The design of the ship's fuel estimation simulator uses a case study of the bung tomo trainer ship

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Abstract. The calculation of ship operating costs is a major element in determining tariffs. The determination of high or low tariff is very important in the shipping business. In other words, determining the proper ship operating costs is the key to the success of the shipping business. There are several components in determining the operational costs of a ship, one of which is the calculation of fuel needed to cover a certain distance. Usually for new routes, the calculation uses the formula specified by the Minister of Transportation No. KM. 58 of 2003. However, this manual calculation requires a lot of time and human error factors will result in inaccurate calculation results. So, we need a more effective and efficient way to calculate the amount of fuel needed to cover a certain distance. In this study, a simulator was developed that uses the concept of a spherical triangle to determine the distance and direction of a ship and then integrates it with the formula of the Minister of Transportation to get the results of the fuel calculation. From the results of 2 trials using the Bung Tomo Training Ship, the calculation results were faster and more accurate. Even more, the simulator users can simply click two points as the beginning and end of the ship's journey. Thus, the simulator can simplify the process of calculating ship operating costs, especially the determination of new routes in the shipping business.

1. Introduction

The determination of vessel operating costs is a major element in determining tariffs. The determination of high and low tariffs is very important in the shipping business. Engine fuel is one component of ship operating costs. Bung Tomo Training Boat is a 1200GT Special Purpose training ship which requires engine fuel on the cruise route. All costs for the use of engine fuel must be calculated in detail. To determine the right objectives for passengers so that the company gets maximum revenue.

However, the problem that must be faced is the calculation of the amount of engine fuel needed is still using the manual method, namely how to calculate manually with the formula. This method takes a long time and can only be done by some people. Researchers are interested in optimizing the calculation time so that it is faster and the determination of the amount of fuel oil can be done by anyone.

The method to be carried out in this research is to create an application that can quickly calculate the amount of engine fuel needed from one place to another simply by clicking on those two places. Henceforth, this application is called as Simulator. A simulator is a tool for the process of implementing
the model into a computer program (software) or electronic circuit and executing the software in such a way that its behavior mimics or resembles a real system [1]. The simulator is designed in the form of software to calculate the estimated operational costs of the ship when the ship will sail [1] [9] [10].

This study aims to describe the process and the results of a good simulator design [2]. A good simulator is the fuel output calculation is the same as the manual method using the formula from the transportation ministry. However, the calculation time with the help of the simulator is faster than the manual method using the formula. Besides, the simulator is said to be good if it is easy to use by anyone.

2. Method
There are three stages in making this simulator. The first stage is the search for ship data (ship type data, ship engine, and ship engine fuel consumption data). In this study, the Bung Tomo training boat was used as a case study. The second step is storing data that has been inputted as a database in my SQL. The third stage is programming the simulator in PHP my Admin. At this stage, the researcher enters the formula from the transportation minister about how to calculate the engine fuel needed to reach a certain distance. The amount of fuel oil consumption can be determined using the following equation:

\[
W_{FL} = \frac{(P_{bme} \cdot bme + P_{ae} \cdot bae) \cdot S}{V \cdot 10^{-6} \cdot Add}
\]

\[
W_{FE} = (P_{ae} \cdot bme) \cdot wp \cdot 10^{-6}
\]

With:
- \( W_{FL} \) = Fuel consumption at sea (Kw)
- \( W_{FE} \) = Fuel consumption at the port (Kw)
- \( P_{bme} \) = Main Engine Power
- \( P_{ae} \) = Auxiliary Engine Power
- \( bme \) = Weight of lubricant in main engine (1.2-1.6gr/Kwh)
- \( bae \) = Weight of lubricant in auxiliary engine (1.2-1.6gr/Kwh)
- \( S \) = Distance (Mile)
- \( V \) = Speed (Knot)
- \( Add \) = Reserve factor (1.3 – 1.5)
- \( wp \) = Time at the port (hour)

The map display used in this simulator is google map. The user can utilize the map display to determine the shipping route by clicking on the map. Besides, it can be inputted by the location coordinates for the shipping route.

3. Results and Discussion
Our discussion begins by identifying the diesel engines of ships that consume fuel. Here are the details (see Table 1):

| Type of engine       | Status   | RPM   | Fuel consumption (Liter) |
|----------------------|----------|-------|--------------------------|
| Main Engine I (SS)   | Full Speed | 1200  | 25/hour                 |
|                      | Idle Speed | 700   | 54/hour                 |
|                      | Manoeuvre  | 900   | 25/hour                 |
| Main Engine II (PS)  | Full Speed | 1200  | 25/hour                 |
|                      | Idle Speed | 700   | 54/hour                 |
|                      | Manoeuvre  | 900   | 25/hour                 |
| Generator SS (STBD)  | Idle Speed | 720   | 30/hour                 |
| Type of engine       | Status         | RPM | Fuel consumption (Liter) |
|---------------------|----------------|-----|-------------------------|
| Generator MS        | Idle Speed     | 720 | 30/ hour                |
| (Middle)            |                |     |                         |
| Generator PS        | Idle Speed     | 720 | 30/ hour                |
| (port)              |                |     |                         |
| Generator Harbour   | Idle Speed     | 600 | 25/ hour                |
| Main Engine AX      | Full Speed     | 50  | 15/ hour                |
| Main Engine AX      | Full Speed     | 100 | 15/ hour                |

This simulator development uses PHP My Admin as a prototype/display, My SQL as a database, and Google map as a digital map [3][4][5]. The simulator design is made/design to facilitate the user in operating it. This simulator is a software to calculate ship engine fuel that can be used easily by users [6][7][8]. Figure 1 follows the simulator display design.

![Figure 1. Main Page Map](image)

To be able to determine Bung Tomo Training Boat’s engine fuel consumption, firstly we input the ship's data as follows (see Figure 2 and Figure 3):

![Figure 2. Input Data of Boat](image)
Then we input Machine Rate Consumption Data (see Figure 4) and Data for Ships Route Plans (see Figure 5) as follows:
After the data input process is done, then we test the simulator that we have made.

3.1. First Trial
The first trial was conducted by shipping routes from the port of Surabaya to the port of Makassar. We can see in Figure 6.

![Figure 6. Route of the First Trial (Surabaya-Makassar)](image)

![Figure 7. Consumption List of Fuel](image)

Based on the first trial data (see Figure 7) the trip from Surabaya to Makassar obtained a distance of 449.73 miles with a travel time of 53 hours 25 minutes, thus requiring 4596.4 liters of fuel on the engine.

3.2. Second Trial
The second trial was conducted by shipping routes from the port of Semarang to the port of Banjarmasin. We can see in Figure 8.
Based on the second trial data (see figure 9) the trip from Semarang to Banjarmasin obtained a distance of 356.82 miles with a travel time of 41 hours 32 minutes, thus requiring 3094.48 liters of fuel on the engine.

4. Conclusion
Based on the description and analysis of the results and discussion, it appears that the Simulator can display the ship's distance and direction of the ship so that the Simulator can display fuel consumption correctly. The time needed for the calculation is not as long as the manual calculation using the formula from the transportation ministry, because the results can be directly obtained after the data input process is carried out. This simulator can be used by anyone with a guarantee that the calculation of the amount of fuel used will be the same as a manual calculation using a formula.

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