AUVSI Design Competition

Figure 1: Senior Telemaster Plus[4]

Deliverable Name: Project Plan and Product Specification

Team Number: 8

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Abstract

The purpose of this report is to discuss the product plan and specifications. The Association for Unmanned Vehicle Systems International (AUVSI) have released their 2015 rules and requirements for participating in the upcoming student competition. Using these rules as a guideline, the team has been investigating the different types of aerial vehicles that it can use to excel in the objectives in the competition. Specifically, the team debated the benefits of using fixed winged aircraft or multi-rotor winged aircraft. This report contains research about the advantages of both aircrafts and how they are related to the competition. Moreover, the disadvantages for each type of aerial vehicles were also considered. During this report, the two different options are compared by taking multiple factors such as build time, complexity, flight time, design time, cost, and competition requirements. By using these factors, team 8 was able to determine what would be the best course to take to compete in the 2015 competition.

1 Introduction

In this project, team eight will be designing an autonomous aerial vehicle. The grand objective of this project is to design an aerial vehicle that will meet the 2015 AUVSI student's competition design requirements and specifications. To do this, the team must build an aerial vehicle that can fly autonomously and complete three separate parts of the competition which are way point navigation, remote air drop, and target identification and location. The team goal is to build a product with optimal features for these competition. To do this, the team researched about the two types of vehicles that it can use to accomplish flight mission objectives. The two options the team compared were a fixed winged aircraft versus and multi rotor winged aircraft. From a performance aspect, both options have their advantages and disadvantages, which are compared in a later section. The main concern for both option is the amount of time each option would take to fully optimize for the competition. To help manage their time and ensure all deadlines are met, a Gantt chart was created to lay out specific tasks and there deadlines.

2 Project Definition

2.1 Background research

The annual competition is split into separate competition to test all aspects of the vehicles design. For each requirement of the competion, the main goals are laid out and then compared for each of the design option team 8 is considering. Finally a design matrix is used to compare the design options and aid the team in its decision.

So under the assumption that the vehicle passes all of the safety test, the aerial vehicle would then have to perform a takeoff and landing.[1] A fixed winged vehicle needs a runway to take off by creating lift, which can be a problem if there is no runway available; such as in the woods, on the beach, or in the desert. A multi-rotor wing vehicle, on the other hand, has the advantage of not needing a specific platform to take off from. A number of propellers are placed about the craft in a way that when properly working together can create enough lift to overcome gravity and elevate the vehicle. The vehicle then can take off vertically and would never need a runway, just enough space to set the vehicle on the ground. The same applies for landing for both designs. The fixed winged aircraft would need an extended runway to land, which hampers its ability in tight situations. The multi-rotor vehicle can land in the same way it takes off, with a vertical decent. A multi-rotor vehicle obviously has the upper hand in the takeoff and landing aspect of the two vehicles.

The second part of the competition is for the vehicle to navigate over defined waypoint coordinates in a specific order and will be scored on how fast and accurately the vehicle can accomplish this task.[1] A fixed winged vehicle would undoubtedly complete the way point challenge quickly, assuming that the fixed wing has the ability to turn effectively while also changing elevation. However, turning and elevation are exactly what a rotor wing specializes in. Both aircrafts have four degrees of freedom and are defined as: roll, pitch, yaw, and altitude.[2] A multi-rotor vehicle can alter its speeds of the propellers to rapidly control theses motions. With this ability, a multi-rotor vehicle can make quick and decisive movements. However, the multi-rotor vehicle will not be able to travel in a straight line as fast as a fixed winged plane. Even though a multi-rotor vehicle may not travel in a straight line direction as fast, the multi-rotor vehicle has the ability to turn around if a waypoint is missed much quicker than a fixed wing and can also elevate and descend while stationary if needed. This ability of the rotor wing will be very useful when navigating waypoints.

Once the waypoint navigation has been completed, the vehicle will enter into the part of the competition where it must locate, image, and transmit images of targets in a designated search area.[1] For anyone who has ever takin a picture, they would know that the key to getting a good picture is being able to hold the camera still. A fixed wing vehicle must be in constant motion while in flight therefore it would not be able to stay still and take a picture. However, the multi-rotor wing vehicle, if made stable enough, can hover in a single position while the image is being taken. With this ability, the multi rotor plane can take significantly better pictures than a fixed wing vehicle.

Besides the competition requirements, each vehicle has other advantages. Since a previous year's team has already started on fixed wing plane, using this vehicle would significantly reduce the cost and time to make the plane flyable. Thought this is beneficial, there are still more concerns with it. The previous year's plane needs a FAA certified pilot and no one in team 8 is certified to fly the plane. This would cause problems when test flights are needed, as an outside pilot would need to be hired which could increase the overall cost of this option. Also, the plane is missing components from last year that were essential for its autonomous flight and image reconnaissance.

For a multi-rotor, there is a concern in the time it would take to design and build the vehicle. To design, build and fly this vehicles would encompass a large amount of team's time and effort. Even still though, once built and finished, the team could test and fly there vehicle themselves and would not need a specialized pilot to fly the vehicle. A design matrix is shown below to give a better representation of all the factors that were used to aid the team in the decision they were going to proceed.

Table 1: Decision Matrix

	Component	**Importance**	**Retrofit**	**Buy (push prop)**	**Build**	**Buy**
	Cost	10	9	3	5	3
	Build Time	10	9	6	3	6
	Weight	4	6	6	5	5
	Duribility	4	4	4	7	7
	Troubleshooting	7	3	3	6	6
	Tech. Development	10	6	4	10	5
Performance	**Stability**	3	5	4	8	8
	Payload	5	8	8	5	5
	Flight Duration	8	7	8	5	5
	Velocity	6	7	9	5	5
	Automation Feasibility	8	8	6	7	7
	Airdrop	4	5	4	8	8
	Agility	4	5	3	8	8
		Total Score	558	437	509	469

2.2 Need Statement

The objective of this project is to build, design, modify, and program an autonomous aerial vehicle. Dr. Shih and Florida State University have sponsored Team 8 to compete in the 2015

SUAS Competition hosted by AUVSI. The aircraft will be designed to comply with competition rules and complete various mission requirements. Additionally the team will be required to provide a report detailing the methodology, systems specifications, and the manner in which challenges were addressed during the project. The mission of the SUAS competition is to "stimulate and foster interest in unmanned system technologies and careers."[1] Unmanned aerial vehicles are still a growing concept, and much research and development can be added to improve existing systems. "There needs to be further advancement in the design and control of autonomous aerial vehicles."

2.3 Goal Statement & Objectives

The goal of this project is to design and build a fully autonomous aerial vehicle to compete in the AUVSI competition in the summer of 2015.

To reach this goal, the objectives are:

- Determine feasibility of previous UAV from last year team and decide on whether to use a rotorcraft design or optimize previous team's fixed wing design.
- Attend Student Day conference call to obtain better knowledge of the rule of the competition.
- Apply for AUVSI competition and submit all supporting document needed.
- Ensure design of new plane or existing plane will meet all the rules of the 2015 AUVSI competition[4]
- Determine new parts that will be needed and collect price quotes, shipping estimates, and performance specifications of new parts.
- Build, program and test an autonomous aerial vehicle that meets all requirements of the SUAS competition.

By completing these objectives before the end of the fall semester, it will put team 8 into excellent position to compete at a high level at the AUVSI challenge. The optimal goal would be to place in the competition.

3 Constraints

In every project, there are some limitations that team members must overcome. Primarily, the people who are involve in this project has academic obligations to fulfill. Therefore, time places a restriction on how and when the design can be built. The team has finite funds that it can spend on acquiring the resources needed to implement the design for the competition. If the design is not built under budget then this project can be considered a failure.

Physical system limitation- The aircraft cannot weigh more than 55 lbs. at any time. Its airdrop system weight cannot exceed .25 lbs. 25% of the different sections of the aircraft must be brightly colored.
Environmental constraints- The vehicle should be capable of flying in winds up to 15 KIAS and gust up to 20 KIAS. The system should operate in temperatures up to 100 degrees Fahrenheit for a maximum of 12 hours.
Image constraints- Image files must be in JPEG with a quality of at least 90 and a resolution of 720p.
Mission constraints- Aircraft must fly between a 100 ft. and 750 ft. MSL.The Aircraft must have a reliable manual override system. The vehicle must be able to fly between 20 and 40 minutes.
Budget- Total expenses on the design must be less than $ 1500.

3.1 Design Specifications

The AUVSI have strict guidelines and requirements for what type of unmanned air vehicle that can partake in its 13th annual student AUS competition. These rules are in place in order to promote fairness and safety[1]. In addition, the design requirements provide judges with a method to test whether individual designs were engineered successfully for different goals and challenges. The design specifications for 2015 competition are listed below.[1]

- The aircraft’s weight cannot exceed 55 lbs
- Cannot travel faster than 100 KIAS or 115 mph
- The Air drop canister must be 1.5 in wide and 2 in long
- Air drop canister must use a drag ribbon that Is malleable and is 1.5 in wide and 5 in long
- Air drop system should not weigh more that 4oz or .25lbs
- 25% of the upper, lower, and lateral segments of the plane must be brightly colored

3.2 Performance Specification

Below is a list of performance specifications laid out by the AUVSI competition rules[1].

- Capable of relaying data about its altitude back to judges

- Capture and identify IR objects
- Manual override during autonomous flight
- Flight termination system for various circumstances such as loss of communication with its ground system
- Communicate across an RF frequency without interference
- Able to land and takeoff under winds of 8KIAS and gust up to 15KIAS
- Able to fly with surface winds of 15KIAS and gust up to 20KIAS
- Withstand temperatures around 100 degrees Fahrenheit for a maximum of 12 hours
- Complete mission tasks when the temperature is around 110 degrees Fahrenheit
- Complete mission objectives between 20 and 40 minutes
- Identify a target within 150 ft
- Fly to specific waypoint autonomously
- The aircraft must autonomously avoid all obstacles in its course.
- Meet the optimal display, upload, and download rate of 10 Hz
- Land airdrop objects within 100 ft of its target location

4 Methodology

During the semester, team 8 has split the project into two main parts. The first part of the project will be a design and manufacturing stage. This part will be will encompass all the design aspects of our project. For a multi rotary aircraft, the design will encompass a frame, mounts, and an airdrop device for the aircraft. By designing and having these manufactured by the end of the fall semester, it will set the team up for a successful spring semester.

The second half of the project be done in the spring semester. For the first couple of weeks, building the rest of the vehicle will occupy most of the teams time. The major goal of the second semester, once the aircraft is built, will be testing the flight operations. Since the competition states that the aircraft must fly manually and autonomously, this part will take an extensive amount of coding and debugging to perfect. Once the code for autonomous flight is perfected, the aircraft will be ready for the competition and the last step would be to show up and compete.

4.1 Schedule

Team 8 Gantt chart is shown in the figure below. The Gantt chart lays out the schedule for team 8 to accomplish all their goals throughout the semester. Each semester, there are specific task laid out the team must complete to ensure they meet all the requirements of the competition and the senior design class. The task have specific time frames assigned to them to ensure both ample time to complete the task and to keep the team on track of complete their design. By following this schedule, the team can complete their design and compete in the annual competition.

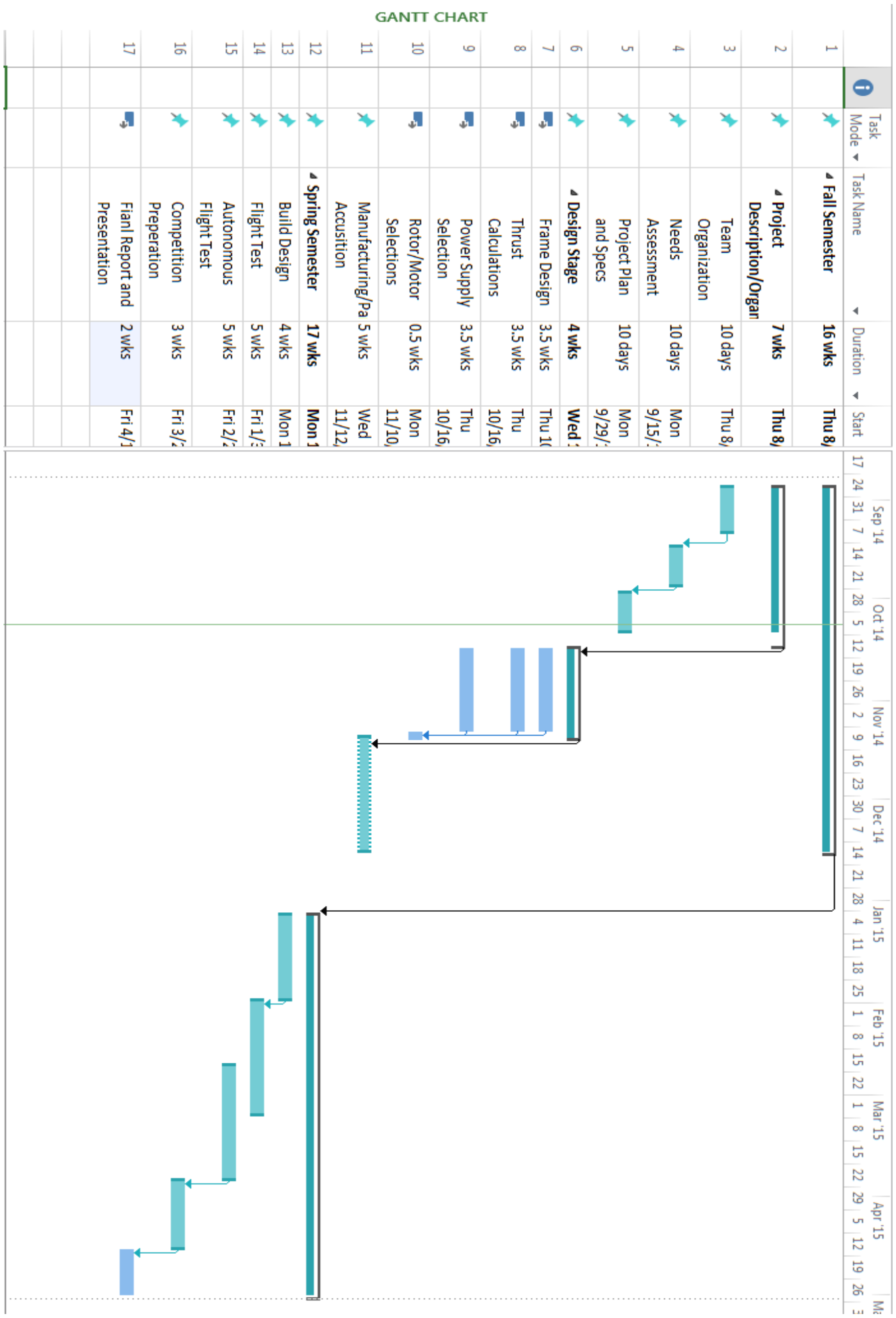

Figure 2: Gantt Chart

4.2 Resource Allocation

Below are specific task and time frames they should be completed in. Note: Task do not have to be done consecutively, but a general time frame for how long each task should take is shown. Reference to the Gantt chart for exact times and dates.

Table 2:Tasks for David Hegg

Task	Type	Time Frame
Thrust Calculations	Calculations	3.5 weeks
Multi Rotary Vehicle Design	Research	1 weeks
Cost Projections	Calculation and Research	1 weeks

Table 3: Tasks for Jermaine Dickey

Task	Type	Time Frame
Frame Design	CAD	3.5 weeks
4,6,8 Rotor Design	Research	1 weeks
Manufacturing Process	Research	2 weeks

Table 4: Tasks for Will Di Scipio

Task	Type	Time Frame
Thrust Calculations	Calculations	3.5 weeks
Copter/Computer Communication	Research	3 weeks
Control Systems Design	Research and Design	2 weeks

Table 5: Tasks for Tavarius Slaughter

Task	Type	Time Frame
Autopilot Research	Research and Purchasing	3 weeks
Camera Selection	Research and Purchasing	4 weeks
Microcontroller/Microprocessor	Research	2 weeks

Table 6: Tasks for Gavarni Leonce

Task	Type	Time Frame
Power Supply Design	CAD and Research	3.5 weeks
Optics	Research	4 weeks
Wiring	Purchasing and Research	2 weeks

Table 7: Tasks for Chris Bergljung

Task	Type	Time Frame
Frame Material Selection	Research and Purchasing	3 weeks
Frame Purchase	Research	1 weeks
Flight Time Enhancement	Research	1 weeks

Table 8: Tasks for John Murnane

Task	Type	Time Frame
DC Motor	Research	2 weeks
Rotor Selections	Research	2 weeks
Air Drop Systems	Research and Design	5 weeks

5 Conclusion

Concisely, this team has read the list of rules posted by the 2015 AUVSI student competition. The team formed opinions of the rules which led them to research about the possibility of designing a fixed wing aerial vehicle or a multi-rotor wing aerial vehicle. The benefits and shortcomings of each the aforementioned type of vehicles were discussed expansively in this report. The listed advantages and disadvantages were mentioned in their relationship with the various mission objectives of the competition. Additionally, the team identify certain problems that this project is trying to solve and how the project can contribute to innovation in AUV designs. Moreover, this report includes a discussion about specifics restrictions that team members must overcome in completing a successful design. There are specific design and performance goals that the design must meet in order to participate in the 2015 AUVSI competition. The team utilized a Gantt chart to tackle key objectives for this project. Individuals were given specific roles based the team's methodology and the Gantt chart. According to the data presented in the background section of this project, team 8 concluded that its AUV design should be to design and build a multi-rotor wing vehicle.

6 References

[1] http://www.auvsi-seafarer.org/media/pdf/2015_AUVSI_SUAS_Rules_Rev_0.9_DRAFT_(14-0922-1).pdf

[2] http://www.thomasteisberg.com/quadcopter/

[3] http://store.3drobotics.com/products/hmc5883l-triple-axis-magnetometer

[4] http://blog.hobbyexpress.com/wing-world-rc-model-airplanes/telemaster/pilot-1-gilmore-waco-telemaster-plus-12/