"I admit that I have read this report and I found that it is suffice from the aspect of scope and quality for the award of the Bachelor Degree of Mechanical Engineering (Design & Innovation)"

Signature : .....

Supervisor Name : SHAMSUL ANUAR SHAMSUDDIN

Date : 8 MAY 2007

DESIGN, ANALYSIS AND FABRICATE SMALL UAV PROTOTYPE FOR DEFENSE SECTOR

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A project report is submitted to the Faculty of Mechanical Engineering in partial fulfillment of the requirement for the award of Bachelor Degree of Mechanical Engineering (Design & Innovation)

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

MAY 2007

"I hereby declare that this project entitled **"Design, analysis and Fabricate Small UAV Prototype for Defense Sector"** is the results of my own research except as cited in the references"

Signature : .....

Author : MOHD NAZRI BIN ISMAIL

Date : 8 MAY 2007

To my beloved Mom, Zaliha and Dad, Ismail,
My colleagues in BMCD and my inspiration, Effa Ezzwin.
You all made everything worthwhile.

ACKNOWLEDGEMENTS

First of all, I am greatly grateful to ALLAH the Almighty on His blessings to make this project a success.

I would like to take this opportunity to express my gratitude to Mr. Shamsul Anuar Shamsuddin for his commitment, support, advice, time share and guidance given. His helps contribute lots in order to complete this project successfully. Not forgotten, for all lectures and technicians involves with their invaluable support, shared of information and also their experiences.

Furthermore, I would like to express my appreciation to my family for their relentless support and understanding. Also not to forget are my dear colleagues in UTeM and also my friends in other institutions who always assisted me when I faced difficulties in studies. Without the mentioned and unmentioned parties, it would be hard for me to complete this project successfully and promptly.

I thank you all very much.

ABSTRAK

Projek ini bertujuan untuk membangunkan sebuah prototaip UAV yang bersesuaian untuk sektor pertahan. Projek ini bermula dengan membuat kajian terhadap rekabentuk UAV sedia ada yang telah dibangunkan di seluruh dunia dan mengkaji ciri-ciri rekabentuk yang diperlukan oleh sektor pertahanan. Di peringkat rekabentuk, projek ini dimulakan dengan membuat ketentuan awal rekabentuk, spesifikasi rekabentuk projek (PDS), penjanaan konsep-konsep, pengimbasan/saringan terhadap konsep-konsep, permarkahan konsep, konsep akhir, dan rekebentuk terperinci menggunakan CATIA V5. Analisis di dalam projek ini difokuskan kepada daya aerodinamik dan momen yang dijanakan di atas permukaan yang bergerak dengan menggunakan pengiraan secara manual (melakukan optimisasi rekabentuk untuk mencari airfoil terbaik) dan menggunakan terowong udara maya kepada model. Akhir sekali, projek ini akan menjalankan fabrikasi untuk membuat prototaip tersebut dengan menggunakan kaedah proses pembuatan yang sesuai dan memberi cadangan untuk kajian seterusnya.

ABSTRACT

This project is to develop the new UAV prototype for defense sector. The project is start with studying the existing UAV design that had developed around the world and the design features that needs by defense sector. At the design stage, the project start with an initial estimate, Project Design Specifications (PDS), concept generate, concept-screening, concept-scoring, final concept and detail design using CATIA V5. Analysis for this project is focus on the aerodynamic forces and moment generated on surface by the motion using manual calculation (make design optimization to select the best airfoil) and using a virtual wind tunnel for the model in FLUENT 6.2. Finally, this project fabricates the prototype of the UAV using the suitable manufacturing process and gives a recommendation for further study.

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LIST OF SYMBOLS

SYMBOL	DEFINITION
A	Wing area
AR	Aspect Ratio
CG	Center of gravity
C_D	Total drag coefficient
C_F	Force coefficient
C_L	Total lift coefficient
C_P	Total pressure coefficient
c	Wing chord, A distance
D	Drag
F	Force
g	Acceleration due to gravity
L	Lift
L_W	Lift generate at wing
L_T	Lift generate at tail plane
M	Moment
Ma	Moment at point A
m	Mass
T	Thrust
V	Velocity
W	Weight
x, X	Distance

GREEK	DEFINITION
α	Angle of incident or angle of attack
ρ	Density

ℓ	Lift per unit span
$\sum$	Summation sign

SUBSCRIPT	**DEFINITION**
front	frontal
max	maximum

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Ever since the development of the first Unmanned Aerial Vehicle (UAV) is Sperry's Aerial Torpedo which made its first successful flight on 6 March 1918 at Copiague [6], many others development had been made. At the early stage of UAV development, the UAV is modifying by removing the cockpit and adding the ground control system from the initial fighting aircraft and called as Remote Piloted Vehicle (RPV). Because of that, the size of the UAV is very by same as the fighting aircraft. Nowadays, UAV is design to be UAV and the size of UAV is going smaller (micro UAV is less than 6 in. in any dimensions) but the performance is increase following the purpose of the UAV. The most argument for development UAV in defense sector is to save lives. In every development of new weapon systems, one of the most important objectives is to minimize the risk to the human operator. Other purpose for UAV is as surveillance, reconnaissance, communication relay, weapon launching and combat.

The design of UAV is going complicated because want to achieve high performance function for all stages. For advance country such as United States, Britain, Israel and Russia, they had developed very high performance UAV which is spending billion dollars for research and development (R&D). For small country, they just buy it from other country (because of need high cost for research) and

modify it if have enough technology. Many countries try to develop UAV because it brings the treat in security of the country.

Malaysia is still far behind in UAV technology. Our neigbour country such as Singapore and Indonesia is going fast in UAV R&D. Some UAV had been developing by private companies and also research by high education institutes for Malaysian Army (ATM). As one of the high education institute in Malaysia, Universiti Teknikal Malaysia Melaka (UTeM) under Faculty of Mechanical Engineering (FKM) want to make a research for UAV design to contribute for Malaysia security and also want to commercialize the design. This project will be going as pioneer project for UAV development at UTeM.

1.2 Project Objectives

i. To understand the design of small UAV
   a) To dealing with the interaction between the dynamics of the UAV and the aerodynamic forces and moment generated on its surface by the motion.
ii. To design the UAV
iii. To fabricate the UAV prototype

1.3 Scope of the Project

i. To do literature reviews
ii. To make validation with the existing system
iii. Investigating the suitable shape, electronic devices and materials for the design
iv. To choose the suitable analysis about movement, materials strength and fluid effect.
v. Using Computer Aided Design (CAD) to design 3D model
vi. Using Computer Aided Engineering (CAE) to analyze the design
vii. To choose the suitable process to fabricate the prototype
viii. To test the prototype

1.4 Flow Chart of Design, Analysis and Fabricate Small UAV

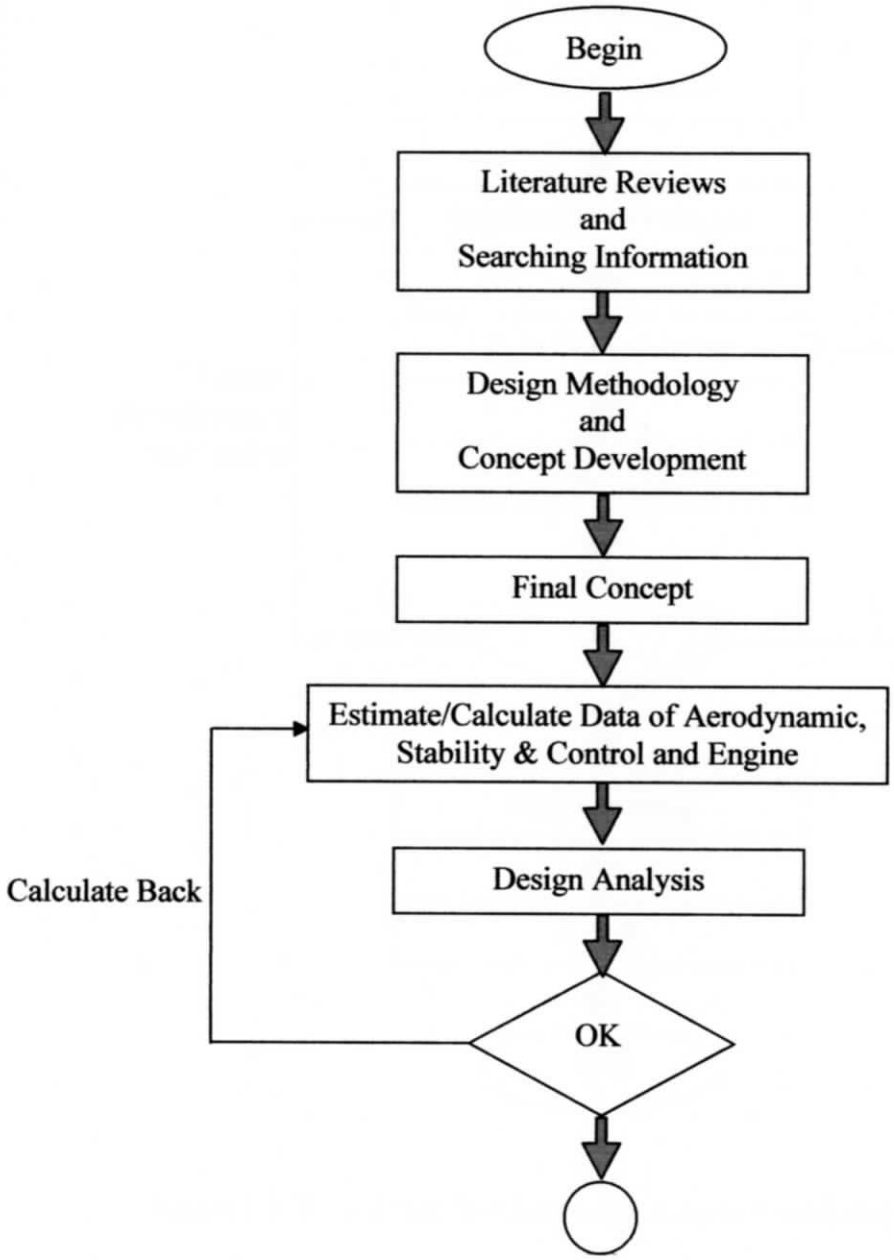

Figure 1.1: Flow Chart for Design and Analysis of the UAV

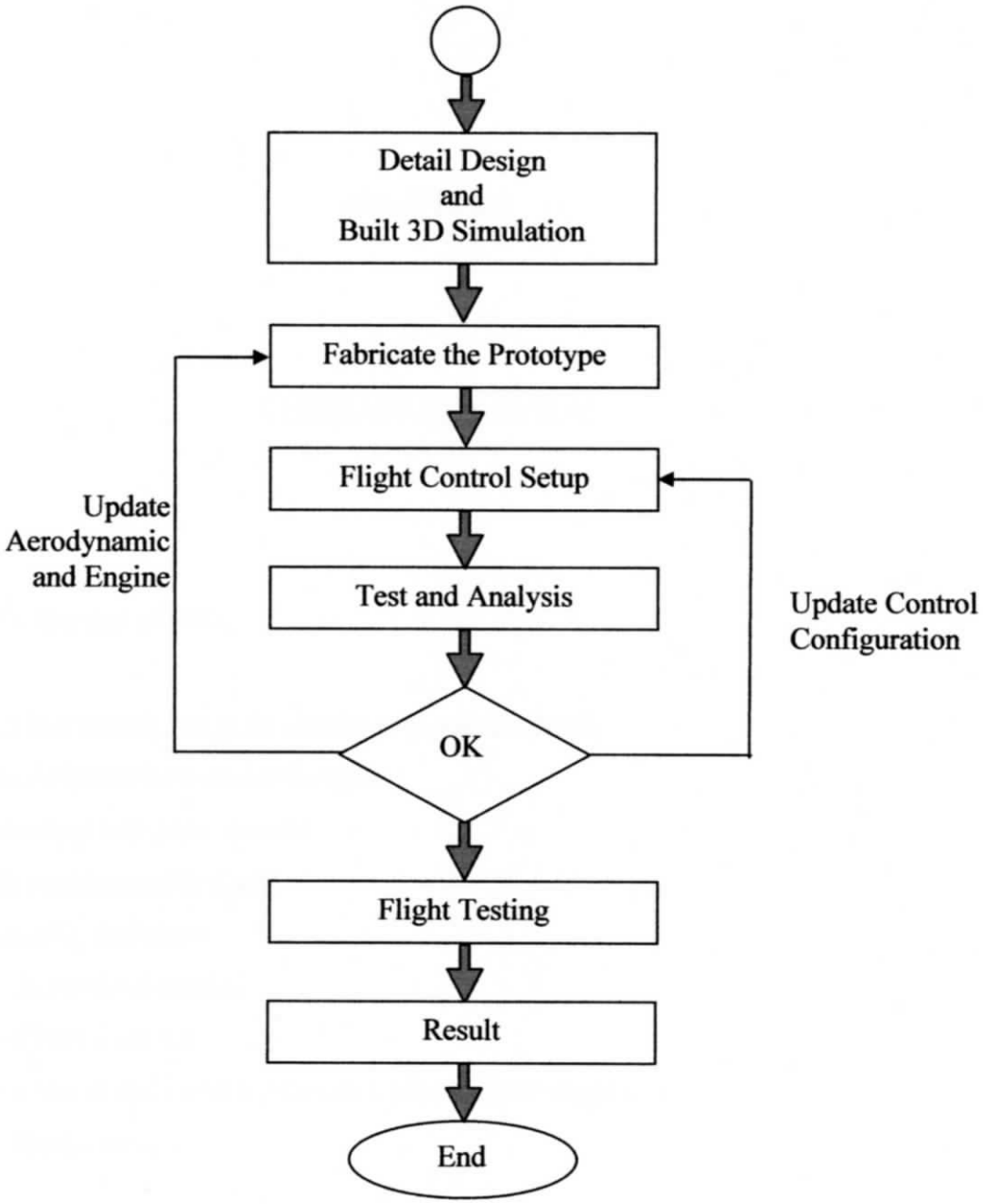

Figure 1.2: Flow Chart for Continuing Analysis and Fabricate the UAV

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of UAV

- UAV is unmanned, but quite similar to manned aircraft
- UAV is different from cruise missiles
- Autonomous, automatic control
- Usually programmable flight
- UAV usually contains:
    - Airborne element
    - Control station
    - Launch and recovery element, plus logistic support
    - Data users

2.2 History of UAV

It is believed that the first UAV is Sperry's Aerial Torpedo which made its first successful flight on 6 March 1918 at Copiague, Long Island, NY. It is the forerunner of today's guided missiles, which can be considered a one-

Figure 2.1: British Fairey Queen

way UAV. The first returnable and reusable UAV was the British Fairey "Queen" variant of the Fairey IIIF aircraft, first flown in September 1932.

2.3 Application of UAV

After many decades' developments, the present configuration of UAV is definitely not like a guided missile of today. As a matter of fact, UAV has shown its numerous applications in many fields.

In military application, UAV can execute such missions as surveillance, reconnaissance, weapon launching, communication relay, and combat. The Predator is one of the famous UAV in this field. It can provide near real-time video imagery day or night in all-weather conditions via satellite worldwide. So the U.S. government uses it to spy the battlefield. Even more than that, it also became a weapon launcher.

In civil applications, the Helios is in flight test phase. Its features of long endurance and high altitude will fill a niche in the telecommunications market. A fully operational Helios will operate at about 60,000 feet, above the weather and traffic, and act like a stationary satellite, but without the time delay. The solar-electric powered aircraft had reached an altitude record of 96,863 feet in Aug 2001. Another good example of UAV is the Aerosonde, which is already famous for its capabilities of meteorological monitoring and long endurance flight. It's the first UAV flying across the North Atlantic Ocean in 1998. The UAV in civil also could be applied to agriculture such as monitor and indicate to the growers which parts of the plantation are ready for harvesting [9]. It also helps in fighting forest fires, evaluating environmental change, or assessing civil emergency responses.

Table 2.1: Applications of UAV. Copy from [6]

Fields	Applications
Military	Surveillance, Reconnaissance, Communication relay, Weapon launching, Combat
Civil	Communication relay, Experiment, Research, Climate monitor
Academic	Education, Training, Experiment

2.4 The Development of UAV around the World for Defense Sector

The most argument for development UAV in defense sector is to save lives. In every development of new weapon systems, one of the most important objectives is to minimize the risk to the human operator. In a fighter aircraft for example, numerous system has been developed to make sure the pilot will survive in case if the fighter succumbs to enemy fire. The cost for using pilot is very high. For example, it will cost approximately $17 billion just to design and implement the F-22's advanced cockpit interface, initial cost training for fighter pilot is estimated at $2 million, US Air Force spend around $1 billion per year to maintain its 2000 strong F-16 pilots and to design Anti-G suit [11]. By removing the pilot and his supporting subsystems, it will increase the aircraft performance such as aircraft maneuver perform up to 20G (A latest anti-G suit only support for 11-12G), load with more advanced weapon system and can be use in almost any kind of situation without any worry of headache in planning contingencies for saving any pilot.

2.5 UAV Technology

New capabilities projected for UAVs over the next twenty-five years include silent flight (as fuel cells supplant internal combustion engines), 60% gains in endurance and rotorcraft capable of high speeds (40 kts plus) or long endurance while retaining the ability to hover. Target detection using CCD (camouflage) techniques and the capacity to search, geolocate, classify and track targets with