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Regular Research Article

The General Arrangement of Water Bus on Mahakam River's

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Abstract: Mahakam River is located at the heart of domestic and foreign tourists. The beauty of the Mahakam River can be enjoyed using a wooden water bus. Currently, there are 2 (two) water buses are available on the Mahakam River to serve tourists who want to explore their beauty. The water bus did not meet adequate safety and seaworthiness standards. The purpose of this study is to provide an alternative to the existing water bus design to rejuvenate the tourism fleet operating on the Mahakam River. The research stages included designing a general arrangement for a tourism water bus that produces data in the form of main dimensions, hull form coefficients, line plans, general arrangements, 3D designs, and ship accommodation interiors. The results obtained are the main size of the ship with the following details; L = 14.04 m, B = 5 m, H = 1.4 m, T = 1.1 m, Vs = 10 knots, Engine Power = 87.4 HP (For 2 Engines), Number of Passengers and Crew = 80 Persons. The initial stability met these criteria.

Keywords: Water Bus; Vacation; Mahakam River; Parent ship approach; tourism

1. Introduction

According to the Government Agency Performance Accountability Report (LAKIP) of the Ministry of Tourism and Creative Economy [1], tourism is one of the 3 (three) foreign exchange earners after income from the oil and gas sector and palm oil in Indonesia; in 2011, the tourism sector contributed more than 8.5 billion US dollars in foreign exchange. With complete natural resources, there are more than 17,000 islands, more than 740 ethnic groups, 583 regional languages, and a wide variety of local wisdom and cultural features, which have enormous tourism potentials for Indonesia [2]. It should be remembered that the Mahakam River is a very valuable icon for the city of Samarinda and the charm of beautiful marine tourism to be enjoyed at dusk. Thousands of people flock to this location to relax and enjoy the riverbank. The original habitat of Mahakam Pesut, which can no longer be found around the edges of Mahakam. More effort is required to see it. According to the BPS data, the number of tourists in Samarinda City is volatile. This amount is listed in Table 1 [3].

Table 1 shows the number of domestic and international tourists visiting the Mahakam River. This confirms that the Mahakam River has a special place in the hearts of both domestic and foreign tourists. The beauty of the Mahakam River can be enjoyed using a wooden water bus. Currently, there are 2 (two) water buses on the Mahakam River that serve tourists who want to explore their beauty. It was found that water buses did not meet safety and

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seaworthiness standards [4]. The water bus transports passengers and goods through water that sails in large rivers, lakes, and seas.

Table 1. Data on the Number of Tourists in Samarinda City in 2018

Month	Foreign tourists	Domestic touristm	Total
January	42	101695	101757
February	15	88090	88105
March	24	86470	86494
April	45	108245	108290
May	9	113249	113258
June	21	159217	159238
July	40	110306	110346
August	28	118955	118983
September	47	107096	107143
October	14	20386	20400
November	30	21936	21966
December	0	35231	35231

The renewal of the river transportation fleet for tourism can be approached through scientific study. Alamsyah and Nugroho conducted a scientific study related to the application of the water bus design on the Mahakam River using a statistical method or trend curve approach [5]. Setiawan et al. studied the design of transport vessels suitable for shallow water areas using hydrofoil technology [6]. In a different sector, Alamsyah et al studied the application of a special fast boat design in the health sector which was operated in the Mahakam river basin using the parentship method [7]. The waters in East Kalimantan mostly consist of river water areas with their own characteristics. This has implications for ship designs. Alamsyah et al. reviewed the design of fishing boats operating in the waters of East Kalimantan using B-Spiline and parametric approaches with optimum load capacity output and fishing gear technology according to ministerial regulations [8]. These studies are an effort of a scientific approach that is carried out to find design and development technologies that are suitable for shallow water in East Kalimantan. Several design technologies have been developed for ships operating in East Kalimantan waters, such as the use of bottom glass on tourism boats on Derawan island [9]. The use of a multihull hull for 40 GT fishing vessels is expected to provide a high level of ship stability, considering that fishing vessels have more extreme operations [10]. Ding and Jiang also reported that multihull vessels exhibit high speed and excellent hydrodynamic performance [11]. Su et al. (2020) conducted experimental tests and numerical simulations to determine the relationship between hydrodynamic performance and main hull shape in multihull form [12]. One type of transportation/tourism ship suitable for river water areas is the water bus [5][9]. The water bus transports passengers and goods by water that sails on large rivers, lakes, and seas. The following shows the water bus is shown in Figure 1.

Figure 1. Water bus

Figure 1 shows a water bus with a catamaran hull. A catamaran- type boat has better stability than a single-hulled boat because of the effect of a catamaran boat that has two hulls, which can break waves and currents with little rocking on the ship, and also makes the boat more stable, making it possible to carry heavy loads from different sides of the boat [13].

Catamaran has several advantages and disadvantages compared to monohull boats [14]. The advantages of a catamaran are as follows: On a ship with the same width, the frictional resistance of the catamaran is smaller; therefore, at the same thrust, the speed is relatively high. The deck area of the catamaran was wider. The volume immersed in water and the wet surface area were smaller. Good stability because it has two hulls. With a high-frequency wave, the amplitude is relatively small, and thus, the comfort level is higher. Because it has a low resistance, the operational costs are low. Passengers' concerns about the ship capsize factor are smaller; therefore, passengers feel safer. A catamaran designed at high speed has a special tunnel on the hull, called the tunneled palnning hull [15]. Tunnel catamarans can create aerodynamic lift and achieve a very significantly reduce drag [16]. In addition, the design of the ship must be ergonomic so that the crew and passengers can feel safe and comfortable using the ship [17]. The shape of the catamaran's hull, according to Molland, is shown in Figure 2. as follows

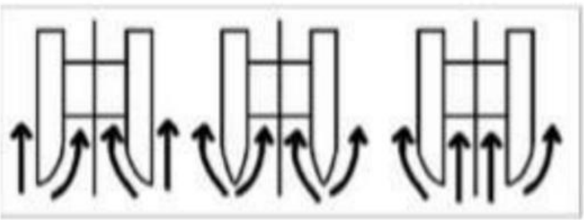

Figure 2. catamaran hull shape [18]

Catamaran hull technology is also used on ships that can operate in amphibious modes [19][20][21][22]. The study of the development of the catamaran hull was also carried out on an asymmetric type by varying the shape of the inner flat, outer flat, and accumulated width of the ship [23]. This research focuses on the design of ships intended for river transportation that have adequate passenger capacity and a high level of ship stability. The waterbus is specifically designed for tropical rivers such as the Mahakam, Mekong, and Kapuas, taking into account several specific factors, such as resistance to dynamic river conditions, strong currents, and changing water levels. The composite hull material is resistant to corrosion caused by river water and tropical weather. In addition, this research is expected to provide an alternative to the existing water bus design in an effort to rejuvenate the tourism fleet operating on the Mahakam River. The research stages included designing a general plan for a tourism water bus that produces data in the form of main dimensions, hull form coefficients, and lines plans.

2. Materials and Methods

The methodology used was the parentship design method and was optimized using B-Spiline software (ship basic data/parametric ship design). The initial data were taken from the reference ship, JC1450 to obtain the main size of the ship that is safe and appropriate. In its implementation, the B-Spiline application was used to obtain the desired line plan drawing, as shown in Figure 3 and Table 2.

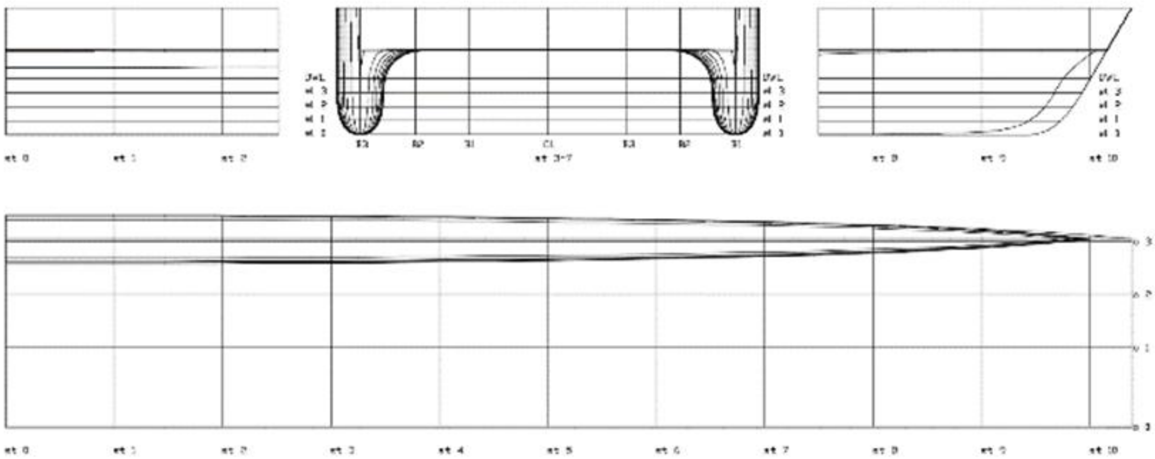

Figure 3. the example shape of the lines plan of the catamaran.

The picture above is a line plan using the Maxsurf Modeller application, which will later be exported into Auto Cad form to describe a general plan in accordance with the required conditions. The next stage is to export the image into the Sketch Up application to draw a 3-dimensional shape of the ship that has been made a general plan. This aims to facilitate the visualization of the ship by the owner or other related parties. In this context, a line plan is developed to determine the initial shape of the hull. This is used to visualize the principal dimensions that have been determined. A language that can describe the hull shape must be developed. The second is the design of a general arrangement for determining the specifications of the ship to be built. The condition of the location of the tank and machinery is visualized in the general arrangement. The layout of the interior conditions and supporting parts of the ship are described in the general arrangement plan. It is impossible to describe the size, type, and placement of an item with a narrative. Based on the initial main size data obtained from the linear regression process, the next step was to create a lines plan using the Maxsurf Education Version-Maxsurf Modeler and CAD software. The line plan is a projected image of the ship's hull cut transversely (body plan), lengthwise (sheer plan), and vertically lengthwise (half-breadth plan).

Table 2. Data parentship & decision

Particulary	Value	Units
L_{pp}	13.46	meters
B	5	meters
B_1	1.43	meters
H	1.4	meters
T	1.09	meters
V_s	10	knots

Table 2 lists the primary measures obtained using the JC1450 Catamaran parentship design method. This main measure will be used in the process of drawing line and general plans. The main size obtained was then corrected using several main size ratio parameters, specifically for catamarans [18][24].

Table 3. Constrain of main dimension

Ratio of particular	Range value	Sourches
L/B_1	$6 < L/B_1 < 11$	Insel & Molland
L/H	$4 < L/H < 10$	Insel & Molland
B/H	$0.7 < B/H < 4.1$	Insel & Molland
S/L	$0.2 < S/L < 0.5$	Insel & Molland
S/B_1	$1 < S/B_1 < 4$	Insel & Molland
B_1/T	$1 < B_1/T < 3$	Insel & Molland
B_1/B	$0.15 < B_1/B < 0.3$	Multi Hull Ships (Dubrovsky, 2001)
C_B	$0.36 < C_B < 0.59$	Multi Hull Ships (Dubrovsky, 2001)

The resistance of the catamaran hull was calculated using the method of Insel and Molland [18].

$$R_T = 0.5 \times \rho \times 2 \times WSA \times V^2 \times C_{tot} \quad (1)$$

where RT is the total resistance of the ship (kN), is the density of the fluid (kg/m3), WSA is the surface area of the hull submerged in water (m2), V is the speed of the ship (m/s), and Ctot is the coefficient of the total catamaran drag. The research flow is illustrated in Figure 4.

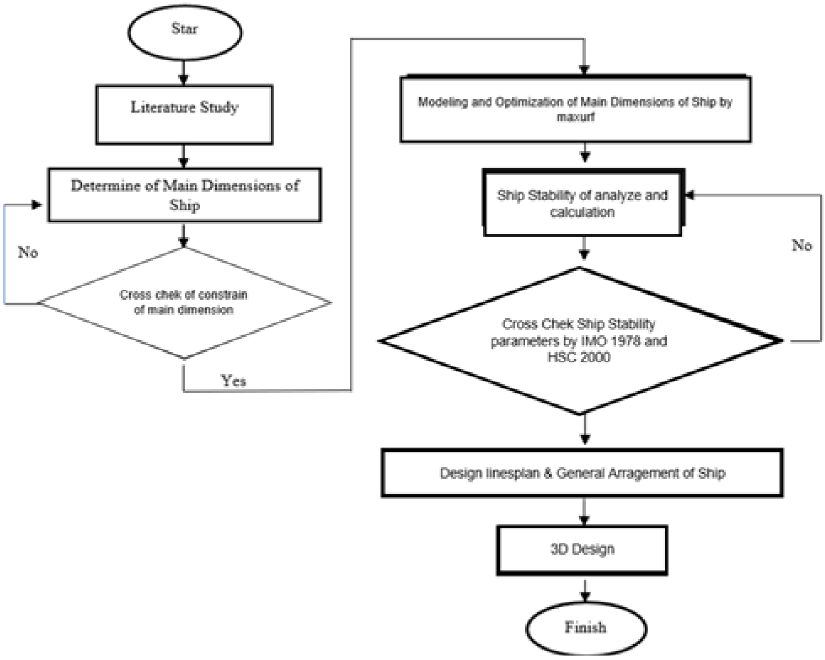

Figure 4. Flowchart Research

Figure 4 illustrates the stages of this study. The first stage began with a literature review. The second stage is to determine the dimensions of the ship using the parentship method, in which samples of existing vessels that have been tested during operation are developed. The advantage of this method is that the resulting ship has the same characteristics and work performance as the parent ship. The third stage is the size of the resulting ship, which is then empirically corrected using certain constraints according to Dubrovsky (2001) and Insel Molland (1991) [24][18]. The fourth stage ensures the size of the designed ship according to the owner's requirements using the approximate formula. At this stage, ship design modeling was carried out using a Maxurf modeler. In the Maxurf modeler, this optimization occurs automatically when inputting the main size of the vessel design. In the application, several fixed variables of the ship and independent variables were determined according to the type of ship. The fifth stage analyzes the stability of the ship under a full-load scenario. Planned scenarios are appropriate when a ship is in operation. The results of the analysis of ship stability were evaluated based on the IMO and HSC. The sixth stage is to make a general plan for the ship, including the LWT and DWT values, spatial planning, determination of engine power, and safety equipment. The seventh stage is the 3D interior design of the passenger deck using the sketch-up software.

3. Results

3.1 Determine of Main Dimension of Ship

Tables 4 and 5 show the main ship sizes used for modelling. This ship is planned to load 80 people (crew and passengers), and each person is assumed to weigh 75 kg and 10 kg of luggage, respectively. To control for severe displacement and design displacement, the following empirical formula is used [25];

$$\Delta = \nabla_t \times \rho_{fresh\ water} \quad (2)$$

where Δ = displacement of the draft ship, ∇t is the= total volume displacement, and ρfreshwater= freshwater density = 1000 kg/m3. Total displacement volume, freshwater= freshwater density = 1000. The designed ship has one owner requirement, which states that the weight of the cargo is the weight of the passengers and their luggage of 6.8 tons. Meanwhile, the ship weight approach using B-Spiline-based software states that the ship displacement is 32.95 tons.

Table 4. Constrain of main dimension

	Particulary parentship		Particulary decision	
L_{pp}	13.46	meters	13.5	meters
B	5	meters	5	meters
B_1	1.43	meters	1.44	meters
H	1.4	meters	1.4	meters
T	1.09	meters	1.09	meters
V_s	10	knots	10	knots

.

Table 5. Constrain of main dimension

Ratio of particular actual	Range value	Sourches	Status
$L/B_1 = 9.38$	$6 < L/B_1 < 11$	Insel & Molland	Accepted
$L/H = 9.64$	$4 < L/H < 10$	Insel & Molland	Accepted
$B/H = 3.57$	$0.7 < B/H < 4.1$	Insel & Molland	Accepted
$S/L = 0.17$	$0.2 < S/L < 0.5$	Insel & Molland	Accepted
$S/B_1 = 1.59$	$1 < S/B_1 < 4$	Insel & Molland	Accepted
$B_1/T = 1.32$	$1 < B_1/T < 3$	Insel & Molland	Accepted
$B_1/B = 0.28$	$0.15 < B_1/B < 0.3$	Multi Hull Ships (Dubrovsky, 2001)	Accepted
$C_B = 0.42$	$0.36 < C_B < 0.59$	Multi Hull Ships (Dubrovsky, 2001)	Accepted

3.2 Modeling Water Bus of Catamaran Hull

After obtaining the main size of the ship, the hull shape was modeled using a B-Spiline-based application based on the main sizes of the ship, including LOA, B, H, and T. The hull pattern of the catamaran for a water bus is shown in Figure 5.

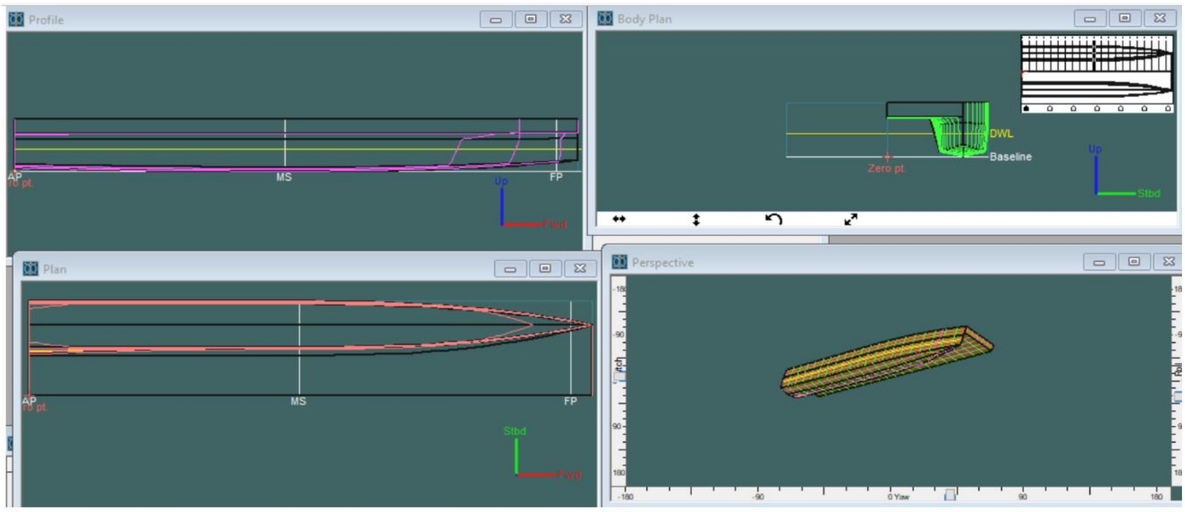

Figure 5. Catamaran hull of Fishing Vessel on Software B-Spiline Application

3.3 Ship Stability Analysis

In calculating ship stability, the initial stability approach includes longitudinal stability (trim) and transverse stability (initial stability). The trim is the difference between the front draft at the bow and rear draft at the stern. The triangle denotes the longitudinal angle of the ship. The trim calculation is based on the Parametric Design method described in, Chapter 11 by Parsons [25]. In this method, to check the terms and trim of the ship, several inputs are used, such as the value of KB (vertical distance of the keel to the bouyancy point transversely), KG (vertical distance of the keel to the center of gravity of the ship transversely), and BMT (distance from the boyancy point to the metacenter transversely). BML (longitudinal distance of boyancy point to metacentra), LCG (center of the ship's center of gravity measured longitudinally from midship), LCB (longitudinal ship boyancy point measured from midship), and GML (longitudinal distance of gravity point to metacentre). To obtain these values, the following empirical formula was used:

Table 6. Variable input in determining ship trim

Particulary decision		Sourches	Actual value
KB	T (0.9 – 0.3 x C_M – 0.1 x C_B)	Parametric Ship Design pag. 11 – 18	0.8 meters
BM_T	$\frac{I_T}{\nabla}$	Parametric Ship Design hal. 11 – 18	3.23 meters
BM_L	$\frac{I_L}{\nabla}$	Parametric Ship Design pag. 11 – 18	20.4 meters
GM_L	KB + BM_L - KG	Parametric Ship Design pag. 11 – 18	19.71 meters
Trim	$\frac{(LCG - LCB)LPP}{GM_L}$	Parametric Ship Design pag. 11 – 18	0.05 meters

.

Table 6 shows the related variables in determining the ship trim conditions, including T is the draft, CM is the midship coefficient, CB is the block coefficient, IT is the transverse inertia, IL is the longitudinal inertia, and LPP is the distance between the after perpendicular and fore perpendicular points. Next, we calculated the condition of transverse stability of the ship. In this context, the author used a B-spiline-based application in the process. The initial conditioning of the transverse stability of the ship used a 100% load scenario.

Table 7 shows the loading conditions of the water bus contained in the operational tanks and the passenger compartment, all of which amounted to 100%. This load case is the critical point for water bus stability. While stability at 100% load is considered safe, conditions at 75%, 50%, and 25% are also considered safe. Furthermore, a stability analysis was performed using a B-spiline-based application. The simulation results show the static stability arm of the ship, as shown in Figure 6. Figure 6 shows the stability arm curve that provides information about the maximum GZ value occurring at an angle of = 25° of 4.26 meters and an initial GM of 0.26 meters. In addition, the area under the curve at various angles of slope and the minimum allowable standard are listed in Table 8.

Table 7. Loadcase of water bus

Type fluid of tank	Loadcase full load
Fuel Oil Tank SB	100%
Fuel Oil Tank PS	100%
Fresh Water Tank SB	100%
Fresh Water Tank PS	100%
Ballast tank SB	0%
Ballast tank PS	0%
Payload	100%

Table 8. Result of simulation & standar allowble [26][27]

Limits Area Allowable Under Of Arm Stability Curve		Sourches	Actual Value	Status
A0-30°	min. 3.15 meters°	IMO 1978 & HSC 2000	Act. 24.15 meters°	Accepted
A0-40°	min. 5.15 meters°	IMO 1978 & HSC 2000	Act. 34.68 meters°	Accepted
A30-40°	min. 1.71 meters°	IMO 1978 & HSC 2000	Act. 10.45 meters°	Accepted
$GZ_{max.}$	min. 25°	IMO 1978 & HSC 2000	Act. 25°	Accepted
$GM_{initial}$	0.15 meters	IMO 1978 & HSC 2000	Act. 4.26 meters°	Accepted

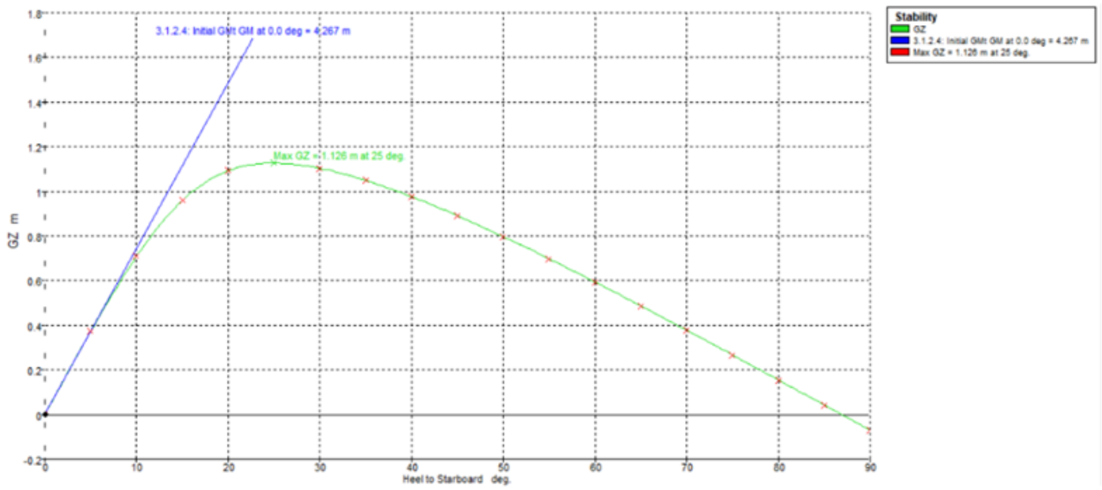

Figure 6. Arm Stability of curve (GZ) Loadcase 100%

3.4 Design of General Arrangement of Water Bus

The next stage is to arrange the layout of the compartments on board the ship, including passenger and crew decks, operational tanks, and transverse and longitudinal bulkheads on the ship. This has implications for the weight of the ship, which includes lightweight tons (LWT) and dead-weight tons (DWT).

Figure 7 shows the general arrangement of the water bus, which will then be broken down, starting with the determination of powering, construction weight, and cosumble/supply components on the ship. To calculate the power on the ship, we started by detecting the total resistance value (RT) using Equation 1. Therefore, we obtained an RT of = 17.33 kN with a maximum achievable speed of 10 knots.

Data on the total resistance of the ship and the desired service speed are important inputs when planning the ship power. The value of ship power is approximated by the following equation [28];

$$P_E = R \times V \qquad (3)$$

= 28.29 [kW] with; 1 [Hp] = 0.7355 [kW]

= 38.4 [Hp]

where PE is the effective horsepower (Hp). The PE value was the basis for determining the PB value as the final selection for determining the main engine power.

$$P_B = P_D + (x\% \times P_D) \qquad (4)$$

where x% = Machinery of correction [10%-15%]. To used 15 %

$$P_D = \frac{P_E}{P_C} \qquad (5)$$

$$P_C = \eta_R \times \eta_P \times \eta_H \qquad (6)$$

where ηR is the= relative rotational efficiency, ηH is the= efficiency of the hull, and ηP is the= efficiency of the propeller mounted on the back of the ship. Langrange value interpolation was used to determine the engine efficiency value.

$$\eta_P, \eta_R, f(x) = \frac{(x-x_1)}{(x_0-x_1)} \times f(x_0) + \frac{(x-x_0)}{(x_1-x_0)} \times f(x_1) \qquad (7)$$

$$\eta_P \rightarrow f(x_0) = 0.55 \quad \eta_R \rightarrow f(x_0) = 0.984$$

where ηH is determined based on the following formula [25] :

$$\eta_H = \frac{(1-t)}{(1-w)} = 0.997 \qquad (8)$$

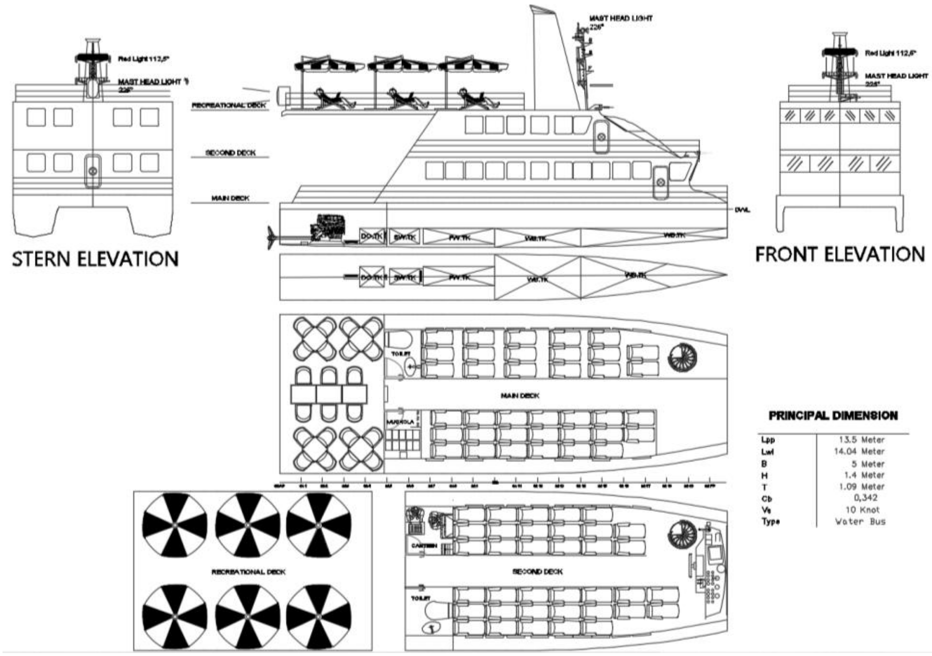

Figure 7. General arrangement of water bus

The propulsion efficiency of the PC is 0.53, PD (delivery hormonse power) is 51.64 [Hp], and that of the PB (Break Horsepower) is 87.4 [Hp] (59.74 kW). The PB value is a reference for determining engine specifications. Generally, Catamaran hull ships generally use 2 engines of the outboard type. An Outboard machine is very easy to install on a stand [29]. The catamaran hull design required 87.4 [Hp] of power using an outboard engine.

Furthermore, the breakdown of the weight of the ship includes LWT + DWT as shown in Tables 9 and 10.

Table 9. Breakdown DWT of Water Bus

No	Total weight of DWT		
	Item	Value	Unit
1	weight crew & provision	0.68	Tons
2	weight of Fresh Water	5.14	Tons
3	weight of Fuel Oil	1.47	Tons
4	weight passenger & provision	6.12	Tons
5	weight of lubricant oil	0.045	Tons
	Total	13.46	Tons

Table 10. Breakdown LWT of Water Bus

No	Total weight of LWT		
	Item LWT	value	unit
1	Hull weight	0.03	tons
2	deck weight	3.4	tons
3	Construction estim.	2.7	tons
4	bottom of weight	3.24	tons
5	superstructure	3.97	tons
6	machinery system	3.96	tons
7	equipment and supplies	1.21	tons
	Total	18.69	tons

The table above shows the total weight of the ship which is 32.16 [tons] when compared to the displacement of the ship lift of 34 [tons]. This shows that the catamaran has met the design weight correction with a difference of not more than 5% based on Archimedes' law point of view.

3.5 Design 3D of Water Bus

The 3D modeling of the water bus ship was performed using sketch- up software. At this stage, 3D modeling was performed to facilitate the visualization of the design drawing. The data required for the modeling were line plans and general arrangements. The 3D design includes a global image of the ship, passenger compartment, and weather deck, as shown in Figure 10.

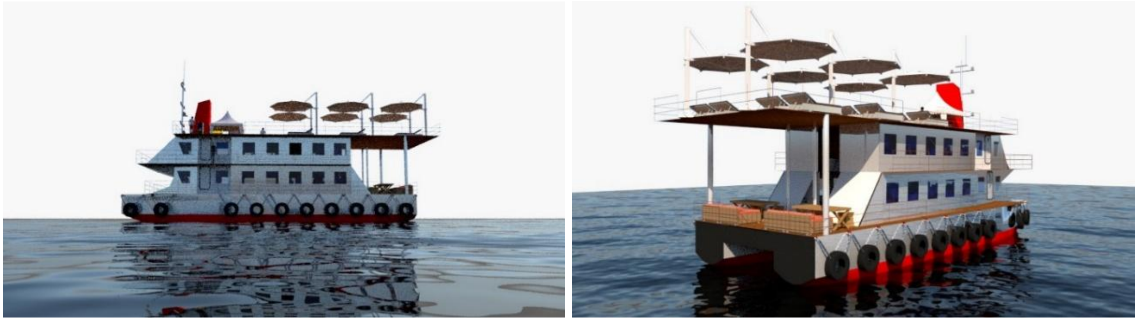

Figure 10. 3D of water bus

4. Conclusions

This study detects the main size of the optimal water bus, namely Lenght of perpendicular (Lpp) = 13.5 [m], beam (B) = 5 [m], beam of each hull (B1) = 2.31 [m], height (H) = 1.4 [m], draft (T) = 0.6 [m], Crew of number = 8 person, passenger of number = 72 person, and speed (Vs) = 10 [Knots]. The required power of Catamaran is a power of 87.4 [HP]. For stability analysis based on the regulations of the International Maritime Organization (IMO) section A.749 and High-Speed Craft 2000 annex 7 Multihull criteria, the standard was met with a full load case load. To develop this research in the future, it will be necessary to analyze the motion of the ship and its relationship with the age of the ship.

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Author Contributions: Alamsyah: Conceptualization, Methodology, Software, Writing – original draft. Muhammad Uswah Pawara: Funding acquisition, Conceptualization, Methodology, Writing – review, Supervision. Chris Jeremy Verian Sitorus: Conceptualization, Methodology, Writing – review, Supervision. Rodlian Jamal Ikhwani: Methodology, Numerical Simulation, and Niti Gede Kumandang: Methodology, Numerical Simulation

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