The 12th Annual General Assembly of IAMU
GREEN SHIPS, ECO SHIPPING, CLEAN SEAS
iamu AGA12

Influence of Human Factor on Marine Casualties

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Abstract: According to the reports of the Japan Coast Guard, recently the number of marine casualties has not changed so much and major cause of marine casualties is human factor. Human factor is analyzed by case studies, even using the case studies can not prevent all marine casualties. In this study, we introduce a new simulation model to prevent marine casualties or minimize damages caused by human factor.
This model simulates a navigation of ships while predicting dangerous situation such as collisions using information of ships such as position, speed and course. The model uses System Dynamics Computer Simulation combined m-SHELL model analysis.
Inputting data of past marine casualties into this simulation model, each ship will avoid dangerous situation in the simulation. Therefore, this simulation model makes judgment of safety navigation and it is the notable features. It will be possible to prevent marine casualties caused by human factor which making judgment of this simulation model not by watch keepers. When we simulated by using the situation of past collision, this simulation model showed information to navigate safely and to avoid collision.
In the future, it will be possible to navigate safely by assisting judgment by this simulation model.
Keyword: Human Factor, System Dynamics Computer Simulation, m-SHELL Model Analysis

1. INTRODUCTION

Equipments for navigation and performance of ship have been advanced. We can navigate more safely with these advances and expect decrease in marine casualties. However, the actual situation is different from it. According to the reports of the Japan Coast Guard, the number of marine casualties has not changed so much and the percentage of marine casualties caused by human factor to total is about eighty percent (80%). We can say that the major cause of marine casualties is human factor. There is the close relationship

between human factor and marine casualties and we have to prevent marine casualties caused by human factor.

Human factor is mainly analyzed by the case study such as verifications of past accidents and investigations of mistakes. However, it is not enough from the perspective of prevention because there is some possibility of not preventing marine casualties without past accidents having similar circumstances. In other words, a method of preventing marine casualties under any circumstance is necessary.

According to the reports from the Japan Coast Guard, marine casualties caused by human factor are mainly human error such as improper navigations and insufficient lookout. Human error happens in spite of various measures to prevent it, because human factor certainly happens under systems related human. We consider that it is possible to prevent marine casualties caused human factor by decreasing navigator's judgment and propose the simulation model. Using this simulation model, we can analyze human factor more quantitatively with simulating circumstances of past marine casualties and assessing effect of human factor too. Therefore, the objective for this study is constructing the simulation model to prevent marine casualties or minimize damages under any circumstance. Also, we will report the effect of applying to this simulation model to prevent marine casualties or minimize damages.

2. SIMULATION MODEL

2.1 Outline of simulation model

In this study, we constructed the simulation model for navigating two ships using the System Dynamics Computer Simulation combining m-SHELL model analysis. This simulation model can consider human factor by combining m-SHELL model analysis. Also, we can simulate collisions which are the most in marine casualties. Inputting position, target course and target speed of ships, subjects of simulation, into this simulation model, the model shows necessary information to navigate safely.

2.2 System Dynamics Computer Simulation

The System Dynamics Computer Simulation (hereafter SD) interacts in the models and computes about dynamic systems changing as the time passed. Features of the SD are as follows.

- Advanced to analyzing feedback loops
- Advanced to analyzing complex dynamic systems
- Advanced to simulating for a long term
- Applicable to optimize
- Applicable to capture causal relations of system visually

Navigating condition is complex dynamic system as the situation including the parties concerned such as ships and navigators changes as the time passed. Especially, human factor is influenced each other by various factors. Therefore, we applied the SD.

2.3 m-SHELL model analysis

When the accidents caused by human error occurred, in general the parties concerned should be responsible personally and they were punished. But we have found that human error doesn't decrease. In fact, human error happens in the situation including the parties

concerned not only by the parties concerned. The next step is to consider the situations which humans hardly make errors. The effective method of considering the situation is m-SHELL model analysis. It is the way to classify the situation into five factors such as Software, Hardware, Environment, Liveware(the parties concerned) and Liveware(others) and consider influences each other. Software is information and supporting systems such as manuals, regulations and training. Hardware is facilities and machines. Environment is situations to work such as weather, temperature, visibility and lights. Liveware is humans. In Figure1, management is emphasized. This shows that the management is considered bases of everything. And Table1 shows relation between m-SHELL model analysis and the factor in the model.

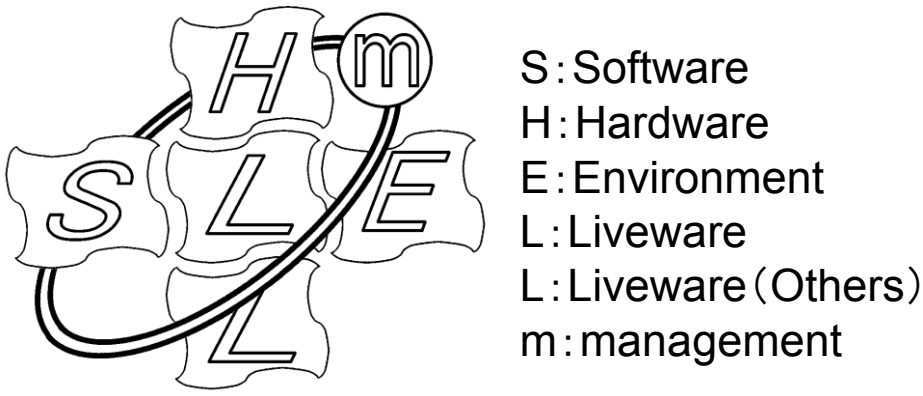

Figure1. m-SHELL model analysis

Table1. Relation between m-SHELL model analysis and human factor in simulation model

SHELL	Factor	Factor in the simulation model
Software	Regulation	Behavior based on COLREGS
Hardware	Performance of ship	Performance of turning and adjustment
Environment	Visibility	Visible distance of light
	Weather	Change of speed and course
Liveware	Navigator's judgment	Position of ship to other ship
Liveware (Others)	Information of other ship	Position and course of other ship

2.4 Concept of simulation model

This simulation model consists of the main model and the two sub models. The main model is judgment of collision. The sub model is controlling navigation environment of each ship, subjects of simulation, and divided into four sections which are position of the ship, control speed and course, judgment of navigation and control of avoiding collision. Position of ship is the model to control position as latitude and longitude and influences calculating distance

between the ships and judgment of navigation. Control of speed and course is the model to keep the target speed and course and influences position of ship. Judgment of navigation is the model to judge whether or not to avoid and influences control of avoiding. Control of avoiding is the model to control speed and course for avoiding and influences position of ship. Figure 2 shows relations between the models.

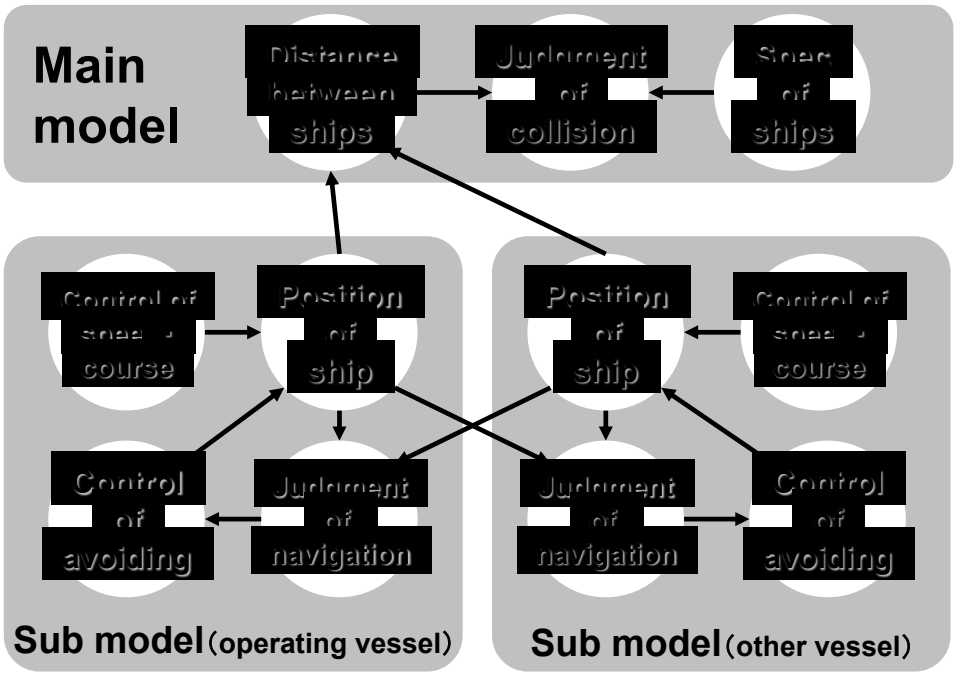

Figure2. Concept of simulation model

2.5 Simulation model of navigation

Figure3 shows the simulation model. The main model is judging of collisions from distances between the ships and specifications of the ships. Inputting the data of position as latitude and longitude at start of simulation into the sub model, position of ship, real-time position of ship in simulation is calculated automatically. Inputting the target speed and course into the sub model, control of speed and course, the model controls to keep it. The sub model for *judgment of navigation* judges whether or not to avoid from relation between two ships obeying Act on Preventing Collisions at Sea. The sub model for *control of avoiding* controls speed and course for avoiding separately from control speed and course when the sub model for *judgment of navigation* judges that a ship has to avoid. Each ship avoids dangerous circumstances in simulation and these simulation models shows necessary information for the safety navigation.

Also, the combined m-SHELL model analysis is effective when we analyze human factor by simulating situations of the past accidents.

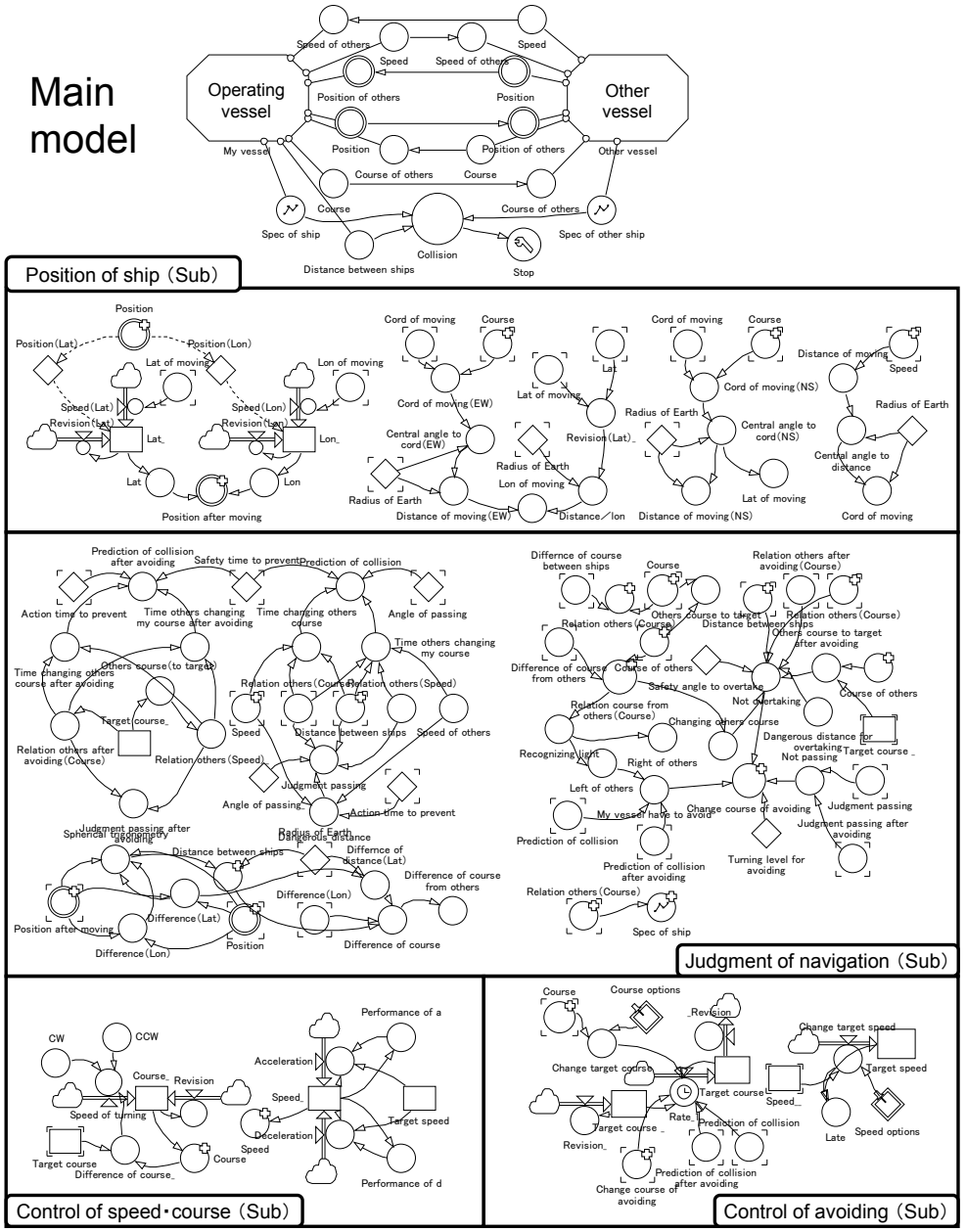

Figure3. Simulation model of navigation

3. VERIFICATION OF THE MODELS

We simulated using the circumstance of the past collision to show validity of the simulation model. There are two objectives for verification. First, we show the accuracy of

the simulation model. Second, we show that it is possible to propose effective ways to prevent collisions or minimize damages. The circumstance we used is the collision between the ship E and the ship I. This collision occurred because the ship E took avoiding operation at 1:37 in Figure 4. We simulated premising that *"Operating vessel"* in the simulation model(1) as the ship E, *"Other vessel*" in it as the ship I, and the ship E avoids dangerous circumstances as necessary.

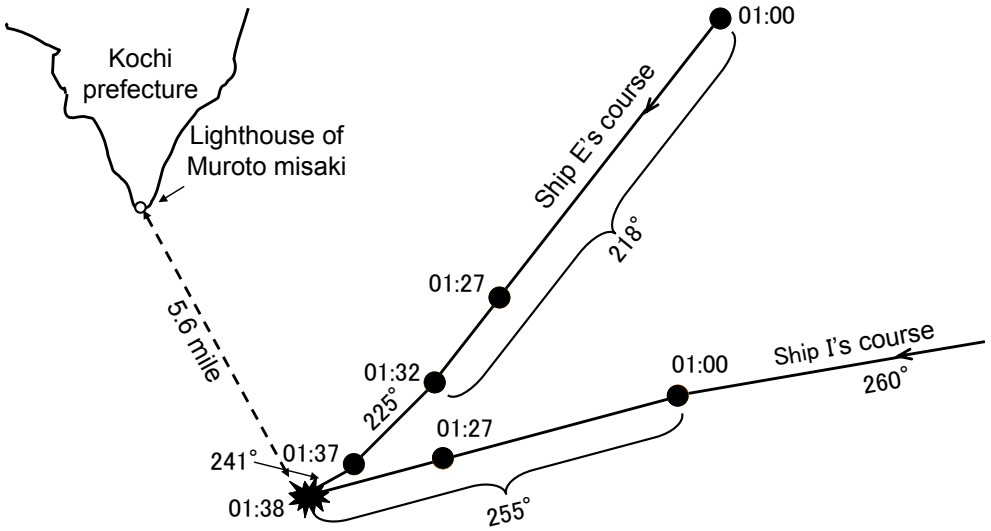

Figure4. Circumstances of the collision

First, we simulated under the same circumstances of the real collision to show the accuracy of the simulation model. Table 2 shows the results of simulation. From Table 2, the results of simulation (1) and actual circumstance are almost the same. Therefore, the simulation model (1) is accurate enough to simulate.

Table2. The results of simulation (1)

	Results of simulation	Actual circumstances
Collision	Happening	Happening
Time of collision	1:37:59	About 1:38
Position of collision	(33˚11'54.15"N, 134˚16'30.20"E)	(33˚11'54"N, 134˚16'30"E)

Second, we simulated under judgments of the simulation model to show that it is possible to propose effective ways to prevent collisions or minimize damages. In consequence, the collision did not happen. Figure 5 shows the circumstances in simulation (2). From Figure 5, the ship E changed course to 255 degrees for avoiding at 1:33. This judgment prevented the collision. This is judges from time until *operating vessel's* course crosses *other vessel's* course, time until *other vessel's* course crosses *operating vessel's*

course and action time to prevent collision. Table 3 shows the results of simulation. From Table 3, there are great differences on avoiding between results of simulation (2) and actual circumstances. In other words, avoiding action of the ship E was too late to prevent the collision. Therefore, if the ship E navigated as the simulation model (2) shows, it was possible to prevent the collision.

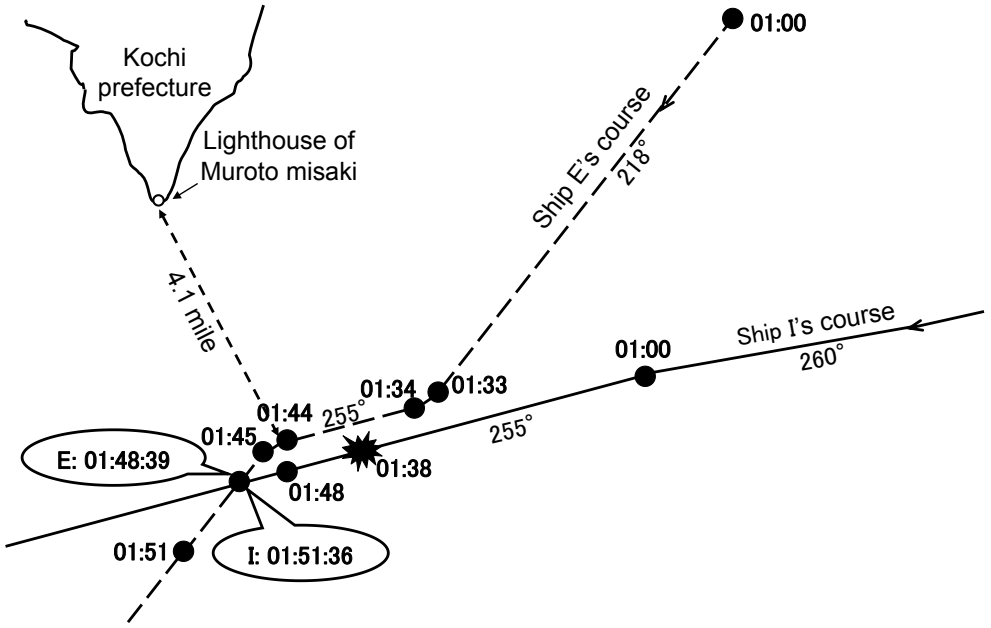

Figure5. Circumstances in simulation

Table 3. The results of simulation (2)

	Results of simulation	Actual circumstances
Collision	Not happening	Happening
Time of avoiding	1:33:48	About 1:37
Position of ship in time of avoiding	1.10 km	0.1 km

4. CONCLUSION

We found when and how to avoid for safety navigation. In other words, the simulation model showed necessary information to navigate safely. Therefore, the System Dynamics Computer Simulation combined m-SHELL model analysis is effective method of proposing any way to prevent marine casualties.

In the future, it will be possible to prevent human error and navigate safely by judging navigation in this simulation model not by the watch keepers in the bridge. Also, the results of simulation showed that the ship E had to avoid at 1:33 etc. In other words, the simulation model showed what the watch keepers should be attention to prevent the collision. Though we simulated using the circumstance of only the past collision between the ship E and the ship I in this study, this simulation model shows what the watch keepers should be conscious of to prevent marine casualties by simulating many circumstances of the past accidents.

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