



Development of a Platform Supply Vessel: Design, Resistance Assessment, and Prototype Fabrication for Offshore Operations in Natuna, Indonesia

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Abstract: Maritime transportation serves as a vital component of inter-island connectivity in Indonesia, particularly in supporting offshore oil and gas exploration activities. This study focuses on addressing the rarity of Platform Supply Vessel in the Natuna Islands, which are needed to support offshore operations to optimize the exploration of Natuna's abundant natural resources. The design process begins with the determination of the vessel's principal dimensions, derived from benchmark vessel data and dimensional ratio analysis. The hull form is subsequently developed into a 3D model to produce a lines plan. Resistance analysis is conducted based on the Holtrop method, encompassing components such as frictional resistance, wave-making resistance, transom drag, and air resistance. A scaled physical model is also constructed using a non-molded hull fabrication technique to validate the design. The findings indicate that the proposed hull design satisfies the specified performance criteria and demonstrates favorable resistance characteristics. This research answers the rarity of studies on Platform Supply Vessel specifically for Natuna by contributing a comprehensive study focusing on design, fabrication, and cost analysis.

Keywords: design; prototype; fabrication; PVS; Natuna



SDGs Problem Solving

This study supports SDGs by addressing regional challenges with practical engineering solutions. Designing and prototyping a Platform Supply Vessel aligns with SDGs Chapter # 9, focusing on resilient infrastructure, technological advancement, resolving infrastructure deficits, promoting sustainable industrial development, and enhancing maritime innovation for a more sustainable and efficient future.

Conflict of Interest Statement: The author(s) declares that the research was conducted in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

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1. INTRODUCTION

Maritime transportation serves as a crucial component in connecting Indonesia's vast archipelago and supporting national logistics. According to the Ministry of Transportation, inter-island sea transport continues to play a strategic role in ensuring the flow of goods and people across 17,000 islands. Indonesia, as an archipelagic and maritime nation, depends heavily on shipping as the backbone of its economic integration and offshore operations (UNCTAD, 2023; BPS, 2025).

Recent increases in industrial and offshore activities have accelerated innovation within the maritime sector. One of the most significant developments has been the growth of offshore infrastructure, particularly to support energy exploration and subsea logistics. The offshore oil and gas industry in Indonesia is projected to expand toward deeper waters, supported by advancements in ship design, automation, and marine engineering technologies (Margaretha, Syuzairi and Mahadiansar, 2024; Marliani, 2024).

The oil and gas industry is one of the fundamental pillars of the global economy and a country's energy security, with exploration and production activities increasingly moving offshore. In this logistics ecosystem, Platform Supply Vessels (PSV) play a central role as the backbone of operations. PSV are specifically designed to transport various types of vital supplies from onshore bases to offshore platforms (Vianna et al., 2025).

In Indonesia, one of the most strategic areas in terms of energy resources is the Natuna Islands. This region is known for its abundant natural resources, especially oil and gas. This high amount of energy potential has led to a lot of offshore exploration and production activity in the area (Yusgiantoro et al., 2024). This activity directly creates a constant and crucial demand for maritime logistics support services, such as PSV, to ensure smooth operations.

Table 1 shows that the number of freight ship fleets in the Natuna Sea is still less than the local passenger ship fleet. This is also one of the reasons that the exploration of natural resources in the Natuna Sea is still not optimal (SatuData, 2024).

Table 1. Natuna sea transportation quantity data in 2022 – 2024 (SatuData, 2024)

Fleet types	Years		
	2022	2023	2024
Regional Passenger Ship Fleet	5	4	5
Local Passenger Ship Fleet	10	14	28
School Ship Fleet	7	0	2
Regional Cargo Ship Fleet	1	1	1
Local Cargo Ship Fleet	10	10	10
Traditional Ship Fleet	523	0	47
Ferry Crossing Fleet	3	2	2
Total	559	31	95

Based on the article by Sidik (Sidik, 2021), which cites data from the Ministry of Energy and Mineral Resources as of December 2021, the Natuna region has significant oil and gas resources. The article summarizes quantitative data on the total oil and gas production in the Natuna region, as presented in Table 2.

Table 2. Production overview of oil and gas in Natuna – 2021

	Working area and contractor	Product	Total
MMSTB: Million Stock Tank Barrel	South Natuna Sea B - Petrochina International Jabung LTD	Oil and Condensate	15.942
	Natuna Sea Block A - Pertamina Hulu Energi Siak	Oil	1.705
	Northwest Natuna - NI East Sepinggan LTD	Oil	-
BSCF: Billions of Standard Cubic Feet	Natuna Sea Block A - Premier Oil Indonesia	Natural gas	212.86
	South Natuna Sea B - Medco E&P Natuna	Natural gas	173.01
	Northwest Natuna - AWE (Northwest Natuna) PTE. LTD	Natural gas	-

With the many services that must be fulfilled in the Natuna Sea offshore building, there will be an increase in sea transportation, one of which is the supply vessels. These vessels not only facilitate logistical support but also play a crucial role in emergency response operations, highlighting their importance in ensuring the safety and efficiency of offshore activities.

The research objective is to obtain the main size of the PSV ship through a comparative analysis approach with similar ships and to calculate the resistance of the resulting design. The calculation of resistance is carried out using the Holtrop method. The Holtrop method is a statistical approach widely used to predict ship resistance, with advantages such as: (1) practical in calculating ship resistance and providing accurate results at the initial design stage; (2) applicable to various types of ships; (3) applicable to various ship speeds ([Juliante et al., 2021](#)). In addition, this research also has purpose to realize the design results through prototype fabrication process.

2. METHODOLOGY

This study adopts a quantitative methodology with an experimental research design aimed at evaluating the performance and efficiency of a PSV hull prototype. This approach facilitates controlled testing environments and precise measurement of technical parameters, thereby ensuring objectivity and feasibility in prototype realization.

The study population comprises a variety of surface vessel prototypes developed through prior experimental investigations and design projects. A purposive sampling method was employed, based on specific design attributes such as the V-shaped hull form and other innovative configurations. Selection criteria included conformity with principal dimensional parameters, resistance efficiency, and the magnitude of resistance generated.

Data collection involved a combination of comparative ship analysis to obtain reference vessel data and direct experimental testing. Resistance simulations were conducted using manual calculations based on the empirical Holtrop method.

The experimental phase commenced with the construction of a scaled PSV model, encompassing the design process and frame fabrication utilizing a pre-prepared lines plan. The hull was fabricated using a non-molded technique, iteratively refined to achieve an optimal form. The final hull quality was assessed based on its adherence to the intended geometric design and the absence of distortions such as unintended concavities or convexities.

Data analysis was performed using both descriptive and comparative approaches, juxtaposing simulation outputs with empirical test results. Resistance values derived from Holtrop's empirical calculations were analyzed to determine total resistance affecting vessel performance. These insights serve as the basis for evaluating hull design efficiency and informing the development of more optimized hull forms.

3. RESULTS AND DISCUSSION

3.1. Determine the Main Size of the Vessel

Prior to designing the vessel, it is essential to determine the principal dimensions of the ship. A comparative vessel analysis method is employed to establish the Length of the Perpendicular (LPP), Beam (B), Depth (H), and Draft (T) of the vessel. This analysis incorporates data from five reference vessels. The collated data from these sources is summarized in [Table 3](#).

Table 3. Comparison vessel data ([VesselFinder, 2007](#); [DeepOcean, 2023](#); [GSP, 2023](#); [CCS, 2025a, 2025b](#))

No	Ship Name	L (m)	B (m)	H (m)	T (m)
1	GSP FALCON	100.04	22.5	11	7.27
2	HAI YANG SHI YOU 291	96.3	24	9.8	6.5
3	HAI YANG SHI YOU 289	110.8	22	9	6,5
4	OLYMPIC ARES	108.25	22	7.12	7.12
5	HOS STRONGLINE	120.6	21	7.62	5.3

After obtaining the data from the comparison vessels, the principal dimensions are determined using established empirical formulas. The set of methods is including the Posdunine formula for LPP, empirical approximations for draft, and general design formulas for beam and depth are based on standard preliminary design practices as documented in Bertram and Schneekluth ([Bertram and Schneekluth, 1998](#)). The approach involves incorporating the data into these relevant equations, summing the results, and calculating the average to derive the final values. Ship's length recommended by Posdunine ([Bertram and Schneekluth, 1998](#)):

$$L_{pp} = C \times \left(\frac{V}{V+2} \right)^2 \times \nabla^{\frac{1}{3}} \quad (1)$$

where C is Coefficient value obtained from the mean amount of comparison ship data; V is Speed (knot).

$$\nabla = L \cdot B \cdot T \cdot C_b$$

$$L_{pp} = 6.45 \times \left(\frac{14}{14+2} \right)^2 \times 10956.2^{\frac{1}{3}}$$

$$L_{pp} = 109.8 \text{ m}$$

Formula for finding ship draft (Bertram and Schneekluth, 1998):

$$T = C \sqrt{\frac{\Delta}{L_{pp}}} \quad (2)$$

where Δ is Displacement; C is Coefficient value obtained from the mean amount of comparison ship data.

$$T = 0.64 \times \sqrt{\frac{12409.3}{109.8}}$$

$$T = 6.78 \text{ m}$$

Formula for finding ship beam (Bertram and Schneekluth, 1998):

$$B = \frac{\Delta}{L \cdot T \cdot C_b \cdot \rho} \quad (3)$$

where ρ is Seawater density (kg/m^3).

$$B = \frac{12409.3}{109.8 \times 6.78 \times 0.367 \times 1.025}$$

$$B = 44.33 \text{ m}$$

Formula for finding ship depth (Bertram and Schneekluth, 1998):

$$D = \frac{T}{C} \quad (4)$$

where C is the value obtained from the sum of the average results of the distribution of the draft and the height of the comparison ship.

$$D = \frac{6,78}{0,71}$$

$$D = 9.59 \text{ m}$$

Formula for finding LOA and LWL:

$$LOA = \frac{100}{96} \times L_{pp}$$

$$LOA = \frac{100}{96} \times 109,8$$

$$LOA = 114,39 \text{ m}$$

$$LWL = \frac{96}{95} \times L_{pp}$$

$$LWL = \frac{96}{95} \times 109,8$$

$$LWL = 110,9 \text{ m}$$

The principal dimensions obtained from the initial formula calculations are considered preliminary. These values can be adopted directly if they satisfy the dimensional ratio criteria established in the design guidelines. However, if the calculated dimensions fall outside the acceptable range, adjustments (either increases or decreases) must be made accordingly. The dimensional ratio used as reference in this study follows the criteria proposed by Lewis (Lewis, 1988). Table 4 as shown primary size of final ship.

- Ratio of length to breadth, $L/B = 3.5 < x < 10 : 2.5$
- Ratio of length to draft, $L/T = 10 < x < 30 : 16.8$
- Ratio of breadth to draft, $B/T = 1.8 < x < 5 : 6.5$

Since the initial size of the calculation does not meet the ratio limit requirements, adjustments are made until it meets the requirements :

$$LOA = 125.5 \text{ m}$$

$$B = 34.17 \text{ m}$$

$$H = 13.62 \text{ m}$$

$$T = 8.8 \text{ m}$$

Then, the ratio changes to :

$$L/B = 3.5 < x < 10 \rightarrow 3.6$$

$$L/T = 10 < x < 30 \rightarrow 14.2$$

$$B/T = 1.8 < x < 5 \rightarrow 3.8$$

Table 4. Primary size of final ship

Size	Value	Unit
Length Overall (LOA)	125,5	m
Length Waterline (LWL)	115,8	m
Length Between Perpendicular (LPP)	109,8	m
Breadth (B)	34,17	m
Height (H)	13,62	m
Draught (T)	8,8	m
Vs	14	Knot

3.2. Drawing Lines Plan and General Arrangement of Ship

After determining the principal dimensions of the ship, the hull form is defined in three dimensions, which results in a lines plan drawing that serves as the basis for laser cutting (see Figure 1). From the lines plan, a frame cutting line is created to facilitate the cutting process.

Following the completion of the hull design and general arrangement (see Figure 2), these elements are integrated to create a complete 3D visualization of the entire vessel (see Figure 3). Given the absence of specific constraints or requirements, this process allows designers the flexibility to apply their creativity in shaping the vessel's final form.

3.3. Resistance Calculation

Calculations to estimate resistance are essential to determine power requirements and operating efficiency. In this study, resistance calculations were conducted using the Holtrop method, with its statistical formulations sourced from Birk (Birk, 2019), because it is practical and fairly accurate.

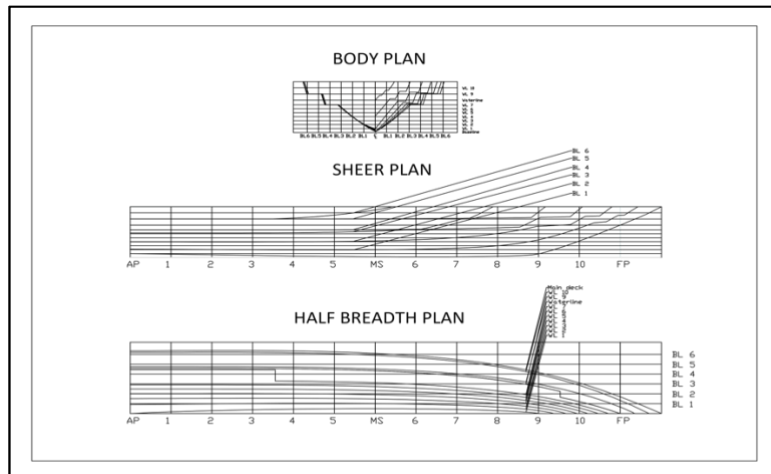


Figure 1. Lines plan of ship

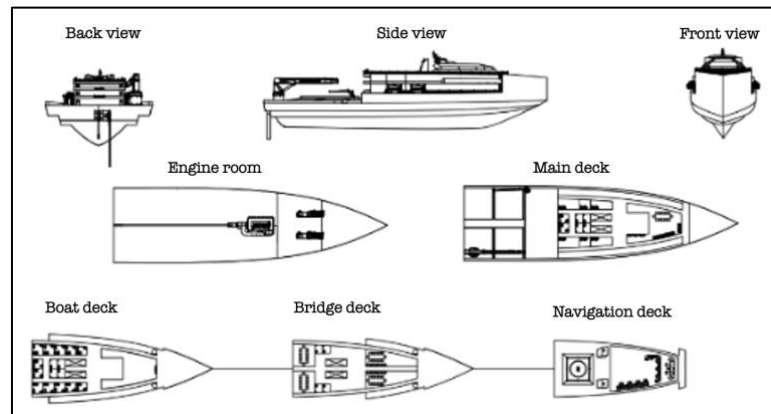


Figure 2. Technical design of general arrangement of the ship



Figure 3. 3D view of vessel design

The calculations focused on the four main components of resistance that affect ship performance the most: frictional resistance, wave resistance, transom resistance, and air resistance. The calculations were made at a speed of 14 knots, which represents the normal operational conditions of the ship when sailing.

Frictional resistance is calculated based on the ITTC 1957 model–ship correlation line approach (Birk, 2019), using the following formula:

$$R_F = \frac{1}{2} \rho v^2 s S C_F \quad (5)$$

where S is Wetted surface (hull); C_F is Friction Coefficient ($\frac{0,075}{[\log_{10}(Re)-2]^2}$); Re is Reynold number; and v^2s is Ship speed.

$$R_F = \frac{1}{2} \times 1,025 \times (7,201)^2 \times 3204,9 \times 0,0016$$

$$R_F = 136,32 \text{ kN}$$

Transom resistance is calculated using the Holtrop and Mennen, with the following formula (Birk, 2019):

$$R_{TR} = \frac{1}{2} \rho v^2 s A_T c_6 \quad (6)$$

where A_T is Immersed transom area; c_6 is $0,2 (1 - 0,2Fr_T)$ if $Fr_T < 5$.

$$Fr_T = \frac{vs}{\sqrt{\frac{2gA_T}{(B+B_{WP})}}} \quad (7)$$

$$R_{TR} = \frac{1}{2} \times 1,025 \times (7,201)^2 \times 97,42 \times 0,1481$$

$$R_{TR} = 383,55 \text{ kN}$$

The formula for determining wave resistance for Froude numbers < 0.4 was originally proposed by Holtrop (Birk, 2019):

$$R_{WA}(Fr) = c_1 c_2 c_5 \rho g V \exp [m_1 Fr^d + m_4 \cos (\lambda Fr^{-2})] \quad (8)$$

where:

$$c_1 = 2223105 c_7^{3,78613} \left(\frac{T}{B}\right)^{1,07961} (90 - i_E)^{-1,37565}$$

$$c_2 = e^{(-1,89\sqrt{c_3})}$$

$$c_3 = 0,56 \frac{A_{BT}^{1,5}}{[B T (0,31 \sqrt{A_{BT}} + T_F - h_B)]}$$

$$c_5 = 1 - 0,8 \frac{A_T}{B T C_M}$$

$$c_{16} = 8,07981 C_P - 13,8673 C_P^2 + 6,984388 C_P^3$$

$$m_1 = 0,0140407 \frac{L_{WL}}{T} - 1,75254 \frac{V^{(\frac{1}{3})}}{L_{WL}} - 4,793232 \frac{B}{L_{WL}} - c_{16}$$

$$m_4 = 0,4 c_{15} e^{(-0,034 Fr^{-3,29})}$$

$$d = -0,9$$

$$\lambda = 1,446 C_P - 0,03 \frac{L_{WL}}{B}$$

V = Volume displacement

then:

$$R_{WA}(Fr) = 26,9 \text{ kN}$$

The formula for determining air resistance follows the ITTC procedure (Birk, 2019):

$$R_{AA} = \frac{1}{2} \rho_A v^2 s C_{DA} A_V \quad (9)$$

where ρ_A is the density of air is 1,225 kg/m³; C_{DA} is the default air drag coefficient is 0,8; A_V is the area of the lengthwise projection of hull and superstructure above the waterline.

$$R_{AA} = \frac{1}{2} \times 1,225 \times (7,201)^2 \times 0,8 \times 257,87$$

$$R_{AA} = 6,55 \text{ kN}$$

The previously calculated resistance components are combined to obtain the total resistance according to (Birk, 2019):

$$R_T = (1 + k) R_F + R_{TR} + R_W + R_{AA} \quad (10)$$

$$R_T = (1 + 0,7922) 136,32 + 383,55 + 26,9 + 6,55$$

$$R_T = 661,31 \text{ kN}$$

3.4. Prototype Fabrication and Cost Calculation

The prototype ship fabrication process includes hull construction techniques. One such technique is the non-molded hull method. In this method, the size of the ship is scaled 1:100 from the original size. This approach involves shaping the hull structure directly based on the lines plan design, with the frame profiles determined through predefined cutting paths. In this method, the hull is constructed using plywood or timber, which is cut and assembled into frame sections, then layered with balsa wood and polyester putty to achieve the desired hull form. The estimated fabrication costs for the prototype, including material expenses associated with the non-molded hull technique, are presented in Table 5.

The fabrication process follows these structured steps; The first stage involves precisely cutting plywood or wood into ship frames according to the predetermined cutting path design as shown in Figure 4. This ensures structural accuracy and alignment.

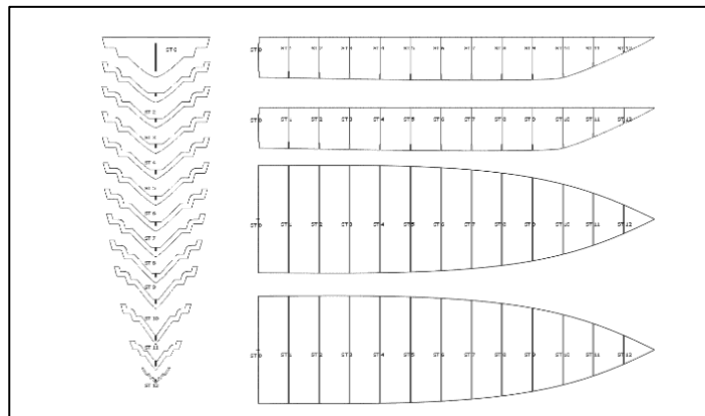


Figure 4. The frame cutting path

Table 5. Draft fabrication cost budget

No	Item	Qty	Unit Price (Rp)
1	Diton 9012 (Green)	1	43,000
2	Diton 9422 (Blue)	1	35,000
3	Diton 9128 (Clear)	1	33,000
4	Diton 9311 (Red)	1	33,000
5	Dextone glue	5	7,800
6	Clear resin and catalize	2	58,000
7	Dextone Non Sag Epoxy Resin	2	40,800
8	Polyster Putty and Hardener	1	44,000
9	Acrilic paint 12 colours	1	43,990
10	Sandpaper120	1	3,900
11	Sandpaper 80	1	3,900
12	Balsa wood (2mm) 30cm x 10 cm	20	10,000
13	Balsa wood strip (2mm x 5mm x 100cm)	30	2,000
14	Balsa wood strip (2mm x 40mm x 100cm)	30	6,500
15	PVC board (2mm 60cm x 40 cm)	6	15,000
16	Korea glue (50 pcs/Box)	1	126,500
17	Balsa Plywood 3mm x 30 x 40 cm	5	6,000
18	Paper tape	3	4,940
19	Aibon glue	1	74,000
20	Carbon fiber 12K Spread Tow 200 gsm	1	215,000
21	Laser cutting services	1	567,500
Sub Total			2,049,210

Next, as shown in [Figure 5](#), assemble each hull frame using adhesives. Make sure that it is straight and sturdy in preparation for the balsa wood installation stage. This stage is crucial for achieving the precise shape of the hull.



Figure 5. Assembly of the hull frame

The installation of balsa wood is carried out to form the hull structure of the prototype ship. This process starts from the formation of the hull skin to achieve the contours according to the design. Using balsa wood enables precise shaping of the hull, thus facilitating fabrication and final shaping. To increase strength and water resistance, the inside of the hull is coated with waterproof tissue fibers, which provide additional protection and minimize the risk of leakage while strengthening the hull's overall structure. [Figure 6](#) and [Figure 7](#) shows the step.



Figure 6. Balsa wood installation



Figure 7. Clear resin coating

After the balsa wood is installed and equipped with a fiber layer on the inside of the hull, the next step is to evenly coat the surface using polyester putty. This is followed by sanding to create a smooth, sturdy, and waterproof surface. A protective layer that can minimize surface scratches or damage is created through the process of hull painting. To achieve the best coloring results, the surface must be clean and flat. This process generally involves two stages: first, gray primer paint is applied as a base to ensure the adhesion of the main paint, which is then applied in a color tailored to the vessel's design theme. As a final touch, a spray gun or pilox is used to apply a glossy or matte finish, which gives the hull a smooth appearance and adds protection.



Figure 8. External hull coating with putty



Figure 9. Finished result of ship prototype of fabrication

For comparison, some previous studies are used in the present study, especially in fabrication process. It is useful to compare this fabrication process with similar design studies. For example, Raharja et al. focused on electric boat control systems (Raharja *et al.*, 2023), while Yuniarto et al. described specific design stages for catamaran prototypes. Different from other studies that focus on fabrication systems or techniques, this research adds another contribution (Yuniarto and Kusuma, 2023). This study not only explains the steps in making a prototype but also complements it with detailed cost calculations for fabrication. The addition of this cost analysis is important because it covers not only the technical aspects of fabrication, but also the implementation costs of making a ship prototype.

4. CONCLUSION

This study has achieved its objective of developing a preliminary design for a Platform Supply Vessel (PSV) to support offshore operations in the waters of Natuna, Indonesia. The design process began by determining the main dimensions through a comparison of five reference ships, which was verified based on standard design ratios. The empirical resistance analysis using the Holtrop method, that the proposed hull design has a total resistance characteristic of 661.31 kN at an operational speed of 14 knots. In addition, the design was physically created through the fabrication of a non-molded hull prototype, which was completed at a detailed cost of Rp 2,049,210. This approach combines technical design with fabrication and cost estimation, which differs from similar studies that focus on the design stage.

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