Needs Assessment

Team 8

Design an Unmanned Tilt-Rotor Aircraft for Multi-Mission Application

Members:

Kade Aley – Ka11d@my.fsu.edu

Jake Denman - Jad13h@my.fsu.edu

Daylan Fitzpatrick - Df12b@my.fsu.edu

Christian Mård – Kam11y@my.fsu.edu

Patrick McGlynn – Pam09e@my.fsu.edu

Kikelomo Ijagbemi - Kikelomo1.ijagbemi@famu.edu

Faculty Advisor:

Dr. Farrukh Alvi

Sponsor:

Dr. Chiang Shih

Instructor:

Dr. Nikhil Gupta

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Table of Contents

ABSTRACT

The purpose of this Needs Assessment Report is to clarify the design intended to be entered in the AUVSI’s 16th Annual Student Unmanned Aerial System Competition. The focus of the competition is to safely develop and operate an autonomous Unmanned Aerial System that can accomplish a specific set of tasks. Such tasks include capturing waypoints, GCS display, as well as search and classification of targets. As well as the competition testing the autonomous capabilities of the design, it will also be capable of vertical takeoff.

1. Introduction

The AUVSI competition has two very important problems. The first being autonomous waypoint travel which means having an aerial robot fly from one point to another without the assist of a person. The second being target identification which is responsible for recognizing shapes, colors, and symbols and record their location. These two problems when solved together create a very powerful machine that could be used for discrete reconnaissance, patrolling guarded areas, and running small payloads of equipment to those in need of it.

A requirement from the FAMU-FSU College of Engineering for this project is to apply VTOL, or vertical takeoff and landing, to the design. Team 8 has decided to use a tilt-rotor built into the frame of the aircraft and utilize a motor transition to achieve the horizontal flight needed for long duration flying. VTOL in aircrafts solves problems like the need for a cleared run way and also cuts down many of the parameters for takeoff and landing which allows for a fully autonomous flight.

2. Background and Literature Review

Department of Defense defines UAVs as powered, aerial vehicles that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload[1]. Early UAV development started as a design for a weapon as far back as the civil war[2], but has evolved beyond that. UAV development became pressing around wartime, and there hasn't been a conflict where a UAV was not deployed since the first Gulf War[2]. Modern UAV's are capable of not only acting as a weapon, but as reconnaissance and payload delivery as well. UAV's can be controlled both remotely and autonomously, with the aid of a ground control system monitoring its actions and transmitting its data. Overall, the ability to control an aerial system autonomously makes UAV's an important technology in both present and future endeavors.

4.5 Needs Statement

The objective of this project is to design, assemble, and program an unmanned autonomous aerial vehicle capable of vertical take-off and landing. This vehicle is intended to compete in the 2016 SUAS competition by the AUVSI. The competition will require our vehicle to navigate waypoints and complete objectives in a search area. Primary tasks for the project include assessing the feasibility of the previous teams design concept and upon the results decide how to move forward in 5 key areas. These areas include vehicle structure, method of VTOL, method of flight control, sensor packages, and ways to insure the vehicle is competition ready.

"There needs to be an autonomous aerial vehicle able to compete in the SUAS competition capable of vertical take-off and landing."

4.6 Goal Statement and Objectives

Design an unmanned aerial vehicle capable of autonomous vertical take-off and landing to compete in the 2015 AUVSI competition.

In order to reach these goal we must define a few objectives, these objectives are:

- Determine feasibility of previous team's design vs. concept design
- Finalize VTOL vehicle design
- Purchase, gather, or manufacture all components

- Integrate mechatronics of vehicle via firmware development
- Test mechatronic and firmware integration
- Assemble VTOL prototype and conduct benchmarking
- Test manual control in VTOL, transition, and horizontal flight
- Test autonomy in VTOL, transition, and horizontal flight
- Develop senor package
- Test sensor package and telemetry during flight
- Quantify vehicle performance
- Investigate performance improvements
- Ensure safety at all time
- Compete at competition

4.7 Constraints

Based on the 2016 Seafarer Association of Unmanned Vehicle System (AUSVI) competition, the Unmanned Aerial Vehicle (UAV) is expected to sustain autonomous flight.

4.7.1 General Constraints

- The maximum takeoff gross weight of the aircraft shall be less than 55 pounds, when fueled and weighed with a calibrated scale; unless in compliance with the AMA Large Model Airplane program. (AMA Document 520-A.)
- The maximum airspeed of the UAV shall not exceed 100 KIAS
- The UAV shall sustain flight within 100 and 750 feet. Flight of about 400 feet above ground level within three (3) miles of an airport without notifying the airport operator is not allowed.
- The UAV should not interfere with operations and traffic patterns at any airport, heliport or seaplane base except where there is a mixed use agreement.
- The UAV should not operate aircraft with metal-blade propellers or with gaseous boosts except for helicopters operated under the provision
- The UAV should not operate model aircraft carrying pyrotechnic devices that explode or burn, or any device which propels a projectile or drops any object that creates a hazard to persons or property.
- The UAV should not operate a turbine-powered aircraft, unless in compliance with the AMA turbine regulations. (AMA Document #510-A.).
- Based on the competition flying time is 30 minutes maximum.

4.7.2 Other Requirements

- The UAV should sense, detect and avoid moving or stationary obstacles along its path

- Radio Control model aircraft must use the radio-control frequencies currently allowed by the Federal Communications Commission (FCC). For the competition, transmission is allowed on Wi-Fi (2.4/5.8GHz), (except for 900 MHz) on multiple Radio Frequency (RF) communications bands at the same time.
- The UAV is expected to achieve controlled take-off and properly changeover to autonomous flight. In the same manner, transit from autonomous flight to a properly achieved controlled landing.
- Aircraft must be able to navigate using GPS coordinates
- The UAV shall upload position information at a target rate of 10Hz from the first takeoff until the last landing with an average upload rate of 8Hz or more.
- Aircraft should be able to operate in winds up to 15 knots, gusts up to 20 knots and surface temperatures up to 110 degrees Fahrenheit

3. Methodology

4.1 Design Stage

The design stage will focus on the creation of an appropriate UAV platform. During this stage, the basic principles of flight will be referenced to bring about a design in which vertical flight and horizontal flight work harmoniously. Research will be conducted on previous successful designs to initiate a proof of concept for the design in question. This research includes the manipulation of microcontrollers to allow for smooth transition between varying flight modes.

4.2 Prototype Stage

The ending of the design stage allows for the prototype stage to take form. In this stage, materials and parts for the UAV will be gathered. The inheritance of certain parts, such as motors and electronic speed controllers, allow a stable transition from the design phase. The parts and materials will be used to construct a basic prototype. When the prototyped design is assembled, the continuation to the verification stage is possible.

4.3 Verification Stage

The verification stage is used to ensure basic necessary functions are possible. Crucial functions include, but are not limited to: (a) stable vertical flight, (b) transition from vertical flight to horizontal flight, (c) stable horizontal flight, (d) acceptable sensor output.

4.4 Modification Stage

If any of the crucial functions do not behave as intended, the modification stage will be used to correct them. If the crucial functions do not need to be worked on then the Modification Stage will serve as an opportunity to optimize the design in any way appropriate. These optimizations can place emphasis on completing the competitions' secondary objectives.

4. Expected Results

Due to the longevity of this project, the expected results have been broken up into segments to ensure proper functionality of the team and vehicle throughout the year.

4.1 Before Competition

- All necessary documentation will be review by team and submitted prior to deadline
- Proper organization of documentation, reports, presentations, designs, and testing results will be kept, in order to provide a well versed technical journal
- The team will maintain a high level of safety when working with vehicle
- All necessary measures will be taken to ensure vehicle is safe to operate
- Constant communication will be kept with Sponsors and Advisors through process

4.2 Vehicle

- The vehicle will meet all constraints set forth by the AUVSI Seafarer Chapter
- Vehicle will be capable of manual VTOL, Transition, Horizontal flight by mid-year
- Vehicle will be capable of autonomous flight in all flight modes by end of year
- The vehicle will be adapted with sensor package to ensure mission readiness
- In case of system failure, vehicle will provide necessary failsafe parameters
- Communications with vehicle will be within the required operating constraints and maintained at all time
- Vehicle will be capable of completing all threshold task and most secondary task

4.3 During Competition

- Team will ensure proper transportation of vehicle
- Team will represent FSU & FAMU in a respectful and professional manner
- Team will ensure of vehicles readiness and compliance
- The vehicle will fly with a certain magnitude of distance to each mission waypoint
- The vehicle shall be able to identify targets, analyze targets, and relay information of targets
- Team shall be prepared to provide judges with hard copies of recon intelligence
- Vehicle shall properly deploy payload at designated location

5. Conclusion

The AUVSI competition requires an unmanned aerial vehicle to both navigate waypoints and search for objects and display their location, autonomously. Team 8 has assessed the feasibility of last year model and has decided to create a new platform for the upcoming competition. The design and construction of this new platform will incorporate many of the facets of the engineering design process from brainstorming to deployment of the final design. Using the official 2016 rules for the AUVSI competition and the requirement of including VTOL, as specified by Dr. Shih, in the design Team 8 will be able to produce a product that fills the needs of the competition.

References

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[2] C. Tetrault, 'A Short History of Unmanned Aerial Vehicles (UAVs)', Draganfly.com, 2015. [Online]. Available: http://www.draganfly.com/news/2009/03/04/a-short-history-of-unmanned-aerial-vehicles-uavs/. [Accessed: 24- Sep- 2015].

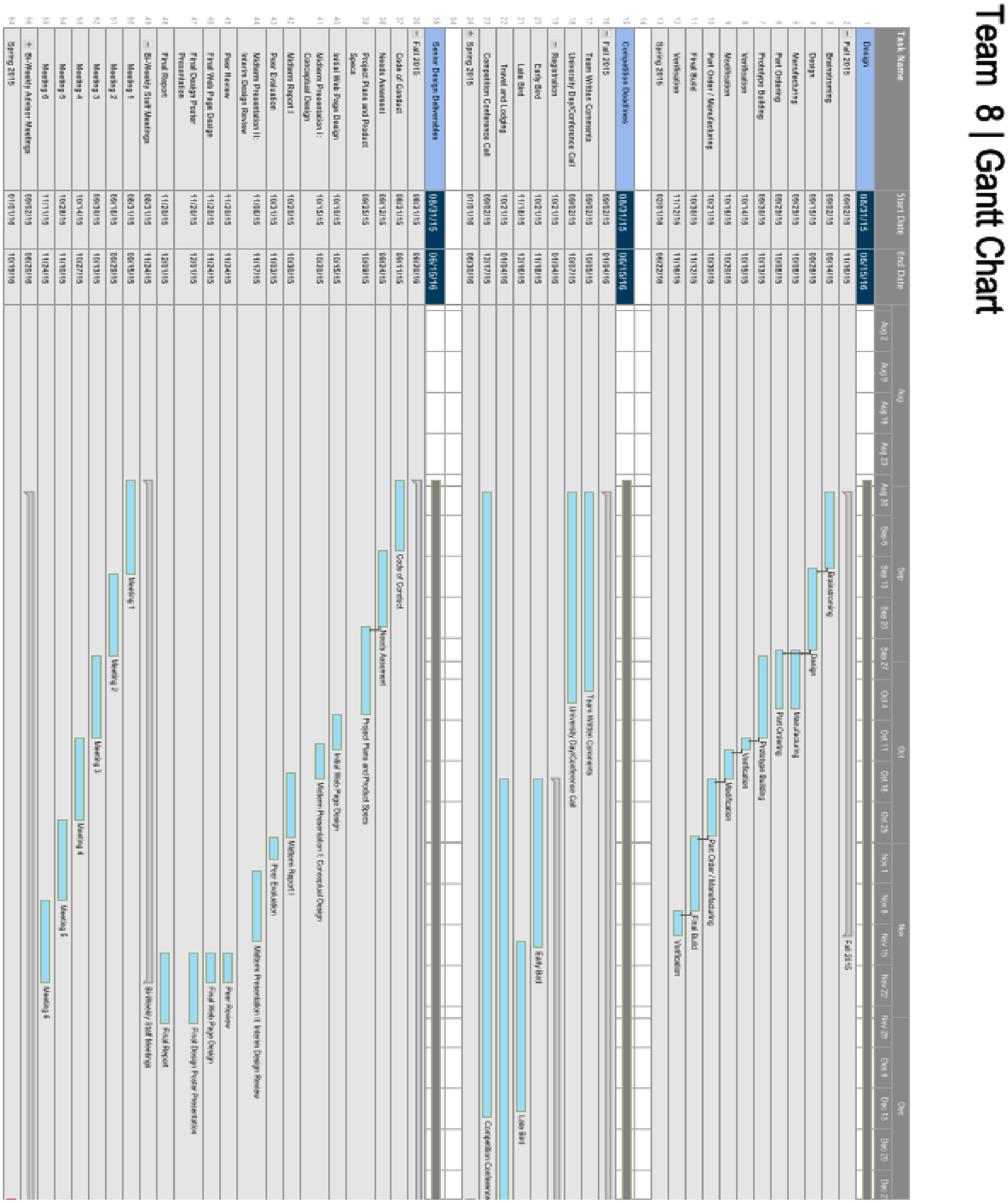
[3] Academy of Model Aeronautics (AMA) National Model Aircraft Safety Code,

(http://www.modelaircraft.org/files/105.pdf)

[4] AUVSI, DRAFT 2016 Rules for AUVSI Seafarer Ch (n.d.): n. pag. AUVSI. AUVIS, 16 Sept. 2015. Web. 16 Sept. 2015 (http://www.auvsiseafarer.org/documents/2016Documents/2016_AUVSI_SUAS_Rules_Rev_0.9X_DR

Appendix A

A.1) Gantt Chart



A.2) House of Quality