Development of Fuel Calculation Applications Android Based for Ship Operations

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Abstract. This study aims to develop an android-based application to calculate the amount of fuel adjusted to the distance and speed of the ship based on the trajectory (way point). The calculation of distance in this application uses the concept of a spherical triangle which is used in voyage navigation. This development adopts the Waterfall model with the stages of Requirement Engineering, Design and implementation, Testing, Release and Maintenance. At the product review stage, it involves software experts (to provide criticism and suggestions for improvement), then testing is carried out by comparing the results of calculations using applications with manual calculations and ECDIS (electronic Chart Display Information System). The test results show that there is no significant difference between the results of calculations using the application with manual calculations and ECDIS. Thus, this application can be used to calculate the amount of fuel needed according to the distance traveled and the speed of the ship based on the selected trajectory.

1. Introduction
Sailing planning requires readiness both from the deck and from the engine. One of the preparations needed in sailing is determining the amount of fuel that will be used during the sailing period from the port of departure to the port of destination. Thus, the ship will not be short of fuel during sailing, nor will it have excess fuel, thereby increasing the load that affects the ship’s motion and ship speed. Efficient use of fuel is not only needed by ship operators but also ship owners. Thus, it can be estimated effectively and efficiently the amount of fuel that should be filled in the tank [1,2,3].

In addition, the calculation of fuel also considers the speed and direction of ocean currents, the type and condition of the main engine, the type and condition of auxiliary machinery, the history of fuel use and distance traveled, the direction of the ship and the speed of the ship, as well as the distance traveled by each way point to be traversed. Taking into account the many factors above, it is deemed necessary for practical calculations that make it easier to calculate the amount of fuel needed using Android-based software so that it is easy to use by sailors and cadets as well as ship owners by using applications that can be installed on each user’s cellphone [4,5,6].

The android system used in this software development research uses android version 4.0 Ice Cream Sandwich which is in accordance with the Android SDK developed by Google. Android is an operating system and programming platform developed by Google for smartphones and other mobile devices (such as tablets). Android can run on several kinds of devices from many different manufacturers (GDTT, 2016: 6). Software Development Kit or SDK is a program that is used to compose coding in producing application programs that are used in tablet and smartphone devices. The SDK can be
installed on any operating system on Windows, Macintosh and Linux. The advantage of this SDK is that it can interact with other systems, namely the Java Development Kit (JDK) and the Eclipse integrated development environment (IDE). They are not used directly in Android coding, and connections can be made with both systems [7,8,9,10].

2. Method
Research on the development of Android-based ship fuel calculation software uses the waterfall development model. The development of this product has several stages, namely: Requirement Engineering, Design and Implementation, Testing, Release, and Maintenance.

2.1. Requirement Engineering
The development of Android-based ship fuel calculation software begins with a needs analysis process, namely communicating between developers and users (seafarers, cadets and lecturers of Politeknik Pelayaran Surabaya). According to this model, the user must provide all the terms and conditions in advance.

2.2. Design and Implementation
The design of Android-based ship fuel calculation software development includes all calculations of costs, time, labor for Android-based ship fuel calculation software, and manufacturing schedules. Next is the implementation, namely the development of Android-based ship fuel calculation software in accordance with the requirements proposed by the user. In this process, the developer creates an Android-based ship fuel calculation software according to the schedule (time line) that is made so that the Android-based ship fuel calculation software can be completed on time.

2.3. Testing
At this stage the test is carried out to test the development product in the form of Android-based ship fuel calculation software for sailors, cadets and lecturers of the Surabaya Shipping Polytechnic. Products can be downloaded at https://pelautmodern.com. This test also involves cognate teachers to see test activities and provide assessments and input to the developer. In this test, it is seen how the product is used by cadets and how the evaluation is carried out by the developer to see the effectiveness of the product. Then it is seen whether there are product deviations because they do not comply with the requirements at the beginning.

2.4. Release
The final result is the stage of product refinement after undergoing testing. so that the product developed is the final product that has been refined and is directly used by the user. All seafarers, cadets, and teachers can access the Android-based ship fuel calculation software through the https://pelautmodern.com website.

2.5. Maintenance
Improvements will be made after receiving feedback on the results of the product release.

To calculate the fuel used by the main engine can use the formula below:

\[
W_{FL} = \frac{(Pbme.bme + Paé.baé) S}{V.10^{-6}.Add}
\]

\[
W_{FE} = (Paé.bme).wp.10^{-6}
\]

With:
- \(W_{FL}\) = Fuel consumption at sea (Kw)
- \(W_{FE}\) = Fuel consumption at the port (Kw)
- \(Pbme\) = Main Engine Power
- \(Paé\) = Auxiliary Engine Power
- \(bme\) = Weight of lubricant in main engine (1.2-1.6gr/Kwh)
As with the Waterfall development model, the following stages have been carried out, namely Requirement Engineering, Design and Implementation, then the testing stage has been carried out. The testing phase aims to test the development product in the form of an android-based ship fuel calculation application by comparing the results of the software with the results of manual calculations and also using ECDIS. In the test, the results of the calculations will be presented to determine the suitability and error of each calculation.

In the manual calculation test, to get the results of ship fuel, a calculation will be carried out in several stages, namely: distance calculation, travel time calculation and fuel consumption calculation. Calculation of this fuel will be selected 5-way points as the menu displayed in the application. 5 Way Points data as follows:

| Way Point | Latitude   | Longitude    | Status   | Speed | Fuel consumption |
|-----------|------------|--------------|----------|-------|------------------|
| WP0       | 7.195893 S | 112.734147 E | Maneuver | 3 knot | 40 liter/jam     |
| WP1       | 7.171708 S | 112.697175 E | Full speed | 8 knot | 100 liter/jam    |
| WP2       | 6.832139 S | 112.630298 E | Full speed | 8 knot | 100 liter/jam    |
| WP3       | 6.652843 S | 112.575968 E | Full speed | 8 knot | 100 liter/jam    |
| WP4       | 6.252691 S | 111.051475 E | Full speed | 8 knot | 100 liter/jam    |

The following is a picture of the position of each way point.

Figure 1. WP0 position (private doc)
Figure 2. WP1 position (private doc)

Figure 3. WP2 position (private doc)

Figure 4. WP3 position (private doc)
Figure 5. WP4 position (private doc)

Tabulation of manual calculations using Microsoft excel as follows.

| Waypoint | Degree  | Distance | Speed | Time  | Fuel Consumption (liter/hour) | Fuel (liter) | Fuel (ton) |
|----------|---------|----------|-------|-------|-------------------------------|--------------|------------|
| WP0      | -       | -        | -     | -     | -                             | -            | -          |
| WP1      | 0.043937| 2.636225 | 3     | 0.8787| 4153                          | 35.149       | 0.02864697 |
| WP2      | 0.345996| 20.75975 | 8     | 2.5949| 6925                          | 259.49       | 0.21148999 |
| WP3      | 0.187238| 11.23429 | 8     | 1.4042| 859                           | 140.42       | 0.1144493  |
| WP4      | 1.566791| 94.00749 | 8     | 11.750| 9362                          | 1175.0       | 0.9577013  |
| Total    |         | 128.6378 |       |       |                               | 1610.1       | 1.3122     |

Based on table 2 regarding the calculation of distance and ship fuel, the distance traveled from each trajectory using the calculation of a spherical triangle is obtained. On track 1 it is different from other trajectories because the ship is maneuvering at a speed of 3 knots, while on track 2 to 5 it uses full speed or full speed of 8 knots. Each trajectory produces different travel times and fuel consumption so that after the accumulated total distance traveled by the ship is 128.6378 miles and the total fuel consumption is 1,610.1688 liters. Conversion in tons with the assumption that the density of diesel fuel is 815 kg/m³ and the result is 1.31 tons of diesel.
Based on Figure 6, it is obtained for the portion of fuel consumption on each track (in tons) along with the percentage calculated at a certain speed and distance so that with this picture it can be easily read the fuel consumption of the ship on each track. The first trajectory is the shortest trajectory with fuel consumption of 0.0286 tons or 2% when maneuvering out of port. The fourth track is the furthest trajectory that covers a distance of 94 miles for 11.7 hours, consuming 0.957 tons of diesel fuel or 73% of the fuel used of the entire track traversed.

For the next test, the calculation using the application is distinguished in 2 conditions of the ship's speed, namely when maneuvering and when the ship is moving at full speed. For calculations on the first trajectory, the ship maneuvers with a ship speed of 3 knots and the fuel consumption is assumed to be 40 liters/hour. The results of the calculation of distance and fuel for the first track from WP0 to WP1 are as follows.

**Figure 6. Fuel consumption based on waypoint**

**Figure 7. Fuel consumption with app in WP1**

**Figure 8. Fuel consumption with app in WP2-4**
Manual calculations using Microsoft Excel give a distance of 2.636225 miles while using the application (see Figure 7) the results are 2.63613 miles or there is a difference of 0.00009459846 miles or 17 cm, because the distance difference is very small, then the difference has no significant effect (if 17 cm compared to a cargo ship length of 53 meters). The amount of fuel based on calculations using Microsoft Excel is 35.149661 liters or 0.0286 tons, this result is close to the application calculation results, which is 0.02865 tons. The difference in the calculation of fuel is 0.00005 tons or 0.06 liters of diesel.

Based on the results of distance and fuel calculations using the application (see Figure 8), there is no significant difference. Calculations using the application obtained a distance of 126,00139 miles, not much different from manual calculations of 126,00139 miles or about 26 cm. Calculation of the amount of fuel from tracks 2 to 4 is estimated to spend 1.28364 tons of diesel. The results of the application calculation when compared with manual calculations showed 1.283 tons with these results there was no significant difference because there was only a difference of 0.0064 tons or about 7.8 liters.

4. Conclusion
From the result and discussion, it shows that this android application can display fuel consumption correctly based on the ship’s velocity and distance. After inputting the ship’s data, this android application automatically shows the result. So, the time needed for calculation is very short when compared with manual calculation using formula of transportation ministry. For the validity, the results of calculations using the application with manual calculations and ECDIS has no significant difference. Therefore, this application can be used to calculate the amount of fuel needed based on the selected trajectory.

5. References
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