AC 2009-1346: DESIGN, BUILD, FLY PROJECT HIGHLIGHTS

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AIAA Design, Build, and Fly Competition: The Design of A^2

Abstract

The American Institute of Aeronautics and Astronautics (AIAA) Design, Build, and Fly Competition (DBF) brings students from around the nation to compete each year. The competition calls for an unmanned, remote controlled aircraft capable of meeting mission goals and design requirements. For the 2008-2009 competition, a surveillance/attack UAV capable of dropping wing stores and carrying a simulated centerline fuel tank is necessary. The team has chosen a dual engine aircraft with a seven foot wingspan and a gross empty weight of approximately 8.5 pounds. Multiple missions with different mission profiles will be flown requiring the aircraft to carry heavy loads and/or fly with unbalanced wing loadings. The competition will be scored based on the adequacy of flight mission completion and the proficiency of the written paper. The aircraft will be required to fly a maximum continuous distance of 14000 feet. Once the aircraft design was set and the mission was understood a risk analysis for a successful competition as well as for the aircraft itself was conducted. The most detrimental risks present are plane crash and pilot error due to their lack of mitigations. The completion of several mathematical processes and team presentations has instilled a generous amount of educational value in the team. Drawing on the full spectrum of engineering ideas acquired over the years has prepared the team for the competition and for future engineering explorations.

Nomenclature

b	=	wing span
c	=	chord
C_D	=	Drag Coefficient
C_{Do}	=	Profile and Friction Drag Coefficient
C_L	=	Lift Coefficient
E_{max}	=	Max Lift to Drag Ratio
e	=	Oswald Efficiency Factor
HP/W	=	Horsepower to Weight Ratio
K	=	Induced Drag Coefficient
RAC	=	Total System Weight
S	=	Wing Area
SFC	=	System Complexity Factor
W/S	=	Wing Loading

I. Introduction

The AIAA Design, Build, and Fly (DBF) Competition brings schools from around the world to compete. Each year the teams design, fabricate, and demonstrate the flight capabilities of an unmanned, electric powered, radio controlled aircraft in order to meet a specified mission profile. This year the competition calls for a surveillance/attack UAV. The capabilities of the aircraft include carrying a large simulated fuel tank and four Estes rockets. There will be five stages of judging for the contest:

1) Written paper.
2) Speed of assembly.
3) Ferry flight with simulated fuel tank empty.
4) Surveillance flight with simulated fuel tank full.
5) Rocket release flight with unbalanced wing loading.

There are also certain requirements the aircraft must meet including no more than a 40 amp current draw, maximum take off gross weight of less than 55 pounds, and maximum take off distance of 100 feet. Using these guidelines as a basis for the engineering of the aircraft, the team will build a UAV using an innovative design based on different concepts already in practice as well as unique concepts developed by the team [1].

II. Aircraft Requirements

The most important preliminary step in designing an aircraft is developing an understanding of the aircraft requirements. The majority of the requirements for this competition are set by AIAA itself. This year, the aircraft must meet the following requirements set by AIAA along with several requirements put in place by the team. It must be a fixed wing, electric powered aircraft, have a maximum gross take off weight of 55 pounds and be able to take off within 100 feet. Each electric motor is limited to a 40 amp current draw which can be supplied by battery packs with a total weight of no more than four pounds. The sizing of the aircraft is also an integral part of the aircraft design as the aircraft and all its components must be broken down to fit into two, 2 feet x 2 feet x 4 feet boxes. In addition to the basic vehicle design requirements, the aircraft will be required to carry different payloads. For two of the missions the aircraft must carry a one gallon centerline fuel tank, empty or full. In the other mission, the aircraft must carry four Estes rockets on the wings capable of being dropped individually, which creates another set of design requirements. The rockets must each be weighted to 1.5 pounds and the first rocket on each wing must be at least 2 feet off the centerline of the aircraft. Additionally, each other rocket must be at least 0.5 feet from the innermost wing store [1]. In order to complete this final mission the rockets are going to be carried by a clamp, and, when actuated, will open and release the rocket.

III. Mission Profiles, Range, and Scoring

The following section outlines the mission profiles, corresponding ranges, and the scoring involved for each mission as determined by the AIAA DBF Competition. The course layout, which allows for a better visual understanding of the following sections, is shown in Fig. 1.

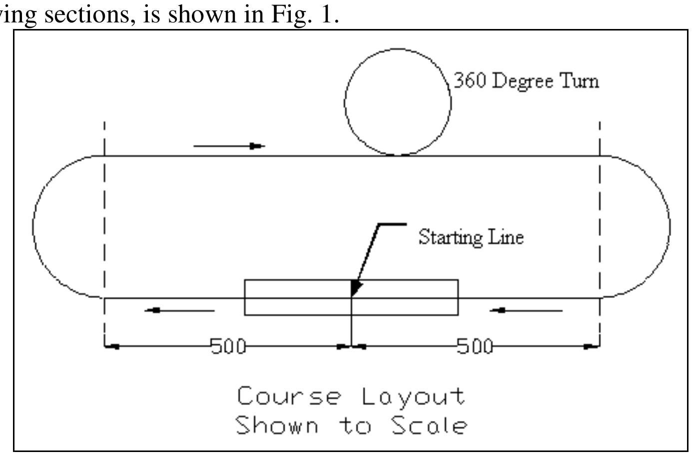

Figure 1: Course layout.

A. Mission Profiles

The aircraft must complete four different missions, these missions are listed below:

1) Pre-Mission: Assembly.
2) Mission 1: Ferry flight.
3) Mission 2: Surveillance flight.
4) Mission 3: Store/Release asymmetric loads flight.

The pre-mission requires a timed assembly of the flight vehicle with full store load. The full store load includes the centerline fuel tank and four rockets ballasted on wing pylons. The storage boxes will be weighed with all contents inside and then dropped from 6" onto a cement surface. If the contents are damaged in any way during the drop, the pre-mission will not be scored.

The first mission, ferry flight, requires the aircraft to fly two full laps of the course and then land on the runway. All this must be done while carrying the empty simulated centerline fuel tank. A diagram of this mission profile is displayed in Fig. 2. [1]

The second mission, surveillance flight, requires the aircraft to fly four full laps of the course and then land on the runway. This must be completed by carrying the centerline tank filled with one plus gallons of water. A diagram of this mission profile is presented in Fig. 2.

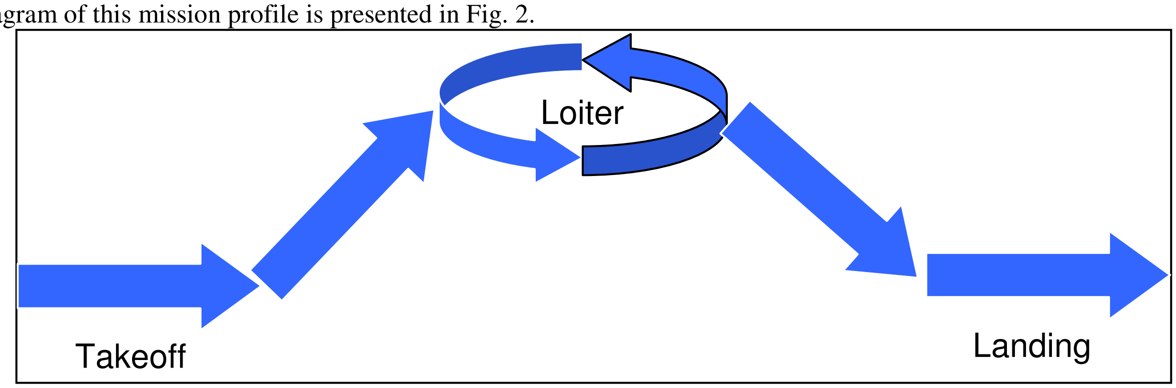

Figure 2: Ferry and surveillance flight mission profile.

The third and final mission, store/release of asymmetric loads flight, creates the most difficult mission profile for the competition. The aircraft must fly four consecutive laps, landing and dropping a wing store after each lap. Four rockets will be attached, two on each wing, at the start of the mission, and they will be dropped in the order declared by the judge at the beginning of the flight. Once the aircraft lands each time, the team will be required to direct the aircraft to drop a rocket in a designated area and then continue with the mission. The mission profile is displayed in Fig. 3 below [1].

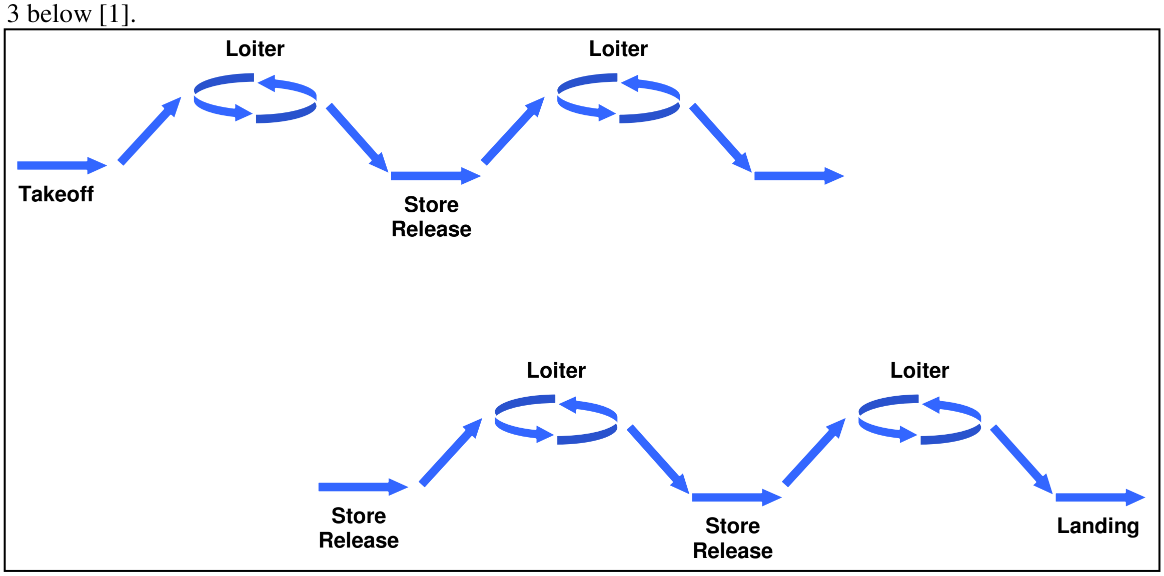

Figure 3: Store/Release mission profile.

B. Range

The range of our aircraft is different for each mission depending on the mission profile because the battery packs are able to be recharged after each mission. An individual lap around the course is approximately 3000 feet (see figure 1) which includes only the linear distance flown and does not include any vertical distances. For the ferry flight mission, the aircraft is required to fly two laps around the course which requires a range of about 6000 feet. Four laps are then flown in the reconnaissance mission requiring a range of roughly 12000 feet. The final mission, store/release, requires four laps as well; however, after each lap the plane must land, taxi, and then take off again which creates a range between 12000 and 14000 feet depending on landing accuracy and other factors of the flight. [1]

C. Scoring

The overall scoring for each team will be a combination of their written paper score and their total flight score using equation (1) below.

$$\text{SCORE} = \text{Written Report Score} * \text{Total Flight Score} \tag{1}$$

The written report will be graded out of 100 points. The flight score will be a combined score of all three different flight missions. The scoring for each flight is different, and each team is allotted one extra attempt for each mission in order to better their initial score. No flights will be scored unless the landing is completed properly during and/or at the end of each mission. The pre-mission establishes the system complexity factor (SCF) which uses the total system weight (RAC) and the assembly time. The SCF is established using equation (2) below.

$$SCF = \frac{1}{RAC \times Assembly\_Time} \tag{2}$$

For the ferry flight mission, the score is calculated by taking the SCF divided by the flight time. This is the only mission where the actual flight time is considered in the scoring. The surveillance mission score is simply the SCF; however, the mission will not be scored unless the aircraft completes a successful landing. The final mission, store/release, is scored by the SCF divided by the loading time, where the loading time is the time it takes the team to equip the aircraft with all four rockets. [1]

IV. Weight Sizing

The weight of the aircraft is dependent on the materials used and the efficiency of their implementation. For this aircraft, aluminum, balsa wood, foam, and fiberglass will be the key structural components and the remaining weight will be a factor of the motors, batteries, servos, propellers, and stores used. The fuselage is made of fiberglass which is molded around a foam core creating a rough weight of somewhere between 1 and 2 pounds. The boom, which protrudes from the fuselage and leads back to the tail, is made of balsa wood weighing approximately .25 pounds. Monocote, aluminum, and balsa wood make up the empennage creating a weight of about .25 pounds. The wing is also made of balsa wood and monocote spanning seven feet with a chord of 1.5 feet and a weight of 3 pounds. The servos will be chosen based on the power output needed once the final design is completed; however, with roughly ten servos needed a net weight of approximately a half a pound is expected. The two engines were chosen in the same manner, with a combined weight of a about a pound and will be powered by four battery packs weighing roughly 2.5 pounds. All of these components listed thus far make up for the vehicle empty weight of about 8.5 pounds. The different stores add additional weight to the aircraft creating variable gross vehicle weights for each mission. The full one gallon bottle of water weighs nearly 9.5 pounds with fairings and the four rockets weigh a combined 6 pounds. These create 18 and 15 pound gross vehicle weights respectively. The size and weight of each component along with the total weights are displayed in Fig. 1 below. [2]

Part	Weight (lbs)	% Empty Weight
Boom and Tail	0.5	5.9
Fuselage	1	11.8
Wing	3	35.5
Servos	0.35	4.1
Batteries	2.5	29.6
Motors	1	11.8
Propellers	0.1	1.2
Rockets	6	
Fuel tank (full)	9.5	
	Totals:	
	Empty	8.45
	W/ Fuel tank	17.95
	W/ rockets	14.45

Figure 4: Total Weight Sizing.

V. Vehicle Design

A. Structural Design

The latest three- view drawing illustrates a basic visual representation of the design of the aircraft. The three figures below display the front, side, and top view of the aircraft.

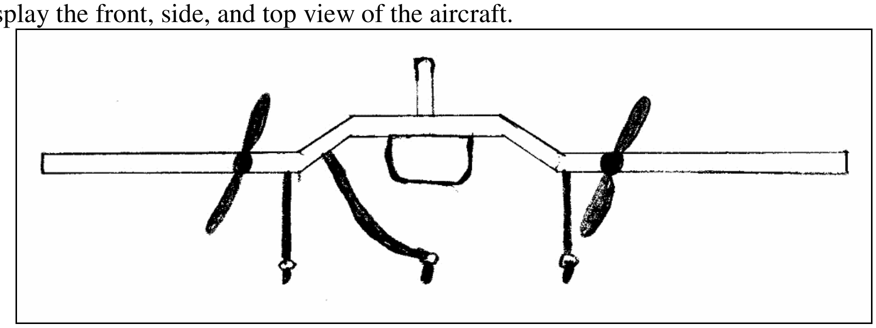

Figure 5: Front View.

Fig. 5 above illustrates the front view of the proposed aircraft. It can be seen from this picture that the largest structure in the aircraft is the wing. This is due to the aircraft's requirement of lifting the 18 pound full vehicle weight. Also from this picture, the landing gear design is apparent. The aircraft is equipped with a tricycle landing gear with a steerable nose gear. The nose gear is to be specially made to fit around the simulated fuel tank when attached to the aircraft. This type of landing gear will allow for the greatest amount of support in landing as well as maneuverability on the ground. As the team continued to revise the stability and control aspects of the aircraft, it became clear that when the bottle became attached, the translation of the vertical center of gravity had to be accounted for. In order to minimize the effect of the change in vertical center of gravity, the team looked to other aircraft for a possible solution. Looking back at the F4U – Corsair provided the best solution by dropping the wings, and therefore, lowering the vertical center of gravity.

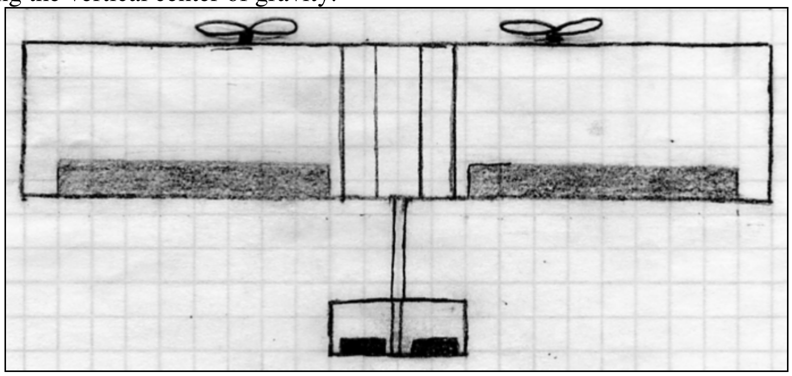

Figure 6: Top View.

Fig. 6 displays the top view of the aircraft. Once again it is easy to see the wing, with its 7 foot wingspan, makes up the majority of the aircraft. In addition from this picture it is observed that the tail design is standard. The vertical tail protrudes from the horizontal tail and the horizontal tail is rectangular. The two propellers and motors will be placed a little over a third of the distance off the centerline of the aircraft.

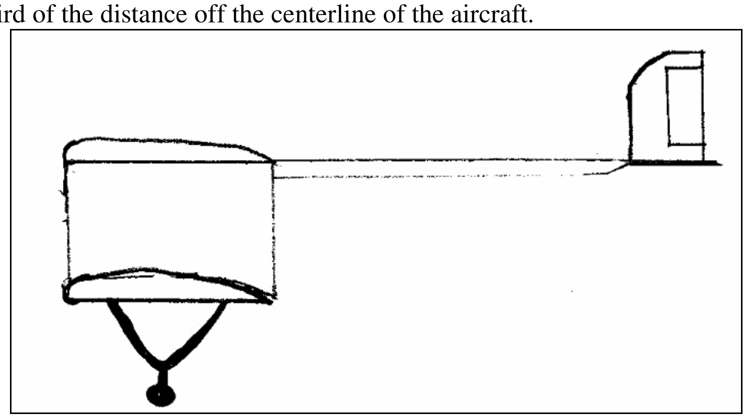

Figure 7: Side View.

The side view is displayed in Fig. 7 above. From this angle the bottle positioning point is evident. The bottle will be placed between the two landing gears and attached to the fuselage. The bottle is allowed 15 inches with fairings, so the 18 inch space allows for some flexibility in center of gravity positioning.

B. Control Systems

The control system of the aircraft is based off of a typical radio controlled aircraft. The usually consists of a radio transmitter, a receiver, a speed control(s), and servos controlling the elevator, rudder/landing gear, and ailerons. A^2 however, requires this plus an additional four servos controlling the release of the wing stores and simulated centerline fuel tank. A block diagram of this control system is shown in Fig. 8.

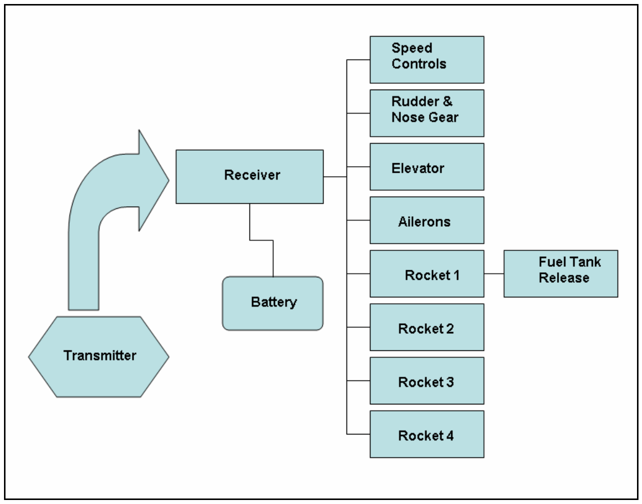

Figure 8: Block Diagram of Basic Control System

The second main control system is the motor control system. As seen in Fig. 9, the systems consist of the two motors, two speed controls, two fuses, two battery packs, and the receiver from the basic control system.

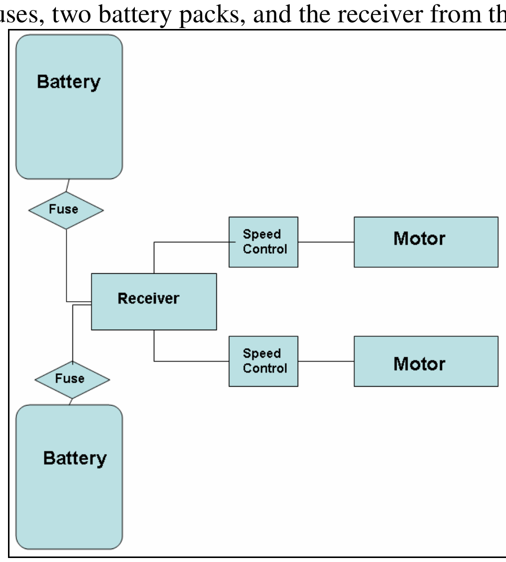

Figure 9: Block Diagram of Motor Control System

C. Mission Systems

As the vehicle has evolved, several other design issues surfaced. The first was how to attach the wing stores to the wings so that each rocket can be individually released. To solve this problem, the team has designed a clamping mechanism that will be servo actuated. The basic design can bee seen in Fig. 10:

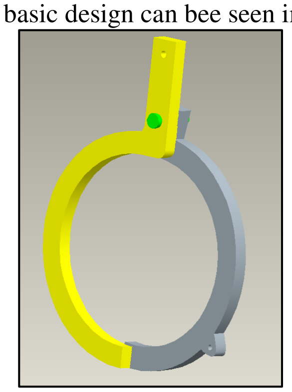

Figure 10: Initial Clamp Design.

The clamp will function by servo actuation. The yellow portion of the clamp will be held stationary permanently and be attached to the aircraft wing. The gray portion of the clamp will be actuated by an attached servo that will raise the lever arm and drop the store simultaneously.

The second mission system is the bottle release mechanism. This mechanism must be capable of releasing the simulated fuel tank if required by the competition. The team is currently testing several ways of releasing the simulated fuel tank, but has not yet determined the best solution.

VI. Constraint Analysis

The first step in determining the design space for the aircraft was to determine the major design constraints to be considered. The answer to this question is found in the aircraft requirements set by AIAA. The aircraft must be able to takeoff in 100 feet or less. This was the driving requirement for the constraint analysis. Along with takeoff, constant velocity, constant altitude cruise, and rate of climb were also considered. The analysis was done using two different weights and two different takeoff distances. Weight one was set to 20 pounds and weight two was set to 16 pounds. Distance one was set to 90 feet and distance two was set to 80 feet. Using these ranges of weights and takeoff distances ensures that the aircraft will fall within the required takeoff distance of 100 feet. Along with these four assumptions, several others had to be made. The first assumption was that the goal rate of climb would be 5 feet per second, which was determined by assuming a flight altitude of 50 feet. The team determined that it would be desirable to reach this altitude in about 10 seconds after takeoff. The second assumption was that the $C_{L,max}$ of the aircraft was 1.1, and third important assumption was the propeller efficiency of .85. Using these assumptions and equations for aircraft performance found in Ref. [3], a Matlab program was written to compute the design space for the aircraft.

The program was written to determine the horsepower to weight ratio required for a given wing loading. The wing loading was iterated from 1 to 2.5 psf. This range was determined from common wing loadings found from commercially available radio controlled aircraft. The physical constraints of the competition were then implemented into the program in order to narrow the range. Using the assumption that the wing span is between 6-7 feet, the chord can be determined. The physical constraint of having to fit the wing into a box measuring 2 ft x 2 ft x 4 ft and that the boxes are to be dropped, it was determined that a chord of approximately 1.5 feet was desirable. This allows for the addition of padding on the inside of the box in order to protect the wing during the drop test. This narrows the initial range down to a wing loading of between 1.85 to 1.95 psf. The span was then chosen to be 7 feet. From these two pieces of information a wing loading of 1.9 and a horsepower to weight ratio of 0.073 was calculated. After several iterations of the preliminary weight sizing the program was updated. Weight one was reset to 18 pounds and weight two was reset to 15 pounds. Using the same geometric and physical constraints as above, the finalized design point was reached. A wing loading of 1.7 psf and a horsepower to weight ratio of 0.033 were determined. As seen below in Fig. 11, the design point lies between the two takeoff distances. Having the design point between the two constraints, but closer to the constraint formed by distance 2, ensures that the aircraft will be able to meet the 100 foot takeoff distance requirement with some cushion for outside factors.

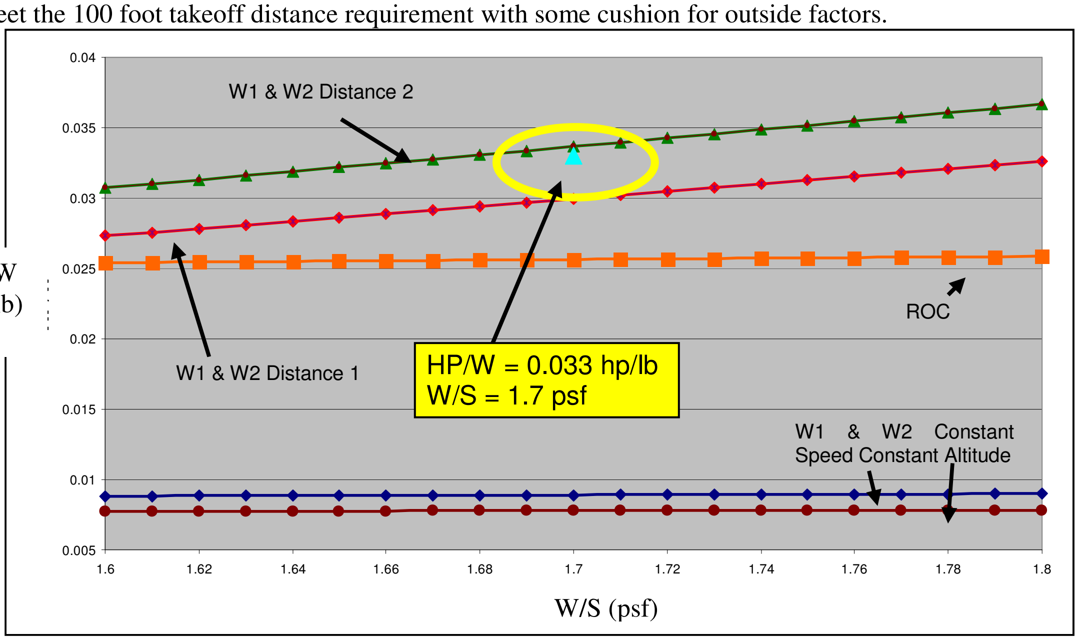

Figure 11: Constraint Analysis Design Space

VII. Comparison to Commercially Available Radio Controlled Aircraft

A comparison to other radio controlled aircraft was done. A summarization of the data collected can be found in Fig. 12.

Aircraft	S (ft^2	b (ft)	Empty Weight (lbs)	W/S (lb/ft^2)	Hp/W (Hp/lb)
Sig Spacewalker II	7.71	7	12	1.56	0.208
Top Flight Cessna 182 Skylane	6.29	6.75	12	1.91	0.208
Sig Clipped Wing Cub	9.02	7.17	15	1.66	0.167
Great Planes Ultra .60	4.91	5.125	7	1.43	0.271
Great Planes Skybolt	6.46	4.75	9	1.39	0.278
SAE Aero 2007 Channel Wing	10	10	17	1.7	0.224

Figure 12: Comparison to Commercially Available Radio Controlled Aircraft [2]

As seen above, the determined wing loading (W/S) of 1.7 psf is within the range of the given aircraft. The determined horsepower to weight ratio is considerably lower than those listed above; however, this can be contributed to the different mission requirements of the aircraft above. Most of the aircraft above are considered sport aircraft, and therefore require more power for maneuvering flight as opposed to takeoff. It is also important to note that the horsepower to weight ratio determined in the constraint analysis is the bare minimum necessary to meet the requirements.

VIII. Motor and Battery Selection

The competition has set several requirements for the engine and battery characteristics. Each individual engine must have less than a 40 amp current draw and be powered by a battery pack that weighs less than 4 pounds. In order to narrow down the selection of an electric motor, the team consulted the program MotoCalc. MotoCalc has been used by DBF teams in the past, as well as SAE teams to restrict the number of possible electric motors. The program requires some basic inputs in order to help narrow down the motors. These inputs include aircraft weight, airfoil, estimated flight time, number of motors, and other physical aircraft parameters. Using these inputs, the program examines the known characteristics of several hundred commercially available motors and refines the list to a group of about 30. From this list the team was able to determine the proper motor using constraints such as motor weight, performance, and available power. The program then outputs the available power. Using the available power output given by the program and the assumed propeller efficiency of 0.85, the available power can be graphed. Ultimately, the team selected two Hacker A30-10XL motors to power the aircraft. As seen in Fig. 13 the A30 provides the required excess power required by the aircraft which allows enough power for overcoming unseen obstacles such as head or side winds. The team will also verify the power available curve once the motors have been purchased and received.

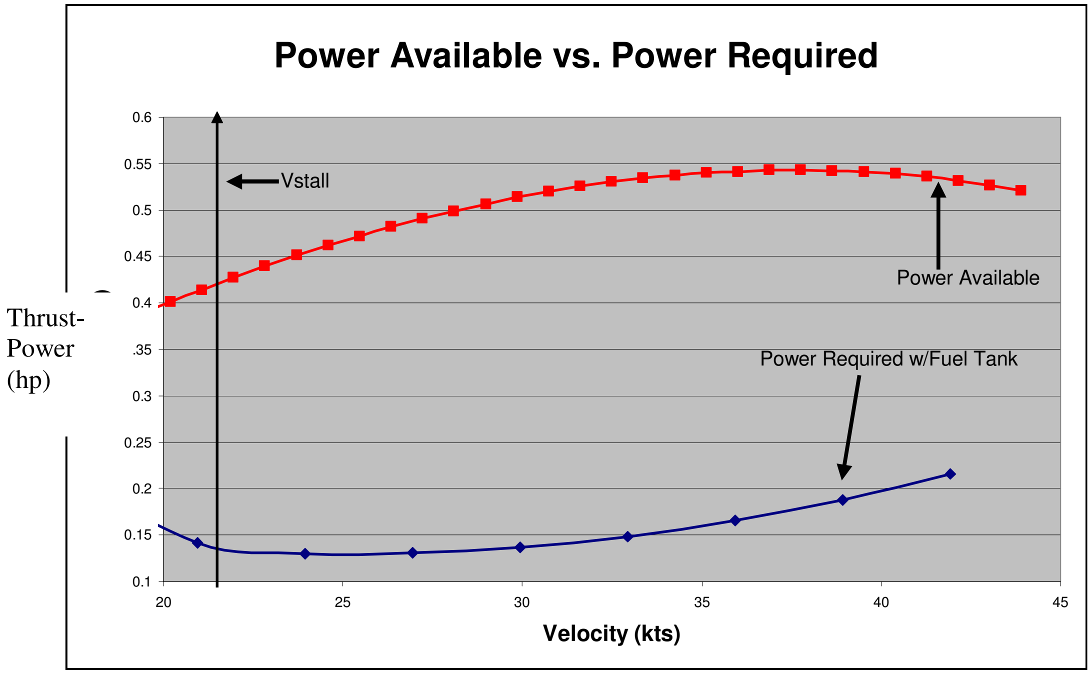

Figure 13: Power Available vs. Power Required

Once the motor was selected, the next step was to determine a battery with enough power to fuel the motors. The battery or batteries must be sized in order to power the aircraft over the course of the missions. The group determined the store/release mission would be the most taxing and would require the greatest endurance. As seen in Fig. 14 the power required for the store/release mission would be at least 4233 mAmph.

Stage	Time (s)	Amps	mAmph
Takeoff	30	37	308
Lap	90	25	625
Land	30	15	125
Total	150		1058
	mAmph		
Total for Store/Release Mission	4233		

Figure 14: Initial Estimate for Battery Usage

The team is now conducting a trade study in order to determine the best configuration of batteries.

IX. Aerodynamics and Drag

The following sections outline the airfoil selection, wing characteristics, and drag determination for the aircraft. Many assumptions were made based off knowledge of already existent aircraft and design constraints set by the AIAA competition.

A. Airfoil Selection

The first step was to determine the operating range of Reynolds numbers for the aircraft. The aircraft operates at Reynolds numbers ranging from 350,000 to 675,000. This leads to a major dilemma in engineering because the lowest Reynolds number used for testing most airfoils is in the one million range. This is significantly above the operating range of this aircraft. There is however, one airfoil that has been tested at comparatively low Reynolds numbers, the Eppler E387. The E387 can be seen in Fig. 15.

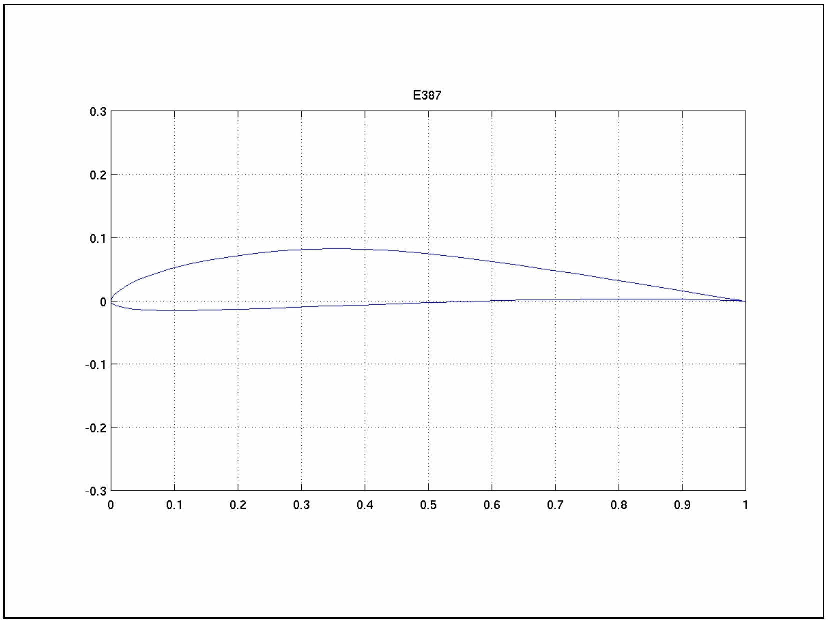

Figure 15: Eppler E387 [5]

The availability of reliable data led to the selection of the Eppler E387. The E387 has a $C_{L.max}$ of 1.25 and lift curve slope of 0.1025/degree.[4]

B. Wing Characteristics

The driving force behind the wing characteristics was the construction of the wing and the AIAA requirements of having to be broken down into two boxes measuring 2 ft x 2 ft x 4 ft long. It was determined that for ease of construction, a relatively straight, untwisted wing was preferable. The wing span was determined to be 7 feet and the chord was calculated from the constraint analysis to be 1.5 feet. Since the wing was determined to be relatively straight and untwisted, the mean aerodynamic chord is the actual chord of 1.5 feet. From these values an aspect ratio of 4.67 was found. Using this, the span efficiency, e, was determined to be 0.9 [6]. Then using Ref. [6] an examination of ground effect on the lift distribution was done. This examination found that the phenomena, known as ground effect, causes the factor e to increase as the aircraft moves closer to the ground which causes an increase in the lift produced by the wing.

C. Drag Build-up

In order to determine the drag of the aircraft, a few assumptions had to be made. The first was that the horizontal and vertical tails were assumed to have NACA 0006 airfoils with a C_{Do} of .01. The next was that 10% of the total drag was due to interference drag. The rockets and bottle were found to have a C_D of 0.75 and 0.295 respectively [7]. The fuselage was considered a rocket because of its small size and aerodynamic shape. Using this information, a drag build-up was completed. The group also determined the design point for the drag decomposition was with the simulated fuel tank attached because this configuration was the heaviest of all the configurations. The decomposition can be seen in Fig. 16 below.

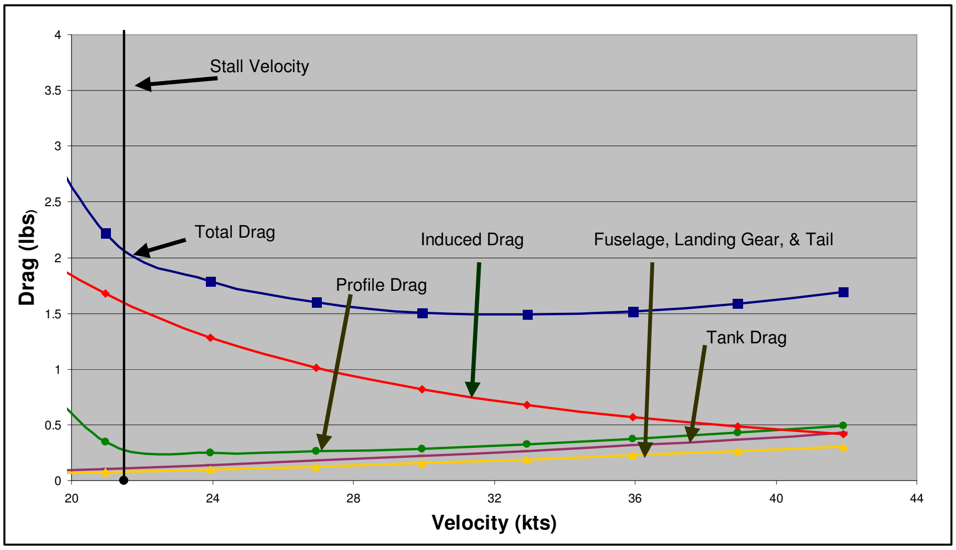

Figure 16: Drag Decomposition with Simulated Fuel Tank Attached

The drag polar follows equation (3) below:

$$C_D = C_{Do} + K*C_L^2 \qquad (3)$$

where C_{Do} is 0.0277 and K is 0.0757. Using this information the motor selection was then conducted.

X. Team Dynamics

A key concern with any team is the ability to make decisions and communicate among one another. As the school year has progressed, the team has become more proficient in communication and decision making allowing the project to proceed efficiently. Initially, the team met solely during class time which allowed for the realization that more productive work is accomplished outside of class. Weekly meetings outside of class hours as well as during class time have supplied sufficient time for completion of the project. Communication outside of class is done through email primarily but also by telephone allowing for constant, real time updates on project status. In order to make educated, unrivaled decisions, the group has assigned jobs to individual members. These jobs consist of the project leader, performance and stability engineer, test engineer, structures engineer, and aerodynamics engineer. Due to the small size of the group, several tasks have been split among a couple different members. All decisions, calculations, and ideas are presented to the group as a whole and discussed rationally to arrive at the best possible decision. Creating structured decision making processes and communication among the members of the team has allowed for smooth transitions through each step of the project designing process.

XI. Risk and Risk Management

As part of the design process, it was important to recognize the possible risks to A^2. The possible operational risks were assessed. The top eleven risks can be seen in Fig. 18.

Number	Risk	Consequence	Likelihood
1	Engine Failure	3	2
2	Signal Loss/Reciever Error	5	2
3	Damage in Assembly	3	3
4	Injury to Team	5	1
5	Wind Gust During Take-off and Landing	4	4
6	Overcharging Batteries	2	1
7	Frequency Mixing	5	3
8	Crash	5	4
9	Pilot Error	5	4
10	Damage During Transportation	5	4
11	Improper Assembly	4	3

Figure 18: Operational Risks to A^2

The operational risks can be more easily understood using a risk matrix as in Fig. 19.

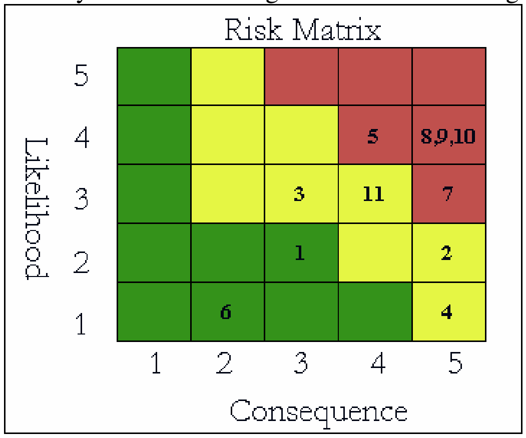

Figure 19: Operational Risk Matrix

Once the risks have been identified, each must be mitigated to reduce its likelihood and/or consequence. The mitigations for each risk can be found in Fig. 20.

Number	Mitigation	Final Likelihood
1	Use two new name brand quality motors	1
2	Pre-flight procedures, double check battery strength	2
3	Practice assembly and design modifications	2
4	Use flight line procedures and exercise caution	1
5	Survey winds prior to flight	3
6	Proper use of battery charger	1
7	Pre-flight frequency scan	2
8	Pre-flight checks, refinement of aircraft stability, design modifications	4
9	Test flights and pilot experience	3
10	Team is driving to competition; Boxes Will contain padding	2
11	Pre-Flight Procedures; Practice	1

Figure 20: Risk Mitigations

Once the mitigations have been applied to the operation of the aircraft, the final risk matrix can be determined as in Fig. 21.

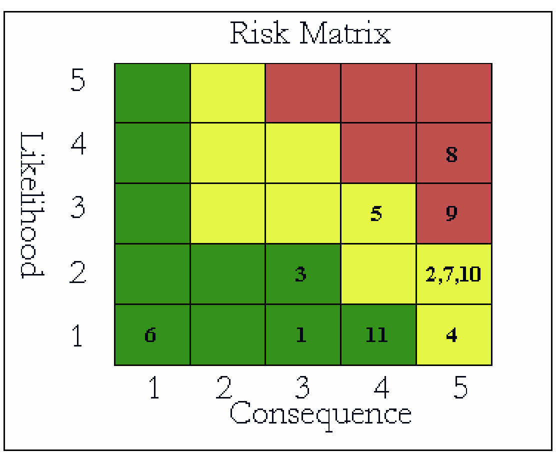

Figure 21: Mitigated Risk Matrix

From the mitigated risk matrix it is clear that the main two operational risks to A^2 is crash due to an undetermined cause and pilot error.

XII. Educational Experiences

The design of the 2009 Parks College AIAA DBF aircraft has provided a generous amount of educational value for the team. Initially, the assignments allocated seemed overwhelming and the time frame for completion of the project was unclear. In response to this, the team created a time table and a detailed schedule to produce a more structured environment. Also, structured assignment of tasks to individuals in the group became very important due to time issues and recognition of each individual's skill set. Eventually, an understanding of how to quickly and efficiently allot assignments for each group member became apparent. Apart from the scheduling and task management portion of the project, practical engineering knowledge was learned.

The design of the aircraft proved very challenging for each member of the group as this is the first aircraft any member has built from scratch. Before the design could be conceived and the calculations could be made, an understanding of the mission requirements and design parameters was vital. Once the group read and understood the mission at hand, deadlines were created for certain portions of the aircraft calculations. While undergoing the initial and final calculations for aircraft performance, sizing, and propulsion, an understanding of mathematical processes and their practical applications was achieved. In order to make the necessary calculations and understand the processes, knowledge from all prior coursework was combined. This was the first time the members of the group were able to apply learning from the entire spectrum of engineering knowledge to make collaborative, informed decisions.

As the project advances, the group becomes more knowledgeable of the aircraft itself and the procedure used in designing it. With this knowledge arises the challenge of presenting and explaining the ideas; which has supplied additional educational value for the group. Understanding the knowledge gained during the design of the project has been a difficult task; however, presenting to peers as well as faculty and industry is equally as challenging. Taking the information gathered over months of work and condensing it into a short presentation proves very challenging. The group has spent a lot of time understanding the important information necessary for instilling a sense of comprehension in an audience. This ability will prove vital in industry in the future as all work accomplished must be presented clearly and efficiently while being understood by others.

XIII. Conclusion

The AIAA Design, Build, and Fly competition for 2008-2009 requires the building of a surveillance/attack unmanned aerial vehicle. Prior to the design of the aircraft, the team created an organized atmosphere by implementing a strict, conservative time line. In doing this, communication and decision making skills needed to be implemented. In order to achieve this environment, each team member was assigned tasks based on individual aptitude and the requirements for the vehicle design. Once the organizational portion of the project was implemented, the team was able to focus on the design and fabrication of the aircraft itself.

A wide variety of mission parameters are set by AIAA for the competition. After a thorough understanding of these parameters was made, it became clear that the crucial mission of the aircraft is quick assembly which allows for the use in real world combat. The aircraft also needs to be versatile enough to deal with any potential threats that arise during flight. It was decided that in order to succeed, these two mission requirements should be focused on primarily. The aircraft is required to carry a 1 gallon simulated fuel tank and 4 Estes Patriot Rockets. The aircraft must have the capability of dropping each of these rockets individually, as well as the centerline tank, which will be done using a clamping method described previously. There are additional aircraft requirements that must be met, including a maximum battery weight of 4 pounds and a maximum of a 40 amp current draw per motor. In addition, the aircraft must be able to be broken down into 2 boxes measuring 2 ft x 2 ft x 4 ft. From this information a weight sizing was completed yielding an estimated empty weight of 8.5 pounds. When the aircraft is equipped with the bottle and the rockets, it produces an estimated weight of 18 and 14.5 pounds respectively. A constraint analysis was done in order to determine a wing loading of 1.7 and a power loading of 0.033 for the aircraft.

The next step was to select an airfoil. The Eppler E387 was selected using the determining factor that it allowed for operation at low Reynolds numbers within the flight envelope. The motors and batteries were then selected using all the gathered information for power input required. The conclusion was that the aircraft needed two Hacker A30-10XL motors. It is estimated that the motors will require a minimum of 4200 mAmph from the battery packs and the team is continually considering the battery options commercially available. Next, a drag build up was conducted at the design point of the aircraft yielding a C_{Do} of 0.0277. The final design of the aircraft produced through a grouping of engineering knowledge and set mission parameters will allow for the team to fly successfully and contend competitively at the contest this April.

XIV. Future Work

Continuing into this semester the team has set forth many goals that will aid in the completion of a successful design. The goal of the group is to finalize the initial design, refine the stability calculations, and build a visual representation in CAD. This will be followed by a the fabrication of a wind tunnel model and wind tunnel testing.

From the data gathered during wind tunnel testing, the aircraft will be modified to create the best possible structure. After the model has been modified, a prototype will be built followed by flight testing. During the flight test the aircraft will be modified to fix any glitches or major problems. Once the model is perfected the final design will be constructed and used for the competition in April.

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Appendices

A. Performance Calculations

Using the drag decomposition, the theoretical performance calculations were found. From the decomposition the E_{max} was found to 12.44. The velocity of best range was found to 58 feet per second or 34.73 knots. The velocity of minimum power was found to be 54 feet per second or 32.2 knots. The service and absolute ceilings were not calculated because the aircraft would never operate at that high of an altitude which is dictated by the mission requirements set by AIAA.