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ANALYSIS OF PASSENGER EVACUATION ON FERRY KMP TRISNA DWITYA USING PATHFINDER

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ABSTRACT

The use of ships as a transportation is growing rapidly, of course, this is also related to transportation safety related including ship accidents. The National Transportation Accident Commission (KNKT) recorded 86 accidents in the sea transportation sector from 2010 to 2019. In 2018, the KMP Trisna Dwitya ferry ran aground, which resulted in 28 passengers having to be evacuated. Safety on ships must be optimized by minimizing casualties. The determining factor in evacuation is the time it takes for passengers to get out of the waiting room on the ship. Hence, it is necessary to calculate the time for the evacuation process. The purpose of this study is to obtain results in the form of evacuation time during a fire and evaluate the simulation of passenger evacuation in the fastest time. The method used is modeling and simulation, where modeling is used to simulate and analyze the time required for evacuation with the Pathfinder software. The results of the analysis and simulation yielded 3 different scenarios. Scenario 1: When the fire point is on the main deck where the motorized vehicle with evacuation time reaches 20 minutes 21 seconds. Scenario 2, when the fire point is in the left side engine room, reaches 20 minutes 57 seconds. Scenario 3, when the fire point is in the right-side engine room, the time obtained is 21 minutes 1 second. So that the 3 scenarios have met the requirements of the IMO, which is less than 60 minutes during the evacuation process on a passenger ship.

Keywords: Evacuation, IMO, KNKT, ship accident, pathfinder

Introduction

Sea transportation makes a significant contribution to the national and regional economies, as stated in Law No. 17 of 2008, that it is very strategic for national insight and is an important instrument in supporting the goal of national unity and integrity. The contribution of sea transportation is becoming important because the costs incurred by sea transportation are minimal compared to the costs of land and air transportation [1].

Ferries play an important role in several regions, so ferry activities are quite busy. The number of passengers and vehicles that must be transported, and the safety elements on the ship, must be prepared. Supporting equipment in case of fire, ranging from life jackets to emergency boats to evacuate passengers, must be prepared. Not only preparing the equipment, but it is also necessary to learn the evacuation route so that passengers can quickly and safely go to the designated muster point.

Transportation and public buildings generally require the relevant agencies to provide evacuation

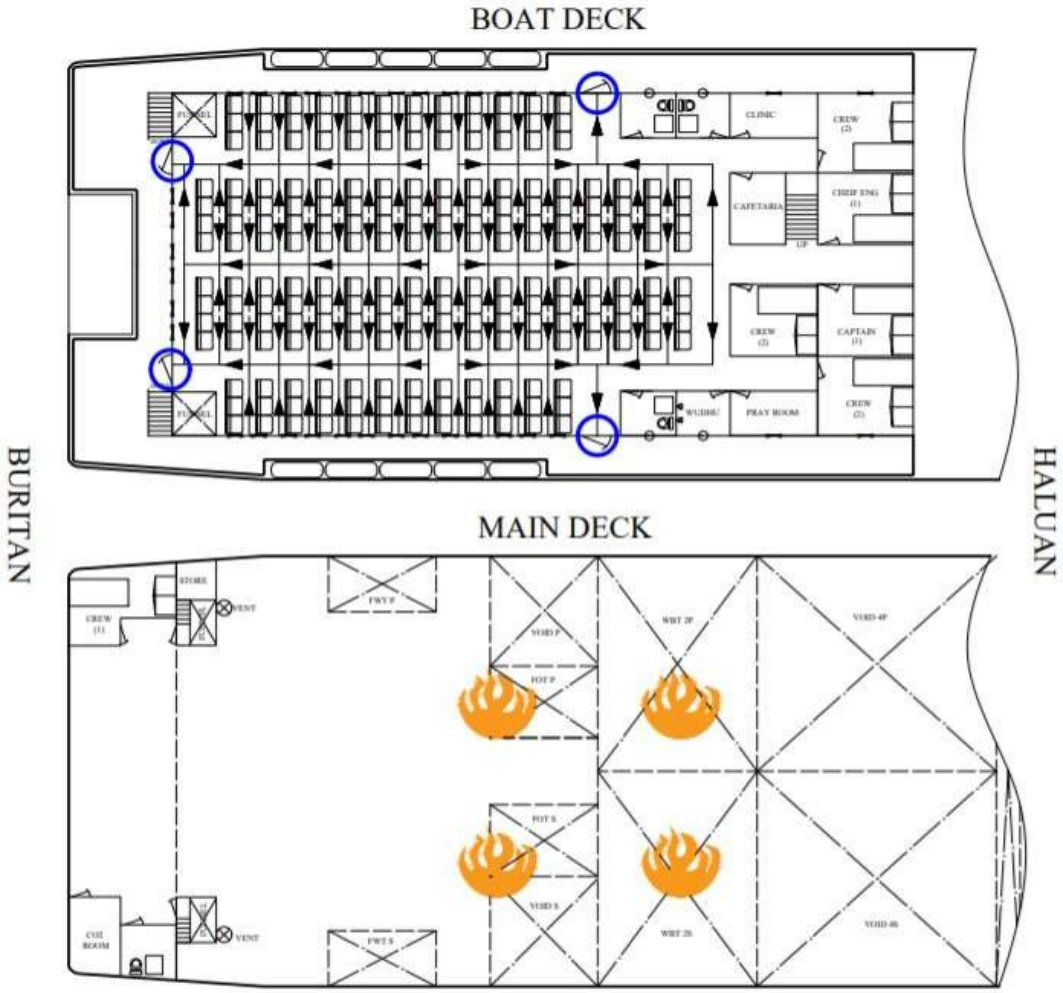

Figure 1. Evacuation route when the fire is on the main deck

plans during emergencies, and they must be followed by everyone in the environment. Based on the analysis of post-disaster events related to habitual human behavior, namely: 1) Most people do not start walking when the alarm sounds. In this case, there is a delay in reacting to the alarm, called the awareness time. 2) People often take the path they know rather than following the directions of

the symbols on the emergency exits. 3) People are generally influenced by the movements of people around them, which tend to be dominant. 4)

5) Physical and psychological conditions are very important, and each person has different circumstances. 6) People can go through smoky areas with limited visibility if someone acting as a leader leads them. 7) In crowded conditions, there is often panic [2].

Evacuation time under the International Maritime Organization (IMO) criteria is partial, i.e., evacuated passengers are considered to gather at a certain point, before moving together to the next point, so that the determination of passenger evacuation time is strongly influenced by changes in passenger density against movement speed. However, in reality, the movement of passengers during the evacuation process can be said to move simultaneously. One of the efforts made to reduce the density of the evacuation route is to unravel the pile of passengers on alternative routes that might speed up the evacuation [3].

The speed of walking in groups will reduce the speed by 20% compared to walking alone, with a distance of 3 m between groups. Furthermore, the walking speed of the group in front will be faster than the walking speed of the group behind it. However, individual walking speed in the opposite direction can be slower than group walking speed [4].

In 2018, KMP Trisa Dwitya had an accident, running aground while crossing on Saturday in July 2018. The ship was dragged by the current until it finally ran aground near the navigation lights. The ship carried 28 passengers. The evacuation process was carried out 3 times so that it could be evacuated safely [5]. Based on this, this research aims to

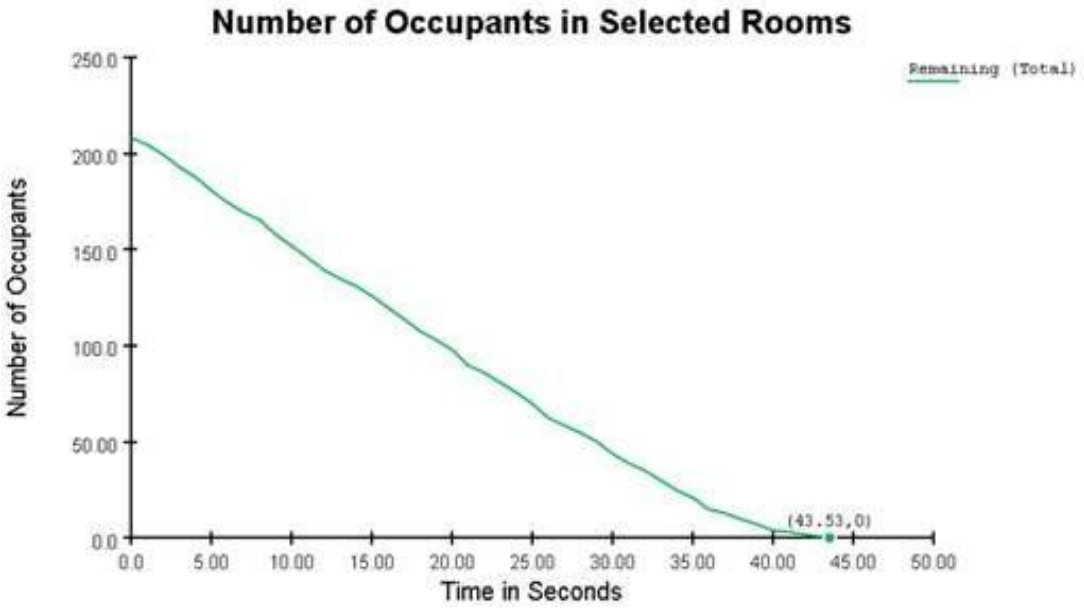

Figure 2. Graph of evacuation time leaving the waiting room (scenario 1)

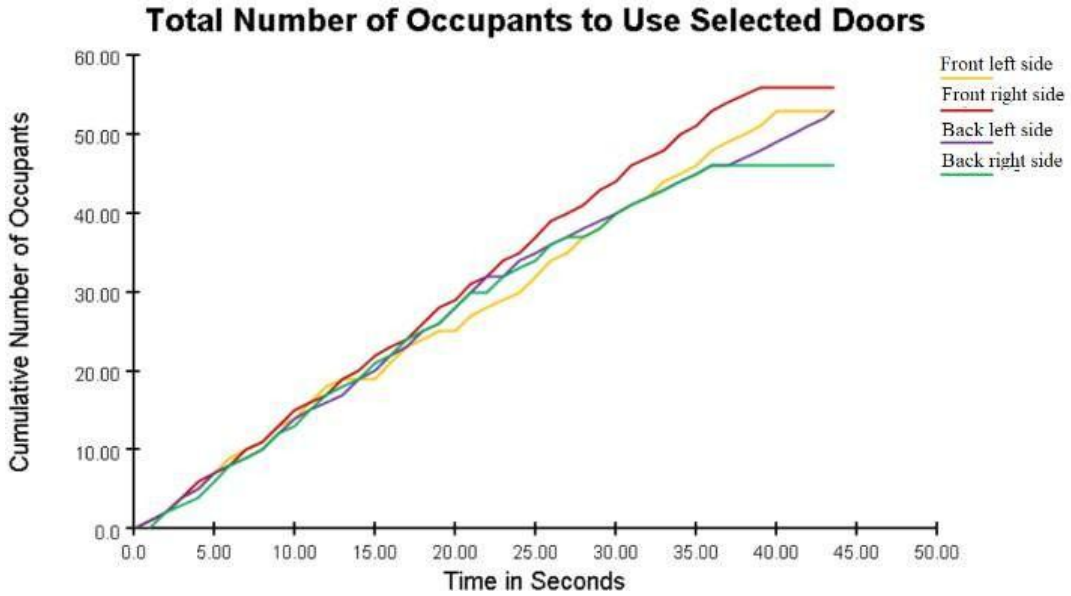

Figure 3. Graph of the number of exiting passengers at each door (Scenario 1)

determine how long it takes for the evacuation process and simulate the. evacuation process to get a fairly efficient time in the event of an accident.

Methodology

This research is a simulation, which is a form of research that aims to obtain an overview through a small-scale or simple system (model) in which the model will be manipulated or controlled to see the effect [6].

a. Literature Study

Literature study is carried out to study theories that can support existing problems. Literature studies are obtained from several theories and discussions on the flow during passenger evacuation from books, journals, theses, and the

internet. Evacuation on the ship refers to the safety plan contained on the ship. Evacuation on the ship is carried out quickly so that there are no casualties. Evacuation simulations are carried out to find the time required when evacuate ship passengers during a fire. Evacuation simulations are analyzed using Pathfinder software (one of the evacuation path simulation software based on human simulator agents and movements) with several fire situations, to determine the time required during the evacuation process.

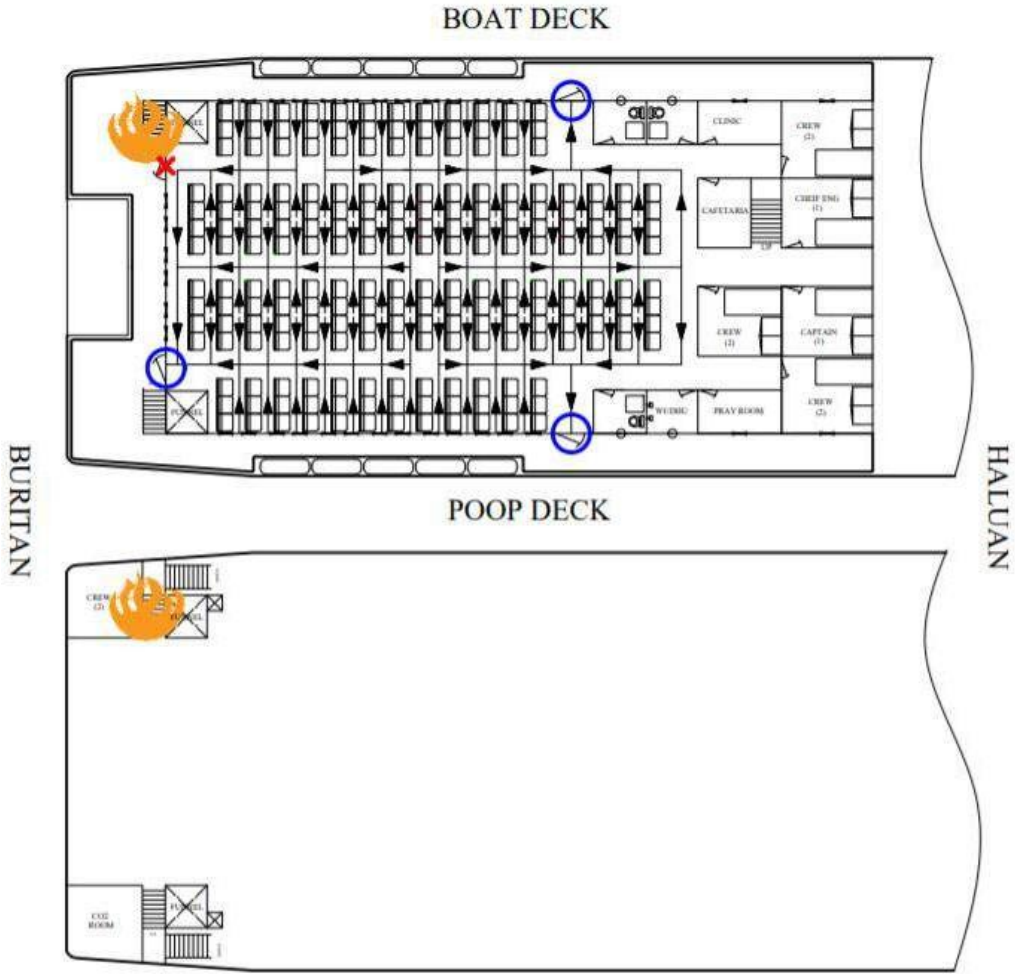

Figure 4. Evacuation route when the fire is in the left side engine room.

b. Data Collection

Data collection aims to clarify the subject to be raised in the thesis; the data required are: safety plan, general arrangement, and ship passenger capacity. At this stage, supporting data about matters that are per the methods used are collected for further analysis.

The data used is KMP Trisna Dwitya, using a general arrangement and safety plan with the following ship data:

Panjang total (LOA)	= 54,90 m
Lebar (B)	= 14,40 m
Tinggi kapal (D)	= 3,50 m
Sarat (T)	= 2,57 m
Crew	= 13 lives
Passengers	= 208 lives

c. Model Design and Simulation

Scenario Design and modeling are done using Autocad and Pathfinder software, by drawing the design of the waiting room on KMP Trisna Dwitya using Autocad as a background on the Pathfinder.

Placement of fire points in fire-prone places because in the section that is the point where fires easily occur. So that 3 scenarios are obtained that will be used in the simulation, like: scenario 1 when the fire point is on the main deck of the ship, scenario 2 when the fire point is in the left engine room, and scenario 3 when the fire is in the right side of the ship's engine room. The simulation process is carried out using Pathfinder software by entering data such as: the location of the exit, the area that can be passed by passengers, and the number of passengers in the room.

d. Data Analysis and Simulation Results

Data analysis is carried out by paying attention to several points such as the number of exits, the placement of passenger seats, access roads that will be through by passengers, and the placement of hotspots that have the potential for fire, such as the left side engine room, right side engine room, and main deck, where motorized vehicles.

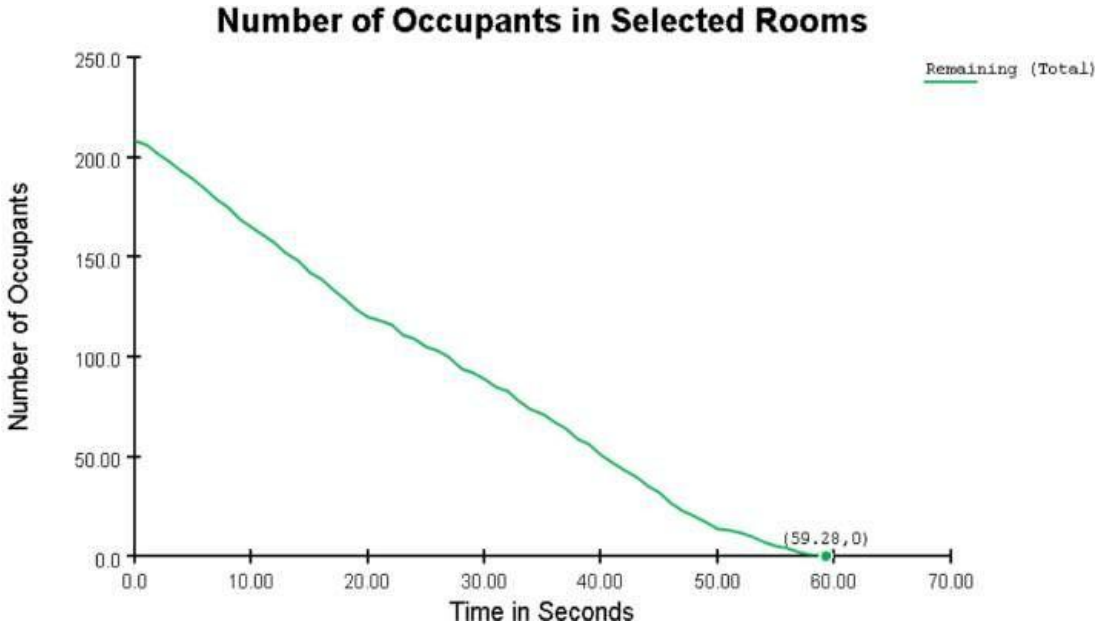

Figure 5. Graph of evacuation time leaving the waiting room (scenario 2).

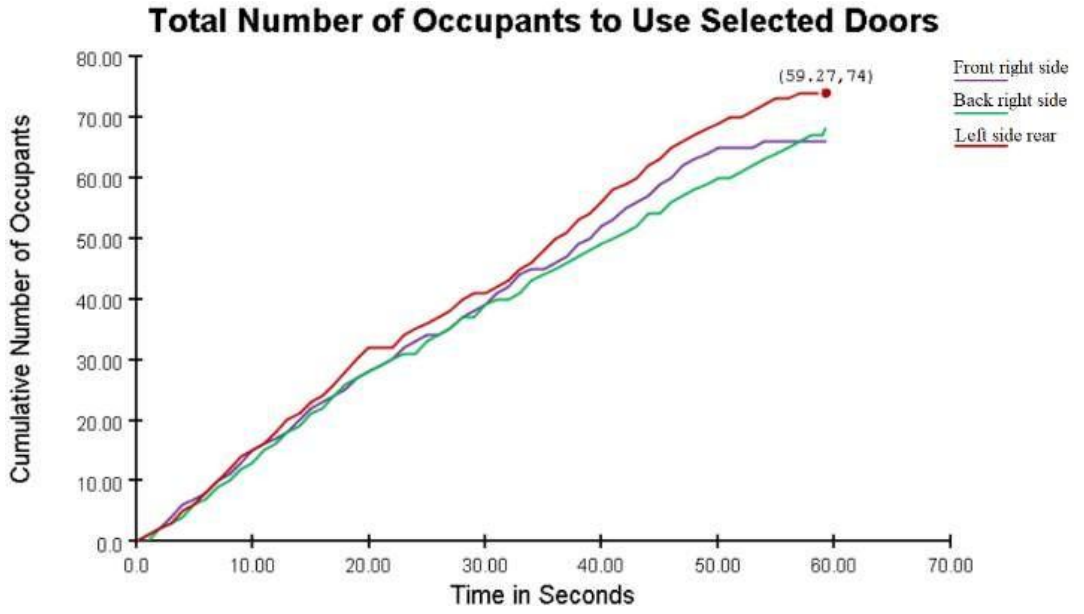

Figure 6. Graph of the number of passengers exiting each door (Scenario 2).

Simulation results using Pathfinder software in the form of graphs and time. In this case, the graph shows the value of the object's movement in choosing its evacuation path, while the time shows the time it takes to leave the passenger room on the KMP Trisna Dwitya ship.

The results obtained from the simulation must meet the standards set by IMO, which is no more than 60 minutes for the evacuation process on passenger ships [7], [8].

e. Evaluation of the Simulation Results

According to [8], after obtaining the results of the passenger evacuation simulation, the simulation results will be evaluated against the standards set by the IMO. If the results obtained meet the specified standards, it can proceed to the conclusion stage; if the simulation results do not meet the predetermined standards, the model design and simulation process must be repeated until the results are under safety requirements [7].

Result and Discussion

The evacuation process aims to save passengers or cabin crew. In this article, there are 3 scenarios

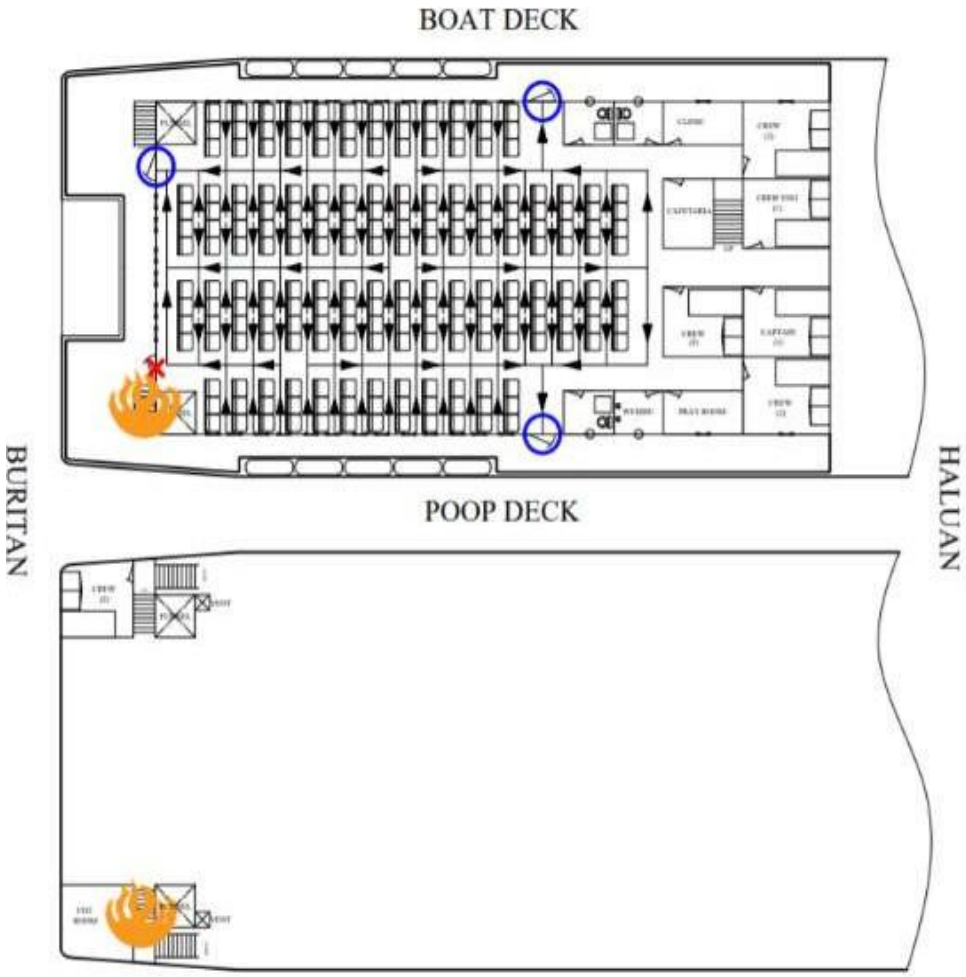

Figure 7. Evacuation route when the fire is on the right side of the engine room (Scenario 3).

used, namely when the fire point is on the main deck, left, and right-side engine rooms.

The placement of the fire point in scenario 1 is on the main deck. The placement of the fire point is based on the location of the vehicle on the main deck so that it can become a source of fire.

Based on the evacuation simulation in Figure 1, the results obtained are that 208 ship passengers need 43.53 seconds to evacuate out of the room. 43.53 seconds with the condition that all exits can be used.

Based on Figure 2, the right rear door is the door that is not chosen by many ship passengers, with 46 people. The right-side front door is the exit access chosen by many people, reaching 56 people. The left front door and the left rear door were passed by 53 people. The majority of passengers choose to exit through the front door of the ship, either the right front or the left front.

The simulation results show that the total time required for the evacuation process is 43 seconds (T). The response time is 5 minutes during the daytime (A). In this case, the overlap time uses 22 minutes 3.12 seconds (E+L), so that the time required for evacuation is as follows:

= 1.25(A+T) + 2/3(E+L)
= 1.25(5'+43") + 2/3(22'3.12")
= 20'21"

So, the simulation results of the evacuation process in scenario 1 took about 20 minutes and 21 seconds.

The fire point in scenario 2 is in the left side engine room. During the evacuation process, the door near the left staircase cannot be used because the position of the door is too close to the fire source, so there are only 3 doors that can be used. Therefore, the evacuation route simulated for the evacuation process only uses 3 exit accesses in the ship's waiting room, namely the right-side rear door, the left side front door, and the right-side front door (Figure 4).

The results of the evacuation simulation in scenario 2, out of 208 passengers on board, took 59.28 seconds to evacuate the room, with the condition that the left side rear exit door could not

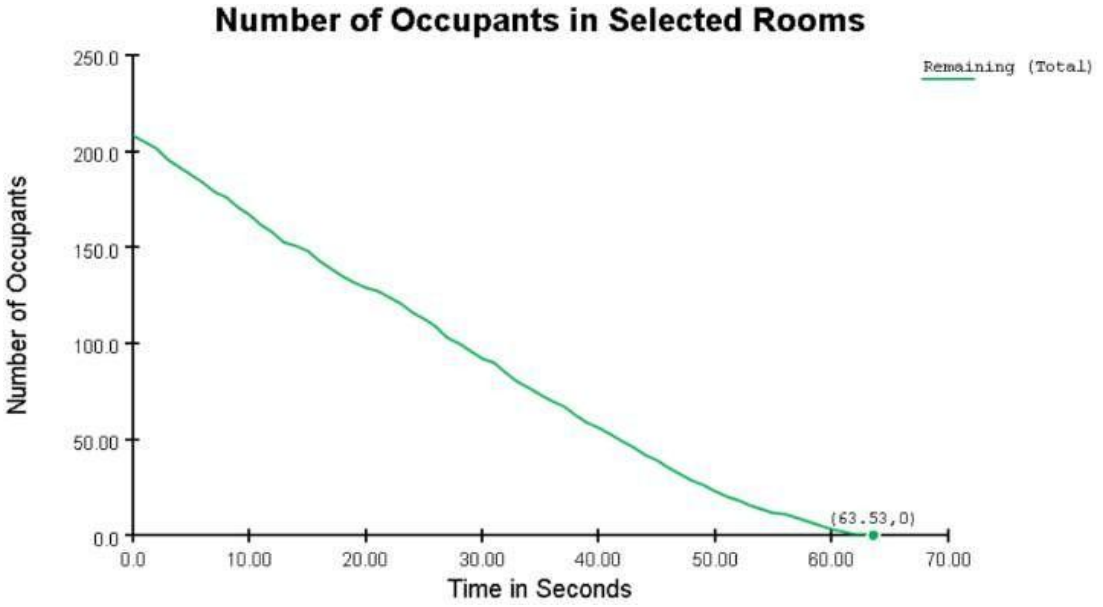

Figure 8. Graph of evacuation time leaving the waiting room (scenario 2).

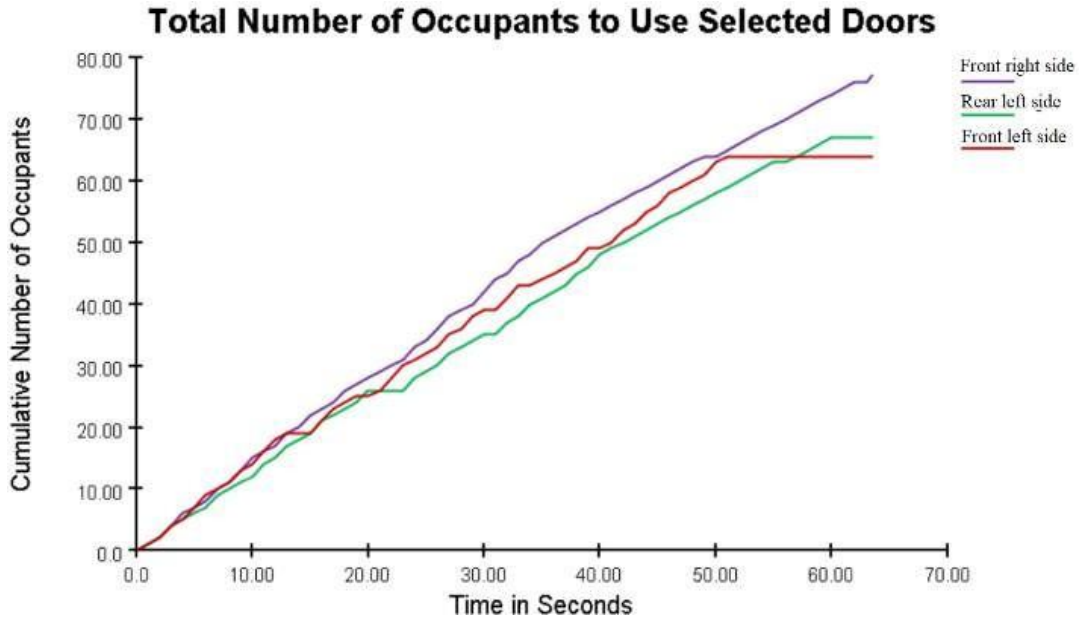

Figure 9. Graph of the number of passengers exiting each door (Scenario 2).

be used because it was too close to the fire source (Figure 5).

The number of passengers at each door, namely the right front door, is an access door that is not chosen by many ship passengers, with 66 people. The left front door of the ship became the exit access chosen by many people, as many as 74 people, and on the right side of the back door, the number of people reached 68 passengers (Figure 6).

Based on the simulation results in scenario 2, the total time required for the evacuation process is 59 seconds (T). The response time is 5 minutes during the daytime (A), and the overlap time uses 22 minutes 3.12 seconds (E+L), so that the time required for evacuation is as follows:

= 1.25(A+T) + 2/3(E+L)
= 1.25(5'+59") + 2/3(22'3.12")
= 20'57"

So, the simulation results in scenario 2 are about 20 minutes 57 seconds for the evacuation process.

In scenario 3, the fire point is in the right-side engine room, so that during the evacuation process, the door near the starboard staircase cannot be used because the position of the door is too close to the source of the fire, so there are only 3 doors that

Table 1. Results of the 3 scenarios

No	Scenario	Number of passengers on board	Number of usable doors	Evacuation time obtained	Evacuation time limit
1.	Scenario 1	208	4 doors	20 minutes 21 seconds	< 60 minutes
2.	Scenario 2	208	3 doors	20 minutes 57 seconds	< 60 minutes
3.	Scenario 3	208	3 doors	21 minutes 1 seconds	< 60 minutes

can be used. So that the evacuation route simulated for the evacuation process uses 3 exit access doors, namely the left side rear door, the left side front door, and the right side front door (Figure 7).

The evacuation simulation in scenario 3 obtained the results, namely from 208 ship passengers it takes time to be able to evacuate out of the room for 63.53 seconds with the condition that the exit door at the back of the right side cannot be used because it is too close to the fire source (Figure 8).

Based on Figure 9, the left front door is the door access that is not chosen by many ship passengers, with a total of 64 people. The most intended number is the right front, with a total of 77 people, and at the back of the left, totaling 67 people. The majority of passengers choose to exit through the door at the front of the ship.

Based on Figure 9, the left front door is the door access that is not chosen by many ship passengers, with a total of 64 people. The most intended number is the right front, with a total of 77 people, and at the back of the left, totaling 67 people. The majority of passengers choose to exit through the door at the front of the ship.

From the simulation results above, the total time required for the evacuation process is 1 minute 3 seconds (T). The response time is 5 minutes during the daytime (A), and the overlap time uses 22 minutes 3.12 seconds (E+L), so that the time required for evacuation is as follows:

= 1.25(A+T) + 2/3(E+L)
= 1.25(5'+1'03) + 2/3(22'3.12)
= 21'1"

So, the simulation results in scenario 3 are about 21 minutes and 1 second for the evacuation process.

Based on the 3 scenarios that have been carried out, the simulation results for KMP Trisna Dwitya have met the regulations set by MSC.1/Circ. 1238, which is less than 60 minutes, so that during the evacuation process in the future if there is a fire incident on the ship, passengers can evacuate quickly so that casualties occur a fire incident on the ship, passengers can evacuate quickly so that casualties can be minimized (Table 1).

Based on experiments from several simulations, it can be seen that there are differences and the evacuation time process. One example in terms of time, when the evacuation process in the scenario when the fire point is on the main deck is quite short because the exit access can be accessed maximally by using all available doors, namely 4 access doors.

In the scenario simulation when the fire point is in a certain place such as above the engine room which coincides under the up and down access to the passenger room, so that it can hamper the evacuation process. so that the time needed is slightly longer because the exit access cannot be accessed optimally because the exit can only be used 3 out of 4 doors.

The simulation process with Pathfinder software only has a predictive and simulation function based on the regulations that have been implemented. IMO calculation guidelines: there are several things in the calculation, including waiting time on each deck and estimation of the level of awareness in humans towards the environment, to cause an extension of time. While in the simulation, there is no waiting time and awareness, so that the simulation time can run simultaneously.

Conclusion

Based on the simulation results for scenario 1, where the fire point is located on the main deck of the ship, the evacuation time is 20 minutes 21 seconds. In scenario 2, where the fire point is located in the engine room on the left side of the ship, the evacuation time is 20 minutes 57 seconds. In scenario 3, where the fire point is located in the

engine room on the starboard side of the ship, it takes 21 minutes and 1 second.

The evacuation results from scenarios 1 to 3 are already a fast evacuation and are by the provisions of the IMO, which is less than 60 minutes. So that KMP Trisna Dwitya has met the standards that have been determined.

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