Standard Design of Patrol Boats

By Budianto Budianto

Standard Design of Patrol Boats to Facilitate Maritime Surveillance Based on Analytical Hierarchy Process and Regression Linear

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Abstract

The problem is that many patrol boats have a variety of different equipment and spare parts, even though they are also sister ships, so a standardized design for patrol boats is needed to facilitate operation and easy maintenance. The design of a patrol boat should prioritize safety, effectiveness, and efficiency in the intended operational environment, while also taking into account budgetary and other constraints. The focus is on environmental and patrol boat operations such as the monitoring of marine pollution, the monitoring of illegal fishing, and the monitoring of maritime traffic as part of the maritime and coastguard operations. Based on the Analytical Hierarchy Process method, the percentage result is 28.1 percent of the proposed categories. The results of categories like speed, SFOC, displacement is the basis for selection. Linear regression method to get the new principal dimension for patrol boat. A new principal dimension for a standard patrol boat design is obtained by considering the deadweight, which is determined by examining the correlation between DWT-LPP, DWT- B, DWT-H, and DWT-T. The following is shown with the results of the new principal dimensions as follows: Lpp 36.50 m; B 7.80 m, H 4.25 m and T 1.90 m. Patrol boat design standards can be implemented in a variety of drawings, including line plan drawings, general arrangement drawings, construction drawings, capacity tank, and analysis result of patrol boat maneuver patterns. In this design of the operating conditions, the patrol boat is capable of operating until sea state number four conditions.

Keywords : design, standard, patrol, boats, drawing, operation, principal dimension.

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Introduction

Indonesia has a vast sea territory, which is one of the largest in the world. Its maritime territory includes the waters surrounding the thousands of islands that make up the Indonesian archipelago, as well as the seas between Indonesia and neighboring countries such as Malaysia, Singapore, the Philippines, and Australia. The total area of Indonesia's maritime territory is approximately 5.8 million square kilometers, with a coastline of approximately 54,716 kilometers. Indonesia's maritime territory is rich in natural resources, including fish, oil, gas, and minerals. It is also an important shipping route for international trade, with many vessels passing through the waters around Indonesia on their way to and from other parts of the world. In recent years, Indonesia has been taking steps to assert its sovereignty over its maritime territory, including increased patrols by the Indonesian Navy and Coast Guard, as well as efforts to combat illegal fishing and other monitoring for illegal fishing, smuggling, and other illicit activities. Coast Guard operates a range of vessels, from small patrol boats to larger offshore patrol vessels. The Ministry of Marine Affairs and Fisheries also operates a fleet of patrol boats for the purpose of monitoring and enforcing fishing regulations in Indonesian waters. While Indonesia has made significant investments in its patrol boat fleet in recent years, there are still challenges to be addressed, including the need for more vessels to cover Indonesia's vast maritime territory, the need for modernization and upgrades to older vessels, and the need for improved coordination and cooperation among different government agencies. The problem is that many patrol boats have a variety of different equipment and spare parts, even though they are also sister ships, so a standardized design for patrol boats is needed to facilitate operation and easy maintenance (Grant, 2002). Case study in Territory Indonesia can be seen in the image below, (Geospatial map of Indonesia, 2022).

Figure 1: Indonesia Territory

forms of maritime crime. Indonesia has a relatively large fleet of patrol boats operated by various government agencies, including the Indonesian Navy, the Indonesian Coast Guard, Ministry of Transportation as Sea Transportation and Coast Guard, and the Ministry of Marine Affairs and Fisheries. The Indonesian Coast Guard operates a fleet of patrol boats that are primarily focused on maritime law enforcement, including Monitoring marine pollution is an important task for the Indonesian government to protect the marine environment and the health of its citizens who rely on marine resources for their livelihoods (MARPOL, 1974/1978). There are several government agencies responsible for monitoring marine pollution in Indonesia, including the Ministry of Environment and Forestry, the Ministry of Marine Affairs and Fisheries, and the

Indonesian Coast Guard. These agencies use a variety of methods to monitor marine pollution, including regular sampling of seawater, sediment, and biota, as well as remote sensing and aerial surveys to detect pollution events and monitor the movement of pollutants in the water. They also work to identify sources of pollution, such as industrial discharges, oil spills, and illegal dumping, and take appropriate action to address these issues. One of the major sources of marine pollution in Indonesia is plastic waste, which is a significant problem throughout the country. To address this issue, the Indonesian government has implemented a range of policies and initiatives, including a ban on single-use plastics in some cities and the establishment of recycling programs in coastal communities. The government has also worked with international organizations and neighboring countries to develop regional strategies to address marine plastic pollution. In addition to monitoring and addressing pollution, the Indonesian government has also established MPAs to conserve marine biodiversity and promote sustainable use of marine resources. These MPAs are monitored and managed by the government and local communities to ensure that they are effectively protecting the marine environment. Despite these efforts, there is still much work to be done to monitor and address marine pollution in Indonesia. For coastal management and engineering, coastal resource exploration, navigation, tidal and biodiversity research, design of marine structures and aquaculture, understanding the characteristics of the seabed and the ocean is crucial (Darvar, 2023). Continued investment in monitoring technology and infrastructure, as well as education and awareness-raising campaigns, are needed to protect Indonesia's valuable marine resources. Marine pollution is a major problem in Indonesia, with the country being one of the world's largest producers of marine plastic waste. Here is some statistics figure on marine pollution average in Indonesia as shown below.

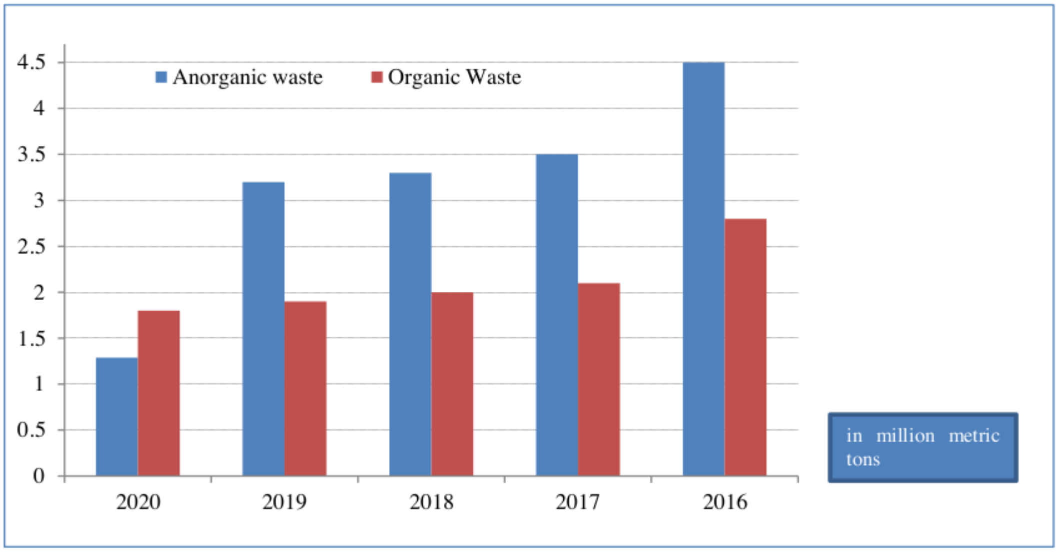

Figure 2: Statistics indicate that marine

These statistics indicate that marine pollution is a significant problem in Indonesia, with the country being a major contributor to ocean plastic waste. The government and various organizations are taking measures to address this issue, but there is still much work to be done to reduce marine pollution and protect Indonesia's marine resources.

Illegal fishing is a significant problem in Indonesia, with foreign vessels often entering the country's territorial waters to fish without permission or in violation of Indonesian fishing laws. This activity not only threatens the sustainability of Indonesia's fish stocks but also procces a significant security threat to the country. To combat illegal fishing, Indonesia has implemented several measures, including increasing patrols by the navy and coast guard, implementing stricter penalties for illegal fishing, and improving monitoring and surveillance technology. The country has also cooperated with neighboring countries and international organizations to share information and coordinate efforts to combat illegal fishing in the region (Fyson, 2021). One of the most significant actions taken by the Indonesian government was the establishment of a moratorium on foreign fishing vessels in 2014.

This policy required foreign fishing vessels to obtain licenses to operate in Indonesian waters, and many vessels that did not comply were seized and destroyed by Indonesian authorities. The policy has been credited with reducing illegal fishing in Indonesian waters and helping to promote sustainable fishing practices. However, illegal fishing remains a persistent problem in Indonesia, and there are still many challenges to be addressed. These include the vast size of Indonesia's waters, the limited resources of the country's navy and coast guard, and the complicity of some local officials in illegal fishing activities. Nevertheless, the Indonesian government remains committed to tackling the issue and protecting its maritime resources for the benefit of the country and its people. Illegal fishing is a significant problem in Indonesia, with many foreign fishing vessels illegally operating in Indonesian waters.

Table 1: Illegal fishing in Indonesia

Years	Quantity (Pieces)	Case
2020	56	It's caught illegally operating in Indonesian waters
2019	33	Illegal fishing vessels
	18	Illegal fishing vessels
2018	125	That was caught illegally operating in Indonesian waters.
2017	110	Illegal fishing vessels
2016	23	That was caught illegally operating in Indonesian waters.

According to the Indonesian Ministry of Maritime Affairs and Fisheries, the estimated loss from illegal fishing in Indonesia is around 300 trillion rupiahs (approximately 21 billion USD) per year. The following data on illegal fishing in Indonesia is presented. These statistics show that illegal fishing is a persistent problem in Indonesian waters. The government is taking action. However, much remains to be done to ensure sustainable fishing practices and protect Indonesia's marine resources.

Maritime accidents can be caused by a variety of factors (Asri, 2021). These include Human error, weather conditions, equipment failure, collision, fire or explosion, and environmental factors (Liu, 2020). To prevent maritime accidents, it's important to have effective safety management systems in place, including proper crew training, regular maintenance and inspection of equipment, and using appropriate safety equipment and procedures (Mansour, 2002). However, here are some notable maritime accidents that have occurred in Indonesia over the last 5 years, as shown in the table below.

Table 2: Accidents in sea transportation

Years	Ship Name	Case	Victims (people)
2018	MV Sinar Bangun ferry	The ferry capsized in Lake Toba.	200
2019	MV Sinar Baru boat	The boat sank in the Sunda Strait	31
2019	MV Sabuk Nusantara	The ship ran aground on a reef in West Papua	21
2019	MV Nur Allya cargo	The cargo ship sank in waters off Sulawesi Island	25
2020	MV Karya Indah boat	The boat sank in the Sunda Strait	10

It is also important to have effective communication and cooperation between ships and with shore-based authorities to ensure that all ships are aware of potential hazards and can take appropriate action to avoid accidents. It is difficult to provide an up-to-date list of maritime casualties in Indonesia over the past 5 years, as there are numerous incidents and accidents that occur frequently in Indonesian waters. These accidents highlight the importance of improving safety standards and regulatory oversight in the maritime transport sector in Indonesia. The Indonesian government has taken steps to address these issues, such as increasing safety inspections and implementing stricter regulations for vessel operators. However, more needs to be done to improve the safety of passengers and crew members on board ships and ferries in Indonesian waters.

Material and Method

Ship Design

Ship design involves creating a plan and specifications for a vessel that can operate safely and efficiently in a particular environment, such as on the open ocean or in a river system (Abdelwahed, 2019). The process of designing a ship typically involves multiple stages, including conceptual design, preliminary design, and detailed design. During the conceptual design phase, designers consider factors such as the ship's intended purpose, size, shape, and propulsion system. They may also conduct research on similar vessels and consult with stakeholders to determine specific requirements for the ship's design (Andrews, 2021). Once a basic concept has been established, the preliminary design stage involves refining the design and creating more detailed plans. This may include designing the hull, creating plans for the ship's systems and machinery, and specifying materials and construction methods (Ul Haq M, 2021). During the detailed design stage, the ship's design is finalized and detailed plans are created for construction. This stage may involve creating 3D computer models of the ship, conducting simulations to test its performance, and finalizing plans for all of the ship's systems and components (Bonsa Regassa Hunde, 2022). Throughout the ship design process, designers must consider a wide range of factors, including the ship's intended use, environmental conditions, safety regulations, and the needs of crew and passengers. They must also ensure that the ship is designed to be cost-effective, durable, and easy to maintain over its expected lifespan.

There are several methods used in ship design, each with its own advantages and limitations. Some common ship design methods include:

- Experience-based design, This method is based on the experience of ship designers and shipbuilders in designing and constructing ships. The design is based on past successful designs, and modifications are made based on the ship's intended use, size, and other factors.
- Model testing, This method involves creating scale models of the ship and testing them in a controlled environment, such as a towing tank or wind tunnel. The results of these tests are used to optimize the ship's design and performance.
- Computational fluid dynamics, This method uses computer simulations to model the behavior of fluids around the ship's hull and other components. Computational fluid dynamics can provide detailed information about the flow of water around the ship and can be used to optimize the ship's design for performance and fuel efficiency.
- Finite element analysis, This method uses computer simulations to analyze the strength and structural integrity of the ship's hull and other components. Finite element analysis can be used to identify potential weaknesses in the design and to optimize the structure for strength and durability.
- Integrated design software, This method involves the use of computer-aided design software that integrates different design tools and analysis methods. This allows ship designers to create a comprehensive design that considers all aspects of the ship's performance and construction.
- Optimization algorithms, This method involves using optimization algorithms to find the best design solution based on a set of design criteria and constraints. Optimization algorithms can be used to optimize the ship's performance, weight, and cost (I K A P Utama, 2020).

Overall, ship design methods are constantly evolving as new technologies and tools become available (Molland, 2008). The most effective ship design method depends on the specific needs and requirements of the ship being designed, as well as the available resources and expertise of the design team. The method used in this research is the use of optimisation algorithms. These algorithms use linear regression to determine the new principal dimension.

Sea state 4 is considered a rough sea state, with significant wave heights of 2.5 to 4 meters. In this sea state, waves are generally higher and more pronounced, with whitecaps and spray becoming more frequent. The sea is generally choppy, and waves can be breaking and irregular (Angel M. Costa, 2020). Navigating in sea state 4 can be challenging, especially for smaller vessels. It is important to take into account the wind direction and speed, as well as the direction and frequency of the waves, in order to maintain control and stability of the vessel. Speed may need to be reduced in order to minimize the impact of waves on the vessel, and additional safety measures may need to be taken to ensure the safety of crew and passengers. It is always recommended to consult the latest weather reports and forecasts before setting sail in order to make informed decisions about navigation and safety. The patrol boat design is planned under Sea State 4 conditions. This makes the limitations and conditions of the planned manoeuvre clear, as it is based on the general operational weather conditions in Indonesia.

Analytical Hierarchy Process

The AHP (Analytical Hierarchy Process) process involves pairwise comparisons between the elements at each level of the hierarchy. The pairwise comparisons are done using a scale of relative importance, typically ranging from 1 to 9, where 1 represents equal importance and 9 represents extreme importance. Data developed this scale based on his theory of subjective judgment and has guidelines for assigning values to reflect the relative importance of elements. After obtaining the pairwise comparison judgments, the AHP calculates priority weights for each element in the hierarchy using mathematical calculations. The weights reflect the relative importance of each element with respect to the goal. Consistency checks are performed to ensure the judgments are reliable and consistent. Once the priority weights are calculated, the AHP aggregates the weights to determine the overall priority or ranking of the alternatives. This information can be used to make informed decisions by selecting the alternative with the highest priority. The AHP method is widely used in various fields, such as business, engineering, project management, and public policy, where complex decisions involving multiple criteria and alternatives need to be made. It provides a systematic and structured approach to decision-making, incorporating both qualitative and quantitative factors, and helps to clarify and prioritize the decision criteria.

Regression Linier For New Principle Dimension

Linear regression is a statistical modeling technique used to analyze the relationship between a dependent variable and one or more independent variables. If you want to apply linear regression to predict a new principal dimension of a ship, you would need a dataset that includes both the principal dimension you want to predict (dependent variable) and other relevant variables (independent variables) that might influence it. Collect data with Gather a dataset that includes information on the principal dimensions of ships as well as other relevant variables such as ship weight, length, width, or any other factors that you believe may be related to the principal dimension you want to predict. Explore the data to analyze the dataset to understand the relationships between the principal dimension and other variables. Use techniques such as scatter plots or correlation analysis to identify any potential linear relationships. Split the data to divied the dataset into a training set and a testing set. The training set will be used to build the linear regression model, while the testing set will be used to evaluate its performance. Build the model with use the training set to create a linear regression model. In this case, you will have one dependent variable (the principal dimension) and one or more independent variables (e.g., ship weight, length, width). The model will estimate the coefficients for each independent variable, indicating the strength and direction of their relationship with the principal dimension. Evaluate the model with Once the model is built, use the testing set to assess its predictive performance. Calculate metrics such as mean squared error or R-squared to measure how well the model fits the testing data. Predict the new principal dimension to once it has a satisfactory model, you can use it to predict the principal dimension of a new ship based on its other characteristics. Plug in the values of the independent variables into the model, and it will provide an estimate for the principal dimension. It's important to note that the quality and relevance of the dataset you use for regression analysis greatly impact the accuracy of the predictions. Additionally, linear regression assumes a linear relationship between the dependent and independent variables, so it may not capture complex nonlinear relationships in the data.

Result

AHP Matrix

Scoring Value, the assessment of the resulting score is based on values from poor to excellent, each with a score of 1 to 9 points. This scoring is based on the standards of the AHP method scoring matrix.

Table 3 Indicator Requirements

Normalized Score Table							
Speed, SFOC, Displ.	0.06	0.33	0.32	0.36	0.28	1.35	28.1 %
Operation Equipment	0.28	0.05	0.24	0.27	0.22	1.06	20.1 %
Manoeuver and Stability	0.22	0.24	0.04	0.32	0.22	1.04	20.7 %
Spart Part	0.22	0.19	0.20	0.05	0.25	0.91	18.2 %
Maintenance	0.22	0.19	0.20	0.01	0.03	0.65	13.0 %
Col. Total	1.00	1.00	1.00	1.00	1.00	5.00	

This 28.1 % is the Percent ratio Scale of Priority Column. This is also called Customer Preference. Here it can be clearly seen that for calculation.

Table 4 Scoring matrix

CSI RATING	CSI SCORE	AHP SCORE	GEOMETRIC MEAN
EXCELLENT	5	9	9
VERY GOOD	4	7 - 8	7,5
GOOD	3	5 - 6	5,5
AVERAGE	2	3 - 4	3,5
POOR	1	1 - 2	1,5

This Particular Customer Response from manufacturer carries the greatest preference. The customer rates Response from the manufacturer at the highest priority and is implying that the Marketing Dept. or the sales backup team is giving maximum response.

Ship Design Process

The determination of a ship's principal dimensions is a critical step in ship design, as it sets the basis for other design parameters. The calculation of principle dimensions for a ship depends on various factors such as the ship's intended use, size, speed, and other design requirements. The key principal dimensions of a ship include: Length Overall, Beam, Draft, Freeboard, and Displacement. The determination of the principal dimensions is typically based on a range of factors, including the intended use of the ship, its size and speed requirements, and the regulatory requirements governing its design. In general, larger ships will have larger principal dimensions, while smaller ships will have smaller dimensions. The determination of a ship's principal dimensions typically involves an iterative process, in which the designer evaluates a range of potential options based on the above factors, and selects the optimal design based on a range of considerations, including performance, stability, and regulatory compliance. Computer-aided design software is often used to model and evaluate different design options, allowing designers to quickly assess the impact of changes to the ship's principal dimensions on its overall performance. In addition, numerical methods such as Computational Fluid Dynamics can be used to simulate the hydrodynamic performance of a ship at different principal dimensions, allowing designers to optimize the design for performance, efficiency, and stability.

A new principal dimension for a standard patrol boat design is obtained by considering the deadweight, which is determined by examining the correlation between DWT - Lpp, DWT - B, DWT - H, and DWT - T.

Table 5 ship exsiting data

Ship Name	DWT	Lpp[m]	B[m]	H[m]	T[m]
Grajour Offshore Patrol Vessel	110	46.50	7.50	4.83	2.30
Bracue Class Patrol Vessel	225	55.22	8.59	4.87	2.78
JX-Class Patrol Vessel	230	54.73	8.46	4.77	2.71
Padro Teixey Patrol	250	55.01	8.45	4.75	2.72
KR 27 Class Patrol Boat	260	54.98	8.91	4.65	2.78
FSB 513 Class Patrol Boat	285	53.98	8.29	4.85	2.78
Obizor Patrol Boat	270	53.89	8.67	4.77	2.89
Piratane-Class Patrol 1	200	54.03	8.76	4.79	2.78
Piratane-Class Patrol 2	200	54.29	8.45	4.77	2.72
Armidale Patrol Boat	230	55.39	8.59	4.81	2.78
Kapal Patroli 11	250	52.99	8.69	4.89	2.78
Customs Patrol Triten	200	53.09	8.35	4.79	2.78
Cupe Class Patrol	200	54.72	8.45	4.83	2.78
Meghner Patrol Boat 511	220	53.92	8.7	4.87	2.78
Island Patrol Vessel	200	54.34	8.12	4.85	2.78

The calculation of principle dimensions for a ship involves determining the size and shape of the hull and other major components, including the length, beam, draft, and displacement. The following are the typical steps involved in calculating the principal dimensions such as determine the ship's purpose, calculate the displacement, calculate the length and beam, determine the draft, calculate other parameters and refine the design. Other parameters that are calculated include the freeboard (the distance from the waterline to the main deck), the block coefficient (a measure of the ship's fullness), and the prismatic coefficient (a measure of the ship's shape). At first the principal dimensions have been calculated, the next design is refined to optimize the ship's performance, stability, and safety. This may involve adjusting the shape of the hull, adding or removing weight, or changing the placement of equipment and systems. Calculating the principal dimensions is a critical step in ship design and requires a thorough understanding of the ship's purpose, performance requirements, and other design constraints. The calculations must be accurate to ensure that the ship is safe and seaworthy.

Deadweight is an important concept in the design and operation of ships, as it refers to the total weight of cargo, fuel, ballast, and other materials that a vessel can carry. Deadweight is typically expressed in metric tons and is an important consideration for shipbuilders, shipowners, and operators. One of the main reasons that deadweight is important is that it is a key factor in determining a ship's capacity and efficiency. The amount of cargo that a ship can carry depends on its deadweight capacity, and ships with higher deadweight capacities are generally more efficient, as they can transport more cargo per trip. This can help to reduce transportation costs and increase profitability for shipowners and operators. Deadweight is also important for safety considerations, as ships must be designed and operated within safe weight limits to ensure stability and avoid overloading. Ships that are overloaded or exceed their safe weight limits can be at risk of capsizing, sinking, or other types of accidents. Finally, deadweight is an important consideration for regulatory compliance, as many countries have laws and regulations governing the maximum weight that ships can carry. Overall, deadweight is an important concept in the shipping industry that affects the design, operation, safety, and regulatory compliance of ships.

The results of the DWT and Lpp relationship from the comparison ship data produce the formula shown in the equation below. By entering the desired deadweight data for the principal dimension of the new ship, a new length perpendicular (Lpp) is obtained. The results of the linear regression of the DWT and LPP relationship are as follows.

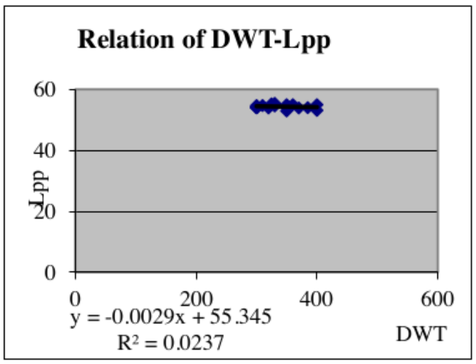

Figure 1 Relation DWT-Lpp

The results of the DWT and B relationship from the comparison ship data produce the formula shown in the equation below. By entering the desired deadweight data for the principal dimension of the new ship, a new Breadth is obtained. The results of the linear regression of the DWT and B relationship are as follows.

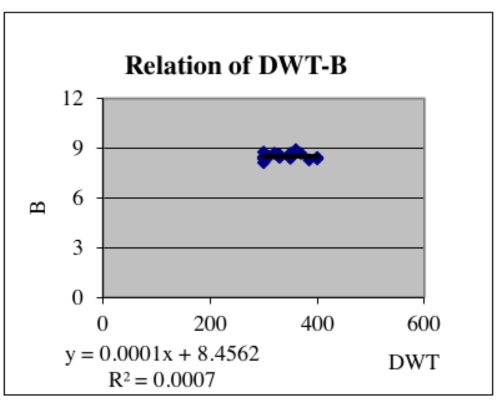

Figure 2 Relation DWT-B

The results of the DWT and H relationship from the comparison ship data produce the formula shown in the equation below. By entering the desired deadweight data for the principle dimension of the new ship, a new height (H) is obtained. The results of the linear regression of the DWT and H relationship are as follows.

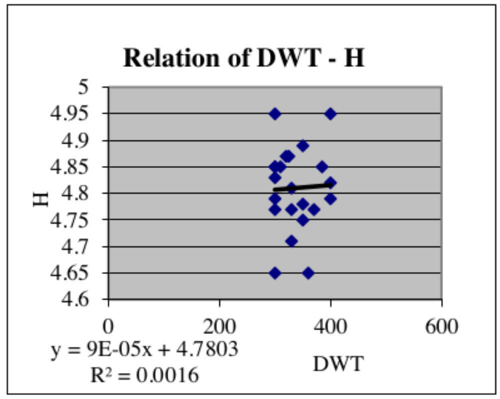

Figure 3 Relation DWT-H

The results of the DWT and T relationship from the comparison ship data produce the formula shown in the equation below. By entering the desired deadweight data for the principle dimension of the new ship, a new draft (T) is obtained. The results of the linear regression of the DWT and T relationship are as follows.

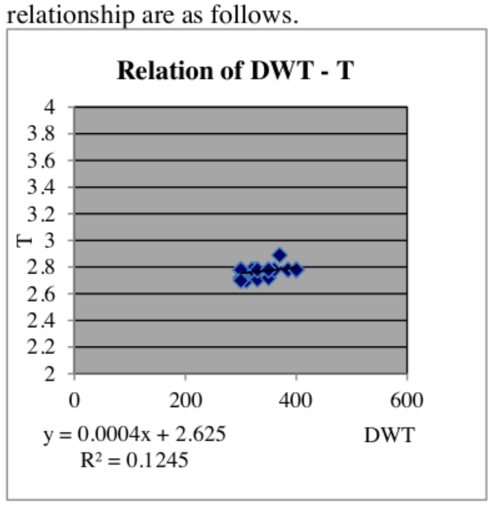

Figure 4 Relation DWT-T

By entering a deadweight value of 225 tonnes deadweight, a new principle dimension is obtained. In this way, the principle dimension for the new patrol boat design standard is consistent with operations in Indonesian waters. Patrol Boat to Principle dimension optimisation result as shown below.

Table 6 Priciple dimension

Principle Dimension of Patrol Boat Design					
DWT [ton]	Lpp [m]	B [m]	H [m]	T [m]	Vs knot
225	36,50	7,80	4,25	1,90	30

Lines plan

A lines plan is a set of detailed drawings that provide a graphical representation of the shape and dimensions of a ship's hull. It is typically created during the preliminary design stage of ship design and is used to determine the vessel's hydrostatic properties and overall performance characteristics. The lines plan includes a series of cross-sectional views of the ship's hull at regular intervals along its length, as well as a longitudinal view of the hull from bow to stern. Each cross-section shows the shape of the hull at that particular point, including the shape of the bottom, sides, and deck. Designers may use computer software to manipulate the lines plan and create three-dimensional models of the ship's hull for further analysis and optimization.Overall, the lines plan is an essential tool for ship designers and naval architects, providing a detailed and accurate representation of the ship's hull that allows for precise calculations and analysis of the vessel's performance. Please see, figure below:

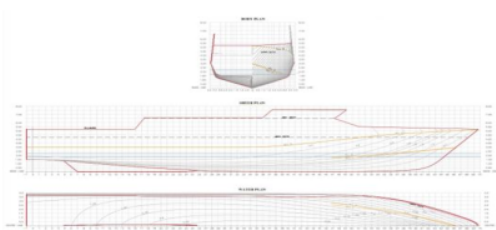

Figure 5 Lines Plan

The spacing between the cross-sections is typically determined by the length of the vessel, with more sections provided for longer ships.The lines plan is used to calculate various properties of the ship, such as its displacement, center of buoyancy, and waterplane area. It is also used to evaluate the ship's stability, resistance, and propulsion characteristics.

Manouvering Simulation

Maneuvering simulation is the process of simulating a vessel's motion and behavior in various conditions to determine its maneuvering capabilities and to optimize its design. The simulation can be used to evaluate the vessel's performance in different scenarios, including in calm or rough sea conditions, with or without cargo, or with different propulsion configurations. Maneuvering simulation can be conducted using specialized software that takes into account the vessel's design parameters, such as its hull shape, weight, and propulsion system. The software can simulate the vessel's motion and behavior in different sea conditions, taking into account factors such as wind, waves, and currents. The simulation can also be used to evaluate the vessel's response to different commands and steering inputs, such as turning, stopping, or changing speed. The results of the simulation can be used to optimize the vessel's design and to develop operational procedures to ensure safe and efficient operation (Hover, 1994). Maneuvering simulation is an important tool for ship design and operation, as it allows designers and operators to evaluate the vessel's performance in a variety of conditions and to identify potential safety risks or operational challenges before they occur.

In the design of the operating conditions, the patrol boat is capable of operating in Sea State 4 conditions. Sea state 4 conditions in sea waves can range from 2.5 metres to 4 metres. The simulation is carried out by following the wave conditions in sea state 4. This can be seen in the following wave simulation.

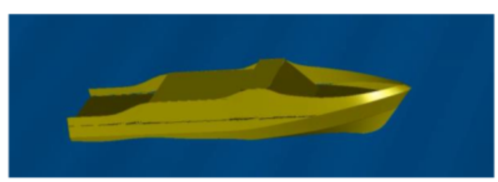

Figure 6 Manouvering Simulation Result

Wave conditions for maneuvering simulation depend on the specific purpose of the simulation and the type of vessel being simulated. Generally, the simulation should include a range of sea states and wave conditions that are representative of the expected operating conditions for the vessel. This can include calm sea conditions, moderate seas, and rough seas with significant wave heights of up to several meters. For a specific vessel, the wave conditions used in the simulation should be based on the vessel's intended operating area and the expected weather conditions in that area. The simulation should also take into account any unique features of the vessel's design that may affect its behavior in waves, such as its hull shape, size, and weight. The International Maritime Organization provides guidelines for simulating wave conditions for ship design and operation (IMO, 2011). These guidelines include recommendations for the range of wave conditions to be simulated, as well as the statistical distributions and wave spectra to be used (SOLAS, 1974/1978). In general, the simulation should include a range of wave directions and periods to provide a comprehensive evaluation of the vessel's behavior in different conditions. The simulation should also take into account any specific maneuvering scenarios, such as turning, stopping, or emergency maneuvers, to ensure that the vessel can safely and effectively operate in all conditions

Rough seas with significant wave heights refer to ocean conditions in which the waves are large and powerful enough to significantly impact the behavior of ships and other vessels. The significant wave height (Hs) is defined as the average height of the highest one-third of the waves in a given sea state. In general, rough seas are characterized by significant wave heights of 4 meters (13 feet) or more, although the exact threshold for what constitutes rough seas may vary depending on the type and size of the vessel. At these sea states, waves can become steep and unstable, and can pose a risk to vessels through the potential for capsizing, loss of stability, or damage to the hull and superstructure.When designing ships and other vessels, it is important to consider their performance in rough seas and to ensure that they are capable of safely operating in these conditions. This may involve incorporating features such as strengthened hulls and decks, high-capacity bilge and ballast systems for maintaining stability, and effective propulsion and maneuvering systems to enable the vessel to respond quickly and safely to changing sea conditions.It is also important for ship operators to be aware of the sea conditions in which their vessels are operating, and to take appropriate precautions to ensure the safety of the crew and cargo. This may include altering course or speed to avoid particularly rough areas, securing loose objects and equipment, and ensuring that the vessel's ballast and trim are properly adjusted to maintain stability.

Capacity Plan Simulation

A ship's capacity plan is a document that outlines the vessel's maximum cargo-carrying capacity, including the volume and weight of cargo that it can transport. The capacity plan is an important part of the ship's design and is used to ensure that the vessel can safely and efficiently transport cargo while meeting all relevant regulatory requirements. The capacity plan typically includes a number of key parameters, such as the vessel's length, width, and depth, as well as its draft and displacement. These parameters are used to calculate the vessel's total cargo volume and weight capacity, taking into account any restrictions on cargo type or loading arrangements. The capacity plan may also include information on the vessel's cargo hold arrangements, such as the number of cargo holds, their dimensions and capacities, and any special features or equipment used to load or unload cargo (Murdjito Murdjito, 2023). This information is important for determining the optimal loading and stowage arrangements for different types of cargo, as well as for ensuring that the vessel remains stable and balanced during loading and unloading operations. In addition to its cargo-carrying capacity, the capacity plan may also include information on other important ship systems and components, such as the propulsion and steering systems, electrical and mechanical systems, and safety and emergency equipment. This information is used to ensure that the vessel is capable of safely and reliably transporting cargo under a wide range of operating conditions, and to identify any potential weaknesses or areas for improvement in the vessel's design or operation.

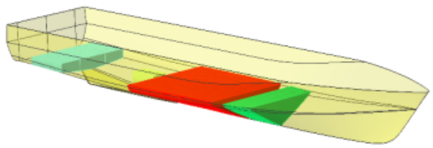

Figure 7 Tank simulation design

General Arrangement

A General Arrangement drawing is a detailed plan that provides a graphical representation of the layout and arrangement of a ship's major components and systems. It is typically created during the detailed design stage of ship design and is used to ensure that all of the ship's equipment and systems are properly located and configured for maximum efficiency and safety.The GA drawing shows the ship's internal and external layout, including the location and arrangement of cabins, cargo holds, machinery spaces, and navigation and control areas (Larissa Queiroz Minillo, 2020). It also includes details of the ship's systems, such as ventilation, heating and cooling, electrical, plumbing, and fire protection systems.The GA drawing is typically created using computer-aided design software, which allows designers to create detailed 3D models of the ship's interior and exterior. This enables them to visualize and test the arrangement of components and systems before the ship is actually built, helping to identify and resolve potential issues and conflicts. The General Arrangement drawing is an essential tool for shipbuilders, shipowners, and crew members, providing a detailed plan that serves as a guide for the construction and operation of the ship. It helps to ensure that the ship is built to the required specifications and that all of the equipment and systems are properly installed and configured to operate safely and efficiently (Marinicheva, 2021).

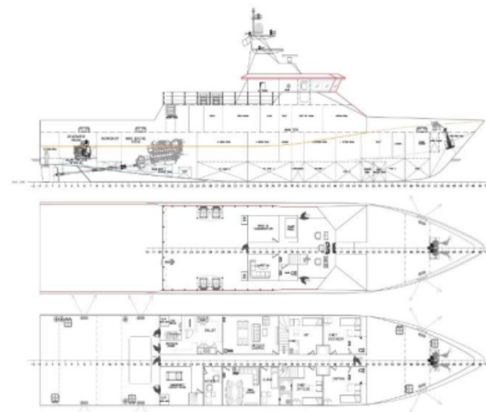

Figure 8 General Arrangement

Midship Section

A midship section is a cross-sectional view of a ship's hull taken at a specific point along its length, typically the midpoint or amidships. The midship section provides a detailed representation of the ship's structural features, including the shape of the hull, the arrangement of compartments and tanks, and the location of major systems and equipment (Budianto, 2018). The midship section is typically created during the preliminary design stage of ship design and is used to evaluate the vessel's stability, strength, and resistance characteristics. It provides valuable information about the ship's hydrostatic properties, such as its displacement, draft, and waterplane area, and can be used to calculate important performance parameters, such as speed and power requirements (Philipus Valentino, 2022).

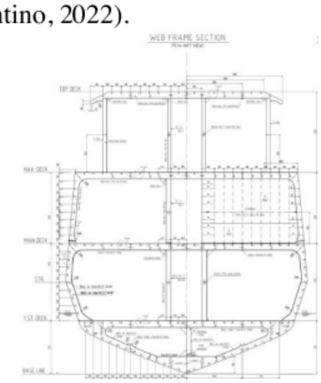

Figure 9 Midship section

The midship section is also used to evaluate the ship's structural integrity and to ensure that it meets regulatory requirements and industry standards for safety and durability. Designers may use computer software to create detailed 3D models of the midship section and perform simulations to test the ship's performance and structural integrity under various conditions.Overall, the midship section is an essential tool for ship designers and naval architects, providing a detailed and accurate representation of the ship's hull that allows for precise calculations and analysis of the vessel's performance and structural characteristic.

Discussion

Based on the AHP method, the percentage result is 28.1 percent of the proposed categories. The results of categories like speed, SFOC, displacement are the basis for selection. This customer reference because of maximum response from prefer operation condition with result 28.1 % with focus to contract speed, SFOC, and displacement. Based on the AHP method, the percentage result is 27 percent of the proposed categories. The results of categories like speed, SFOC, displacement are the basis for selection. A new principal dimension for a standard patrol boat design is obtained by considering the deadweight, which is determined by examining the correlation between DWT- LPP, DWT-B, DWT-H, and DWT-T. The following is shown with the results of the new principal dimensions as follows: Lpp = 36.50 m; B = 7.80 m H = 4.25 m, T = 1.90 m, by design requirement with speed (Vs) 30 knots and main engine (ME) 2x3000 kW. Deadweight is an important concept in the design and operation of ships, as it refers to the total weight of cargo, fuel, ballast, and other materials that a ship can carry it. Deadweight is typically expressed in metric tons and is an important consideration for shipbuilders, shipowners, and operators. Patrol boat design standards can be implemented in a variety of drawings, including design standards such as line plan drawings, general arrangement drawings, construction drawings and analysis of patrol boat maneuvering patterns. In the design of operation to constrains conditions, the patrol boat is capable of operating in sea state number 4 conditions.

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