DESIGN AND DEVELOPMENT OF UNMANNED SURFACE VEHICLE HULL FOR WATER QUALITY MONITORING SYSTEM

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ABSTRACT

In this modern era, there is a lot of industry sector to produce advance technology. Hence, people love to have machine with technology in order to make their work life easier. With no required lot of movement and effortless, no wonder these advance machines have high demand in global market. Because of this factor, lot of country make this sector as one of their main economy to generate main source of income. Despite of this increasing industry factor, many of the factories did not care about their surrounding environment especially when releasing their waste materials in variety way of form whether in solid state or liquid mainly to the river. Most of these waste materials have one common characteristic which are mixing of chemical substances that may give harm to surrounding ecosystem. This harmful chemical wasted could cause death to aquatic life even to human as river also is one the main source to human for their daily uses. Thus, this problem needs to be solved by create or build a device to monitor the quality of the water. The most sufficient device that suitable to monitor this situation is Unmanned Surface Vehicle (USV). This USV will have one main task which is to monitor the quality level and give information to people in instant with real time data. Hence, the purpose of this project is to develop and design an USV that will be used in specific area. The USV required a suitable design to be used in the main streams such as in the river environment. The design of the USV should consider several aspects such as in term of overall cost, durability of the boat, and the capability movement. These aspects also can be achieved by doing some research on previous project or in existing market. Other than that, the right tools and material will affect the durability of the USV to overcome variety of whether condition and environment. As for the movement of the boat, it required good mobility components and mechanisms in order to change the direction of the boat. The USV boat also need to be stable to prevent the boat to be flipped upside down.

ABSTRAK

Dalam era moden ini, terdapat banyak sektor industri untuk menghasilkan teknologi canggih. Oleh itu, manusia lebih suka untuk mempunyai mesin dengan teknologi untuk menjadikan kehidupan kerja mereka lebih mudah. Dengan tiada pergerakan yang diperlukan dan mudah untuk digunakan, tidak hairanlah mesin berteknologi tinggi ini mempunyai permintaan yang tinggi dalam pasaran global. Oleh kerana faktor ini, banyak negara menjadikan sektor ini sebagai salah satu ekonomi utama mereka sebagai sumber utama pendapatan. Walaupun faktor industri yang semakin meningkat, banyak kilang tidak peduli dengan persekitaran di sekeliling mereka terutamanya apabila melepaskan bahan buangan mereka dalam pelbagai bentuk sama ada dalam keadaan pepejal atau cecair terutamanya ke sungai. Kebanyakan bahan buangan ini mempunyai satu ciri umum iaitu pencampuran bahan kimia yang boleh memberi mudarat kepada ekosistem sekeliling. Sia-sia kimia berbahaya ini boleh menyebabkan kematian kepada kehidupan akuatik dan juga kepada manusia kerana sungai juga merupakan salah satu sumber utama kepada manusia untuk kegunaan harian mereka. Oleh itu, masalah ini perlu diselesaikan dengan mencipta atau membina peranti untuk memantau kualiti air. Peranti yang paling sesuai untuk memantau keadaan ini adalah Kenderaan Permukaan Tanpa Pemandu (USV). USV ini akan mempunyai satu tugas utama iaitu memantau tahap kualiti dan memberi maklumat kepada orang seiring dengan data masa yang selari. Oleh itu, tujuan projek ini adalah untuk membangunkan dan merekabentuk USV yang akan digunakan di kawasan tertentu. USV ini memerlukan reka bentuk yang sesuai untuk digunakan dalam aliran utama seperti dalam persekitaran sungai. Reka bentuk USV harus mempertimbangkan beberapa aspek seperti dari segi kos keseluruhan, ketahanan bot, dan keupayaan pergerakan. Aspek-aspek ini juga boleh dicapai dengan melakukan beberapa kajian mengenai projek terdahulu atau di pasaran sedia ada. Selain itu, alat dan bahan yang betul akan memberi pengaruh kepada ketahanan USV untuk mengatasi pelbagai sama ada keadaan dan persekitaran. Bagi pergerakan bot, ia memerlukan komponen dan mekanisme mobiliti yang baik untuk menukar arah bot. Bot ini juga perlu seimbang untuk menghindari daripada terbalik dari atas ke bawah semasa dalam air.

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LIST OF SYMBOLS

mm	millimeter
V	voltage
A	ampere
W	Watt
sin	sine
cos	cosine
Ø	theta
°	degree angle
kg/m^3	density
N	newton
m^3	cubic meter
m/s^2	acceleration
mAh	milliamp hour
Wh	Watt hour
Π	pie

LIST OF ABBREVIATIONS

3D	Three-dimensional
ALANIS	Aluminum Autonomous Navigator for Intelligent Sampling
DC	Direct Current
GPS	Global Positioning System
pH	Potential of Hydrogen
PWM	Pulse-Width Modulation
RM	Ringgit Malaysia
RMS	Root Mean Square
ROAZ	Regionaal Overleg Acute Zorgketen
RPM	Rotation per Minutes
PVC	Polyvinyl chloride
USV	Unmanned Surface Vehicle

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CHAPTER 1

INTRODUCTION

1.1 Introduction

As for the beginning, this chapter will introduce about the main purpose of Unmanned Surface Vehicle (USV) in water quality monitoring. Besides, it also included about the existing development and design of the USV that will be implemented in this prototype. The design also needed to consider the cost to build the prototype. The most important is the USV need to be waterproof and float on the water besides suitable shape and size.

1.2 Project Background

Unmanned Surface Vehicle (USV) is one of the advance technologies that can complete various type of task in marine environment. One of the obvious non-similarities with common surface vehicle is someone who will drive the vehicle. Hence, USV does not require any people on the vehicle to drive, but it will be controlled through wireless signal in distances from the ground. In addition, this will minimize the harmful of people's life. (Ru-jian Yan, 2010)

The main purpose of this project is to develop a water monitoring control prototype which to analyze the water quality in certain area. It consists of the controlled system to drive the direction of USV and sensor system to collect the data from the water. Other than that, the design of the USV need to be compatible with the condition of the water. Generally, these three main aspects should have for a water monitoring in USV.

In terms design, the USV needed to be low cost to be built as the existing product usually require lot of cost just to build the USV. This is because of the USV are placed on the water which require a waterproof material in order to prevent the USV to be filled with water inside. In other words, waterproof material must be implemented to avoid this condition. (Wonse Jo, 2019)

The shape of the USV must be suitable with the type of water and stream that want to be monitored. There are many shapes of USV can be found in the market, but the most common shape that usually being built is boat shape. This is because boat shape or rectangular with edge at one side is very suitable to move in liquid fluid as it can cut through the water with low energy required and can move with long distance with that small amount of energy.

Other than that, the size of the USV also needed to be considered as it will depend on where the USV will be sailed. Plus, the function of the USV also influence the size of the USV. If the USV used a lot of components or the space for a component require a lot of space, then the size of the USV will be bigger. Hence, the size of the USV will affect the design of the hull in order to support the buoyancy force and movement ability of the USV.

The most important part of designing a USV is the hull of the boat. Hull is at the bottom side of the boat. In marine technology, hull is the core of a boat or ship which it acts as watertight enclosure of the boat. It also protects the inner side of the USV from various type of water, weather or structural damage. Eventually, a suitable type and shape of hull are very important aspect for a USV to overcome all the resistance on the water.

1.3 Problem Statement

Water has covered up seventy percent of our earth surface. Hence, it is become our priority for main source of all living things in this world. A good quality of water is necessary for a healthy life for human, animal and even plant. Before revolution era of industry, water in the main river even at the sea are free from any pollution that can harm flora and fauna. During that time, there is no need to monitor the quality level of the water. Hence, all living things should use it safely without give any harmful to their life health.

As the time flow, there are lot of open industry as the people tend to like new technology and machine to make their life become easier. This resulting a lot of waste material produced by the factory and sadly this waste chemical let flow into river and other main stream. As for the result, the ecosystem in the river have been affected which cause of death to flora and fauna life. Human also affected by this chemical waste which can harm their healthy life and even worse it can cause mutation.

Besides can be harmful to all living things, it also may cause a lot of financial problem to the government or agency to provide and bought equipment to treat the harm water. In 2019, Johor state government had to spend an emergency fund of RM 6.5 million to speed up the cleaning work of Kim Kim River as it has affected a lot of citizen. In other words, the larger the size of area certain water surface that have been polluted, the higher the cost that need to be allocated to control and clean the pollution in the water. (The Straits Time, 2019)

To avoid and overcome all this situation, a device needed to be developed for monitoring the water quality level in that related area especially in industrial and power plant area. The most efficient and suitable solution is using an USV equipped with water quality monitoring system. This because, it does not require a crew to be sit on the boat which can save for hiring cost. Other than that, it will read the quality level in real time state and transfer data in nick of time. Lastly, it can be move from one position to another position to collect different data from different position in that particular river.

Hence, the water pollution can be monitored easily by getting information for water quality level in real time. Hence, if there is drastic change from average normal, people will take a quick action to find main source of pollution and stop it from spreading widely to another area. With this device, it can save a lot of cost and lost to human life even for the flora and fauna in the ecosystem. The water is generally saved to be used as long the quality level is in good condition.

1.4 Objectives

There are several objectives have been set to be accomplished based on this project that was built:

- To design and develop an USV that low in cost and attached with onboard water quality monitoring system.
- To develop and design an USV that can be moved and float on water according to river condition.
- To develop and design an USV which are water resistance.

1.5 Scope of Project

In order to build a low cost of USV, the best material for a small type of boat is wood and plastic. This is because, wood is known for the low-density property material compared to water which could help it to be float. This situation same as plastic which their natural property which is light and low-density. Other than that, these materials are easy to be formed and shaped with suitable tools in order to fabricate into boat according to design. But wood is not a water proof material as it can absorb liquid and eventually the wood will sink to the bottom as it has same density with water. In other hand, plastic is basically waterproof and does not absorb liquid. To prevent the wood from absorbing the water, it needed to be sealed. Malaysia generally experience tropical weather with little bit humid that may spoil the material. Hence, the sealed also act as prevention material for this problem.

1.6 Limitation of Project

There are several limitations in this project that have been discovered. One of them is the USV may be not fit in small area and cannot be moved to particular position due to its size and shape. Other than that, the body of USV may be break due to very high chemical reaction from the waste industry. Besides, the USV will eventually break into pieces if it falls from high waterfall or crash with hard object such as rock in high speed. The obvious limitation is the range of the USV can move from the controller device as it has range limitation of signal. Lastly, the electronic components inside the USV may be broken due to long exposure to hot and cold weather as the casing cannot withstand high temperature.

1.7 Report Organization

To complete this report, there are 5 Chapter that need to be done. The Chapter 1 is about introduction to our project. It consists of what was the purpose of this project, problem statement, and the objectives that want to achieve at the end of the project. It also included the scope and limitation of the project that reflect about the cons of the project.

Chapter 2 consist of literature review to tell about the previous product that have been existed in the market and make a comparison with the current project based on the advantages, design, and the functionality. It also consists of up-to-date materials that are used to make this entire product.

Chapter 3 is about the methodology that will explain how the project was constructed step by step from the beginning to last step which is demonstration of the project that will undergo testing and troubleshooting of the project if there were something wrong about it.

Chapter 4 will tell about the result and discussion obtained based on the project. It is the summarization of the data collected and the statistical treatment. It also consists of the observation and measurement that has been record while conducting the procedures described in the methods section. Plus, the discussion from the results obtained related with

the hypothesis that has been made earlier either it agrees with corroborates extends, refines, or conflict with other result.

Lastly, Chapter 5 consists of conclusion of the project's thesis reaffirms the statement, discusses the issues and reaches a final judgement. Other than that, the future recommendations of the project also being stated in this chapter based on the conclusion have been made.

1.8 Chapter Summary

As the summarize of this chapter, for the introduction of the project, background of study, problem statement, objectives, scope and limitations has been discussed in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will show some review of the project and studies. It included the history of the USV from the first centuries it has been created until now. It also consists of technology applied to different type of USV with different function uses. Plus, the innovation idea through many years that implemented on the USV and make an overview comparison between the similar projects before and this project is also stated in this chapter.

2.2 Previous Project Background

2.2.1 Aluminum hull USV for coastal water and seafloor monitoring

This journal tells about Construction and Development of the Aluminum Autonomous Navigator for Intelligent Sampling (ALANIS), an unmanned surface vehicle (USV) developed by the Autonomous robotic systems and control group of CNR-ISSIA Genova basically for coastal monitoring. The onboard automation system of the rubber boat shaped aluminum vessel manages the steering and throttle of a conventional outboard motor on the base of user desires and measurements supplied by the navigation package. An automatically controlled winch is devoted to deployment and recovery of scientific instrumentation through a suitable hole in the vehicle prow. (M. Caccia, 2009)

Figure 2.1: ALANIS USV

Figure 2.2: ALANIS USV performing basic guidance and control tests

2.2.2 Development of an Unmanned Surface Vehicle Platform for Autonomous Navigation in Paddy Field

This project carried out to develop an unmanned surface vehicle (USV) platform for autonomous navigation in the paddy field. The surface vehicle used in this research was a radio control air propeller vessel that had been modified into an unmanned surface vehicle platform. A GPS compass system was attached to the top of the USV platform as the navigation system to provide the position and heading angle. The USV platform can autonomously navigate to the predefined navigation map. From the GPS trajectory data of the map-based navigation experiment, the in-system root mean square (RMS) lateral error

from the target path was observed to be less than 0.45 m, and the in-system RMS heading error was 4.4 degree or less. The purpose of the research is to realize the autonomous weeding, intelligent fertilization or paddy growth management based on this USV platform. (Yufei Liu, 2016)

Figure 2.3: Unmanned surface vehicle platform

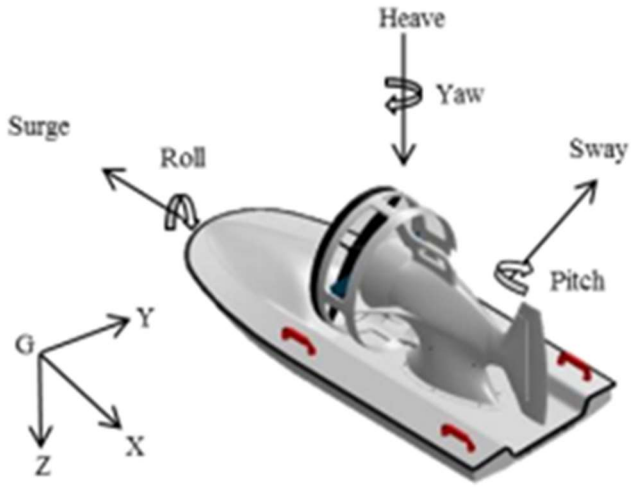


Figure 2.4: The 6-DOf motion of the USV platform in geodetic coordinate system

2.2.3 Radar Based Collision detection developments on USV ROAZ II

This work presents the integration of obstacle detection and analysis capabilities in a coherent and advanced C&C framework allowing mixed-mode control in unmanned surface systems. The collision avoidance work has been successfully integrated in an operational autonomous surface vehicle and demonstrated in real operational conditions. We present the collision avoidance system, the ROAZ autonomous surface vehicle and the results obtained at sea tests. (Carlos Almeida, 2009)

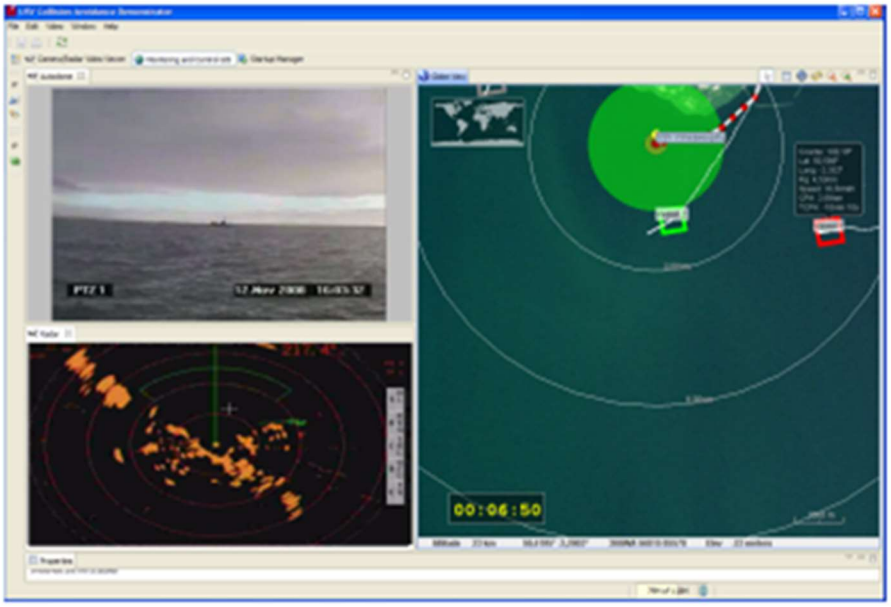


Figure 2.5: Target detected and leaving closest approach zone

Figure 2.6: ROAZ II Autonomous Surface Vehicle

2.2.4 Development of Navigation System for Unmanned Surface Vehicle by Improving Path Tracking Performance

A fundamental of a fully unmanned vehicle entails the use of Global Positioning System (GPS) and sensors module that emits USV a series of a waypoint for moving towards the target. In other words, GPS provides an accurate data location longitude and latitude for monitoring purposes. However, this real-time tracking path needs to extend their application for moving in curvature motion. Based on this fact, the real-time autonomous navigation system of USV will improve in this research by implementing the mathematical equation that will communicate with the GPS sensor. (Putri Nur Farhanah, 2020)

Figure 2.7: Shows the location on the google map

Figure 2.8: USV platform searching the target platform location

2.2.5 An Unmanned Surface Vehicle for Multi-mission Applications

A small camera equipped with remotely operated system based on wireless local area network is developed and used as a universal platform. Outfitted with different appliances and instruments, the USV is tested for various applications including harbor surveillance, water quality sampling, hydrologic survey, maritime search and rescue. (Jianhua Wang, 2009)

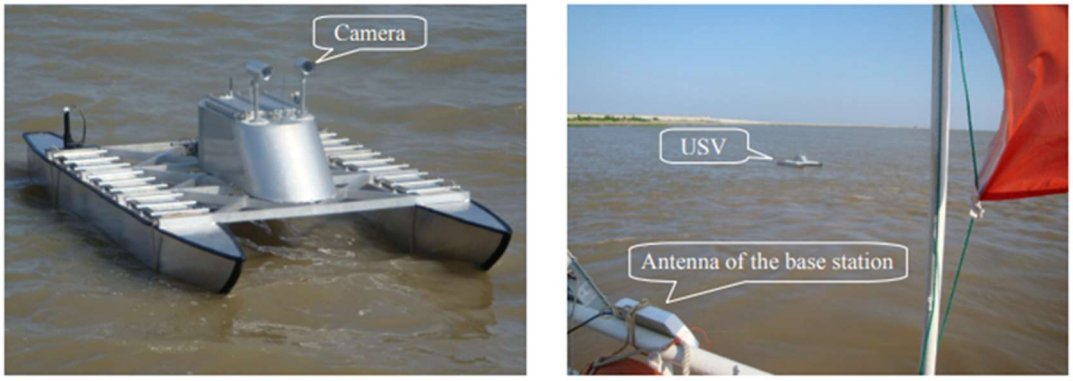


Figure 2.9: Multipurpose USV attached with a small camera (left). Base station and the USV being tested (right)

Figure 2.10: The multipurpose USV can carry up to a man on it

2.2.6 Design of a Twin Hull Based USV with Enhanced Maneuverability

The development of a catamaran-like autonomous surface vessel. The vessel is intended to serve as an experimental platform to study algorithms for control, sensor data fusion as well as path planning and collision avoidance. The mechanical design, the electronics and software architecture were described together with the sensor and actuator setup. The propulsion system comprises of two azimuth thrusters with limited azimuth angles. This concept provides additional degrees of freedom resulting in an over actuated control system. A mathematical model of the vessel has been adapted and implemented for model-based control strategies, simulation and hardware in the loop testing. (Michael Blaich, 2013)

Figure 2.11: USV of the HTWG Konstanz is a twin hull USV for rivers and inland waters

2.3 Chapter Summary

It can be concluded that the development of USV has been made before. It shows lot of criteria that can be implanted in the USV. Thus, there are very different task for each of the USV as it will follow the main purpose of the project. Plus, with different type of task will require different shape and design of the USV. The technologies that have been implemented also different with one another. Hence, based on this research will give the ideas on what need to implemented in this project which is based on water quality monitoring.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will explain in details on the procedures of designing and drawing of the USV. It also including the process of marking and cutting of the main body. Thus, the designing part will be divided into two which are boat and thruster design. All the materials details that needed to be used also been stated in this chapter. The methods that have been used in this chapter are aimed to achieved the objectives of this project.

3.2 Flowchart of Project Process

The flowchart of the whole project as shown in Figure 3.1 below.

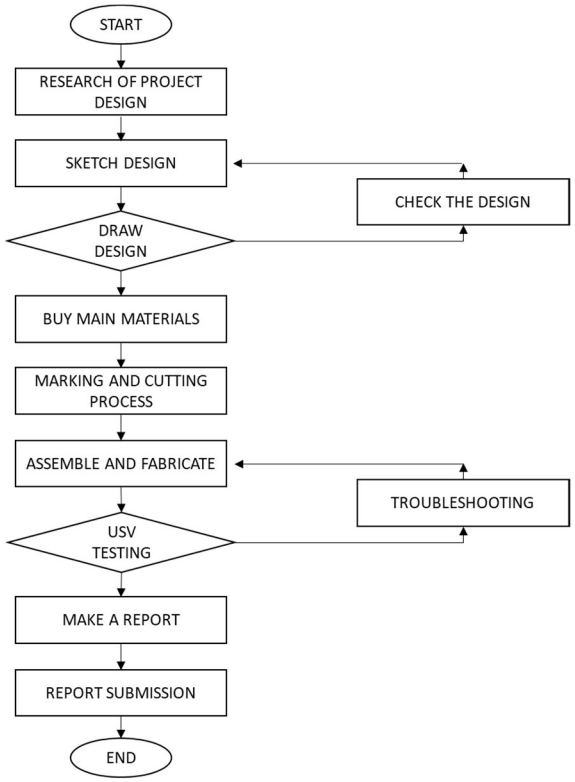


Figure 3.1: Flowchart process of whole project

3.2.1 Research of Project Design

Time to gather some information about the previous project or existing product in the market that are related to the project. There are many types of medium that were used to gather all the information such as magazines, journals, articles, and books.

3.2.2 Sketch Design

In this process, there were some ideas that need to propose and discussion have been made. Hence, there are six ideas that have been proposed and have been sketched on the paper. The discussion is about the overall size of USV and the criteria that must have for a boat.

3.2.3 Draw Design

After finalize one of the ideas, the design has been drawn by using Solidworks software. The design has been drawn in details which all the aspects for an USV. Other than that, this drawing will help in cutting process which all the sides of the boat need to be shown. Hence, if the drawing not suitable and match with sketching design, the process will be repeated until it met all the criteria needed.

3.2.4 Buy Main Materials

When all the materials that need to be used have been finalized, this will make buying main components process much easier as it is easy to find the only related components in the store. Thus, it can save a lot of time that can be used for other purposes.

3.2.5 Marking and Cutting Process

This is the most crucial process as it can save the cost to buy the main components. Marking process need to be done precisely to avoid wrong measurement of the main body. Hence, after marking process have been done, the material needed to cut into pieces according to measurement in the drawing of design.

3.2.6 Assemble and Fabricate

In this process, the fabrication of the main body has been done by using adhesive materials and tools. The electronics components also been assembled on the top of the main body together with sensors.

3.2.7 USV Testing

This process needed to be done in order to observe whether the boat is floating or not. It also including electronics components testing. If there is problem such as any leaking spot on the body or the electronic component not working properly, troubleshooting process need to be done.

3.2.8 Make a Report

Once the USV successfully full functioning and floating as planned, a report needed to be wrote on the progression of the project. In the report, it will explain all the things that are related with this project such as results, analysis, and conclusion.

3.2.9 Report Submission

Finally, submit the report before the dateline ends according to the SDP II due date.

3.3 Boat Design Sketching

This is the first step in order to design the whole project. There are six different sketch designs with each of them have different position of sensor holder and support mechanism. Thus, this will generate some ideas on how to improve the selected sketch design to be drawn as reference for marking cutting process. Hence, this sketching process does not include thruster design.

3.3.1 First Sketch Design

For the first sketch design, the electronic components case is put between two boat with four PVC pipe were connected perpendicularly with these two boats. Hence, the boat is made up plywood and the case are made up of plastic. Other than that, the sensor holder will be placed at the front side of the case.

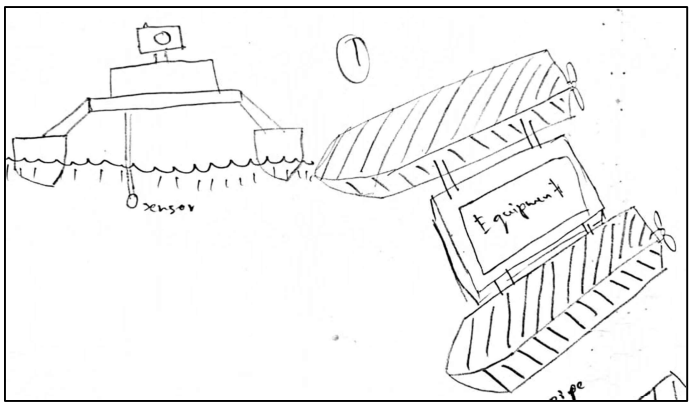


Figure 3.2: Isometric view of first sketch

3.3.2 Second Sketch Design

In this second sketch design, the position of the electronic components case is same with first sketch design. But does not connect with PVC pipe. In other words, the case is attached together with the side of the two boats. Hence, the sensor holder will be placed at the front side of the case.

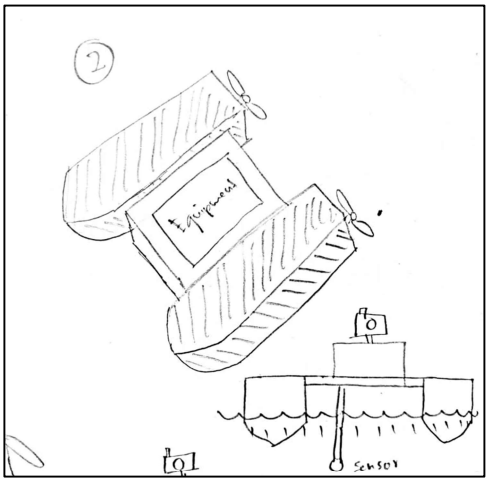


Figure 3.3: Isometric view of second sketch

3.3.3 Third Sketch Design

For the third sketch design, all the components are placed on one boat only. Besides, the sensors holder will be placed at the both sides of the both. The electronic components case will be placed on top side of the boat to make a distance between the surface of water and the case.

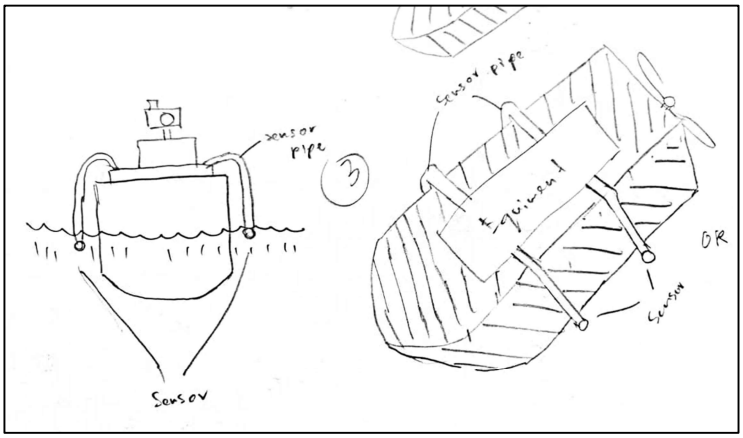


Figure 3.4: Isometric view of third sketch

3.3.4 Fourth Sketch Design

In this fourth sketch of design, there is no use of plywood as the floating mechanism. Instead, it will be replaced with bigger PVC pipe that. The electronic components case is placed between two PVC pipes. Hence, the three main body were attached closed to each other. Other than that, the sensor holder will be placed at front side of the case.

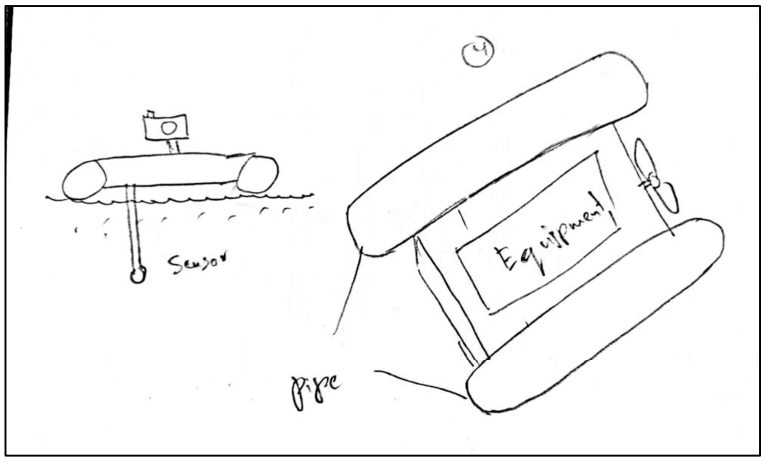


Figure 3.5: Isometric view of fourth sketch

3.3.5 Fifth Sketch Design

For the fifth sketch of design, the boat is placed between two PVC pipes at the both sides. Hence, they were attached closed to each other and the electronics components case is placed at the top side of the boat. Besides that, the sensor holder will be placed at the front side of the boat.

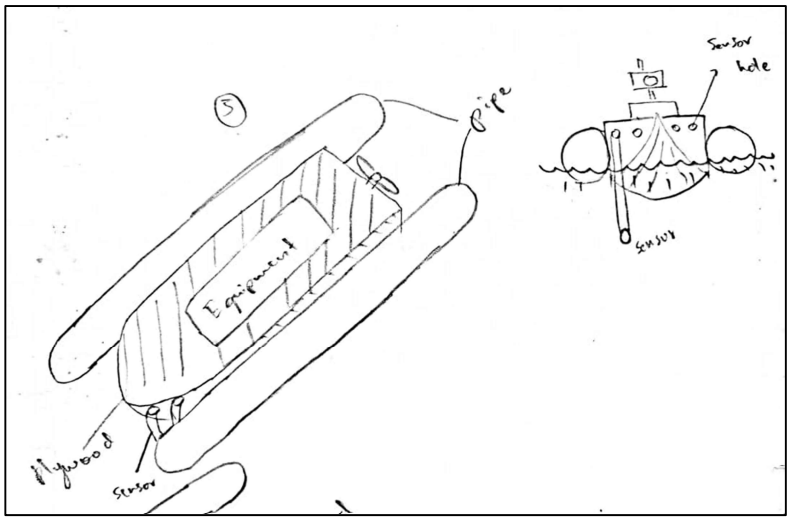


Figure 3.6: Isometric view of fifth sketch

3.3.6 Sixth Sketch Design

As the final sketch of the design, the position of the boat is placed same with fifth sketch design. But the PVC pipes were connected with smaller four PVC pipes which perpendicularly with the body of the boat. Besides, the electronics components case is placed at the top side of the boat with the sensor holder at front side of the boat.

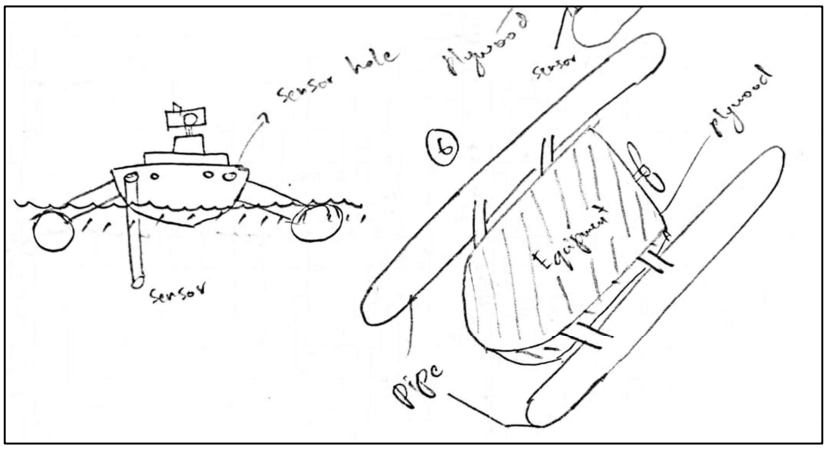


Figure 3.7: Isometric view of sixth sketch

3.4 Selected Sketch Design Details

After some discussion with other members, the sixth sketch of design has been selected to be boat design drawing that will be drawn using Solidworks software. This is because, it fulfills the requirement of conventional or commercial shape with standard material that need to be used. Other than that, the two PVC pipes will be acted as the support mechanism in order to prevent the USV flips upside down. It also acts as support floating mechanism as it will create empty space inside the pipes which to be known as air sack. With the position of the electronics components case at the top of the boat, it will create distance gap between the surfaces of the water and the case to avoid water splash that will enter inside the case. Besides that, sensor holder will be placed at both side of the boat in order to avoid the sensor break when it hits obstacle at the front. In other words, it will reduce the impact on the sensor with the obstacles. Hence, in order to draw the design, some aspects need to be detailed as it required measurement to draw the overall size and shape of the boat. The detail of the boat has been sketched as Figures 3.8 below.

3.4.1 Top View Measurement

From the top view of the design, the total width of the boat is 200 mm length as it not too big nor too small for a water quality monitor USV. Other than that, the total length of the both PVC pipes is 500 mm with the 100 mm of diameter. Hence, it enough to create empty space inside it as the air is trapped and air sack have been produced simultaneously. The thickness of the plywood that needed to be used for the main body is 5 mm while 2 mm thickness of plywood will be used as the top cover of the body. Other than that, the diameter of another type of PVC which act as connector between bigger PVC and boat is 20 mm.

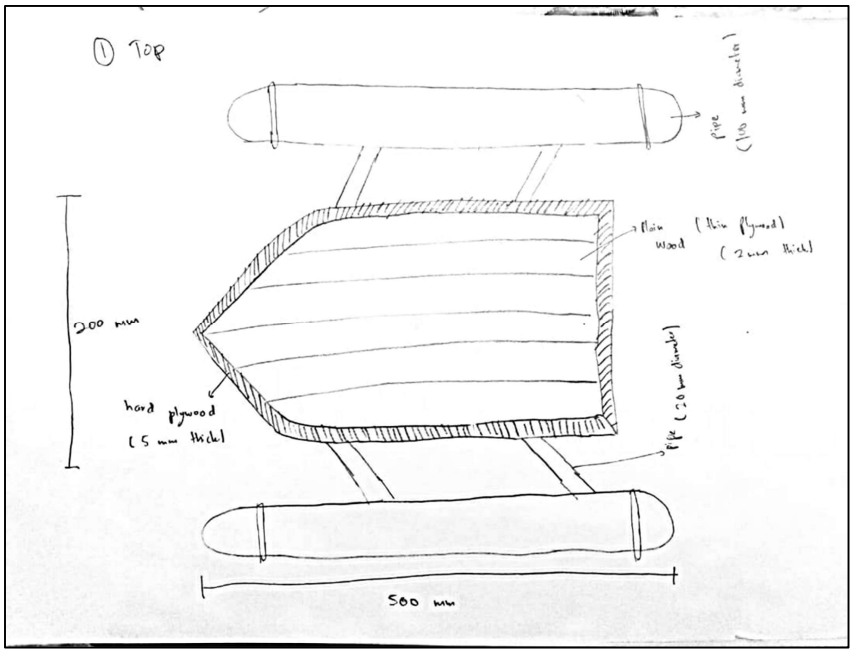


Figure 3.8: Top view measurement drawing

3.4.2 Front View Measurement

From this cross section of front view of sketch design, the boat will be divided into two sections which are upper side and lower side. The upper side will be used to put the electronics components case. The lower side of the boat will be act as floating mechanism as it will trap air inside it which also to be known as air sack. The overall height of the boat is 150 mm with 70 mm for upper side and 80 mm for lower side.

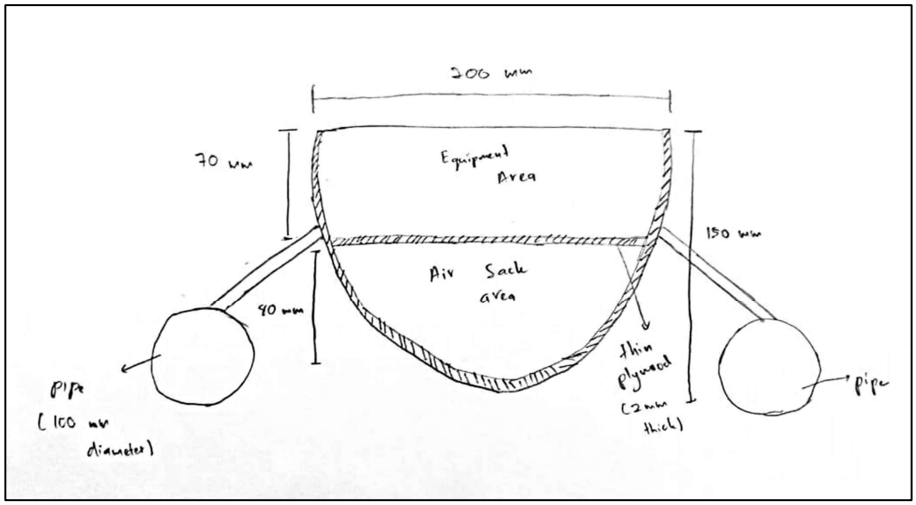


Figure 3.9: Front view cross-section of measurement drawing

3.4.3 Side View Measurement

From this cross section of the side view of the sketch design, it shows the position for sensor holder holes which at the both side of the boat. The diameter of the holes is 20 mm each. The height position of the holes from top to lower side of the boat is in the middle.

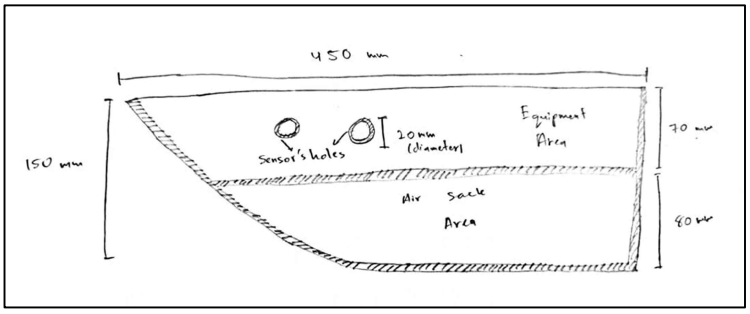


Figure 3.10: Side view measurement drawing

3.4.4 Frame View Measurement

In order to create a strong core of the boat, a structure of frame needed to be created. Hence, in this frame view measurement of sketch design has shown there are variety of spinal fish bone shape which start from the front to back side of the boat. Other than that, the width and height of the frame will increase from front to back side. For starting front side of the boat, the width and height of frame are equal which is 50 mm. Next, the middle part has 120 mm of width and 100 mm of height. Lastly, at the very end of the back side of the boat have 200 mm of width and 150 mm of height. All these frames are attached with the spinal cord of wood stick which located at the bottom side of the boat.

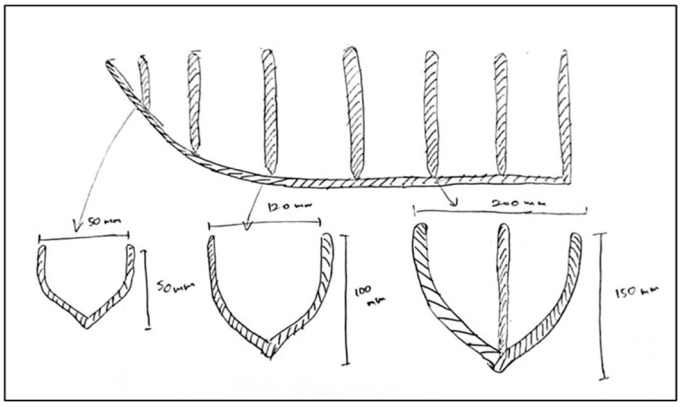


Figure 3.11: Frame view cross-section of measurement drawing

3.5 Hull Design

As for hull design, there are various of type of hull that can used in this design. But the hull design needed to be suited with the boat design in order to get ideal shape for moving in the river. For this project, the V type of hull has been chosen as the main core of the boat. This is because vee type of hull offers smooth cruise on the various type of water. If there are mixture of chemical or rough mixture in the water, the USV should overcome these obstacles with ease. Other reason is when moving on the water, it require less energy consumption for a certain speed resulting save of energy used and will make power life of USV become longer. Hence, for a better performance it must have a much deeper of V shape to cut through the water easily.

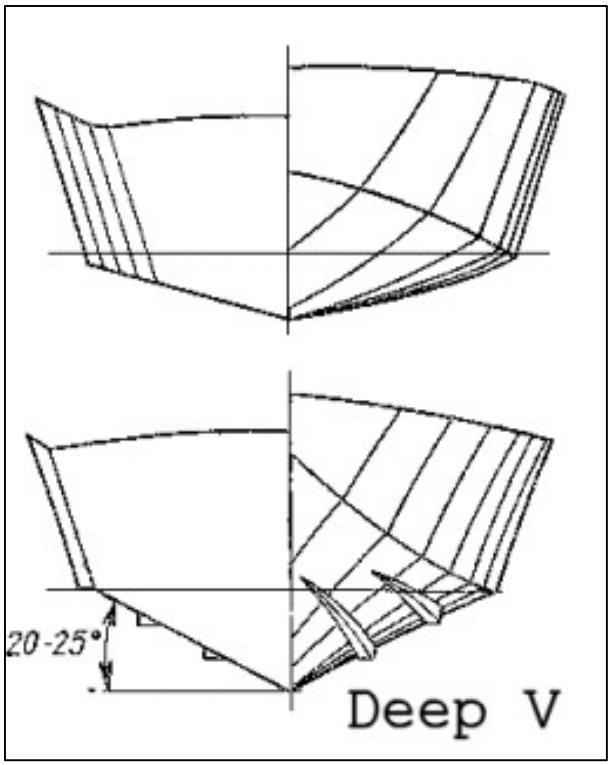


Figure 3.12: The hull design drawing that will be used

3.6 Boat Design Drawing

After further research and discussion about the design of the boat. It is hard to follow the exact shape of the boat as in sketch design. This is because, there is lack of skill and knowledge on how to build the boat which made up of plywood compared to professional worker skills. In order to continue and achieve the objectives, there are some modification that needed to be done in the boat shape design. Hence, to keep the main concept from the selected sketch design, some of the measurements and sides of the boat will be unchanged. To draw this design, Solidworks software is the most suitable software as it specializes to draw a three-dimension (3D) object.

3.6.1 Isometric View of Design

In this point of view, it shows that the whole design of the boat which at the front side of the boat has edge side shape to produce low force of contact between front side and water as it can cut through the water easily. Hence, it also contributes to low force that need to apply on the boat to move it on the water. However, it only has three core of the boat which made up of thick plywood in order to create more space for battery and motor.

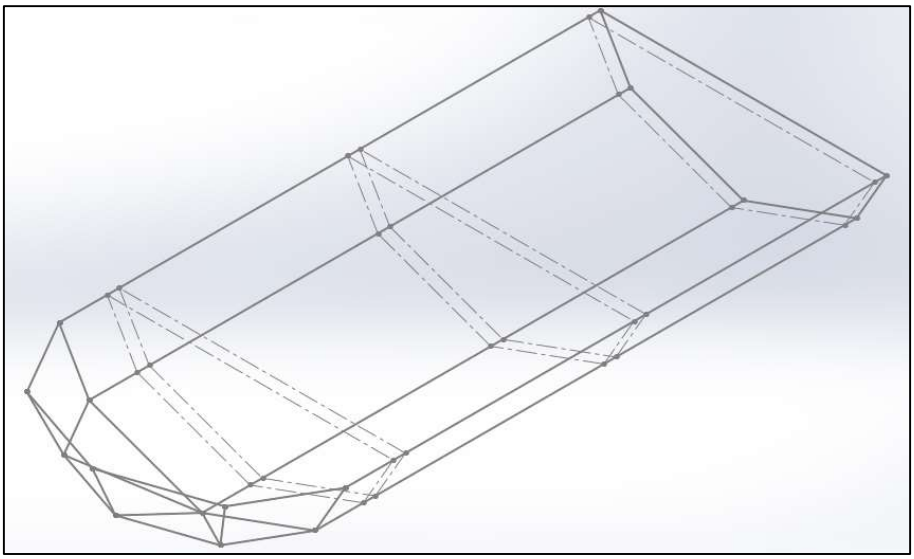


Figure 3.13: Isometric view of design drawing

3.6.2 Top View dimension of Design

From this point of view, it can be shown that the total length of boat is 541.24 mm as from the front to the back side of the boat. The overall width of the boat is 237.94 mm. At the front side of the boat, it has sides edge shape with two different length as 73.10 mm and 87 mm respectively that are attached together side by side.

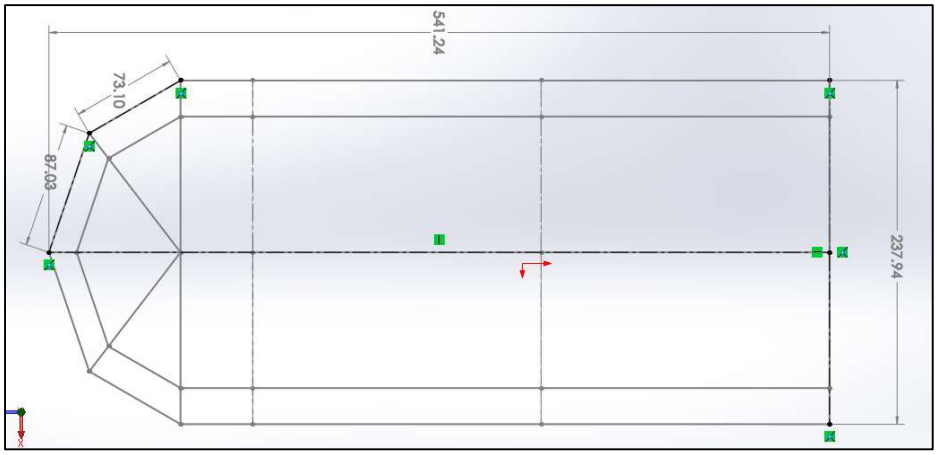


Figure 3.14: Top view dimension of design drawing

3.6.3 Side View dimension of Design

In this side view of dimension, it can be seen that total height of the boat is 77.50 mm which include from the top side to bottom side of hull. Other than that, the length of the hull is 450 mm which at the bottom side of the boat. As for the front side of the boat which is sides edge shape also have two different length which are 47.35 mm and 79.77 mm as both of them also attached together side by side.

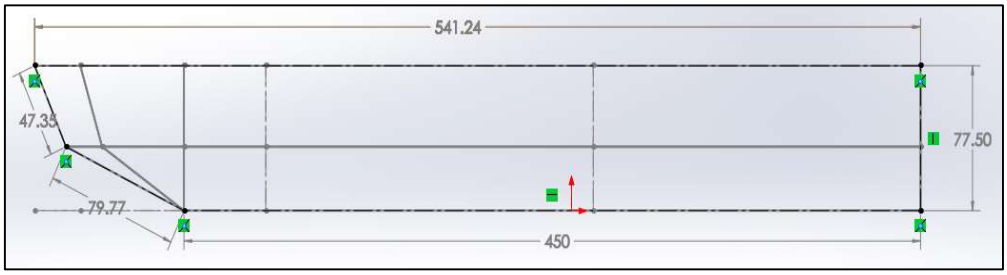


Figure 3.15: Side view dimension of design drawing

3.6.4 Front View Dimension of Design

From this view of dimension, it shows that the V shape of the hull. Hence, it has edge chin at the both side of the boat. There are two different of V shapes length as the bigger shape which the length of 50 mm and 100 mm is located between the body and the most front side of the boat. Then, another V shape is the most front side of the boat which will create an edge at the end of the front side with the length of 46.64 mm and 75.53 mm.

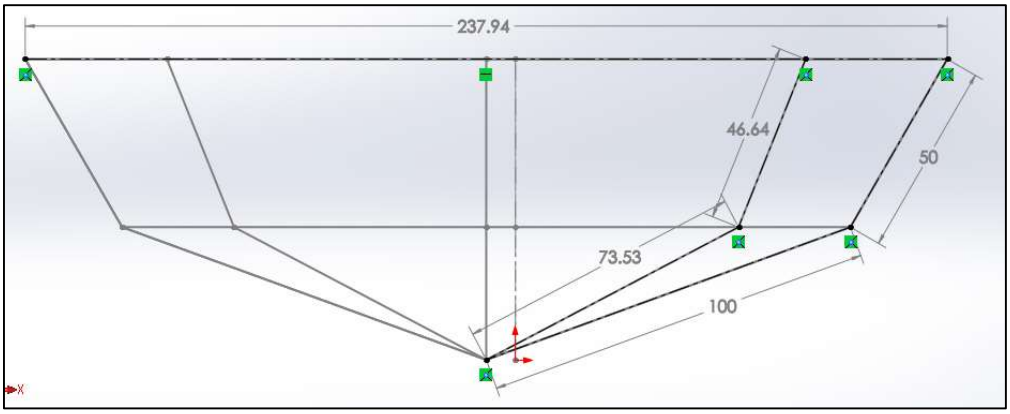


Figure 3.16: Front cross-section view of design drawing

3.7 Thruster Design Drawing

In order to move the USV on the water, a mechanical device need to be designed to move the boat forward. Basically, the thruster has three main components which are propeller, shaft and motor. Hence, all these three components are combined and attached together to become one compound.

3.7.1 Propeller Design

As the isometric view of the propeller, it can be shown that the length of radius for the blade from the center point to edge of the blade is 19.35 mm which resulting 38.7 mm of diameter. Thus, it is the ideal diameter of propeller to move the USV as it can create enough thrust force when the motor rotate. Hence, this propeller is made up of mixture of strong plastic to avoid from broken and heavy duty uses.

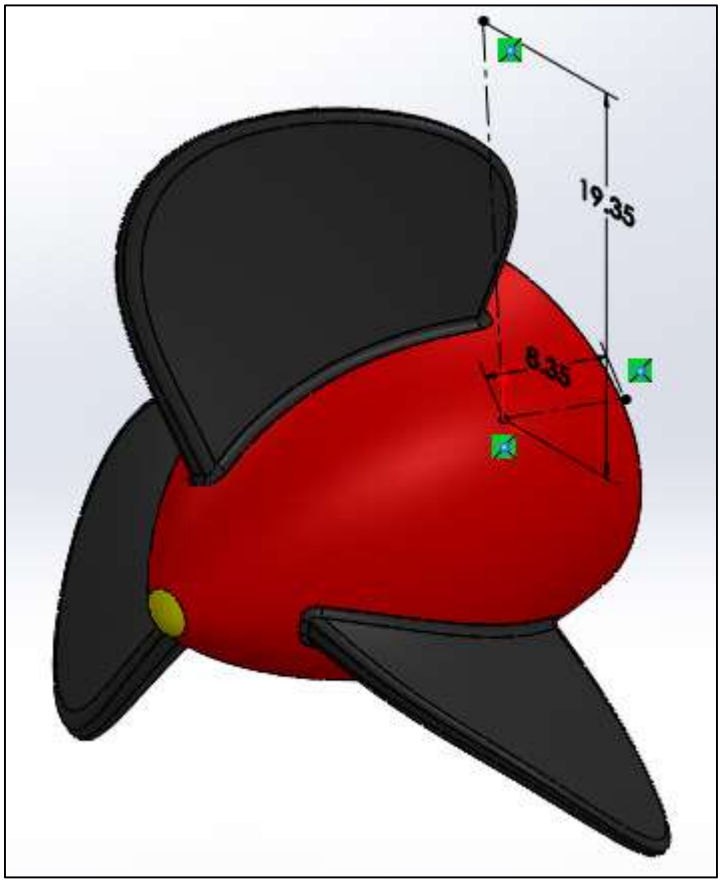


Figure 3.17: Isometric view of propeller

3.7.2 Shaft Design

With this side view of the shaft, it can be shown that the total length of the shaft which is 250 mm with diameter of 5 mm. Shaft act as the connector between motor and propeller. This part does not affect the performance of the propeller when it is in rotation condition as the energy transfer from the motor is equal to energy that will produce at the propeller. Hence, the is no power loss from motor to propeller. Other than that, this shaft is made up of steel alloy in order to prevent from rusting and also for heavy duty uses.

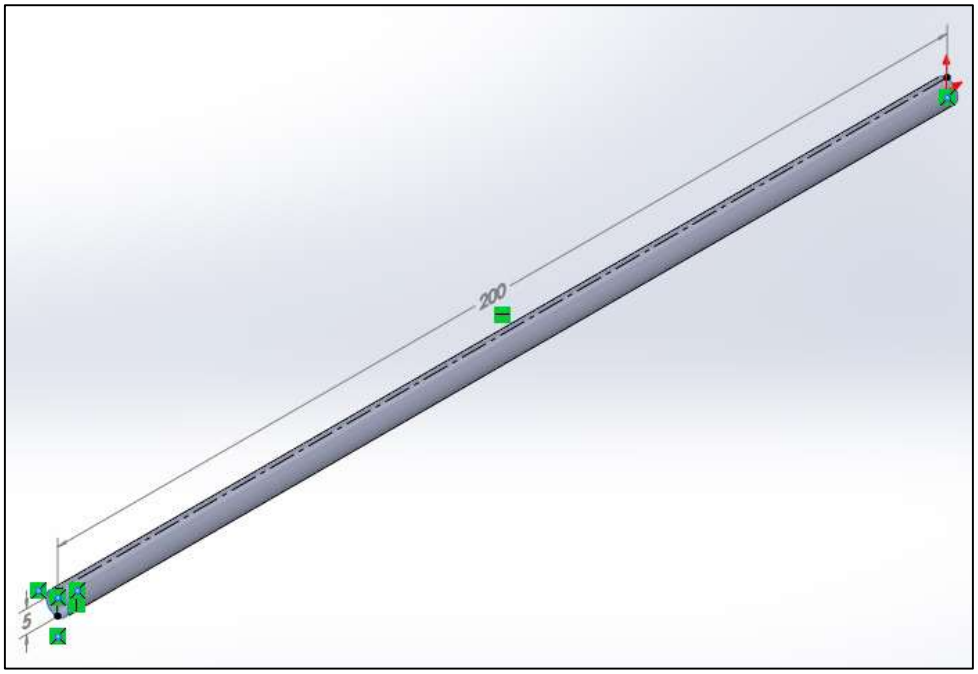


Figure 3.18: Isometric view of shaft

3.7.3 Motor Design

As for the motor, the total length is 30 mm equipped with the strong holder at the back side. This holder will hold the motor tightly when it attached to the body of the boat. This will use brushless motor as it can generate high rotation per minutes (rpm) with DC power supply which is the battery itself.

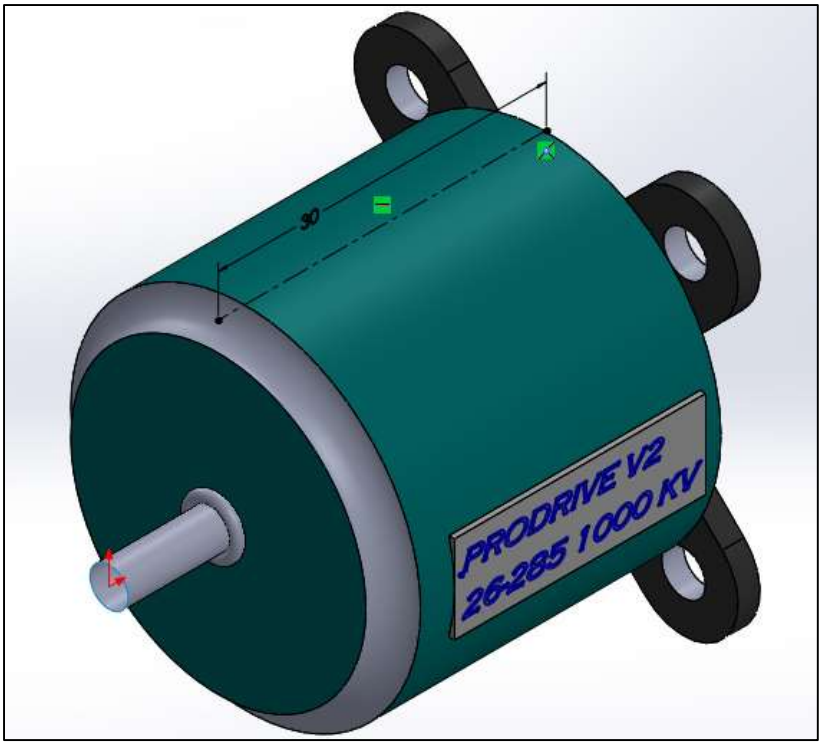


Figure 3.19: Isometric view motor

3.8 Materials and Components

3.8.1 1 mm Thickness of Plywood

This 1 mm thickness of plywood will the main material of the boat which act as protective mechanism for inner side of the boat. With light weight characteristics will be the main advantage for the boat to be floated on the water. Hence, with cheap and easy to buy also have achieve one of the objectives which are low cost USV.

Figure 3.20: 1 mm thickness type plywood

3.8.2 10 mm Thickness of Plywood

This 10 mm thickness of plywood will act as the core of the boat which to hold the thinner plywood. Hence, this plywood will be placed inside the boat and will be cut into three pieces with same angle and length of each sides. Even though has more thickness, but the weight of the plywood still light and also have less density compared to water.

Figure 3.21: 10 mm thickness type plywood

3.8.3 Fiberglass Sheet

As everybody know, even though plywood have lighter density compared to water. But it still one of the good absorbers of liquid which resulting the density of the plywood will be equal to density of water which may resulting the plywood to sink. To overcome this problem, the plywood needed to be sealed with other water proof material which is fiberglass sheet to prevent the water absorbed by the plywood.

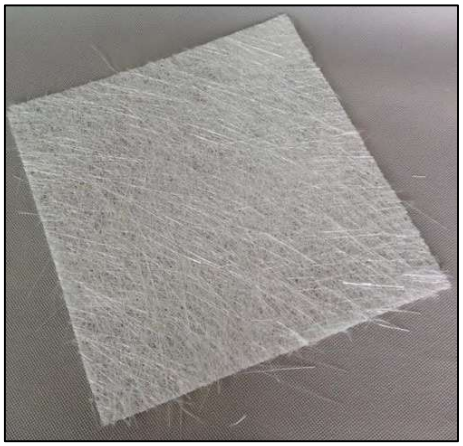


Figure 3.22: Fiberglass sheet cut

3.8.4 Fiberglass Resin and Hardener

In order to stick the fiberglass sheet, a mixture of fiberglass resin and hardener needed to be added as the adhesive material. Hence, once this mixture has dried, it will become harden like a plastic.

Figure 3.23: Resin and Hardener to make a mixture

3.8.5 1-inch Diameter of PVC

To hold the pH sensor, this 1-inch diameter of PVC is suitable to be used as the diameter of the pH sensor literally below 1 inch. Hence, it will create less space between the sensor and the wall of PVC pipe. Thus, this resulting less adhesive material to cover up the empty space

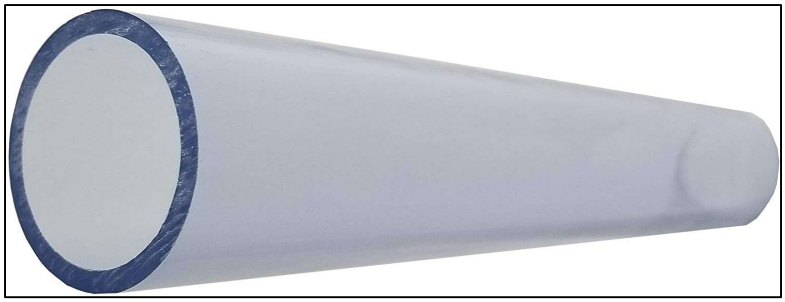


Figure 3.24: 1-inch diameter type of PVC

3.8.6 1.5-inch Diameter of PVC

With the diameter of turbidity sensor 1.4 inch, the size of the PVC pipe needed to be more than that size to hold the sensor. With 1.5 inch of diameter PVC pipe, this type will be most suitable for a sensor holder as there will create less empty space between the sensor and the wall of the pipe.

Figure 3.25: 1.5-inch diameter type of PVC

3.8.7 A2212/6T-2200KV Brushless Motor

To create enough force to rotate the propeller and move the USV forward, a brushless motor needed to be used as it has 80% of efficiency when 13 A of max current been applied. Other than that, the constant velocity of the rotation is 1000 revolution per minute per voltage. Thus, the speed of the motor will be controlled using PWM that needed to be coded in simulation software.

Figure 3.26: Brushless motor that will be used

3.8.8 Servo Motor

In order to steer the USV to left side and right side, a servo motor needed to be used as it can rotate 180-degree angle of rotation. Thus, the angle of the rotation also being set using PWM technique which needed to be coded in simulation software. Thus, it only required 5 V to be operated.

Figure 3.27: Servo motor that will be used

3.8.9 Propeller

To convert from electrical energy to kinetic energy, a propeller needed to be used in order to create a thrust force toward the water which may resulting the USV will be moved forward. With 40 mm of diameter, this size is enough to make the USV move forward with thrust force.

Figure 3.28: 40 mm diameter of propeller

3.8.10 Rod Shaft

To transfer the kinetic energy to the propeller, a high-quality shaft needed to be used for heavy duty uses. By using this shaft that made up of steel alloy, it will prevent it from rusting as it will be placed under the water surface. This rod will make zero loss of energy transfer from motor to propeller. Hence, the length of the shaft is 200 mm with diameter of 5 mm.

Figure 3.29: Variety length of shaft

3.8.11 Li-Po Battery

To supply enough power to the motor, this Li-Po battery is suitable to be used as it draw DC voltage to the motor. This type of battery can be recharged once the battery capacity is drained which can contribute to save cost objectives. With ability to produce maximum of 11 V of voltage output, it is very suitable for any brushless motor that require high output voltage to be operated.

Figure 3.30: 2200 mAh type of battery capacity

3.8.12 Aluminum Sheet

Aluminum sheet purposely used in this project is to cut into rudder shape that will be attached at the backside of the USV as steering mechanism to turn to right or left direction. With waterproof ability and light weight characteristic, it is the suitable material to be used as rudder of the boat. Another unique characteristic of aluminum sheet is it does not undergo rusting process in short time of period.

Figure 3.31: One of several type of aluminum sheet

3.9 Marking and Cutting Process

Marking and cutting process is another step to fabricate this project. With right tools and measurement, the marking process need to be done carefully and precisely in order to avoid wrong measurement on the plywood. Thus, wrong measurement could resulting increase the cost to build this project as it needed to buy another material. Other than that, it also contributes waste of time as it need to wait the material for being dispatch out by the seller. Cutting process required technical skill and good judgement on the marked material. This to avoid miss cut which also contributes to loss and increasing the cost. With proper cutting tools such as grinder machine, cutter machine, or small hand saw, the plywood can be cut into pieces.

3.9.1 Marking process of front Side of the Boat

For marking process of the front side, there are some side that Solidworks could not be measured as it required higher level of skill to retrieve the measurement. In order to solve the problem, it required mathematics knowledge to calculate the side and angle measurement.

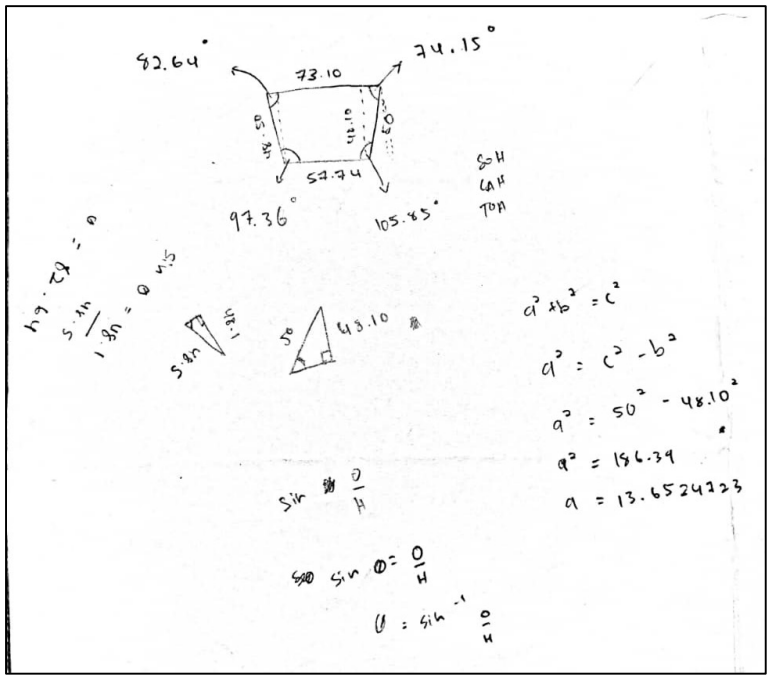


Figure 3.32: Parallelogram side calculations measurement for small size

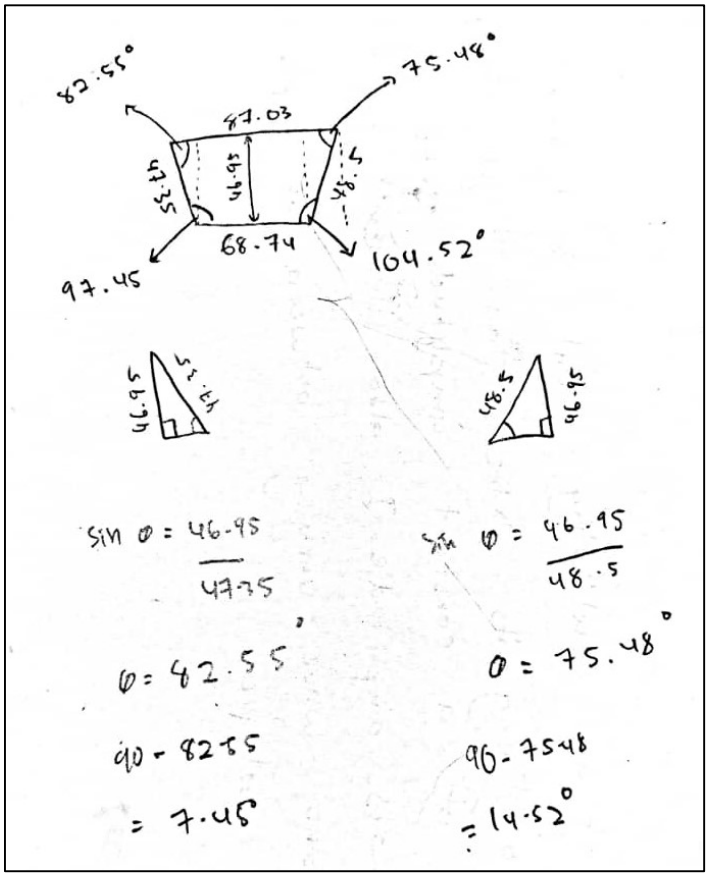


Figure 3.33: Parallelogram side calculations measurements for big size

For the parallelogram shape, to calculate every angle inside of it needed to make cutting part into right angle shape. Hence, from the right-angle shape with the sides measurement that can retrieved by Solidwork, it possible to calculate every edge of the angles by using Pythogoras theorem. There are two parallelograms with different length of side, which the angles of every edge inside it cannot be retrieved by the Solidworks software.

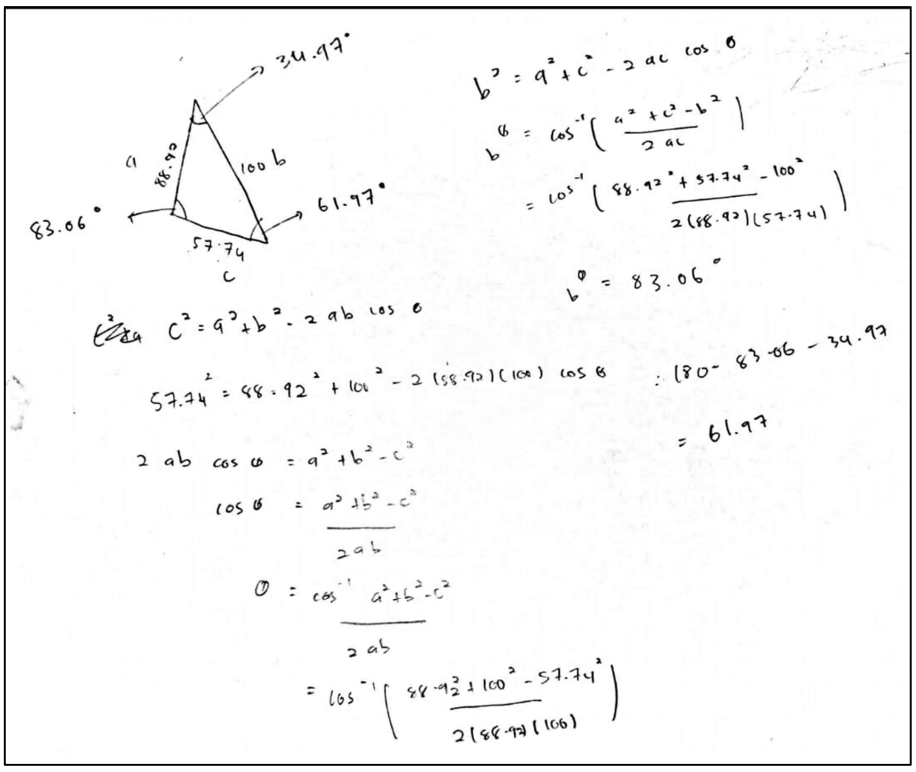


Figure 3.34: Calculations for side measurement for big inequilateral triangle

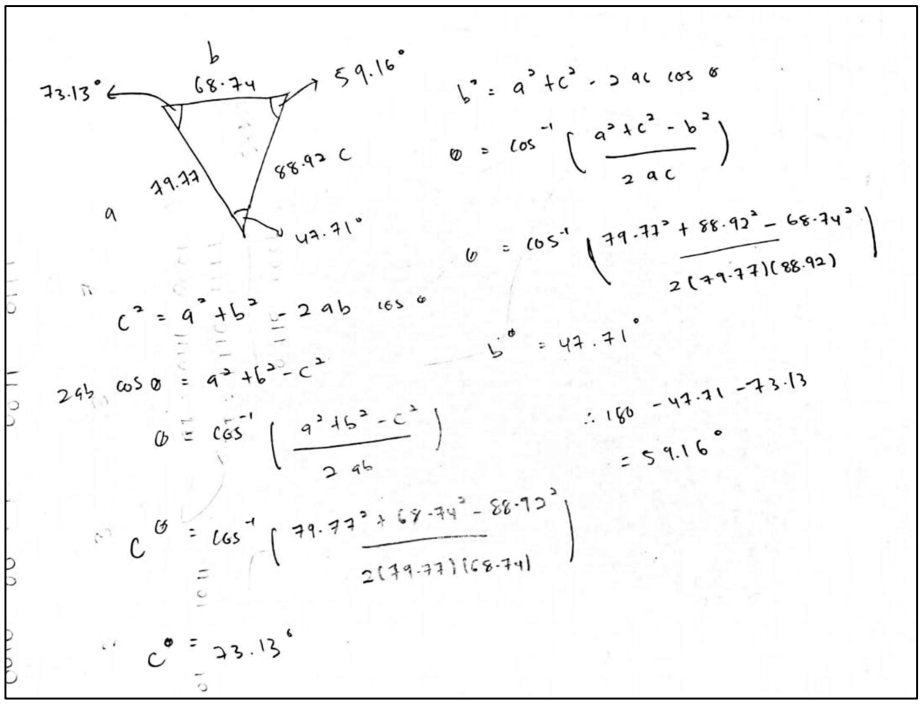


Figure 3.35: Calculations for side measurement for small inequilateral triangle

For these two Figures, there are two inequilateral triangle which all the sides and angles is not same. Hence, only sides of the triangle that can be measured using Solidworks software. Since it cannot determine the all the angles inside inequilateral triangle, it required specific mathematical equation to solve the problems. Thus, all these four shapes are the front side section of the boat. Besides that, all these side dimensions will be marked on the plywood by using L shape ruler, measuring tape, and protractor in order to determine the angle for each shape.

3.9.2 Cutting Process of Main Body of the Boat

As been shown earlier, the main body basically is rectangular shape and will be cut by using cutter machine. The marked plywood will be cut into four main pieces with two different dimensions. For the hull dimension which the lower side of the boat, the plywood will be cut into 100 mm width and 450 mm length. As for another upper side of the boat, the plywood will be cut into 50 mm width and the length is same with lower side which is 450 mm. Thus, this process required good judgment technique to avoid smaller cutting dimension of the main body. Hence, in this main body cutting process also included the cutting of three identical measurement of core of the boat.

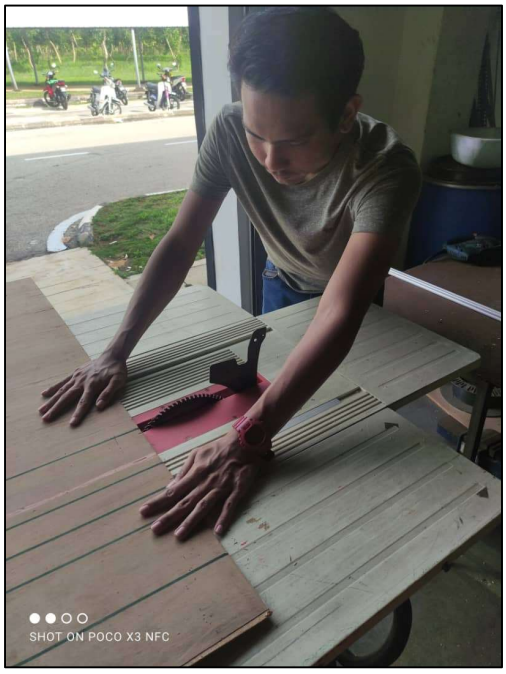


Figure 3.36: Cutting process for main body

3.9.3 Cutting Process of Front Side of the Boat

As for the final cutting process on the plywood, cutting the plywood with respected angle need to be done carefully to avoid misplace on the cutter. This is because there are two main shape with four different side dimensions needed to be cut. The plywood that have been marked using protractor and L shape ruler will be cut into eight pieces as for the front side section of the boat. Thus, this process also required good cutting technique to determine the gap between the cutter and the marked line to avoid small cutting shape which resulting inaccurate angle and side. Once the plywood not cut with required dimension, to assemble the boat will be hard and the shape is not same with drawing of the design.

Figure 3.37: Cutting process for front side of boat

3.10 Assemble and Fabricate Process

For the last step, in order to make the boat similar as design, assemble process needed to be done to attached all the pieces into one body. Hence, it required the right tools and materials to attached the plywood together. It also needs adhesive material to enclose the small gap between the pieces. As for fabricate process, the body will be sealed with resin in order to make the boat waterproof.

3.10.1 Assemble Process of Main Body of the Boat

Before all the pieces of plywood attached with the core boat, the pieces need to be arranged first to form the main body as expected in the design drawing. This is required to avoid wrong position pieces on the core. Thus, on the Figure 3.37 above the hull of the boat has been formed which is V type of hull.

Figure 3.38: Assemble arrangement for boat hull

After finalized the position, the pieces of plywood have been attached using 4 mm diameter of screw. Thus, the reason using screws instead of nails is to avoid the 1 mm thickness of plywood to break as knocking the nail will put a lot of pressure on the surface of the plywood by using hammer. Another thing using screw is, the screw will produce more gripper compared to nails as it has natural characteristic of helical surface of the thread.

Figure 3.39: Assemble process for main body

3.10.2 Assemble Process of Front Side of the Boat

Since the front side section does not required core stick which it acts as the frame to hold the small pieces of plywood. So, in order to create the front side, all the pieces are being attached together by using cellophane tape as the holder which located on the outer side. But the cellophane tape is only for temporary usage as it will break when immerge into water. An adhesive material which is wood glue being used to sealed the space between the plywood pieces and also will hold the pieces permanently. Thus, the cellophane tape will be removed once the glue is dried.

Figure 3.40: Assemble process for front side of boat

3.10.3 Fabricated Process of Whole of the Boat

After all assembly process have been done, the fabricated process is need to be done as the final step to make the entire boat. In this fabricated process, the cover of the top side of the boat will be placed accordingly before it will be sealed permanently. Hence, the cover of the main body will be attached using screw while the cover for front side of the boat will be attached using fiberglass and resin as does not have frame core.

Figure 3.41: Fully assembled of body before fabrication process

In order to make the plywood waterproof, fiberglass and mixture of resin needed to be used as the adhesive material. It also can cover up the empty gap between pieces of plywood. Once the resin has been dried, it will form a strong hard cover for the outer side of the boat. To make a smooth surface of the fiberglass, the surface needed to be rub using grinder machine. Hence, this sealed process also include for the top side of the boat.

Figure 3.42: Fabrication process of the boat using resin and fiberglass

3.11 Chapter Summary

As to summarize this chapter, there are lot of process that need to be done in order to achieve the main objectives of this project. Other than that, sketching and drawing need to be applied to generate the idea to design the USV boat. Researching on suitable components also aided to produce a low cost USV. Besides, technical skill and mathematical knowledge also one of the main components to determine the actual length of the design. For assemble and fabricate process, it required good mechanical skill to avoid wrong assembling part.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, it will explain about the results that have been obtained based on the methodology that have been used. Hence, it will show on the USV that will be floated or not with further analysis. Other than that, finding the discussion about results that have been obtained.

4.2 Results

As for the results, based on the main objectives that have been set earlier, it will include the overall cost on the making of the USV boat. Other than that, the project also been tested the movement in river condition where similar condition of water being used. Besides that, for the most crucial part is whether the USV can be float or not and is it a waterproof or not. Hence, the finished product of the project ad figure below. The overall size of the boat has been increased from initial measurement during marking process. This is because, the sealed materials which are fiberglass and resin have contributed to this increasing of size.

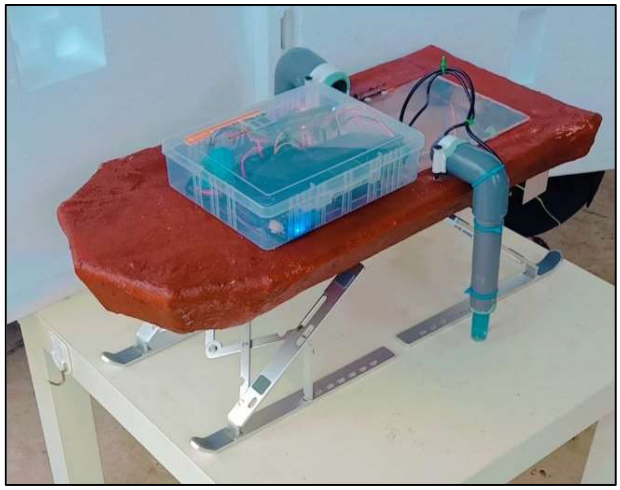


Figure 4.1: The final product of the USV

4.2.1 Overall cost of Boat

After all the materials have been bought, the overall cost can be calculated. From the calculation, the total cost just to build the USV boat is around RM 200. Hence, all the prices of the materials depend on the type of seller that have been approached. Other than that, the sealed materials are one of the high prices among them which can changed to other material.

4.2.2 Boat Capability

To observe whether the boat is waterproof or not, it has been put into the water as figure above. Hence, there is no leak on the boat and there is no water that can enter into the USV. This has achieved one the objectives which the boat has been proof to be waterproof. Other than that, the USV also floated in the water as the lower side which the hull has been submerged in the water.

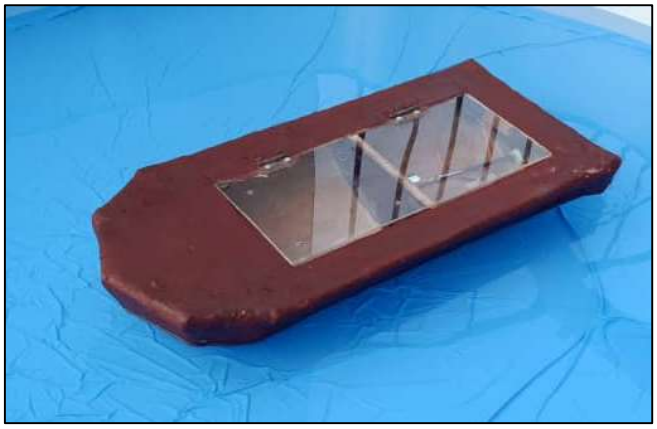


Figure 4.2: USV boat tested on the water

4.2.3 Movement of the Boat

As to move the boat forward, the thruster have successfully generated enough repulsive force in the water that could move the USV boat forward. Apart from that, the movement direction to steer the boat to the left or to the right side will be changed by the rudder. As the dimension of the rudder enough to steer the water flow current with the width of 40 mm and the length of 100 mm.

Figure 4.3: USV boat movement testing

4.3 Analysis

From the result that have been obtained, there are some parts that can be analyzed which are the density between water and the whole USV boat. Other than that, the durability of the boat to move in river condition based on power supply. Plus, the revolution of the motor produce by using PWM method. It also be applied on the servo motor to rotate the rudder in respected angle.

4.3.1 Density Comparison

Based on the observation, the boat is successfully float on the water. This mean there is different of density that can be analyze and calculated. Hence, during the boat was placed in the water, the height of the submerged part has been measured. The height of submerged part is about 40 mm from the bottom side of the hull. If the different density has been obtained, then the buoyant force that applied on the boat also can be calculated. The density of the boat can be obtained by plywood datasheet.

Table 1: Density value for different type of plywood

Type of Plywood	Density
Birch Plywood	680 kg/m3
Mixed Plywood	620 kg/m3
Conifer Plywood	density 460-520 /m3

Based on the datasheet, the density of the mixed plywood is 620 kg/m^3 while the density of the water is 997 kg/m^3. This mean, the boat which mainly made up of plywood has lower density compared to density of water. With small different of value between these two densities, this have proved that there some part of the boat especially at the hull of the boat will be submerged in the water. Hence, this will create a buoyance force in order for the boat to keep floating on the water.

In order to calculate the buoyance force, it uses Archimedes principle where the total buoyance force equal to volume of submerged object times by its density and gravitational force. The equation based on Archimedes principle to calculate the buoyance force as follow:

$$F_b = V_s \times D \times g$$

where:

F_b = Buoyancy Force

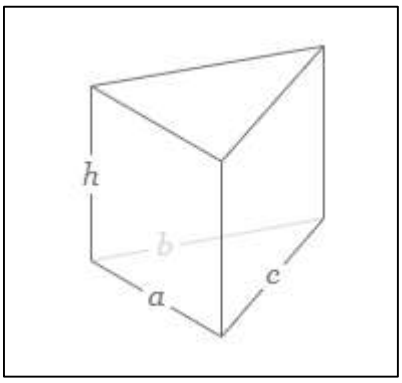
V_s = Volume of submerged object

D = Density of fluid

g = Gravitational Force

In order to obtain the submerged object, since the submerged object is in triangular prism shape, then it required another equation to get the volume of the submerged hull of the boat. Hence, the equation to calculate the submerged volume as follow:

$$V = \frac{1}{4} h \sqrt{-a^4 + 2(ab)^2 + 2(ac)^2 - b^4 + 2(bc)^2 - c^4}$$



where:

V = Volume of prism

h = Height of prism

a = Base side

b = Base side

c = Base side

Hence, the volume of the submerged part has been calculated as below:

h = 450 mm

a = 188 mm

b = 100 mm

c = 100 mm

Where will get the total value of the prism as follow:

$V = 1.44 \times 10^{6}\ mm^3$

Hence, $V = 1.44 \times 10^{-3}\ m^3$

Hence based on the Archimedes principle formula, it can be calculated the buoyance force that has been applied on the boat where the value as follow:

$$Fb = 1.44\times10^{-3}\ m^3 \times 997\ kg/m^3 \times 9.807\ m/s^2$$

$$Fb = 14.08\ N$$

Based on the calculation, the total buoyancy force that applied on the boat is 14.08 N. Thus, based on Archimedes theory, buoyance force is equal to the weight of the liquid that have been displaced.

4.3.2 Power Consumption

To determine whether the USV can be moved and operated for long time of period, an analysis for the power consumption needed to be made. This data is required to compare with other type of USV which may use different type of battery capacity and output voltage. As for this project, the power supply used is Li-Po rechargeable battery with 2200 mAh of power capacity. Thus, the power consumption for each of the components in the USV as table below:

Table 2: Calculation of power consumption

Component	Current (A)	Voltage (V)	Quantity	Power Consumption (W)
Arduino Mega	800 mA	5 V	1	4 W
Brushless Motor	13 A	11.5 V	1	150 W
Servo Motor	800 mA	5 V	1	4 W
Sensors	40 mA	5 V	3	0.6 W
ESP32-CAM	800 mA	5 V	1	4 W
TOTAL				162.6 W

$$P = Battery\ Volatge * Battery\ Capacity$$

$$P = 11.1\ V * 2200\ mAH = 24\ 420\ Wh$$

$$Time = Battery\ Power\ Capacity\ /\ Power\ Consumption$$

$$Time\ (hour) = 24\ 420\ WH\ /\ 162.6\ W = 150.18\ hour$$

Based on the calculation, it shows that the period of the USV can be operated which it based on the power supply. Thus, this calculation only estimation with constant speed velocity of the brushless motor.

4.3.3 Speed of Brushless Motor

As for the speed rotation of the brushless motor, it can be adjusted using PWM code with respected value. Thus, PWM use concept of binary digital which are 'high' and 'low' pulse. In other words, the percentage of digital 'high' and 'low' will affected the pulse-width during PWM period. If the percentage of 'high' digital is more, then the speed of the brushless motor will increase. Hence, in this project it used 45% of duty cycle. The pulse-width period can be shown in Figure 4.4:

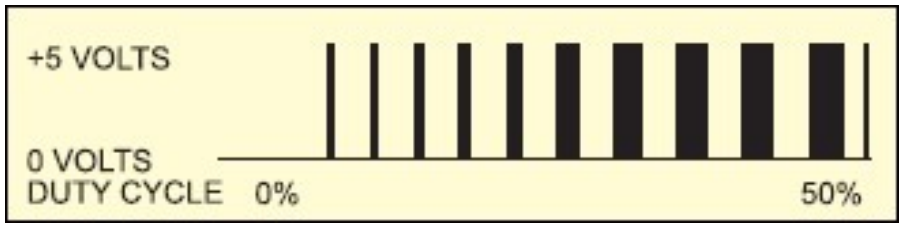


Figure 4.4: Pulse-width duty cycle period

4.3.4 Angle Rotation of Servo Motor

In order to steer the USV boat to the left or right by controlling the angle of the rudder, it used a servo motor. This servo also being controlled by sending an electrical Pulse Width Modulation (PWM). It also uses same concept of brushless motor to rotate 'high' and 'low' pulse. Thus, it can turn 90 degree of angle in either direction which resulting total of 180 degree of movement. To determine the position of the shaft is based on the duration of the pulse sent. In other words, the longer the pulse period, the more angle of the shaft can be turned.

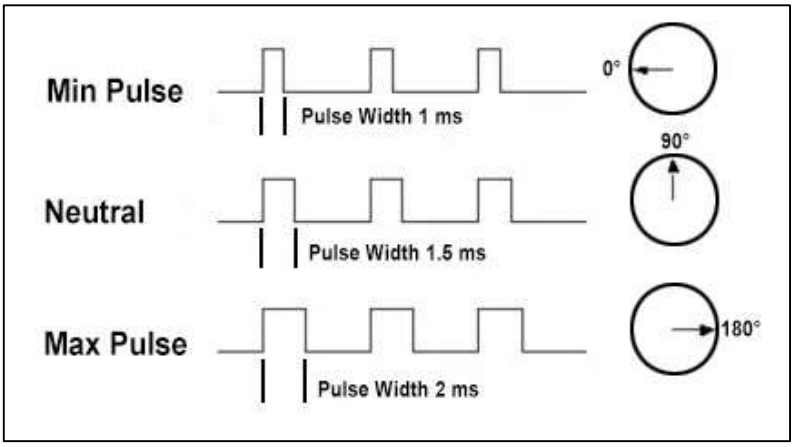


Figure 4.5: Pulse-width modulation for servo motor

4.4 Discussion

Based on the results and analysis that have been obtained and gathered, there are some parts that can be discussed. First point that can be discussed is the changed of drawing design from the selected sketch. This happen because of the type of plywood that is used in this project which it cannot to bend produce edge corn shape at the front side of the boat. Due to achieve the main objectives which to produce a low-cost product, this resulting used of regular quality of plywood which can break when bending process. Thus, marine plywood is best type of plywood with high durability and waterproof. Hence, using marine plywood gradually increasing the total cost as it is the main component to build the boat.

Next, other point that can be discussed is the comparison density between the boat and the water. Different type of water generally has almost same properties in terms of density, mass, pressure and other characteristics. Thus, the density of the normal water compared to river or any other lake have almost same density which is 997 kg/m^3. In other words, the density of the water can be change due to mixture of other chemical substances that dissolve in the water. The density of the water also affected with changed of temperature where higher temperature will produce lower density of the water. Sea water has more density than fresh water due to high quantity of salt which also affecting the mass of the sea water which is heavier that fresh water.

4.5 Chapter Summary

This chapter was focused on the results that we have obtained in more detail. The overall cost of the boat also being stated in this chapter. The analysis section contains the calculation that have been done to calculate the density and buoyance force that applied on the USV boat. Other than that, the calculation for power consumption for each component need to operate have been explain in detail. It also explains the concept of the rotation for both brushless and servo motor. Other than that, it also discussed about the project progression during completing this project that also being explain with enough information.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In this chapter, it will explain about the conclusion of the project which based on the objectives. Hence, it is concluded whether the objectives have been achieved using project's methodology and research. Other than that, for recommendation part it will explain about customized methodology in order to improve the current project to be more advanced in terms of technology used.

5.2 Conclusion

Based on the whole project that have been carried out, it can be concluded that the objectives of this project have been achieved. As for the total cost for all the materials that have been used, it still manages to cut the cost based on the main material which are regular plywood and still can fabricate the USV boat like other commercial product in the market. Compared to other researched on USV, the overall cost of them is quite high as they use of high-quality material such as aluminum sheet, acrylic sheet, or even marine plywood which already waterproof without any seal material. Thus, total cost for an USV also changed based on the size of the USV which the bigger the size of the boat, the more the cost required. Other factors that may influence the cost of the USV is what are the main purpose or sensors that have been used.

Next, the development of the USV which can be moved and float on the water according to river condition also have been achieved. Based on the results that have been shown, the USV is capable to move forward while steering to the left or right side controlled by the controller from the ground by transmitting the signal to electronics board. The main mechanism for moving forward of the boat is thruster part with brushless motor enough to generate a stable repulsion force in the water. Other than that, servo motor and rudder also the main reason for the USV to steer to the left or right side. Hence, the USV have been tested on the normal water which its characteristics and the environment is nearly similar with river condition.

Lastly, as for the USV is waterproof and can overcome the Malaysian whether environment have been achieved. With aided of fiberglass and resin, it has sealed the empty space between the plywood pieces and also cover up the outer side of the boat. This sealed also act as protective mechanism and can overcome extreme environment as it is hard and strong characteristics. Plus, the fiberglass also prevents the plywood from exposed to water as it is one of good water resistor materials.

5.3 Recommendations

For future development of this project that maybe can be add or customize of the current project. First, the size of the project can be customized into more compact and smaller as it can move into narrow space in the streams. Other than that, customized the hull to become more stable when the environment is changed gradually due to whether or any other factor that possibly can flip the boat upside down. Next, by adding GPS system into the USV in order to track back the boat when sudden loss of connection or battery have been drained. Last but not least, the main material could be customized by replacing it with other strong lightweight material such as polycarbonate plastic with very high durability as it also can be used in military sector.

5.4 Chapter Summary

To summarize of this chapter, it has been concluded that all the objectives of this project has been successfully achieved with the right method and materials. Other than that, good technical and lot of research contribute to this successful factor. Besides that, on the recommendation section, there are some ideas or improvement that can be carried on the future development of design of USV.

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APPENDICES

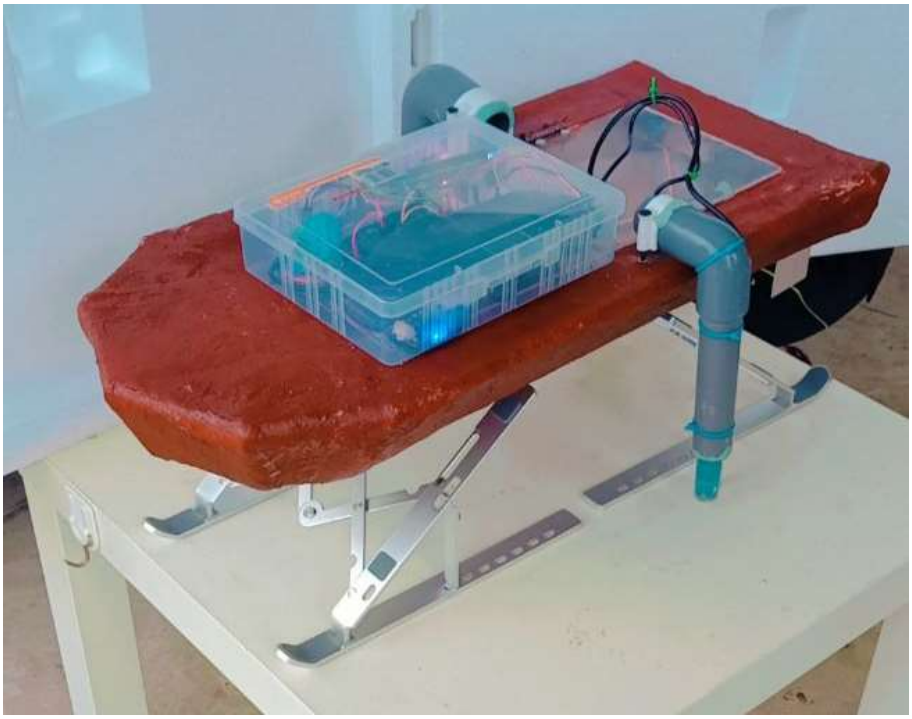
Appendix A: Gantt Chart

TASK/WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Logbook Progress														
Meet Supervisor														
Make Research on Project														
SDP 2 Project Report Progression														
Sketch Product Design														
Drawing Product Design														
Make Research on Related Components														
Order and Buying Components														
Marking and Cutting Process														
Assemble and Fabricate of Project														
Testing of Project														
Troubleshoot Process														
Submission of SDP 2 Technical Project														
Presentation of SDP 2														
Submission of SDP 2 Logbook														
Submission of SDP 2 Report														

Appendix B: Overall Costing

No.	Materials	Quantity	Price
1	LiPo Rechargeable Battery 11.1V 2200mAh 30C	1	RM 49.90
2	Servo motor (SG90 Micro Servo)	1	RM 4.90
3	Fibreglass Resin 1kg + Hardener 25ml	2	RM 39.00
4	Fiberglass Sheet	1	RM 30.66
5	RC Brushless Motor A2212/6T-2200KV- DXW	1	RM 18.00
6	1.5-Inch Diameter of PVC Pipe	1	RM 5.00
7	1.0-Inch Diameter of PVC Pipe	1	RM 2.50
8	1 mm Thickness of Plywood	1	RM15.00
9	10 mm Thickness of Plywood	1	RM 20.00
10	Aluminum Sheet	1	RM 17.00
	Total Cost		RM 201.96

Appendix C: Final Product Project



Appendix D: Project Poster

Universiti Malaysia PAHANG

G17

DEVELOPMENT OF AN AUTOMATED WATER SAMPLER ONBOARD A USV

FTKEE

Supervisor: DR. ZAINAH MD ZAIN

Students: 1. TANESH A/L MARAN TB17003

2. CHE KU MUHAMMAD DANIEL AIMAN BIN CHE KU MAZLAN TB17019

3. ABDUL QAIYUM BIN HAJI RAMLI TB17041

PRODUCT BACKGROUND

Water as one of our main sources of living

- All living things requires water to grow and produce.

Worldwide water pollution crisis.

- In 2019, Kim Kim river was polluted due to chemical substances.
- No water quality monitoring until some citizens were effected by the pollution.

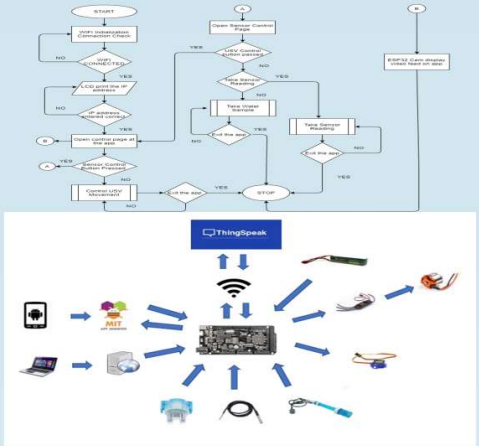
OBJECTIVE

- To design and develop an USV that low in cost and attached with onboard water quality monitoring system.
- To develop a water quality monitoring system that can send data real time from the sensors on the USV to the platform.
- To develop remote control system via mobile application to control the USV and display the data from the sensor in real time.

BENEFIT

- Low cost Water quality monitoring.
- Monitor water quality and control USV through Internet.
- Portable & easy to use.

METHODOLOGY/MATERIALS



PRODUCT CHARACTERISTICS

RESULT AND DISCUSSION

ACKNOWLEGMENT

- We would like to express our sincere gratitude to Dr. Zainah Md Zain, our supervisor, for her invaluable idea and support with the project. We also want to express special thanks to Mr Razman for his help with this project. Thanks to the faculty (FTKEE) for providing facilities for us to complete the 2020/2021 Senior Design Project.

MARKETIBILITY

- Agriculture
- Marine Technology
- Assist in water polluted system

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