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Navigational Safety Model In Port Operation

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ABSTRACT

Navigational safety is an essential and very important element within an effective port and its operations. Relevant literature states that studies and researches on the service attributes of ports for ship navigation safety should be done as it enhances the ships passing through the narrow, shallow and busy waterways. In this study, a fuzzy Analytic Hierarchy Process (*AHP*) model is proposed to identify the perspectives of shipmasters on the service attributes of ports for ship navigation. Initially, those attributes will be investigated based on relevant literature and the features of ship navigation in ports. The quality of process in the fuzzy *AHP* model will be improved by the implementation of six sigma method. Causes of defects (errors) will be identified and removed. The variability analytical processes will be minimized. Dissatisfaction Attitude (*DA*) index will be used to determine the attributes' priorities, where the port authorities may invest new policies to improve ship navigation safety. The result is expected to construct number of port service attributes for ship navigation safety. Besides that, the theoretical and managerial implications of the findings for port authorities in improving ship navigation safety are discussed.

KEY WORDS: *Dissatisfaction Attitude (DA), Fuzzy AHP model, Service attributes, Ship navigation safety, Six sigma method.*

NOMENCLATURE

AHP	Analytic Hierarchy Process
DA	Dissatisfaction Attitude
SA	Service Attributes
C.I	Consistency Index
VTC	Vessel Traffic Centre
IMO	International Maritime Organization

1.0 INTRODUCTION

Ship navigation safety is a significant intangible index in terms of port competitiveness. It ensures a strong profitability against port competitions for shipping and port operators. Ships in world, aren't only becoming faster and larger, but also rapidly increasing in quantity. A growing number of vessels will lead to increasing maritime accidents. Generally marine causalities occur near ports most frequently [1]. Common accidents include collisions, running on a reef, and grounding. In practice, when a ship is navigating into those areas, there is more vessel traffic and less space, leading to marine casualties occurring more often.

Hence, the problem that occurs in safe ship navigation in ports should be studied and preventive measures should be taken. Previous studies on this issue focuses more on the internal human factor[2][3], neglecting the external environment of the vessel. Hence, it is essential and significant to conduct a case study on the service attributes of ports for ship navigation safety. This research work proposes a navigational safety model, a fuzzy *AHP* model in port operations which focusses on external environment that contributes to marine casualities.

Fuzzy logic proposed in this research paper is a form of many-valued logic that deals with approximate reasoning instead of fixed and exact. Relevant studies shows that a safety model constructed using fuzzy logic approach by employing fuzzy specified rules can model the qualitatve aspect of human knowledge and reasoning processes without employing precise quantitative analyses[4].

Meanwhile, the analytic hierarchy process (*AHP*) is a structured technique for organizing and analyzing complex decisions. Users of *AHP*, firstly, decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently. And, in

the final step of the process, numerical priorities are calculated for each of the decision alternatives. Thus, the fuzzy *AHP* model proposed in this paper is expected to study the navigational safety in ports.

Initially, the factors contributing to a two-layer hierarchical structure of service attributes (*SAs*) of ports for ship navigation safety will be identified. Next a fuzzy *AHP* model based on two layer hierarchical structure of SAs will be constructed to identify those *SAs* from the shipmasters' perceptions. Besides that, this research paper is aimed to propose a method to improve the quality of process in the conventional fuzzy *AHP* model, for better outputs. This research paper was also design to determine the *SAs* priority based on the outputs, for the port authority to make improvement policies for ship navigation safety.

2.0 METHODOLOGY

2.1 Research Framework

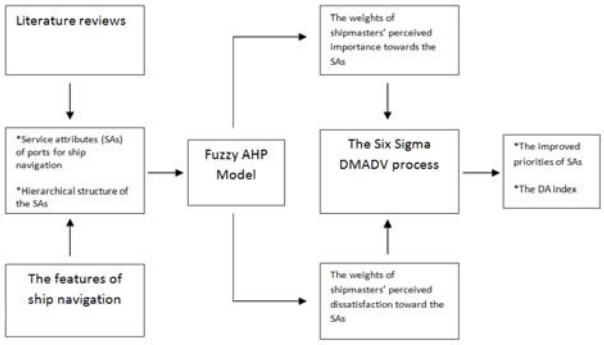

Figure 1: Processes involved in research framework

Figure 1 shows the research framework proposed in this study. The port's Service Attributes (*SAs*) and their hierarchical structure for ship navigation safety will be investigated first accordingly to features of ship navigation and relevant literature.

2.2 Measurement of Service Attributes (*SA*)

2.2.1 Definitions of *SA*

Initially, the selected ports' *SAs* for ship navigation safety will be constructed aided by relevant literature and features of the ship navigation. The constructed *SAs* will be confirmed and revised from the consultation of senior staffs from *VTC* department of Singapore straights and practical shipmasters with navigation experience at Singapore ports/terminals. The five dimensions of *SAs* are expected to be created and defined as per following:

i. *VTC* Services
ii. Navigation aids
iii. Marine pilots
iv. Fairway traffic
v. Ship berthing

The listed definitions will be used to construct a two-layer hierarchical structure of *SAs*, where the first layer consists of (4-8) *SA* constructs and second layer made of (15 – 20) SAs constructs.

2.2.2 Questionnaire Design

As the next step of this research paper, an *AHP* questionnaire [5] with a nine point rating scale will be designed. It will be used to measure and study the perceptions of navigators on the relative 'importance' and also 'dissatisfaction' by being related to each *SA* respectively.

The designed *AHP* questionnaire is expected to consist approximately 4 – 8 criteria and 15 – 20 sub-criteria. The scale will be validated by a pre-test conducted by two shipmasters with navigation experience at Singapore port/terminals. This will ensure the clarity of the statements and also to notice the important questions that might be listed out.

2.3 Research Sample

The shipmasters berthing theirs ships at Singapore port/terminals will be surveyed since this research paper focuses on the service operations of Singapore ports/terminals for ship navigation as an empirical study to validate the proposed research model. The subjects will qualified on several criteria such as the respondents must be shipmasters and respondents whom had sufficient navigation experiences at Singapore port/terminals. This scope for number of respondents is 30.

Consistency Index (*C.I*) will be computed to test the consistency of each respondent's pairwise comparison matrix. Besides that, the profiles of each respondent's characteristics will be recorded accordingly and respectively.

2.4 The Weights of Service Attributes (*SAs*)

2.4.1 Consistency Tests

This research paper consists of 30 subjects as sample set. Thus, 30 pairwise comparison matrices will be obtained for each comparison of *SAs* in each layer. Each pairwise comparison matrices will be different and the numeric rations from comparing the two SAs for the 30 subjects are expected to be uncertain.

A problem may arise on the integration process of 30 pairwise comparison matrices into one. Thus, in such uncertain scenario, a fuzzy *AHP* model will be used to integrate the 30 pairwise comparison matrices into a fuzzy positive reciprocal matrix. The output, fuzzy positive reciprocal matrixes will be used to identify which *SAs* fit into first layer and which *SAs* goes into second layer. Consistency tests will be carried out aided by the fuzzy reciprocal matrices. The weights of the *SAs* will be determined, where the respondents perceived 'importance' and 'dissatisfaction' weights are included.

2.4.2 The Consistency Test

The consistency of fuzzy positive reciprocal matrix should be tested before calculating the weights of the *SAs* in the first and the second layers. Problems may arise since the entries within the positive reciprocal matrix are fuzzy numbers. Thus, the consistency of the fuzzy positive reciprocal matrix cannot be tested directly as done in *AHP*.

The present paper adopted Buckley's (1985) [7] method to defuzzify the fuzzy positive reciprocal matrix. It is compulsory to defuzzify the fuzzy numbers which then converts the fuzzy positove reciprocal matrix into a crisp matrix. This conversion enables the consistency test to be taken for the crisp matrix in the same way as *AHP*.

2.4.3 The Local Weights of *SAs*

The local weights of the *SAs* can be determined from the eigen vectors of Ã. Based on the special structure of the positive reciprocal matrix, Saaty (1980)[5] suggested four solution methods to find the eigenvectors: Average of Normalized Columns (ANC), Normalization of the Row Average (NRA), Normalization of the Reciprocal of Columns Sum (NRCS), and Normalization of the Geometric Mean of the Rows (MGM). This paper adopted the MGM method since it was applied very popularly in previous studies.

2.4.4 The Global Wight of *SAs*

From all the steps explained and shown in detail part of this research paper, we can find all the local weights of the *SAs*. The global weight of the *SAs* can be found by multiplying their low level of local weights by their corresponding high level of global weights.

2.5 The Priorities of *SAs*

A *SA* with higher degrees of importance and dissatisfaction should be improved with higher priority. Obeying the concept, a Dissatisfaction Attitude (*DA*) index was proposed to determine the priorities [9].

3.0 ANTICIPATED RESULTS AND DISCUSSIONS

3.1 Anticipated Results

In general, the outcome of this research is expects the subjects (shipmasters) to emphasis more on the Marine Pilot and *VTC* constructs for port services. Besides that, The SAs will be determined in terms of degree of importance throughout the analysis of result. The result is expected to identify the operator's professional literacy as the main determinant of the ship navigation safety. Thus, it would validate the previous relevant studies, where human factor is stated as an important determinant of vessel accidents in container shipping context [2].

Hence, improvement of operator's capabilities should be considered as significant issue for port authorities. In general, the main operators in a port's service operations in ship navigation include *VTC* regulators, marine pilots and tugboat drivers.

3.2 Discussions

Main operators in a port's service operations for ship navigation will be often considered as main key factor in avoiding marine collisions or accidents. Thus it is advised that to enhance some capabilities and work attitudes for those operator in several terms.

The response capability of operators for emergencies should be enhanced since most vessel accidents occur at an instant. Thus, it is proposed to improve response capability by regular trainings and also by enhancing operator's language ability.

Besides that, the mental and physical condition of operators is also considered as a significant enhancement of capabilities and work attitudes for those operators. Relevant literatures show that human fatigue contributes to marine collisions [10].

Thus, this paper suggests that operators should practice themselves to be flexible with working hours and pose a high discipline to maintain a good physical and mental condition for work. Or, introducing a shift system and providing sufficient man power for each shift is also an effective measure to overcome consequences of operator fatigue.

The communication within different department operators should be upgraded and polished since a safe navigation from the entrance of the port to the wharfs requires the cooperation of various operators. Additionally, the communication skills of *VTC* regulators should be enhanced in terms of wording. A communication with inappropriate terms/wordings might risk the drivers of piloted vessels, which is considered as a dangerous piloting operation.

The communication in between marine pilots and captains also takes a lead as a factor that should be improved. A communication gap seems to occur when a piloted vessel is being picked up late by the marine pilot. This delay should be used by both marine pilot and captain to exchange information on the fairway, berthing plan and vessel performance. The communication gap should be used in a beneficial way.

As a last suggestion, the service attitude of operators shall be enhanced too. Accomplishment of vessel operations in a port such as navigating, loading and unloading cargoes. Thus, the port operators must have an outstanding service attitude in piloting the ship as stated in the *IMO* Resolution (2003) and the Pilotage Law (Article 32).

4.0 CONCLUSION

This study was designed to explore the service attributes of a port for ship navigation safety. In this proposal, a fuzzy *AHP* model with improvement aided by the six sigma method and Dissatisfaction Attitude (*DA*) index were implemented to identify the attributes from the shipmasters' perspective, where the port authorities can make new policies to improve their service quality. Frequent marine disasters in a port and its vicinity is often studied and analyzed from the internal human factors of ship.

Studies investigating the external environment determinants of ship navigation are less. Thus, the service attributes for port operators that are identified through this paper are able to provide valuable references for further research on ship navigation safety in ports. This proposal was validated by implementing the proposed model on the navigation services of Singapore ports/terminals.

Results obtained showed that the professional literacy of the operators is the main determinant of ship navigation safety. In practice, the main operators of a port include *VTC* regulators, maritime pilots, and turbot drivers. Thus, those operators' personal capabilities should be enhanced in several criteria such as professional skills, communication abilities, and work attitudes.

Besides that, for Singapore ports/terminals, currently, the traffic control of the fairway should be improved for ship navigation. The results may provide practical information for Kaohsiung port and the other port authorities to make policies in improving ship navigation safety.

5.0 RECOMMENDATION

Further research on this research topic may incorporate the vessel's seaworthiness factor into the proposed model. The vessel's seaworthiness may affect their navigation safety in terms of steering gear performance, communication equipment and crews' capabilities which are neglected in this paper.

In practice, for the determinants of ship navigation safety in ports, in addition to the navigating services of ports, the vessel's seaworthiness may also affect their navigation safety, such as the performance of steering gear, communication equipment, and the crew's capabilities. However, in this paper, those determinants are not considered. Thus, further research may incorporate those factors into our model.

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