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Design of Catamaran Propulsion System with Demihull Distance Variation on Hospital Ship

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***Abstract*—various problems faced by health services in the area of remote islands based on survey data Ministry of Health, that limited human resources in health and treatment facilities, as well as the difficult geographical conditions causing problems transport and communication are the main problem. From the above, the problems faced by means of a mobile hospital in the form of vessels operating from one small island to another small island is the solution of health problems for the people living within the island of Madura. In this thesis the work will be done planning catamaran ship propulsion system with a variety of distances and determine the power demihull hospital equipment. From the calculation results in a variation within demihull get with B = 19.51 m, 0,1B = 21.46, 0,2B = 23.41, 25.36 resulting 0,3B = 97.8 kN after the engine power of 812.71 kW obtained. From the selection of the engine 10 criteria obtained type Caterpillar 3508B engines. Power generators are required for a hospital ship is 75kW for 4 gensets.**

Keywords— catamaran, demihull, hospital ship, propulsion system, ship resistance

I. INTRODUCTION

According to survey done by Ministry of Health, there are various problems faced by health services in the isolated area. The first problem is the limited human resources in health and treatment facilities. Thus, the difficult geographical conditions lead to transportation and communication problems.

From the problems mentioned, a hospital mobile in the form of operating vessels from one island to another small island is the solution of health problems for people living in the Madura island.

The aims of this paper are to plan catamaran propulsion system with demihull distance varieties and determine the power of hospital equipment.

II. LITERATURE REVIEW

Catamaran is a type of vessel which has two hull (demihulls) connected by a construction so that it becomes a unity as a single ship. Catamaran type can be divided based on the shape of the hull under water [2]

- Asymmetric Catamaran
- Symmetrical Catamaran
- Wave Piercing Catamaran

1. Twinhull ship model which both sides are symmetrical stream line (Model B)

It is ssumed as two monohull vessels in which both hulls are associated with a certain distance. Then, the system will have the same wave with a stream line shape of the vessel. Around the submerged ship in water, it will develop and produce movement. This system can be seen schematically in FIG. It may be divided into two kinds of wave, the diverging wave and transverse wave. Generally, both waves placed near the prow and stern of the ship then move forward along the hull [6].

2. Doublehull ship model which both sides are asymmetric, the outside line stream hull which straight in the inside. (Model D)

At the end of front part is the point of spreading fluid into sideways (follow the stream line) which almost the same with the image. The difference lies in the inner side walls are straight so the flow follows the shape of the hull straight up to stern ship. When it is implemented, this form will create waves to the considerable side [7].

3. Doublehull ship model which both sides are asymmetric, the inner side is stream line and straight in outside. (Model A and C)

Fluid flow is formed from the prow of the ship concentrated in the middle vessel (between two hulls) which moves into stern ship. While in the sideways, the straight flow follows the hull of outer shape until the stern as shown in picture. This model is suitable for operating vessels in rivers or places surrounded by a lot of people because the catamarans model do not cause waves to the side larger than the catamarans model which streamline as the outer.

The different between model A and C come to the deck area in each vessels [1]. Ship model C has a larger deck than the ship model A.

Some advantages catamaran ship as follows:

1. Have a larger deck to carry passenger, vehicles, and large quantity goods.
2. With different hull from mono hull, this has important role to reduce the resistance on the vessel so it can produce the high speed and reduce fuel consumption.

Kinds of Propeller

Ordinary Propeller

- Fixed pitch propeller
- Controllable pitch propellers

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- Adjustable bolted propeller (Organized propeller with bolt)

1. Azzimuth thrusters [3]
2. Tunnel thrusters
3. Waterjets
4. Electrical pods
5. Voith Scneider Propeller

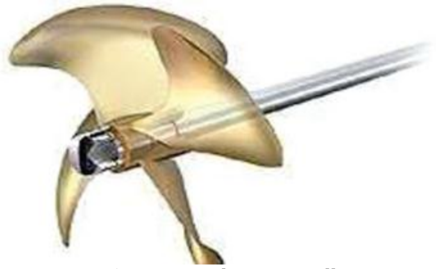

Figure. 1. Ordinary Propeller

Figure. 2 Azzimuth Thrsters

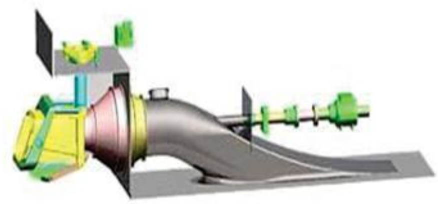

Figure. 3. Watersjets

Basic Calculation Barriers

According to Rawson and Tupper (2001), the total resistance suffered by moving ship in calm water surface consists of several components, for instance wave making resistance, skin frictional resistance, viscous pressure resistance, and water resistance resistance and appendage.

Holtrop method [4] is used to calculate the displacement full vessel obstacles in any conditions in the fixed speed remaining unchanged. The formula for calculating the barriers is:

$R_T = 1/2 \times \rho \times WSA \times V^2 \times C_T$ (1)

$CT = C_F + C_A + CAA + C_R$ (2)

$CF = 0.075/[\![(\text{Log } Rn\text{-}2)]\!]^2$ (3)

$Rn = (V . Lwl)/v$ (4)

Based on the calculation of main engine [5]:

- Effective Power
  PEservice = RT(service) x Vs (5)
- Efisiensi Propulsi
  Eficiency total
  $\eta T = \eta H . \eta O . \eta R. \eta S$ (6)
  where:
  ηH = Efisiensi Hull
  ηO = Propeller in open water condition
  ηR = Relative rotative efficiency
  ηS = Transmission efficiency
- Trust Horse Power
  THP =EHP / ηH (7)
  The hull efficiency is the wake fraction function, w, and thrust deduction fraction, t, [Harvald 1983]
  $\eta H = (1 – t)/(1 – w)$ (8)

- Delivery horse power (PD)
  $\eta O . \eta R$ efficiency behind propeller $\eta B = \eta O . \eta R \sim \eta O$ the normal amont is approximately 0,9 and 1,05
- Shaft Horse Power (SHP)
  In the planning of back side engine room location, there will be 2% lossing part while the location of the engine room on a ship midship area suffered losses of 3%. It is mentioned in the book "Principal terms of Naval Architecture 131
- Brake Horse Power (BHP)
  There is an efficiency influence of the transmission gear wheel system (ηG)

- *method of prisoners*
- Holtrop Method
- Guldhammer Method
- Yamagata Method
- *Component Prisoners That Works At The Ship In The Water*
- Friction Resistance
- Residual Resistante
    - Wake Resistance)
    - Air Resistance)
    - Custody forms
- Added Resistance

Hardware General Hospital

A completion of a required public hospital is a hospital medical equipment. Medical devices will be the means of service in public hospitals to provide action to the patient, care, and treatment. Generally, if it is seen from government regulation of medical devices, there are devices which are goods, apparatus, or instrument with each component of the array of parts produced and sold for maintenance, treatment, diagnosis, prevention, mitigation, and recovery for any symptoms of disorders of health that occur in the Alat bantu jalan

- Tools respirator
- Measuring instrument
- Test and laboratory equipment
- Medical Device
- Hospitals Tools

Figure. 4. Wheel chair

Figure. 5. Pregnancy Test Tool

Figure. 6. tools mixer drugs

Figure. 7. Aid Measure

III. RESULT AND DISCUSSION

A. *Ship Dimension*

Type : Catamaran
Lpp : 65,00 m
B : 21,46 m
H : 10 m
T : 3,5 m
Rute : Raas and Kangean Island

- Prisoners Data

By using the software maxsurf dongle resistance, at a speed of 14 knots is produced by prisoners as follows

TABLE 1.
SHIP RESISTANCE

Speed	Fn	Fn Vol	Resistance				
			0.11 B	0.12 B	0.13 B	0.14 B	0.15 B
14	0.292	0.75	98.3	98.3	98.2	98.3	98.3
			0.16 B	0.17 B	0.18 B	0.19 B	0.2 B
			98.3	98.4	98.4	98.5	98.5

- Power Calculation Engine

1. Calculating the Effective Power Boats

➢ Effective Power or EHP is the power required to drive the boat in the water or to pull the boat with a speed v. Calculation of the effective power vessel.

EHP = Rtdinas × Vs
= 113,05 × 7,202
= 814,18 kW

➢ Calculate Power on the stern tube Propeller Shafts

DHP = EHP/ PC, PC = ηH x ηrr x ηo.

Hull Efficiency and Wake Friction (w)

ηH = (1-t)/(1-w)
w = 0,5Cb-0,05
= (0,5 x 0,523)-0,05
= 0,2115

Thrust Deduction Factor (t)

Values t can be sought from the value w which known as that t = k.w k values between 0.7-0.9 and taken the value of k = 0.8= 0,8 x 0,2115 = 0,169

ηH = (1-t)/(1-w)
= 1,053

Rotary Relative efficiency (ηrr)

The ηrr value for ships with a propeller-type twin screw is 0.95 to 1.0 In planning the propeller and shaft tube is taken ηrr = 1.0

Propulsion Efficiency (ηo)

is open water efficiency which efficiency of the propeller at the time of open water test. The amount is between 40-70%, and taken 55%.

Coeffisien Propulsif (PC)

PC = ηH x ηrr x ηo
= 1.053 x 1 x 0.55
= 0,5795

Then, power on the propeller shaft tube is calculated from the ratio between the effective power and the propulsive coefficient:

DHP = EHP/PC
= 1404,9 kW
= 1910,2 HP

➢ Calculate Power On Propeller Shaft

SHP = DHP/ηs ηb
= 1949,18 HP
= 1453,5 kW

➢ Calculate Prime Mover Power Required

➢ BHPscr

The influence the efficiency of the transmission gear wheel system (ηG), on this assignment system uses a single reduction gear or single reduction gears with a loss of 2% for the forward direction so ηG = 98%.

BHPscr = SHP/ηG
= 1988,96 HP
= 1483,2 kW

➢ BHPmcr

Power is obtained when the engine is maximum. The value of the engine when the engine is taken from the state service margin between 80% -85%. Therefore BHPmcr obtained in the following manner:

power BHPscr taken 90% BHPmcr

BHPmcr = BHPscr/0.90
= 2209,95 HP
= 1625,42 kW
= 1617,15/2
= 812,71 kW

a) Engine SFOC

SFOC $= 1 - \left(\frac{SFOC\ engine - SFOC\ smallest}{SFOC\ smallest}\ x\ 100\%\right)$

Cat $= 1 - \left(\frac{62{,}6 - 62{,}6}{62{,}6}\ x\ 100\%\right)$ = 100%

Cummins $= 1 - \left(\frac{64{,}2 - 62{,}6}{62{,}6}\ x\ 100\%\right)$ = 91%

ABC $= 1 - \left(\frac{65{,}6 - 62{,}6}{62{,}6}\ x\ 100\%\right)$ = 88%

Best price is IDR 20.000.000.000

Price $= 1 - \left(\frac{Price\ engine - lowest\ price}{lowest\ price}\ x\ 100\%\right)$

Cat $= 1 - \left(\frac{5{,}2\ B - 5{,}2\ B}{5{,}2\ B}\ x\ 100\%\right)$ = 100%

Cummins $= 1 - \left(\frac{5{,}6\ B - 5{,}2\ B}{5{,}2\ B}\ x\ 100\%\right)$ = 85%

ABC $= 1 - \left(\frac{6{,}1\ B - 5{,}2\ B}{5{,}2\ B}\ x\ 100\%\right)$ = 80%

b) Engine dimension

Dim $= 1 - \left(\frac{engine\ dimension - smallest\ dimension}{smallest\ dimension}\ x\ 100\%\right)$

Cat $= 1 - \left(\frac{3944{,}8 - 3944{,}8}{3944{,}8}\ x\ 100\%\right)$ = 100 %

Cummins $= 1 - \left(\frac{4235 - 3944{,}8}{3944{,}8}\ x\ 100\%\right)$ = 88 %

ABC $= 1 - \left(\frac{4379 - 3944{,}8}{3944{,}8}\ x\ 100\%\right)$ = 82 %

c) Engine Weight

Weight $= 1-(\frac{engine\ weight - smallest\ weight}{smallest\ weight}\ x\ 100\%)$

Cat $= 1-(\frac{1772{,}8-1772{,}8}{1772{,}8}\ x\ 100\%) = 100\ \%$

Cummins $= 1-(\frac{1889-1772{,}8}{1772{,}8}\ x\ 100\%) = 84\ \%$

ABC $= 1-(\frac{1983-1772{,}8}{1772{,}8}\ x\ 100\%) = 79\ \%$

d) Engine rpm

RPM $= 1-(\frac{RPM\ engine - RPM\ propeller}{RPM\ propeller}\ x\ 100\%)$

Cat $= 1-(\frac{1835-363{,}3}{363{,}3}\ x\ 100\%\ ) = 70\%$

Cummins $= 1-(\frac{1800-363{,}3}{363{,}3}\ x\ 100\%\ ) = 71\%$

ABC $= 1-(\frac{750-363{,}3}{363{,}3}\ x\ 100\%\ ) = 100\%$

e) Gearbox

Engine $= 1-(\frac{Gear\ box\ price - lowest\ Gear\ box\ price}{lowest\ Gear\ box\ price}\ x\ 100\%)$

Cat $= 1-(\frac{18\ M-18\ M}{18\ M}\ x\ 100\%) = 100\%$

Cummins $= 1-(\frac{22\ M-18\ M}{18\ M}\ x\ 100\%) = 85\%$

ABC $= 1-(\frac{22\ M-18\ M}{18\ M}\ x\ 100\%) = 85\%$

f. Power of Engine

Power $= 1-(\frac{engine\ power - power\ requirement}{power\ requirement}\ x\ 100\%)$

Cat $= 1-(\frac{960-812{,}71}{812{,}71}\ x\ 100\%\ ) = 81\%$

Cummins $= 1-(\frac{979-812{,}71}{812{,}71}\ x\ 100\%\ ) = 79\%$

ABC $= 1-(\frac{983-812{,}71}{812{,}71}\ x\ 100\%\ ) = 78\%$

g. Fuel

Fueled MDO and HFO engines selected then all get the same value.

h. Maintainability

This type of machine and the installation will affect the treatment affects the cost and the number of crew aboard.

i. Reliability

The more stuff there is getting cheaper conversely the few goods that the market will be more expensive because hard to find.

Then 10 criterias of assessment resulting Caterpillar engines (3508B) which meets the requirements Propeller Selection.

TABEL 2.
VARIASION DEMIHULL

	B	19.51	m
B+	0.11	21.6561	m
	0.12	21.8512	m
	0.13	22.0463	m
	0.14	22.2414	m
	0.15	22.4365	m
	0.16	22.6316	m
	0.17	22.8267	m
	0.18	23.0218	m
	0.19	23.2169	m
	0.2	23.412	m

TABEL 3.
ELECTION MACHINE WITH10CRITERIA

Criteria	Weight	Caterpillar (3508B)		Cummins (KTA 38 M1)		ABS (8 DXC-750-100)	
SFOC	20%	100%	20%	91.0%	18%	88.0%	18%
Price	15%	95%	14%	85.0%	13%	80.0%	12%
Dimension	5%	100%	5%	88.0%	4%	82.0%	4%
Weight	5%	100%	5%	84.0%	4%	79.0%	4%
RPM	15%	70%	11%	71.0%	11%	100.0%	15%
Gearbox	5%	100%	5%	85.0%	4%	85.0%	4%
Power	15%	81%	12%	79.0%	12%	78.0%	12%
Fuel	10%	100%	10%	100.0%	10%	100.0%	10%
Maintainability	5%	100%	5%	100.0%	5%	100.0%	5%
Reliability	5%	100%	5%	86.0%	4%	75.0%	4%
		Total	92%		86%		87%

TABEL 4.
PROPELLER SELECTION

Series	Ae/A0	1/Jb	P/Db	η_b	A0	Ae	Ap	Vr^2	Pitch
B-5	0.45	1.91	0.94	0.55	21.97	9.89	8.42	81.95	4.9732
	0.6	1.92	0.92	0.552	22.19	13.31	11.40	82.46	4.8919
	0.75	1.93	0.93	0.545	22.42	16.82	14.36	82.96	4.9698
	0.9	1.88	0.96	0.537	21.32	19.19	16.25	80.47	5.0025
	1.05	1.84	1.02	0.52	20.45	21.47	17.90	78.52	5.2067
	0.45	2.2	0.98	0.579	29.62	13.33	11.23	86.55	6.0202
	0.6	2.28	0.95	0.576	31.36	18.82	15.98	89.73	6.0042
	0.75	2.25	0.97	0.575	30.48	22.86	19.32	88.13	6.0447
	0.9	2.24	0.98	0.56	30.20	27.18	22.90	87.60	6.0781
	1.05	2.18	1.04	0.548	28.49	29.91	24.80	84.48	6.2659

TABEL 5.
CAVITATION

Series	Ae/A0	T	tC	$\sigma_{0.7R}$	Cavitation
B-5	0.45	94.69	0.268	0.351	Cavitation
	0.6	94.69	0.196	0.348	No Cavitaiton
	0.75	94.69	0.155	0.345	No Cavitation
	0.9	94.69	0.141	0.359	No Cavitation
	1.05	94.69	0.131	0.372	No Cavitation
	0.45	94.69	0.190	0.326	Cavitation
	0.6	94.69	0.129	0.311	No Cavitation
	0.75	94.69	0.109	0.318	No Cavitation
	0.9	94.69	0.092	0.321	No Cavitation
	1.05	94.69	0.088	0.337	No Cavitation

TABEL 6.
THE TYPE OF PROPELLER USED

Propeller type	Db (ft)	n (rpm)	P/Db	η_b	Pitch
B5-60	6.32	363.37	0.95	0.576	6.004

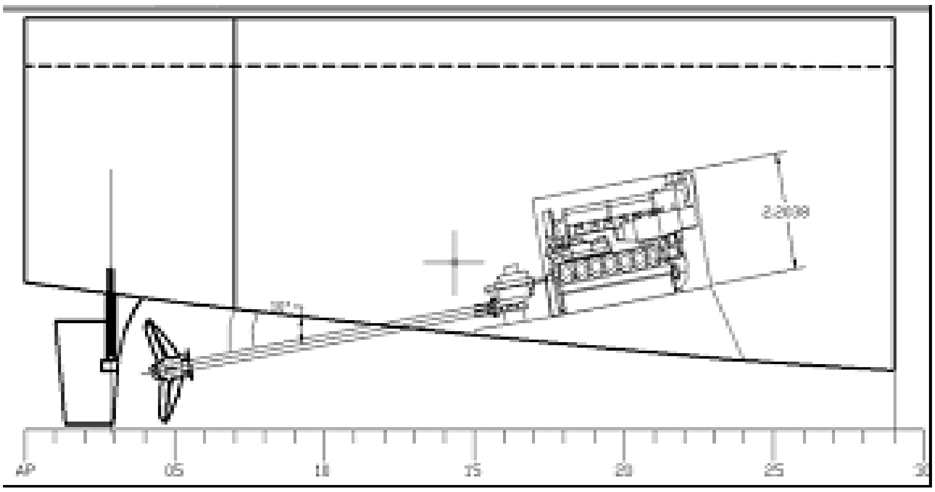

Figure. 8. The laying machine

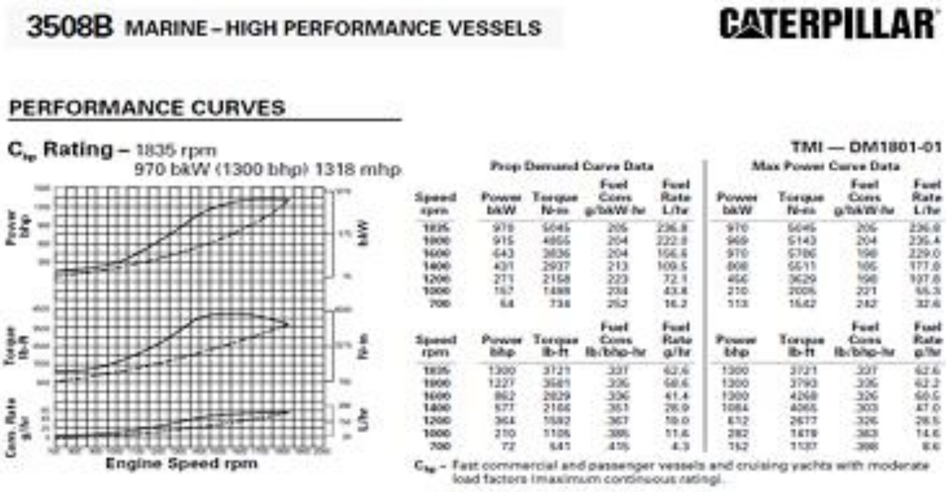

Figure. 9. The Katalog

B. Criteria Genset With 10

a. SFOC *Selection*

SFOC $= 1-(\frac{SFOC\ genset - smallest\ SFOC}{smallest\ SFOC}\ x\ 100\%)$

Lovol $= 1-(\frac{15,45-15,45}{15,45}\ x\ 100\%) = 100\%$

Cum $= 1-(\frac{16-15,45}{15,45}\ x\ 100\%) = 93\%$

Deutz $= 1-(\frac{16,5-15,45}{15,45}\ x\ 100\%) = 75\%$

b. Best price is IDR 10.000.000.000

Lovol $= \frac{120\ M}{75\ kW} = 1,600/kW$

Cum $= \frac{163\ M}{85\ kW} = 1,917\ /kW$

Deutz $= \frac{169,2\ M}{88\ kW} = 1,922\ /kW$

Genset $= 1-(\frac{Genset\ price/kW - lowest\ price/kW}{lowest\ price/kW}\ x\ 100\%)$

Lovol $= 1-(\frac{1,600-1,600}{1,600}\ x\ 100\%) = 100\ \%$

Cum $= 1-(\frac{1,917-1,600}{1,600}\ x\ 100\%) = 85\ \%$

Deutz $= 1-(\frac{1,922-1,600}{1,600}\ x\ 100\%) = 81\ \%$

c. Dimension

Genset $= 1-(\frac{Dimension\ of\ genset - smallest\ dimension}{smallest\ dimension}\ x\ 100\%)$

Lovol $= 1-(\frac{4750-4750}{4750}\ x\ 100\%) = 100\ \%$

Cum $= 1-(\frac{4900-4750}{4750}\ x\ 100\%) = 93\ \%$

Deutz $= 1-(\frac{5150-4750}{4750}\ x\ 100\%) = 82\ \%$

d. Weight

Genset $= 1-(\frac{weight\ of\ genset - smallest\ weight}{smallest\ weight}\ x\ 100\%)$

Lovol $= 1-(\frac{1242-1124}{1124}\ x\ 100\%) = 89\ \%$

Cum $= 1-(\frac{1124-1124}{1124}\ x\ 100\%) = 100\ \%$

Deutz $= 1-(\frac{1384-1124}{1124}\ x\ 100\%) = 86\ \%$

e. RPM

Genset $= 1-(\frac{RPM\ genset - smallest\ RPM}{smallest\ RPM}\ x\ 100\%)$

Lovol $= 1-(\frac{1500-1500}{1500}\ x\ 100\%) = 100\%$

Cum $= 1-(\frac{1800-1500}{1500}\ x\ 100\%) = 89\%$

Deutz $= 1-(\frac{1500-1500}{1500}\ x\ 100\%) = 100\%$

f. Frequency

Genset $= 1-(\frac{frequency\ of\ genset - frequency\ requirement}{frequency\ requirement}\ x\ 100\%)$

Lovol $= 1-(\frac{50\ Hz-50\ Hz}{50\ Hz}\ x\ 100\%) = 100\%$

Cum $= 1-(\frac{60\ Hz-50\ Hz}{50\ Hz}\ x\ 100\%) = 94\%$

Deutz $= 1-(\frac{60\ Hz-50\ Hz}{50\ Hz}\ x\ 100\%) = 94\%$

g. Genset power

Genset $= 1-(\frac{power\ of\ genset - power\ requirement}{power\ requirement}\ x\ 100\%)$

Lovol $= 1-(\frac{75\ kW-75\ kW}{75\ kW}\ x\ 100\%) = 100\%$

Cum $= 1-(\frac{85\ kW-75\ kW}{75\ kW}\ x\ 100\%) = 91\%$

Deutz $= 1-(\frac{88\ kW-75\ kW}{75\ kW}\ x\ 100\%) = 88\%$

h. Fuel

Fueled HSD and MDO engines selected then all get the same value.

i. Maintainability

This type of machine and the installation will affect the treatment affects the cost and the number of crew aboard.

j. Reliability

The more stuff there is getting cheaper conversely the few goods that the market will be more expensive because hard to find.

TABEL 7.
SELECTION CRITERIA GENSET WITH 10 CRITERIA

Criteria	Weight	Caterpillar (3508B)		Cummins (KTA 38 M1)		ABS (8 DXC-750-100)	
SFOC	20%	100%	20%	91.0%	18%	88.0%	18%
Price	15%	95%	14%	85.0%	13%	80.0%	12%
Dimension	5%	100%	5%	88.0%	4%	82.0%	4%
Weight	5%	100%	5%	84.0%	4%	79.0%	4%
RPM	15%	70%	11%	71.0%	11%	100.0%	15%
Gearbox	5%	100%	5%	85.0%	4%	85.0%	4%
Power	15%	81%	12%	79.0%	12%	78.0%	12%
Fuel	10%	100%	10%	100.0%	10%	100.0%	10%
Maintainability	5%	100%	5%	100.0%	5%	100.0%	5%
Reliability	5%	100%	5%	86.0%	4%	75.0%	4%
		Total	92%		86%		87%

TABEL 8.
GENSET CATALOG

Engine Model	Alternator model	Standby power		Prime Power	
LOVOL	STAMORD	kVA	kW	kVA	kW
1004G	BCI184G	34	27	31	25
1004G	BCI184H	41	33	38	30
1004G	BCI184J	46	37	42	34
1004G	UCI224D	50	40	45	36
1004TG	UCI224D	55	44	50	40
1004TG	UCI224E	65	52	60	48
1004TG	UCI224F	76	61	70	56
1006TG1A	UCI224G	94	75	85	68
1006TG2A	UCI274C	110	88	100	80
1006TAG	UCI274D	125	100	114	91
1006TAG	UCI274E	150	120	135	108

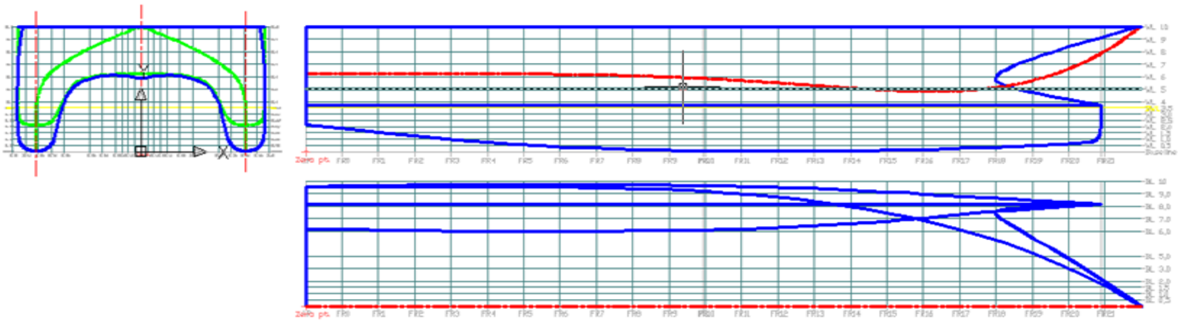

Figure. 10. Linesplan

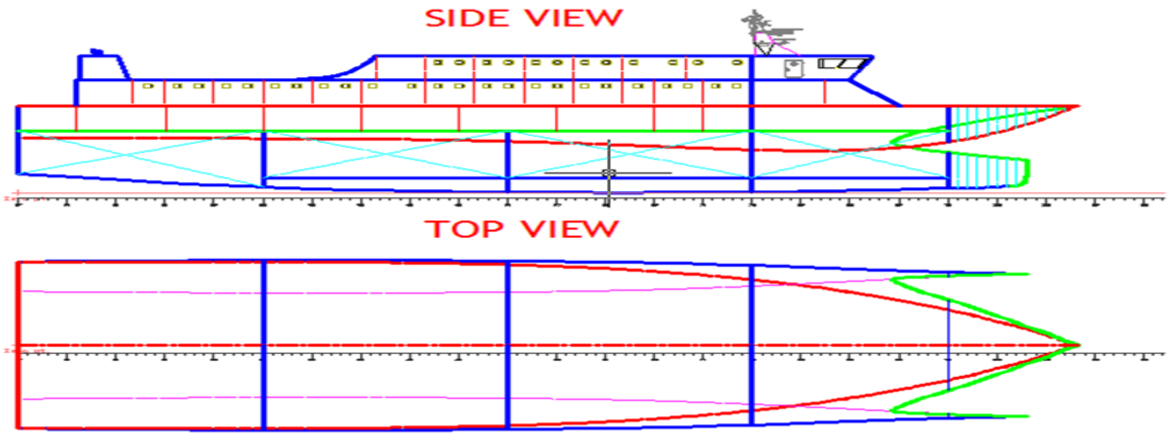

Figure. 11. General arrangement

IV. CONCLUSION

The floating hospital ship model is obtained with these lenght in 65,00 metres, beam in 21,46 metres, max draught in 3,5 metres, speed in 14 Knots and route from Raas to Kangean Island.

This hospital ship has emergency and hospitality facilities services, surgery specialist, obstetricians and children's specialist with the total of patient's bed is 30 people.

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