DEVELOPMENT OF AN UNMANNED UNDERWATER REMOTELY OPERATED CRAWLER (ROC) BASED ON WHEEL MECHANISM

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FEATURE EXTRACTION OF FOREARM EMG SIGNAL FOR EXOSKELETON HAND

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I hereby declare that I have read through this report entitle “Development Of An Unmanned Underwater Remotely Operated Crawler (Roc) Based On Wheel Mechanism” and found that it has comply the partial fulfillment for Bachelor of Mechatronics Engineering.

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A report submitted in partial fulfilment of the requirements for Bachelor of Mechatronics Engineering

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I declare this report entitle “Development Of An Unmanned Underwater Remotely Operated Crawler (Roc) Based On Wheel Mechanism” is the result of my own research except as cited in references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……………...

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Date : ....

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ABSTRACT

Underwater vehicles are a type of vehicle that a type of vehicles that able to explore the underwater world. Remotely Operated Crawler (ROC) is one of the Unmanned Underwater Vehicle (UUV) that can be categorized in Remotely Operated Vehicle (ROV) class. The specialty of ROC allows for underwater intervention by staying a direct contact with the seabed. The common issues face for the crawlers are the underwater pressure, maneuverability, power and control. Besides that, the surface of the seabed become one of the problems in that restrict on ROC maneuverability. Designing a ROC that can crawl in any surface conditions is one of the issues emerged in this project. This project is about developing such ROC in order to fulfil a specific mission involving certain tasks. ROC lend themselves to long-term work and offer a very stable platform for manipulating objects and taking measurements better than other ROV. SolidWork is used as the software and platform in designing the crawler. Simulation test is done using application available in the software which is the SimulationXpress. Development an ROC based on wheel mechanism that allows the ROC moves with direct contact with the seabed without any glitch and have an ability to operate in any condition of the underwater environment. The wheel mechanism is adapted based on the tanks which is the chain type wheels. The performance of the ROC will be verified based on experiments conducted on the cluttered condition either on the surface or underwater. The ROC is capable to climb an obstacle of the maximum height of 9.5 cm. The operation of ROC can achieve excellent performance with an unexpected level of environmental condition.

ABSTRAK

Kenderaan dalam air merupakan satu kenderaan yang mampu meneroka dunia bawah air. Perangkak Kawalan Jarak Jauh (ROC) merupakan antara satu Kenderaan Tanpa Pemandu (UUV) bawah air. Keistimewaan ROC adalah keupayaannya beroperasi di dasar dengan secara lansung. Isu-isu biasa dihadapi oleh perangkak adalah tekanan bawah air, kebolehan-kendalian, kuasa dan kawalan. Selain itu, permukaan dasar menjadi antara masalah yang membataskan kebolehan-kendalian ROC. Merekabentuk ROC yang boleh merangkak di mana-mana keadaan permukaan adalah satu isu yang muncul dalam projek ini. Projek ini adalah tentang penciptaan ROC yang dapat memenuhi misi yang ditetapkan dalam tugas-tugas tertentu. ROC mampu beroperasi dalam jangka masa panjang dan menawarkan platform yang sangat stabil daripada ROV lain. Perisian SolidWork digunakan dalam proses merekabentuk ROC. Ujian simulasi dibuat menggunakan SimulationXpress. Pembangunan ROC berdasarkan mekanisma roda membolehkan ROC bergerak pada dasar tanpa sebarang masalah dan berupaya untuk beroperasi di bawah air. Mekanisma roda diadaptasikan berdasarkan roda kereta kebal jenis rantai. Prestasi ROC akan dikenalpasti berdasarkan eksperimen yang dijalankan pada keadaan tidak rata sama ada di daratan dan bawah air. ROC mampu mendaki halangan sehingga ketinggian 9.5 cm. Operasi ROC boleh mencapai prestasi cemerlang dengan tahap persekitaran yang tidak dijangka.

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CHAPTER 1

INTRODUCTION

This chapter is introduction of the project that covers briefly about the research background. The motivation and significant of the research is also included in this chapter. By motivation, the problem statement of this project has been concluded. The objectives of the project also explained in detail. In this chapter, the project scopes are determined and lastly, the report outline is executed.

1.1 Introduction

Before the creation of underwater vehicles, people tend to dive into the sea and river. They hunt for food, searching for sea products and even for pleasure. But humans have limits. We cannot dive too deep into the water and dive for a very long time. Most of the Earth's surface is covered by water in the proportion of 71%. This underwater exploration is impossible back then. In 1797, Karl Klingert [1] invents a diving suit that has an airtight metal helmet and a breathing tube as shown in Figure 1.1. Then, in 1934, Charles William Beebe and Ortis Barton made a record-setting descent to 3,028 feet (923m) below the waters of the Bermuda Island in a bathysphere [2]. Figure 1.2 shows a photo of Beebe and Barton with their bathysphere. This is a step in underwater exploration. Then it begins the age of submarines, sea explorations, deep sea dive and later the age of Unmanned Underwater Vehicles (UUV).

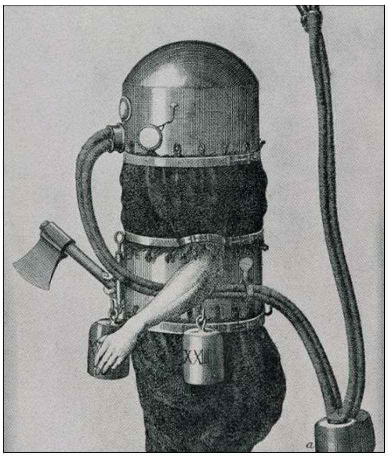

Figure 1.1: Helmet Suit by Karl Klingert [1].

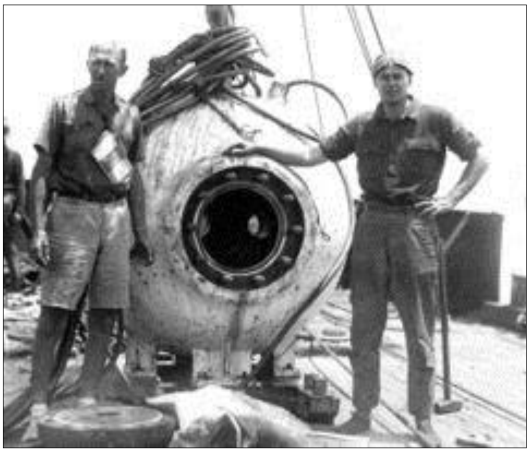

Figure 1.2: Charles William Beebe and Ortis Barton with their bathysphere [1].

The needs of underwater vehicles are getting more important for wildlife research, seabed mapping, weather forecast, offshore and mining industries, archeology and also operation of search and rescue. Types of underwater vehicles are more sophisticated and advance in technologies. The current technologies have removed the need for pilots to control and dive into the deep water and eliminate the risks of man diving. As we know, the UUV remove the need of a man inside the vehicle. This will reduce the risk taken for a pilot to dive deep into the water and giving a chance to travel deeper into the abyss. The design could be smaller and more versatile since there is no needed space for the man inside the vehicle. In this project, the field of research is focusing on the remotely operated vehicle (ROV) which specific discussion on the design and development of a remotely operated underwater crawler. The prototype of the crawler will be tested in the lab and getting the data on depth, pressure, strength and maneuverability of the crawler. Previously, the use of underwater crawler is quite unpopular than the submarine type ROV. So, it is important to design and build a crawler that fits into any field. The significant of this study are targeting more area of usage for the crawler. For example; the crawler can be used in archeology, seabed monitoring for earthquakes, search and rescue, offshore maintenances and even military purposes. The remotely operated crawler (ROC) will be working alongside with the ROV. Both vehicles have their advantages and disadvantages. By working alongside, both vehicles can give more data and sight of a certain situation, for example search and rescue operation.

1.2 Motivation

Oil and gas have become an essential to us. The oil and gas industries give a lot of impact in our civilization. With this type of commodity, many new inventions have been created, changes the landscape of a country, economic growth and more in our life. Most of the time in our daily life related to petroleum base products. As a report by U.S Energy Information Administration (EIA), for the year 2013, United States consumed 6.89 billion barrels of petroleum products at the rates of 18.89 million barrels per day (bbl/d) [3]. In Figure 1.3 shows the world fuel consumption over the year 2009 until 2014 and expected projection in 2015. U.S. Energy Information Administration (EIA) projects world petroleum and other liquids supply to increase by 1.6 million bbl/d in 2014 and by 0.9 million bbl/d in 2015, with most of the growth coming from countries outside of the Organization of the Petroleum Exporting Countries (OPEC). The graph of the world liquid fuels consumption as shown in Figure 1.4. Forecast non-OPEC supply grows by 1.9 million bbl/d in 2014 and 1.2 million bbl/d in 2015. The United States and Canada account for much of this growth. Projected world liquid fuels consumption grows by an annual average of 1.0 million bbl/d in 2014 and 1.2 million bbl/d in 2015 [4].

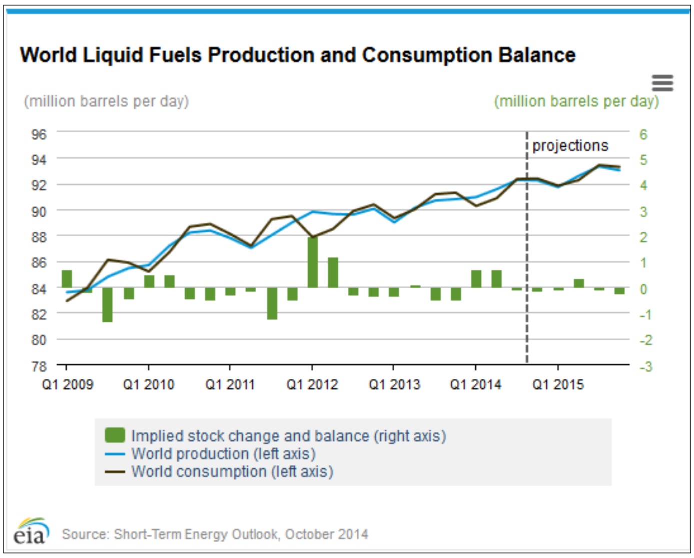

Figure 1.3: Chart of world fuels production and consumption for the year 2009 to 2015 [3].

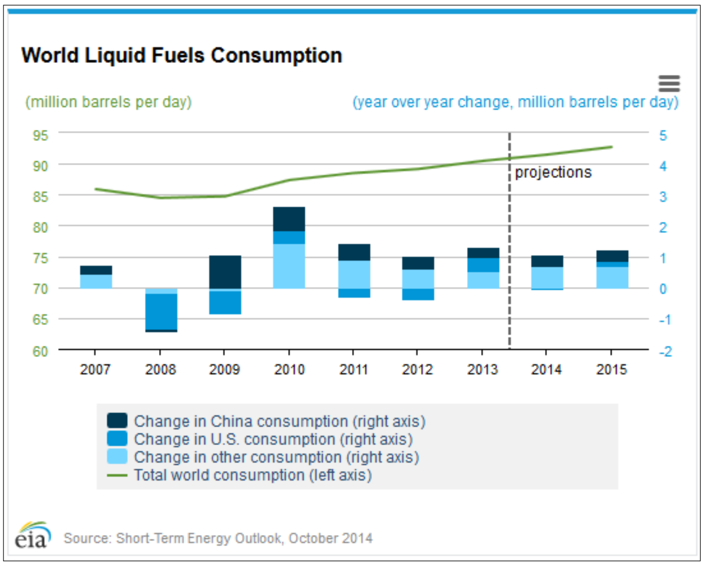

Figure 1.4: The fuel consumption graph for the year 2007 to 2015 [5].

The exploration of the oil and gas industries is not concentrated at on the land, but also in the offshore and deep sea as more oil wells found. Thus, as offshore explorations have increase the risk taken by man and women to drill petroleum. There are many cases regarding on the drilling, pipelines, transportation and storage accidents. Even though there are safety measures performed, yet accident can happen anytime without notice.

Underwater pipelines have a total distance of kilometers. They carry oil, gas, condensate, and their mixtures. Pipelines are among the main factors of environmental risk during offshore oil developments, along with tanker transportation and drilling operation. The causes of pipeline damage can be range from material defects and pipe corrosion to ground erosion, tectonic movements at the bottom of the sea and encountering ship anchors and bottom trawls. Statistical data show that the average probability of accidents occurring on the underwater main pipelines of North America and Western Europe is 9.3×10^{-4} and 6.4×10^{-4}, respectively. The main causes of these accidents are material and welding defects just like what happened in Russia offshore project Sakhalin-1, in the year of 1994 and cause a huge impact to the arctic ecosystems as the pipeline collapse [6].

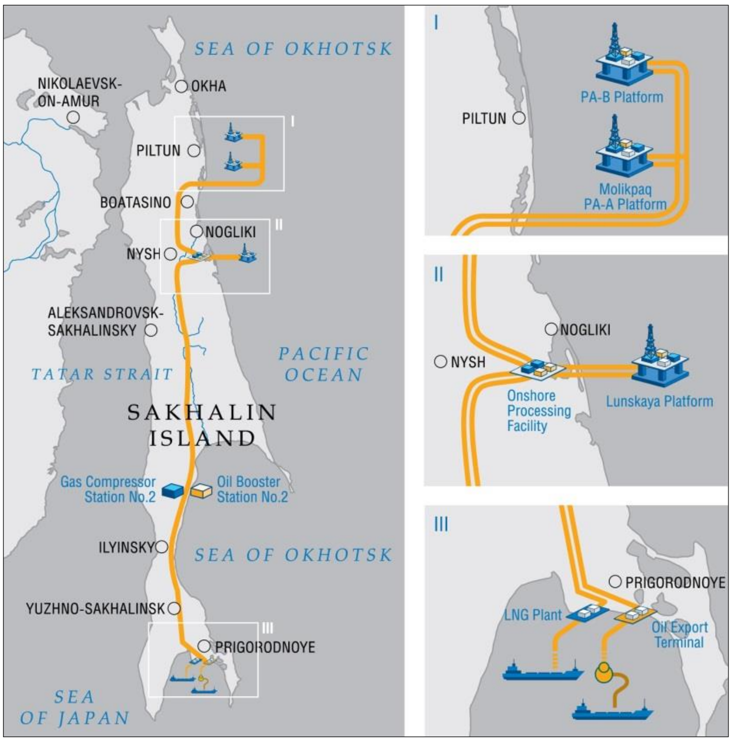

Figure 1.5: Sakhalin Offshore Projects [5].

Modern technology of pipeline construction and exploitation have been introduced. For example the usage of ROV and ROC in construction the underwater pipeline connections. This technology eliminates the risk taken by divers to dive into the deep and cold water condition. The ROC used in pipeline inspections and even constructions on the seabed along with other types of ROV and reduce human intervention doing the welding and inspection process.

Thus, this kind of incident motivates to study on the ROC design requirement to fulfil underwater inspections based on the project's scope and later there will be innovations in the development of ROC that help to build offshore facilities. One of the ROC design for the task of pipeline construction is the subsea crawler as shown in Figure 1.6 owned by IHC Marine and Mineral Projects, South Africa. The crawler is owned by Qinetiq North America as shown in Figure 1.7 which mainly use for Explosive Ordnance Disposal (EOD) Hull inspection.

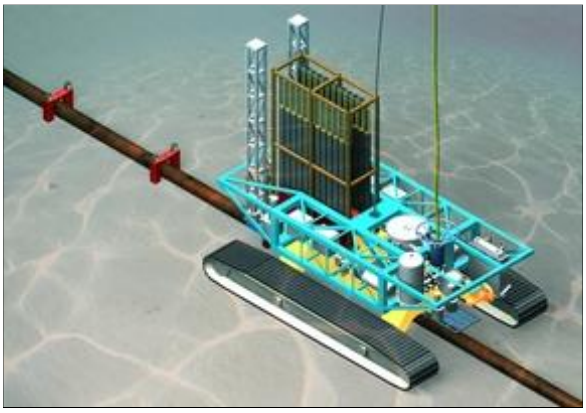

Figure 1.6: Subsea crawler for oil and gas pipeline constructions [14].

Figure 1.7: Hull Crawler by Qinetiq North America [15].

1.3 Problem Statements

The ROV is widely use in sea exploration. Even that so, it has limitations regarding on usage on the seabed. This ROV just at the certain depth and cannot operated in the cluttered environment as expected and direct contact with the seabed. Besides that, the ROV will cause sediment or mud on the seabed to shake and reduce visualization. It is also unstable due to the effect of environmental disturbance such as sea waves, current and unexpected underwater condition.

Investigation have been done in designing an unmanned underwater vehicle (UUV). The most problems are more regarding on the reliability of the UUV to work underwater without any glitch. Tadahiro Hyakudome (2011) from the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) [7], Japan has listed a few problems in designing a UUV such as the seawater and water pressure environment, sinking capability, power unit and controller design. The author also stated that:

> *"When such underwater vehicles are made, it is necessary to consider about the following things such as seawater and water pressure environment, sink, there are no gas or battery charge stations, Global Positioning System (GPS) cannot use and radio waves cannot be used."*

The main concern of the problem is regarding on the underwater pressure environment. The deeper we go, the higher the pressure exerted to the ROC structure. The pressure increase by 10 bars or 1 ATM for every 10 meter dive. The density of the water also influences the pressure exerted. Hence, it is important to determine the pressure exerted so that the structure will not collapse or buckling. Besides that, the underwater environments are unpredictable. Underwater conditions can change anytime. Climate can affect the tides of the shore, waves, temperature and wind. Without proper design and material selections, the structure of the ROC can damage.

Designing a frame and determine the best material could give a headache. From the journal written by researchers in Ocean Engineering at Florida Institute of Technology, USA, they tested every frame's design using many type materials. Modification and strengthening of the frame was necessary after cracks were discovered in several welds of motor support. Adding ribs to the outer frame support between the main frame of the crawler and the motor housing frame made of 1/4" 6061-T6 aluminium solved this issue [8]. The stress on the frame must be considered and choosing the best materials are required. The materials must be lightweight yet strong enough to support the ROC motor and components and withstand the force and pressure. Some materials to be considered in the design are titanium, carbon fibre and aluminium.

Besides that, the design should be hydrodynamic in order to reduce drag and power usage. Based on the conference paper by researchers of Department of Marine Science & Engineering, Malek-Ashtar University of Technology, Iran at International Conference on Underwater Technology (USYS'12), they discussed on the resistance effect on the body of a submarine within different design. They concluded that the lower the resistance, the higher speed generated [9]. The ROC design by another manufacturer is basically using a chain type wheel. This type of wheel increases the tractions and suitable in any condition of sea floor.

Since there is no energy supply beneath the water surface, power source becomes one of the main issues to consider. Designing, development and research of the power source, following things need to be considered:

1. Size and light weight
2. Resist to pressure and water
3. Reliability to supply enough power
4. Maintenance of the power unit (rechargeable or not)
5. Power capacity
6. Low vibration and produce noise

For communication, radio wave is not usable in the sea or underwater. However, it is crucial for ROC or ROV to communicate with the support vessel. The effective method of underwater communication is acoustic telemetry. There are analogue and digital communication for acoustic telemetry [7]. The controller for some ROC design split into two analogue and digital. The analogue use relays while digital uses an Arduino micro-controller. The usage of cables gives less mobility to the ROC since the seabed is not flat and have obstacles.

Basically, from the review of JAMSTEC journal, most power source is the heaviest unit of the vehicle. When the power source becomes big in proportion to scale up of the body, maneuverability and energy efficiency worsen. Low vibration and low noise produce is important so that it will not interfere acoustic equipment and communications devices [7].

1.4 Objectives

The purposes of developing an unmanned underwater Remotely Operated Crawler (ROC) as follows:

1. To design and analysis of unmanned underwater Remotely Operated Crawler (ROC) using CAD software.
2. To develop a Remotely Operated Crawler (ROC) based on the selected design.
3. To analyze the movement and maneuvering of the Remotely Operated Crawler (ROC) underwater and on land.

1.5 Scopes and Limitations

Scopes for this project are limited into few aspects. First, the crawler will have two degrees of freedom (DOF) for the maneuverability. Then, upon completion, the crawler will be tested on the hard surface underwater bed. The motions of the controller will be designed as forward, reverse, left and right movement. The design specifications are based on the scope drafted which are the operation depth is more or less than 5 meters. The control range of the crawler are strictly depends on the length of the connection cord and the pressure to withstand is about more than 0.5 bars. The crawler must be water and shock resistance and durability in term of maneuverability and movement, either on the land or underwater. The flow of the design is shown in the Figure 1.8 which is the K-chart of the flow of the design.

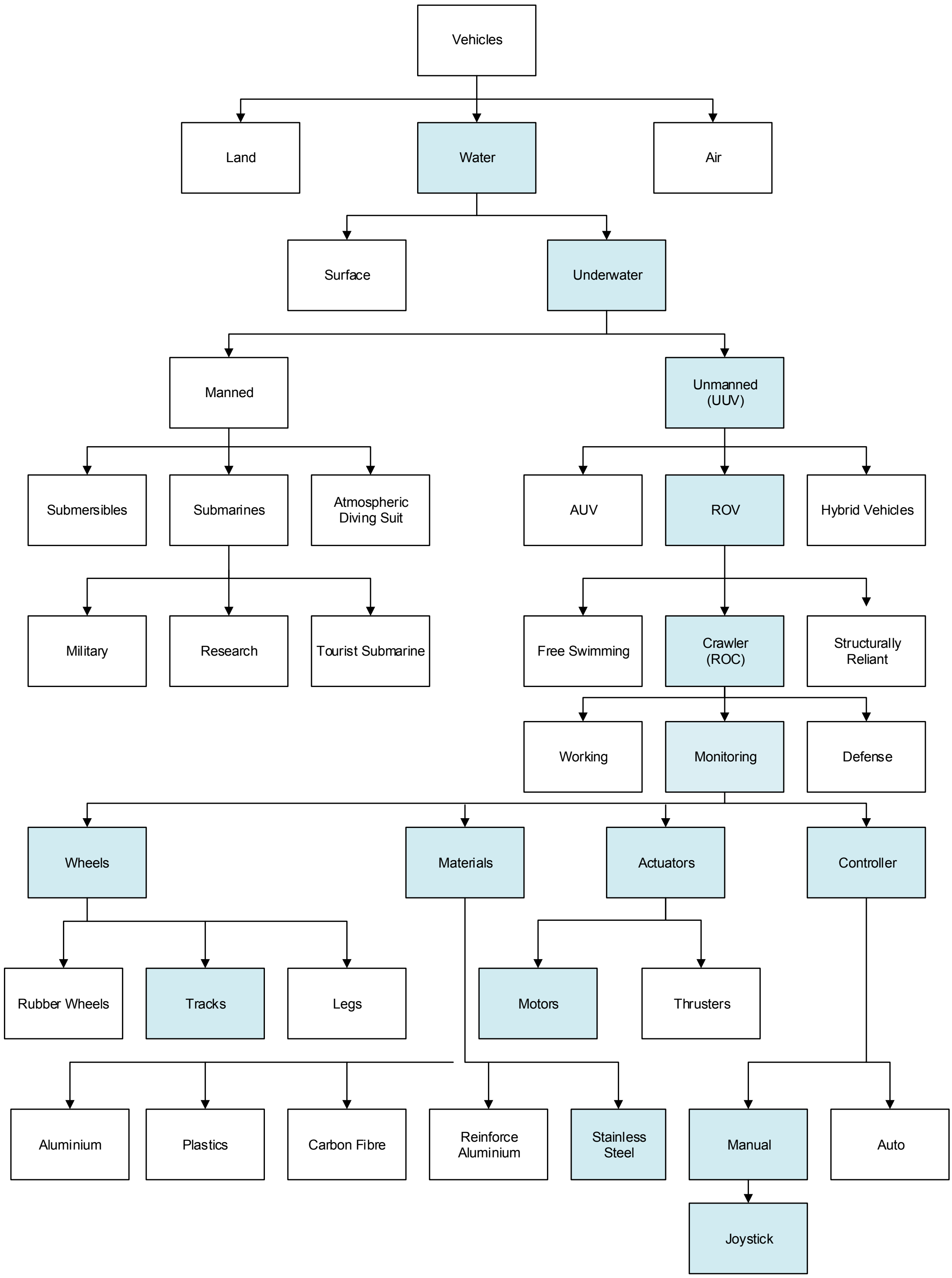

Figure 1.8: The K-Chart of the Project Design.