Project Plan and Project Scope

EML 4552C – Senior Design – Spring 2012 Deliverable

Student Unmanned Aircraft System
Team # 14

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Project Plan

The plan for completing this design project can be broken into five different categories, each with their own number of activities. They are management, initial testing, interim testing, aircraft construction and prototype.

Management *Weeks 1-16*

Project management deals with the day to day management of the project team, as well as the completion of the required deliverables and presentations.

Initial Testing *Weeks 1-3*

Initial testing basically starts with collecting and unpacking the purchased parts, and testing them on an individual basis. It is important in this step to make sure all the ordered parts are the correct components, are in working order and will fulfill their respective requirements.

Interim Testing *Weeks 4-7*

After the parts are individually analyzed, the parts are then combined into subsystems and further tested. The performances of the various subsystems are verified before moving on. A pre-built RC airplane will be used in this phase for the flight testing of the systems.

Aircraft Construction *Weeks 2-9*

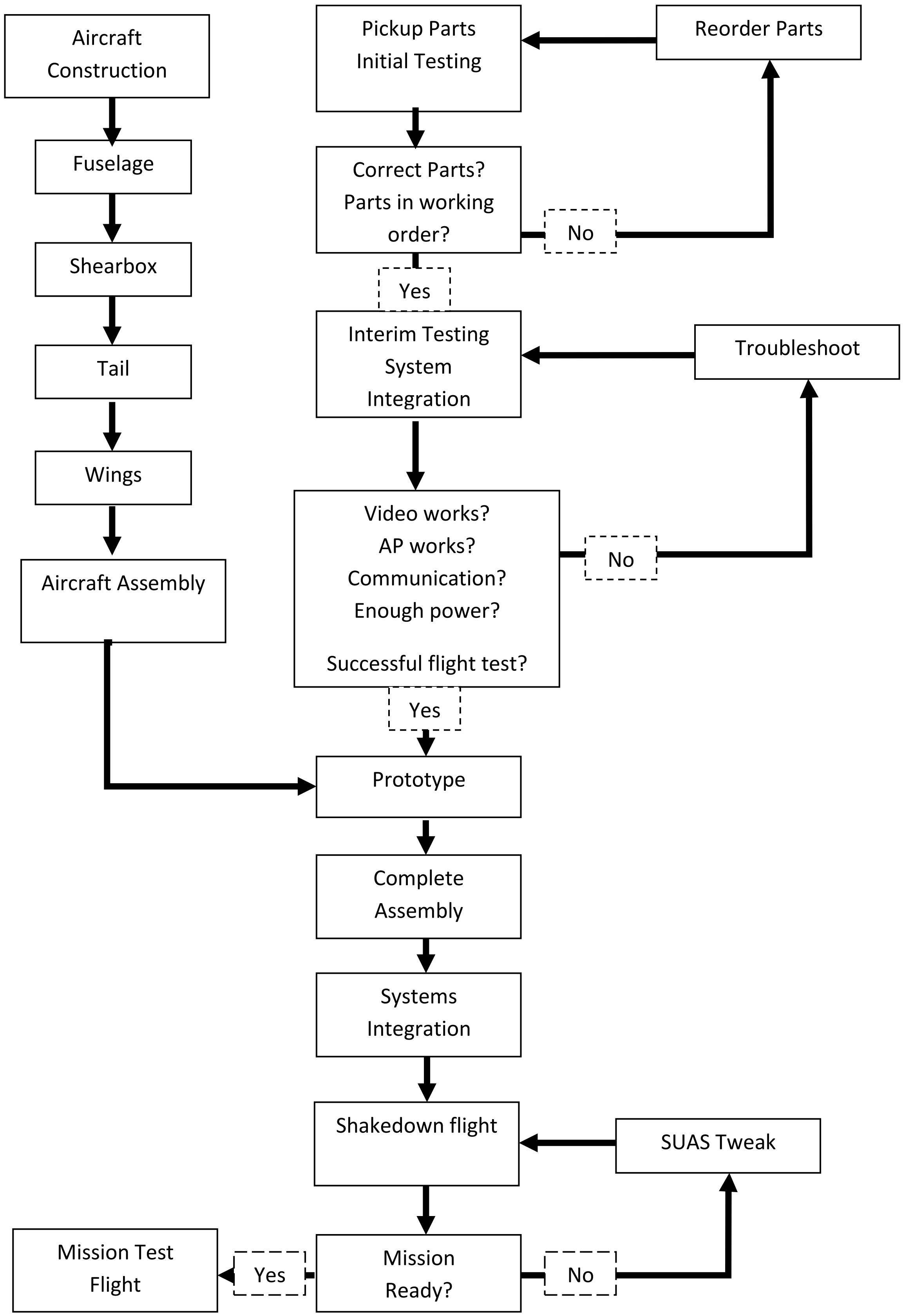
While the various aircraft systems are tested, the physical aircraft structure will be constructed. During this phase, the aircraft structure components will be fabricated and in the final step, assembled into the full aircraft structure.

Prototype *Weeks 10-16*

After the aircraft systems are tested and the aircraft structure assembled, the project will enter the prototype phase. In this phase, the complete aircraft system will be assembled and the various systems integrated. Once the full SUAS is completely assembled and the systems integrated with one another, mission testing of the aircraft will commence. This includes a shakedown flight, where the various characteristics of the SUAS can be tweaked. On successful completion of the mission test flight, a simulated flight of the competition mission, the SUAS will be ready for the AUVSI SUAS competition.

The project plan outline is included as a Gant chart at the end of the document.

The following flow chart shows the progression of the Spring 2012 Project Plan.



Project Scope

Background and Justification

The United States military has been using UASs for "dull, dirty and dangerous" scenarios for over 50 years. The use of unmanned systems in "dull" situations allow for a better sustained alertness of the subsystems over that of humans. Unmanned aircrafts can be used in "dirty" conditions, such as biological warfare, to take samples of the disaster area without putting a pilot's life in jeopardy. The same can be said for dangerous situations, such as reconnaissance missions over war stricken areas, where the probability of the mission's success is greater for unmanned systems over manned aircraft due to the risk involved. There has been an increased use of unmanned systems over the past 10 years in roles outside of the military such as in civil and commercial applications ranging from border patrol to agricultural processes.

The advancement of micro-electromechanical systems (MEMS) has driven a recent development in miniature sensors, efficient small propulsion systems, and inexpensive microcomputers and GPS navigation systems. These recent improvements in MEMS technologies have enabled the use of unmanned aerial systems at the university level for research purposes due to a lowered cost and smaller systems. Research and development of UAVs at the university level is extremely important for the future of autonomous unmanned systems. The future of unmanned systems must possess a large range of autonomous capabilities to perform or assist in navigation, system monitoring, and flight control functions.

Problem Statement

The increasing use of unmanned aerial systems requires significant research from the industrial and university level for the advancement in systems technologies. Our challenge is to design and manufacture an unmanned aerial system that can perform autonomous tasks with imagery capability for reconnaissance purposes. Testing and validation of the design will be performed to optimize our design towards the specific operational requirements.

Problem Statement

The primary objective of our senior design project is to design, test and develop a safe, reliable and cost effective Unmanned Aerial System that is capable of meeting a set of operational requirements. These requirements include path planning and trajectory generation through waypoint navigation, autonomous area search for ground targets, onboard imagery for the detection of these targets, and the ability to communicate with a ground station during flight. While this system is being designed, tested and developed we must take into account the performance, stability, control and effectiveness of our UAS for use in the 2012 AUVSI Student UAS Competition. The successful completion of competition mission requirements that closely match our operational requirements is merely a motivation behind the development of our UAS.

Methodology

We will be utilizing a systems engineering approach during the design of our UAS. A UAS is a complex system that is composed of interrelated subsystems that function together towards the completion of some common objective, which in our case are the operational requirements that were given by our sponsor. The interdisciplinary nature of each of these subsystems requires us as a group to be well versed in the functionality of each subsystem for the successful implementation into a complete UAS. Some examples of subsystems that are typically found on unmanned aerial systems are shown in Figure 1.

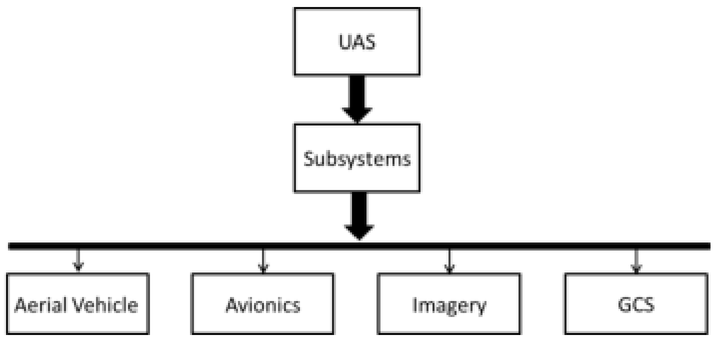


Figure 1: Major subsystems of a UAS.

The aerial vehicle is a complex system in itself because it is comprised of the components necessary for maintained flight including: the wing, tail, fuselage, internal structure, and propulsion system. The avionics is also an exceptionally complex subsystem that includes components such as the autopilot, inertial measurement unit, and data link. It can be argued that the aforementioned components are each subsystems themselves, due to the fact that they each contain numerous components that must function together for successful implementation into the system. The imagery subsystem contains components such as the camera and gimbal which are necessary for reconnaissance missions of the UAS. The GSC, or ground station control, links the onboard computer of the autopilot to a computer on the ground to verify that the UAS is operating safely within the design parameters, displays the location of the UAS based on the heading and coordinates from the GPS, and displays the imagery that is being taken from the onboard camera for possible target location.

We initially divided and alloted each of the subsystems that comprise our UAS to a group members for background research at the beginning of the project. During our biweekly meetings, all team members reported back to project the leaders on the progress of their research. All of this information was recorded in a Dropbox online storage utility and outlined in meetings minutes. A product specification was identified while working with the groups advisor which outlined the future goals of our design and development phase. Following is a figure outlining the basic flow of our design process.

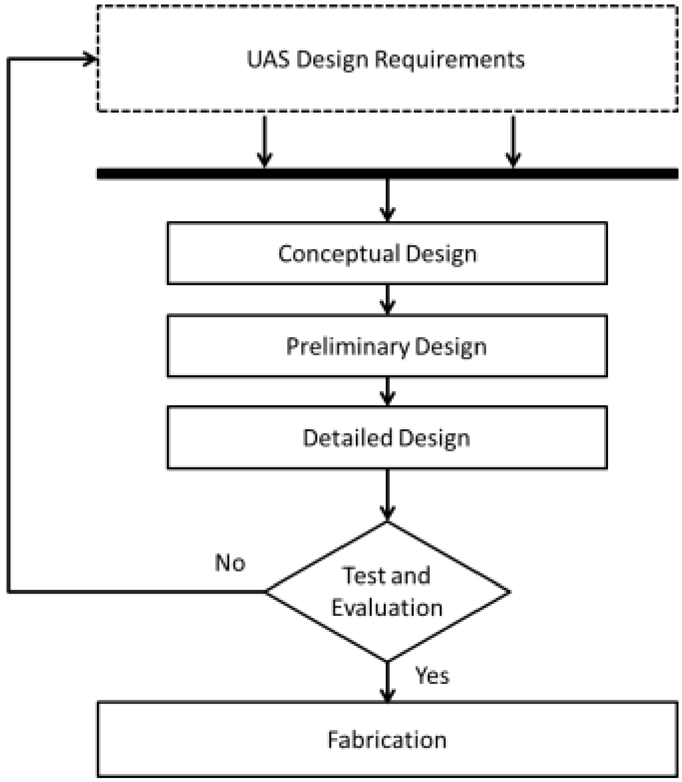


Figure 2: Iterative design procedure for our UAS.

We decided to approach the design phase of our UAS in an iterative manner to allow the optimization of our system around the operational requirements. After the product specification was identified we entered a conceptual design phase. In this phase of the design process, we sought to determine whether a fixed wing or rotary wing aircraft would successfully fulfill the operational requirements given by our sponsor while also providing the best base for our payload. The payload components available for our price range were researched and determined, supplying guidelines for the weight and aerodynamics of the craft. A fixed wing design based off of existing scale craft was chosen during this phase. During the preliminary design phase, the fundamental parameters of the UAV were identified including the weight, speed, power, and preliminary autopilot calculations. From this a detailed design was completed in which all parameters of each of our subsystems was calculated to get a rough estimate of the performance of our UAS. Once this base was found each system was optimized and all structure and aerodynamic features endured multiple iterations to reach a final design point. During the following week the final design will be further scrutinized as materials are delivered and access to construction facilities are granted. Testing of the autopilot systems on a Telemaster test craft will begin as the construction of our craft begins.

Constraints

The main constraints we will encounter during the design of our UAS are established by the AUVSI Competition rules and guidelines. Although the competition is a motivation for the successful completion of our system, we must be aware of the constraints that the competition has for its competitors. These constraints include a weight of less than 55 pounds, the ability to operate at a flight altitude of 100-750 feet, the ability to accept additional navigational waypoints and modify search areas, the ability to fly in crosswinds up to 25 knots, the ability to switch back to remote control by a ground pilot during flight, and the ability to maintain fight for a minimum of 20 to 40 minutes.

There are also constraints developed by the current budget of $3000 for the group and constraints on the construction of the UAS with the accessible composite molding processes and the groups current training level, stopping the craft from having an overly complex design.

Expected Results

At the conclusion of the project an unmanned aerial system capable of automatic flight path generation and attitude adjustment through supplied GPS waypoints, identifying target location and basic geometric characteristics, autonomous ground area search for said targets, communication with a ground station, and a sustained flight window of 30 to 40 minutes shall be produced. All components used in the craft will be either manufactured in an easily reproducible process or be available in the civilian consumer market. The craft, including its fuselage, wings, tail section, and all control surfaces, will be produced by the team in an easily reproducible manor. The system will also be easily transportable for real world applications.

The Undergraduate AUVSI Unmanned Aerial System (UAS) Competition is scheduled to be held on June 13-17, 2012. At this competition our team will be showcasing our final system design which complies with all AUVSI 2012 stated rules and regulations, including safety requirements. Our system will also surpass all of the design thresholds placed by the competition.

Currently everything in the design phase has been completed and the project is on schedule for the construction and testing phases.

Team 14 Spring 2012 Gannt Chart

#	Activity	Planned Begins	Ends	Start	Dur	% Done
	Management					
1	Project Management	4-Jan-12	27-Apr-12	1	16	8%
2	Progress Report	4-Jan-12	19-Jan-12	1	2	0%
3	Mid-Point Review	19-Jan-12	16-Feb-12	3	5	0%
4	Final Project Review	16-Feb-12	5-Apr-12	8	8	0%
5	Final Report	16-Feb-12	5-Apr-12	8	8	0%
6	Operations Manual	16-Feb-12	5-Apr-12	8	8	0%
7	Open House	5-Apr-12	12-Apr-12	14	2	0%
8	Website	4-Jan-12	27-Apr-12	1	16	75%
	Initial Testing (Separate)					
7	Propulsion System	4-Jan-12	17-Jan-12	1	3	0%
8	Power Supply System	4-Jan-12	17-Jan-12	1	3	0%
9	Imagery System	4-Jan-12	17-Jan-12	1	3	0%
10	Autopilot System	4-Jan-12	17-Jan-12	1	3	0%
11	Avionics	4-Jan-12	17-Jan-12	1	3	0%
12	Aircraft Performance	4-Jan-12	17-Jan-12	1	3	0%
13	Communications Testi	4-Jan-12	17-Jan-12	1	3	0%
14	Autonomous Navigatic	4-Jan-12	17-Jan-12	1	3	0%
15	Image Recognition	4-Jan-12	17-Jan-12	1	3	0%
	Interim Testing (Intergrated)					
7	Propulsion System	17-Jan-12	14-Feb-12	4	4	0%
8	Power Supply System	17-Jan-12	14-Feb-12	4	4	0%
9	Imagery System	17-Jan-12	14-Feb-12	4	4	0%
10	Autopilot System	17-Jan-12	14-Feb-12	4	4	0%
11	Avionics	17-Jan-12	14-Feb-12	4	4	0%
12	Aircraft Performance	17-Jan-12	14-Feb-12	4	4	0%
13	Communications Testi	17-Jan-12	14-Feb-12	4	4	0%
14	Autonomous Navigatic	17-Jan-12	14-Feb-12	4	4	0%
15	Image Recognition	17-Jan-12	14-Feb-12	4	4	0%
	Aircraft Construction					
26	Fuselage Fabrication	10-Jan-12	17-Jan-12	2	1	0%
27	Shear Box Fabrication	17-Jan-12	24-Jan-12	3	1	0%
28	Tail Section Fabricatio	24-Jan-12	31-Jan-12	4	1	0%
29	Wing Fabrication	31-Jan-12	7-Feb-12	5	1	0%
30	Aircraft Assembly	7-Feb-12	14-Feb-12	6	1	0%
	Prototype					
31	Complete Assembly	14-Feb-12	28-Feb-12	7	2	0%
32	System Integration	21-Feb-12	6-Mar-12	9	2	0%
33	Shakedown	6-Mar-12	20-Mar-12	11	2	0%
34	SUAS Tweak	20-Mar-12	3-Apr-12	11	2	0%
35	Mission Test	3-Apr-12	24-Apr-12	13	4	0%
	Planned					

Current Week: 2 — Completion ● — Weeks 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16