Project Definition Document

*Aerospace Senior Projects (ASEN 4018 & 4028)
Fall 2004 and Spring 2005*

Project Title

Heavy-lift Aerial Vehicle for the University of Colorado (HAVUC).

1. Project Customer

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2. Background and Context

Often the payload constitutes only a small fraction of the total weight of an aircraft. With the case of Unmanned Aerial Vehicles (UAVs), the size of the aircraft is such that only small payloads can be carried. Therefore, a UAV with the ability to carry aloft a payload that contributes to more than half of the total aircraft weight would be quite a valuable asset, especially to the University of Colorado. CU has had limited success with past UAV designs, and thus has few flying platforms. Those that are flying are small and carry relatively light payloads. An aircraft with a heavy-lift capability would allow for a larger variety of packages to be flown, while the size of the aircraft would still be small enough that it could be managed by the University.

The Society of Automotive Engineers (SAE) has an annual Aero Design competition that deals specifically with this design challenge. The focus of the competition is for each team to design and fabricate an airplane that can carry aloft as much weight as possible while following the stringent requirements for engine displacement and takeoff distance. The competition also challenges the team’s ability to accurately predict the performance of the airplane.

3. Objectives

3.1. Overall Objective

The objective of this project is to conceive, design, fabricate, integrate, test and verify a UAV with a heavy lifting capacity that abides by the requirements of the SAE annual Aero Design competition in 2005.

These are the functional objectives based on the SAE competition rules for 2004. Rules for 2005 are expected in September 2004.

3.2. Aircraft Configuration

3.2.1. Objective

Aircraft must be of a fixed-wing configuration.

3.2.2. Discussion

In accordance with the requirements specified by the SAE Aero Design competition only fixed-wing aircraft are permitted. This requirement rules out designs such as dirigibles, lighter-than-air craft, and rotary craft.

3.3. Control

3.3.1. Objective

The aircraft will by piloted via R/C control

3.3.2. Discussion

The aircraft will be under constant human control via common R/C.

3.4. Payload Bay

3.4.1. Objective

The arbitrary payload must be carried in a designated bay and cannot contribute the structural integrity of the aircraft. There is no size limitation for the payload bay.

3.4.2. Discussion

A designated payload bay increases the overall versatility of the aircraft. Mission specific payloads should theoretically be interchangeable with relative ease. Requiring that the payload cannot contribute to the structural integrity of the aircraft ensures that the aircraft can operate independently of the payload.

3.5. Engine(s) Displacement Volume

3.5.1. Objective

The total displacement volume of the AMA approved internal-combustion engine(s) must be less than or equal to 0.92 cubic inches.

3.5.2. Discussion

Limiting the displacement volume confines the overall size and cost of the aircraft.

3.6. Payload-Empty Weight Fraction

3.6.1. Objective

Achieve a minimum payload weight fraction, $\frac{Payload\ Weight}{Payload\ Weight + Empty\ Weight}$ of 60%.

3.6.2. Discussion

To qualify as a heavy-lift aircraft at least 50% or more of the takeoff weight should be payload. The teams that entered in the SAE competition in 2004 payload weight fractions of 52%, 56%, 73%, 77% and 79%.

3.7. Takeoff Distance

3.7.1. Objective

Aircraft must have a takeoff distance no greater than 200 feet.

3.7.2. Discussion

The takeoff distance limit forces the size and weight of the aircraft to be designed to a manageable amount. The limit also ensures that the aircraft can operate out of the majority of R/C airfields.

3.8. Minimum Attainable Altitude

3.8.1. Objective

Carry aloft a payload meeting the above weight requirement to a minimum altitude of 20 feet above the surface terrain.

3.8.2. Discussion

Flight at 20 feet above the ground should place the aircraft outside of any ground effect, which would increase the lifting capacity of the aircraft.

3.9. Wireless Communication

3.9.1. Objective

Transmit input commands and output telemetry between the aircraft and a computer on the ground through wireless communication.

3.9.2. Discussion

Communication must be maintained up to a line of sight distance of 1/4 mile under standard remote control (RC) flight conditions. Communication system must send TBD% (at least 90%) of telemetry values accuracy.

3.10. Electronics and Flight Data Acquisition

3.10.1. Objective

Obtain real-time flight data to verify that the aircraft's performance requirements have been met. The parameters that will be measured include:

The input command voltage to every control servo will be recorded TBD (at least one) times per second, accurate to TBD volts.

Attitude will be measured in the body fixed inertial reference frame accurate to TBD (between 1 and 5) degrees along each axis at least once every second.

True air speed will be measured accurately to TBD (at least +/- 5) mph at least once every second. Angle of attack will be measured accurately to TBD (between 0.5 and 5) degrees between the range of -5 and +20 degrees at least once every second.

Pressure altitude will be measured accurate to TBD (between 4 and 10) feet at least once every second.

(Stretch Goal) - Attitude rates will be measured via inertial measurement unit (IMU) or computed from attitude angles. These rates will be accurate to TBD degrees per second.

3.10.2. Discussion

The primary objective of this project is to design an aircraft to meet specific flight performance requirements; therefore data acquisition will be used to verify that these requirements have been met.

The true air speed and angle of attack measurements will be used to compare the actual lift curve to our theoretical values. The altitude measurements will verify that the minimum altitude requirement of 20 ft has been accomplished.

3.11. Aerodynamic Testing

3.11.1. Objective

Verify aerodynamic performance, parameters TBD.

3.11.2. Discussion

This could include wind tunnel testing of airfoils and/or a scale model aircraft, depending on the availability of resources. Another possible option could be hard mounting a scaled or full-size aircraft to an automobile.

3.12. Structural Testing

3.12.1. Objective

Perform testing of various combinations of materials and structures to achieve a TBD strength to weight ratio. One of these tests will include a wing breaking test.

3.12.2. Discussion

One of the primary objectives of this project is to achieve a high payload weight fraction, thus it is important to have a lightweight structure capable of withstanding large amounts of stress.

3.13. Basic Air-Maneuvering (Stretch Goal)

3.13.1. Objective

Aircraft is able to perform basic horizontal maneuvering, such as banking turns. The aircraft is not required to perform rolls or any vertical maneuvers (i.e. loops or hammerheads).

3.13.2. Discussion

The ability to perform basic maneuvers while in flight will allow for course corrections and varying flight patterns, all of which improve upon the usefulness of the aircraft.

3.14. Prescribed Flight Pattern (Stretch Goal)

3.14.1. Objective

Fly the prescribed flight pattern dictated by the SAE Aero Design competition rules, which states that once aloft, the aircraft must complete at least one full 360º turn and then land in the same direction as the takeoff.

3.14.2. Discussion

Following a predetermined flight pattern verifies to a further extent the ability of the aircraft to maneuver precisely to the pilot inputs.

3.15. Landing (Stretch Goal)

3.15.1. Objective

Landing must occur in the same direction as take-off within a designated 400 foot landing zone. The aircraft is allowed to roll beyond this zone; however the wheels cannot leave the ground outside of the landing zone. Crash landings and touch-and-goes are not considered valid landings.

3.15.2. Discussion

The controllability of an aircraft during landing is typically a major concern. Therefore, this requirement is meant to ensure proper controllability during this phase of flight.

4. Engineering Expertise

Technical Expertise	Application
Mechanical Design	Develop conceptual and detailed solid 3D models of system components
Mechanical Fabrication	Component machining and assembly
Radio Control Flight	Piloting of the aircraft
Flight Mechanics	Develop conceptual and detailed design of an aircraft and verify its performance
Structural Fabrication	Aircraft construction and flight control assembly
Control Software	Real-time control subsystem (stretch goal)
C Programming	Manipulating flight data
Wireless Communication	Data transmission for performance verification
Aerodynamic Design	Aerodynamic design of aircraft
Structural Testing Aerodynamic Testing	Verification of structural design and material properties Verification of aircraft's aerodynamic performance

5. Resources

5.1. Facilities

The project will have access to the Senior Design Laboratory, the Aerospace Machine Shop, the ITLL Manufacturing Center, the ITLL or University of Kansas wind tunnel, the ITLL Electronics Center and a local R/C airstrip.

5.2. Additional Advisors

RECUV Faculty

5.3. Funds

The University of Colorado Aerospace Department will provide $4,000 in funding. Proposals to the Undergraduate Research Opportunity Program and the Engineering Excellence Fund will be made for additional grants.