SAFETY ASSESSMENT MODEL OF COASTAL PASSENGER VESSEL IN THE PERSPECTIVE OF LIFE JACKET COMPATIBILITY

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To my beloved family, teachers and supporting group in UTM
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ABSTRACT

This research was conducted due to frequent occurrence of passenger vessel accidents related to the use of life jackets, which believed due to incompatibility between life jackets and passenger vessels. To address this problem, the research sets to develop a safety assessment model of coastal passenger vessel (CPV) in the perspective of life jacket’s compatibility, which is known as Life Jacket Compatibility Index (LCI) model. The main purpose of LCI model is to evaluate the life jacket’s compatibility with CPV. The LCI model was developed based on a combination of variables from four previous safety models. Compatibility was introduced as a new variable in the present model. The development of the LCI model started by mapping the variables from both life jacket model and passenger vessel safety combined model. Variables were selected based on the research criteria and used to develop the Life Jacket Compatibility Index (LCI) model. The LCI model was transformed into LCI Static and LCI Dynamic algorithms that are based on Fault Tree analysis approach. The LCI Static assesses the life jacket’s compatibility with CPV which is under the approved plan and number of passengers, while the LCI Dynamic assesses the same compatibility during CPV is in the operational mode. The LCI model’s accuracy was verified by using regression method and the results were further validated by case studies and sensitivity analyses. Results from LCI Static showed that the open-deck CPV Explorer 320 equipped with inherently buoyant life jackets has better compatibility (2.79) than closed-deck CPV Dutangkor 3 and Bahagia No. 1 (1.79 and 1.84 respectively). The LCI model was used to improve the safety performance of Bahagia No. 1. It was found that LCI Dynamic of the vessel can be improved by 3.4% when the number of passengers was reduced from 57 to 55. In conclusion, the newly developed LCI model is significant to assess and improve the safety of CPV.
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<tr>
<td>BSS</td>
<td>Boating Safety Scale</td>
</tr>
<tr>
<td>C</td>
<td>Comply</td>
</tr>
<tr>
<td>CATI</td>
<td>Computer Assisted Telephone Interviewing System</td>
</tr>
<tr>
<td>CLIA</td>
<td>Cruise Lines International Association, Inc.</td>
</tr>
<tr>
<td>FAA</td>
<td>Federal Administration of Aviation</td>
</tr>
<tr>
<td>FSA</td>
<td>Formal Safety Assessment</td>
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<tr>
<td>GA</td>
<td>General Arrangement</td>
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<tr>
<td>HELP</td>
<td>Heat Escape Lessening Position</td>
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<tr>
<td>IMO</td>
<td>International Maritime Organization</td>
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<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>LCI</td>
<td>Life Jacket Compatibility Index</td>
</tr>
<tr>
<td>LOA</td>
<td>Length Overall</td>
</tr>
<tr>
<td>LSA</td>
<td>International Life Saving Appliances Code</td>
</tr>
<tr>
<td>LSI</td>
<td>Life Saving Index</td>
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<tr>
<td>LWL</td>
<td>Waterline Length</td>
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<tr>
<td>MAIB</td>
<td>Marine Accident Investigation Branch</td>
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<tr>
<td>MCA</td>
<td>Marine and Coast Guard Agency UK</td>
</tr>
<tr>
<td>MSC</td>
<td>Maritime Safety Committee</td>
</tr>
<tr>
<td>MV</td>
<td>Motor Vessel</td>
</tr>
<tr>
<td>NC</td>
<td>Not Comply</td>
</tr>
<tr>
<td>NTSB</td>
<td>National Transport Safety Board</td>
</tr>
<tr>
<td>PFD</td>
<td>Personal Floatation Device</td>
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<tr>
<td>RBCM</td>
<td>Risk Based Compliance Assessment Model</td>
</tr>
<tr>
<td>RRN</td>
<td>Risk Ranking Number</td>
</tr>
<tr>
<td>SOLAS</td>
<td>International Convention on the Safety of Life at Sea 1974</td>
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<tr>
<td>SEE</td>
<td>Standard Error of Estimate</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package for Social Science</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>TMI</td>
<td>Turning Moment Index</td>
</tr>
<tr>
<td>TSB</td>
<td>Transportation Safety Board of Canada</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>USCG</td>
<td>United States Coast Guard</td>
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## LIST OF SYMBOLS

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<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>Iₑ</td>
<td>Physical Effectiveness; the probability the PFD maintains the wearer in a position which permits continuous breathing.</td>
</tr>
<tr>
<td>Iᵣ</td>
<td>Reliability; the probability that the PFD performs as designed.</td>
</tr>
<tr>
<td>Iₜ</td>
<td>Wearability; the probability that PFD is worn by the victim when he enters the water in a marine accident.</td>
</tr>
<tr>
<td>Iₜ</td>
<td>The probability that PFD is worn immediately prior to entering the water in an accident.</td>
</tr>
<tr>
<td>Iₜ</td>
<td>The probability that the PFD is accessible to a boater but not worn initially upon entering the water in an accident (accessibility index)</td>
</tr>
<tr>
<td>Pₚ</td>
<td>The probability that the accident victim dons the PFD in the water</td>
</tr>
<tr>
<td>Pₚ</td>
<td>The probability that the accident victim holds or lies upon the PFD in the water</td>
</tr>
<tr>
<td>Eₜ</td>
<td>The probability that the PFD maintains or turns the wearer in the water to a position with a minimum required freeboard to the lower respiratory passage within a specified time limit (effectiveness when worn)</td>
</tr>
<tr>
<td>Eₜ</td>
<td>The probability that the PFD provides minimum required freeboard to the lower respiratory passage for a relaxed person holding or lying upon the device in the water (effectiveness when held)</td>
</tr>
<tr>
<td>R</td>
<td>The probability that a PFD will operate successfully for a specified period of time and under specified conditions when used in the manner and for the purpose intended (reliability).</td>
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<tr>
<td>Iₐₙ</td>
<td>Index of Accessibility</td>
</tr>
<tr>
<td>Fₐₘₐₓ</td>
<td>the greatest possible unadjusted accessibility factor score = 3.41</td>
</tr>
<tr>
<td>Fₐₘᵢₙ</td>
<td>the smallest possible unadjusted accessibility factor score = -6.51</td>
</tr>
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$F_{AO}$ - the adjusted accessibility factor score taken as the zero point for $I_{AC}$

$NV5$ - Proportion of Time Candidate PFD was Kept Accessible or Worn

$V70$ - PFD worn by you + worn by another person (hour)

$V71$ - PFD kept in open place (hour)

$V73$ - Duration of outing (hour)

$E_{WB}$ - The probability that the PFD turns the unconscious/relax wearer to a position with adequate freeboard.

$E_F$ - The proportion of dummies tested representing females on which the PFD performed satisfactorily.

$P_F$ - The proportion of the recreational boating accident population which is female. $E_M$ and $P_M$ are defined comparably for males.

$I_A$ - Accessibility Compatibility Index

$I_{SI}$ - Safety Instruction Compatibility Index

$I_{SC}$ - Space Compatibility Index

$I_{AC}$ - Accessibility Compatibility Index

$T_{AC}$ - Duration of LJ kept accessible (hour)

$T_D$ - Duration of LJ donned by passenger (hour)

$T_j$ - Duration of journey (hour)

$t_{ace}$ - time of life jacket end accessible

$t_{acs}$ - time of life jacket start accessible

$t_{de}$ - time of life jackets taken off by passengers

$t_{ds}$ - time life jackets don by passengers

$t_{je}$ - time of journey end

$t_{js}$ - time of journey start

$I_{SI}$ - Safety Instruction Compatibility Index

$S_{Bo}$ - Safety Briefing Observed

$S_{Br}$ - Safety Briefing Required

$S_{Bo}$ - Safety Briefing Observed

$I_{Ao}$ - Information on Emergency Alarm/Notification Observed

$I_{Xo}$ - Information on Location of Emergency Exit Observed

$I_{Lo}$ - Information on Location of Life Jacket Observed
$I_{JDo}$ - Information on Life Jacket Donning Demonstration/Instruction Observed

$I_{Eo}$ - Information on Location of Assembly Area or Embarkation Area Observed

$I_{Po}$ - Information on Location of Safety Placards/Instructional Poster for Life Jacket Observed

$I_{JWo}$ - Information on When To Don Life Jacket Observed

$A_i$ - Availability of each element

$F_i$ - Effectiveness of each element

$s_j$ - score of effectiveness of each element observed

$w_k$ - weightage of each element

$F_{i}'$ - denotes $F_i$ in fuzzy form.

$S_{Br}$ - Safety Briefing required

$I_{Ar}$ - Information on emergency alarm/notification required

$I_{Xr}$ - Information on location of emergency exit required

$I_{lr}$ - Information on location of life jacket required

$I_{JDr}$ - Information on life jacket donning demonstration/instruction required

$I_{Er}$ - Information on location of assembly area or embarkation area required

$I_{Pr}$ - Information on location of safety placards/instructional poster for life jacket required

$I_{JWr}$ - Information on when to don life jackets required

$I_{SCS}$ - Space Compatibility Index Static

$S_A$ - Space available to don

$S_{D_S}$ - Space required to don static

$A_s$ - Area for each space

$C_s$ - Possibility to don life jackets according to compatibility between type of space and type of life jacket

$J_{BF_e}$ - Inherently buoyant type life jacket not compatible to don in fully enclosed space

$J_{BP_e}$ - Inherently buoyant type life jacket not compatible to don in semi-
enclosed space

\( J_{bo} \) - Inherently buoyant type life jacket compatible to don in open space

\( J_{ife} \) - Inflatable type life jacket compatible to don in an enclosed space

\( J_{ipe} \) - Inflatable type life jacket compatible to don in semi-enclosed space

\( J_{io} \) - Inflatable type life jacket compatible to don in open space

\( J_{cfe} \) - Combination of Inflatable and Inherently Buoyant life jacket in fully enclosed space

\( J_{cpe} \) - Combination of Inflatable and Inherently Buoyant life jacket in partially enclosed space

\( J_{co} \) - Combination of Inflatable and Inherently Buoyant life jacket in open space

\( N_i \) - Number of inflatable life jacket

\( N_b \) - Number of inherently buoyant life jacket

\( H_2 \) - The inherently buoyant life jacket is not compatible with fully enclosed space of coastal passenger vessel

\( H_3 \) - The inherently buoyant life jacket is compatible with open space of coastal passenger vessel

\( H_4 \) - Inflatable life jacket is compatible with fully enclosed space of coastal passenger vessel

\( H_5 \) - Inflatable life jacket is compatible with open space of coastal passenger vessel

\( H_6 \) - The inherently buoyant life jacket is not compatible with partially-enclosed space of coastal passenger vessel

\( H_7 \) - Inflatable life jacket is compatible with partially-enclosed space of coastal passenger vessel

\( S_{DS} \) - Space required to don static

\( A_D \) - Area required to don one life jacket

\( N_P \) - Approved maximum number of passengers

\( LCI_D \) - Life jacket Compatibility Index Dynamic

\( I_{AC} \) - Accessibility Index

\( I_{SI} \) - Safety Instruction Index

\( I_{SCD} \) - Space Compatibility Index Dynamic

\( I_{SCD} \) - Space Compatibility Index Dynamic
\begin{itemize}
\item $S_A$ - Space available to don
\item $S_{DD}$ - Space required to don dynamic
\item $S_{DD}$ - Space required to don dynamic
\item $A_d$ - Area required to don one life jacket
\item $N_{pi}$ - Number of passenger dynamic
\end{itemize}
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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter highlights the necessity of research on the development of the safety assessment model of coastal passenger vessel in the perspective of compatibility of life jackets with coastal passenger vessels. The problem statement and the research objective have been stated. The scope of the study and the significance of the research have also been itemized to show the research boundary and its strength and contribution respectively.

1.2 Background of Study

The safety of passenger vessels has been addressed by the establishment of the relevant national and international regulations since the aftermath of the RMS Titanic accident in 1912. One of the most important international safety regulations is the International Convention on the Safety of Life at Sea (SOLAS), 1974. Through the convention, continuous improvement on safety is introduced to passenger vessels in the aspect of design of passenger vessels, life-saving appliances, carriage of safety equipment and safety management system (IMO, 2009b).
Besides the introduction of safety regulations to improve the safety of passenger vessels, another way to improve the safety of passenger vessels is through the application of the assessment models. The examples of such models are Formal Safety Assessment for Cruise Ship introduced by Lois, et al. (2004), Boating Safety Scale introduced by Virk and Pikora (2011) and Crucial Safety Assessment Criteria for Passenger Ferry Services introduced by Lu and Tseng (2012).

One of the important safety aspects of passenger vessels is the carriage of life-saving appliances that contribute directly to the safety of passengers. The examples of the personal life-saving appliances are life jackets, life buoys, and immersion suits. Among the aforementioned, life jackets is the most important and carried for every person on board. The research on standards of life jackets has been initiated since 1950s until the present day (Ayub and Nejaim, 2003; Doll et al., 1978b; Funkhouser and Fairlie, 1991; Gabb et al., 1965; Hart, 1988; Herrmann, 1989; Lockhart et al., 2005; Macdonald et al., 2011; Macesker and Gareau, 1997; Macesker and White, 1992; Macintosh and Pask, 1957; Pask and Christie, 1962; Pask, 1961). The current enforced international standards for life jacket are International Life Saving Appliance Code under SOLAS 1974 and International Standard ISO 12402 (IMO, 1998, 2005, 2010; ISO, 2005). Similar with the passenger vessels, the improvement on safety of life jackets is through the introduction on assessment models. Examples of such research are Life-Saving Index model by Doll et al. (1978a, 1978b, 1978c) and Risk-Based Compliance Assessment Model by Ayub and Nejaim (2003).

Despite the continuous improvement on standards and the introduction of assessment models of passenger vessels and life jackets, accidents associated with the use of life jackets on board passenger vessels persist, although the number of cases is not significant. The examples of the two accidents highlighted in the following paragraph described the use of the inherently buoyant life jackets (fixed foam life jackets) in the enclosed space.

The first accident occurred in the year 1991 in Portsmouth, UK that caused loss of life of a nine year old female pupil that was wearing an inherently buoyant life jacket (MAIB, 2001). Upon capsizes, the pupil seated in the middle of the boat...
was trapped under the up-turned boat. Her escape impeded by the buoyancy force of life jacket that pushed her towards the surface. Her chances of survival would be higher if she trapped in an air pocket under the up-turned boat. Her situation worsened by the further submerged of the up-turned boat due to the weight of some of the pupils that sat on top of the boat and some clung to the side.

The second accident occurred in 2007 in Scotland, UK that had caused loss of life of a 15-year-old female cadet who was using an inflatable life jacket (MAIB, 2008). Initially upon capsized, four cadets was under the up-turned boat. Three cadets who were not inflating their life jacket managed to swim-out. However, the fourth cadet who inflated her inflatable life jacket was unable to swim-out from the up-turned boat due to the buoyancy force of her life jacket that forced her towards the surface. Her chances of survival would be higher like the three cadets who survived, if she did not inflate her life jacket.

1.3 Problem Statement

This study considered the examples of accidents stated in section 1.2 caused by compatibility issue between the life jackets and passenger vessels (Groff and Ghadiali, 2003). Furthermore, Doll et al. (1978) and Groff and Ghadiali (2003) suggested life jackets should be compatible with the user activity. With respect to the records of accidents and suggestion, the existing assessment models of passenger vessel do not address the issue of safety with respect to compatibility of life jackets with passenger vessels (Lois et al., 2004; Lu and Tseng, 2012; Virk and Pikora, 2011). Instead, the existing models only emphasize on the availability and carriage of life jackets without looking into the aspect of suitability and support for life jackets to don and operate by passengers on board the passenger vessels.
1.4 Objective

With respect to the accidents associated with the usage of life jackets, this study would address the issue by developing a safety assessment model for the coastal passenger vessels in the perspective of compatibility of life jackets with the coastal passenger vessels as the main research objective. The development of the new model is based on a combination of the assessment models of life jackets with assessment models of the passenger vessels. The new model would be able to rate the compatibility of life jackets with coastal passenger.

The goal can be achieved by meeting the following objectives:

i. To develop a conceptual model to assess the compatibility of life jacket with passenger vessel by using variables in the previous models of life jackets and passenger vessels.

ii. To develop algorithm to assess compatibility of life jacket with coastal passenger vessel.

iii. To determine the algorithm is accurate and robust for application.

1.5 Scope of Study

The research limits its scope in the respective areas:

i. Coastal passenger vessels involved in single or multiple leg voyages in the coastal area (within 12nm or 21.6km from the nearest coast) and not equipped with cabin facility for passengers to stay overnight and must comply with the national regulations.

ii. Types of life jackets used this study are inherently buoyant (solid foam) and inflatable type, which comply with the national or international standard and available on board CPV in the required quantity.

iii. Survey to verify the new variable is carried out among Marine Officers of Marine Department Malaysia, which is the leading regulatory body in Malaysia with respect to maritime safety and shipping in Malaysia.
iv. The current model is developed based on a combination of variables from existing models of life jacket and models of passenger vessel which combines by compatibility as the new variable.
v. The variables selected to develop the new model should be able to produce result by on site evaluation without the additional requirement to conduct laboratory tests.
vi. The algorithm for the current model is developed by Fault Tree Analysis and Boolean Logic gate.

vii. Validation of the current functional test and one-at-a-time sensitivity analysis.

1.6 Significance of Study

The significances of this research are as follows:
Contribution to the knowledge of the new model is the assessment of coastal passenger vessel in a new perspective and would complement the existing assessment models.
The new model would serve as an enforcement tool for maritime authority to regulate the safety operation of the commercial coastal passenger vessels.
The new model would serve as a tool for plan approval of coastal passenger vessel for maritime authority, which determines the maximum capacity of passengers in a new way or perspective.
The new model is a new contribution to the field of maritime safety.
The new model would improve the safety of lives at sea.
1.7 Theoretical Framework

The development of the new model is based on the combination of two types of safety assessment models, namely safety assessment model for life jackets and assessment model for passenger vessels, and using compatibility variable to combine these two types of models. The assessment models for life jackets are Life Saving Index (LSI) model developed by Doll et al. (1978b) and Risk-Based Compliance for Personal Floatation Device (Risk-Comp PFDs) developed by Ayub and Nejaim (2003). While the assessment models for the passenger vessels are Formal Safety Assessment (FSA) for Cruise Ship developed by Lois et al. (2004), Crucial Safety Assessment Criteria for Passenger Ferry Services by Lu and Tseng (2012) and Boating Safety Scale by Virk and Pikora (2011). The combination of the two types of the model is to develop a new model to assess the safety of coastal passenger vessels, in the perspective of compatibility of life jackets to access, don and operation in the coastal passenger vessel.

1.8 The Organisation of the Thesis

This thesis is divided into six chapters, namely Introduction as Chapter 1, Literature Review as Chapter 2, Research Methodology as Chapter 3, Results as Chapter 4, Discussion as Chapter 5 and Conclusion as chapter 6. This is followed by References and Appendices.

This thesis divided of six main chapters where each chapter will focus on the topics as follows:

Chapter 1 is an introduction to the research where it describes briefly the background of the research, the problem statement, the research objective and the significance of the research.

Chapter 2 of the report contains a literature review for the purpose of understanding the topic of the research in detail. This chapter contains related literature on life
jackets, passenger vessels, safety assessment models of life jackets, safety assessment models of passenger vessels, compatibility, accidents associated with life jackets and fuzzy.

Chapter 3 describes the methodology adopted for the research such as the mapping of variables, statistics, Fault Tree analysis, Boolean logic gate, Triangular Fuzzy Number, and One-At-a-Time Sensitivity Analysis.

Chapter 4 shows the results of the research, namely model of Life Jacket Compatibility Index Static, Life Jacket Compatibility Index Dynamic, algorithm of Life Jacket Compatibility Index Static, algorithm of Life Jacket Compatibility Index Dynamic, results of verification and results of validation.

Chapter 5 discusses the results of chapter 4 in detail. The discussions focused on the achievement of the research objectives, the comparison of the current model with the existing models and the contribution of the current model in the field of maritime safety.

Chapter 6, which is the final chapter, presents the overall conclusion and recommendations for future research. This chapter highlights the findings and the contribution of the current research.

1.9 Summary

This chapter serves an introduction to this research, which mainly explains the background of the research, the problem statement, objectives of the research, scope of study, theoretical framework, and organisation of the whole thesis.
REFERENCES


Prevention, 43(3), 1049–55.


CLIA. (2012). Operational Safety Review Executive Summary. CLIA.


Canada. Toronto.


