Design Multi-Sides System Unmanned Surface Vehicle (USV) Rocket

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Abstract. This study aims to design and test USV multislide forms. This system is excellent for maneuvering on the x-y-z coordinates. The disadvantage of a single side USV is that it is very difficult to maneuver to achieve very dynamic targets. While for multi sides system easily maneuvered though x-y-z coordinates. In addition to security defense purposes, multi-side system is also good for maritime intelligence, surveillance. In this case, electric deducted fan with Multi-Side system so that the vehicle can still operate even in reverse condition. Multiple-side USV experiments have done with good results. In a USV study designed to use two propulsions.

1. Introduction
The state of Indonesia has consists mainly of the sea and has separated islands extending from Sabang city to Merauke city. Therefore, the government, especially the Navy has difficulties and limitations for monitoring the security of each island. Along with changes in emphasis, new capabilities will require navies in the field of maritime intelligence, surveillance, reconnaissance and assault.

Unmanned surface vehicle (USV) is an unmanned vehicle that is operated on the surface (surface) for a particular purpose. USV is also known as autonomous surface vehicle (ASV) or an automatic surface vehicle because it uses a global positioning system (GPS) in determining the direction of the purpose of the movement of the vehicle [1] - [2].

Many researchers have done on USV topics. [3] and [4] researchers presents an automatic method to acquire, identify, and track obstacles from an Unmanned Surface Vehicle (USV) location in marine environments using 2D Commercial Of The Shelf (COTS) video sensors, and analyzing video streams as input. The researcher also shows the guiding line of this research is to develop real-time automatic identification and tracking abilities in marine environment with COTS sensors.

Another researcher [5] states a USV with a trajectory planning and tracking approach for following a differentially constrained target vehicle operating in an obstacle field. The developed approach includes a novel algorithm for computing a desired pose and surge speed of the target boat, jointly defined as a motion goal, and tightly integrates it with trajectory planning and tracking components of the entire system. The trajectory planner generates a dynamically feasible, collision-free trajectory to allow the USV safely reach the computed motion goal.

However, in this study, the authors propose new design of USV rocket. The USV consist of four sides with two propellers as electric deducted fan (EDV).
Unmanned surface vehicle (USV) is indispensable in everyday life. Especially in the field of surveillance or observation in places that are harmful to humans. System Unnamed to reduce the risk to the manned forces. Research on USV has been widely practiced in various countries of the world in both the hull model and the USV drive system, but there less study of USV for multi-sides systems that use rockets as propulsion.

2. Literature Review

2.1 Rocket
A rocket is a spacecraft, a missile, or a flying vehicle that gets a boost through a rocket reaction to the rapid discharge of the fluid material from the engine output of the rocket. The action of the output in the combustion chamber and the developer nozzle, capable of making the gas flow at hypersonic speed so as to generate a large reactive impulse for the rocket is proportional to the counter reaction, in accordance with the Law of Newton III.

The movement of a rocket is determined by the angle of movement of the three rocket fins. In the presence of elevator control fins, rudder control fins and aileron control fins. The elevator control fins are the controls that adjust the motion of a rocket up and down with a certain degree (pitch angle change). Full rudder fins are controls that can deflect the rocket nose to the left and right or so-called yaw movements. While the aileron control is a surface control that can control the motion of rocket roll [6]

USV rocket system works more or less the same as a rocket in general, but rocket work on the water surface is much easier. The system moves in control by adjusting the speed of both USV rocket boosters, turn by temporarily halting or reducing the speed of one of the driving forces.

Mechanical made in the form of ship with catamaran concept. The ship type has 4 symmetrical main hulls (Hulls) on the right and left sides and has two sides of the upper and lower hull that allow the ship to operate even in reverse and can. Move (Maneuver) more balanced.

2.2. Control System
Control issues are closely related to strategies that allow a microcontroller to direct the movements of a robot through the sensor and deliver the robot's response to the microcontroller. The control system has three elements: input, process and output [7].

![Control System](image)

Figure 1. Control System

Input is generally a signal and a transducer is a tool that can change the physical quantities into electrical quantities, such as buttons, limit switches, thermostat and others. The transducer provides a quantifiable quantity, then this quantity can be processed by the process part, may be a control circuit using electrically assembled equipment or a programmable control system such as a microprocessor and microcontroller system.
Information processing called input signal, generates an output signal, which is then used to activate the actuator as output equipment, which can be an electric motor, contactor, solenoid valve, lamp etc. With output equipment, the quantity of electricity converted into physical quantities.

3. Research Method

3.1 Work Design
Mechanics made in the form of USV rocket with catamaran concept. The USV rocket has four hulls. Two symmetrical hulls on the right and left sides at the bottom of the USV rocket, while the other two hulls are at the top of the USV Rocket in the same position. Such gastric construction allows the USV rocket to remain in operation even in reverse.

![Figure 2. Electronic Circuit Scheme](image)

3.2 Electronic Device System
Electronic devices on USV rockets that will be made include Electric Ducted Fan (EDF), IMU GY-88 Sensor, Electronic Speed Controller (ESC), arduino mega 2560 and Remote Control. The circuit schematic shown in Figure 3.

![Figure 3. Model of Multiside System unmanned surface vehicle](image)
3.3 User Interface with Google Earth
The user interface display can be seen in figure 19. The displayed data consists of roll, pitch, yaw, compass and current direction. The data shown is the current position data of the rides and the trajectory.

The selection of Google Earth to show the position of the rides is due to its easy use and user friendly or easy to use interface. Google Earth is also available with unpaid maps making it easy to access the locations used.

![Google Earth User Interface](image)

Figure 4. Google Earth User Interface

4. Results and Discussion

4.1. Experiment Results
4.1.1. Measurement of thrust force.
The thrust force in the multimotor is due to the propeller-generated lift force. Since the pitch angle of the propeller is fixed, then to increase or decrease the lift force is by increasing or decreasing the speed of the propeller angle. This can be found in figure 4

![F_thrust vs Ω](image)

Figure 5. Relationship between thrust force $F_{thrust}$ (N) with rotation speed $\Omega$ (rad / s).
Because the propeller is rotated has a dimension and mass large enough. To be able to provide high angular speed, the motor requires considerable power (watts). This can be seen in Figure 6.

![Figure 6. The relationship between the thrust force F_{thrust} (N) and power P (watts).](image)

Because the measurement is done with tools that are less precision, such as tachometer that still uses the touch system. So there is an inaccuracy of data retrieval. This can be seen in the measurement of the thrust force constant (Ns²).

![Figure 7. The result of the measurement of the thrust force constant (Ns²).](image)

4.1.2. Measurement of moments.

Then the motor will produce a moment that direction in the opposite direction with the direction of propeller rotation, because the motor rotates propellers that have mass. In the USV rocket, this moment is used to rotate the USV rocket body on the z axis. The greater the rotation speed of the propeller, the greater the moment produced. This can be seen in figure 8.
Figure 8. The relationship between the moments τ (Nm) with the angular velocity of propeller Ω (rad / s).

Because the size of the power affect the speed of rotation, the higher the power given the higher the greater the moment generated. This can be seen in Figure 9.

Figure 9. Relationship between moment τ (Nm) with power P (watts).

Just like the thrust gauge, the moment measurement also uses a tachometer with the touch system. Thus the propeller rotation readings become less accurate. This results in less accurate data on the measurement of drag factor d (Nms²).
5. Conclusion

Unmanned surface vehicle rockets have been made in accordance with the design. The USV rocket has a length of 720 mm, a width of 475 mm, a height of 305 mm, and a total weight of 5579 grams. This rocket is driven by two electric motor ducted fan 90 mm 1600_kv, two ESC 160_A, FlySky i6 remote controller, and Li-Po 18.5_V 4000 mAh battery power source as much as two pieces.

Using a 4000 5S 18.5 Volt battery composed in series, the amount of power the motor needs to reach its maximum speed is 3825.93 watts and the maximum thrust force the motor can generate at a maximum rotation of 4562.629 rad / s is 66,378 N. The moment that the motor can generate at maximum rotation is 0.270578 Nm. This is due to the Voltage of used batteries and the load of the rides.

Based on the observation of trajectory USV rocket when moving through variation of the path. Total error of 1896 cm and the largest deviation is 200 cm at the time of USV rocket cornering. This is because USV rockets need a big turn for cornering.

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