Development of Safety Evaluation Model for Management of Navigation Safety in an Entire Ship Route Area

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論文内容の要旨

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専　　攻　Maritime Sciences

論文題目（外国語の場合は，その和訳を併記すること。）

Development of Safety Evaluation Model for Management of Navigation Safety in an Entire Ship Route Area

（船舶運航海域における航行安全性管理のための評価法の開発）

指導教員　Professor Eiichi Kobayashi

（注）1,200 字～2,400 字でまとめること。

A marine accident can result in tragic consequences such as the loss of ships and materials damage to marine infrastructure and environment. It has led to the economic losses and long time to recover. In order to prevent such marine accidents, safety is a significant issue in shipping and ship navigation in industrial fields. Therefore, many safety regulations pertaining to ship design and equipment have been developed to promote ship safety. However, significant marine accidents continue to occur, and it has come to light that one of the main causes of marine accidents is human error. Human factors were adopted among the causes to be investigated in marine accidents in Resolution A.884 (21) (IMO, 2000). A large proportion of marine accidents are ship collisions caused by human error. As one of the major sources of human error, navigators play an important role in navigating ships.

The need to ensure safety of navigation has led to the implementation in terms of supporting a navigation officer operating a ship. It has come to light the need for safety evaluation methods to estimate risk involved in ship navigation. This quantitative approach using the evaluation methods is able to predict risk and manage potential risk. Other approach is that VTS (vessel traffic service) is established in Resolution A.857 (20) (IMO, 1997). It has a role to monitor navigation situation and to assist navigation officers for manage potential risk in observation area

The primary of this thesis introduces a new model for evaluation of the navigation safety zone throughout an entire ship route for use by a port safety authority or vessel traffic service center. In evaluating the risks associated with a navigation situation, this model considers a variety of factors that affect a navigation officer's perceptions while navigating. A risk quantification method reflecting the knowledge of navigators was incorporated in this model, and a new algorithm was developed for evaluating safety in an entire ship route. To verify the effectiveness of the proposed model, a simulation was carried out for the Osaka Bay area. The proposed model was found to be effective in quantifying navigation safety throughout an entire ship route in Osaka Bay. This model can be helpful to vessel traffic centers and port safety authorities in ship navigation safety management.

This thesis is structured as follows. The literature review in terms of existing safety evaluation models is presented in Chapter 2 and Chapter 3 describes structure and basic concept of a new safety evaluation model. In Chapter 4, it describes safety index as risk quantification to identify risk in ship navigation in this model. An algorithm developed to evaluate risk throughout whole ship route area is presented in Chapter 5. Simulation results in Osaka bay utilizing proposed model are exemplified in Chapter 6. The findings and proposals for future work are included in Chapter 7.

In Chapter 2, it will explain the overview of existing models how risks in ship navigation may be quantified and how to evaluate the ship navigation situation.

The common point of the various methods of safety evaluation models consists of risk quantification and algorithms how to evaluate the ship navigation situation. In order to develop a new safety evaluation model, it has to approach as follows. Firstly, safety evaluation models have their own risk quantification to estimate navigation environment. Secondly, Algorithm is developed to evaluate risk associated with navigation situation between ships.

A new safety evaluation model is presented in this chapter 3. It consists of three parts, which are definition of safety index, safety index factors and its structure. The main purpose of safety index indicates a variety of navigation situation quantitatively, which takes into consideration of a navigation officer's perception. Ship navigation situation is complexity. Each movement of ship affects a navigation officer's perception while navigating own/other ships each other. This study defines a section and the meaning of navigation situation as follows: at the first, a section is the vital solution for evaluating safety throughout a whole ship route. A section is defined as one of the meshes that whole ship route is divided into several sections. Safety index indicates risk in a section that includes navigation situation of all ships in a section. In order to identify risk reflecting a navigation officer's perception, safety index factors are classified according to ship information, relationship between ship and environmental situation (time, day). Ship information is grouped according to ships' types and length of ship. This factor affects the navigation officers make decisions based on such information, which is important when considering maneuverability. In addition, these can exhibit the attributes of traffic route and ship speed. Relationship between ships is classified according to relative speed, distance difference between ships and encounter situations. It has impact when the navigation officer alters own ship's course/speed. According to encounter situations, proper action of ship is different. Environmental situation is grouped according to time and day. Sailing time includes the information who navigates a ship, which means that a navigation officer's experience will be taken into consideration. In this chapter, new model was presented approximatively. In order to complement the existing safety evaluation model, it proposed the solution. The approach was to consider various factors that reveal a navigation officer's perception. Outline of procedures of how to evaluate on an entire ship route was introduced.

In Chapter 4, this chapter described how to identify the risk of each factor in this model. Risk quantification was proposed in order to calculate safety index associated with navigation situation in a section. Elements of each factor were designed, which was quantified by the result of questionnaire investigation. A questionnaire is useful tool to measure the degree of risk. In the questionnaire, navigation officers were asked how much each factor affects their perception, using a nine-level evaluation scale.

The results reflect the navigation officers' opinion in a quantitative manner that can be incorporated into the safety evaluation model. In Chapter 5, this chapter proposes the algorithm that can be used to determine the navigational safety zone. This algorithm takes into consideration the analysis of ship navigation situation in real-time and estimate the risks of ship navigation situation in entire ship route area. It is proposed the ship route area is divided into several section at regular distance. Each ship navigation situation at entire ship route area can be quantified in terms of safety index based on the ship data within a specified distance range. The safety level of each section is expressed by a representative value reflecting the navigation officers' perception. The results using this algorithm can be used to determine the navigational safety zone. The proposed algorithm is to be effective in quantifying navigation safety throughout an entire ship route area. It can be helpful to vessel traffic centers and port safety authorities in ship navigation safety management. To verify the effectiveness of the proposed algorithm, a simulation will carry out in Chapter 6.

In Chapter 6, it shows that proposed model can be used to evaluate the safety of an entire ship route area on the basis of navigation officers' perceptions. This chapter presents an assessment of the suitability of the proposed model for use as a safety evaluation method in assessing risk for an entire ship route area. A simulation was carried out to validate the proposed model for use as a safety evaluation model. It was conducted for Osaka Bay. Osaka bay is Japan's largest semi-enclosed sea, which is located at the eastern end of Seto Inland. This bay has two entrances for the Osaka/Kobe port areas, which are the Akashi Strait and the Tomogashima Channel. According to the Port Authority of Japan (2010), the area used is latitude N34°14′ to N34°46′ and longitude E134°54′ to E135°26′. This simulation was carried out using AIS data. The receiving system of AIS is installed on the top floor of a building at Kobe University, and AIS data from Osaka Bay is acquired continuously.

Some Conclusion regarding to proposed safety evaluation model has been performed in Chapter 7. Development of safety evaluation model in port safety management is importance to be studied in order to manager the potential risks of ship navigation situation. The safety evaluation models consist of two major parts. One is to develop the risk quantification in order to estimate the risks of ship navigation situation. The other is to propose the algorithm to evaluate the ship navigation situation. In this research, the risk quantification was developed based on several elements affecting the navigation officer's perception in ship navigation situation. The algorithm was proposed to evaluate the risks along entire ship route area.

（別紙１）　　論文審査の結果の要旨

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論文題目	Development of Safety Evaluation Model for Management of Navigation Safety in an Entire Ship Route Area (船舶運航海域における航行安全性管理のための評価法の開発)		
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要　　旨

概要
船舶が関与する海上での事故は人だけでなく船舶そのものや積荷、様々な施設に甚大な被害を与える場合があるため、航行の安全確保は海運にかかる人や組織にとって非常に重要な課題である。事故を防ぐ様々な運用面や研究面での取り組みが継続的におこなわれているにもかかわらず、特にヒューマンエラーを原因とする事故はいまなお発生し続けている。本研究では、実務運航者への危険度認識にかかるアンケート調査をベースとして、航行中の安全性を具体的な指標として表わす手法の開発を行い、その指標を活用することにより、合理的・客観的な航行管制や航行の評価へ応用し、特に輻輳海域での衝突などの事故の軽減につなげようとするものである。

この論文は７つの章から構成される。
第一章では、研究の背景や既往事故事例などを参照しつつ、現役の航海にかかる業務従事者への広範なアンケート結果を分析し、それに基づき導き出す新たな安全性指標開発とその応用性の考察にかかる本研究の目的を述べている。

第二章では、本研究で課題とする航行安全性指数が運航実務者や港湾管理者の業務に活用できるという前提のもと、その航行安全性を評価する指数について、既往研究で示されているものの分析を行い、それぞれ何が評価でき何ができないかなどの特徴をまず示した。そしてそれぞれの長所短所について詳述し、それらの既往指数で表現できなかった、合理的な手法に基づく定量的な評価基準の導入が必要であると示している。

第三章では、具体的に開発された指標（以後 SI; Safety Index と略す）について述べている。まず既往の同類の指標が、例えば避航開始距離の基準設定を目的としていたり前方の周辺環境が操船者に与えるストレスに着目していたことに対して改良され、また新たに評価できることになる項目（例えば船の種類や相手船の運動状態）を示し、この SI の基本的な考え方や取り扱う範囲などを説明している。さらに、COLREG(海上における衝突の予防のための国際規則に関する条約)との関連や、自船と相手船の相対位置関係と、この SI の関連を詳述している。さらにこの新たな指標は AIS（船舶自動識別装置）データを活用するためリアルタイムでの港湾の航行安全管理などへも応用可能であるとしている。

第四章では、その SI を構築するために実施するアンケート調査に先立ち、航行の安全性にかかる船舶の大きさ、種類、相手船との見合い関係、風・波などの環境外乱条件などの項目の抽出経緯と妥当性、およびどのように指標化するかその具体的な手順を示している。さらにアンケートの具体的な実施要領についての説明を行うとともに、得られたアンケート結果から SI として指標化するための手順の解説も行っている。

第五章では、SI を実務的に得るための手法を示している。すなわち神戸大学で継続的に取得している大阪湾の船舶動態 AIS データを活用して得られる船舶の動態を格子状領域に分けて評価するための手法の提案と解説を行っている。

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第六章では、解析評価の事例として、AIS（船舶自動識別装置）により取得された大阪湾に存在する船舶を対象として、刻々と変化する SI の解析を行っている。具体的には、指定されて航路に沿って SI の変化の様子を時刻歴として示しその傾向が一般に言われている比較的危険で航行に注意を要する水域と合致していること、その数値が航行管制に使用できる可能性のあることを示している。

最後に第七章では本研究で取り組んできた、航行安全性確保の視点からの新たな港湾管理手法や、安全航行を評価するための航行安全性指標の開発などについてその有用性や評価できる内容の限界についての考察など、本研究の結論を示している。さらに将来に向けた課題の整理とその解決方法の提示を行っている。

以上述べてきたように、本研究は船舶運航実務者が持つ安全に関する知識を数値化し、それをもとに安全性指標を設定しようとする極めて新しい取り組みである。具体的な指標化のためにアンケート調査の為の項目抽出やそれに続くアンケートを実施し、その結果を整理して指標（SI）を設定している。これを AIS で取得されたデータを用いて大阪湾航行の船舶を対象に解析を行いその妥当性を示した。今後の応用についても言及しており、今後の海上交通の安全評価を具体的な数値として表す試みの意義は大きい。この研究成果は主に査読付学会論文２編、国際学会プロシーディング２編にまとめられ公表されている。

よって本論文は，学位論文に値するものと認める。