MAKARA-02 Autonomous Robotic Boat 2013 Competition

Muhammad Hary Mukti*, Aditya Meisar*, Novika Ginanto**
Irvan JP Elliika**, Yulian Mahendra**,Muhammad Anwar Ma'sum***,
Ayun Arifianti****
Naval Architecture, **,Electrical Engineering, *,*
*Faculty of Computer Science, ****Faculty of Pharmacy, Universitas Indonesia*
Roboboat.ui@gmail.com

Abstract
Universitas Indonesia has designed MAKARA-02; an ASV (Autonomous Surface Vehicle) to participate in the 6th annual competition organized for the Association of Autonomous Unmanned Vehicle Systems International. We focused on the following engineering concepts of; naval system, mechatronics, and electrical engineering. A catamaran made of high-density foam equipped with GPS, compass, Laptop, thermal sensor, and USB cameras was developed to function autonomously to pursue its directed tasks. These tasks are focused on image recognition as well as navigation and thermal sensing to do certain task needed thermal sensor.

1. Introduction

MAKARA-02 Robotic boat is the 2013 design of the Universitas Indonesia. The boat was designed in order to participate in the 6th Annual International AUVSI Competition (Autonomous Surface Unmanned Vehicle). With the dimension of 4.94ft x 2.96ft x 0.73ft and made of high-density foam, this design has a major purpose geared to achieve the missions of the competition. A key aspect of MAKARA-02 design is the ease of transportability from Indonesia to the United States and for the ability to assemble as well as disassemble easily.
With limited funds and the need of high-tech devices it was decided to create a control board to manage the output signal generated from anLaptop which analyzes and processes all the data. The controller system includes; 1) ATMEGA2560 and Laptop for CodeBlocks software as the main coding source, 2) USB cameras, compass, thermal sensor, and GPS as the sensory systems, 3) Wireless hub for communications and programming. Additionally, self-designed water cannon with a small conventional water pump and series of servo motors were added to find targets in different orientations. A Turnigy brushless motor thrust was included to generate the desire propulsion for greater speed.

2 Mechanical Design

The basic structure of the boat relies on a SWATH (Small Waterplane Area Twin Hull) to avoid the usual problems of stability and reduce the amount of power needed to propel the boat. The boat contains two tubing that submerged.
On the middle part of each hull, a hole was made to put the entire electric and power system, so it was completely protected from any water contact. The protective cover was made by a combination of plywood and plastic. On the very front of the platform a 10 inch wide piece of plywood was placed to protect the other subsystems on the platform and also to accomplish one of the missions on the competition, which is to push a red button to stop a water fall. After a series of test we found out that the addition of a stiffener connected in between the front piece of the plywood and the hulls front stiffener was needed to provide a

better altitude to the cameras and water cannon for better recognition of images and hitting targets.
Based on the V shape catamaran used last year, with little draft there was too much exposition to the lake water letting the electric part be exposed to danger. To counter this problem from last year, we made a double size boat with triple draft. The most challenging part of the design was to make a puzzle boat that is as lightweight as possible, due to the international shipping conditions. Each part of the entire boat, screws/bolts joining method was decided for facilitating assembling/dissembling process and transporting, without sacrificing the structure strength.
This is the hull specification:

1. LoA = 83 cm
2. BoA = 52.68 cm
3. H = 44.29 cm
4. LWT = 3 Kg
5. DWT = 6 Kg (*payload*)
6. Displacement = DWT+LWT = 9 Kg

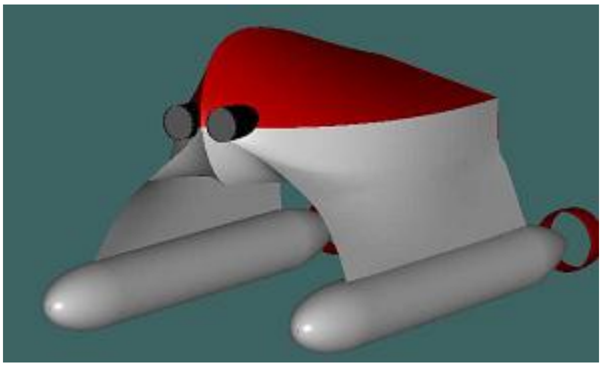

Fig 1. Design of Makara-02

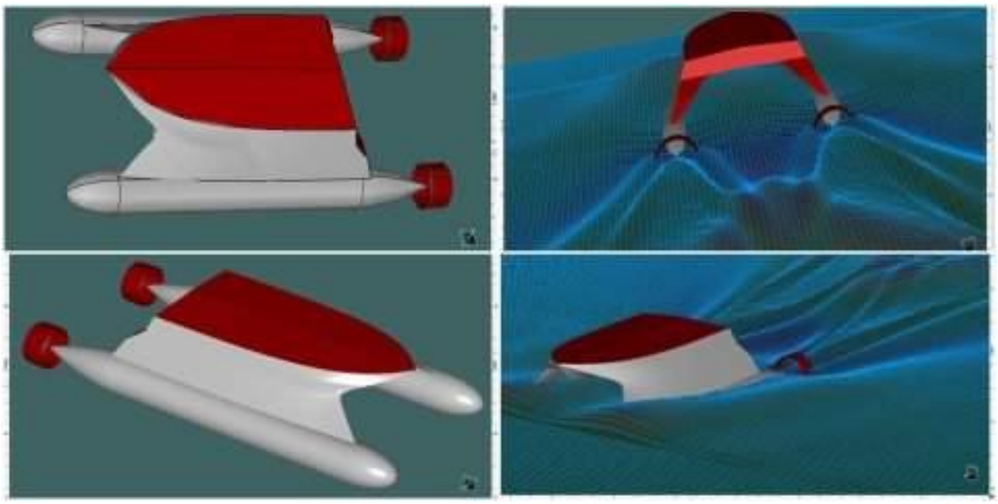

Fig.2. Hull Design and flow simuation (3D Maxsurf Professional)

A. Step of hull fabrication:

1. Make the tube first.

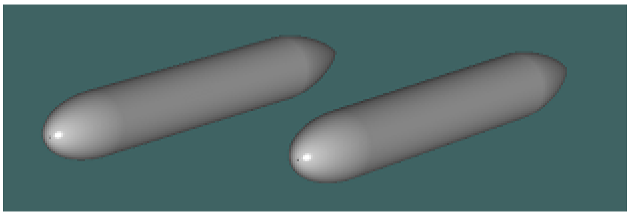

Fig.3. Making Tube

2. Make Cord Nozle

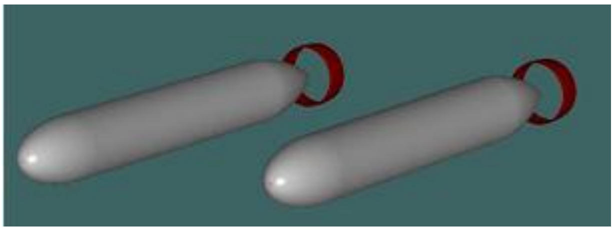

Fig.4. Making Cord Nozzle

3. Making a connector of hull and main super structure

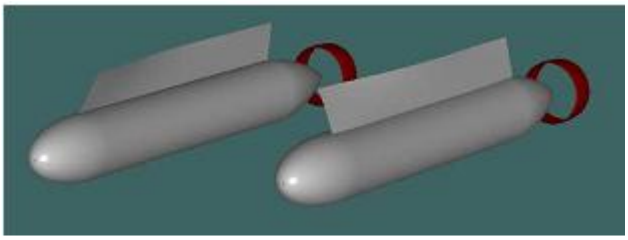

Fig.5. Making Connector of Hull and Main Super Structure

4. Fabrication of super structure

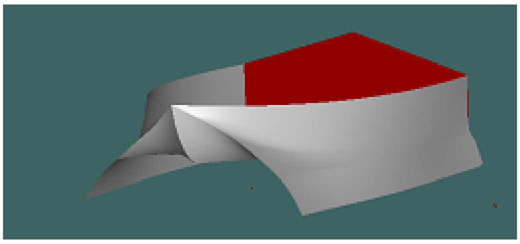

Fig.6. Fabrication of Super Structure

5. Instalation of hull and superstructure

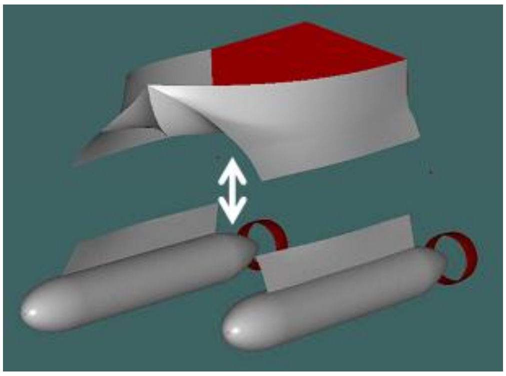

Fig.7. Instalation of Hull and Super Structure

6. Make the cover and electronical installation

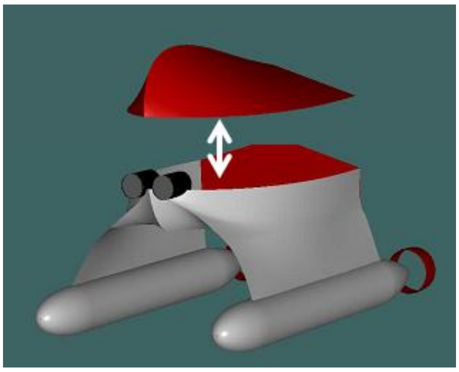

Fig.8. Making Cover and Electronics Installation

7. Finishing

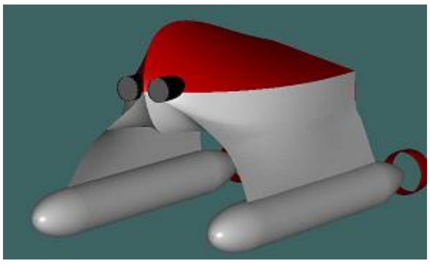

Fig.9. Finishing

2.1. Propulsion

The propulsion system consists of two brushless motor. This XK3665-B-2700KV Brushless Inrunner is an engine give great power to the propellers. It’s mounted in the 3/4 length of AP of the boat using its system, which is regulates the speed of the motor.

Table 1. XK3665-B-2700KV Brushless Inrunner

Details	Specs	Details	Specs
# of poles:	4	Kv (rpm/v) :	2700
Max Amps:	90A	Weight (g)	275
Max Volt:	11.1V	Max Current (A)	90
Max Watts:	1000W	Resistance (mh)	8
Rpm/V:	2700kv	Max Voltage (V)	11
Resistance:	0.0075 ohms	Power(W)	1000
No-load Current:	2.7A(7.4V)	Shaft A (mm)	5
Dimension:	36.0mm x 65.0mm	Length B (mm)	65
Mounting hole depth:	6mm	Diameter C (mm)	36
Length of extend Shaft:	16mm	Can Length D (mm)	63
Shaft diameter:	5mm	Total Length E (mm)	81
Weight:	275g		

Before that we Use CFD, Hullspeed Maxsurf Profesional program to predict the waves and resistance that hull create. Thus we can choose what propulsion is the best for this hull. It provides 30lbs (13.6 kg) of thrust when a 360Watts is supplied. Because of the dimension of

MAKARA-02, such power is not needed, so we only made use of 120Watts. A 11.1V LiPo battery provides enough power to the motor and water pump for about 1 hour.
This One of our strategy in naval technology is rotating ability for the ASV, use twin screw propellers at each hull which can make the boat rotating in the place such picture below:

Fig.10. ASV

And this is the hole supporting hardware for propulsion system. P1.4*D33/3 Propeller (PK2)-Warrior & Sea Rider

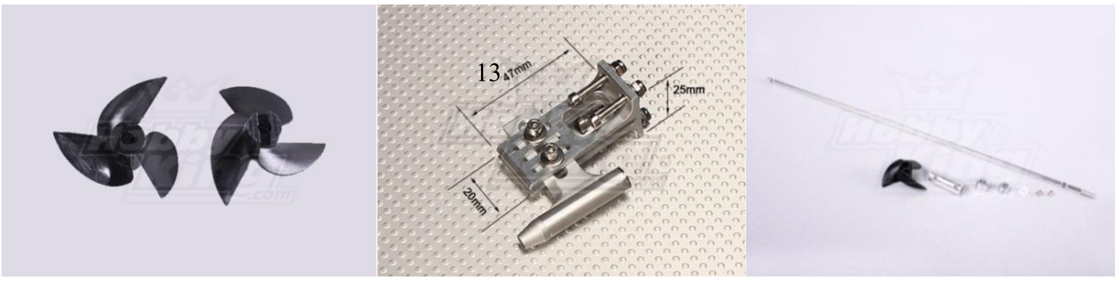

Fig.11. Propulsion System

Shaft and Prop set 4mm, includes couplings.
Specs.
Length: **269mm**
Diameter: **4mm**
Prop: **3 blade 28mm**
Motor Shaft: **3.175mm**
Suits sleeve 12925

Fig.12. ESC

Table 2. Programmable Settings

Reverse		Battery:	**2-6SLipoly**
Low Voltage	(none/2.8v/3v/3.2v/3.4v)	BEC:	**3A/6v**
Brake:	(none/soft/hard)	Motor Type:	**Sensorless Brushless**
Timing	(0.00/3.75/7.50/11.25/15.00/18.75/22.50/26.25)	Size:	**94 x 33 x 18mm**
Constant Current:	**120A**	Weight:	**91g**
Burst Current:	**240A**	*Speed:	100,000+rpm(2 Pole)
Resistance:	**0.0007ohm**		

Red Aluminum Motor Heat Sink w/adjustable fan (top) 36mm Inrunner Motors for motor efficiency.

Fig.13. Red Aluminium Motor Heat Sink

3. Electrical and Electronic Subsystems

The electrical and Electronic Subsystems were designed to supply the power and do the automotion in MAKARA-02. The Electrical subsystem contains the Power Distribution System and Electronic Subsystem contains the Control board diagram, Communication Protocol, and Sensory Subsystem. Following is description of the Electrical and Electronic Subsystems.

3.1. Power Distribution System

To supply all the component in electronic system, power distribution system is needed to prevent the interrupt for the Control Board and supply the power what is needed. This power distribution system use 2 battery LiPo 11.1 V 5000 mAh, 1 battery LiPo 7.4 V, and Lithium Battery in Laptop. This following is the Power Distribution Diagram to describe the power distribution system in MAKARA-02.

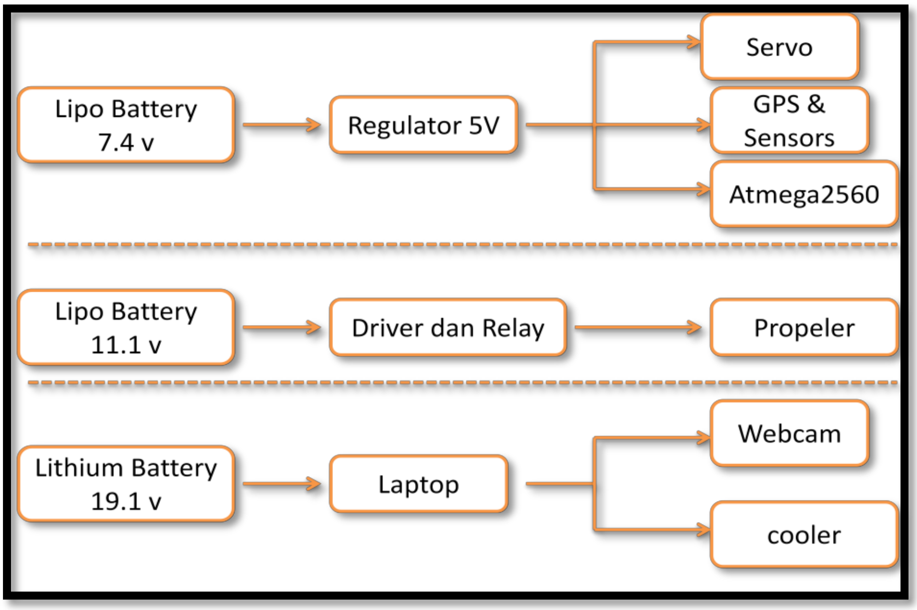

Fig.14. Power Distribution Diagram

LiPo Battery 7.4 V is used to supply the board Atmega2560 for logic application, wireless transceiver, all sensors (such as balancing sensor, safety alarm, temperature sensor, etc), and GPS after regulated with Regulator 5V. LiPo Battery 11.1 V is used to supply Electronics Speed Control (ESC) and Propeler. This subsystem prevents the interrupting the power supply for Atmega2560 so that no reset occurs in Atmega2560. Lithium Battery take a role in supplying the power for the Laptop, webcam, and cooler system. For establishing this power distribution system, the board power distribution is made from PCB to switch on or off easily.

3.2. Control board diagram

Control Board diagram contain two controller that establish the automotion system, namely Laptop and Atmega2560. Laptop is used to do image processing, or another high level processing and Atmega2560 is used to control all actuators and sense the temperature, electronics compass, and another low level processing. The following diagram shows the control board/computer communication system:

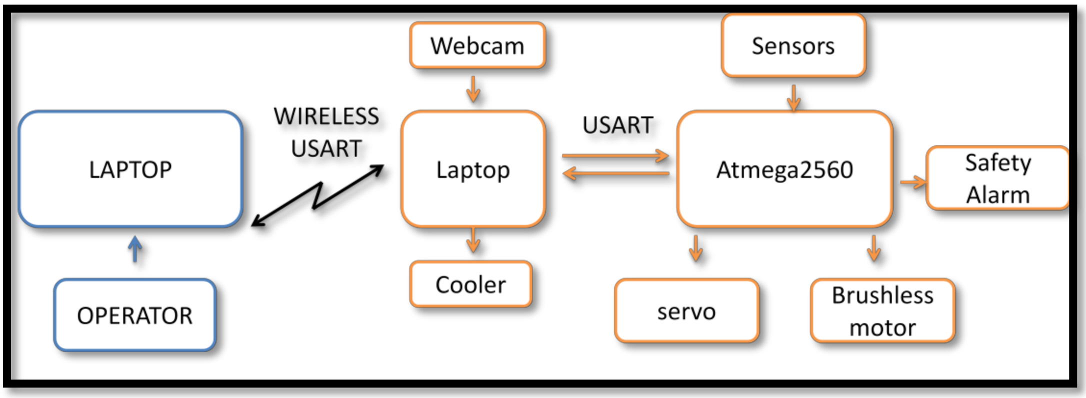

Fig.15. Control Board Diagram

The Atmega2560 features the following main control; 1) Controlling Propeler and all actuators, such as Servo motor and DC Motor, 2) Sensing temperature task with thermal

sensor, 3) Navigating with balancing sensor and GPS module, 4) Communicate with Laptop to ask for the data from Laptop about image processing, wireless, and GPS. This board was programmed using C language.
The Laptop features the following control; 1) image processing, 2) visual debugging. This Laptop has Linux OS to operate OpenCV to do good image processing with webcam. Image processing in Laptop yields the command for Atmega2560 to navigate as well as the navigation.
Atmega2560 also is essential in controlling servo motors which allow webcam and water cannon to move in X-Y direction. Two servo motors were added to the water gun to increase the strength on moving it upwards and downwards for better focus on the target.
To prevent water from getting into the Laptop and Atmega2560, an acrylic plate was placed on top of the electronic system. All the electrical components are totally covered and kept away from contact with water.