Autonomous Aerial Vehicle

Deliverable 2: Project Plans and Product Spec

Team Six

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Problem Statement

Unmanned Aerial Vehicles (UAVs) are pilotless aircrafts, controlled either by onboard computers or through the use of a remote control on the ground. They have become widely used in a variety of civilian, industrial, and military applications. One of the more public (and perhaps controversial) uses of the drone technology is to provide aerial reconnaissance for military commanders and ground troops in forward deployed locations. On the other end of the spectrum, this technology can be used by local law enforcement for search and rescue operations. These drones, programmed with complex imagery systems, can be extremely effective in scanning oceans for stranded vessels, national parks for lost hikers, or neighborhoods for abducted children (think AMBER alert). Why stop there? It is hard to argue against a swarm of autonomous helicopters bombarding a wildfire with flame retardant, routing to a defined refill zones, and doing it all over again. Many of these applications would typically put an onboard pilot in danger, making the UAV even more appealing.

These difficult and pivotal missions have led to a rising demand for more advanced autonomous aerial technology. Most of these applications require substantial research, testing, and development of complex autonomous systems. Luckily, much of the ground work is already done. There are autopilot systems that require only slightly more work than planning a trip using Google Maps. Computer vision systems that can recognize faces have been researched for decades.

This project will work to combine these advanced autonomous systems with fundamental mechanics of flight, while incorporating cooperation between the FAMU/FSU College of Engineering and UNIFEI in Brazil, in order to produce a competition-ready UAV. The aircraft built by previous Senior Design teams will be used for flight training and to test new electrical equipment and programming, while a new aircraft is simultaneously being designed and built. The aircraft will be tested according to a list of tasks resembling a reconnaissance mission. Upon successful completion of the tasks, Team Six will take this aircraft to the Association for Unmanned Vehicle Systems International (AUVSI) Competition to be held in the summer of 2014.

Justification

The Unmanned Aerial Vehicle (UAV) was first introduced in the 1960’s by the United States Air Force to perform aerial missions without risking the pilot’s life. The UAVs provide a number of additional advantages:

- Greater maneuverability and stealth capabilities due to its small size
- Greater design flexibility as pilot’s physiological constraints are removed
- Greater endurance: physical durability and increased flight time

With such advantages, interest in UAVs has grown consistently over time as technological advancements have made its use more reliable and feasible. However, due to the still high accident rate (crashing and civilian casualties in military operations) the technologies involved in the UAVs are also a growing field of research and improvement.

Furthermore, the increase of non-military use of UAVs in the recent years has brought more significance to the development. UAV's non-military applications include remote sensing and surveillance, domestic policing, exploration and scientific research, search and rescue, and transportation to name a few. With the growing popularity and growing number of functions, design projects such as this will contribute to the development of a great engineering field.

Objectives

The goal of this senior design project is to design and build an autonomous search and rescue remote control plane. The plane is set to go to competition for the AUVSI during the summer of 2014. The competition requires that the plane autonomously fly a search and rescue pattern while searching the ground for targets that should be identified by the following criteria: location, color, size, shape, orientation, letter on target, and color of letter on target. Takeoff and landing can be done by remote control, however, bonus points are awarded for autonomous takeoff and landing, so this project will attempt to include those tasks.

In addition to the tasks for competition, the plan for this project includes improvements on some parts of last year's similar project. Team Six will consider ways to make the plane modular, so that in the event of crashes, it can be more easily repaired. The Gimbal video system will be improved to receive less vibration from the motor and therefore read the targets more effectively. Team Six also plans to improve the camera system programming so that the objectives can be read and deciphered accurately by the system. The last objective of this project is to communicate and work efficiently internationally. One member of Team Six is currently working from Brazil, and he will be returning to America at the midpoint of the project. At this time, another team member will leave for Brazil. To complete this project at its highest potential, Team Six must communicate effectively and work together between the two countries.

Methodology

<u>Theoretical Analysis:</u>

- Determine current state/status of previously used equipment
    - Inspect structural reliability of current airplane
    - Ensure the motor is in working order
    - Determine if transmitter/receiver is in working order
    - Make certain the auto-pilot controls are working properly

- Ensure camera is capable of detecting objects/targets up to 750ft

- Determine if parts/supplies should be replaced
  - New airplane (lighter, sturdier, larger, smaller, etc)
  - New transmitter/receiver with user interface (UI) to display images on portable CPU
  - New motor (possibly electric to reduce jitter in camera)

- Learn to fly/control airplane
  - Lessons
  - Training Software
  - Certification

Experimental Analysis:

- Will be completed based on results/findings of Theoretical Analysis

Constraints

Several constraints are involved in developing a system capable of functioning as required by 2014 Undergraduate Students Unmanned Aerial Systems Competition. In order to present the constraints, the following list is given with brief description about the topics stated by the Seafarer Chapter (AUVSI; International).[1]

Constraints before the Flight:

- **Gross Weight Limit -** The aircraft may not exceed fifty five (55) pounds in weight.

- **Radios -** The use of 2.4 GHz radio is required for all competing aircraft (Team 6 enrolled in Senior Design 2014 inherited a compatible radio).

Constraints during Takeoff/Flight:

- **Takeoff -** Takeoff shall take place within one of two designated Takeoff/Landing areas, depending on wind direction during competition.

- **Waypoint Navigation** - Air vehicles must autonomously navigate to selected waypoints, and will be restricted to assigned airspace and avoid no-fly zones.
  - **Waypoints** - GPS coordinates (ddd.mm.ssss) and altitudes will be announced the day prior to the flight competition.

- **Enroute Search** – Air vehicles will be required to fly specific altitudes while identifying several targets along the predefined entry route.
- **Targets** - Targets will be constructed of plywood of a given size, basic geometric shape, and color. Each target will be a different shape and a unique color.

- **Area Search** - Once transitioning into the predefined search area via the entry/exit route, the air vehicle shall autonomously search for specific targets of interest.

- **Landing** - Landing shall be performed completely within the designated takeoff/landing area.

- **Total Mission Time** - Total mission time is the time from declaration of mission start from the judges and permission to turn on transmitters until the vehicle has safely landed, transmitters are shut off, and target data sheet (or spread sheet) is handed to the judges.

- **Real Time Actionable Intelligence** - Extra credit will be given for providing complete and accurate information (actionable intelligence) during flight within the search area: once that information is provided, it cannot be modified later.

<u>Other Constraints:</u>

- **Budget:** a budget of $1500 is available to develop the entire project.

- **Time:** As the project involves routinely testing, the given amount of time might be short.

Work Breakdown Structure (Task Assignment)

1. Initial meeting with Team sponsor/advisor (ME and ECE)
    a. Contact advisor/sponsor to set up appointment

2. Asses state of old plane/equipment (ME and ECE)
    a. Gain access to portable
        i. Acquire key copies
    b. Consult previous team member

3. Needs assessment (ME and ECE)
    a. Meet with team
    b. Divide sections between team members
    c. Compile sections and format for report

4. Work on website (Web Developer and Secretaries)
    a. Initialize webpages

        i. Set up general structure
    b. Gather profile information from team members
    c. Add deliverables
    d. Insert media

5. Code of Conduct (ME and ECE)

6. Research possible planes (ME and ECE)
    a. Visit hobby shop
        i. Consult RC experts
    b. Research internet

7. Purchase practice plane (Team Leader)
    a. Discuss procurement procedures with Jon Cloos
    b. Consult expert about practice plane

8. Practice flying (Volunteer Pilots)
    a. Obtain AMA membership

9. Midterm report/presentation (ME and ECE)

10. Make last year's plane flyable (ME and ECE)
    a. Test engine
    b. Test flight controls
    c. Test telemetry
    d. Test physical integrity of plane

11. Purchase competition plane (Team Leader)
    a. Acquire approval from sponsor
    b. Procurement procedures with Jon Cloos

12. Test autopilot system (ECE)
    a. Connect to computer
        i. Perform simulation
    b. Physical testing
        i. Fly plane autonomously

13. Determine necessary hardware and software for flight (ECE)

14. Buy necessary hard/software (ECE Leader)
    a. Acquire approval from sponsor
    b. Procurement procedures with Jon Cloos

15. Possibly purchase new camera system (ECE Leader)

    a. Acquire approval from sponsor
    b. Procurement procedures with Jon Cloos

16. Build plane (ME)
    a. Assemble body

17. Imagery Analysis (ECE)
    a. Communication between camera and computer
    b. Write code for processing images

18. Design CAD drawing retractable landing gear (ME)
    a. Acquire physical measurements
    b. Conceptual design/analysis
    c. Model in Pro-E

19. Design CAD drawing gimbal system (ME)
    a. Acquire physical measurements
    b. Conceptual design/analysis
    c. Model in Pro-E

20. Design CAD drawing trap door mechanism (ME)
    a. Acquire physical measurements
    b. Conceptual design/analysis
    c. Model in Pro-E

21. Final webpage design (Web Developer and Secretaries)

22. Final presentation/report (ME and ECE)

23. Equip plane with Gimbal/landing gear (ME)

AUVSI Project Plan

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION
Initial Meeting with Team Sponsor	2	1	2	1
Assess State of Old Plane/Equipment	3	2	3	2
Code of Conduct	2	6	2	6
Work on Website	3	11	3	5
Needs Assessment	4	1	4	1
Research Possible Planes/Visit Hobby Shop	4	3	4	3
Purchase Practice Plane	7	1	7	1
Make Last Year's Plane Flyable	7	3	7	1
Practice Flying	8	8	0	0
Purchase Competition Plane	8	1	0	0
Midterm Report	8	2	0	0
Midterm Presentation I	9	1	0	0
Build Plane	9	2	0	0
Test Autopilot System	9	3	0	0
Imagery Analysis	9	4	0	0
Determine Necessary Hardware and Software for Flight	10	2	0	0
Design CAD Drawing for Retractable Landing Gear	10	3	0	0
Design CAD Drawing for Trap Door Mechanism	10	3	0	0
Purchase New Camera System if Necessary	12	1	0	0
Buy Necessary Hardware and Software	13	1	0	0
Design CAD Drawing for Gimbal System	13	2	0	0
Final Report	14	2	0	0
Final Design Presentations	15	1	0	0
Begin Equipping Plane with Gimbal/Landing Gear	15	2	0	0

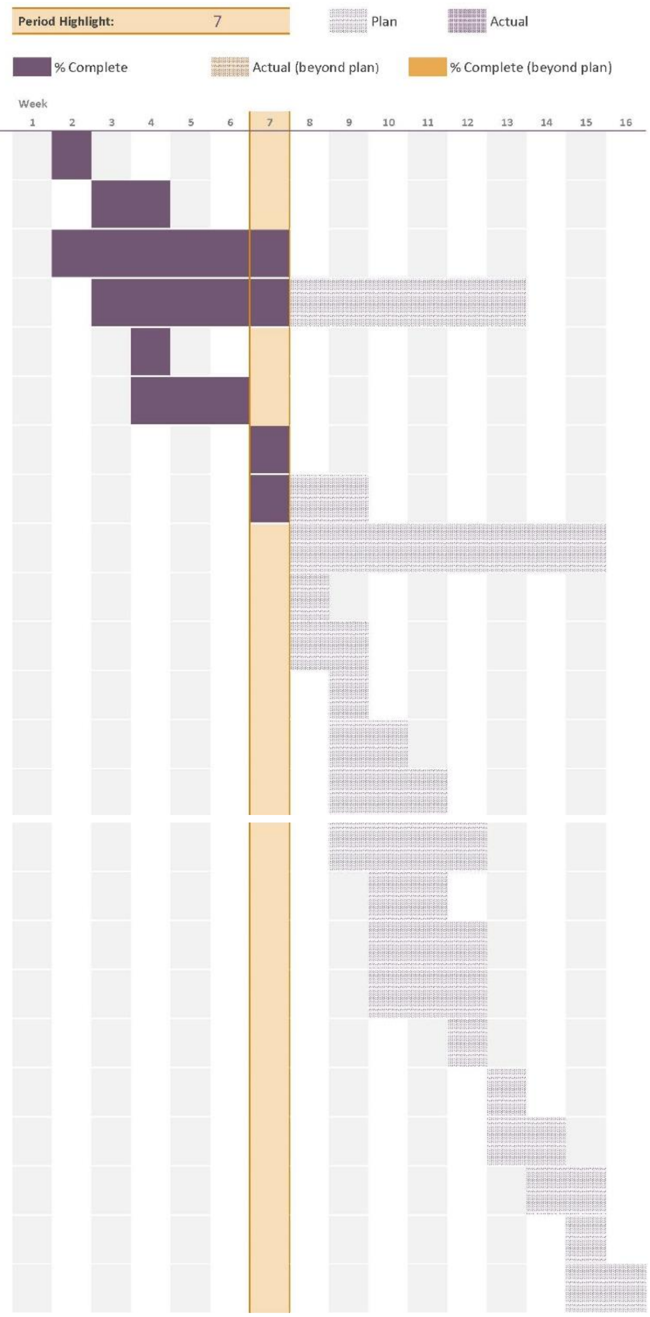

Figure 1: Gantt Chart

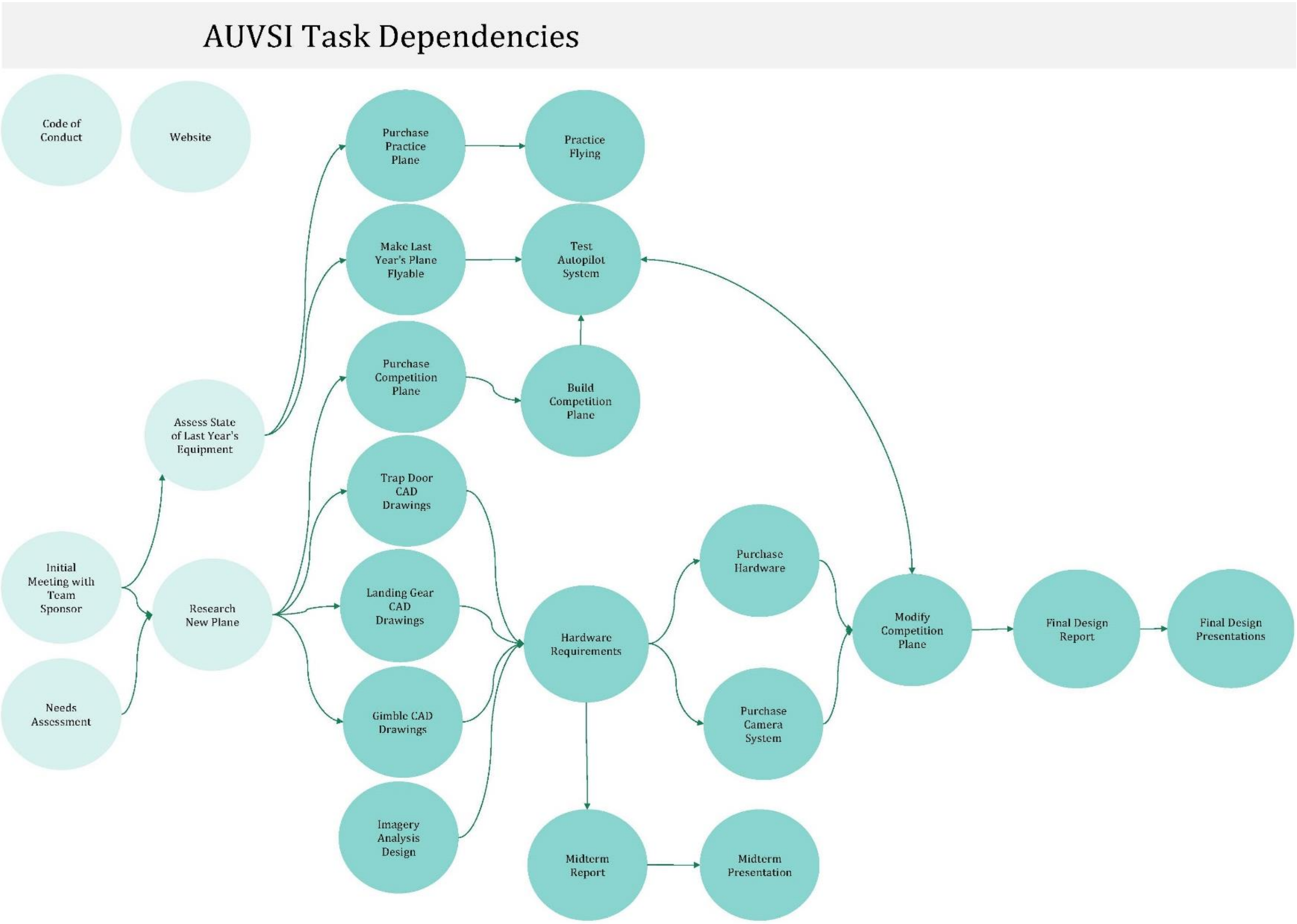

Figure 2: Task Dependencies

Product Specifications

Design Specifications:

- Weight under 55 pounds
- Lifting capability of 25 pounds
- Fuel efficiency to achieve 40 minute flight time
- Adequate vibration damping for accurate image processing
- Flaps to achieve autonomous landing/takeoff

Performance Specifications:

- Flight duration between 20 and 40 minutes
- Able to lift all of necessary equipment
- Autonomous flight
  - Possible autonomous Takeoff/Landing
- Waypoint navigation
- Imagery sensing accuracy
  - Number detection
  - Able to detect targets within required altitude
- Record video and transfer to computer
- Post flight analysis meets competition requirements