

CHAPTER I

INTRODUCTION

This chapter discusses about the main frame of the study. The chapter consist of background of the study, description of problem, objective of the study, scope and limitation, method of research, and organization of the thesis. This chapter describe about the reason, method, and focus of the study.

1.1. Background of the Study

UAV (Unmanned Aerial Vehicle) is a vehicle that can fly without a pilot on-board and it is designed to be controlled from far away by a remote control or by an autopilot system. Nowadays the technology that is used in the UAV has been developed rapidly, making it possible to be used in many fields, including agriculture, mapping, military, transport, and search-and-rescue [1]. The advantage of using UAV is that it can reach hard-to-access or dangerous areas such as volcano, forest, cave, and cliff, with relatively short time and with zero casualty risk. [2]

Indonesia, as a nation that concerns with UAV technology, gives authority to LAPAN (Lembaga Penerbangan dan Antariksa Nasional) as the national aerospace research agency of Indonesia to conduct researches and develops the technology in Indonesia. UAV has been used for many purposes in Indonesia especially for mapping and surveillance. To improve its functionality for mapping and surveillance, LAPAN has been developing some UAV that can fly for a longer distance, have a long endurance, and can fly autonomously.



Figure I.1 Photograph of LAPAN Surveillance UAV – 02 [3]

LAPAN Surveillance UAV (LSU)-02 as shown in Figure I.1. is one of the products that is designed by LAPAN to have long endurance, with ability to capture image while flying autonomously, and therefore can be used for surveillance and mapping above large areas. It is a fixed-wing UAV with a span of 2.3 m and using a piston-propeller engine to generate thrust. LSU-02 consists of fuselage, wing, landing gear, horizontal tail, and vertical tail. The fuselage is used to hold the engine, avionics system, and to contain fuel. The engine is piston-propeller type with pusher configuration, placed at rear part of the fuselage. LSU-02 uses high-wing configuration and it has two vertical tail planes, connected to the wing by a pair of tail-booms.

Nevertheless, the first design of LSU-02 has a problem with stability because of rotational flow at the rear part of the UAV, induced by the propeller during the operation. Longitudinal stability was compromised because the horizontal tail plane position is inside the zone that is affected by the rotational flow. To avoid that, the horizontal tail plane was moved to a higher position, as it can be seen in Figure I.2.



Figure I.2 Photograph of Modified LSU-02 at a runway [4]

After the said modification, LSU-02 has been used to conduct several flight tests and surveillance missions again. The first flight test was held at Nusawiru Cianjur and the other was held at Rumpin Bogor. One of the missions is image capturing of village border in Kretek subdistrict, Bantul, Special District of Yogyakarta in 2017. The other is mapping mission, where the LSU-02 took-off from FASI (Federasi Airsport Indonesia) airfield at Depok Beach, Special District of Yogyakarta. In that mission, LSU-02 demonstrated its ability to follow the determined waypoint in two hours and ten minutes flight duration. [3]

Present LSU-02 has been equipped with automatic flight control system (AFCS) that allows it to follow determined way point by itself. The AFCS consists of autopilot system, flight control surfaces, remote control, connecting linkages, and the necessary operating mechanisms to control an aircraft's direction in flight. The autopilot system was design by using autotune feature of the Pixhawk to get the PID (Proportional, Integrator and Derivative) controller for the system.

However, the present AFCS can be unstable in certain flight condition because it wasn't made based on LSU-02 flight dynamic characteristic. So, it is necessary to adjust the automatic FCS that is installed to the LSU-02 with its own flight dynamic characteristics. Therefore, the topic of present research is making a waypoint guidance that is adjusted with LSU-02 stability and control characteristics. This waypoint guidance consists of stability augmentation system, heading hold system and waypoint follower. But before that, to make a proper control system for the waypoint guidance mathematical model should be build based on aerodynamic characteristic of the UAV. Hence, the data building of aerodynamic and stability characteristic of the UAV is also a part of this study.

1.2.Description of Problems

To develop a waypoint guidance based on the mathematical model of LSU-02, the aerodynamic characteristic data should be available, and then making mathematical model and defining specific mission that will be carried out autonomously by the LSU-02. So, the problems in this research can be formulated as follows,

1. How is the aerodynamic characteristics of LSU-02 at design cruise flight condition?
2. How is the stability characteristic of the mathematical model as a representation of the LSU-02 at design cruise flight condition?
3. What are the missions that will be carried out by LSU-02 using waypoint guidance?
4. How is the ability of the waypoint guidance system to follow the desired flight track in the mission simulation?

1.3. Objectives of the Study

Based on the problem description that mentioned before, there are four objectives of the study as follows,

1. To obtain the aerodynamic characteristic data of LSU-02 at design cruise flight condition.
2. To develop mathematical model of LSU-02 and analyse the stability characteristic of LSU-02 at design cruise flight condition.
3. To determine the mission for LSU-02 to be carried out using waypoint follower,
4. To design the waypoint guidance based on mathematical model of LSU-02 for determined mission and evaluate it as an example of automatic control and guidance system.

1.4. Scope and Limitations

The scope and limitation of this study are mentioned as follow,

1. Focus of this study is on the LSU-02 as an object,
2. Study are done at design cruise flight condition only,
3. The aircraft is assumed to has a constant mass and fixed CG location,
4. The aircraft is modelled as a rigid body,
5. The earth is assumed to be flat and has a constant gravity field,
6. As an example of automatic control and guidance system are designed using the mathematical model, waypoint guidance is build using linear control design methods.

1.5. Research Methodology

Method that is used in this study are literature study and numerical simulation.

For detail, the steps of research with the method are presented as follows,

1. Build the data of LSU-02 aerodynamic characteristic using USAF DATCOM.
2. Build mathematical model of LSU-02 and analyse its stability characteristic using MATLAB/Simulink.
3. Determine specific mission for application of the waypoint guidance.
4. Design the waypoint guidance and analyse its ability on mission simulation using MATLAB/Simulink.

Research is started by learning several literatures to obtain understand the problem, background theories that can be used to solve the problem and what other people has done related to this research. To develop the mathematical model of LSU-02, then the required data must be obtained from any possible and reliable source including data sheet, engineering document, DATCOM, etc. After that, flight envelope is developed to be used as a reference of the limit of flight performance of LSU-02 and analyse the steady state (trimmed) condition at a specific flight condition. Based on the trimmed condition, the mathematical model is developed including linear and nonlinear model. Then, the stability characteristic of each model is analysed. After the stability characteristic of each model is known, then the waypoint guidance is developed as an example of automatic flight and guidance system. Finally, the waypoint guidance is simulated in certain mission. The flow chart of the research is shown in Figure I.3

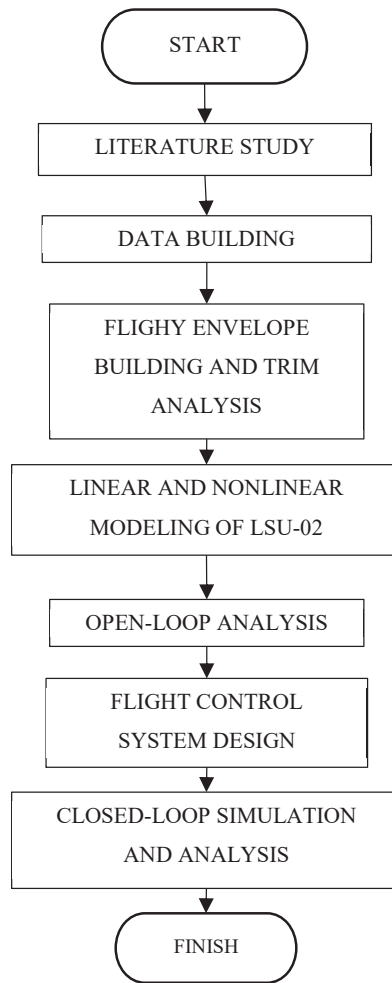


Figure 1.3 The Research Flow Chart

1.6. Organization of Thesis

The writing Systematic of the thesis is as follow,

Chapter II is about flight dynamic and automatic flight control system of UAV, which includes theory about flight dynamic of the aircraft, definition of frames of references, orientation between frames of reference, mathematic modelling of aircraft, waypoint guidance system, pole placement, and PID controller.

Chapter III is about the modelling of LSU-02, which includes the definition of geometry and specification, weight and balance, aerodynamic and stability data building using USAF DATCOM, propulsion force and moment, and trim analysis. The last part is about flight dynamic modelling in linear form and non-linear form also.

Chapter IV is about simulation and analysis of the open-loop system in linear model and non-linear model. This chapter includes the analysis of damping ratio and frequency of each characteristic motions based on linear model. The linear model gives more information about stability characteristics compare to non-linear model, but non-linear model can show more realistic response of the aircraft.

Chapter V is about designing waypoint guidance system for LSU-02 which uses the linear model as a basis for the design. As a part of designing waypoint guidance system, stability augmented system and heading hold designing process will also be presented. Then there will be explanation about the implementation on the non-linear model of the aircraft.

Chapter VI is about the simulation of waypoint guidance system which include the simulation in several specific cases and the simulation result analysis. The analysis is about performance of the waypoint guidance system. The simulation is done using non-linear model to evaluate the performance of the waypoint guidance system in certain obstacle effect.

Chapter VII is about the conclusion of what has been done in this research and recommendation that can be proposed for further research about this topic. The conclusion contains the evaluation for the objectives of this study, whether the objective is fulfilled or not. Recommendation is suggestion for next research based on the results of this research.