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A Study on Collision Avoidance Action in the Situation of Encountering Multiple Ships by the Reserve Officer

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Abstract : *The proportion of collision in the total marine accidents is high. The main causes of collisions are navigation rule violation, safety speed violation, neglected watch-keeping and improper collision avoidance action. There are two main ways of avoiding collision situations during maritime navigation: the method of altering course and reducing ship's speed. The purpose of this study is to analyze the result of the collision avoidance action of the reserve officer in case of encountering a multiple number of ships using the ship handling simulator. Full-mission ship handling simulator was used to experiment the situation scenarios that encountered multiple ships. After the experiment, the questionnaire about the experiment was investigated. A total of 50 subjects were participated in the experiment. Experimental results showed that the number of the experimenters who used the engine was 11 and the number of the experimenters who did not use the engine was 39. In the case of using the engine, there were 0 collision accident, 1 grounding accident, and 10 no accidents. However, when the engine was not used, there were 28 collision accidents, 2 grounding accidents, and 9 no accidents. The causes of these results can be found in the survey results. 74 % of the non used engine participants said they were hesitate to use the engine. As can be seen from these results, the reserve officer are hesitant to use the engine and need a way to get correct of it. Maritime course subject can emphasize the importance of using ship's engines and case study also can be it. So, It is considered that various case study scenario will need to developed by various tools in the future.*

Key Words : *Officer, Ship, Encountering situation, Collision, Avoidance action*

1. Introduction

The ratio of collision accident during the entire marine accident is as high as 65 % of the marine accidents published by Korean Maritime Safety Tribunal (KMST, 2014) during 2010 to 2014. In these marine accidents, the ratio of accidents caused by human errors was more than 85 % (KMST, 2017). In this regard, various studies are being conducted to reduce marine accidents, and many studies have been published especially on human behavior and cognition (Celik and Cebi, 2009; Yim et al., 2014; Park et al., 2017).

Especially, in the last 5 years data from the Korean Maritime Safety and Tribunal, it was found that the accident related to the third officer took a considerable proportion of the total accidents, and the most of the marine accidents was caused by human error (Lee et al., 2013).

Among the 1,417 maritime accidents that occurred from 2010 to 2014 in the annual korean maritime accident statistics of the korean maritime safety tribunal, 923 collisions accounted for 65 %. Korean Maritime Safety Tribunal reported that such collisions were due to various causes. The main causes was identified as follows; navigation rule violation, safety speed violation, neglected of watch-keeping, and improper collision avoidance action (KMST, 2017).

There are two main ways of avoiding collision situations during maritime navigation: the method of changing direction and controlling speed of the ship (Lin, 2006). The method of changing direction is to control of ship's rudder to make left and right turn, and the control of ship's speed means to adjust and slow down the main engine of the ship.

In recent years, research on the prevention of ship collision accidents such as research on the initial action of ship operators has been reported (Lee et al., 2014).

According to the written verdict on the all most of collision accidents, a large number of officers tried to alter the his ship's course to avoid the collision, but there was not much to find out the trials to control the speed of ship.

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In order to clarify the reason of such collisions, we tried to investigate the collision avoidance action for reserve officers who would soon become the third officer. In this study, we analyzed collision avoidance action of the reserve officers, using data acquired through experiments on the ship handling simulator with a scenario of encountering multiple ships.

2. Research Method

2.1 Study Procedures

Fig. 1 represents the study procedures.

- Step 1 : Understanding of the rules for collision prevention. The representative maritime rule related to the collision prevention is international regulations for preventing collisions at sea a
- Step 2 : Recruiting participants. Participants was recruited from the 4th grade student in Mokpo national maritime university.
- Step 3 : Conducting experiments. Participants took parts in the experiment with situation scenario where they encounter multiple ships using Full-Mission Ship Handling Simulator (FMSHS).
- step 4: Analyzing of data Data acquired from the experiments and questionnaire were analyzed.

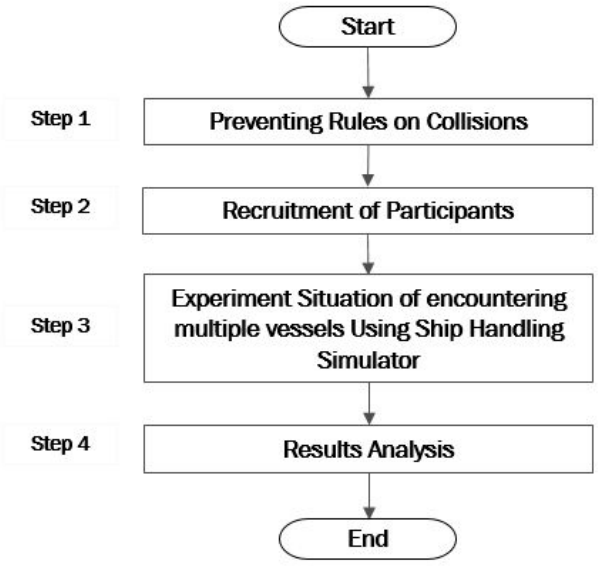

Fig. 1. Study procedures.

2.2 International Regulations for preventing collisions at sea

In order to prevent collisions at sea, IMO (1972) has declared the International Regulations for preventing Collisions at sea (COLREG). COLREG describes rules related to collision prevention. Particularly Article 6 (Safe Speed), Article 7 (Risk of Collision), and Article 8 (Action to Avoid Collision) are important provisions for situations encountering multiple ships.

In order to avoid collision by applying this rule, it is necessary to recognize the danger of collision with the opponent ship and act in a safe speed.

Table 1. International Regulations for preventing collisions at sea, brief of Rule 6 to 8

Rule	Title	Contents (example)
Rule 6	Safe speed	Every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate to the prevailing circumstances and conditions. In determining a safe speed the following factors shall be among those taken into account:
Rule 7	Risk of collision	(a). Every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist. (b). Proper use shall be made of radar equipment if fitted and operational, including long-range scanning to obtain early warning of risk of collision and radar plotting or equivalent systematic observation of detected objects.
Rule 8	Action to avoid collision	(a). Any action to avoid collision shall be taken in accordance with the Rules of this Part and shall, if the circumstances of the case admit, be positive, made in ample time and with due regard to the observance of good seamanship. (b). Any alteration of course and/or speed to avoid collision shall, if the circumstances of the case admit, be large enough to be readily apparent to another vessel observing visually or by radar; a succession of small alterations of course and/or speed should be avoided. (d). Action taken to avoid collision with another vessel shall be such as to result in passing at a safe distance. The effectiveness of the action shall be carefully checked until the other vessel is finally past and clear. (e). If necessary to avoid collision or allow more time to assess the situation, a vessel shall slacken her speed or take all way off by stopping or reversing her means of propulsion.

Ultimately, to prevent collisions, proper engine machinery should be used to maintain a safe speed, and actions to avoid collisions should be made using a rudder to properly control the vessel. These two are important action to prevent collision.

A summary of the contents of Rules 6, 7 and 8 of CORLEG, which is closely related to this study, is shown in Table 1 (IMO, 1972).

3. Experiment

3.1 Participants and equipments for experiments

Full mission ship handling simulator used for the experiment was Kongsberg's FMSHS, located at the Mokpo national maritime university. The FMSHS consists of Radar, Electronic Chart Display Information System (ECDIS), a telegraph, and auto-pilot, navigation instrument, indicator and adjustable display.

50 reserve officers in the Mokpo National Maritime University took part in the experiments. These students have at least one year of boarding experience as a apprentice officer.

And all of them have experience using Kongsberg's ship handling simulator.

The scenario for experiment were situations that were encountering with multiple ships. After the experiment, participants discussed concerning collision avoidance action and responded on the given questionaries.

3.2 Research range

The range of the study is as follows.

- The experimental equipment was Kongsberg's FMSHS.
- The FMSHS consists of Radar, Electronic Chart Display Information System (ECDIS), a telegraph, and auto-pilot, navigation instrument, indicator, and adjustable display.
- Experiments were conducted on 50 reserve officers attending Mokpo National Maritime University. These students have at least one year of boarding experience as a apprentise officer and all have experience using Kongsberg's ship handling simulator.
- Experimental scenario is encountered with multiple ships. In this paper, the subject discusses matters concerning collision avoidance action.

3.3 Experiment method

Table 2 shows the experimental methods. At the first step, the experimenter explained general description of the experiment to the participants for 5 min. It was reported that there are no restrictions on the use of the engine and the other equipments such as radar and ECDIS.

In the second step, although participants were already familiar with full mission ship handling simulator, participants were allowed to familiarize themselves with Kongsberg's FMSHS use for 10 minutes. In this process, the experimenter explained the method of engine operation, radar interface and operations of the other equipments. In addition, the experimenter checked the maneuvering performance of the model ship to be used in the experiment.

In the third step, the experiment was run for 15 minutes with the scenario of encountering multiple vessels.

At the fourth step, the results of the experiment were analyzed and after the experiment questionnaire was conducted.

Table 2. Experiment procedure

Step	Procedure	Time Due
Step 1	Explanation how to avoid collision situation	5 Mininutes
Step 2	Familiarization with Ship Handling Simulator	10 Mininutes
Step 3	Situation of encountering multiple vessels	15 Mininutes
Step 4	Evaluation and questionnaire of experiment	5 Mininutes

3.4 Characteristics of target ships and own ship

The own ship (A ship in the Fig 2) used in the experiment was a product tanker with a length of 180 meters. Ship A is the ship of a product carrier with a pilot who is a reserve officer. The initial setting value of Ship A is the ship's heading of 000° and the ship's speed is 13 knots. Experiments were conducted through scenario as shown in Fig. 2.

All the target ships used in the experiment were classified into four types; B to E. The arrow indicates the direction of the ship. Table 3 shows target ship movements and characteristics from ships B to E.

The ships B, C, D, and E were moving with a fixed bearing and line speed. Ship B was a passenger ship, ship's heading was 265° and her speed was 18.0 knots. Ship C was a container vessel, vessel's heading was 180° and her speed was 15.0 knots. Ship D was a passenger ship, ship's heading was 340° and her speed was 18.0 knots. Ship E was fishing boat and ship's heading was 090° but the heading is not important because there is no speed. Simulator for the experiment and the scene of a participant

is shown in Fig. 3. The process of all experiments was recorded by camera.

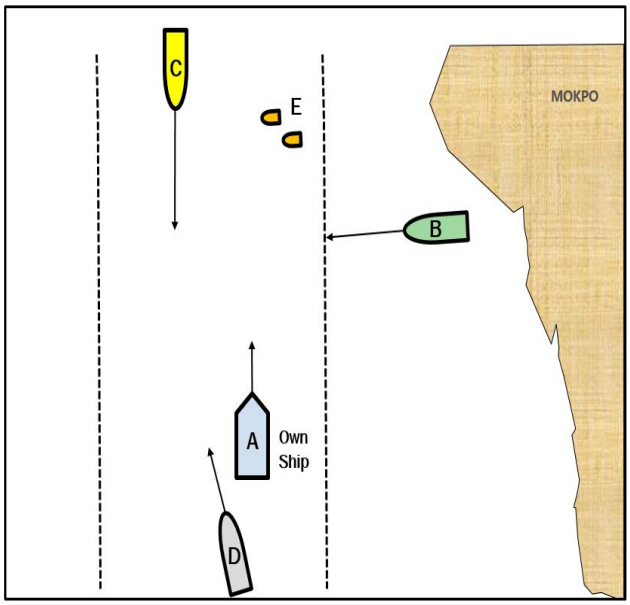

Fig. 2. Situation of encountering multiple vessels.

Table 3. Vessel characteristics in scenario

Vessel	Ship's Type	Ship's Heading (°)	Ship's Speed(knots)
A	Product Tanker	000	13.0
B	Passenger Ship	265	18.0
C	Container Vessel	180	15.0
D	Passenger Ship	340	18.0
E	Fishing Boat	090	0.0

Fig. 3. Experiment Scene Recording.

3.5 Survey method

After 15 minutes of experiment, the questionnaire was conducted. In the questionnaire, we surveyed the plans how to use the steering and engine machinery, which were determined by the experimenter in the context of encountering multiple ships. Surveys were conducted as subjective responses and there was no limit on the length and time of the responses.

In addition, participants who did not use ship's engine were asked for the reason.

4. Experiment results and discussion

4.1 Experiment results

A total of 50 participants were recruited in the experiment. In this experiment, we tried to investigate the collision avoidance actions of a reserve officer in the situation of encountering multiple ships.

It was analyzed if participants utilized either rudder or engine for the collision avoidance.

Firstly, the use of rudder did not have significant meaning in terms of the quantitative index. All participants used rudder and there was no difference between turning the rudder to the port or to the starboard of the accident. Therefore, the use of rudder was not analyzed.

Secondly, the number of the using ship's engine are shown in Table 4. The number of cases of using the engine was 11 and the number of no use of the engine was 39. In the case of using the engine, collision accidents did not occurred. There were 1 grounding accident and 10 no accidents. However, when the engine was not used, there were 28 collision accidents, 2 grounding accidents and 9 no accidents.

Table 4. Experiment result for using engine

Number of Participants	Whether the Engine is used or not		Number of Accident	
50	Yes	11	Collision	0
			Grounding	1
			No accident	10
	No	39	Collision	28
			Grounding	2
			No accident	9

4.2 Survey results

The results of the survey are shown in Table 5. After the end of the experiment, the questionnaire was completed over an average of 10 minutes and was conducted for all participants.

The responses to the questionnaire were processed as duplicates. The most frequent answers to the questionnaires were those who were embarrassed in the situation encountering multiple ships. The number of the answers are 39.

The second high ratio of answers was 32. They had the plan for collision avoidance, but

there was a difficulty in actually doing their ship's control.

The third answers was 29. They hesitated the use of the engine. The fourth answers were that they did not use the engine of their ship because the engine was not used for the collision avoidance action in past experience. The third and fourth answers were responses to participants who did not use the engine. The fifth answers included various answers such as other vessel's speed was high.

Table 5. Top 5 for Survey results

No.	Answer	Number (%)
1	It was embarrassed that the simulations were carried out with many vessels encountered	39 (78)
2	I had planned to avoid a situation where I encountered a number of vessels, but when I actually controlled it, it was difficult because of unexpected parts	32 (64)
3	Using Engine was hesitant to use (include only did not use the engine)	29 (74)
4	In my apprentice officer experience, normally didn't use engine when avoiding vessel, So I couldn't used it (include only did not use the engine)	27 (69)
5	etc., (other vessels speed is high, so I can't avoid, or etc.,)	-

4.3 Discussion

The most important point of the experimental results is that the action of participants for collision avoidance were a clear difference in the situation that encountered multiple ships.

Only 22 % of the participants used the engine and the remaining (78 %) did not use the engine. In the case of the engine use, the accidents were only 9 %, which was very effective in collision avoidance operation.

However, when the engine was not used, the rate of accidents increased to about 72 % including collision and grounding accidents. These causes of high rate of accidents could be found in the survey results.

The reserve officers were hesitant to use the engine. In addition, the difficulty in using the engine might be induced from their experience that the actual use of the engine in the vessel was not used for the collision avoidance operation. According to the these results, it is needed to find out an effective training way that the reserve officers could use the engine without hesitance to avoid ship collision.

Since there are many considerations regarding the use of ship's engine such as great influence on the economy, it is difficult to specify it in ship's manual. However, it should be considered in the following ways. The method is to emphasize the importance of using ship's engines for maritime navigation in the process of ship handling training.

It is also emphasized that the slow down of ship's speed is important for safe navigation.

So, a variety of ship handling scenario that the ship speed should be slow down will need to be developed for the safe ship navigation training.

5. Conclusions

The ratio of ship collision in the total marine accidents is very high. The main causes of ship collision accidents are navigation rule violation, safety speed violation, neglected of watch-keeping, and improper collision avoidance.

There are two main ways of avoiding collision during maritime navigation: the method of alter course and change speed of the ship. The purpose of this study was to analyze the result of the collision avoidance action of the reserve officers in the situations of encountering multiple ships using the full mission ship handling simulator (FMSHS).

A full mission ship handling simulator (FMSHS) was used to do the experiment based on the situation involving multiple ships. A total of 50 participants were included in the experiment. After the experiment, a questionnaire survey was conducted. Experimental results showed that the number of the participants who used the engine was 11 persons and the number of the participants who did not use the engine was 39 persons.

In the case of using the engine, there were 0 collision accidents, 1 grounding accident, and 10 no accidents. However,

when the engine was not used, there were 28 collision accidents, 2 grounding accidents and 9 no accidents. The most important points of the experimental results are as follows.

The most important points of the experimental results are as follows.

Firstly, the only 22 % of the participants used the engine and the remaining (78 %) did not use the engine. Secondly, in case of using the engine use, no accident occurred was approaching to 91 %, while in cases that the engine is not used, the accidents including ship collision and grounding was about 72 %. Thirdly, according to the survey results. 74 % of the non-used engine participants said that they were hesitate to use the engine. 69 % of participants said that they were afraid to use it because they had little experience.

According to the these results, it is needed to find out an effective training way that the reserve officers could use the ship engine without hesitance to avoid ship collision.

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