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

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論文内容の要旨

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専　攻 海事科学専攻

論文題目（外国語の場合は，その和訳を併記すること。）

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））

指導教員 古莊　雅生

The originality and creativity of this research can be summarized as follow:

1. Application of Human Error Assessment and Reduction Technique (HEART) method in maritime sectors, which is still scarce in maritime industry.
2. Categorization of Error Producing Conditions (EPC) to 4M factors, man, machine, media, and management. The aim of this categorization is to make it easily understandable from which perspective the cause is commonly occurred. Because it might be important to determine the mitigation action based on which factor.
3. Utilizing the Multi – Criteria Decision-Making (MCDM) tool, named Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), to show the interdependencies among factors, to overcome the deficiency of HEART calculation process, and to reduce the subjectivity in calculating the Human Error Probability (HEP) Value.

Executive summary:

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). 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).

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). 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 second-generation methodologies consider the influence of internal and external context on the error and the cognitive context that may influence the system operation.

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 complex systems, such as nuclear power plant, railway transportation, aviation, off-shore platform, maritime industry. The HEART method has some developments to handle its limitation, especially for calculating the value of Human Error Probability (HEP).

Although many developments of HEART methods to overcome the limitations and shortcomings, most of these developments lack consideration to the relation among EPCs. 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 EPCs are 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.

The aims of this study are:

i. To investigate the potential navigational likelihood of maritime accidents.
ii. To propose a hybrid maritime accident analysis to enhance safety at sea.

The dissertation structure:

Chapter 1 – Introduction

This chapter provides a background explanation about the importance of this study, objectives, the steps of this study, and the impacts of this study on maritime academia and industry. The dissertation structure is also constructed in this chapter to make the reader convenient to find out the content in this study.

Chapter 2 – Literature Review

There are 2 subchapters, maritime accidents and human error, and human reliability assessment (HRA). In maritime accidents and the human error subchapter, the author explained the world's previous notable maritime accidents and how the international maritime organizations respond to it. Moreover, the influence of human error in maritime accidents is also explained in this chapter.

Furthermore, in HRA sub chapter, the brief explanation about development of HRA by researchers for the previous ten years are explained. This sub chapter shows the gap that being had by the previous HRA development. The HRA that originally comes from the maritime industry is scarce, whereas the maritime industry is rapidly developed and the number of human error influences in the accidents is high.

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).

Chapter 3 – Maritime Accident Analysis and Reduction Technique (MAART)

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, following by identifying 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 categorizes 38 EPCs into man, machine, media, and management.

The second step is 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. Finally, HEP can be calculated. There is also the calculation example for a case to give the reader a better understanding. More explanation about the methodologies used to develop the MAART method will be explained in this chapter.

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Chapter 4 – Applications

In this chapter, the MAART method will be applied in three kinds of accidents, collision, grounding and sinking accidents. 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. The total ship that is used in this study is 500 ships, from 381 data reports. A systematic accident database was generated in Microsoft Excel by tabulating the accident data into a textual format. The detailed data distribution and the application results of the MAART method are explained in this chapter.

Chapter 5 – Discussion and Consideration

In chapter 5, it will be furtherly discussed about the results that found in the chapter 4. The discussion is consisted of maritime accidents characteristics from all countries in that different kind of accidents and in general.

Moreover, the evaluation of MAART applications in those maritime accidents. 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) is the interaction during which the most errors occur, leading to accidents.

Chapter 6 – Conclusions

This chapter concludes all the maritime accidents causal factors and the application of MAART method. Furthermore, in this chapter also explained the contribution of this study to the academic literature, the maritime industry, and recommendations.

Appendices

In this part, all the data used in the analysis are shown. There are explanations about the detailed Generic Task, selected Error Producing Condition, the weight of Assessed Impact Value, and Human Error Probability for every case.

（別紙１）　　論文審査の結果の要旨

氏名	LUDFI PRATIWI BOWO		
論文題目	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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要　旨

概要

ヒューマンエラーが原因で発生する海難件数は多く、この状況は世界的な傾向である。海上輸送システムにおける人間信頼性分析（HRA：Human Reliability Analysis）の研究は不足している。そこで、本研究は、海難の潜在的要因の調査、及び海上輸送システムにおける人的要因の新しい方法を提案する目的に基づいて、4大陸12か国の政府が公表する海難データ（500件）の新しい分析手法（MAART: Maritime Accident Analysis and Reduction Technique）に基づく研究論文である。

第１章は、研究の重要性、目的、手順、及びこの研究が海事科学と海事産業に与える影響の背景を説明している。本研究は、海難の航海要素の違いによりその可能性を調査すること、及び船舶の安全運航の貢献できる海難解析手法（MAART）を提案する２つの目的を示している。

第２章は、文献のレビューを、３つの観点から示している。まず、海難事故とヒューマンエラーについて、主要な海難とヒューマンエラーとの関係を説明している。次に、人間の信頼性評価（HRA）について、原子力発電産業で開発された1975年から2005年までの期間を３世代に分け、HRA開発の経緯を述べている。そして、海事産業におけるHRAについて、2008年から2019年までの海事産業におけるHRA開発と開発された方法の欠陥を説明している。

第３章は、海難分析及びその削減手法（MAART）を述べている。MAARTは海難分析の新しい提案手法であり、人的要因、管理、機械、環境等の他の要因との関係に着目している。この方法は、定性的ステップと定量的ステップという２つのステップを示している。定性的ステップは、HEARTと4Mフレームワークの適用を示している。また、定量的ステップは、最適解との類似性による順序優先手法（TOPSIS：Technique for Order Preference by Similarity to Ideal Solution）と多基準意思決定（MCDM：Multi-Criteria Decision-Making）法を用いている。２つのステップすべての詳細情報、及びMAARTの適用事例を述べている。

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第4章は、三種類の海難（衝突、乗揚げ、沈没）にこの手法（MAART）を適用しながら検証している。この研究調査で使用するデータは、インターネットで検索できる公開された2008年から2018年までのデータであり、4大陸12か国の国家調査委員会によるデータレポート（381件）を収集し、500隻の船舶総データである。衝突海難と乗揚げ海難の原因には類似性を認められるが、沈没海難の原因は異なる結果を示している。

第5章は、第4章の結果を基にさまざまな種類の海難に言及し、調査した12か国の海難の特徴とMAARTの特徴という2つの観点から考察している。まず、衝突海難は穏やかな晴天時に発生する傾向があり、管理要因が事故原因であることを示している。次にHEP（ヒューマンエラー確率）は経年的に減少傾向を示し、海難におけるヒューマンエラーの改善策が効果的であること示している。

第6章は、この研究の結論である。MAARTは海難におけるHEPの価値を決定するための実用的なツールであり、海事科学の学術的貢献と海事産業の船舶安全（海難撲滅）に向けた有用な貢献であると結論付けている。

本研究の成果は、各国政府による運輸安全委員会が公表している海難データを基に、海難解析における主観評価と客観評価を融合させた、人間信頼性分析に基づく新しい方法論としてMARRT（Maritime Accident Analysis and Reduction Technique）を提案したことである。公表される海難船舶データ（500隻）の分析とそれらの統一的な解析を新しく提案するMARRTにより海難原因を明らかにした点は、本研究の独創性と有効性が認められ、海難原因における人的要因の重要性をさらに強調する成果として価値ある集積である。

研究成果は、この研究論文を構成する主な投稿論文として、5編の査読付きジャーナル論文として公表されている。

提出された論文は、海事科学研究科学位論文評価基準を満たしており、学位申請者のLUDFI PRATIWI BOWOは、博士（海事科学）の学位を得る資格があると認める。