Needs Assessment and Project Scope

EML 4551C – Senior Design – Fall 2011 Deliverable

Team # 14

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Needs Assessment:

Military investment in unmanned aerial vehicles (UAV) research, systems and applied technologies has increased significantly over the last decade and the potential uses for civil and commercial applications are currently being investigated by federal, state and local government. UAVs offer the ability to have an aerial vehicle in “dull, dirty, or dangerous” situations where having manned aircraft is too costly, from both a safety and monetary standpoint. There is a need for the advancement in not only the UAVs themselves but also the systems that comprise the air vehicle for the safe completion of operational requirements. These systems that are required for the use of unmanned flight as well as the aerial vehicle itself are often termed unmanned aerial systems (UAS). It is our task as a senior design project to design, test and develop a UAS that can be used for research purposes to advance the field of unmanned flight. As a motivation for the successful completion of our senior design project, we will be entering our design in the tenth annual Association for Unmanned Vehicle Systems International (AUVSI) Student Unmanned Aerial Systems (SUAS) Competition held in June of 2012.

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.

Background/ 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 micro-computers 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 lower 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.

Objective:

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 our UAS. Some examples of subsystems that are typically found on unmanned aerial systems are shown in Figure 1.

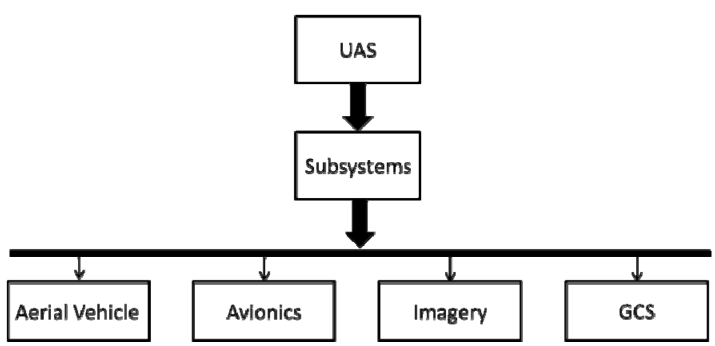

Figure 1: Major subsystems of a UAS.

The aerial vehicle is a complex system in itself because it includes the components that are necessary for the system to maintain flight, such as the wing, tail, fuselage, 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 will initially be dividing up the subsystems that will comprise our UAS to each of the group members for background research purposes. During our biweekly meetings, all team members will report back to project leader on the progress of their research, in which a database of information will be developed to ease the process of subsystem integration. After product specifications have been identified, the design and development of the subsystems will commence, in which all team members will closely work together to verify the functionality between all components.

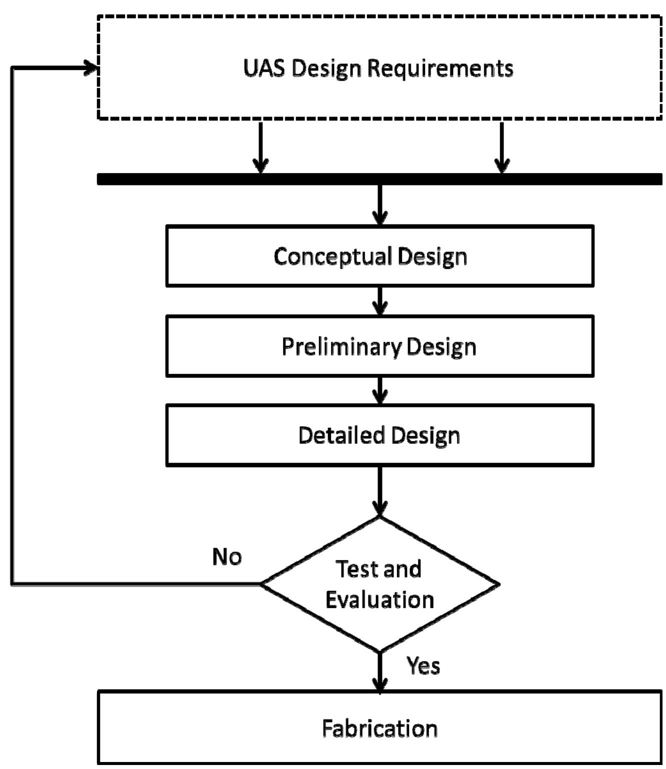

Figure 2: Iterative design procedure for our UAS.

We will approach the design phase of our UAS in an iterative manner to allow the optimization of our system around the operational requirements. A diagram of the design phase is shown in Figure 2. Once the requirements and product specifications of our UAS have been established, we will begin with a conceptual design in which the initial configuration of our system will be identified. In this phase of the design process, we will determine whether we believe a fixed wing or rotary wing aircraft will successfully fulfill the operational requirements given by our sponsor. Based on this decision, we will then identify the major components the aircraft requires that will satisfy the operational needs and establish a trade-off analysis for the selection of the appropriate components. During the preliminary design phase, the fundamental parameters of the UAV will be identified such as the weight, speed, power, and preliminary autopilot calculations. Once this has been established, a detailed design will be completed in which all parameters of each of our subsystems will be calculated to get a rough estimate of the performance of our UAS. During these phases, we will be performing a multidisciplinary optimization of all subsystems to determine the best possible design of our UAS. Once the detailed design has been finalized, testing and evaluation will commence to verify that the operational requirements will be satisfied by our optimized design. If for some reason they are not satisfied, we will return back to the previous design phases to reevaluate key parameters that we might have missed.

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.

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.

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