of information		0.3255	1.4882	26	Progress tracking lack		0.0502	1.0201
28	Low meaning		0.1473	1.0589	36	Task pacing		0.0530	1.0032
HEP		0.2625							
3	2009	31-Jul	0:44	MV FULL CITY	Bulk Carrier	15,873	0.02	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3921	1.7843	13	Poor feedback		0.0635	1.1905
17	Inadequate checking		0.2505	1.5010	12	Misperception of risk		0.0084	1.0251
23	Unreliable instruments		0.2536	1.1521	33	Poor environment		0.0010	1.0001
HEP		0.3389							
4	2011	17-Feb	19:52	M/V GODAFOSS V2PM7	Container vessel	17,042	0.09	E	0.02
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3762	1.7524	13	Poor feedback		0.0689	1.2067
12	Misperception of risk		0.3326	1.9979	19	No diversity of information		0.0324	1.0486
10	Knowledge transfer		0.1898	1.8542					
HEP		0.1643							

IX. Germany

Table C. 9 Germany's Grounding Results

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	2-Jan	4:54	LT Cortesia	Container ship	90,449	0.1	E	0.02
EPC			APE	AIV	EPC			APE	AIV
35	Sleep cycles disruption		0.2695	1.0270	10	Knowledge transfer		0.0888	1.3994
26	Progress tracking lack		0.2296	1.0919	17	Inadequate checking		0.0758	1.1516
22	Lack of experience		0.1447	1.1157	16	Impoverished information		0.0757	1.1514
12	Misperception of risk		0.1124	1.3372	33	Poor environment		0.0013	1.0002
	HEP	0.0621							
2	2008	9-Apr	9:06	MV Pacific Challenger	Container ship	9,966	0.08	E	0.02
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3235	1.6469	26	Progress tracking lack		0.1967	1.0787
19	No diversity of information		0.2548	1.3822	2	Time shortage		0.0279	1.2793
16	Impoverished information		0.1971	1.3942					
	HEP	0.0876							
3	2011	29-Jun	23:35	Amphitrite	traditional sailing vessel	184	0.07	C	0.16
EPC			APE	AIV	EPC			APE	AIV
2	Time shortage		0.5145	6.1449	33	Poor environment		0.0211	1.0032
1	Unfamiliarity		0.4644	8.4310					
	HEP	1							
4	2011	16-Sep	11:40	Fiducia	Container Ship	16,211	0.06	E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2647	1.1059	17	Inadequate checking		0.1497	1.2994
12	Misperception of risk		0.2456	1.7369	10	Knowledge transfer		0.0863	1.3883
13	Poor feedback		0.2434	1.7303	24	Absolute judgments required		0.0017	1.0010
	HEP	0.1200							
5	2012	15-Jan	23:00	Deutchland	Passenger ship	22,496	0.08	E	0.02
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3921	1.7843	10	Knowledge transfer		0.1890	1.8505
26	Progress tracking lack		0.3255	1.1302	33	Poor environment		0.0932	1.0140
	HEP	0.0757							
6	2012	14-Aug	0:45	Katja	Oil tanker	52,067	0.07	D	0.09
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.5145	2.5435	33	Poor environment		0.0211	1.0032
12	Misperception of risk		0.4644	2.3933					
	HEP	0.5496							
7	2013	18-Apr	9:31	MV Norfolk Express	Container Ship	36,606	0.05	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3259	1.6517	33	Poor environment		0.0421	1.0063
10	Knowledge transfer		0.3240	2.4579	23	Unreliable instruments		0.0017	1.0010
12	Misperception of risk		0.3043	1.9129					
	HEP	1							
8	2014	9-Jan	21:24	MV Merita	Cargo Ship	3,329		D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1.0000	1.6000					
	HEP	0.1440							
9	2015	17-Dec	7:55	BBC Maple Tea	Multi-purpose Vessel	9,611	0.07	D	0.09
EPC			APE	AIV	EPC			APE	AIV
13	Poor feedback		0.5210	2.5631	26	Progress tracking lack		0.1253	1.0501
16	Impoverished information		0.3179	1.6358	12	Misperception of risk		0.0358	1.1074
	HEP	0.4388							
10	2016	3-Feb	22:10	CSCL Indian Ocean	Container Ship	187,541		C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.6711	1.4026	33	Poor environment		0.3289	1.0493
	HEP	0.2355							
11	2016	4-Dec	6:28	CMV Hanni	Container Ship	5,056		D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1.0000	1.6000					
	HEP	0.1440							

X. Denmark

Table C. 10 Denmark's Grounding Results

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	24-Feb	5:26	WANI WILL	General cargo	2,020	0.08	A	0.55
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.3303	1.3303	26	Progress tracking lack		0.1388	1.0555
37	Lack of human resources		0.1889	1.0057	17	Inadequate checking		0.1224	1.2447
11	Performance ambiguity		0.1734	1.6937	31	Low morale		0.0462	1.0092
HEP		1							
2	2008	17-May	2:00	MCL TRADER	General cargo	3,466	0.03	B	0.26
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3565	1.7130	34	Low mental workload		0.0509	1.0051
26	Progress tracking lack		0.2366	1.0946	24	Absolute judgments required		0.0394	1.0236
37	Lack of human resources		0.1015	1.0030	25	Unclear allocation of function		0.0438	1.0263
15	Operator inexperience		0.0863	1.1726	14	Delayed/incomplete feedback		0.0212	1.0424
28	Low meaning		0.0637	1.0255					
HEP		0.6473							
3	2008	2-Jul	3:05	ROSETHORN	General cargo	1,213	0	C	0.16
EPC			APE	AIV	EPC			APE	AIV
37	Lack of human resources		0.3233	1.0097	36	Task pacing		0.1405	1.0084
29	Emotional stress		0.2719	1.0816	15	Operator inexperience		0.0685	1.1371
26	Progress tracking lack		0.1392	1.0557	28	Low meaning		0.0565	1.0226
HEP		0.2163							
4	2012	16-Aug	8:21	VEGA SAGITTARIUS	Container Ship	9,750	0.01	C	0.16
EPC			APE	AIV	EPC			APE	AIV
25	Unclear allocation of function		0.1772	1.1063	14	Delayed/incomplete feedback		0.0912	1.1825
17	Inadequate checking		0.1517	1.3034	19	No diversity of information		0.0852	1.1278
16	Impoverished information		0.1476	1.2951	12	Misperception of risk		0.0839	1.2516
13	Poor feedback		0.1336	1.4008	26	Progress tracking lack		0.0175	1.0070
10	Knowledge transfer		0.1006	1.4527	37	Lack of human resources		0.0115	1.0003
HEP		1							
5	2013	1-Aug	5:17	DART	Tanker	926		D	0.09
EPC			APE	AIV	EPC			APE	AIV
35	Sleep cycles disruption		0.6786	1.0679	23	Unreliable instruments		0.3214	1.1929
HEP		0.1146							
6	2017	10-Feb	18:17	VICTORIA	Container Ship	17,188	0.08	E	0.02
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.5238	2.0476	26	Progress tracking lack		0.0239	1.0096
36	Task pacing		0.4193	1.0252					
HEP		0.0424							

XI. United Kingdom

Table C. 11 United Kingdom's Grounding Results

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2009	16-Sep	7:15	Maersk Kendal	Container ship	74,642	0.08	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2695	1.1078	12	Misperception of risk		0.0888	1.2663
24	Absolute judgments required		0.2296	1.1378	16	Impoverished information		0.0757	1.1514
22	Lack of experience		0.1447	1.1157	36	Task pacing		0.0758	1.0045
17	Inadequate checking		0.1124	1.2248	23	Unreliable instruments		0.0013	1.0008
HEP	0.4040								
2	2011	9-Aug	10:24	CSL Thames	Bulk carrier	19,538	0.1	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.5238	2.0476	10	Knowledge transfer		0.0239	1.1077
12	Misperception of risk		0.4193	2.2578					
HEP		0.8193							
3	2012	15-Nov	5:59	Amber	Bulk carrier	10,490	0.02	D	0.09
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.3601	2.6206	4	Features over-ride allowed		0.0639	1.5111
17	Inadequate checking		0.3254	1.6509	26	Progress tracking lack		0.0530	1.0212
16	Impoverished information		0.1473	1.2947	22	Lack of experience		0.0502	1.0401
HEP		0.8091							
4	2013	28-Oct	18:51	Stena Alegra	RoPax	22,152	0.02	D	0.09
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.3601	2.6206	33	Poor environment		0.0639	1.0096
21	Dangerous incentives		0.3254	1.3254	17	Inadequate checking		0.0530	1.1059
12	Misperception of risk		0.1473	1.4420	22	Lack of experience		0.0502	1.0401
HEP		0.5235							
5	2014	14-Jul	15:15	Commodore Clipper	RoPax	14,000	0.07	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3976	1.1591	12	Misperception of risk		0.1571	1.4714
16	Impoverished information		0.3594	1.7188	17	Inadequate checking		0.0855	1.1710
HEP		0.3089							
6	2015	3-Jan	21:15	Hoegh Osaka	RoPax	51,770	0.07	E	0.02
EPC			APE	AIV	EPC			APE	AIV
11	Performance ambiguity		0.2711	2.0845	21	Dangerous incentives		0.0225	1.0225
17	Inadequate checking		0.2643	1.5286	16	Impoverished information		0.0099	1.0197
28	Low meaning		0.1841	1.0736	18	Objectives conflict		0.0060	1.0090
12	Misperception of risk		0.1688	1.5063	25	Unclear allocation of function		0.0022	1.0013
34	Low mental workload		0.0711	1.0071					
HEP		0.1093							
7	2015	11-May	13:28	Hamburg	Passenger ship	15,067	0.06	C	0.16
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.2335	2.0508	17	Inadequate checking		0.1411	1.2822
13	Poor feedback		0.2047	1.6142	33	Poor environment		0.0814	1.0122
26	Progress tracking lack		0.1706	1.0682	12	Misperception of risk		0.0193	1.0578
28	Low meaning		0.1488	1.0595	16	Impoverished information		0.0005	1.0010
HEP		0.8238							
8	2016	22-Aug	0:32	Vasco de Gama	container vessel	178,228	0.03	E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5980	1.2392	24	Absolute judgments required		0.0174	1.0105
10	Knowledge transfer		0.1987	1.8943	17	Inadequate checking		0.0080	1.0159
16	Impoverished information		0.1444	1.2888					
HEP		0.0621							
9	2008	31-Jan	19:22	Riverdance	ro-ro cargo vessel	6,041	0.073	B	0.26
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2079	1.0831	11	Performance ambiguity		0.0991	1.3963
17	Inadequate checking		0.2009	1.4019	18	Objectives conflict		0.0382	1.0573
12	Misperception of risk		0.1337	1.4012	19	No diversity of information		0.0370	1.0556
21	Dangerous incentives		0.1337	1.1337	33	Poor environment		0.0427	1.0064
16	Impoverished information		0.1063	1.2127	5	Spatial and functional incompatibility		0.0007	1.0049
HEP		1							
10	2008	12-May	16:19	CFL Performer	dry cargo	4,106	0.008	C	0.16
EPC			APE	AIV	EPC			APE	AIV

17	Inadequate checking		0.3635	1.7270	28	Low meaning		0.1020	1.0408
26	Progress tracking lack		0.2925	1.1170	5	Spatial and functional incompatibility		0.0547	1.3829
19	No diversity of information		0.1782	1.2673	22	Lack of experience		0.0091	1.0072
HEP		0.5671							
11	2008	10-Mar	7:25	Astral	chemical tanker	7,636	0.092	B	0.26
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2435	1.0974	34	Low mental workload		0.0360	1.0036
10	Knowledge transfer		0.2092	1.9414	33	Poor environment		0.0256	1.0038
17	Inadequate checking		0.2042	1.4083	13	Poor feedback		0.0097	1.0291
6	Model mismatch		0.1542	2.0791	12	Misperception of risk		0.0017	1.0052
24	Absolute judgments required		0.1140	1.0684	21	Dangerous incentives		0.0020	1.0020
HEP		1							
12	2008	18-Feb	4:20	Sea Mithril	cargo vessel	1,382	0.087	C	0.16
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.2080	1.9362	16	Impoverished information		0.1245	1.2490
14	Delayed/incomplete feedback		0.1632	1.3264	37	Lack of human resources		0.0737	1.0022
26	Progress tracking lack		0.1349	1.0540	25	Unclear allocation of function		0.0485	1.0291
17	Inadequate checking		0.1262	1.2524	33	Poor environment		0.0007	1.0001
36	Task pacing		0.1202	1.0072					
HEP		0.7038							
13	2011	15-Feb	5:46	K-WAVE	Container	7,170	0.097	A	0.55
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2396	1.0959	31	Low morale		0.1527	1.0305
17	Inadequate checking		0.2170	1.4340	28	Low meaning		0.0488	1.0195
11	Performance ambiguity		0.1948	1.7790	1	Unfamiliarity		0.0012	1.0189
21	Dangerous incentives		0.1459	1.1459					
HEP		1							
14	2012	2-Jul	4:43	COASTAL ISLE	Container ship	3,125	0.018	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2973	1.1189	30	Ill-health		0.0833	1.0167
17	Inadequate checking		0.2864	1.5729	31	Low morale		0.0289	1.0058
35	Sleep cycles disruption		0.2089	1.0209	25	Unclear allocation of function		0.0008	1.0005
21	Dangerous incentives		0.0943	1.0943					
HEP		0.1810							
15	2012	3-Apr	20:08	Carrier	cargo ship	1,587	0.078	C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.4662	2.3987	18	Objectives conflict		0.0310	1.0465
13	Poor feedback		0.3669	2.1007	2	Time shortage		0.0026	1.0258
33	Poor environment		0.1332	1.0200					
HEP		0.8828							
16	2012	12-Dec	3:08	Beaumont	Dry Cargo	2,545	0.002	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2527	1.5053	26	Progress tracking lack		0.1254	1.0502
37	Lack of human resources		0.1970	1.0059	21	Dangerous incentives		0.0849	1.0849
25	Unclear allocation of function		0.1432	1.0859	27	Physical capabilities		0.0517	1.0207
35	Sleep cycles disruption		0.1365	1.0137	34	Low mental workload		0.0086	1.0009
HEP		0.1746							
17	2013	14-Jun	3:22	FRI OCEAN	general cargo vessel	2,218	0.057	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2335	1.4671	34	Low mental workload		0.1411	1.0141
26	Progress tracking lack		0.2048	1.0819	21	Dangerous incentives		0.0814	1.0814
35	Sleep cycles disruption		0.1706	1.0171	6	Model mismatch		0.0193	1.1349
5	Spatial and functional incompatibility		0.1488	2.0416	37	Lack of human resources		0.0005	1.0000
HEP		0.3692							
18	2013	26-Feb	2:56	DOUWENT	general cargo	1,311	0.098	D	0.09
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2701	1.5402	26	Progress tracking lack		0.0890	1.0356
16	Impoverished information		0.2302	1.4603	19	No diversity of information		0.0760	1.1139
37	Lack of human resources		0.1450	1.0043	34	Low mental workload		0.0759	1.0076
35	Sleep cycles disruption		0.1127	1.0113	11	Performance ambiguity		0.0013	1.0052
HEP		0.2402							
19	2013	16-Mar	3:30	Danio	General cargo	1,499	0.030	D	0.09

EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2355	1.4710	26	Progress tracking lack		0.1207	1.0483
36	Task pacing		0.2156	1.0129	10	Knowledge transfer		0.1151	1.5180
37	Lack of human resources		0.1598	1.0048	34	Low mental workload		0.0020	1.0002
35	Sleep cycles disruption		0.1512	1.0151					
HEP		0.2177							
20	2013	5-Aug	18:35	FV PROSPECT	Fishing vessel	72	0.062	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3294	1.6588	26	Progress tracking lack		0.1534	1.0613
19	No diversity of information		0.2303	1.3455	36	Task pacing		0.0960	1.0058
17	Inadequate checking		0.1890	1.3780	31	Low morale		0.0019	1.0004
HEP		0.2956							
21	2014	30-Nov	8:04	Vectis Eagle	general cargo	6,190	0.095	C	0.16
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.3762	1.5643	31	Low morale		0.0689	1.0138
26	Progress tracking lack		0.3326	1.1331	2	Time shortage		0.0324	1.3240
17	Inadequate checking		0.1898	1.3796					
HEP		0.5252							
22	2015	18-Feb	2:32	Lysblink Seaways	General Cargo	7,409	0.043	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2620	1.5239	33	Poor environment		0.0650	1.0097
26	Progress tracking lack		0.2002	1.0801	21	Dangerous incentives		0.0529	1.0529
28	Low meaning		0.1653	1.0661	31	Low morale		0.0356	1.0071
37	Lack of human resources		0.1366	1.0041	11	Performance ambiguity		0.0009	1.0037
25	Unclear allocation of function		0.0815	1.0489					
HEP		0.3178							
23	2016	10-Jul	12:54	Royal Iris	passenger ferry	464	0.074	D	0.09
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3978	1.1591	19	No diversity of information		0.1572	1.2358
17	Inadequate checking		0.3595	1.7190	12	Misperception of risk		0.0855	1.2565
HEP		0.2785							
24	2016	3-Dec	2:50	Muros	General cargo	2,998	0.096	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.2645	1.3967	18	Objectives conflict		0.1180	1.1770
10	Knowledge transfer		0.2327	2.0470	34	Low mental workload		0.0398	1.0040
26	Progress tracking lack		0.2029	1.0812	21	Dangerous incentives		0.0009	1.0009
17	Inadequate checking		0.1413	1.2825					
HEP		0.4220							
25	2017	10-Jun	13:03	Ocean Prefect	Bulk carrier	29,323	0.004	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.5218	2.0436	22	Lack of experience		0.0377	1.0302
12	Misperception of risk		0.3824	2.1473	15	Operator inexperience		0.0077	1.0155
19	No diversity of information		0.0503	1.0755					
HEP		0.4443							
26	2017	10-Oct	23:11	Ruyter	general	2,528	0.056	D	0.09
EPC			APE	AIV	EPC			APE	AIV
31	Low morale		0.3125	1.0625	17	Inadequate checking		0.1326	1.2653
28	Low meaning		0.2943	1.1177	26	Progress tracking lack		0.0573	1.0229
11	Performance ambiguity		0.1647	1.6587	21	Dangerous incentives		0.0386	1.0386
HEP		0.2383							
27	2017	8-Oct	2:42	Islay Trader	general cargo	1,512	0.096	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.2645	1.7934	11	Performance ambiguity		0.1180	1.4720
24	Absolute judgments required		0.2327	1.1396	23	Unreliable instruments		0.0398	1.0239
26	Progress tracking lack		0.2029	1.0812	22	Lack of experience		0.0009	1.0007
17	Inadequate checking		0.1413	1.2825					
HEP		0.3847							
28	2018	27-Mar	14:38	Celtica Hav	general cargo	1,537	0.066	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.2863	1.5726	10	Knowledge transfer		0.1108	1.4984
17	Inadequate checking		0.2229	1.4458	21	Dangerous incentives		0.0091	1.0091
26	Progress tracking lack		0.1846	1.0739	12	Misperception of risk		0.0032	1.0097
19	No diversity of information		0.1830	1.2745					
HEP		0.7602							

XII. Finland

Table C. 12 Finland's Grounding Results

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	29-Jan	9:16	MS Tali	Bulk Carrier	13,340		C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		1.0000	4.0000					
HEP		0.6400							
2	2008	27-Feb	12:20	M/S OOCL NEVSKIY	Container Ship	9,981	0.04	C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.2412	1.7237	19	No diversity of information		0.1085	1.1628
11	Performance ambiguity		0.2145	1.8581	5	Spatial and functional incompatibility		0.0773	1.5414
16	Impoverished information		0.1752	1.3504	14	Delayed/incomplete feedback		0.0236	1.0472
17	Inadequate checking		0.1596	1.3192					
HEP		1							
3	2008	2-Apr	13:58	MS Anne Sibum	Container Ship	10,585	0.05	D	0.09
EPC			APE	AIV	EPC			APE	AIV
10	Knowledge transfer		0.3259	2.4664	22	Lack of experience		0.0421	1.0336
11	Performance ambiguity		0.3240	2.2959	36	Task pacing		0.0017	1.0001
26	Progress tracking lack		0.3043	1.1217					
HEP		0.5910							
4	2008	7-Apr	23:17	M/S FORTE	Ro-Ro	3,998	0.03	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3200	1.6399	19	No diversity of information		0.1495	1.2243
12	Misperception of risk		0.2786	1.8358	5	Spatial and functional incompatibility		0.0206	1.1445
26	Progress tracking lack		0.2313	1.0925					
HEP		0.7374							
5	2009	11-Dec	8:22	EMSRUNNER	Dry cargo ship	4,102	0.1	C	0.16
EPC			APE	AIV	EPC			APE	AIV
14	Delayed/incomplete feedback		0.2645	1.5290	16	Impoverished information		0.1180	1.2360
26	Progress tracking lack		0.2327	1.0931	12	Misperception of risk		0.0398	1.1195
19	No diversity of information		0.2029	1.3044	28	Low meaning		0.0009	1.0003
17	Inadequate checking		0.1413	1.2825					
HEP		0.6192							
6	2010	13-Oct	0:07	NORDLAND	General cargo	5,052	0.08	D	0.09
EPC			APE	AIV	EPC			APE	AIV
19	No diversity of information		0.2835	1.4253	16	Impoverished information		0.1004	1.2009
25	Unclear allocation of function		0.1641	1.0984	7	Irreversibility		0.0531	1.3719
10	Knowledge transfer		0.1588	1.7146	26	Progress tracking lack		0.0050	1.0020
17	Inadequate checking		0.1187	1.2374	32	Inconsistency of displays		0.0005	1.0001
14	Delayed/incomplete feedback		0.1158	1.2316					
HEP		0.6078							
7	2010	29-Dec	0:15	STADION GRACHT	Dry cargo ship	16,639	0.06	D	0.09
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.4640	2.3921	14	Delayed/incomplete feedback		0.0978	1.1955
10	Knowledge transfer		0.3124	2.4059	32	Inconsistency of displays		0.0025	1.0005
16	Impoverished information		0.1058	1.2117					
HEP		0.7507							
8	2012	18-Apr	12:58	PHOENIX J	Container Ship	10,585	0.04	E	0.02
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.3549	1.1419	12	Misperception of risk		0.0402	1.1205
16	Impoverished information		0.3041	1.6082	33	Poor environment		0.0400	1.0060
17	Inadequate checking		0.2609	1.5217					
HEP		0.0630							
9	2014	11-Oct	2:14	SYLT (AG)	Container Ship	9,993		D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.6786	2.3571	23	Unreliable instruments		0.3214	1.1929
HEP		0.2531							

D. Sinking

I. Indonesia

Table D. 1 Indonesia's Sinking Results

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	17-May	3:36	Samudra Makmur Jaya	Cargo	495	0.009	A	0.55
EPC			APE	AIV	EPC			APE	AIV
22	Lack of experience		0.6711	1.5368	1	Unfamiliarity		0.3289	6.2632
	HEP	1							
2	2009	11-Jan	4:00	Teratai Prima	Ferry	747	0.04	A	0.55
EPC			APE	AIV	EPC			APE	AIV
15	Operator inexperience		0.6283	2.2565	22	Lack of experience		0.0969	1.0775
20	Educational mismatch		0.2522	1.2522	2	Time shortage		0.0023	1.0234
	HEP	1							
3	2009	22-Nov	9:28	Dumai Express 10	Ferry	147	0.091	B	0.26
EPC			APE	AIV	EPC			APE	AIV
8	Channel overload		0.3732	2.8658	15	Operator inexperience		0.0762	1.1525
9	Technique unlearning		0.2712	2.3562	26	Progress tracking lack		0.0625	1.0250
5	Spatial and functional incompatibility		0.1228	1.8594	18	Objectives conflict		0.0096	1.0144
16	Impoverished information		0.0822	1.1643	31	Low morale		0.0023	1.0005
	HEP	1							
4	2010	6-Mar	12:00	Ammana Gappa	Cargo	2,095	0.06	E	0.02
EPC			APE	AIV	EPC			APE	AIV
22	Lack of experience		0.2647	1.2118	14	Delayed/incomplete feedback		0.1497	1.2994
16	Impoverished information		0.2456	1.4913	15	Operator inexperience		0.0863	1.1726
10	Knowledge transfer		0.2434	2.0955	5	Spatial and functional incompatibility		0.0017	1.0116
	HEP	0.116732							
5	2011	27-Aug		Windu Karsa	Ferry Ro-Ro	1,376	0.080	D	0.09
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.3921	1.7843	23	Unreliable instruments		0.1890	1.1134
12	Misperception of risk		0.3255	1.9764	24	Absolute judgments required		0.0932	1.0559
	HEP	0.3731							
6	2013	24-Dec		Irama Nusantara	Cargo		0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.4296	1.2578	19	No diversity of information		0.0176	1.0264
24	Absolute judgments required		0.3878	1.2327					
	HEP	0.1432							
7	2013	3-Jul		Pemudi	Container	4,249	0.095	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3762	1.7524	26	Progress tracking lack		0.0689	1.0276
16	Impoverished information		0.3326	1.6653	1	Unfamiliarity		0.0324	1.5185
19	No diversity of information		0.1898	1.2847					
	HEP	0.9360							
8	2014	26-Aug		Pertama I	General Cargo	595	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
22	Lack of experience		0.4296	1.3437	26	Progress tracking lack		0.0176	1.0070
14	Delayed/incomplete feedback		0.3878	1.7756					
	HEP	0.2162							
9	2014	3-Jan		Munawar Ferry	Ferry Ro-Ro	522	0.05	B	0.26
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.3259	1.6517	11	Performance ambiguity		0.0421	1.1682
26	Progress tracking lack		0.3240	1.1296	24	Absolute judgments required		0.0017	1.0010
14	Delayed/incomplete feedback		0.3043	1.6086					
	HEP	0.9126							
10	2016	14-Oct		KM. Pertama I	Ferry Ro-Ro	1,518	0.09	D	0.09
EPC			APE	AIV	EPC			APE	AIV

26	Progress tracking lack		0.4219	1.1688	17	Inadequate checking		0.2411	1.4821
12	Misperception of risk		0.2473	1.7420	23	Unreliable instruments		0.0098	1.0059
HEP		0.2732							
11	2016	4-Mar		RAFELIA 2	Ferry Ro-Ro	1,108	0.061	D	0.09
EPC			APE	AIV	EPC			APE	AIV
6	Model mismatch		0.2531	2.7715	19	No diversity of information		0.0978	1.1466
22	Lack of experience		0.2023	1.1618	21	Dangerous incentives		0.0929	1.0929
26	Progress tracking lack		0.1746	1.0698	17	Inadequate checking		0.0454	1.0909
9	Technique unlearning		0.1318	1.6588	11	Performance ambiguity		0.0008	1.0033
HEP		0.7053							
12	2016	13-Dec	15:20	Aisyah 08	oil tanker	1,199	0.099	E	0.02
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.4432	1.8863	25	Unclear allocation of function		0.0311	1.0187
21	Dangerous incentives		0.2564	1.2564	26	Progress tracking lack		0.0152	1.0061
6	Model mismatch		0.2489	2.7420	18	Objectives conflict		0.0053	1.0079
HEP		0.1343							
13	2016	29-Dec	11:30	Karamando	Passenger ship	104	0.085	C	0.16
EPC			APE	AIV	EPC			APE	AIV
16	Impoverished information		0.4311	1.8622	5	Spatial and functional incompatibility		0.1131	1.7916
23	Unreliable instruments		0.2495	1.1497	33	Poor environment		0.0036	1.0005
22	Lack of experience		0.2027	1.1621					
HEP		0.7136							
14	2017	20-Mar		Sweet Istanbul	Container	4,665	0.07	C	0.16
EPC			APE	AIV	EPC			APE	AIV
28	Low meaning		0.5145	1.2058	23	Unreliable instruments		0.0211	1.0126
17	Inadequate checking		0.4644	1.9289					
HEP		0.3768							
15	2017	6-May	14:00	SAS 02	landing craft	294	0.076	D	0.09
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		0.5417	1.3250	33	Poor environment		0.0248	1.0037
26	Progress tracking lack		0.4336	1.1734					
HEP		0.1405							
16	2017	17-Sep	8:00	Fungka Permata III	Passenger ship	107	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.5417	1.5417	34	Low mental workload		0.0248	1.0025
23	Unreliable instruments		0.4336	1.2601					
HEP		0.3116							
17	2018	3-Jan	17:30	Awet Muda	Passenger ship		0.06	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2670	1.1068	24	Absolute judgments required		0.2456	1.1473
12	Misperception of risk		0.2670	1.8010	6	Model mismatch		0.0870	1.6093
9	Technique unlearning		0.2478	2.2388	5	Spatial and functional incompatibility		0.0017	1.0117
HEP		1							
18	2018	27-Jan	17:00	Pinang Jaya	Cargo	1,052	0.09	E	0.02
EPC			APE	AIV	EPC			APE	AIV
9	Technique unlearning		0.3542	2.7709	23	Unreliable instruments		0.0533	1.0320
15	Operator inexperience		0.2877	1.5753	25	Unclear allocation of function		0.0237	1.0142
20	Educational mismatch		0.2755	1.2755	5	Spatial and functional incompatibility		0.0056	1.0394
HEP		0.1211							
19	2018	18-Jun	17:10	Sinar bangun 4	Passenger ship	35	0.096	c	0.16
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.2645	1.5290	15	Operator inexperience		0.1180	1.2360
20	Educational mismatch		0.2327	1.2327	23	Unreliable instruments		0.0398	1.0239
18	Objectives conflict		0.2029	1.3044	33	Poor environment		0.0009	1.0001
5	Spatial and functional incompatibility		0.1413	1.9889					
HEP		0.9901							

II. HongKong

Table D. 2 Hong Kong's Sinking Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2012	3-Apr	8:04	New Lucky VII	General Cargo	4,143	0.09	C	0.16
EPC			APE	AIV	EPC			APE	AIV
13			0.4586	2.3757	17			0.2620	1.5240
33			0.2688	1.0403	12			0.0106	1.0318
HEP		0.6218							
2	2012	25-Jul	13:30	Hai Yang Shi You 699	supply vessel	2,264	0.056	C	0.16
EPC			APE	AIV	EPC			APE	AIV
19			0.2670	1.4005	28			0.1510	1.0604
33			0.2456	1.0368	12			0.0870	1.2611
11			0.2478	1.9910	23			0.0017	1.0010
HEP		0.6192							
3	2013	14-Aug	11:56	Trans Summer	Bulk Carrier	33,044	0.076	C	0.16
EPC			APE	AIV	EPC			APE	AIV
17			0.5417	2.0833	7			0.0248	1.1733
33			0.4336	1.0650					
HEP		0.4165							

III. United States of America

Table D. 3 United States of America's Sinking Results.

No	Year	Date	Time	Ship's Name	Ship's Type	GT	CR	GT	NHU
1	2008	23-Mar		Alaska Ranger	Fish Processing Vessel	1,562	0.0090	F	0.003
EPC			APE	AIV	EPC			APE	AIV
22	Lack of experience		0.4586	1.3668	23	Unreliable instruments		0.2620	1.1572
21	Dangerous incentives		0.2688	1.2688	12	Misperception of risk		0.0106	1.0318
HEP		0.0062							
2	2008	22-Oct	0:00	Katmai	FISHING VESSEL	148	0.064	C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.2801	1.8404	18	Objectives conflict		0.0748	1.1121
14	Delayed/incomplete feedback		0.1995	1.3991	35	Sleep cycles disruption		0.0369	1.0037
21	Dangerous incentives		0.2034	1.2034	33	Poor environment		0.0282	1.0042
9	Technique unlearning		0.1771	1.8854					
HEP		1							
3	2009	24-Mar	5:10	Lady Mary	FISHING VESSEL	105		C	0.16
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.6786	1.6786	33	Poor environment		0.3214	1.0482
HEP		0.2815							
4	2012	25-Jan	6:00	Heritage	FISHING VESSEL	109	0.054	C	0.16
EPC			APE	AIV	EPC			APE	AIV
12	Misperception of risk		0.4237	2.2710	21	Dangerous incentives		0.1151	1.1151
11	Performance ambiguity		0.3971	2.5883	33	Poor environment		0.0638	1.0096
HEP		1							
5	2012	21-Feb	7:20	Plan B	FISHING VESSEL	189	0.069	C	0.16
EPC			APE	AIV	EPC			APE	AIV
9	Technique unlearning		0.5145	3.5724	15	Operator inexperience		0.0211	1.0421
23	Unreliable instruments		0.4644	1.2787					
HEP		0.7617							
6	2012	20-Sep	20:30	Allison C	FISHING VESSEL	112		E	0.02
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1.0000	1.6000					
HEP		0.0320							
7	2012	7-Oct	9:00	Viking II	FISHING VESSEL	101		C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1.0000	1.6000					
HEP		0.2560							
8	2012	29-Oct	4:26	Bounty	Square-rigged	266	0.040	C	0.16
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.2622	1.1049	18	Objectives conflict		0.1473	1.2210
21	Dangerous incentives		0.2436	1.2436	15	Operator inexperience		0.1089	1.2177
23	Unreliable instruments		0.2243	1.1346	33	Poor environment		0.0112	1.0017
12	Misperception of risk		0.1473	1.4419					
HEP		0.5357							
9	2013	18-Jan	3:15	Seaprobe	research vessel	295	0.069	D	0.09
EPC			APE	AIV	EPC			APE	AIV
21	Dangerous incentives		0.5145	1.5145	11	Performance ambiguity		0.0211	1.0843
18	Objectives conflict		0.4644	1.6967					
HEP		0.2508							
10	2013	13-Apr	14:55	Delta Captain	Towing vessel	89		C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1.0000	1.6000					
HEP		0.2560							
11	2013	4-May	19:51	Kaleen McAllister	towing vessel	243	0.069	B	0.26
EPC			APE	AIV	EPC			APE	AIV
17	Inadequate checking		0.5145	2.0290	26	Progress tracking lack		0.0211	1.0084
15	Operator inexperience		0.4644	1.9289					
HEP		1							
12	2013	30-May	7:02	Ricky B	Offshore supply vessel	89	0.069	B	0.26
EPC			APE	AIV	EPC			APE	AIV
26	Progress tracking lack		0.5145	1.2058	12	Misperception of risk		0.0211	1.0632
17	Inadequate checking		0.4644	1.9289					
HEP		0.6429							
13	2013	15-Nov	20:30	Long Shot	FISHING VESSEL	114		C	0.16
EPC			APE	AIV	EPC			APE	AIV
23	Unreliable instruments		1.0000	1.6000					

	HEP	0.2560							
14	2013	25-Nov	15:55	Stephen L. Colby	towing vessel	597		B	0.26
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.6786	2.3571	26	Progress tracking lack		0.3214	1.1286
	HEP	0.6917							
15	2014	8-Jun	18:05	Nash	Tank barge	2,168		B	0.26
	EPC		APE	AIV		EPC		APE	AIV
23			1.0000	1.6000					
	HEP	0.4160							
16	2014	1-Jul	12:00	Jim Marko	Towing Vessel	158	0.069	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
18	Objectives conflict		0.5145	1.7717	12	Misperception of risk		0.0211	1.0632
21	Dangerous incentives		0.4644	1.4644					
	HEP	0.4414							
17	2014	29-Nov	6:11	Blazer	FISHING VESSEL	160		C	0.16
	EPC		APE	AIV		EPC		APE	AIV
23	Unreliable instruments		1.0000	1.6000					
	HEP	0.2560							
18	2014	6-Dec	10:00	Spirit of Adventure	passenger vessel	99	0.090	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
21	Dangerous incentives		0.4586	1.4586	5	Spatial and functional incompatibility		0.2620	2.8340
15	Operator inexperience		0.2688	1.5377	32	Inconsistency of displays		0.0106	1.0021
	HEP	0.5733							
19	2014	30-Dec	23:00	King Neptune	passenger vessel	72		C	0.16
	EPC		APE	AIV		EPC		APE	AIV
33	Poor environment		1.0000	1.1500					
	HEP	0.1840							
20	2015	22-Jan	15:10	Nalani	Towing vessel	98	0.069	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.5145	2.0290	12	Misperception of risk		0.0211	1.0632
21	Dangerous incentives		0.4644	1.4644					
	HEP	0.5055							
21	2015	10-Jun	5:40	Kupreanof	FISHING VESSEL	137		G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
23	Unreliable instruments		1.0000	1.6000					
	HEP	0.0006							
22	2015	30-Aug	22:00	Capt Richie Rich	FISHING VESSEL	131		C	0.16
	EPC		APE	AIV		EPC		APE	AIV
23	Unreliable instruments		1.0000	1.6000					
	HEP	0.2560							
23	2015	31-Aug	3:30	Margaret	Deck barge	1,161	0.090	G	0.0004
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.4586	1.1834	17	Inadequate checking		0.2620	1.5240
23	Unreliable instruments		0.2688	1.1613	32	Inconsistency of displays		0.0106	1.0021
	HEP	0.0008							
24	2015	1-Oct	7:00	SS El Faro	Cargo vessel	31,515	0.091	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.2500	1.1000	5	Spatial and functional incompatibility		0.0269	1.1882
12	Misperception of risk		0.2230	1.6690	16	Impoverished information		0.0090	1.0180
17	Inadequate checking		0.1675	1.3350	2	Time shortage		0.0038	1.0376
18	Objectives conflict		0.1680	1.2521	21	Dangerous incentives		0.0019	1.0019
14	Delayed/incomplete feedback		0.1499	1.2998	33	Poor environment		0.0001	1.0000
	HEP	0.8025							
25	2015	3-Dec	20:18	Orin C	FISHING VESSEL	28		E	0.02
	EPC		APE	AIV		EPC		APE	AIV
9	Technique unlearning		0.6786	4.3929	23	Unreliable instruments		0.3214	1.1929
	HEP	0.1048							
26	2015	14-Dec	15:40	Spence	Towing vessel	189		C	0.16
	EPC		APE	AIV		EPC		APE	AIV
23	Unreliable instruments		1.0000	1.6000					
	HEP	0.2560							
27	2016	11-Jul	4:00	Capt. Kevin	FISHING VESSEL	127	0.069	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
26	Progress tracking lack		0.5145	1.2058	23	Unreliable instruments		0.0211	1.0126
21	Dangerous incentives		0.4644	1.4644					
	HEP	0.2861							
28	2016	15-Aug	4:53	Lady Gertrude	FISHING VESSEL	119		C	0.16
	EPC		APE	AIV		EPC		APE	AIV

23	Unreliable instruments		1.0000	1.6000					
	HEP	0.2560							
29	2016	6-Dec	21:40	Exito	FISHING VESSEL	188		F	0.003
	EPC		APE	AIV		EPC		APE	AIV
23	Unreliable instruments		1.0000	1.6000					
	HEP	0.0048							
30	2016	26-Jul	11:30	Alaska Juris	FISHING VESSEL	1,658	0.08	D	0.09
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.3922	1.7845	20	Educational mismatch		0.1890	1.1890
23	Unreliable instruments		0.3255	1.1953	2	Time shortage		0.0932	1.9322
	HEP	0.4410							
31	2016	12-May	16:55	Maximus	passenger vessel	42	0.069	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.5145	2.0290	6	Model mismatch		0.0211	1.1475
23	Unreliable instruments		0.4644	1.2787					
	HEP	0.4763							
32	2016	23-Jul	22:09	Ambition	FISHING VESSEL	138	0.069	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
11	Performance ambiguity		0.5145	3.0580	17	Inadequate checking		0.0211	1.0421
23	Unreliable instruments		0.4644	1.2787					
	HEP	0.6520							
33	2016	15-Feb	14:40	Capt. David	FISHING VESSEL		0.069	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
23	Unreliable instruments		0.5145	1.3087	11	Performance ambiguity		0.0211	1.0843
33	Poor environment		0.4644	1.0697					
	HEP	0.2429							
34	2016	28-Oct	15:30	Atlantic Raider	Towing Vessel	147	0.069	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.5145	2.0290	6	Model mismatch		0.0211	1.1475
23	Unreliable instruments		0.4644	1.2787					
	HEP	0.4763							
35	2017	30-Oct	22:15	Ben & Casey	FISHING VESSEL	118	0.074	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.3978	1.7956	26	Progress tracking lack		0.1572	1.0629
12	Misperception of risk		0.3595	2.0785	23	Unreliable instruments		0.0855	1.0513
	HEP	0.6673							
36	2017	5-Sep	0:35	Savage Ingenuity	Towing Vessel	121	0.076	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
21	Dangerous incentives		0.5417	1.5417	5	Spatial and functional incompatibility		0.0248	1.1733
23	Unreliable instruments		0.4336	1.2601					
	HEP	0.3647							
37	2017	22-Jun	11:40	Lady Damaris	Fishing Vessel	103	0.025	B	0.26
	EPC		APE	AIV		EPC		APE	AIV
11	Performance ambiguity		0.3602	2.4407	33	Poor environment		0.0639	1.0096
12	Misperception of risk		0.3255	1.9764	18	Objectives conflict		0.0530	1.0794
23	Unreliable instruments		0.1473	1.0884	21	Dangerous incentives		0.0502	1.0502
	HEP	1							
38	2018	18-Sep	5:32	Capt. M&M	Fishing Vessel	103	0.056	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.2670	1.5340	26	Progress tracking lack		0.1510	1.0604
15	Operator inexperience		0.2456	1.4911	23	Unreliable instruments		0.0870	1.0522
13	Poor feedback		0.2478	1.7433	6	Model mismatch		0.0017	1.0117
	HEP	0.7202							
39	2018	14-Nov	8:00	Aaron & Melissa II	Fishing Vessel	139	0.024	B	0.26
	EPC		APE	AIV		EPC		APE	AIV
18	Objectives conflict		0.4047	1.6070	23	Unreliable instruments		0.0655	1.0393
21	Dangerous incentives		0.2617	1.2617	12	Misperception of risk		0.0086	1.0259
11	Performance ambiguity		0.2585	2.0341	33	Poor environment		0.0010	1.0001
	HEP	1							
40	2018	4-Nov	8:40	PTC 598	Barge	705	0.090	C	0.16
	EPC		APE	AIV		EPC		APE	AIV
25	Unclear allocation of function		0.4586	1.2751	17	Inadequate checking		0.2620	1.5240
21	Dangerous incentives		0.2688	1.2688	6	Model mismatch		0.0106	1.0742
	HEP	0.4238							
41	2018	6-Mar	16:30	Ms Nancy C	Towing Vessel	82		C	0.16
	EPC		APE	AIV		EPC		APE	AIV
17	Inadequate checking		0.5417	2.0833	21	Dangerous incentives		0.0248	1.0248
6	Model mismatch		0.4336	4.0350					
	HEP	1							