

Designing a Real-Time Fuel Consumption Monitoring Dashboard for Ships

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Article History:

Received 24 April 2025;

Revised 5 May 2025;

Accepted 8 May 2025;

Available Online 2 June 2025

Keywords:

Dashboard

Fuel

Monitoring

Vessel

Real-Time

Abstract

Fuel usage on ships is a crucial aspect of maritime operations, affecting cost efficiency and sustainability. A calculation carried out by the operational team is required in order to obtain information about the ship's fuel usage. However, the method of calculating fuel usage that is still manual by sounding is still prone to calculation errors and inefficient. Therefore, a system is needed that can assist the operational team in calculating and obtaining fuel usage data quickly and efficiently. This research aims to design a dashboard monitoring system that can monitor ship fuel usage in real-time. Real-time monitoring is important for quick identification of inefficiencies, ensuring safety, and supporting timely decision making. This system can assist the operational team in obtaining data and information on fuel usage more quickly and accurately. The methodology used in this research includes analyzing system requirements, designing system architecture, and implementing dashboard monitoring software. The result of this research is a dashboard system that is able to provide real-time information about fuel usage, making it easier for the operational team to monitor and make decisions. With this system, the efficiency of fuel usage can be increased and the pros of fuel usage can be improved.

I. INTRODUCTION

The maritime sector plays a very important role in the global and local economy. As the backbone of international trade, the maritime sector provides efficient distribution channels for goods and resources. This results in significant economic growth and can create considerable employment opportunities for the community. In addition, the maritime sector also plays a key role in the transportation of energy and natural resources such as oil, natural gas and mines. Approximately 90% of the world's total trade volume is carried by sea and around 61% of the world's oil is also distributed by sea (Ismail & Kartika, 2019).

However, in the midst of the rapid development of the maritime industry, there are important things that need to be considered for the continuity of ship activities in operation, one of which is the use or consumption of ship fuel. Fuel oil (BBM) in the operation of the engine on board is a basic need that cannot be separated (Nugraha et al., 2022). Ship fuel consumption is one of the most important and crucial aspects in the sustainability of ship operational activities, because it has a direct impact on the efficiency and cost of operating the ship. Fuel consumption on board is one

of the things that uses the largest operational budget with a range of 70% of the total ship operating costs (Almuzani et al., 2020). Fuel costs for the maritime industry are the most important expense item (Uyanik et al., 2019). In response to this, shipping companies and ship-owners are also exploring ways to reduce fuel consumption and improve ship energy efficiency, which requires obtaining fuel consumption data in a timely and accurate manner (Yin et al., 2017).

Of course, this will be a special concern for companies engaged in the maritime sector to always monitor and manage the use of fuel on ships optimally so that there is no waste (Nugraha et al., 2022). Therefore, it is necessary to carefully monitor the use of fuel on the ship. One way to monitor fuel usage is by conducting manual fuel sounding by the team on duty, namely the ship's crew. The ship's crew is tasked with carrying out the fuel sounding task and monitoring the data obtained from the fuel sounding results is the task of the operational team.

Fuel sounding is the process of measuring or monitoring the level of fuel oil remaining in a ship's tanks. It is an important practice in ship management and voyage planning as fuel is the main source of energy to run the ship's engines and propulsion. This process is usually carried out periodically by the ship's crew using specialized gauges. Fuel sounding is done by inserting the measuring device into the ship's fuel oil tank through the measuring hole on top of the tank. Once the device reaches the surface of the fuel in the tank, the fuel level can be read on the scale or markings found on the gauge. The information obtained from this sounding process is then recorded and used to monitor the ship's fuel consumption and for planning the next refueling. This fuel sounding process is carried out routinely by the crew, especially before and after the voyage, as well as during the voyage to ensure that the vessel has enough fuel to reach its destination safely. In addition, regular monitoring of fuel levels also helps in detecting leaks or other problems that may occur in the vessel's fuel tanks.

Of course, in monitoring ship fuel consumption there are obstacles and difficulties that must be faced such as, the operational team is very dependent on the ship's crew to receive fuel usage data, the ship's crew must have the knowledge and ability to conduct fuel sounding so that there are no errors in obtaining fuel usage data or prone to human error, the time and process required to obtain fuel usage data on the ship is not flexible, if you want to get usage data for one hour then the ship's crew must be ready to do sounding every one hour periodically, ship and sea conditions that do not allow for fuel sounding such as strong waves, the absence of a system that helps the operational team in monitoring fuel in real-time and other obstacles. Manual monitoring presents several challenges: supervisors find it difficult to observe thousands of monitoring points in real-time simultaneously, the process is time-consuming, and it requires high mobility. Implementing technology offers a viable solution to overcome these limitations. A system-based environmental monitoring approach can automatically and simultaneously detect environmental conditions in real-time (Darmatasia et al., 2021). With the difficulties that must be faced, it will certainly slow down the performance process of the ship's crew in conducting fuel soundings and slow down the process of obtaining fuel usage data for monitoring by the operational team. Therefore, a system is needed that is able to help and facilitate the operational team in monitoring fuel usage on ships efficiently and productively.

II. LITERATURE

By considering the existing obstacles, a system is needed that assists the operational team in calculating fuel usage on board efficiently. One promising solution is the integration of Internet of Things (IoT) technology, which has significantly advanced digitalization in various sectors (Ye et al., 2024). The proposed system uses automatic monitoring with sensors integrated into IoT

networks, with data displayed in real-time through a web-based dashboard to track fuel usage on ships. The data used by the system comes from a Flow Meter type sensor device installed directly on the ship, then the data that has been read by the sensor will be sent to the Data Center via satellite using a satellite terminal. In a related application of IoT-based monitoring, IoT-connected RFID systems can communicate with centralized servers to update and manage access data in real-time, providing administrators with up-to-date information on access points. RFID sensors operate based on radio signal principles, enabling the identification of specific objects and translating the captured data into other useful information formats (E. D. Kusuma et al., 2023). IoT is a system that can integrate various smart devices into a network, allowing them to communicate with each other as well as interact with their surrounding environment. IoT can also be used for inventory management, asset tracking, and energy management, among other applications. Smart factories use IoT devices to create a connected and automated environment that enables real-time monitoring, analysis, and control of manufacturing processes (Soori et al., 2023). These systems can also integrate with web platforms and communication applications, to provide notifications and streamline user access remotely management and real-time notifications, and evaluating the system's accuracy in identifying valid ID cards for authorized access. It is anticipated that this prototype will provide an effective and efficient solution for campus access management and serve as an inspiration for similar security system implementations (Anwar et al., 2025). Data that is already in the Data Center can be accessed using the API endpoint that has been provided.

Research conducted by Hapsari et al. (Hapsari et al., 2021) aims to develop an automatic fuel consumption monitoring system using a flow sensor type YF-S201 and ultrasonic level sensor type HC-SR04 connected to an Arduino MEGA microcontroller. The results of the measurements of these two sensors will be displayed through the LCD installed on the system and sent to the IoT Cloud on the website using the WI-FI module. From the results of this research, it is concluded that the Arduino microcontroller can be used as a tool for automatic fuel monitoring. The ultrasonic level sensor provides fairly accurate results with a deviation of ± 0.5 cm, allowing precise measurement of the volume of fuel in the tank. The HC-SR04 ultrasonic sensor is a device used to measure the distance of an object, with a measurable range of approximately 2–450 cm. However, the results of the flow sensor measurement still have a considerable difference with an accuracy of 59% which is caused by the flow of fuel below 1 liter/minute not being measured by this type of flow sensor (L. W. Kusuma et al., 2023).

Research conducted by Chen et al. In (Chen & Chien, 2015) discusses the development and implementation of a Fuel Management System (FMS) aimed at monitoring several vehicles simultaneously. This system is made to monitor real-time fuel consumption through a combination of Vehicle Tracking System (VTS), GPS, GPRS/3G modem, and Web Server using Machine to Machine (M2M) technique with data coming from the On-Board Diagnostics 2 (OBD-II) system of each vehicle. The system can display data in the form of a comparison chart between the fuel consumption of the vehicle and the driver. By looking at the chart data comparison, this system can help distinguish the driver or vehicle that has a problem, such as if one vehicle is used by different drivers but shows the same fuel consumption results and it is quite wasteful then the problem is the vehicle, and vice versa. With the results obtained by Chen et al. concluded that using M2M techniques as the main structure of the research can save costs and can also provide data instantly and precisely. By combining the developed fuel usage calculation system and OBD-II data transmission technique using GPRS/3G Modem to FMS Management Server (MS), it can calculate and analyze fuel usage precisely and in real-time.

III. RESEARCH METHOD

The stages of this research consist of several steps, namely requirements, design, development, testing, deploy, and review, which are shown in Figure 1.

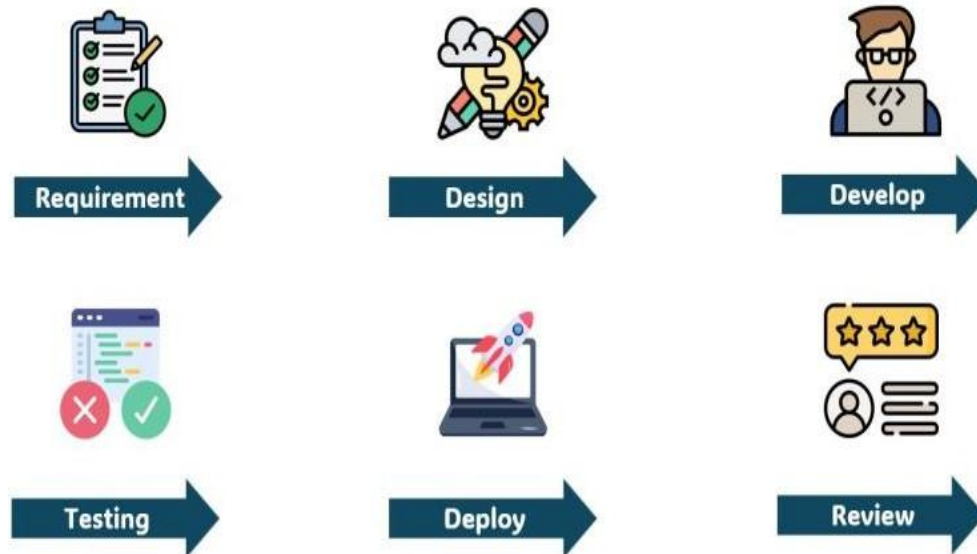


Figure 1. Research Phase

At the requirement stage, a requirement elicitation process is carried out which aims to collect and document system requirements from users. In the context of this research, the main users are the ship's operational team who are in charge of the office to monitor the ship's fuel usage. The requirement elicitation process was conducted through several methods, including direct interviews, surveys, and focus group discussions with the operational team. The purpose of this requirement elicitation is to deeply understand the needs and expectations of users regarding the fuel monitoring dashboard system to be designed.

The operations team needs a system that can display real-time ship fuel usage data. This information is crucial for monitoring fuel usage efficiency and making timely decisions. In addition, the system should be easily accessible to the operational team from various devices and have an intuitive interface so that users can quickly understand and use the system without requiring extensive training. In addition to real-time monitoring, the system should also be able to generate comprehensive reports and analysis on fuel usage within a certain period. This report will assist the team in conducting operational evaluation and planning. The dashboard system to be built should be able to integrate with existing systems in the office, such as the vessel tracking system or fuel management system, to improve efficiency and data accuracy. Given the sensitivity of the information being managed, the system should be equipped with strong data security mechanisms to protect the information from unauthorized access.

At the design stage, the system is designed to display two main pages, each of which serves to fulfill the team's operational needs in monitoring the ship's fuel usage effectively and efficiently. The first page is the chart page, which is designed to display various graphs that provide a visual overview of fuel usage. The graphs include a fuel consumption chart to monitor overall fuel consumption, daily, monthly, and hourly rate fuel consumption charts, and an RPM chart that shows engine revolutions per minute. These visual displays are designed to make it easier for users to analyze fuel usage trends and identify potential operational efficiencies. The system design on the chart page can be seen in Figure 2.

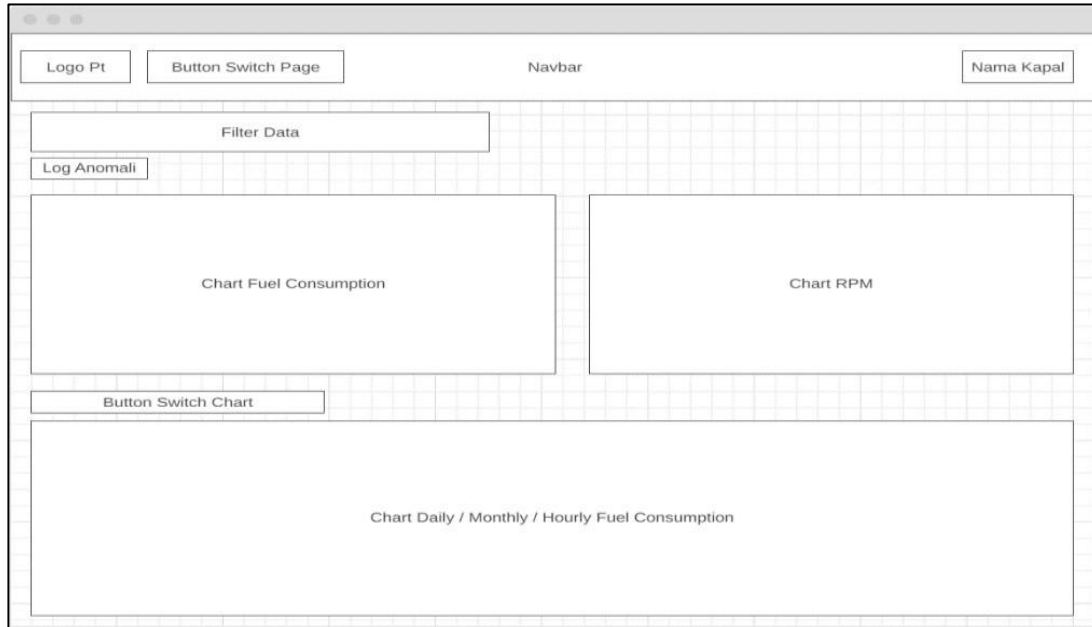


Figure 2. Chart Page Design View

The second page is the trackpoint page, which is designed to display data in the form of a report table. This table includes a summary of fuel usage based on user-defined data filters, as well as the full data held by the dashboard. The design of this page ensures that the information presented can be easily accessed and utilized for evaluation and reporting purposes. To support further documentation and analysis needs, this table can be exported into various formats and sent via email, allowing users to share the information with relevant parties more effectively. The system design view on the trackpoint page can be seen in Figure 3.

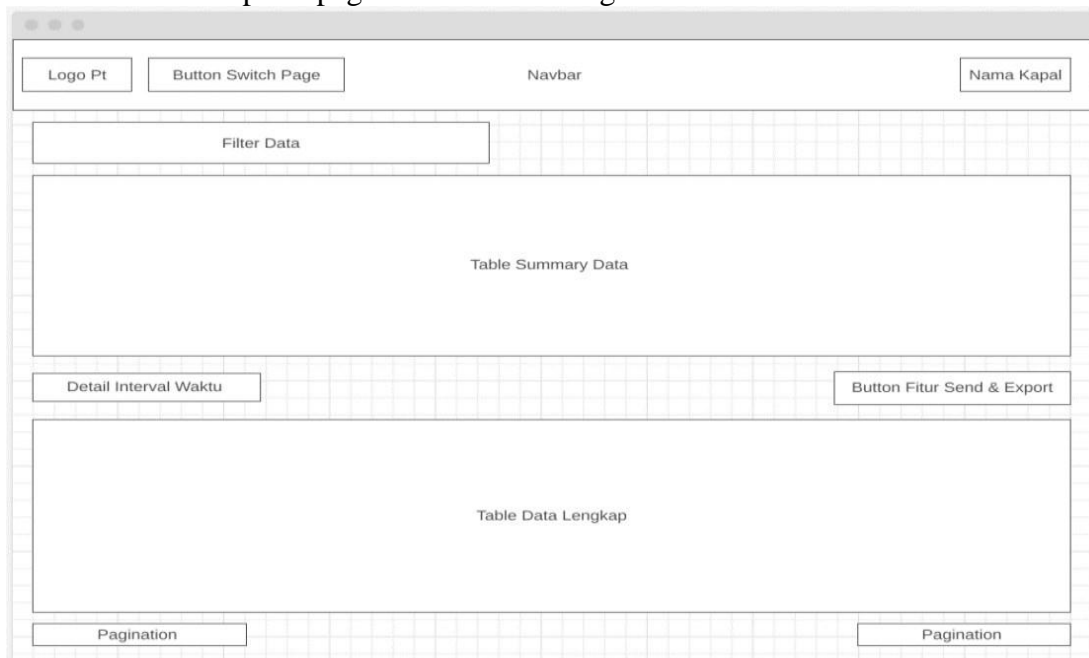


Figure 3. Trackpoint Page Design View

In the development stage, the dashboard monitoring system was developed by utilizing various latest web-based technologies to ensure optimal performance and good user experience. The

front-end or client side of the system is built using ReactJS, a popular JavaScript library that allows the creation of dynamic and responsive user interfaces. ReactJS is a JavaScript library for developing reusable user interface (UI) components (Murti et al., 2021). To improve the visual appearance and speed up the development process, TailwindCSS is used as a CSS framework that facilitates consistent and efficient styling. Tailwind CSS is a CSS framework designed to simplify the creation of website display components by offering important functions such as setting margins, object sizes, positions, colors, and more (Arhandi et al., 2022).

On the back-end or server side, development is done using Node.js and Express.js. Node.js is a JavaScript runtime environment that allows the execution of JavaScript code on the server, providing fast performance and good scalability. Node.js is an open source and cross-platform runtime environment used to develop web applications (Rismanto et al., 2016). Express.js, as a minimalist and flexible framework, is used to build APIs and handle HTTP requests efficiently. Express.JS is a framework derived from Node.JS that serves to simplify the creation of Node.JS-based applications (Sulistiyorini et al., 2022). The combination of Node.js and Express.js enables the development of lightweight and responsive servers, and supports the integration of various services and modules.

For data storage, PostgreSQL is used as a relational database management system. PostgreSQL was chosen for its reliability in handling complex data transactions and its ability to manage large volumes of data. The data structure designed in PostgreSQL ensures that all information related to ship fuel usage can be stored and accessed quickly and securely. PostgreSQL is an Object-Relational Database Management System (ORDBMS) that combines features typical of traditional DBMSs with improvements and functionality found in current generation DBMS systems (Aminullah et al., 2020).

At the testing stage, the dashboard monitoring system is tested using a blackbox testing approach to ensure that its functionality meets the specifications set and can be relied on by users. Black Box testing focuses on testing software functions based on input conditions without looking at internal code (Abdi & Nursari, 2022). Blackbox testing focuses on testing external functions without examining internal structures or source code (Basri & Gunawan, 2021). Tests were conducted on the chart page to ensure that charts such as fuel consumption chart and RPM chart display data accurately, as well as on the trackpoint page to ensure that the report table can be accessed and exported correctly.

In addition, testing also included user interface verification to ensure easy navigation and intuitive interaction. The system was tested to ensure optimal responsiveness and functionality on various devices and screen sizes. With this approach, testing was conducted from the user's perspective to ensure the system can operate properly in a real operational environment and is ready to be used by operational teams to effectively monitor the vessel's fuel usage.

At the deploy stage, the dashboard monitoring system is uploaded to the hosting server to ensure that it can be accessed online by the ship's operational team. This process involves server setup, security configuration, and connection testing to ensure that the system runs smoothly and data can be accessed in real-time. Once all preparations are complete, the system is published and tested again to ensure there are no issues in the production environment. Thus, the operational team can start utilizing this system to monitor the ship's fuel usage effectively and efficiently.

In the review stage, an evaluation of the dashboard monitoring system was conducted by distributing questionnaires to users, namely the ship's operational team, to gather feedback on the suitability of the system to their needs and desires. The questionnaire included questions about ease of use, reliability of the data displayed, and whether the system met all the requirements that

had been set. The results of this questionnaire were analyzed to identify areas for improvement and to ensure that the system can be continuously improved to better meet user expectations. This feedback is essential to ensure that the system functions optimally in supporting ship fuel monitoring operations.

IV. RESULTS

Data Transmission Process.

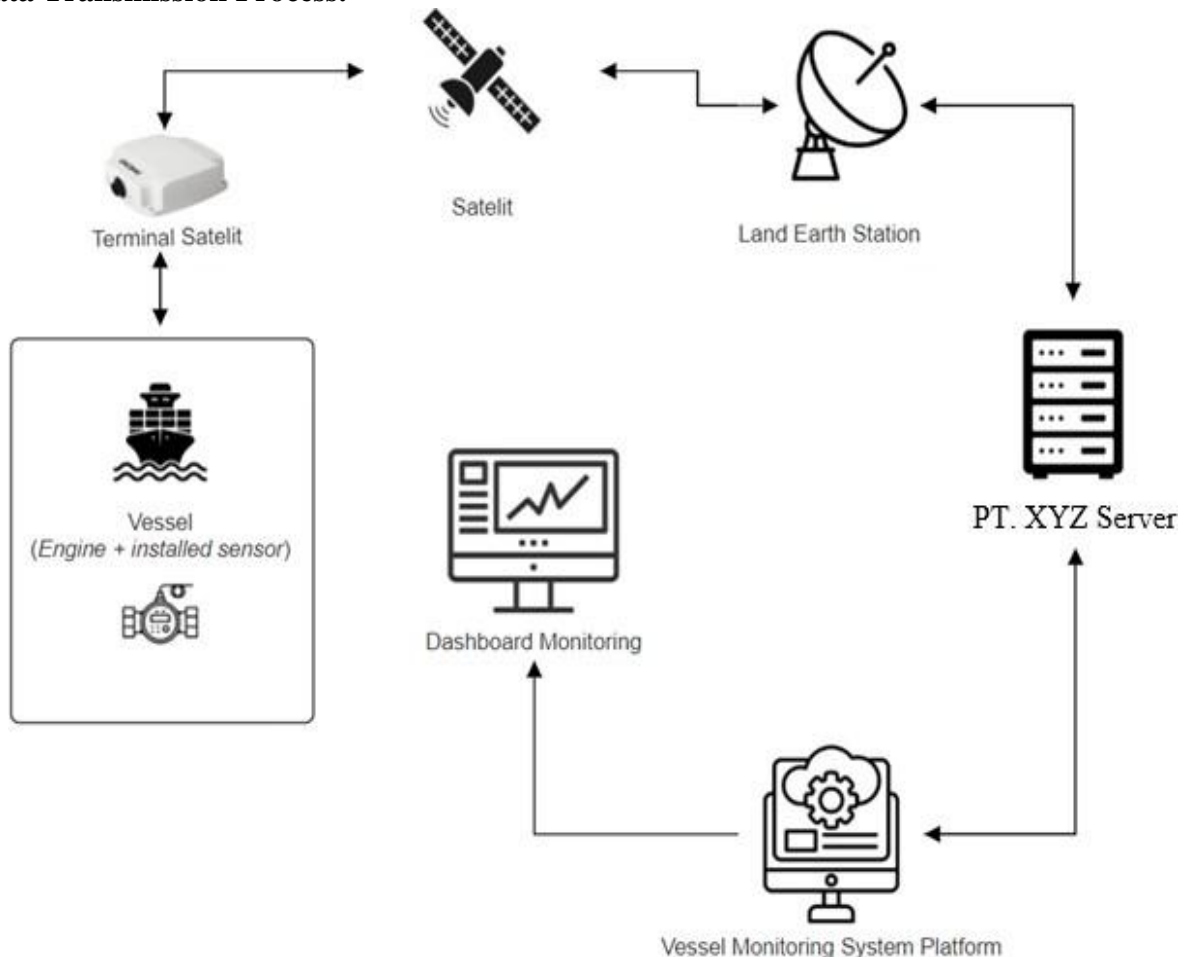


Figure 4. Data Transmission Process

The data transmission process is shown in figure 4, in this study it involves the use of an Internet of Things (IoT)-based independent sensor tool installed directly on the ship's engine. Two types of sensors are used: flow meter sensors and RPM sensors. The flow meter sensor serves to measure and read the amount of fuel flow entering and remaining from the combustion of the ship's engine, while the RPM sensor measures the engine rotation speed. The data read by these sensors is then transmitted through two main channels. First, the data is sent to the satellite terminal, which serves as the main brain in processing and transmitting the read data. Second, the data is sent to a satellite that connects the ship with a data center on land. Once the data is received by the data center, it is forwarded to the company's server via the internet network. This server acts as a data processing and storage center, enabling further analysis and real-time monitoring of the vessel's fuel usage.

Data Capture Process.

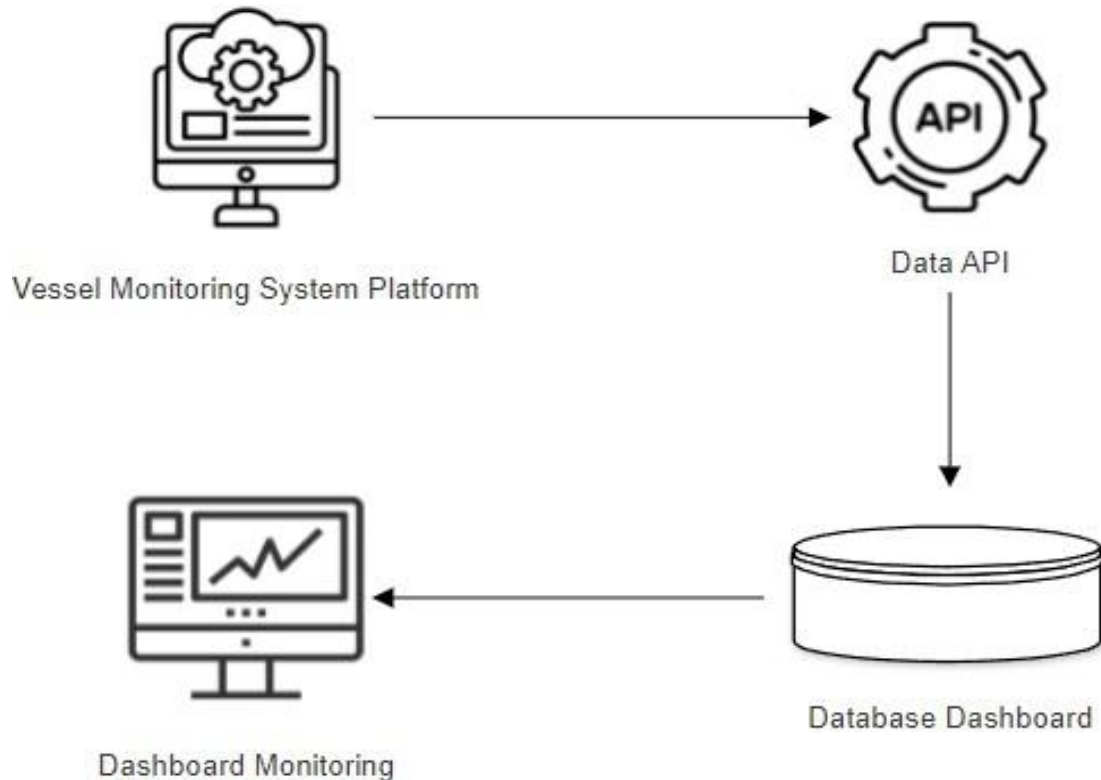


Figure 5. Data Capture Process

The data retrieval process for the monitoring dashboard is illustrated in Figure 5, which delineates the operational flow commencing after the successful storage of data on the central server. Access to the stored data is facilitated via an API Endpoint provided by the organization's primary digital platform. This platform supplies detailed technical documentation outlining the procedures for interfacing with the server through the API Endpoint, including specifications on request formatting, response structures, and authentication protocols. The initial step in the retrieval process involves issuing a data request to the API Endpoint using a pre-generated API token. This token functions as a secure authentication and authorization mechanism, ensuring that only verified and authorized users can access the stored data. Upon successful verification of the token by the API system, the server responds by transmitting the requested data in a predefined JavaScript Object Notation (JSON) format. This standardized format is designed to support efficient parsing and downstream data manipulation.

Once the data is received, it undergoes a series of processing stages to extract information pertinent to the research objectives. These stages may include data normalization, filtering based on specific parameters, categorization, and transformation into formats that are more suitable for analysis. The processed data is then stored in a local or cloud-based database specifically optimized for rapid querying and seamless integration with the monitoring dashboard interface. This workflow ensures that the dashboard continuously reflects the most accurate and up-to-date information available, thereby supporting real-time monitoring capabilities. Furthermore, the system architecture promotes both transparency and data integrity, while enabling the integration of advanced analytical modules and real-time data visualization features. Such capabilities are essential for facilitating data-driven decision-making processes and ensuring that the monitoring system remains robust, scalable, and aligned with best practices in contemporary information system design.

System Design

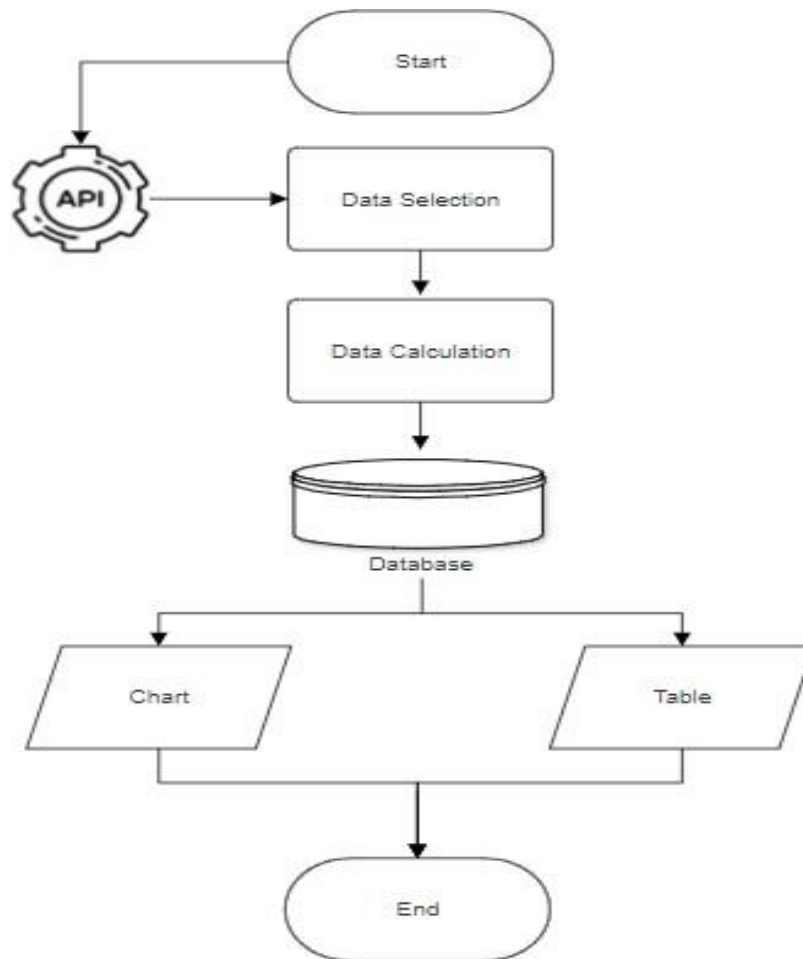


Figure 6. System Design Flowchart

Figure 6 shows that the system designed in this study has two main pages to facilitate users in analyzing fuel usage data effectively and efficiently. The first page of the dashboard displays data in the form of a graph or chart, which allows users to see a visualization of fuel usage. The second page displays data in tabular form, which provides details of fuel usage in a structured and easy-to-read format. Both pages are designed to provide comprehensive and in-depth information on fuel usage, thus facilitating decision-making and operational management.

Data Selection: At this stage is Data Selection or data selection. This process is carried out to make it easier to create a database and get the information needed to create a dashboard. This process involves retrieving data from the API that has been provided by the company. Although the API sends various types of data, not all of the data is relevant for the purpose of this research. There are about 25-50 variables sent by the API of which not all variables can be used and required by the dashboard, such as battery voltage, antenna signal strength and other variables. Therefore, an important first step is to perform data selection to ensure only relevant and useful data is retrieved for further analysis. This data selection process involves several key steps. First, the system will make a data request to the API using the API Key token for authentication. Once the data is received, the system will filter the data based on certain predefined criteria. Data that does not match the criteria will be ignored, while relevant data will be selected and prepared for the next stage. The following variables are selected for use in the monitoring dashboard, which can be seen in table 1.

Table 1. API Variable Table

No	Variable	Detail
1	<i>longitude</i>	Variable containing ship longitude position data
2	<i>latitude</i>	Variable containing ship latitude position data
3	<i>utc</i>	Variable containing the time when the data was sent in ISO UTC format
4	<i>groundSpeed</i>	Variable that contains the speed of the ship's motion
5	<i>mE(n)_RPM</i> (<i>mE1_rpm</i> , <i>mE2_rpm</i> ,)	Variable containing engine rpm data, the letter (n) indicates that this variable can have a certain amount based on the number of sensors installed on the ship.
6	<i>mE(n)_EH_raw</i> (<i>mE1_EH_raw</i> , <i>mE2_EH_raw</i> ,)	Variable containing engine hour data / length of time the engine operates, the letter (n) indicates that this variable can have a certain amount based on the number of sensors installed on the ship.
7	<i>fm(n)_in_raw</i> (<i>fm1_in_raw</i> , <i>fm2_in_raw</i> ,)	Variable containing data on the amount of fuel volume entering the engine, data received in the form of accumulated data from the beginning of sensor installation (raw data), the letter (n) indicates that this variable can have a certain amount based on the number of sensors installed on the ship.
8	<i>fm(n)_out_raw</i> (<i>fm1_out_raw</i> , <i>fm2_out_raw</i> ,)	Variable containing data on the amount of fuel volume remaining from engine combustion, data received in the form of accumulated data from the initial installation of sensors (raw data), the letter (n) indicates that this variable can have a certain amount based on the number of sensors installed on the ship.

Data Calculation: At this stage of system design, namely Data Calculation or data calculation. Data Calculation is the process of processing data to produce useful information or certain outputs. At this stage, the data that has been selected will be processed further to obtain the information needed. The calculation is carried out because the fuel usage data received is in the form of accumulated data since the first installation of the sensor on the ship. Therefore, calculations are needed to find the difference between the latest interval and the previous interval to get fuel usage data that can be used by the dashboard. The following are some of the data calculations carried out:

Amount of fuel entering the engine.

In this calculation, the variable used is *fm(n)_in_raw*, the data contained in this variable is in the form of accumulated data from the amount of fuel volume entering the engine since the beginning of the sensor installation on the ship, therefore a calculation is needed to get how much fuel enters the engine, the calculation is done by finding the difference between the new data and the previous interval data. The following calculation formula used is shown in formula 1.

$$fm_in = data\ terbaru - data\ interval\ sebelumnya \quad (1)$$

Amount of fuel remaining from combustion

In this calculation, the variable used is *fm(n)_out_raw*, the data contained in this variable is in the form of accumulated data from the amount of fuel volume remaining from engine combustion since the beginning of the sensor installation on the ship, therefore a calculation is needed to get how much fuel is left from engine combustion, the calculation is done by finding the difference between the new data and the previous interval data. The following calculation formula used is shown in formula 2.

$$fm_out = data\ terbaru - data\ interval\ sebelumnya \quad (2)$$

Total Fuel Usage

In this calculation, the variable used is a combination of fm(n)_in and fm(n)_out which has previously been processed in advance to get the difference between the latest data and the previous interval data, the calculation is done by finding the difference between the amount of fuel entering and the amount of fuel remaining from engine combustion. The following calculation formula used is shown in formula 3.

$$fm_total_diff = fm_in - fm_out \tag{3}$$

Length of time the machine is in operation

In this calculation, the variable used is me(n)_eh, the data contained in this variable is in the form of accumulated data from the total time the engine has operated on the ship since the beginning of the engine hour installation, therefore a calculation is needed to get data on how long the engine operates at the latest interval, the calculation is done by finding the difference between the new data and the previous interval data. The following calculation formula used is shown in formula 4.

$$me_eh_diff = data\ terbar - data\ interval\ sebelumnya \tag{4}$$

Database: At this stage, a database design is carried out which is needed to store the data that will be used by the monitoring dashboard. In this design, there are two main tables, namely the profile vessel table and the vessel table. The details of the designed tables are as follows:

Profile Vessel Table

The creation of this table is done manually query which serves as the main reference in creating the vessel table, in this table contains data that is input manually based on the information the ship will use the dashboard monitoring system. The list of columns and the structure of the designed table can be seen in table 2.

Table 2. Profile Vessel Table

No	Column	Data Type	Detail
1	Id_app	Varchar(50)	Data to show the client company id
2	Id_user	Varchar(50)	PRIMARY KEY, data to show the client ship id
3	Fms_type	Varchar(50)	Data on the type of fms sensor installed on the ship
4	Me_count	Integer	Data on the number of fms sensors installed on the ship's main engine
5	Eh_count	Integer	Data on the number of engine hours installed on the ship
6	Rpm_count	Integer	Data on the number of rpm sensors installed on the ship
7	Fm_in	Boolean	Data showing whether there is a sensor installed on the fuel inlet
8	Fm_out	Boolean	Data showing whether there is a sensor installed on the fuel outlet

Vessel Table

This table functions as the main table used by the system to accommodate and store previously processed ship API data. The creation of this table is done automatically by the system for each ship. The variables and columns used in this table are based on the ship profile that has been created in the profile_vessel table. In this table there is data such as the time the data was sent, ship speed, rpm data, fuel data entering the engine, fuel data after combustion, longitude position data, latitude, and the amount of fuel used per engine. The list of columns and table structures designed can be seen in table 3.

Table 3. Vessel Table

No	Column	Data Type	Detail
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1	Date_time	Vachar(50)	Timestamp data / time the data was sent
2	Ground_speed	Numeric	Ship speed data when the data was sent
3	Longitude	Numeric	Longitude coordinate data showing the ship's position, in decimal form
4	Latitude	Numeric	Latitude coordinate data showing the ship's position, in decimal form
5	Me(n)_rpm	Numeric	Engine rpm data (average rotations per minute per hour)
6	Me(n)_eh	Numeric	Total engine operating time data
7	Fm(n)_in	Numeric	Data on the amount of fuel entering the ship's main engine.
8	Fm(n)_out	Numeric	Data on the amount of fuel coming out/remaining from the combustion of the ship's main engine.
9	Fm(n)_total_diff	Numeric	Data on the total fuel usage per engine.
10	Fm_total	Numeric	Data on the total fuel usage of each engine (if there are 2 engines, this is the total of the fuel usage of engine 1 + engine 2)
11	Me(n)_eh_diff	Numeric	Data on the difference in engine hours from the previous interval (running hours).

Implementation of Monitoring Dashboard

Chart Page: Figure 7 is the result of the monitoring dashboard implementation on the chart page. On this page, the monitoring dashboard provides various visualizations in the form of charts designed to provide comprehensive information related to fuel consumption and engine speed (RPM). The "Fuel Consumption" chart displays fuel consumption measured based on sensors installed on the number of ship engines, while the "Total RPM" chart shows engine speed data per hour. In addition, this dashboard allows users to view fuel consumption data based on certain time intervals, such as daily, monthly, and hourly. This dashboard is also equipped with an anomaly detection feature, which functions to identify and provide warnings if there are irregularities in the data received. For example, if there is an anomaly in the fuel consumption value detected by the sensor, the system will display a warning that confirms that there is an abnormality in the data. This anomaly detection feature is very useful for monitoring operational conditions in real time and preventing potential problems that may not be detected in the normal monitoring process.



Figure 7. Chart Page View

Trackpoint Page: Figure 8 is the result of the implementation of the monitoring dashboard on the trackpoint page. On the "Trackpoint" page, there are two main tables that display important information about the ship's performance and fuel consumption. The first table is the "Summary" table, which presents important data such as total fuel consumption, average RPM, maximum RPM, and total operating time for each main engine (Main Engine 1 and Main Engine 2). In addition, this table also includes additional information such as average speed, maximum speed, and total distance traveled in the selected time period. The second table is a complete data table that displays more detailed information, including location data (longitude and latitude), ship speed, total fuel consumption, and various other operational parameters such as RPM and engine operating hours. The data in this table can be filtered based on a predetermined time range, and users have the option to export this data to Excel format or send it via email for further use. This page is designed to facilitate monitoring and analysis of ship performance as a whole in a certain time period, with flexibility in data management and distribution.

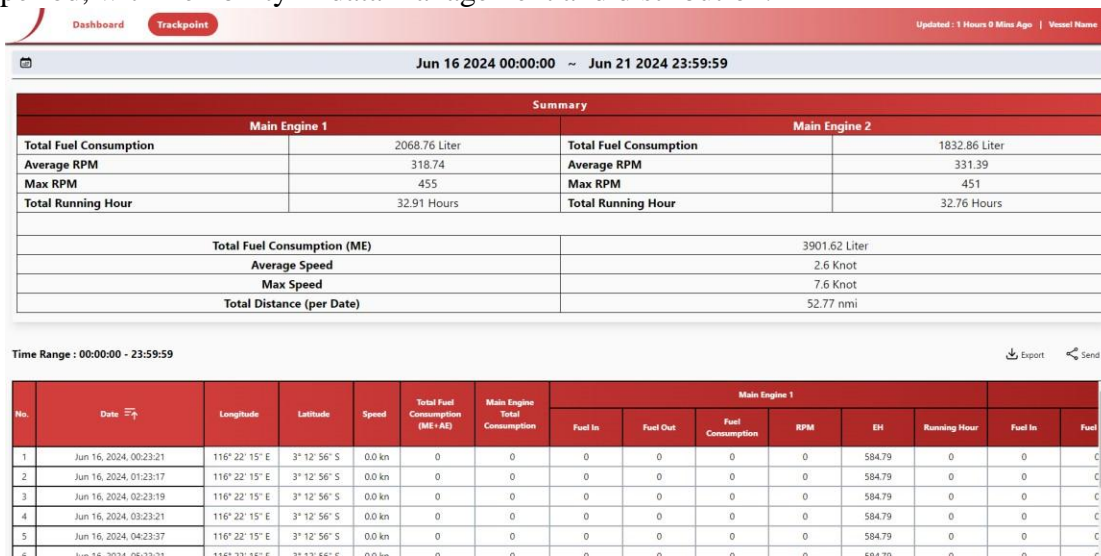


Figure 8. Trackpoint Page View

V. CONCLUSION

This research develops a web-based monitoring dashboard system specifically designed to monitor ship engine fuel consumption in real-time. The system integrates digital sensors, automated computational algorithms, and a user-friendly web interface to collect, process, and display fuel usage data accurately and continuously. By automating data acquisition and analysis, the system eliminates the need for manual data entry and observation, thereby enhancing both the speed and reliability of the monitoring process. The dashboard is capable of providing real-time feedback, allowing stakeholders to access critical operational data from any location via an internet connection. This immediacy of data access significantly improves decision-making processes related to fuel management by enabling timely identification of inefficiencies, detection of anomalies such as fuel leakage or overconsumption, and formulation of more data-driven strategies for energy optimization.

Furthermore, the system enhances transparency and accountability in ship operations. Stakeholders including ship operators, maintenance engineers, and regulatory bodies can easily interpret and act upon the visualized data. The availability of such information contributes to more effective planning, budgeting, and compliance with maritime fuel regulations, including those

related to emissions control and energy efficiency. From a technological perspective, the implementation of this system reflects the application of contemporary innovations such as the Internet of Things (IoT) and cloud computing in the maritime industry. By enabling real-time telemetry and centralized data access, the system supports broader digital transformation efforts aimed at optimizing operational logistics and sustainability within the maritime sector.

Overall, the proposed web-based monitoring dashboard offers a practical and impactful contribution to ship operational management. It facilitates significant fuel cost savings, enhances energy efficiency, and aligns with global trends toward smart shipping and sustainable maritime practices. Future iterations of the system could incorporate predictive analytics, machine learning algorithms, or integration with broader fleet management systems to further augment its functionality and strategic value.

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