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DESIGN AND DEVELOPMENT OF SURFACE UNMANNED VEHICLE (SUV) SYSTEM MECHANISM AND VESSEL

JOANNES NIEGEL ANAK MEKIUN

Thesis submitted in fulfillment of the requirements
for the award of the degree of
BACHELOR OF ENGINEERING TECHNOLOGY (ELECTRICAL) WITH HONS

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ABSTRAK

Kenderaan tanpa pemandu permukaan (SUV) ialah kenderaan yang dikendalikan tanpa anak kapal. Beroperasi dalam pelbagai cara seperti dari jauh dengan menggunakan alat kawalan jauh atau secara autonomi dengan menggunakan navigasi autonomi. Pemantauwan menggunakan kenderaan berpemandu mungkin memerlukan kos yang tinggi terutamanya dari segi keperluan penumpang atau anak kapal dan terhad untuk tugas berisiko yang mungkin berpotensi membahayakan penumpang atau anak kapal seperti kawasan berbahaya atau terkurung. Kenderaan tanpa pemandu kendalian jauh mampu menjalankan tugas dengan lebih ekonomi dan cekap dengan ciri tanpa pemandu. SUV ialah cara alternatif untuk kenderaan permukaan seperti bot dan kapal yang dikendalikan dari jauh dan dengan beberapa konfigurasi autonomi. Walau bagaimanapun, majoriti SUV komersil sekarang wujud dengan harga yang tinggi sama ada kerana jenama atau saiz pasaran yang masih belum mencapai tahap produk penting. Oleh itu, projek ini telah mengambil inisiatif untuk membangunkan kos optimum bot SUV dengan reka bentuk ringkas menggunakan konsep katamaran. Dua badan kapal direka daripada bahagian plastik Polivinil Klorida (PVC) dan badan dibuat daripada polistirena. Selain itu, projek ini direka dengan alat kawalan jauh tanpa wayar dengan transmisi frekuensi radio (RF), mempunyai tontonan secara langsung pada kenderaan air permukaan dan unit Sistem Penentududukan Global (GPS) untuk mengkonfigurasi lokasi koordinat SUV dengan Sistem Global untuk Komunikasi Mudah Alih Teknologi /General Packet Radio Service (GSM/GPRS) untuk memuat naik maklumat data dalam aplikasi perisian antara muka pengguna grafik (GUI). Unit pengawal untuk mengemudi SUV dibangunkan secara jarak jauh dan sistem ini meliputi pemanduan kemudi kenderaan untuk mengubah pergerakannya. Jangkaan hasil projek ini adalah untuk membangunkan prototaip mini SUV dengan kawalan tanpa wayar dan pemantauan untuk kawasan air yang tenang dan ombak kecil.

ABSTRACT

A Surface unmanned vehicle (SUV) is a vehicle that is operated without any crew on board. Operate in various ways such as remotely by using a remote control or autonomously by using autonomous navigation. Surveying using manned vehicle may cost a lot especially in terms of requirement of passenger or crew and limited for risky task that may have potential to jeopardize the passenger or crew such hazardous or confined area. A remote-operated unmanned vehicle is able to carry out the task more economically and efficiently with unmanned features. The SUV is an alternative feature for a surface vehicle such as a boat and ship in which remotely operated and some with autonomous configuration. However, the current existed commercial SUV majority with the high prices either because of the brand or the size of market that still not reach the essential product level. Therefore, this project has taken initiative to develop an optimal cost of SUV boat with a simple design using the catamaran concept. Two hulls are created from Polyvinyl Chloride (PVC) Plastic parts and the body made by polystyrene. Also, this project is designed with a wireless remote control with radio frequency (RF) transmission, has real-time viewing on surface water vehicle and Global Positioning System (GPS) unit to configure the coordinate location of the SUV with Global System for Mobile Communication/General Packet Radio Service (GSM/GPRS) technology to upload the data information in customized graphical user interface (GUI) software. The controller unit for the propulsion of the SUV is developed remotely operated and this system is also covered on driving the rudder of the vehicle for pitching its motion. The expected outcome of the project is to develop a mini-SUV prototype with long-haul wireless control and monitoring for the calm and low tidal water area.

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LIST OF SYMBOLS

r	Radius
ℓ	Length
mm	Millimetre
cm	Centimetre
m	Meters
km	Kilometre
kg	Kilograms
km/h	Kilometre per hour
RM	Ringgit Malaysia

LIST OF ABBREVIATIONS

RC	Remote Control
RF	Radio Frequency
DC	Direct Current
3D	Three Dimension
ASUV	Autonomous Surface Utility Vehicle
SUV	Surface Unmanned Vehicle
USV	Unmanned Surface Vehicle
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GUI	Graphic User Interface
ESC	Electronic Speed Control
PVC	Polyvinyl Chloride

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Project Background

Due to technological progress of computing power has paved the way for the development of Surface Unmanned Vehicle (SUV). SUV have the potential to reduce risk for manned forces, provide necessary tasks to accomplish, and perform tasks that cannot be done by manned vehicles. Moreover, SUV is an unmanned vehicle that can be controlled remotely by using the technology of a control system and navigation system. Figure 1.1 shows the world leading unmanned surface vehicle made up by Oceanalpha, China. [1]

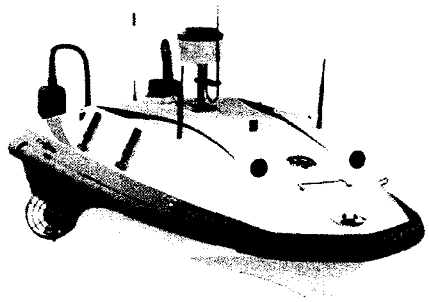


Figure 1.1 Example of Unmanned Surface Vehicle by Oceanalpha, China [1]

As SUV can operate partially autonomous control or operate fully autonomously, this project has taken initiative to involve on design and develop a Surface Unmanned Vehicle technology to provide shock loading that exceeds human limits, a highly capable vehicle to do water monitoring and surveyor. The project will be focusing on low cost and simple design Surface Unmanned Vehicle boat. The movement of the SUV should be able to move in any direction at the lake. Therefore, the project has taken part on moving and control the SUV which emphasized on wireless control via RF remote control.

1.2 Problem Statement

The SUV that has been create and sold by other developer are high cost because of complicated design and sophisticated software system. In this project, the aim of the prototype is to create a low-cost and simple design for surface water vessel of the boat. The main requirement of the prototype is that it need to establishing a wireless remote control with the combination of real-time monitoring on the surface water vehicle. Thus, a creation of a stable power management for mobile use on the surface water vehicle also need to be consider. The parts of the prototype divided equally to 3 main sectors. The mechanical design sector in this project need to consider the material and placement of the component. While the communication and control sector will be facing the wireless operation and control of each component in the surface water vehicle. Finally, the software sector needs to consider on the real-time monitoring system and also the development of the condition when the prototype is operating on water surface or more likely on lake condition.

1.3 Objective

The aim of this project is to develop and design Unmanned Surface Vehicle boat that able to monitor surrounding and surveyor. The main issue of project is to focus on several solution as follow:

i. To design SUV with catamaran mechanism.

ii. To develop SUV vessel with a lightweight material with payload 2.5kg

1.4 Research Scope

The scope of the project is focusing on designing a Surface Unmanned Vehicle boat which the design configuration is using catamaran approach. The catamaran is chosen because of the advantages of stability, easy to assembled and robust. On the two-parallel vessel hull, the boat can determine how much payload the boat can carry and the buoyancy. This design is expected to carry twice of the middle hull size capacity and will have a large amount of buoyant force where the vessel hull will be design two times large.

1.5 Thesis Organisation

The proposal highlights the discussion and progress of development and design Surface Unmanned Vehicle for water monitoring and surveyor of University Malaysia Pahang lake.

Chapter 2: This chapter will be discussing on literature review. The literature review will be emphasized on the project previous research presented by other people in same are with relevant issue to SUV boat. There are about design and technology in SUV. Lastly, there is a summary of the literature review regarding to this project.

Chapter 3: This chapter will be highlighted on concept design of structure and framework of SUV mechanism system. The sketching of design version and the completed vessel design will also be explained in this chapter.

Chapter 4: This chapter will be focusing on the result for the development of Surface Unmanned Vehicle. The discussion on the testing hardware of the surface unmanned vehicle will also be explained in this chapter.

Chapter 5: This chapter will wrap up the research by summarising the important results in connection to the problem statement and objectives, as well as reviewing the research scope. It will also go through the study's limitation and provide recommendations for further research.

CHAPTER 2

LITERATURE REVIEW

2.1 Related Works

2.1.1 SUV Design & Technology

The development of the Unmanned Surface Vehicle that able to control a boat without human on board by using remote control operated with real-time data collection capability and have environmental monitoring. This project is proposed by Department of Marine Technology, UTM Johor Bharu. [2] The project proposed were without human onboard which is by using remote control will be apply on the technology of the project. The USV is capable to perform tasks in variation of environments without jeopardizing human life and operated in more economic and efficient [2] Based on the project, aim of the design will include to perform in the variation environment especially lake condition and having economical with efficient function.

The USV boat in this project is designed based on modified jet-ski hull structure as in Figure 2.1 and equipped with other instruments for such as Global Positioning System, Inertia Movement Unit and etc. [2] . Through the descriptions, the design of the hull is very practical and can be implement, same as the technology of using an equipment such as global positioning system were useful to apply. The design can improve roll stability of the boat, have greater payload, and redundancy in hull rotation by applying catamaran design on jet-ski hull structure [2] . The design of the hull itself define the stability of the finish boat. The catamaran design usually using two hulls but by applying the design to jet-ski is able to make only a hull on catamaran design and have the abilities of the design [2] . The project applies the concept of catamaran design which will also be implement in the design of this SUV project.

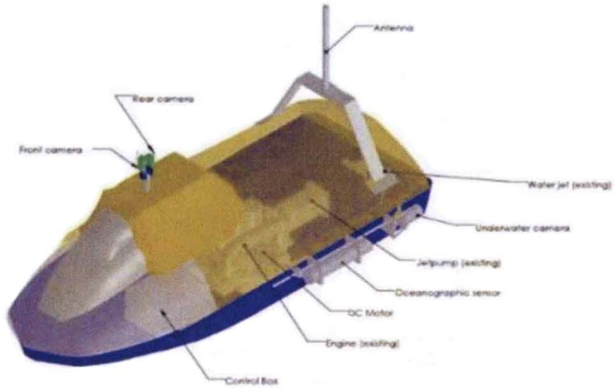


Figure 2.1 The jet-ski hull structure USV [2]

The project is proposed for designing and control an Automated Surface Vehicle (ASV) which is used for able to do any missions that are not constrained due to restriction imposed by human or jeopardize to human life [3] . The objective of the project is to produce a low-cost and easily transportable ASV that can greatly reduce the involved with continuous supervision [3] . Based on the objectives, this project objective also to achieve a low-cost and easily transportable boat. This project also made a custom-made winch as in Figure 2.3 is to lower down the payload into water [3] . As for the hull, it is expected to be a custom-made for the hull. This project is proposed by School of Engineering, Deakin University.

Some key features were highlighted to make inexpensive and robust design which is reduce manufacturing cost and use off the shelf equipment which is extruded aluminium for easy and rapid assembly, design a custom made winch which is capable of carrying a payload of 20 kilograms, include the navigating system on ASV for navigating feature, and the system can be operated remotely and autonomously [3] . The ideas of creating an inexpensive and robust design to reduce cost were relevant as it's one of this project objectives.

The ASV design is used catamaran configuration created with PVC pipes is shown at Figure 2.2 [3] . The concept of using the PVC pipes as main materials were consider in order to make the hull. Custom design of winch as in Figure 2.3 at the centre of the two hulls which is used to lower down the payload into the water up to 30 meters and also convey appreciable amount of payload [3] . Based on the explanation, making the payload in the middle with two hulls attached on sides makes the boat capable of carrying equipment loads. The two hulls need to consider because will impact the weight of the aluminium frame, winch, payload and electronics part of the system can be used. The buoyancy calculation and the weight distribution are used to get the parameter and payload of the boat [3] . The consideration of the two hulls are important as it will impact the weight of all components and hardware involved. The frame of the ASV is made of extruded aluminium rods to make the design easily transportable which can rapidly assembly and reduced cost in fabrication process [3] . The frame or backbones of the hull it's need to be easily transportable and quickly assemble to reduce costing of the boat.

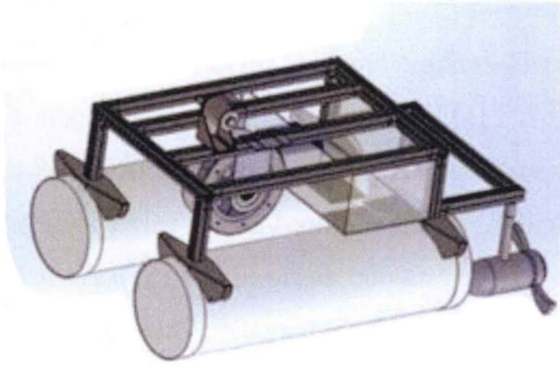


Figure 2.2 Catamaran Design Figure [3]

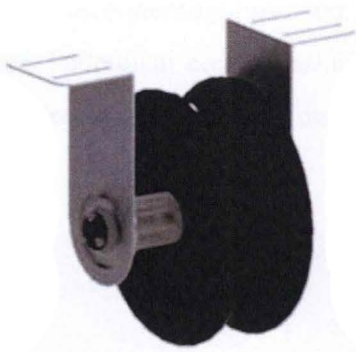


Figure 2.3 The design of custom winch [3]

The LORCA platform is designed to be robust enough for ocean deployment, while small enough to be launched by hand [4] . The design that will be apply were the small boat which can be handle by hand for an easy deployment of the boat. Due to its simplicity and small size, the LORCA is inexpensive enough that a fleet of ten boats can be built, stored and maintained on a reasonable budget [4] . Based on LORCA, this project is to make a simple small size boat with an affordable budget where bunch of same prototypes can be made. A variety of common hobby parts, such as the engine, propeller, speed controller, and rudder servo, are used on the LORCA to help keep costs and development time down [4] . State that LORCA make use of common hobby parts, which will be also great idea to reduce the development time and cost of the project.

Figure 2.4 below shows the LORCA Pond testing. The hull and deck of the LORCA are made of a single piece of carbon fibre shell [4] . The LORCA use a single piece of carbon fibre to fabricated the hull. The deck is domed for self-righting, and there is only one small hatch for accessing internal components [4] . This build is stiff, compact, and watertight, making it ideal for use in ocean conditions. The design of using single hatch door to access the component is relevant for this project build as it makes the boat compact and watertight. Three other configurations have been built using the same shell with some different components. One design is nearly identical, but with the propeller and rudder shifted as far towards the stern as possible. Another design utilizes two outboard motors [4] . These outboards are mounted on the transom of the LORCA shell. The last configuration utilizes a surface-piercing propeller mounted behind the LORCA [4]. The LORCA project makes 3 identical configurations for research purposes with different setup, whereby this project will only make one variant will the design setup apply.

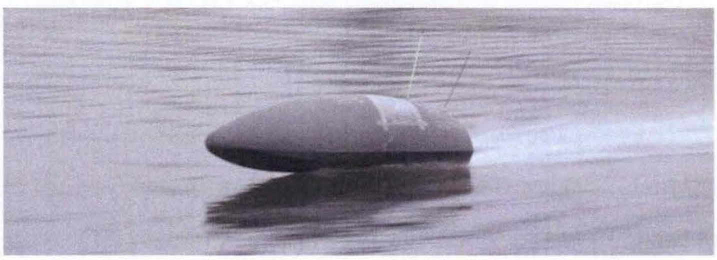


Figure 2.4 LORCA Pond Testing [4]

The requirements of the Junior Design of Autonomous Surface Utility Vehicle (ASUV) procurement were to ensure that it is cost effective, simple to deploy, lightweight, robust and easy to operate, and should have adequate payload capacity to carry a variety of sensory devices [5] . The ideas of ASUV were apply to this project where it ensures to be cost effective, lightweight, robust and easy to operate. The organized modulated framework architecture allows for one that is unfamiliar with the system to quickly become easily acclimatized and up-to-date allowing for system overhaul just by small modifications [5] . The system is standard with a magnetic sensor for Mission start capabilities [5] . An organized framework of ASUV were used for this project which allowed for a further up-to-date upgrade with small modification.

The thruster mount design was inspired by researching RC boat drive mounts [5] . This project reuses the ideas of searching a RC boat drive mounts to the boat. The basic support structure is drilled to the transom of the vessel and is connected via dowel pin that is screwed into the top of the thruster [5] . The servo mount is simple because the servo contains mounting flanges that are used to drill into a support structure. This project implements the design of the ASUV make use of servo mount and also make support structure to attach the motor with its body. The servo needed to be raised to fit the connecting rod elevation and was done so with a block of foam and PVC material that the screws can drill into. Design of raising the servo also apply to connect it to the rudder. The support structure was attached to the vessel by using a strong material called Dual-Lock, which is a very strong form of Velcro. This allows the servo box to be easily removed from the vessel with no damage to the surface of the material of the hull [5] . Design of using a strong material as the hull is important, where ideas of using PVC as the main structural body is reuse.

Pressure ratings, material permeability, saltwater intrusion, reverse polarity, over amperage, heat dissipation, signal disturbances, and even shock absorbance factors were all considered in the electrical system design by the use of properly vented and sealed areas, electronic diode protection and a fuse box that regulates the systems power from over amperage [5] . The researcher explanation variety of outside and inside factors, the project design will consider all of the parameters such as signal disturbances, heat dissipation, sealed area, material permeability and shock which is important for boat lifetime.

The batteries use a Belden 9463 two-wire cable [5] . It contains a PVC jacket, polyethylene insulating material with a tinned copper core [5] . It is very important that wires and cables were kept as short as possible to reduce the amount of signal absorption that robs the systems power, due to its own natural resistance [5] . The ASUV make a protection cover to insulate most of the electronic parts especially the power sources. This project makes use the technology of keeping the wires short to reduce the natural resistance from the copper and properly insulated wire to reduce the signal absorption and power loss of the system.

Another project by Purdue University, West Lafayette, in the United States, called SMARTBoat 3, is a totally open-source, low-cost, and small-sized Unmanned Surface Vehicle (USV) [6]. The researcher state that the existing commercial USV are expensive and not fully based on open-source hardware, making it difficult to purchase them and to modify the designs for making a better USV platform [6] . The platform is by using an open source where parts were easily found and it's small sized making it low cost build.

The Figure 2.5 shows the SMARTBoat 3 platform with a front view, side view and bottom view purpose by Purdue University, West Lafayette in USA [6] . The researcher use buoy design makes from tube to develop the SMARTBoat 3. The design is different compared to the catamaran design. At the bottom of the tube, there are two underwater thrusters and each thruster are powered by a BLDC motor. Out runner motors, a type of brushless DC electric motor often utilized in autonomous surface vehicles, are employed in the prototype. By referring to the dimension, the SMARTBoat3 have 28cm width, 24cm length and 28cm height [6] . Brushless DC motor were utilized as most autonomous surface vehicle effective use this electric motor as a prototype. This shows that the SMARTBoat 3 design is smaller in size and lighter in weight which is the weight of the SMARTBoat 3 is only 3 kg. The design focusing on making a small-sized USV making all of the hardware and component are all close to each other.

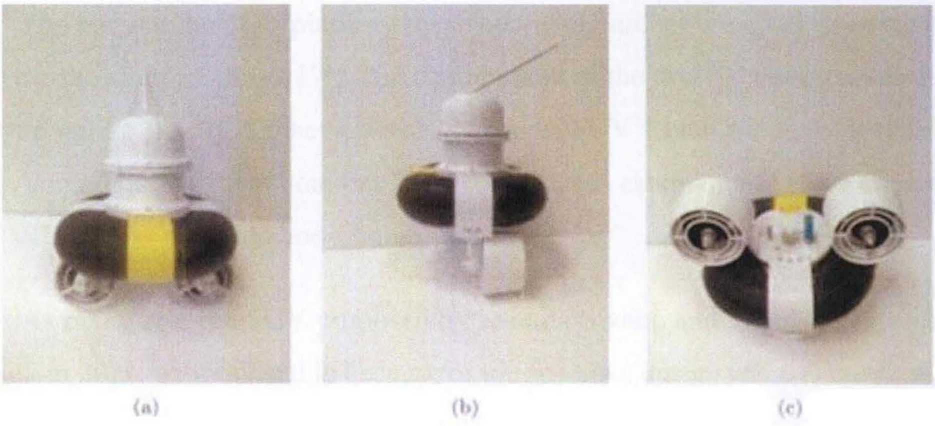


Figure 2.5 SMARTBoat 3 platform. (a) front view, (b) side view, (c) bottom view [6]

Compare to the project in Figure 2.6 purposed by Satetha Siyang and Teerakiat Kerdcharoen, Bangkok in 2016 which they make a catamaran design prototype for the SUV to develop an autonomous platform [7]. The researchers use a catamaran concept to design the prototype and the development of the SUV. A catamaran is a multi-hulled watercraft having two parallel hulls of equal size. It's a geometry-stabilized ship, with stability coming from its broad beam rather than a ballasted keel, as is the case with monohulled boats. Catamarans have a smaller hull volume, less displacement, and a shallower draught than monohulls of same length [7] . Researchers explain the main concept is catamaran design where it has two parallel hulls with equal size attach to both side of the main hull in the middle. Theoretically, the catamaran has a geometry-stabilized design thanks to the large hull volume yet with a same boat length.

Figure 2.6 Example of Surface Unmanned Vehicle by Satetha Siyang and Teerakiat Kerdcharoen [7]

The body of the SUV platform made by the researcher was built by using the hull of two off-the-shelf RC boats [7] . The combination of the two RC boats makes the SUV prototype unlike from the other catamaran design SUV which the hulls is usually not using a combination of two boat but some design used catamaran configuration created with PVC pipes as the main body frame.

As being see, the SUV purposed by Satetha Siyang and Teerakiat Kerdcharoen, Bangkok in 2016 are more stable because of the spacious design and can move smoothly on the water surface. Other than that, the 47 inches hulls were connected by an acrylic junction plate which can accept payload up to 8kg to support and functioning on the water surface [7] . The advantage of using acrylic junction is easy to shape and lighter than glass. Acrylic may be utilised in a wide variety of temperatures and has greater weather resistance to glass and other types of plastic due to its exceptional resilience. It will not shatter under severe impact, and if it does, it will break into huge, dull-edged pieces.

2.2 Summary

From the research and the study, the development of the surface unmanned vehicle prototype is considering to build from catamaran design. The choose of the design is because catamaran has major advantage in stability during on the surface of water or on calm water like lake. Moreover, the catamaran design also has advantage in a simple and attractive design of the body with the two hulls at the rear. With two hulls at the rear will, this will provide a good weight distribution on the design for body parts of the project. The possibility of sunk for this design most likely lesser if compare to other boat design.

CHAPTER 3

METHODOLOGY

3.1 Introduction

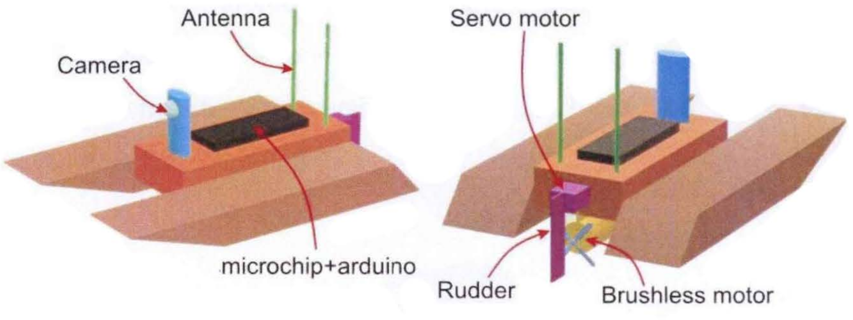
This chapter will be highlighted on mechanical design of structure and framework of SUV mechanism system. The sketching design, block diagram of hardware design, flowchart coding of the project and flowchart of the controller design will also be explained in this chapter.

3.2 Vessel mechanical Design

For the overall mechanical design, there are a few sketch designs of the main vessel to be the main base of the boat. The sketch is done by using a sketching application on the Microsoft store called Paint 3D. The sketching design includes a few unique and important characteristics that need to be taken into consideration. In this project, the type of hull is used is PVC pipe. The PVC pipe have the cylinder shape, where the volume of the two hulls times with the volume of water will give the value of how much weight the boat can carry. The volume can be determined by the formula:

$$2\pi r^2 \ x \ P \qquad 3.1$$

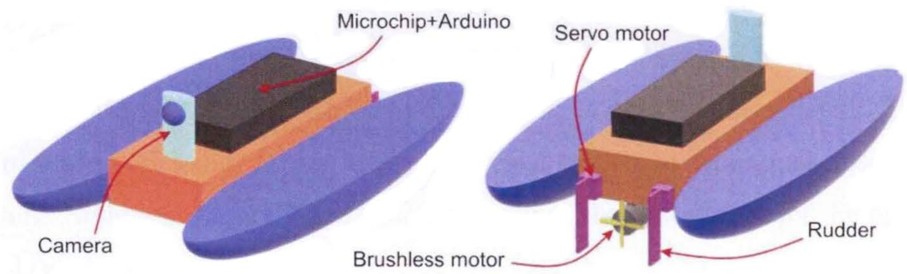
In the first design as shown in Figure 3.1, the boat vessel is sketch in the shape of a rectangular. The shape was modified so that it goes through the water surface and make it easier for water to flow through. The other hardware parts are added to complete the overall design. The exact measure of the prototype was only visualised with a scale of 1:8.



(a) (b)

Figure 3.1 The overall view of the SUV version 1; (a) front view, (b) rear view

Then for the second design as shown in Figure 3.2, after discussion among team group a change is made to the boat vessel design. These changes were made to make the boat design more attractive and to increase the fluid flow so that the boat goes through water even easier from the previous version. Same as the first version, hardware is also added to make a complete overview of the prototype. The sizing of the prototype was only made by visually which are scaled by ratio of 1:8.



(a) (b)

Figure 3.2 The overall view of the SUV version 2; (a) front view, (b) rear view

The final sketching of the second version then was implement to a software design. The design was developed from scratch line by line throughout the 360 Fusion AutoCAD software. In the process of designing the SUV, drawings taking part in making of the boat middle hull, the side hull, and an area to place all the component involved. The design also considering the balance of the hull and the total free space area for components. Early design of the boat is to make a compact and robust vessel. Various version of different hull has been designed to ensure the SUV more stable in the water surface as well having an attractive look. As more features were added, the design also being improved as it will affect the stability and capability of the boat where most of hardware are expected to be heavy in terms of weight. The drawing has been modified by time until it reaches the final version as shown at Figure 3.3, where the concept of catamaran was fully implemented.

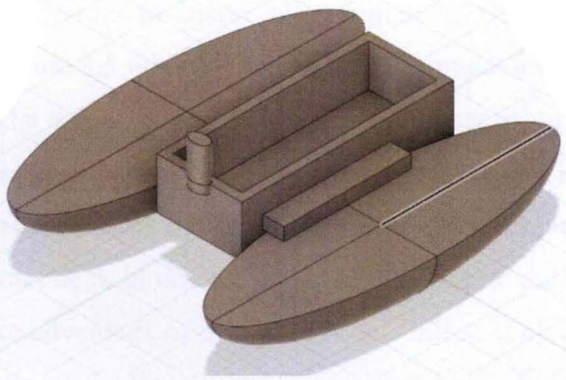


Figure 3.3 Design of SUV version 4 isometric view

The Final design of SUV version 4 from AutoCAD 360 Fusion, is then implement into a real thing. The first prototype is built with the middle hull or middle casing for the component were made from scratch using an acrylic plastic sheet. An acrylic was use because of its ease of fabricating and customizing. The middle hull was rectangular with shapes two sides length of 25 cm and other two sides with length of 10cm. The initial height of the middle hull is 10 cm, but then decrease to 7 cm to decrease the centre gravity of the hull. Shown in Figure 3.4 are the assembly of the first design for the middle hull of the SUV.

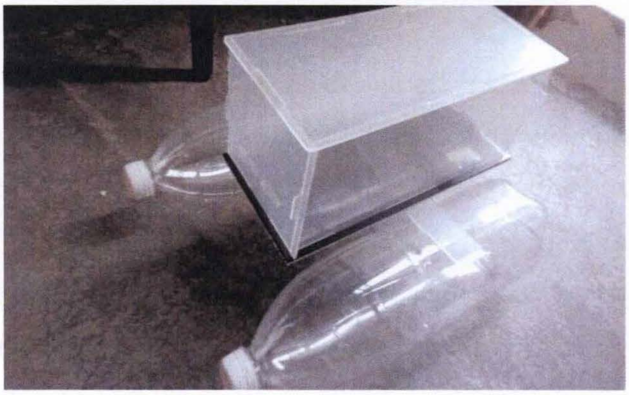


Figure 3.4 First design of the middle hull.

In the assembly of the first prototype, all of the elements and hardware were put together to determine its stability. Unfortunately, as the assembly of the hardware continuous to fulfil the features of the SUV space became less until no more space available. This due to the hardware that is taking too much space and the middle hull loss its stable ability. Due to this, the first prototype was customized and space of the middle hull became two times larger to ensure all components fits in the hull. The second prototype shown in Figure 3.5 with the middle hull has much more space to fit bulk and heavy components. The acrylic sheets are combine together using a silicon sealant for a strong bond and waterproof casing. The acrylic was form with a length on two sides of 25 cm and the other two sides of 24 cm. The height of the second prototype are 10 cm, this is to make a second deck in the hull to place the GPS module and microcontroller. It's necessary to make advantage of the space in the hull as it gives more gaps between each component to reduce wire length and increase heat dissipation when boat is running.

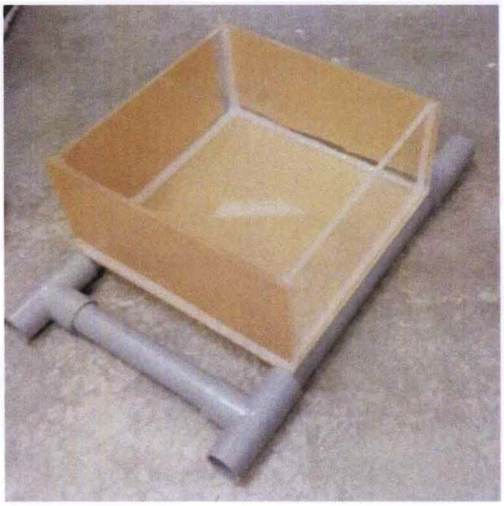


Figure 3.5 Second design of middle hull.

The frame of the boat is made with PVC pipes. The PVC pipes cover and became the main backbones to attach the side hull and middle hull of the boat. Shown in Figure 3.5 are the setup of the PVC attach to the middle hull. At the bottom deck or on the bottom side of the middle hull, lays another layer of thin rectangular acrylic sheet that is glue with the middle hull. This thin layer of acrylic sheet is attached between middle hull and the PVC frame with cable tie. The reasons of using cable tie to attach middle hull with the main frame deck are to make easy access and quick detachment of middle hull in the case of major displacement of the hull or to change and upgrade the side hulls.

The mount for the motor and rudder is also build from scratch with several layer of acrylic sheet. The mounting is placed on the rear side of the hull. The thickness of the acrylic use for the mounting are 3 mm which is very easy to customized in terms of cutting and fabricate to the required size. The mounting shape are square when view from side. The dimension of the mounting is 3 cm width, 13 cm length at bottom with 25 cm length on top, and 6 cm height. The complete customized acrylic sheet has been glue together using hot glue.

On Figure 3.6 shows the top of mounting is purposely long made in order to attached it to the PVC pipe frame using cable tie to ensure it doesn't misplace when motor is running. The rudder mounting is also purposely extended upwards to ensure the rod connecting both servo and rudder. It's also to provide a clear and undisturbed motion when the rudder is moving left and right. The rudder itself is extended to ensure it submerged inside the water and make a more stable movement when turning its direction.

Figure 3.6 Mounting of the rudder and motor

The side hull of the SUV is made with a light and easy fabricated material. The material mention is polystyrene which can be obtain mostly in stationery store. The thickness of the chosen polystyrene is 2.5 cm, but is layered double on top of each other making the whole hull height of 5cm. For the middle hull however, is made only 2.5 cm thick to allowed water pass by on the bottom freely towards the motor. Shown in Figure 3.7 are the side hull with dimension of 45 cm width and 110 cm length. On the front of the side hull, it has been cut into a ship shape structure to make an easy manoeuvre over the water surfaces. On rear of the side hull, the shape is smoothly curve to allowed water flow freely from the boat. Figure 3.8 shows a finish customized side hull that has been attached with the middle deck using a hot glue gun and silicon sealant.

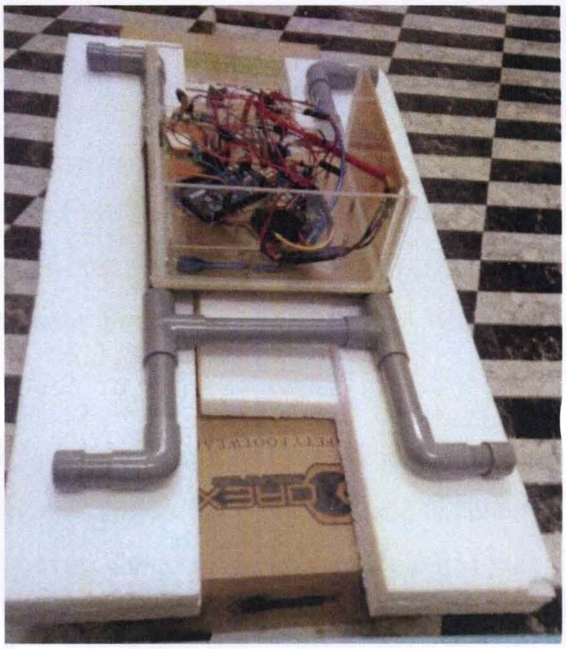


Figure 3.7 Side hull in measure and size estimating

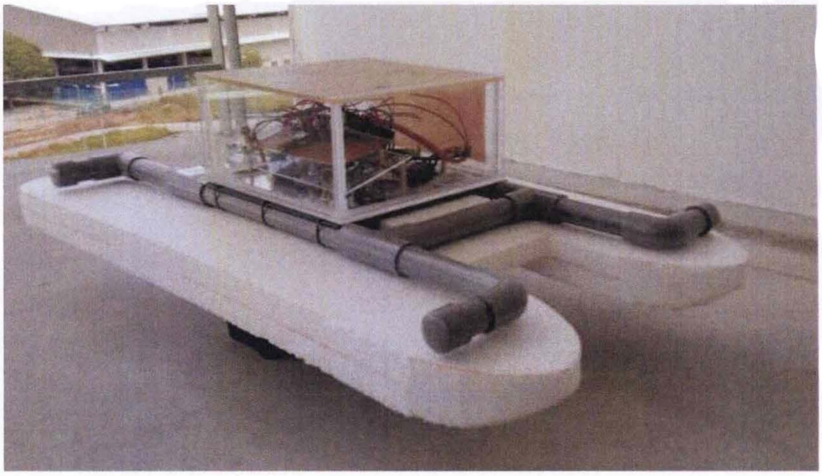


Figure 3.8 Complete customized side hull

3.3 Costing

The costing for this project is divided into several categories including controller, power related devices, mechanism and miscellaneous. For this project, the budget provided for each student are RM 300. As for this project, the number of members included are 3 colleague which sum up the overall project bùdget of RM 900. The budget spends for the mechanism parts are approximately RM 127 by referring table on Appendix D.

Based on costing table that can be view on Appendix F, the overall costing that has been used, at the end this project builds able to save and cut off a little from the budget provided. As mention earlier, the total project budget is RM 900. Overall total costing is RM 876.75 including all the required components. An amount of RM 24 was able to cut from the total budget provided.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter will be focusing on the result for the development of Surface Unmanned Vehicle. The discussion on the testing hardware of the surface unmanned vehicle will also be explained in this chapter.

4.2 Preliminary Test

The aim of this study was to investigate the possibility of using low cost and robust SUVs similar current widely adopted SUVs in monitoring system. The payload and deployment configuration affect the overall performance and endurance of the SUV. However, buoyancy offered using polystyrene and PVC pipe make the catamaran design has very high state of stability on water surface especially during calm sea.

The first testing of the SUV is conducted on the lake B of UMP Pekan. The testing was performed to monitor the stability and SUV performance during common water tidal. The snapshot 1, 2 and 3 from Figure 4.1 shows the forward movement of the SUV when cruising following the direction of water tidal. The snapshot 4, 5 and 6 shows the forward movement of the SUV when cruising against the direction of water tidal. The SUV snapshot of movement proof that the SUV were stable even against the water tidal and still cruising smoothly with less water drag underneath the SUV. This is due to its curve design in the front vessel and rear which cut through the water surface to create a clear pathway for the boat.

Figure 4.1 The snapshot of SUV on tidal testing

The movement of the SUV when changing direction from straight to left side of the boat is shown in Figure 4.2 across the water surface. Figure 4.3 shows the SUV turning from straight to right side. The rudder design is proven to be effective as the boat turn immediately when moving the joystick on remote control.

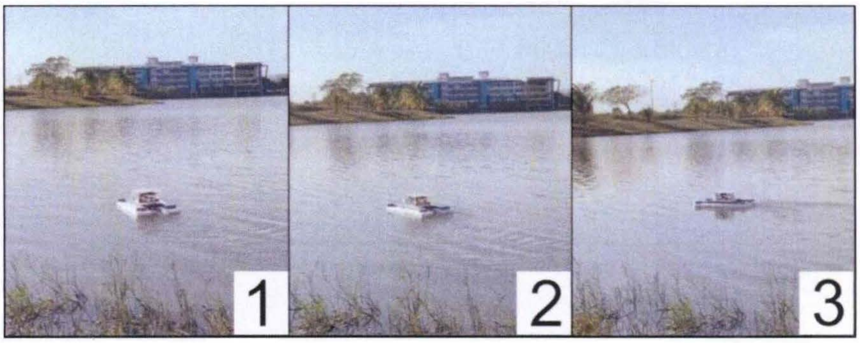


Figure 4.2 The snapshot of SUV turning left on water tidal

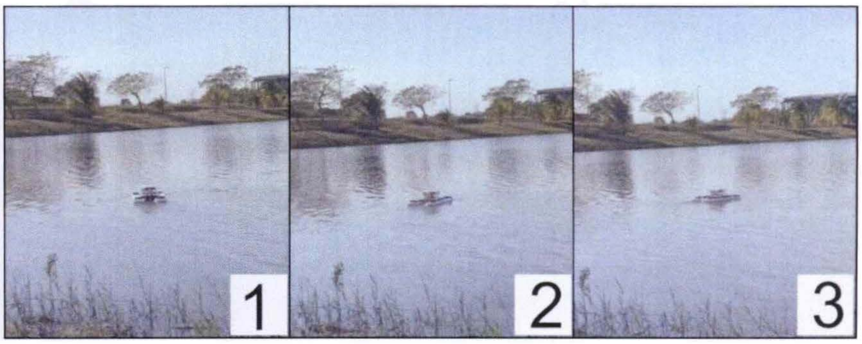


Figure 4.3 The snapshot of SUV turning right on water tidal

4.3 Field Test

The underwater thruster brushless motor works significantly to drive the SUV. The SUV requires the use of two rudders. With the used of two rudders make the SUV turn to left and right as best as possible. Table 4.1 shows the specification of the SUV. Testing of the SUV was attempted on the Lake B in UMP Pekan as shown in Figure 4.4.

Table 4.1 SUV specification

Specification	
Dimension Length x Width x Height	110cm x 45cm x 17.5cm
Weight	2.5 kg
Framework	Perspex, PVC, Polystyrene
Speed	10-15 km/h
Communication	RF transmission 2.4Ghz
	RF transmission 5.8Ghz
Battery size	11.1v 5400maH
	11.1v 2200maH
	3.7V 800maH (camera)
Endurance	3 hours
Special Features	GPS real-time location detection
	Real-time video capture

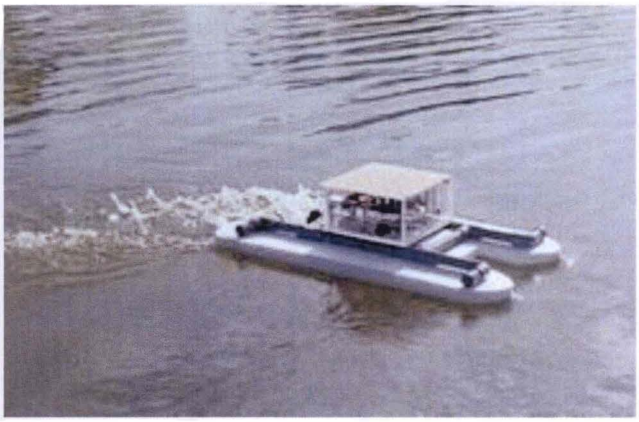


Figure 4.4 SUV testing on lake condition

Then, the focus of the data analysis in this study has been using computationally cheap and open software in contrast in many studies that use proprietary software. This approach helps the continuous development and provides the possibility in real-time viewing and sharing processing data. The SUV was deployed with GPS. The GPS was collecting every 15 second and monitored in real-time sharing. Figure 4.5 shows the processing data can be monitor through the Thingsboard software. The Figure 14 shows the real-time viewing at the Thingsboard software. Ideally, the GPS detect the location when the SUVs is moving which it will automatically plot the current location of the SUV. As expected, the speed is affected by the payload, the SUV speed are slowly and not moving too fast. In fact, the SUV are made for monitoring surrounding, slow speeds are highly encouraged. Figure 4.6 shows the important features which has been implemented. This include the display the current location of the SUV, waypoint location of the SUV and also the location specific coordinate that powered by Google Maps.

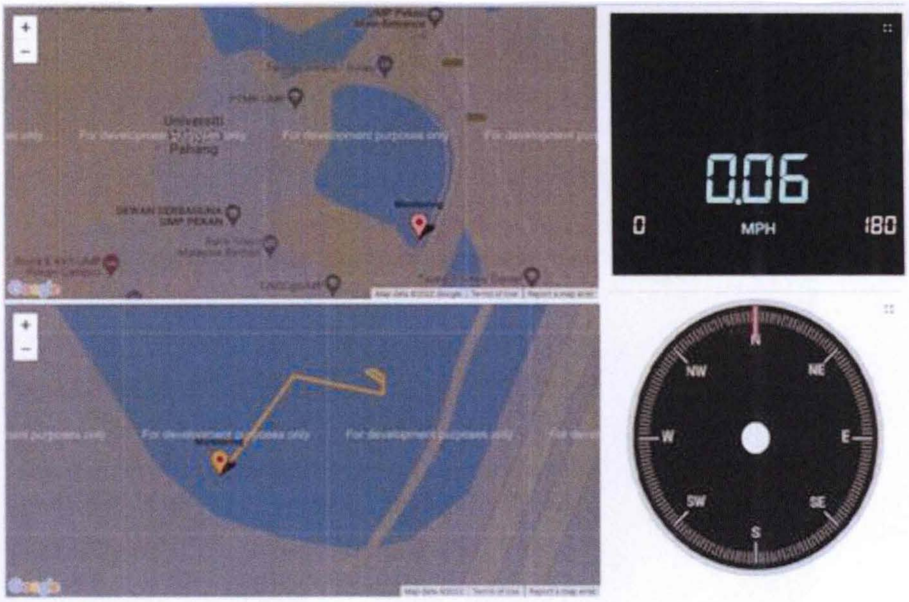


Figure 4.5 Real-time sharing on Thingsboard.

Figure 4.6 Thingsboard parameters.

The focus of this study is also to view the surrounding. The SUV also was deployed by the first-person view camera. The image captured by the camera can be view through the application from the mobile phone. Figure 4.7 shows the image captured in real-time view which allowed users to see images that possible for the SUV to approached.

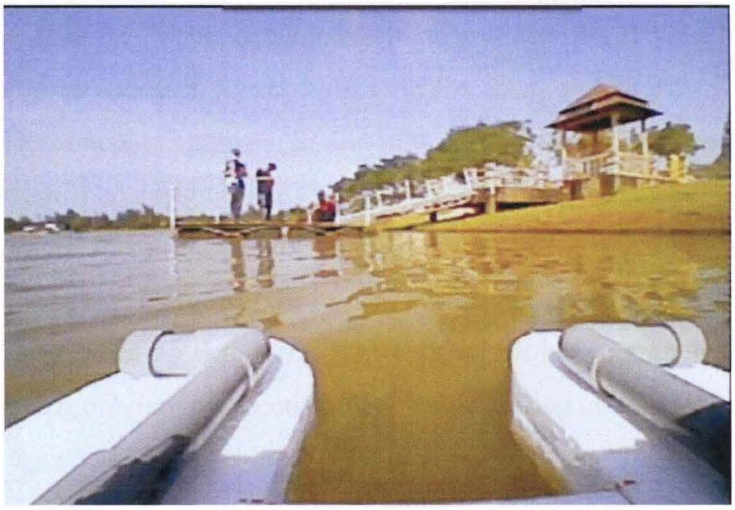


Figure 4.7 On board camera view

The output or images can be easily access throughout most mobile phone that can connect with the camera antenna receiver. The maximum communication distance for the users to constantly receive the captured images is 500 m. However, the SUV movement and direction still can be control to a maximum distance of 1.5 km.

CHAPTER 5

CONCLUSION

5.1 Introduction

This chapter will wrap up the research by summarising the important results in connection to the problem statement and objectives, as well as reviewing the research scope. It will also go through the study's limitation and provide recommendations for further research.

5.2 Conclusion

The increased acceptance of surface unmanned vehicle system has opened the field for SUVs to be employed as a tool for the environmental and monitoring system. Moreover, the SUVs have potential to reduce risk for manned forces and perform tasks that cannot be done by manned vehicles. In this study, the development of surface unmanned has been successfully develop with low cost and simple design of surface water vessel. The concept of catamaran design was successfully implemented and is used in the SUV design. The design has very high state of stability especially during calm sea and the objective of this project is to run the SUV at University Malaysia Pahang lake. The design gives a large impact on the overall performance of the SUV during operating. The SUV features enabling the operator to control the boat remotely while not being onboard and having onboard perspective view without being onboard. With proper circuit management, the power is distributed to every component involved without disturb and interrupt the other running devices in the SUV. The data analysis from the SUV demonstrated the feasibility and versatility of the proposed devices. Throughout the observation also, the SUV design was proven to be very stable and efficiently on water surfaces.

5.3 Recommendation for future works

The SUV that has been develop in this study had achieved all of the objectives and able to carry the task as stated in the research scope. However, there's a limitation that has been approved as the result from testing and data analysis. The limitations of this SUV including the speed of the SUV where the maximum speed on calm lake condition is around 15km/h and the speed decreases as the water wave and current became stronger. Other limitation is that the boat is not autonomous, means a constant input from navigator is needed as the SUV operating. The recommendation for further studies is to add a propulsion device or changing the layout design and position of the propulsion system. Other recommendations for the limitations are to add an autonomous system in case of emergency where the SUV will drive back to its initial placed when having a communication problem.

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APPENDICES

Appendix A: Gantt Chart

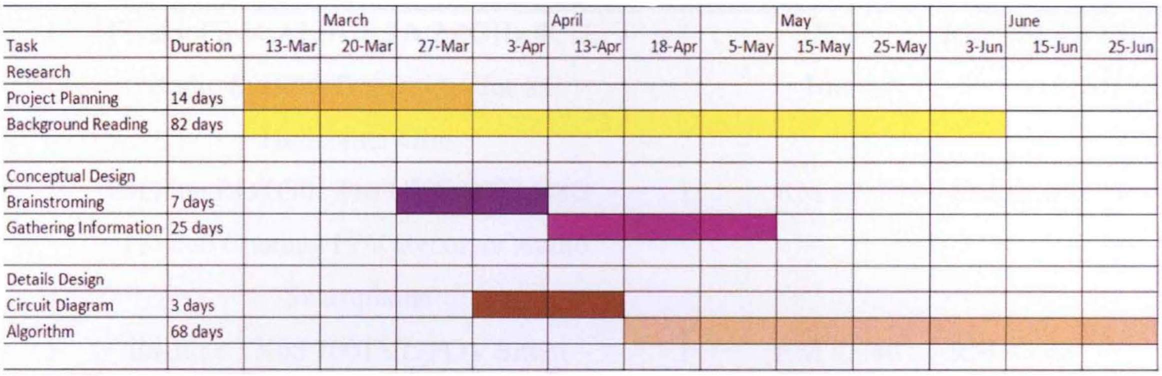

Figure 5.1 SDP 1 gantt chart

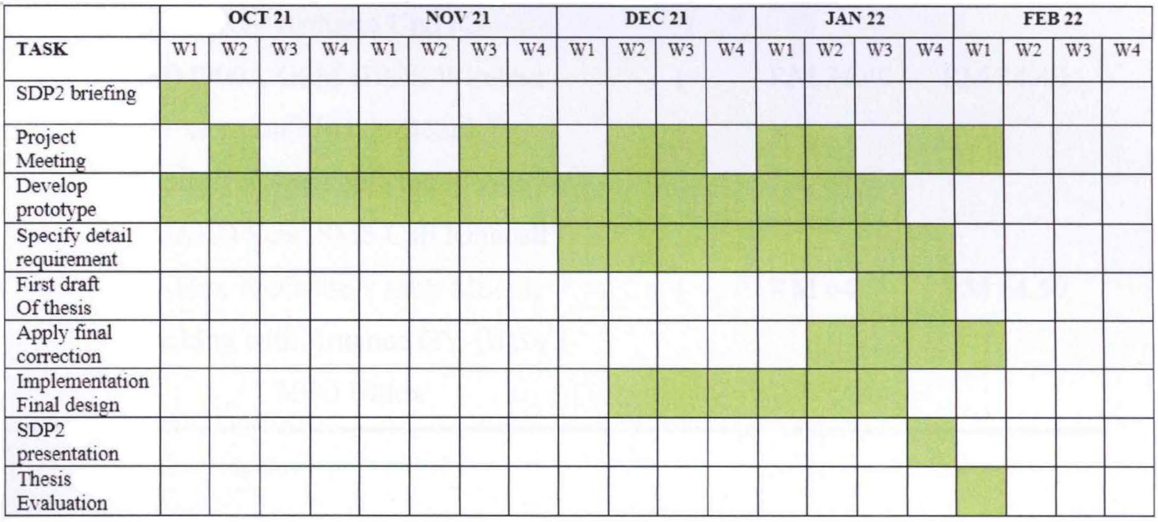

Figure 5.2 SDP 2 gantt chart

Appendix B: List of costing for controller

No	Description	Quantity	Price	Total
1	Flysky FS-i4 AFHDS 2A 2.4GHz 4CH Radio Sysrem Transmitter for RC Helicopter Glid	1	RM 100.85	RM 100.85
2	Eachine ROTG01 Pro UVC OTG 5.8G 15+0ch Channel FPV Receiver Audio Smartphone	1	RM 62.07	RM 62.07
3	Eachine TX06 700TVL FOV Smart Audio Mini FPV Camera AIO Transmitter for RC Drone	1	RM 43.40	RM 43.40
4	UNO Atmel DIP ATMEGA328P UNO R3 / Arduino Uno R3	1	RM 30.90	RM 30.90
5	SIM900A GSM GPRS Wireless Extension Module Board Free Antenna for Arduino/ Handphone SIM CARD Send SMS Call Ringcall	1	RM 34.40	RM 34.40
6	U-blox NEO-M8N GPS Module Tracking with Antenna GY-GPSV3-NEO Ublox	1	RM 64.50	RM 64.50

Appendix C: List of costing for power related devices

No	Description	Quantity	Price	Total
1	12V Underwater Thruster Brushless Motor 80mm propeller 3-5kg 3s	1	RM 109.80	RM 109.80
2	40A Brushless ESC speed controller (long)	1	RM 23.17	RM 23.17
3	TIGER 2S-4S RC Lipo Battery Batteries 4500 5400 2s 7.4v 3s 11.1v 4s 14.8v 6s 22.2v TCB GNB MAXXTRAX batery bateri car	1	RM 119.66	RM 119.66

No	Description	Quantity	Price	Total
4	Syma X5C X5C-1.37V 25C 300mah 500mah 800mah 1200mah 1S LiPo Li-Po Battery – RC Car Drone Quadcopter Helicopter MP3	1	RM 17.90	RM 17.90
5	Tiger RC Lipo battery 2s 4500maH 7.4v	1	RM 69.30	RM 69.30
6	SG90 180/360-degree 9g Micro Servo Motor (blue) with Accessories (suitable for Arduino)	2	RM 7.83	RM 15.66
7	Male to Female | Jumper Wire Cable 40-Wires M-F- 10cm / 20 cm / 30cm for Arduino Raspherry Breadboard Pin-Headers Sensor	1	RM 3.69	RM 3.69
8	Male to Male | Jumper Wire Cable 40-Wires M-M- 10cm / 20cm / 30cm for Arduino Raspberry Breadboard Sensors	1	RM 3.69	RM 3.69
9	Mini USB Cable (Data & Power) @ USB Type-B (Male) to USB Type-A (Male), for Arduino NANO	1	RM 3.59	RM 3.59
10	FTDI – USB to TTL Serial, (TX/RX) UART Converter Module FT232RL (Programmer Arduino Pro, Pro Mini, LilyPad, STM)	1	RM 9.59	RM 9.59
11	Strip (Vero) Board, Pitch 2.54mm Veroboard Stripboard PCB Protoboard	1	RM 6.89	RM 6.89

Appendix D: List of costing for mechanism

No	Description	Quantity	Price	Total
1	Clear Acrylic Display Case 25x25x10cm	1	RM 90.00	RM 90.00
2	[H&D] Feilun FT012-4 Steering Rudder Tail Vane Spare Parts Kits for Feilun FT012 RC Boat	1	RM 13.18	RM 13.18
3	3/4'"(20mm) PVC PIPE 6.0000 FT	6	RM 1.00	RM 6.00
4	3/4"(20mm) PVC 90' 4.0000 NOS	4	RM 1.50	RM 6.00
5	3/4"(20mm) PVC TEE'D' 4.0000 NOS	4	RM 2.00	RM 8.00
6	PVC END CAP 20MM(3/4") 4.0000 NOS	4	RM 1.00	RM 4.00

Appendix E: List of costing for miscellaneous

No	Description	Quantity	Price	Total
1	PVC PIPE CUTTER EA23-1/2/4 – 12/72 9071728	1	RM 12.50	RM 12.50
2	JEBSEN PVC PIPE CEMENT 100g WB104-6AB – 80 9555395800489	1	RM 3.31	RM 3.31
3	Glue stick 8pcs B20cm x 1 set	1	RM 3.85	RM 3.85
4	Hinge GQ-288 1inc x 1pcs	1	RM 1.70	RM 1.70
5	Silicon sealant 1018GP VS X 1pcs	1	RM 7.90	RM 7.90
6	Paper clip combination VS x1set	1	RM 1.25	RM 1.25

Appendix F: List of costing for overall total costing

No	Description	Total
1	Controller	RM 336.12
2	Power related devices	RM 382.94
3	Mechanism	RM 127.18
4	Miscellaneous	RM 30.51
Total		RM 876.75