# FACE VALIDATION METHOD ALTERNATIVES FOR SHIPHANDLING FUZZY LOGIC DIFFICULTY MODEL

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**Abstract**

The development of shiphandling difficulty model for ferry is based on the empirical experience through the Master of Ro-Ro ferries. The SHDMF is consisted from two parts which are the Analytic Hierarchy Process (AHP) and Fuzzy Inference System. Both parts had been validated through internal validation in the form of consistency test for the first part and robustness test for the second part. Further, the external/face validation is required to compare the proposed model with similar model through benchmarking approach. The benchmarking approaches are elaborated for the reliability, validity, possibility, efficiency and effectiveness. Through fuzzy group decision making method, the questionnaire survey is performed to verify the most appropriate approach based on the shiphandling simulator as the most preferred benchmarking tool by experts. Next, the proposed scenario is overviewed and discussed especially related to the advantages and drawbacks of shiphandling simulator.

**Keywords**: shiphandling difficulty, fuzzy group decision making, internal validation

**Abstrak**

Model pengukuran kesulitan pengendalian feri didasarkan pada pengalaman empiris melalui pernyataan nahkoda kapal feri Ro-Ro. SHDMF terdiri atas dua bagian, yaitu Analytic Hierarchy Process dan Fuzzy Inference System. Kedua bagian ini telah divalidasi melalui validasi internal dalam bentuk uji konsistensi untuk bagian pertama dan uji kehandalan untuk bagian kedua. Selanjutnya validasi atau wajah eksternal diperlukan untuk membandingkan model yang diusulkan dengan model yang diperoleh dari *benchmarking*. Pendekatan *benchmarking* dijabarkan untuk kehandalan, validitas, kemungkinan, efisiensi, dan efektivitas. Melalui metode fuzzy kelompok pembuatan keputusan, survei kuesioner dilakukan untuk memverifikasi pendekatan yang paling tepat dengan simulator pengendalian kapal sebagai alat yang paling disukai oleh para ahli untuk *benchmarking*. Selanjutnya skenario yang ditinjau-ulang dan dibahas terutama terkait dengan keuntungan dan kelemahan simulator pengendalian kapal.

**Kata-kata kunci**: kesulitan pengendalian, fuzzy kelompok pembuatan keputusan, validasi internal

## INTRODUCTION

The shiphandling difficulty model for ferry (SHDMF) is designed based on the empirical study from expert knowledge and experiences (Chan et al., 2010). The complexity of shiphandling difficulty is handled through analytical hierarchy process (AHP) to simplify the problems and further the fuzzy logic is used to predict or to estimate the result of shiphandling difficulty on the parameters given. The SHDMF is required to be tested or validated with others available model. This step is known as the external validation or face validation. The external/face validation is a process to validate the developed model with real world where the model will be applied. Therefore, it is necessary to perform the external/face validation.

The external/face validation in certain situation is difficult to be attained because the construction of new developed model is designed with additional variables/parameters. It sometimes raises the question on what validation approach should be considered since the similar model may not suitable for the new developed model.  This situation is also occured with the developed SHDMF model which the similar model is justified non suitable for the external/face validation. Based on this assumption, the benchmarking is one of alternatives for validating the SHDMF model. The benchmarking approach alternatives also need to be justified for the reliability, validity, possibility, efficiency and effectiveness level. This paper elaborates how the benchmarking approach alternatives are proposed and how the most approprite approach is decided to be used for validating the SHDMF model. The paper also presents the designed plan for the next step of the external/face validation through the development of scenarios. The paper is arranged from the references review of related topic, the overview of method, the discussion on the result, the proposed plan for the external/face validation and the conclusion.

The SHDMF consists of two parts. The first part is an AHP part which consists of 20 sub variables and these sub variables are grouped into four variables which are ship condition (A), shiphandling facility condition (B), navigation condition (C) and weather condition (D). For instance, ship condition (A) consists of sub variables of ship tonnage (A1), ship draft (A2), ship type (A3), the age of ship (A4), bridge location (A5) and ship trim (A6).  At the AHP part, the validity test refers to the consistency test. The comparison consistency is justified consistent if the consistency ratio is less than 0.1. Based on this definition, the consistency test for the model has been carried out and concluded that the comparison among variables and sub variables is consistent since all consistency test result were less than 0.1.

The outputs of this first part (AHP part) are used as an input of second part, fuzzy logic part. The procedure of fuzzy inference system (FIS) is begun with the development of membership function (μ), the development application of implication function, the development of rule composition and defuzzification. The method of Mamdani (Max-Min) is used on this model. The method Mamdami is used because of several advantages such as intuitive, wide accepted and suitable by human input. The validity of FIS is performed through two steps. The first step had concerned on the rule development and the second step had related to the algorithm test through robustness test. The first step, the validity of rule development is conducted through expert validation. First, the author proposed the rule development to the experts. Then, the comparison between the proposed rule development and experts rule judgment was taken and the final rule development was formed. The second step, algorithm test through robustness test was made by simulation. The inputs of model was made through dummy scenario and the model was run. The result then logically checked for the intended input. The detail construction of SHDMF is illustrated at Figure 1.

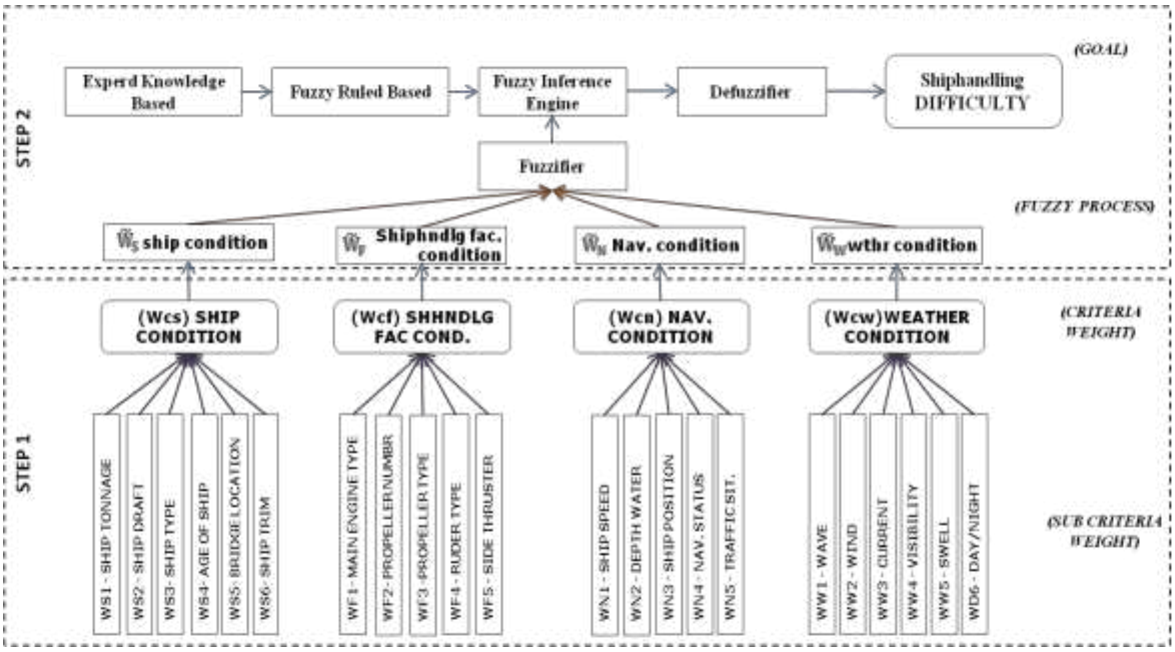


**Figure 1** Shiphandling Difficulty Model for Ferry Framework

The overall test mentioned above is categorised as internal validation, therefore it may still need to perform the external/face validation. The external/face validation is the step of comparison between real word and the output of SHDMF model. the author considers benchmarking between SHDMF model and other related methods to the shiphandling difficulty need to be carried out. Some options of benchmarking approach alternatives based on the non rigorous literature review is identified as comparison result with such as: full mission shiphandling simulator, partial/multi task shiphandling simulator, questionairre to the Ro-Ro ferry Master, direct observation during the operation of Ro-Ro ferry, focus group discussion and DELPHI.

The benchmarking approach alternatives in brief are elaborated in this sub section. A full mission shiphandling simulator has a capability of simulating a fully shipboard bridge operation situation. The capability of such simulator includes the advanced maneuvering in restricted waterways. A part from the function capability, the visual system presents the outside world by a view around the horizon between (240-360) degrees.

Partial task/multi task simulator has capability of simulating a fully shipboard bridge operation situation, however with the limitation on the advanced maneuvering in restricted waterways. In addition, the visual system presents the outside world by a view of at least 120 degrees horizontal field of view and at least the horizon from 120 degrees port to 120 degrees starboard is able to be visualized by any method. The disadvantage of using simulator is generally coming into question that the simulator like a game and the environment is not real or in the other word, the fidelity of simulator is raised as the main consideration. Yet, the simulator has advantage on the dangerous simulation process related to the safety aspects where the real acts may not be gained in the real world (Farah et al., 2008).

Direct observation is a method of collecting required information by observing an activity through the important key of seeing and listening. Therefore, observation offers the chance to note activities, behavior and physical aspects without having to depend upon participants' willingness and ability to respond to questions. The users can be observed in the environment where the system is normally used. This is why direct observation is considered to have high face validity, also referred to as external validity. However, it must be always noticed for the possibility of the respondent may act better under observation because of the attention paid to them.

Questionnaire method is a written, online, or verbal tool for collecting data from individuals or groups that can be analyzed using qualitative and quantitative techniques. The consideration of this method is the efficiency time in collecting data where the number of participants are separated in distance because the situation of the activity. Yet, the validity of this method needs to be paid in attention if the external/face validation is required because the tight procedure need to be followed.

Focal Group Discussion (FGD) is an informal discussion among a group of selected individuals about a particular topic (Priadi et al., 2013). Generally, focus groups are group conversations, which can be smaller large. Focus groups are group discussions which are arranged to examine a specific set of topics or situation. The drawback of this method is generally the restriction to gather the experts into table since sometimes the distance and time are one of the reasons. The expertise level is also considered as the weaknesses because sometimes quite difficult to place the appropriate expert in the topic of discussion.

The Delphi method was conceived as a group technique whose aim was to obtain the most reliable consensus of opinion of a group of experts by means of a series of intensive questionnaires with controlled opinion feedback. The main attributes of DELPHI are its anonymity, iterative process, feedback process and consensus of group members via equal participation in outcomes (Landeta, 2006). Expert prediction has been suggested by many researchers for forecasting tasks. The consensus is one of the critical drawbacks on the DELPHI approach. A consensus defines the degree of agreement on the intended decision task. In most cases, uncertainty is considered to be the opposite of consensus (Rowe and Wright, 1999).

The decision of a group toward a certain topic is commonly formed from the consensus. The consensus itself is source of uncertainty since the final consensus may be formed from most similar judgment. For instance, an individual judgment which is extremely different with others experts' judgments may be omitted for the final consensus. The fuzzy principle used in group decision is one of approach to get the consensus as well as to reduce the uncertainty. The important point of this method is the linguistic part where the human is more aware with the word language than numeric language. The detail of fuzzy group decision method is explained in the next section.

## METHOD

This section consists of method used for choosing the best alternative of benchmarking approaches. It begins with the benchmarking questionnaire survey and the detail of fuzzy group decision making process.

The structured questionnaire survey is prepared for experts identified with the topic of benchmarking of SHDMF such as maritime academician, sea pilot, navigation officer and others related professional with maritime industry background. The questionnaire is constructed into three parts. The first part is designed for collecting information regarding appropriateness of benchmarking approach alternatives. The elements for judgments for each benchmarking alternative are the reliability, validity, possibility, efficiency, and effectiveness.

Reliability is related to the approaches that are consistently good in performance and are able to be believed. Validity is related to the level of acceptance of the approaches based on the quality of being logically. Possibility is related to the approaches that it can be done in a particular situation. Efficiency is related to the use of time in a good manner. It also means in common sense, the time required for conducting the approaches is a primary consideration. Effectiveness is related to the degree to which the approaches is successful in producing a desired result.

This fuzzy group decision approach consists of several dimension such fuzzy preference relation, fuzzy quantifier, fuzzy aggregation and fuzzy exploitation (Herrera, 2006). The result of this approach is subjective preference with “Most” quantifier. For instance, the “Most” value of each score can be considered as maximum score for related subjective preference score. The fuzzy preference relation used is linguistic preference as written in algorithm 1-5.

$$f(\tilde{A}_i, \tilde{A}_j) = \frac{\tilde{A}_i x \tilde{A}_i}{\tilde{A}_i x \tilde{A}_i + \tilde{A}_j x \tilde{A}_j} \tag{1}$$

$$f(\tilde{A}_i, \tilde{A}_j) == \left( \frac{u_i^2}{u_i^2 + u_j^2}, \frac{\alpha_i^2}{\alpha_i^2 + \alpha_j^2}, \frac{\beta_i^2}{\beta_i^2 + \beta_j^2} \right) \tag{2}$$

$$\tilde{A}_i = (u_i, \alpha_i, \beta_i) \tag{3}$$

$$\tilde{A}_j = (u_j, \alpha_j, \beta_j) \tag{4}$$

$$\mu_A[x] = \begin{cases} \frac{x-\alpha}{u-\alpha} & ; x \in [\alpha, u] \\ \frac{x-\beta}{u-\beta} & ; x \in [\alpha, u] \\ 0; & \text{others} \end{cases} \tag{5}$$

with:
ad ≤ ud ≤ b,a lower limit and b upper limit

$$p_{ij}^{k} = g\left(f(\tilde{A}_i, \tilde{A}_j)\right) = \frac{u_i^2}{u_i^2 + u_j^2} \quad (6)$$

The fuzzy quantifier (Q) “Most” is applied from Yager as presented in algorithm 7.

$$Q(r) = r^{1/2} \quad (7)$$

The fuzzy preference relation for kth expert is aggregated by Consistency Induced Ordered Weighted Averaging(C-IOWA), where consistency is defined as additive transitive as written in algorithm 8.

$$p^k = (p_{ij}^k): p_{ij}^k + p_{jl}^k + p_{li}^k = \frac{3}{2}; \forall_i\ , j, 1 \in \{1, \dots, n\} \quad (8)$$

The aggregation of fuzzy preference in group decision maker where the expert is homogen can be written in algorithm 9.

$$P_{ij}^{C} = \phi_Q^I\left(\langle 1 - CI^1, p_{ij}^1\rangle, \dots, \langle 1 - CI^m, p_{ij}^m\rangle\right) \quad (9)$$

For selecting the best alternative from e-th expert, it is suggested to use algorithm 10 and 11.

$$QGDD_i = \phi_Q\left(p_{ij}^c, j = 1, \dots, n, n, j \neq n\right) \quad (10)$$

or:

$$QGDD = \phi_Q^C\left(\langle \bar{p}_{i1}^c, p_{i1}^c\rangle, \dots, \langle \bar{p}_{im}^c, p_{im}^c\rangle\right) \quad (11)$$

The final output of fuzzy exploitation is the best alternative among alternatives given to a case.

## RESULT AND DISCUSSION

### The Benchmarking Questionnaire Survey Result

The result of benchmarking approach alternatives is presented in this section followed by the discussion and proposed plan for doing the external/face validation. The result of benchmarking alternatives method is begun with the respondent profile. The respondent average age is 48 years old. The number of respondents is 24 and they have various maritime professional experiences. 10 respondents have experience as maritime lecture followed by 6 respondents with simulator instructor experience, 7 respondents with simulator researcher experience, 18 respondents with master/deck officer experience and 11 respondents with sea pilot experience.

The next analyzed data is regarding the overall aggregation of benchmarking alternatives which is illustrated in Table 1. The result show that among 24 experts from various maritime professional background, the full mission simulator is the most alternatives chosen for conducting the external/face validation followed by direct observation on Ro-Ro ferries operation and partial/multi task shiphandling simulator. Based on this result, it is considered that the most appropriate method for benchmarking of shiphandling difficulty model for ferry (SHDMF) is by using shiphandling simulator whether full mission simulator or partial/multi task simulator as direct observation may result on longer time required and the possibility of simulated scenario may not be obtained.

**Table 1** The Result of Fuzzy Group Decision on Benchmarking Methods

| | Overall Comparison | | | | | |
|---|---|---|---|---|---|---|
| | Full mission shiphandling simulator | Partial task/cubical shiphandling simulator | Direct observation on Ro-Ro ferries operation | Questionnaire to the master of Ro-Ro ferries | Focal group discussion among experts | DELPHI approach |
| P_CIOWA | 0.0000 | 0.5324 | 0.5070 | 0.5634 | 0.5527 | 0.5370 |
| | 0.4676 | 0.0000 | 0.4819 | 0.5378 | 0.5224 | 0.5106 |
| | 0.4930 | 0.5181 | 0.0000 | 0.5622 | 0.5448 | 0.5293 |
| | 0.4366 | 0.4622 | 0.4378 | 0.0000 | 0.4736 | 0.4639 |
| | 0.4473 | 0.4776 | 0.4552 | 0.5091 | 0.0000 | 0.4888 |
| | 0.4630 | 0.4894 | 0.4707 | 0.5187 | 0. 4942 | 0.0000 |
| QGDD | 0.5002476 | 0.4719425 | 0.494503 | 0.4217531 | 0.4453655 | 0.4549479 |
| Rank | 1 | 3 | 2 | 6 | 5 | 4 |

### The Proposed Scenario Model

The procedure of experiment consists of several steps such as the assignment of respondent, the creation of scenario, the familiarization of shiphandling simulator, actual experiment and result analysis. The respondent of simulator was selected based on the level of experience and competency. Before the experiment is performed, the familiarization of using simulator was conducted based on the scenario which will be used. The familiarization consists of two parts. The first part, the explanation of bridge equipment and scenario overview are given. Secondly, they try all equipment and scenario until the end of scenario for twice. Then, the actual experiment is conducted and at the end the result is analyzed.

Scenario is arranged according to the input of SHDMF, so comparison result as a benchmark can be obtained. The scenarios consider variables as developed in the SHDMF. They consist of ship condition, shiphandling facility condition, navigation condition and weather condition. The experiment will use a shiphandling simulator TRANSAS NAVI Trainer 5000. This simulator has capability for performing shiphandling and navigation activity as well as for recording parameter during experiment. The experiment is performed on ferry passenger with 974 gross tonnages. The ferry has length 58.6 m, engine power 2x637 kW. Some restrictions of inputs are given such as the age of ship and the type of rudder which is not mentioned in the simulator.

## CONCLUSION

Having the result of this research, the benchmarking alternatives approaches for the external/face validation of shiphandling difficulty model for ferry is proposed by using shiphandling simulator. The use of shiphandling simulator is deemed as the most appropriate solution based on the expert judgment. The most important consideration of this approach is the modification of the setting values of the variables/parameters as well as time framing flexibility in the delivery process. This approach is still considered have the limitation. The limitation is on the concept of subjective preferences/opinion of the expert which may lead to the source of uncertainty, yet the concept of quantifier 'most' on the fuzzy group decision making give a clear concept about the limitation of the method.

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