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REDESIGN OF UNMANNED SURFACE VESSEL (USV) HULL TO INCREASE THE PERFORMANCE AND TO SUPPORT NAVAL OPERATIONS

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Abstrak. The Indonesian Navy's current unmanned vessel is the first unmanned ship made by the Indonesian Navy's Research and Development Service. This vessel is not optimal, it is necessary to redesign the hull using the model simulation method with the assistance of Maxsurf software. By using this maxsurf software, it will be easier to analyze hydrodynamic performance, one of which is the vessel's resistance. The redesign shows the results that there is a reduction in ship resistance. By redesigning, the hull of the Indonesian Navy's unmanned vessel by using the model simulation method with the assistance of the Maxsurf software in analyzing hydrodynamic performance, we get the resistance value at maximum speed. Meanwhile, the power required by the ship is at maximum speed so that the speed shows an increase in maximum ship speed, thereby fulfilling the operational requirements and producing good maneuverability. Therefore, it can be concluded that the ship after being redesigned can be better.

Keywords: unmanned vessel; vessel speed; resistance

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INTRODUCTION

The development of technology and science is the main part in driving for the realization of a change. Currently, science and technology can be said to be the elements of progress of a human civilization. Indonesia through the 2010-2025 Minimum Essential Force (MEF) carry out large-scale activities in order to strengthen the military defense system and national security by producing and purchasing Defense and Security Equipment (Alpalhankam) (Permenhan No 23 thn 2016 tentang Pembinaan Industri Pertahanan). Indonesia is actively developing and producing Alpalhankam as an effort to bring independence in the Defense Industry (Susdarwono, 2021).

Based on the MEF, the development of the Navy's posture which includes the level of capability (Collin, 2015); (Susilo, Ciptomulyono, Putra, Ahmadi, & Suharyo, 2019), strength, and pattern of strength degrees in essentially oriented to the achievement of the tasks of the Navy in order to support the national interest. The limited defense budget and the rapid changes in the strategic environment will add to the complexity of the problems in enforcement and security at sea, so it is necessary to rearrange the Navy's combat power which does not only refer to threats at sea, the biggest marine threat at this time is the North Natuna sea threat and the need for security and ship operations that can at any time carry out security at sea (Djalante et al., 2020); (Octavian, Cahyono, & Pranowo, 2020). However, it is also oriented to achieve certain abilities (Capability Based Planning). The research and development of the Unmanned Surface Vessel (USV) or unmanned vessel is carried out for the first time by the Indonesian Navy Research and Development Service (Dislitbangal) (Dwiko Hardianto, Wasis Dwi Aryawan ejurnal, its engineering, ITS 2017. "*Developing the Unmanned Surface Vehicle design concept (USV) for monitoring Indonesian territorial waters*").

Dislitbangal developed this type of Unmanned Vessel in partnership with PT Robo Marine Indonesia which is in Bandung. In the plan to build this ship, it will be placed on the KRIs (warships of the Republic of Indonesia) with the type of ships having a length of 80 meters and above. This is done because these ships are usually as headquarters ships or command ships. This unmanned ship has the task of operating as a combat ship (combatant) or initial attacker and as much as possible as initial intelligence from the KRIs (Milan & Bassiri Tabrizi, 2020); (Ernest et al., 2016) therefore it is necessary to build a ship that is adjusted to a larger size and can load Remote Control Weapon System (RCWS) weapons 7.62 mm caliber, good propulsion system, and good sensor, weapon, and command equipment and electronic equipment (Sewaco) as well.

Based on the above, for the manufacture of unmanned vessels in the future in accordance with the demands of operational requirements (Opsreq) at full load conditions capable of loading even greater loads. Thus, it is necessary to redesign the shape of the Dislitbangal unmanned vessel hull using the modeling method of hull design with software for simulation ship resistance (Bahatmaka, Hadi, & Mulyatno, 2014).

Redesign hull are expected to reduce drag and increase the load on the vessel so that the performance of the vessel can increase.

METHODS

The method used in this research is the method of experimentation and simulation. The hull redesign of the Dislitbangal unmanned ship uses drag analysis and ship stability calculations. The desired results from the simulation of resistance analysis and calculation of ship stability in modeling the shape of the hull are in the form of resistance values to determine the maximum load of the ship, the optimal speed of the ship, and the stability of the ship.

Analysis of Ship Design DataWith Numerical Approach

One of the design stages that is quite important is the analysis stage, where the research analyzes the design of the ship's hull for variations in speed (Yousefi, Shafaghat, & Shakeri, 2013), optimization of hull shape, hull constraints on unmanned vessels made by Dislitbangal. The reference for the analysis needs used is (Report of Unmanned Vessel of PT Robo Marine Indonesia (2019) Dislitbangal):

a. General Specification

1. Length : 1.5 meters
2. Width : 0.8 meters
3. Weight : 64 kgs
4. Speed : 4.7 knots
5. Propulsion : Dual electric
6. Engine : Electric motor 2 x 1 Hp
7. Power : Battery operated
8. Payload Weight: 10 kgs
9. Communication real time range up to 1 km
10. Self righting mechanism

b. Payload

1. Axis video camera gimbal
2. Video transmitter module
3. Inertial measurement Unit (IMU)
4. GNSS positioning system
5. Wireless data communication

The data is used to analyze lines plan data, general arrangement drawings, hydrostatic calculations, resistance values, power values, and stability of the redesigned vessel (Evans, 1959)

Data Analysis Using Software

The research method used is numerical. model simulation ship design software through Maxsurf modeling. Then the analysis uses numerical calculations to determine the resistance, movement and stability

RESULTS AND DISCUSSION

Vessel Model Design

After obtaining the main size of the ship, the next work is model design, model design in shipping technology starts from line planning, general planning and the last is machinery and system planning, (Tsou & Hsueh, 2010) in this study only carried out at the line planning stage or linesplan. The 3-D hull form modeling was carried out using the Maxsurf Modeler Advanced 20

V8i Bentley software and all comparison objects were studied by using software from the Formation Design System Suite, sach as maxsurf resistance, maxsurf stability, and maxsurf motion.

Linesplan Planning

Vessel Linesplan Before Redesign

The dimensions of the main vessel size properties (Abe et al., 2012), which are the fixed parameters according to the technical specifications of the Dislitbangal unmanned vessels made in 2020, are as follows:

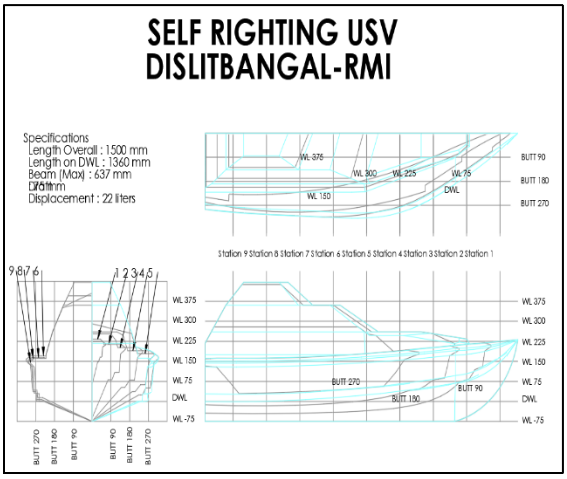

Figure 1. Ship Linesplan before Redesign
Source: Dislitbangal, 2020

Figure 1 is the image of the linesplan of the Dislitbangal unmanned vessel and has several characteristics as shown in the following table:

Table 1. Ship Characteristics before Redesign

Unit	Value	
Displacement	0.022	ton
Volume (displaced)	21466487	mm^3
Draft Amidships	77	mm
WL Length	1361.3	mm
Prismatic coeff. (Cp)	0.711	
Block coeff. (Cb)	0.367	
LCB length	522.8	from zero pt.
LCF length	528.7	from zero

		pt.
LCB %	38.403	from zero pt.
LCF %	38.839	from zero pt.

Vessel linesplan Afterredesign

After doing this research, the linesplan design uses formdata measurements in its design technique, by making changes to the length of the ship (WL = 7,219 m), vessel draft (T) = 0.225 m, then the new linesplan form is as follows and gets changes from the vessel's characteristics.

From the results of design modifications in this study, the linesplan design uses formdata measurements on the main size to make a line plan drawing on the redesigned vessel as follows:

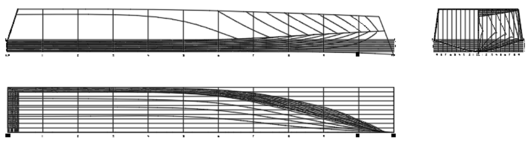

Figure 2. Linesplan after redesign
Source: Researcher, 2021

Table 2. Ship Characteristics after Redesign

Unit	Value	
Displacement	1.217	Ton
Volume (displaced)	1187745261	mm^3
Draft Amidships	225	Mm
WL Length	7218.8	Mm
Prismatic coeff. (Cp)	0.726	
Block coeff. (Cb)	0.35	
LCB length	2744.6	from zero pt.
LCF length	2821.3	from zero pt.
LCB %	38.02	from zero pt.
LCF %	39.082	from zero pt.

Source: Researcher, 2021

Comparison of Vessel Hydrostatic Calculations

To illustrate hydrostatic curves is to make two axes perpendicular to each other where the horizontal axis is the bottom line of the ship while the vertical line shows the draft of each water line which is used as the starting point for measuring the hydrostatic curve. Tables and graphs of the results of hydrostatic curve analysis using maxsurf stability software are as follows:

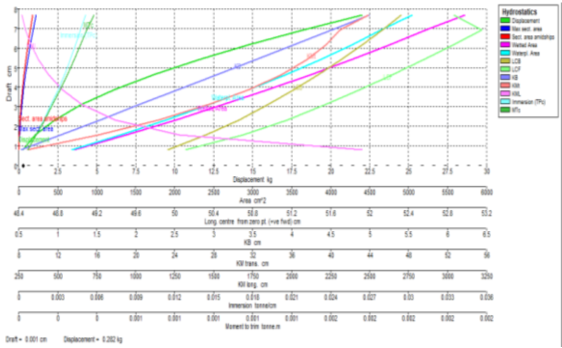

Figure 3. Ship Hydrostatic Curve before Redesign
Source: Researcher, 2021

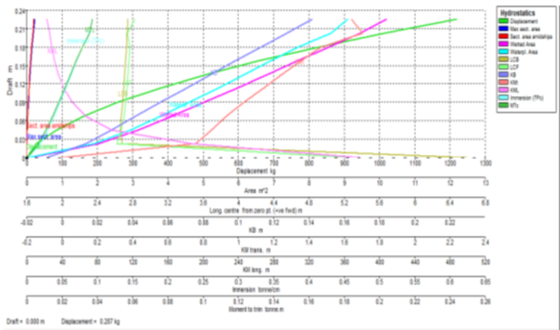

Figure 4. Ship Hydrostatic Curve before Redesign
Source: Researcher, 2021

Comparison of Calculation of Vessel Resistance

The redesigned ship model can then be calculated using the slenderbody method, (Pineda et al., 2010), "*Hull adjustment towards hydrostatic requirements*", e-mail: ajcacho@tecnico.ulisboa.pt.) and calculating resistance using the maxsurf resistance software. At the analysis stage, it is carried out by looking at the value of the ship's resistance at variations in ship speed in the form of the froude number (FN) below:

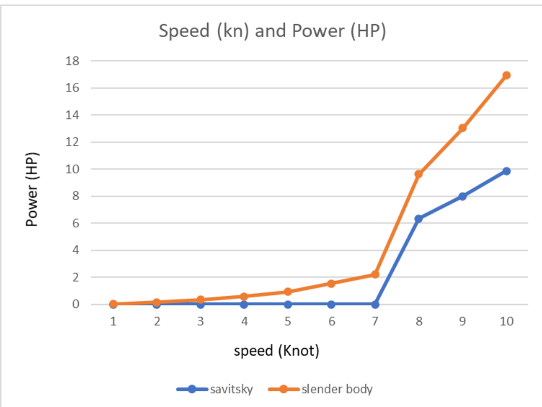

Figure 5. Resistance Against Froude Number (FN) before Redesign

Source: Researcher, 2021

Figure 5 shows the comparison between resistance and speed. The higher the speed, the higher the resistance (SV, 1983). Resistance and Ship Propulsion. Translation by (Sutomo, 1992).

If the ship moves at a speed of 10 knots, the resistance value is 60.50 N. If it is entered into the program, it will result in running and the resistance and effective horse power values obtained by the Savitsky planning method are shown in the form of a table 3 on the ship design as below:

Table 3. Power to speed before redesign

Speed (knot)	Fn	Volume FN	Savitsky (HP)	slender body (HP)
0	0	0	--	--
1	0.141	0.312	--	0
2	0.282	0.623	--	0.003
3	0.422	0.935	--	0.011
4	0.563	1.246	--	0.029
5	0.704	1.558	0.138	0.067
6	0.845	1.87	0.165	0.108
7	0.986	2.181	0.187	0.155
8	1.126	2.493	0.211	0.212
9	1.267	2.804	0.24	0.282
10	1.408	3.116	0.274	0.364

Source: Researcher, 2021

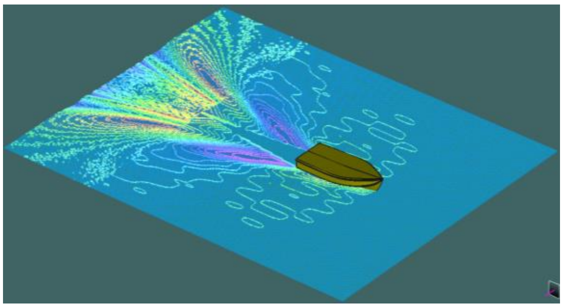

Figure 6. Free Surface wave contour generated by USV Ship model before redesign

Source: Researcher, 2021

With the redesigned model, the vessel's resistance can be calculated using the slenderbody method and the resistance calculation using the maxsurf resistance software. At the analysis stage, it is carried out by looking at the value of the vessel's resistance at variations in vessel speed in the form of the froude number (FN) as follows:

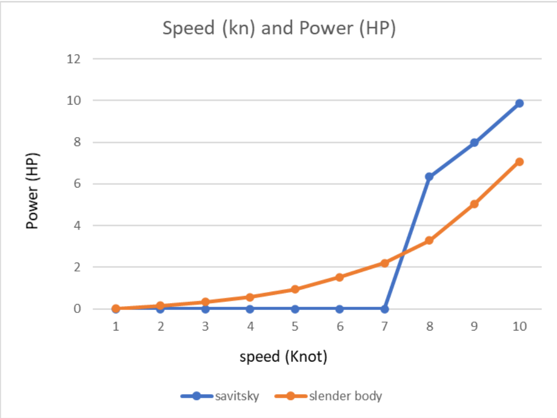

Figure 7. Speed against power after redesign
Source: Researcher, 2021

The results of the running are obtained by the value of resistance and effective hours power with the savitsky planning method which are displayed in the table on the ship design as below:

Tabel 4. Power terhadap Speed Setelah di redesain

Speed (knot)	Fn	Volume FN	Savitsky (HP)	slender body (HP)
0	0	0	--	--
1	0.611	1.596	--	0.013
2	1.223	3.193	--	0.148
3	1.834	4.789	--	0.325
4	2.446	6.385	--	0.571
5	3.057	7.981	--	0.932
6	3.669	9.578	--	1.527
7	4.28	11.174	--	2.196
8	4.891	12.77	6.339	3.282
9	5.503	14.367	7.982	5.047
10	6.114	15.963	9.857	7.074

Sumber: diolah oleh peneliti, 2021

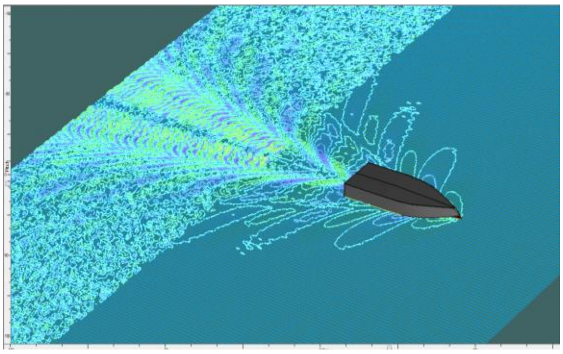

Figure 8. Free Surface wave contour generated by USV Ship model after redesign
Source: Researcher, 2021

From figure 8, it shows that the water flow backwards is very good and the side water flow is not too wide. Therefore, it can be ascertained that the vessel is very fast and the resistance is reduced.

CONCLUSIONS

Based on the results of research conducted by the author, the redesign of the Dislitbangal unmanned vessel hull can be concluded as follows:

1. The results of the hull redesign based on computational analysis using Maxsurf Software obtained the main measurements are as follows:
   Length (L) = 7.218 Meters
   Breadth (B) = 1.676 Meters
   Height (H) = 1 Meter
   Draft (T) = 1.71 Meter
   Service Speed = 10 Knots
   Displacement = 1218 Kgs
   3/The hull capacity increased from the original displacement of only 22 Kgs to a displacement of 1218 Kgs.
2. By considering the ship resistance parameters based on computational analysis using Maxsurf Software and by comparing the results of the ship resistance, the ship's Froude Number (FN) before the redesign is 1.408 compared to the ship after the redesigned Froude Number of 0.611. Therefore, it can be concluded that the redesigned ship has a smaller resistence.

Based on the conclusions above, the researchers made efforts to improve the Dislitbangal unmanned ship design by adding the length of the ship from 1.5 m to 7,219 m, Draft (T) from 0.077 m to (T) = 0.225 m and in meeting the operational requirements in framework for making unmanned ships made by Dislitbangal.

Research suggestions consist of theoretical suggestions and practical suggestions that can be suggestions for further research as follows:

REFERENCES

Abe, Satoshi, Tsujimoto, Masahiko, Yoneda, Ko, Ohba, Masaaki, Hikage, Tatsuo, Takano, Mikio, Kitagawa, Susumu, & Ueno, Takafumi. (2012). Porous protein crystals as reaction vessels for controlling magnetic properties of nanoparticles. *Small*, *8*(9), 1314–1319. https://doi.org/10.1002/smll.201101866

Bahatmaka, Aldias, Hadi, Eko Sasmito, & Mulyatno, Imam Pujo. (2014). Studi Perancangan Lambung Small Waterplane Area Twin Hull (Swath) Kapal Protector Dengan Sistem Unmanned Surface Vehicle (Usv) Untuk Perairan Ambalat. *Jurnal Teknik Perkapalan*, *2*(1).

Collin, Koh Swee Lean. (2015). What next for the Indonesian navy? Challenges and prospects for attaining the minimum essential force by 2024. *Contemporary Southeast Asia*, 432–462.

Djalante, Riyanti, Lassa, Jonatan, Setiamarga, Davin, Sudjatma, Aruminingsih, Indrawan, Mochamad, Haryanto, Budi, Mahfud, Choirul, Sinapoy, Muhammad Sabaruddin, Djalante, Susanti, & Rafliana, Irina. (2020). Review and analysis of current responses to COVID-19 in Indonesia: Period of January to March 2020. *Progress in Disaster Science*, *6*, 100091. https://doi.org/10.1016/j.pdisas.2020.100091

Ernest, Nicholas, Carroll, David, Schumacher, Corey, Clark, Matthew, Cohen, Kelly, & Lee, Gene. (2016). Genetic fuzzy based artificial intelligence for unmanned combat aerial vehicle control in simulated air combat missions. *Journal of Defense Management*, *6*(1), 374–2167.

Evans, J. Harvey. (1959). Basic design concepts. *Journal of the American Society for Naval Engineers*, *71*(4), 671–678.

Milan, Francesco F., & Bassiri Tabrizi, Aniseh. (2020). Armed, unmanned, and in high demand: the drivers behind combat drones proliferation in the Middle East. *Small Wars & Insurgencies*, *3*(4), 730–750. https://doi.org/10.1080/09592318.2020.1743488

Octavian, Amarulla, Cahyono, Priyo, & Pranowo, Widodo Setiyo. (2020). The Influence Of Indonesian Navy Diplomacy Through Naval Presence On The Effectiveness Of Maritime Operations In The North Natuna Sea. *Journal Asro*, *11*(04), 54–60. https://doi.org/10.37875/asro.v11i04.367

Pineda, Juan A., Caruz, Antonio, Rivero, Antonio, Neukam, Karin, Salas, Irene, Camacho, Angela, José C, Palomares, Mira, José A., Martínez, Antonio, & Roldán, Carmen. (2010). Prediction of response to pegylated interferon plus ribavirin by IL28B gene variation in patients coinfected with HIV and hepatitis C virus. *Clinical Infectious Diseases*, *51*(7), 788–795. https://doi.org/10.1086/656235

Susdarwono, Endro Tri. (2021). Increasing Return: Supply Chain Economic in the Development of Indonesia'Defense Industry Independence. *ENTITA: Jurnal Pendidikan Ilmu Pengetahuan Sosial Dan Ilmu-Ilmu Sosial*, *3*(1), 19–36. https://doi.org/10.19105/ejpis.v3i1.3863

Susilo, April Kukuh, Ciptomulyono, Udisubakti, Putra, I. Nengah, Ahmadi, A., & Suharyo, Okol Sri. (2019). Navy Ability Development Strategy using SWOT Analysis-Interpretative Structural Modeling (ISM). *Strategic Management-International Journal of Strategic Management and Decision Support Systems in Strategic Management*, *2*(1).

Sutomo, Jusuf. (1992). *Tahanan dan Propulsi Kapal*. Airlangga University Press, Surabaya.

SV, A. A. (1983). Harvald. *Resistance and Propulsion of Ships. Denmark: John Weiley & Sons.*

Tsou, Ming Cheng, & Hsueh, Chao Kuang. (2010). The study of ship collision avoidance route planning by ant colony algorithm. *Journal of Marine Science and Technology*, *18*(5), 16.

Yousefi, Reza, Shafaghat, Rouzbeh, & Shakeri, Mostafa. (2013). Hydrodynamic analysis techniques for high-speed planing hulls. *Applied Ocean Research*, *4*(2), 105–113. https://doi.org/10.1016/j.apor.2013.05.004