DEVELOPMENT OF A REMOTELY PILOTED AIRSHIP SYSTEM FOR MONITORING AND TRACKING WILDLIFE IN THE WOODLAND

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ABSTRACT

Previously, the surveying and monitoring were done using existing ground-based techniques, for example camera traps installation in the hot spot areas and footprint observation which are potentially imprecise and fallacious and difficult to verify. Besides, surveying threatened and is invasive towards the species making efforts protect the population becoming more challenging as it requires a substantial amount of time and resources invested in the project. After years of studies, the experts came out with UAVs innovation ideas for monitoring and tracking, hence this project is another study for the UAV to implement this technique for that very purpose. The primary objective of this project is to develop a proof of concept for the Unmanned Aerial Vehicle (UAV) flight platform. This project deals with the control of lighter-than-air aircraft which is a non-rigid airship otherwise known as blimp, more specifically focusing on the design of the embedded hardware and software built onto the airship. This system was developed to monitor and track the wildlife in the woodland. UAVs were chosen because it can potentially increase the results accuracy, is human-risk free, and a cheaper platform of aerial surveys.

The challenge for this project was the development of the control flight system and also the navigation and communication control system for the airship. The objective required extended knowledge of electronics and mechanical propulsion. This project was done according to the subsystems which complement the main airship system. The design for the components performance were done up prior to selecting the right components to serve its purpose. Moreover, an electronics system for unmanned flight was designed and built onto the gondola. Then, the systems were integrated as one complete system.

In order to verify the effectiveness of the control system, several tests were done once the system was fully integrated. The purpose of the tests was to observe the performance of the system before going forward with the flight test. The tests were done at different conditions of the performance. Moreover, for the communication system, the experiments were carried out in order to receive video in real time of the subjects to accomplish the objectives. The purpose was to see how effective and feasible the system would be in order to proceed with the mission.

ABSTRAK

Sebelum ini, pengukuran dan pemantauan telah dilakukan dengan menggunakan teknik berasaskan tanah sedia ada, sebagai contoh pemasangan perangkap kamera di kawasan titik panas dan pemerhatian jejak yang berpotensi tidak tepat dan mengelirukan juga sukar untuk disahkan. Selain itu, proses pengukuran mengancam dan juga bersifat invasif terhadap spesies, menjadikan usaha untuk melindungi populasi menjadi lebih mencabar kerana ia memerlukan sejumlah besar masa dan sumber yang dilaburkan dalam projek itu. Setelah kajian bertahun-tahun lamanya, pakar-pakar mendapat ilham idea-idea inovasi UAV untuk fungsi pemantauan dan pengesanan, dengan itu projek ini adalah satu lagi kajian untuk UAV bagi melaksanakan teknik pemantauan dan pengukuran tersebut sebagai tujuan utamanya. Objektif utama projek ini adalah untuk membangunkan satu bukti konsep bagi kenderaan udara tanpa pemandu (UAV) sebagai sebuah platform penerbangan pemantauan dan pengukuran. Projek ini berkaitan dengan kawalan pesawat ringan daripada udara yang merupakan kapal udara bukan tegar atau dikenali sebagai *blimp*, dengan pengkhususan secara utamanya diberikan kepada reka bentuk perkakasan terbenam dan perisian dibina ke kapal udara. Sistem ini dibangunkan bagi tujuan memantau dan mengesan hidupan liar di hutan. UAV telah dipilih kerana ia berpotensi boleh meningkatkan ketepatan keputusan, adalah bebas risiko manusia, dan bentuk tinjauan udara yang berkos rendah.

Cabaran bagi projek ini ialah pembangunan sistem kawalan dan navigasi penerbangan juga sistem komunikasi untuk kapal udara. Objektif projek juga memperlihatkan kepentingan pengetahuan lanjutan elektronik dan dorongan mekanikal bagi menyelesaikan projek. Projek ini telah dilakukan mengikut aturan subsistem yang melengkapkan sistem kapal udara utama. Reka

bentuk untuk menetapkan tahap prestasi komponen telah dilakukan terlebih dahulu sebelum memilih komponen yang bersesuaian dengan fungsinya. Selain itu, sistem elektronik untuk penerbangan tanpa pemandu telah direka dan dibina ke dalam *gondola*. Kemudian, sistem telah diintegrasikan sebagai satu sistem yang lengkap.

Untuk mengesahkan keberkesanan sistem kawalan, beberapa ujian telah dilakukan sekali selepas sistem itu bersepadu sepenuhnya. Tujuan ujian tersebut adalah untuk melihat prestasi sistem sebelum meneruskan dengan ujian penerbangan sebenar. Ujian telah dilakukan pada keadaan yang berbeza kondisinya. Selain itu, bagi sistem komunikasi, eksperimen telah dijalankan untuk menerima video subjek dalam masa nyata bagi mencapai objektif. Tujuannya adalah untuk melihat keberkesanan dan bagaimana sistem boleh dilaksanakan bagi meneruskan misi.

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Fellow Friends and seniors

DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed ………………………………………………………………………. (candidate)

Date: 5th June 2017

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Other sources are acknowledged by giving explicit references. Bibliography/references are appended.

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I hereby give consent for my thesis, if accepted, to be available for photocopying and for interlibrary load, and for the title and summary to be made available to outside organization.

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LIST OF SYMBOLS

F	Force
m	Mass
g	Gravitational force
ρ	Density
V	Volume
a	Acceleration
W	Weight

ABBREVIATIONS

GPS	Global Positioning System
GNSS	Global Navigation Satellite System
ESC	Electronic Speed Controller
APM	ArduPilotMega
HvLi	High voltage Lithium Polymer
UAV	Unmanned Aerial Vehicle
BLDC	Brushless Direct Current Motor
RPM	Rotation per minute
CW	Clockwise
CCW	Counterclockwise
LiPo	Lithium Polymer
GCU	Gimbal Control Unit
RF	Radio Frequency
CPU	Central Processing Unit
UART	Universal Asynchronous Receiver/Transmitter
IMU	Inertia Measurements Unit
RC	Remote Control
RC	Radio Control

CHAPTER 1
INTRODUCTION

1.1 OVERVIEW

This thesis is the documentation of the research on the development of remotely piloted airship system. It includes the study concept, the system design, system integration and method used on the blimp for monitoring and tracking.

1.2 CURRENT ISSUE

Between 1970 to 2000, the populations of many species have decreased by 40% on average which is a large number and the extinction of the population doubled due to crimes against wildlife [4]. Moreover, the profitable gains for the trade increased up to $10 billion annually and this makes the number of the illegal killing and trading to further expand. The endangered species or also known as some of the world's best-loved species which includes elephants, rhinos and tigers are now at stake due to the increased demand for tiger parts, rhino horns and elephant tusks for ivory [5]. Now, even bees are also categorized as endangered species and there is nothing left that people can do but to protect these animals since crimes against wildlife and nature have grown more severe. Hence, here comes the new solution to improve the process of tracking and monitoring these animals. However, there are still more to do in UAVs research.

1.3 REMOTELY PILOTED AIRCRAFT

Remotely piloted aircrafts have many new opportunities which made the experts and scientists conduct extensive research on them. There are numerous designs for UAVs and the differences of those UAVs are their capabilities, physical size and power, payload capacity, range and operating altitude making them suitable for various purposes [32]. The size of the UAVs defines the applications of the UAVs. Mackenzie (2009) has published the various different classification schemes for UAVs that exist and it has been simplified into four main types in as shown in Table 1.3. They are used in surveying industry for surveying product by collecting aerial images for example map and elevation models.

Size	*Characteristics*	*Payload size*	*Operational constraints*	*Example platforms*
Large	Large operating range (~500 km); long flight time (up to 2 days); medium to high altitude (3–20 km)	~200 kg internally and ~900 kg in under-wing pods	High set-up and running costs; requires ground-station support, full aviation clearance, long runway for takeoff and landing, hangar for storage; altitude ceiling above commercial air traffic	NASA *Ikhana* 
Medium	Large operating range (~500 km); medium flight time (~10 hours); medium altitude (< 4 km)	~50 kg	Similar requirements to large UAVs but with reduced overall costs, reduced requirements for takeoff and landing, and easier control	NASA SIERRA 
Small and mini	Small operating range (< 10 km); low endurance (< 2 hours); low altitude (<1 km)	Less than 30 kg (small); up to 5 kg (mini)	Line-of-sight flight only; largely fixed wing; simple launch gear and minimal landing/takeoff requirements; flown by flight planning software or by direct radio control	Quest UAV 
Micro and nano	Small operating range (<10 km); very short flight time (<1 hour); very low altitude (< 250 m)	Less than 5 kg	Hand-launched; line-of-sight flight only; soft landing place required; usually copter-type UAVs with rotor blade control; flown by flight planning software or by direct radio control	AR-Drone Parrot 

Table 1.3 : Classes of UAVs platforms with indicative examples

Remotely Piloted Aircraft System (RPAS) is different with another UAVs in terms of flight time, control system, load capacity and shaping [32]. The classification of RPAS are based on their autonomy, autonomous (fully pre-programmed), semi-autonomous (with the opportunity to intervene) and manual (fully controlled by a pilot) aircrafts. UAVs were used for critical condition tasks such as isolated, dangerous and inaccessible environments to collect the information and data on relatively large areas. Besides, they are possible to reduce the safety risks due to low speed, low altitude, cost-effective and no lives are at stake [17].

1.4 AIRSHIP SYSTEM

Airship has been used since decades ago as a flight platform. The major use of the airship back then was for surveillance and also as a bomb-dropping device. UAVs have proven that they can do a better job than manned aircraft during the operations for example in the Kosovo conflict. Obviously, for unmanned aircrafts, the life risk of the pilot that normally exposed to can be reduced. Previous studies have shown that, there are hundreds of applications that use UAVs such as quadcopter, drone or even a small size aircraft for specific purposes. In this sense, the airship is the most suitable aerial vehicle to be used as a monitoring system because the normal airship, the fastest it can fly is about 50 km/h against the wind which is quite slow in comparison. Moreover, the airfoil-shaped airship is designed in order to improve the buoyancy, the upward force, and lift. The lift gained from the envelope which is filled with Helium gas, a lifting gas that is less dense than the surrounding air. In the early 1900s the Hydrogen gas was used before it was completely banned due to some incidences due to the lifting gas thus the people back then switched to using Helium gas because it is not flammable making it a safer alternative than Hydrogen. Hence, using this advantage the power consumption can be reduced because when the airship is in static there is necessary power needed and the power can be turned OFF for the momentarily. Below is the table of comparison of blimp with fixed and rotary wing as shown in Table 1.4.

Parameters	Blimp	Fixed Wing	Rotary Wing
Cost	Low	High	High
Power Consumption	Low	High	High
Noise Signature	Low	Moderate	High
Stationary Surveillance	Low	Incapable	Capable
Environmental Susceptibility	High	Low	Low
Profile Size	Large	Small	Moderate

Table 1.4 : Comparison of blimp with fixed wing and rotary wing

As can be observed from the table above, it can be seen that blimp has more advantages compared to other flight platforms which makes it suitable for the mission. Besides the low-cost advantage, the blimp also consumes low power, low noise and is capable of stationary surveillance. However, the concern also sees that the blimp is more sensitive to the environment particularly wind disturbances and is also quite large in profile size. Back to the problem statement which is to monitor and track the wildlife, in the animal's sense, the animals are sensitive to the human scent which makes human existence within their vicinity known to them. Hence, by using the airship human scent and sound will be eliminated thus making it easier to track the animals without disturbing their habitats.

The challenge in designing an airship is to make sure the airship's ability to stabilize under the wind disturbance [11]. Besides, the overall weight also plays an important role in order for the airship to rise upward and carry the payload. Hence, the objective of this project would be to research and develop a remotely piloted airship system complete with a communication system.

1.5 MOTIVATION

Other UAVs were commercialized worldwide for many purposes in many fields including agriculture and also photography but airship is still not well known yet. Furthermore, there were so many qualifying experiments that have been done for the animal surveying in other countries such as surveying marine fauna [6]. One of the reason why airship was not used for wildlife monitoring is because in Malaysia, the forest is covered with tall trees known as canopy but this may be solved using high resolution technology such as thermal imaging and also wave communication. The research is to start the first step to develop the system thus in future it may have an autonomous airship system and the technology can be used worldwide. There are so many aspects that need to be considered before the airship can be launched up into the sky and also the system must be close to zero in terms of error. Besides, the airship must be rigidly stable to counter the wind disturbances. The system also must be able to transmit data. In order to achieve good performance of the airship, it is crucial to study the environment characteristic as well as airship characteristic. Moreover, knowledge in electronics and mechanical are also needed throughout this project. For the record, to make something bigger, the fundamental concept must be understood first because everything starts from the basic.

1.6 PROBLEM STATEMENT

Current monitoring techniques are remote photography, camera traps, tagging, GPS collaring, scat detection dogs, and DNA sampling which are considered investment in time and resources [23]. Besides, these techniques have ability limitation to provide accurate and precise population estimates [24]. Moreover, there are some challenges in monitoring wildlife including large size of species' geographic ranges [25], inaccessible habitat [26-27], elusive behaviour [28], low population and sensitivity to disturbance [29]. Furthermore, the increase in availability of low cost UAVs has open up new opportunity to the experts to use this platform to monitor wildlife and hack the challenges in order to get the accurate estimation of species in abundance. However, one of the most important restrictions, is to develop or apply advanced automated image detection algorithm designed for this task [4]. In order to design the automated system, the manual system needs to be discovered first to see how the system functioned and here is the purpose of this project.

1.7 OBJECTIVE

The main objectives of this project is to develop a remotely piloted airship system, generate and develop surveillance and communication systems. System tests were conducted to analyze the functionality of the system before they were integrated. The tests were done on the control system and also on the communication system.

1.8 THESIS ORGANIZATION

This paper consists of five chapters. In Chapter 1, there is the introduction part which includes of some overview on the previous and current situation and also a bit on airship. Then, in Chapter 2, the literature review is presented to highlight the systems based on the significant findings obtained from past studies that relevant to the current study. Next, chapter 3 presented the theory and methodology of the project. Chapter 4 is results and discussion and Chapter 5 is conclusion. After Chapter 5 there will be appendix and also references.

CHAPTER 2

LITERATURE REVIEW

This chapter includes the findings obtained from previous studies and researchers which is relevant to the current research. There are three sections to this chapter. In the first section, it discussed about the current methods used for monitoring and tracking. Then, in second section, it was about the UAVs used for monitoring and tracking. It discussed about the UAVs, the systems and also the tasks that were done on that particular flight platform. Third section discussed about the previous work that used airship for monitoring and tracking. In last part is summary for this chapter. The flow diagram below is the overview of this chapter as given in Figure 2.1.

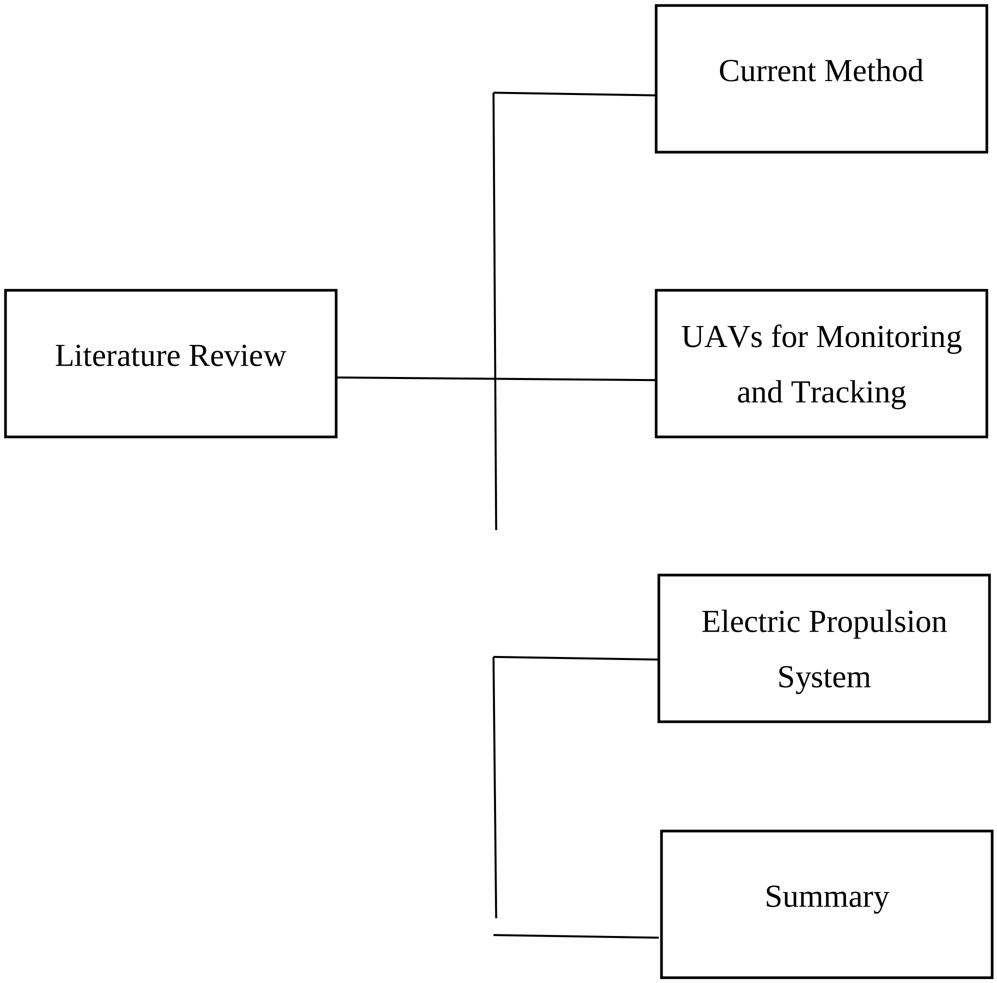

Figure 2.1 : Chapter 2 Overview

2.1 CURRENT METHOD

A. CAMERA TRAP

Since decades ago, camera trapping was a popular method to determine the presence of a species in a certain study area (Rovero et al. 2010; Pitett & Bennett 2014). This method has shown to be particularly useful to determine species richness in rainforest ecosystems (Tobler et al. 2008; Srbek-Araujo & Chiarello 2005). Due to the animals' low density and secretive nature, traditional tracking method like scat collection, track plots, line transects or direct observation, and point counts (Sunarto et al 2013) is unreliable and high cost to implement it across large landscape lacking infrastructure like the Amazon (Long et al. 2008; O'Connell et al. 2011). On the other hand, camera trap method used simple materials and low complexity made the camera trap stations easily deployed on a cost-efficient base. Camera trap is one of non-invasive survey method which opened possibilities for experts to study terrestrial wildlife without much effort in space and time (Long et al. 2008). Figures below show the example of camera trap used in the forest.

Figure 2.1.1 : used in 1956. Lens was protected by a sunshade and speed graphic weather-proofed with plastic [33]

The result of nine camera nights of work from the camera trap above is shown in figure below.

Figure 2.1.2 : White-tailed deer was captured on the camera [33]

Below shows the result from a camera trap study captured in 2014 [34].

Figure 2.1.3 : P. onca captured at camera trap location Cam 16 Phase 1 Reserva Matses (during rainy season) taken with Bushnell Trophy HD 8 MP) [4]

There are some advantages and disadvantage of camera trap method [35] as shown in the table below.

Advantage	Disadvantages
Low labour - Easy to set up & function for weeks without attention	Relatively expensive (but getting more affordable) - Up to $650/camera
Operate in inhospitable environments - Weather and terrain - Monitor large area	Need regular maintenance & malfunction can go unnoticed - Damage - Theft or vandalism
Robust data -Photographs/videos provide a permanent, verifiable record	Requires sufficient knowledge of survey and equipment - Mistakes in setup can mean expensive loss of data
Bonus - Educational and promotional material	May only observe a relatively small area and species/behavior not always clear

Table 2.1.1 : Advantages and disadvantages of camera trap method

Due to the advantages, camera traps have been used to photograph and identify animals in remote area of the world for many years (O'Connell et al. 2011; Karanth et al. 2004 in Thompson 2004). There are some applications of camera trap such as biodiversity and community composition, species' distribution and abundance, ecology and behaviour, conservation management, lower enforcement, human wildlife conflict, and education and citizen science [35]. Camera trap provided physical evidence in the form of image and allow an accurate species determination. Using the information, the species composition in the particular area can be assess also help the experts and researchers to understand the communication between the species (Rovero et al. 2014; Pitett & Bennett 2014).

2.2 UAVs USED FOR MONITORING AND TRACKING

Unmanned Aerial Vehicle (UAV) has been widely used in many applications such as agriculture, mapping and geophysical exploration as flexible aerial photography platform [8]. This method provided high-resolution images which made large-scale mapping possible. Current examples of UAVs use are for wildlife management include monitoring sea turtles [27], black bears, large mammal [18], wildlife radio collar tracking [7] and supporting anti-poaching operations for rhinos [22]. UAVs can record high resolution videos and capture images much closer to the animals with the help of digital and thermal imagery sensors with fewer disturbances [9]. Jones et al. has conducted a test that involved gathering wildlife video and imagery data from more than thirty missions over two years. The test concluded that UAV could overcome safety, cost, statistical integrity and logistics issues associated with manned aircraft for wildlife monitoring. Another advance technology in this field includes autonomous tracking of radio-tagged wildlife [7].

Conventional ground surveys on foot needs time-consuming, high cost and nearly impossible to achieve in remote areas for example ground surveys of orangutan populations in Sumatra, Indonesia can cost up to $250,000 for a three-year-survey cycle [8]. Furthermore, there are many remote forested areas that have never been surveyed. Aerial surveys potentially can overcome some of these constraints although they have their own limitation including high cost of buying or renting a small planes or helicopters, lack of availability in remote areas and the risk involved with flying low over landscape [25]. Basic operation of the UAVs are, these vehicles follow flight plans based on GPS coordinates which are usually programmed before the flights but can be changed during the flight. Some of the UAVs are affordable and easily converted into another UAV with highly affordable open source autopilots like Ardupilot [20] or Paparazzi [19] Below is the example of aerial surveying results as in Figure 2.2.1. Figure 2.2.2 show the conservation of evaluation pipeline [28]. In the figure shows that animals are recorded on video or individual images. The animals are automatically detected, yielding a bounding box per animal per image. Individual detections are stitched together by tracking shared features to obtain an automatic estimate on the number of animals.

Figure 2.2.1 : Animal conservation images taken from a drone. From left to right : an elephant, an orangutan nest, and rhinos [8]

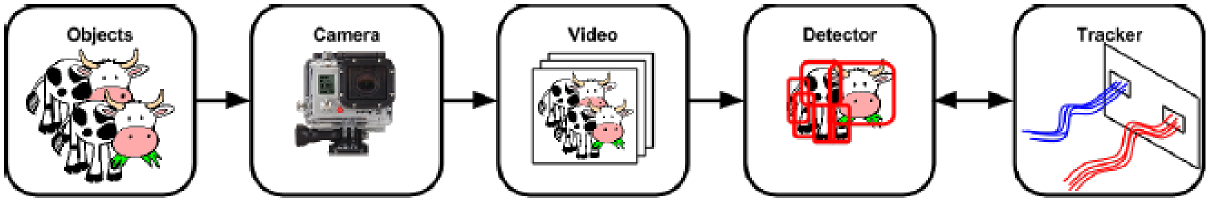

Figure 2.2.2 : Conservation evaluation pipeline

2.3 ELECTRIC PROPULSION SYSTEM

The usage of electric propulsion in UAVs has been increasing. However, there were something lacking in the terms of the benefits of the dynamic model which could be used to optimize design, configuration and flight profiles. The electric propulsion would use the torque and RPM from the requirements generated by the aerodynamic model and provide the desired electric propulsion system [19]. Furthermore, for this electric propulsion system, it consists of electric motors which function as the powerplant, propellers, electronic speed controller and also battery and all of these need a continuous source of electricity. Plus, electric motors are widely used because they are easy to understood which is simple in concept and operation also low cost according to economic scale [19]. Below are the advantages and disadvantages of the electric motor based system [18] tabulated in the Table 2.3.1 :

Advantages	**Disadvantages**
Electrically powered	Electromagnetic interference
Low maintenance	Requires large currents
Reliable	Potential sensitivity to water and other conductive liquids
Robust	
Less issues surrounding overheating as opposed to thermodynamic engines	
High torque	
Scalability	
Less noise	

Table 2.3.1 : Advantages and disadvantages of electric motor

They are also easy to obtain as they are already commercialized worldwide. There are two categories for the electric motor which are brushless direct current motor (BLDC) and conventional (brushed) direct current motor. Below are the figures for BLDC and conventional DC motor.

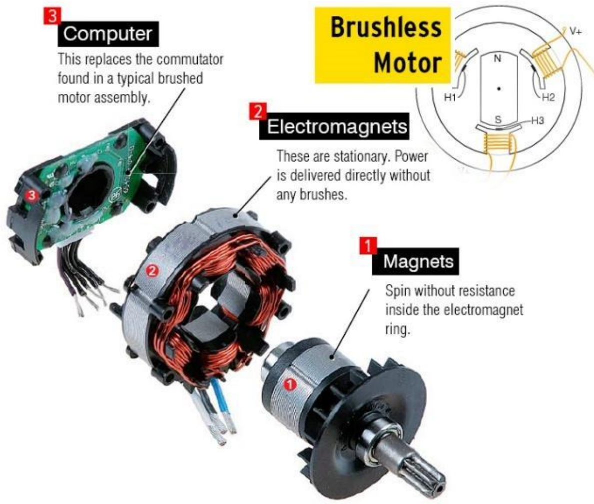

Figure 2.3.1 : Configuration of BLDC motor

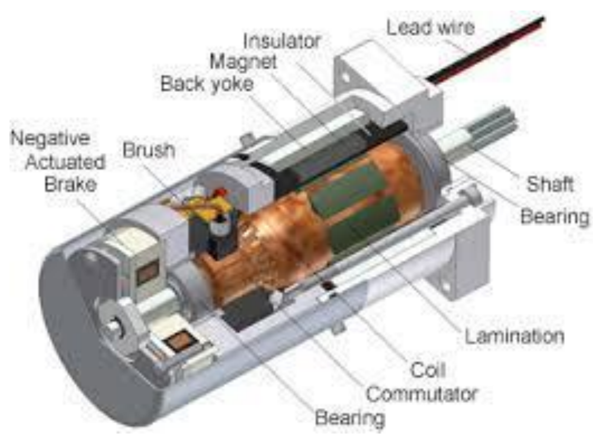

Figure 2.3.2 : Configuration of conventional DC motor

The conventional DC motor functions when the brushes make mechanical contact with the components of electrical contacts on the rotor, creating an electrical circuit between the DC electric source and also the armature coil windings allowing electrical power to continuously flows through the armature coil [18]. Furthermore, for the BLDC motor, it used solid state instead of than a commutator and the electromagnets do not move instead the permanent magnets rotate and the armature remains static. In contrast, for this project the BLDC motors were used because of the easy connection and more efficiency than conventional DC motors. There are some advantages of BLDC motors which are high dynamic response, high efficiency, long operating life, noiseless operation and higher speed ranges [20].

2.4 SUMMARY

Every system that developed by the experts has its own characteristics because it has different application. The system may be complicated with the advance technology applied in it. In order to build a system, the basic knowledge needs to dig in because the complex system starts with the basic system. Besides, there are so many new applications for UAVs and the systems were built according to the purposes.

CHAPTER 3

METHODOLOGY

This chapter presented the fundamental theories and methods that have been implemented in this project. First and foremost, the system used in the project has two segments which are airborne and ground segments. The chapter is divided into five subsystems which are blimp, electric propulsion, payload, communication, and structure. Plus, under these subsystems there are several elements are then that combined together to make every subsystem complete and function. Trade analysis was done on certain components. For the first subsystem which is the blimp, it discussed about the motion of the blimp, the characteristics and mechanism as well as the use of the Helium gas. In the second subsystem which is electric propulsion system discussed about the functionality of all the components and how to select the components according to the requirements. Besides, the selected components are shown under the subsystems. Furthermore, for the third subsystem which is the camera as discussed below, talks about the function and also the mechanism. The fourth subsystem is important as it includes transmitter and receiver, antenna, GPS, microcontroller, flight control and also sensor. Under this subsystem, the theories about the components are discussed as well as how to choose the components in order to get good performance in transmitting the data gathered. In the fifth subsystem, it is about the structure which is the housing. The characteristics of the housing and also the importance of the housing is discussed under this subsystem. The outline of this chapter is summarized in the flow diagram in Figure 3.1.

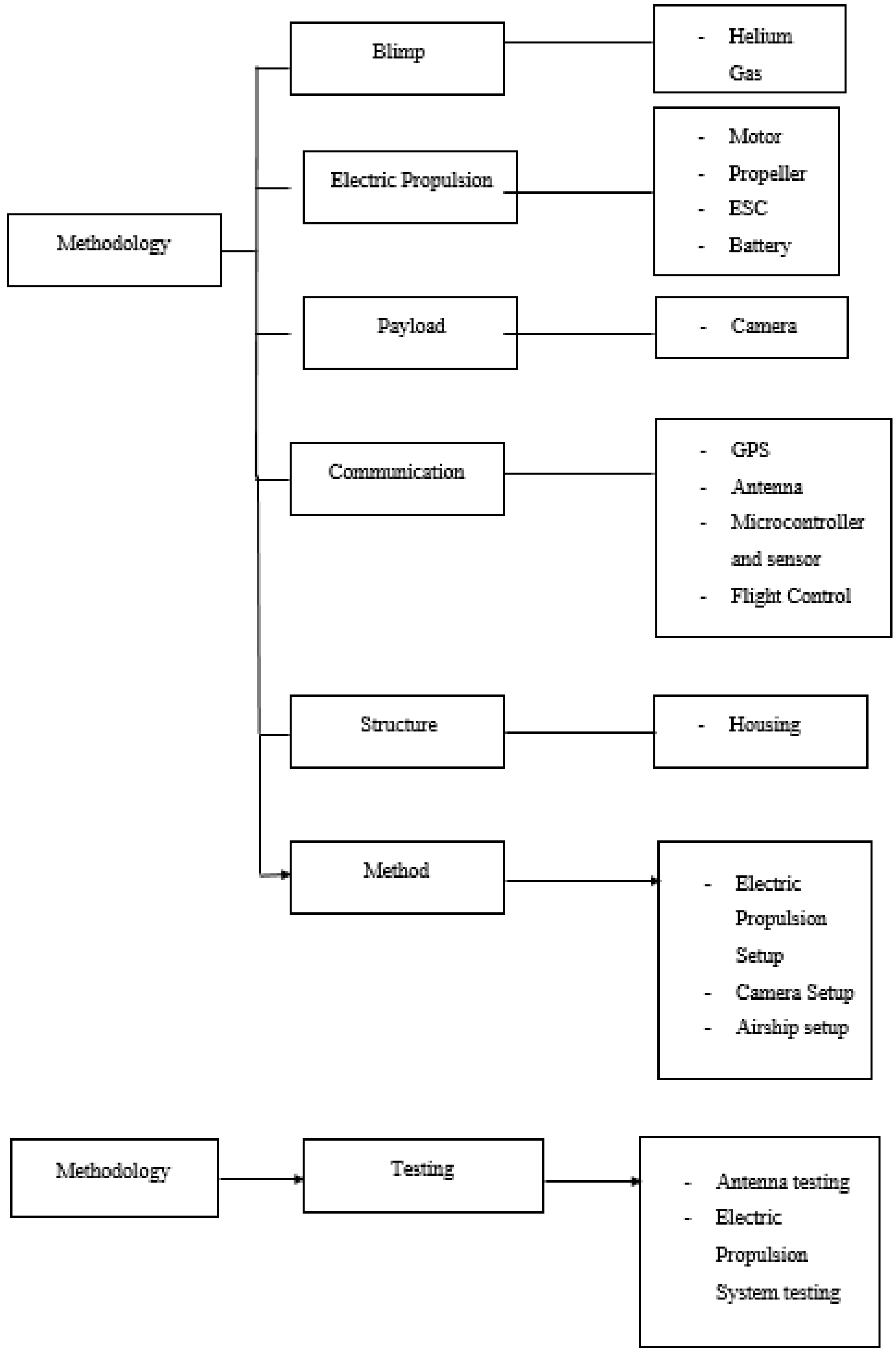

Figure 3.1 : Overview of Chapter 3

3.1 SYSTEM ARCHITECTURE

The system for UAVs have two segments which are onboard (airborne) station and ground station as shown in Figure 3.1. Plus, for the onboard station, it includes electric propulsion for the UAV, navigation system, surveillance apparatus (camera) and gimbal system, sensors and communication system used to transmit data. On the other hand, the ground station consists of ground station software (in laptop), datalink and receivers, and control receiver. The airship weighs approximately 3 kg. In Appendix A shows the weights of components which necessary for remotely piloted flight.

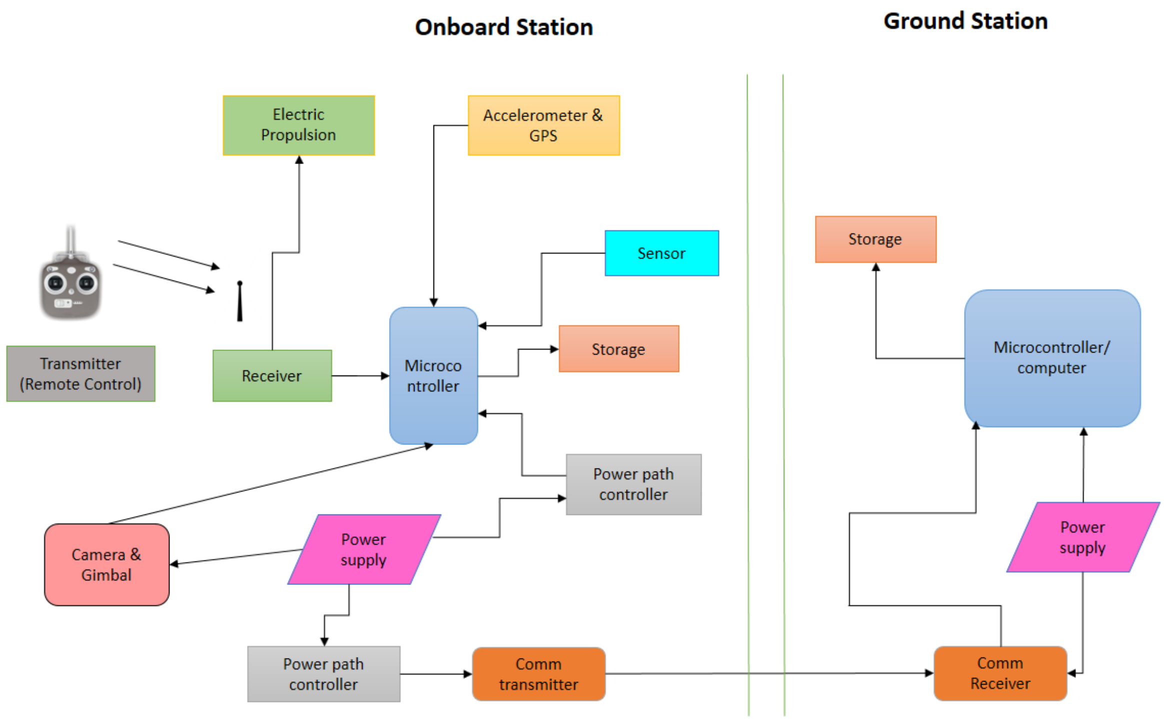

Figure 3.1.1 : Onboard and ground stations system block diagram

3.2 BLIMP

Particularly in airship, the blimp or envelop is the main and biggest part of the body to generate lift force. The airship gains lift from three different sources as shown in Figure 3.2.1. The sources are aerodynamic lift (generated by body hull shape), vectored thrust (four diesel engines, mainly used for take-off and landing), and aerostatic lift (generated by helium contained within craft).

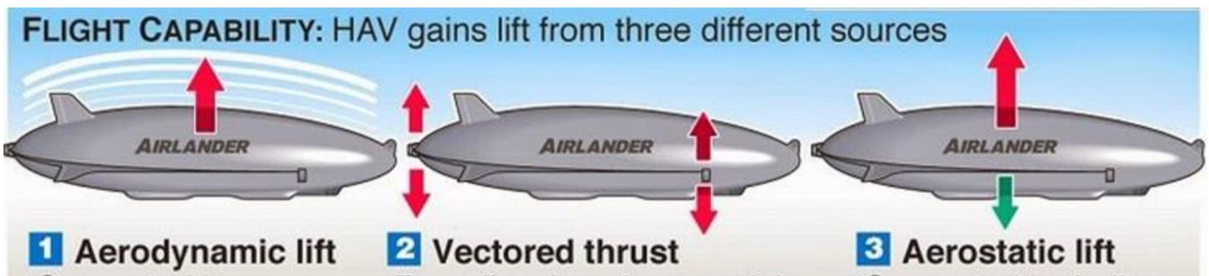

Figure 3.2.1 : Lift force sources

For UAV airship, the main source of lift is the aerostatic lift or buoyancy. This is from Archimedes' principle: when a body is immersed in a fluid, it will experience a force proportional to the volume of the displaced fluid in the opposite direction of its weight. The Archimedes' principle is illustrated in Figure 3.2.2.

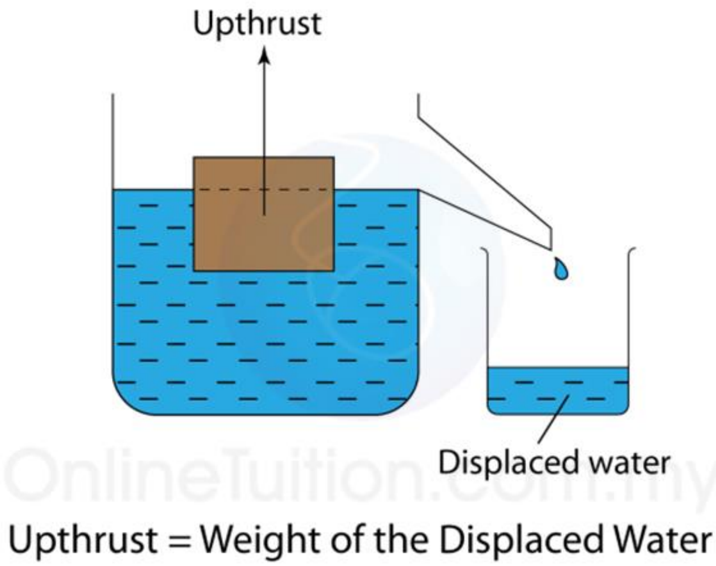

Figure 3.2.2 : Archimedes' Principle

Where,

Buoyant force = weight of liquid displaced

Therefore,

$$F = mg = \rho V g \qquad \text{(Eqn 3.2)}$$

Concern in airship, the airship is inflated with helium (properties of Helium gas is shown in Table 3.2.1) which is a low-density gas than the air surrounding. Because of the large volume of air displaced by the airship, a substantial force is generated. When the buoyant force is greater than the total weight of the airship hence the airship will rise. Due to this, the dynamics of the airship is different with that of other aircraft. The addition in mass and inertia effects changed the airship's dynamic which is much sensitive to wind. Moreover, for the aircraft which is weight less than air, the mass and inertia of air are neglected however particularly in airship, these effects cannot be neglected on the dynamics. Thus, the airship can be maneuvered using this method and this makes the UAV airship to have the ability to be an ideal platform for many applications which includes, surveillance, climate research and terrain mapping.

Specifications	**HELIUM**
Specific Volume	6.06 m3/kg
Density	0.165 kg/m^3
Molecular Weight	4.00
Inflammable	Non-Flammable
Weight of Lifting Gas	46.88 N
Net Lift	292.78 N

Table 3.2.1 : Helium gas properties

3.2.a BLIMP SELECTION

For the project, the blimp selection is done after all of the other components are selected. The element that needs to consider is the total weight of the system. Every single component needs to be included because the weight is very crucial. The lesser the weight the better it is because one of the goals for aircraft design is to reduce the weight. After the total weight of the overall systems have been calculated then only the airship, blimp or envelop can be purchased. For this project, the overall weight is estimated to be about 3 kg including the camera gimbal.

Size	15-Foot Blimp	17-Foot Blimp	20-Foot Blimp	24-Foot Blimp	26-Foot Blimp
Length (m)	4.572	5.000	6.096	7.3152	7.9248
High (m)	1.524	1.800	2.134	2.7432	3.3528
Volume (m^3)	5.230	7.600	10.760	28.317	33.980
Net lift force (kg)	1.814	3.600	4.989	22.679	27.216
Helium used to fill up (tank)	Less than 1	1	1 ½	3 ½	4

Table 3.2.a : Comparison of blimp on various size

Before purchasing the blimp, the details of the blimp are checked. Firstly, the weight or the net