Design of Water Ambulance for Inland Waterways of Regency East Kalimantan

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Keywords: Waterways, health boat, water ambulance, Design. Regresi linear

Abstract: East Kalimantan, which continues to make health services for the community effective. Through the floating health center because of the location of most settlements on the banks of the Mahakam River. The program has been running for the past few years and is thought to be very effective for people who have not been touched by qualified health services. This activity is not without gaps, but it is suspected that this program needs to be equipped with other facilities/facilities, namely the provision of Water Ambulance for each main health center in the Mahakam watershed. The purpose of this research was to determine the design of a health boat on the Mahakam river flow. The used method was the trend curve of comparative ship data and optimization approach of software. The results showed the principal dimension of water ambulance had length overall (L) = 8.81 meters, draft (T) = 0.45 meters, the breadth of each hull (B) = 2.65 meters, and height (H) = 1.23 meters, Cb = 0.32, Voa = 18 knots, crew = 2 person, passenger = 5 person. The boat had resistance is 5,457 kN and than required 150 HP of engine power.

1 INTRODUCTION

The Provincial Government of East Kalimantan is asked to improve health services for remote, inland, and East Kalimantan border communities. People in the area hope that there will be medical personnel, such as specialist doctors. Because general practitioners are also not always in the health center. Lack of medical facilities and medical personnel, he continued, it is not uncommon for people in the area to experience problems with pregnancy and childbirth so that many people who are sick cannot be helped due to lack of medical treatment. Responding to the problem of health services in East Kalimantan that has not been evenly distributed, in fact it must be followed up as soon as possible and cannot be ignored, because health is an absolute means to increase productivity and is the main prerequisite in the formation of quality human resources, so that the people of East Kalimantan appear as reliable, independent people and able to survive amid global competition.

This is in line with the Vision of Development in the Health Sector of East Kalimantan Province, namely: "Health for all towards the realization of the best degree of public health in East Kalimantan outside Java and Bali." The meaning is the increase in access to quality comprehensive health services that are easily obtained by the community and the achievement of the MDGs with achievements above the national average.

Through the vision of "Health for all towards the realization of the best degree of public health in East Kalimantan outside Java and Bali", in several regions a planned program has been carried out by each District Health Office, one of which is in Mahakam Ulu Regency, East Kalimantan, which continues to make health services for the community effective. Through the floating health center because of the location of most settlements on the banks of the Mahakam River.

The program has been running for the past few years and is thought to be very effective for people who have not been touched by qualified health services. The floating health center has limitations, namely the large dimensions of the ship, making it difficult to operate in areas that have narrow waters; it also affects the speed of the ship. To problem-solving, this Water Ambulance is planned. The water ambulance has the main dimension small with consideration of the ability of the ship that allows it to operate in various fields.

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The purpose of Water Ambulance as a solution for remote and inland communities that live along the banks of the Mahakam River. This facility is used in emergencies, especially when people who live in the area must be referred to as soon as possible to a city center that has the complete treatment and care. This Water Ambulance has been implemented in Provinces such as South Sulawesi, Makassar City, and in the Thousand Islands of DKI Jakarta.

2 METHOD

The research methodology used is the statistical method or trend curve approach. Preliminary data were taken from several ready-made vessels as comparison ships, then were regressed using ms. Excel to get the main size. The process of preparing the main dimension of the ship is carried out through the following steps: The comparative ship used is adjusted to the specified length of the ship. The comparative ship data is graphed with an absent L and ordinate ratio of the main dimension of the ship to get the regression equation (R^2). The value of R^2 should be as large as possible, the closer it is to value 1, the better and a minimum of 0,4. For this ship, the type of regression used is linear regression. And next, the data is processed according to the design stages used. Output issued in the form of lines plan and general arrangement of ship. The method is depicted, as shown in Figure 1.

After obtaining the lines plane and general plan (GP) of the ship, it will then be used as the basis for the construction of the Water Ambulance on the river

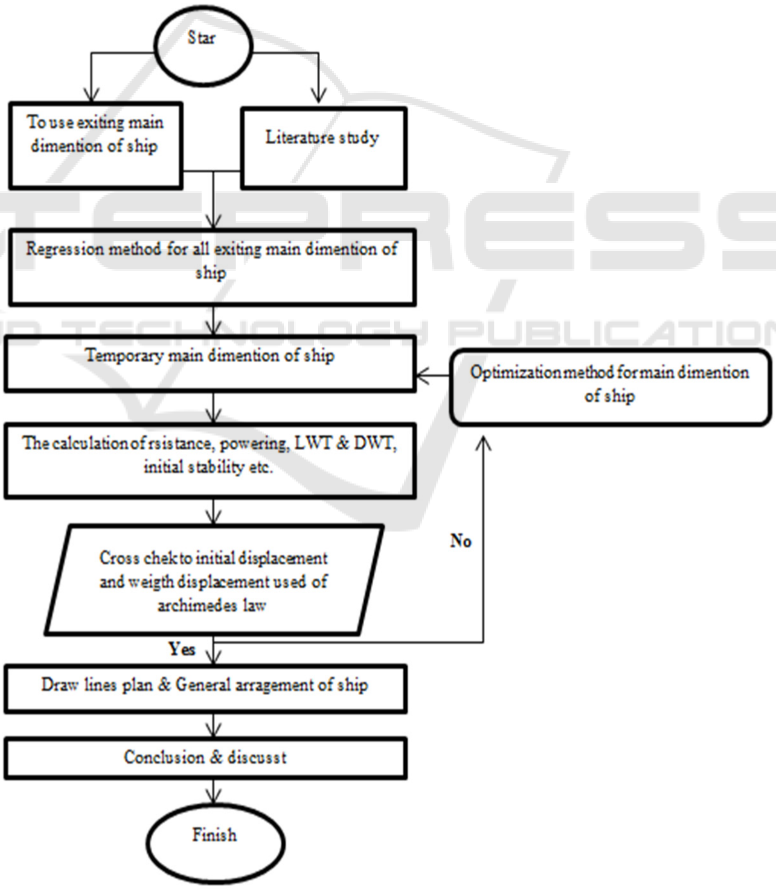

Figure 1. Diagram of Research Method

3 RESULT AND DISCUSSION

Table 1. is the comparative vessel data used as a reference. Ship data consists of displacement, length, breadth, draft, and height. The sampling ship data are shown in Table 1

As explained earlier, the initial data used in the design of the ship are some comparative ship data, as shown in Table 1.

Table 1. Ship sampling data.

NO	Ship Name	L	B	H	T	Weight	Δ
		metres				ton	
1	SBA 1	8,5	2,2	1,1	0,4	0,8	1,7
2	SOT	4,5	1,9	1	0,4	0,5	0,7
3	HD 1380	13,5	3,5	1,4	0,61	5,6	6,5
4	MEDIVAC 2	12,5	3,5	1,2	0,5	3,2	5,1
5	FBI 0822 XA	8,5	2,2	1,1	0,45	0,8	1,7
6	OP	6	2,2	1	0,4	0,8	1,3
7	PATROL FBI	8	2,3	1,1	0,45	0,9	1,9
8	SBP 25	12,5	3,5	1,7	0,5	4,1	5
9	HD 1160	11,6	3,2	1,36	0,55	2,1	3,5
10	SSS	10	2,6	1	0,45	1,1	2
11	AL 625	6,25	2,5	1,25	0,5	0,95	1,2
12	CE A19 F580 SY	5,8	2,29	1,1	0,4	0,6	1,15
13	CE A22F620 SY	5,8	2,29	1,1	0,4	0,6	1,15
14	HD 760	7,6	2,64	1,24	0,42	1,2	1
15	CE A24 F730 SY	7,3	2,29	1,1	0,5	0,65	1,4
16	HD 830	8,3	2,72	1,35	0,41	1,25	3,1
17	HD 860	8,6	2,64	1,24	0,42	1,8	2
18	HD 968	9,68	2,69	1,25	0,41	1,4	2,2
19	AL 1500	15,1	3,67	1,8	0,6	8	9
20	HD 630	6,3	2,3	1,25	0,39	0,75	1,7

3.1 Ship Data Regression

Regression data of the main size of the ship between the variable displacement weight (Δ), and length (L), width (B), height (H), and ladder (T). The results of the regression are linear curves for each of the main size variables show in Figure 2 to Figure 5.

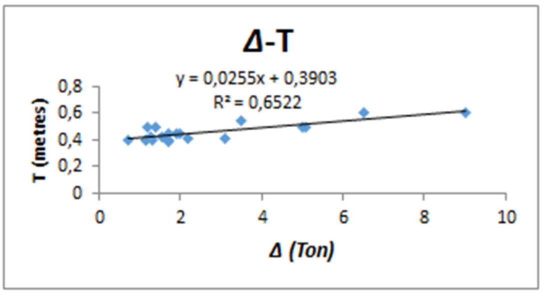

Figure 2. The regression curve of Δ-T

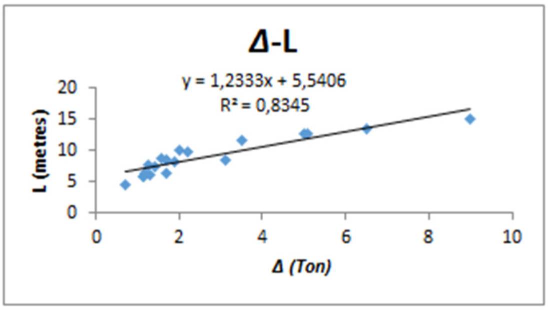

Figure 3. The regression curve of Δ-L

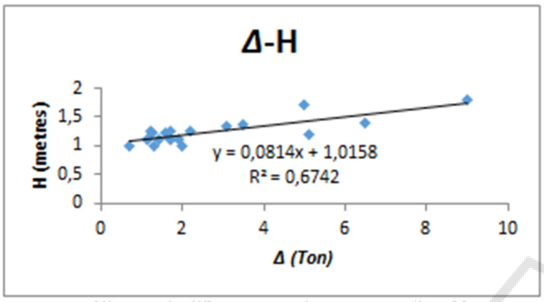

Figure 4. The regression curve of Δ-H

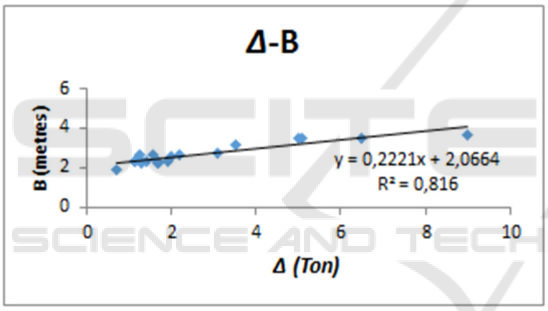

Figure 5. The regression curve of Δ-B

Linear curves resulting from the distribution of regression data between displacement and Lpp produce the value $R^2 = 0{,}834$, displacement and B produce the value $R^2 = 0{,}816$ displacement and H produces the value $R^2 = 0{,}674$ and displacement and T produce the value $R^2 = 0{,}652$, where the minimum standard set at the beginning ie, 0,4. This means that the regression results are feasible or meet to be used in determining the main dimension of the ship. The regression equation on the main dimension variable curve as in the graph, then used as the basis for determining the main dimension of the ship design. The equation to use determining of temporary main dimension to show on equation (2), (3), (4), and (5).

$$L = 1{,}233x + 5{,}540 \quad (1)$$
$$B = 0.222x + 2{,}066 \quad (2)$$
$$H = 0.081x + 1{,}015 \quad (3)$$
$$T = 0.025x + 0.390 \quad (4)$$

Where:
L=length of ship (m)
B = width of the ship (m)
H = Ship height (m)
T = Shipload (m)
x = Δ (Displacement of ship weight) (tons)

So that the main size of the temporary ship is obtained namely;
L = 8,816 meters
B = 2,656 meters
H = 1,232 meters
T = 0.458 meters

After getting the main size, then proceed with inputting the main size in the Maxsurf software. Maxurf output in the form of a general description of the ship, including the lines plane and 3-dimensional shape of the ship design shown in Figure 6.

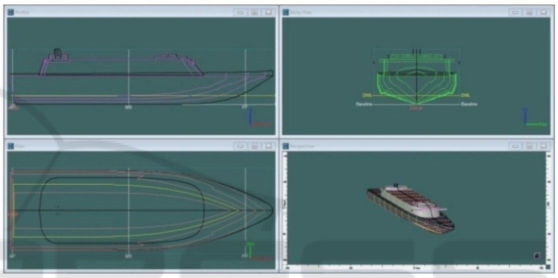

Figure 6. Lines plan uses maxurf software

3.2 Optimization of The Main Dimension of the Ship

The results of the depiction of Maxurf are then optimized, which is processed to get the optimal main dimension and other variables of the monohull. The optimized variables are:

- L (length, the overall length of the ship)
- B (breadth each hull, the width of each hull)
- H (height, the height of the ship to the main deck)
- T (draft, boat-laden)

In the optimization process that is considered constant value, which is a value whose magnitude does not change during the optimization process until it ends, as follows (Harvald, 1972):

- Density (ρ freshwater) = 1000 kg / m3
- Density (ρ seawater) = 1025 kg / m3
- Gravity (g) = 9.81 m / s2

The constraint parameters or constraints used in the optimization process are determined based on the requirements of the calculation method used, as well as the requirements issued by national and international regulatory holders such as IMO, SOLAS, BKI, and others. In this study, there are several limitations including the limitation of the main size of the ship, the limitations related to the ship's weight and the load to the displacement of the ship (Archimedes law), the limits in calculating the stability of the ship, trim limits, and freeboard limits.

3.3 Ratio Comparison

The optimization method uses maxsurf software with the main dimension ratio of the ship to make the ship technically feasible instability and longitudinal strength.

L/T = $10 < L/T > 30$
B/H = $0{,}7 < B/H > 4.1$ (Ship stability)
L/H = $4 < L/H > 10$, (Long. Strenght)
Cb = $0{,}3 < Cb > 0.6$,

The main dimention ratio parameter is used standards in determining the actual size of the ship. The results of optimization of the ship's main dimention such as show on Table 2.

Table 2. The parameters optimization

Parameters	Standart	Result
L/T	10 < L/T > 30	19,25
B/H	0,7 < B/H > 4.1	2,16
L/H	4 < L/H > 10	7,16
Cb	0,3 < Cb > 0,6	0,32

3.4 Calculation of Ship Displacement

Displacement is the weight of water displaced by a hull in the water; in other words, the volume of displacement multiplied by the density of water. To calculate ship displacement, the formula (Parson, 2004) is used as follows:

$$\Delta = \nabla t \times \rho \text{ water(ton)} \quad (5)$$

Where:
t = total displacement volume
ρ fresh water = Density of sea water = 1025 kg / m3

So that the total displacement,

$$\Delta = L * B * T * CB * \gamma \quad (6)$$
$$= 3{,}431 \text{ tons}$$

3.5 Calculation of Coefficient of Ship Shape

3.5.1 Block Coefficient (Cb)

$$Cb = -4.22 + 27.8\sqrt{Fn} - 39.1\,Fn + 46.6\,Fn3 \quad (7)$$
$$= 0{,}3 \quad \text{(from maxsurf)}$$

3.5.2 Midship coefficient (Cm)

$$Cm = 1{,}006 - 0{,}0056\,Cb - 3{,}56 \quad (8)$$
$$= 0{,}599$$

3.5.3 Prismatic Coefficient (Cp)

$$Cp = Cb/Cm \quad (9)$$
$$= 0{,}5008676$$

3.5.4 Waterplan Coefficient (Cwp)

$$Cwp = Cb / (0{,}471 + 0{,}551\,Cb) \quad (10)$$
$$= 0{,}471$$

3.6 Calculation of Ship Resistance

In this experiment calculating the value of the total resistance of fast ships with the V hull model (monohull), Holtrop & Mennen, the total resistance can be calculated with the following formula;

Total resistance

$$Rt = \frac{1}{2}\rho V^2 S_{tot}\left[C_F(1+k)+C_A\right]+\frac{R_W}{W}W \quad (11)$$
$$= 5456{,}566 \text{ N}$$
$$= 5{,}457 \text{ kN}$$

3.7 Main Engine Calculation

3.7.1 Speed of Advance

(ref: PNA vol.II, p.146)

$$Va = V\cdot(1-w) \quad (12)$$

Where ;
V = ship speed = 9,259 m / s
w = coefficient of friction of the wave
= 0.30 CB+10 CV CB - 0.23 D/√(BT)
With;
CV = viscosity coefficient

a. Coefficient of viscosity
(ref: PNA vol.II, p.162)

$$CV = (1+\beta k)\cdot CF + CA \quad (13)$$

Where ;
CA = corelation allowance

(ref: PNA vol.II, p.93, for T / Lwl> 0.04)
CA = 0.006 (LWL + 100) -0.16 - 0.00205 (14)
= 0,0008
So that;
CV = 0.004

b. The coefficient of friction of the waves
(ref: PNA vol.II, p.163, for twin screws)
w = 0.30 CB +10 CV CB - 0.23 D/√(BT) (15)
= 0.077
After the w value is known, the speed of advance:
Va = 8,548

3.7.2 Effective Horse Power

(ref: PNA vol.II, p.153)
EHP = RT · V (16)
= 45,833 kW with; 1 Hp = 0.7355 kW
= 62.31537346 Hp

3.7.3 Horse Power Delivery

(ref: Ship Resistance and Propulsion module 7 p. 179)
DHP = EHP/ηD (17)
Where ;
ηD = Quasi Propulsive Coefficient
(ref: PNA vol.II, p.153)
ηD = With; ηH = Hull Efficiency
ηr = Rotative Efficiency
ηO = Open Water Test Propeller Efficiency

a. Hull efficiency
(ref: PNA vol.II, p.152)
ηH = ((1−t))/((1−w)) (18)

Where ;
t = thrust deduction
(ref: PNA vol.II, p.163)
t = 0.325 CB - 0.1885 D / √ (BT) (19)
= 0.080
So that;
ηH = 0.996

b. Rotative efficiency
(ref: Ship Resistance and Propulsion module 7 pg 180 with a range of 0.97 η ηr ≤1.07)
ηr=0.9737+0.111(CP-0.0227LCB)-0.06327 P/D (20)
= 1,000

c. Open water test propeller efficiency
(assumption based on the results of open water test propeller in general)
ηO = 0.560

the ηD value is obtained as follows;
ηD = 0.558
By getting the propulsion coefficient value, the DHP value:
DHP = 82.179 kW

3.7.4 Break Horse Power

(Parametric Design Chapter 11, pp. 11-29)
BHP = DHP + (X% DHP) (21)
Where ;
X% = correction of shipping area of East Asia region between 15% -20% DHP
X% = 15%

Therefore;
BHP = 94,496 kW
BHP = 128,478 HP

3.7.5 Selection of the Main Engine

After getting the BHP value, the next step is to choose the main engine as the main driver of the ship. The main engine used on this fast boat is an outboard engine due to its easy installation and relatively small engine size, so it doesn't take up too much space. The selection of the main engine is made by considering the engine weight, engine power, and price of the engine. From the catalog (Mercury, 2018), several main engines and their specifications are obtained. The main engine show in Figure 7 and then detail specification is shown in Table 3

Figure 7. The main engine of the boat

Table 3. Detail specification of main engine

Item	Detail
Hp/kW	: 150/110
Engine type	: 8-valve single overhead cam (SOHC) Inline
Displacement	: 3.0
Full throttle RPM	: 5000 ~ 5800
Air Induction	: Performance tuned scroll intake manifold
Fuel Induction System	: Electronic fuel injection
Alternator/watt	: 60 ampere/756 watt
Recommended Fuel Ethanol maximum	: Unleaded regular 87 octane minimum (R+M/2) or 90 ron 10 %
Recommended oil	: Mercury fourestroke oil 10w-30
Engine protection operator warning system	: Smart craft engine guardian
Starting	: Electric (turn key), smart star electric
Controls	: Mechanical Throttle & Shift
Steering	: - Big tiller compatible - Dual cable mechanical - Electro-hydraulic poer steering optional on duals - Hydraulic power steering
Shaft length	: 20"/508 mm& 25"/635mm
Gearcase ratio	: 1.92:1
Dry weight	: 455 lbs/206 kg
CARB star rating	: 3
Bore & stroke	: 4.0 x 3.6 / 102 x 92 mm
Ignition	: Smart craft ECM 70 digital Inductive
Cooling system	: water-cooled with thermostat
Gear shift	: F-N-R
Gearcase options	: Standart
Trim system	: Power tilt, power trim
Exhaust system	: Through proop
Counter rotation	: Available
Lubricant system	: wet sump
Oil Capacity	: 6.3 gts / 6.01
Maximum trim range	: 22"(-6o to 16o)
Maximum tilt range	: 73"(-6o to 67o)

https://www.mercurymarine.com/en/asia/engines/outboard/fourstroke/75-150-hp/

3.8 Ships General Arrangement

Before working on a general plan, first the lines plan obtained using Maxurf is exported in AutoCAD format. Line's plan of the ship consists of the body plan, profile plan, and view plan and then refined again because many forms of lines are not streamlined. The lines plan of the ship shown in Figure 8.

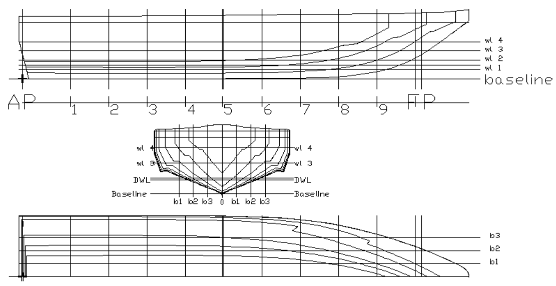

Figure 8. lines plan draw

At the stage of the ship's general plan, the number of passengers and crew members is determined, including all medical equipment in it. The consideration used is to look at the size of the main ship and the comparison ship from the sample used as a reference. Starting from the height of the building above, the layout of the placement of ship equipment, and dimensions of the ship size. The general layout plan of the ship, as shown in Figure 9.

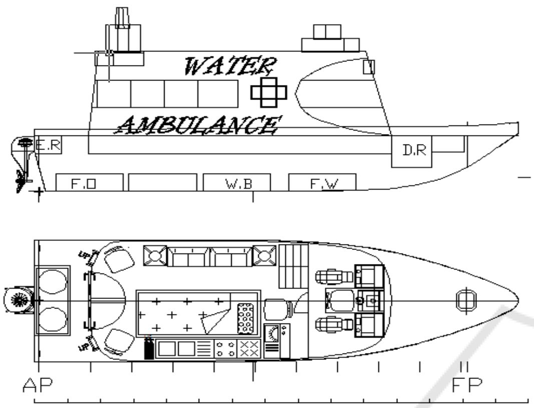

Figure 9. General arrangement draw

3.8.1 Ship Medical Facilities

Health equipment installed in water ambulances consists of ;

- LED Work lights and Electronic Siren, Optional red or blue
- Six (6) Perimeter led Lights, two each side and two on the rear, Optional red or blue
- Three(3) outside ground led spotlights that are activated when the rear doors or side doors are open.
- One additional battery.
- Smart Key Emergency Start
- Intelligent charging regulator(Auto split charge), 12V 140Amp Voltage Sense Relay Kits.
- AC220V Inverter Charger, 1000W pure sine wave inverter with a battery charger.
- Central electrical control system
- Four(4) LED room lights in the Patient compartment
- Double-loop pulse switch control device (Both driver cab and Patient compartment have one its panel can be operated and display.)
- 220V & 12V Outlets
- The Rear View Camera system
- UV Sterilization lamp
- Ventilation system
- Patient compartment Independent Heating and Air System
- Intercom system could improve communication between the patient compartment and driving cab
- Transfusion rack on the interior roof
- Yellow nylon antibacterial handrails mounted on the top
- The partition wall between the driver cab and Patient compartment: with a sliding window
- The interior furnishing is covered by ABS disposable whole.
- Medical cabinet, All of the cabinets were made by 15mm lighting PVC Foamboard
- ABS board plastics-absorption forming package on all face of the cabinet of the inner Patient compartment
- Two(2)Four-compartment suspension cabinet
- One Foldable Seat with safe two-point seat belts in front of the partition wall
- High Back revolving folding Seat with safe three-point seat belts.
- Squad bench has three (3) Seats with safe two-point seat belts.
- Two(2) oxygen cylinder, Water capacity 10 liter
- The oxygen cabinet with aluminum alloy roller shutter door
- Automatic switchover manifold system, German-style quick release, Two(2) outlets in action wall panel
- Ambulance stretcher
- PVC coil flooring of LG Hausys

3.8.2 Calculation of DWT and LWT

Total displacement is a calculation of weight displacement with a breakdown of weight, the LWT, and DWT. Total weight displacement show in Table 4.

Table 4. Breakdown of DWT & LWT

Breakdown of DWT & LWT			
DEADWEIGHT TONS			
No.	Weight item	value	Units
1	Fuel oil Weight	0,003	tons
2	lubricant oil	0,001	tons
3	Freshwater Weight	0,540	tons
4	Passenger Weight and equipment	0,425	tons
5	Crew Weight and equipment	0,170	tons
	SUBTOTAL DWT	1,139	tons
LIGHTWEIGHT TONS			
No.	Weight item	value	Units
	Machinery		
1	Main Engine	0,206	tons
2	Auxilary engine	0,090	tons
	Equipment & Outfitting Weight		
1	Seat passenger	0,025	tons
2	Anchor	0,040	tons
3	Cabin door	0,045	tons
4	Watertight door	0,000	tons
5	Window	0,018	tons
6	Navigation equiptment	0,050	tons
7	Lifejacket	0,011	tons
8	Lifebuoy	0,018	tons
9	Paramedic tools	0,100	tons
	Construction;		
1	keel layer	0,317	tons
2	Hull layer	0,303	tons
3	Deck layer	0,283	tons
4	Superstructure layer	0,258	tons
5	Estimated Ship Construction	0,407	tons
6	Bulwark and Railing	0,037	tons
	SUBTOTAL LWT	2,207	tons
	Total Weight DWT dan LWT	3,346	tons

Displacement corrections, according to Archimedes' Law. Total weight (estimation weight of LWT + DWT) = 3,346 tons. The initial design was of displacement is 3,347 tons. Margin difference of ± 0.05% from the design displacement of the maximum allowable difference of 0,02 tons. Result of margin design is 0,01 tons or 0,029%. So and then conclusion accepted because of allowable margin.

4. CONCLUSION

From the results of this study, a ratio of ship dimensions and other technical specifications were obtained that matched the waters of the Mahakam River, namely ships with a monohull for river water transportation modes in the form of water ambulance. Here are the main dimension and specifications:

L = 8.81 m
H = 1.23 m
B = 2.65 m
T = 0.45 m
Cb = 0.32
BHP = 125 Hp
Engine Type = Mercury Four Stroke 150 Hp
V = 18.00 knots
Passenger capacity = 5 people
Number of crew = 2 people
The height of the upper building = 2.20 meters

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21 academic version of the license so that this paper can be published.

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