Design Build Fly Proposal

Team Aerocats

University of California, Merced

1. Executive Summary

This report entails the proposed design and status of the preliminary design of the University of California, Merced (Aerocats) team aircraft for the AIAA 2015/2016 Design Build Fly (DBF) student competition. The proposed aircraft design is tailored around the following four missions and their parameters: Manufacturing Support Arrival Flight (1), Manufacturing Support Delivery Flight (2), Production Aircraft Flight (3), and the Bonus Mission (4). The planned approaches described in the conceptual design section below are to successfully complete the four missions within their respective parameters, such that the reader has knowledge of the design rules and regulations.[1]

2. Management Summary

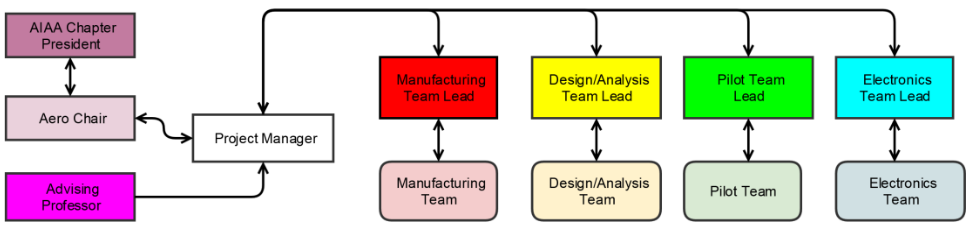


Figure 1- AIAA UCM DBF Organization Flow Chart

Participation in the AIAA 2015/2016 DBF competition would be the Aerocats' second time competing in the annual competition. Based on last years' experience, we have set up this year's team to have self-imposed early deadlines, multiple prototypes, and interdisciplinary engineering to ensure steady and effective progress. By organizing the team into 4 subsections (i.e. pilots, manufacturing, design/analysis, and electronics) members attain a greater level of understanding in their respective fields.

The project manager oversees and directs the whole DBF project utilizing the advice and suggestions from the organization advising professor, aeronautics division chair, and chapter president. The team leads are responsible for the following: Manufacturing - production, repair, and maintenance of the aircraft; Pilots - train new pilots, test prototypes, and appoint the most qualified and top performing pilot to fly at the competition; Designing/Analysis - create CAD models/drawings as well as FEA and CFD for the structure and functionality of the aircraft; Electronics - identify and test electronic components (i.e. servos, batteries, motors etc.) and install them in the aircraft. All team leads work cohesively to insure complete and sound design of a proper competition-ready (and safe) aircraft.

[1] http://www.aiaadbf.org/2016_files/2016_rules_final_20151031.html | Link to design rules and regulations

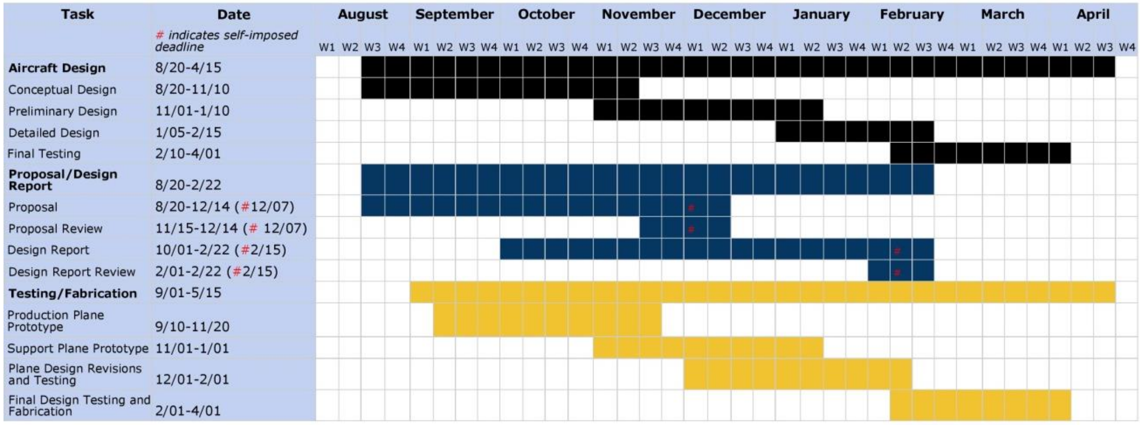


Figure 2: AIAA UCM DBF Gantt Chart

3. Conceptual Design

The objective of the conceptual design process is to implement different techniques and arrive at possible solutions that maximize the overall flight score as outlined in the mission parameters.[1] Based on the scoring criteria, the production aircraft is designed such that it is capable of carrying the required cargo, while maximizing its speed, agility and transportation capabilities. In this stage of the competition, it has been decided to have six subassemblies for the production aircraft: front fuselage, back fuselage, left wing, right wing, folding propeller and landing gear. By breaking up the subassemblies as such, we will have three subgroups (fuselage/landing gear, left/right wings, and tail assembly) that can be transported by the manufacturing aircraft. In order to make assembly/disassembly quicker and more seamless, we are placing the servos directly onto the subassemblies and connecting them by using the servo's wire connectors.

3.1 Manufacturing Plane

Wing Config	Bottom Mounted with Dihedral	To allow for easy access to payload during timed trials and provide stability for low mounted wings.
Tail Config	Conventional T-tail	Allows for easy manufacturing and maneuvering capabilities.
Fuselage	Centered on wings w/ Twin Backbone	Built around payload (subassemblies), batteries, and receiver.
Motor Config	Twin Motor Under Wing Mounted	To provide sufficient thrust due to drag from large size of payload as well as more room for payload and avionics.

3.2 Production Plane

Wing Config	High Wing Mounted Straight Wing	The high mounted wings provide maximum stability and reduce the need for dihedrals.
Tail Config	Conventional T-tail	Allows for easy manufacturing and maneuvering capabilities.
Fuselage	Unibody w/ Detaching Wings and Tail	Built around the payload and mission profiles. Wings detach from the sides and the tail just past the payload.
Motor Config	Single Nose Mounted	To keep size to a minimum, foldable propeller.

4. Preliminary Design Status

Based on last year's weather data, we can expect high wind speeds of up to 39 mph, gusts of over 49 mph, and good visibility with humidity reaching up to 85%. Using this information, the sizing will be determined by estimating the weight to be approximately $5lbs$ and $6\,lbs$ for both Production and Manufacturing plane, respectively, without payload. Using an expected Reynold's Number range of 150,000 - 200,000, we came up with three airfoils to further explore.

NACA 2414	Ideal for high speeds and provides a high lift/low drag ratio, used on sports planes.
E168	Easy to manufacture and used on commercial aircraft for its high efficiency.
N-22	Easy to manufacture, this airfoil is commonly used for cargo transport.

Taking lift, drag, and moment coefficients into consideration, an angle of attack of approximately 12.5 degrees will provide the best lift to drag ratio and the lowest moments on the aircraft for the manufacturing plane. Likewise we plan to use 15 degrees for the production plane. We plan on aiming for a high aspect ratio on the manufacturing plane to provide the maximum stability in air. Whereas a medium aspect ratio will be used on the production plane to keeping the aircraft small while providing enough lift to carry the 32oz Gatorade bottle and all of the electrical components.

5. Manufacturing Plan

5.1 Bill of Materials

Quantity	Part	Type
12	Carbon Fiber Spars	Component
3	Fiberglass Mat (38in x 1 yard)	Material
3	Fiberglass Cloth (38in x 1 yard)	Material
1	Polyester Resin (1 gallon)	Adhesive
2	Carbon Fiber Landing Gear	Component
5	APC Propellers	Component
15	Presentation Board for Prototype (30 in x 20 in x 3/16 in)	Material
15	Foam Boards (24 in x 12 in x ¾ in)	Material
70	Elite NiMh Battery Cell	Component
4	YGE ESC 60 AMP	Component
10	Turnigy Servos	Component
2	Spektrum Receiver	Component
10	Signal Extension Wires	Component
3	Cobra Brushless Motor (24V 500kV)	Component

Figure 3: Shows an early design stage BOM

5.2 Main Processes of Manufacturing

The manufacturing aircraft will utilize polyester resin prepared fiberglass fuselage and wings (foam core) with reinforced carbon fiber spars and backbones. Since the aspect ratio will be high, we will need more structural support for the wings. Fiberglass is a desired material when a combination of high strength, low cost and low weight is needed. Using a low resin to fiberglass ratio we can ensure max strength. To build the foam core we will make a jig using laser cut plywood and sand excess foam material to desired shape. The fuselage will be also made from fiberglass by first creating a core from poster board and then creating a mold.

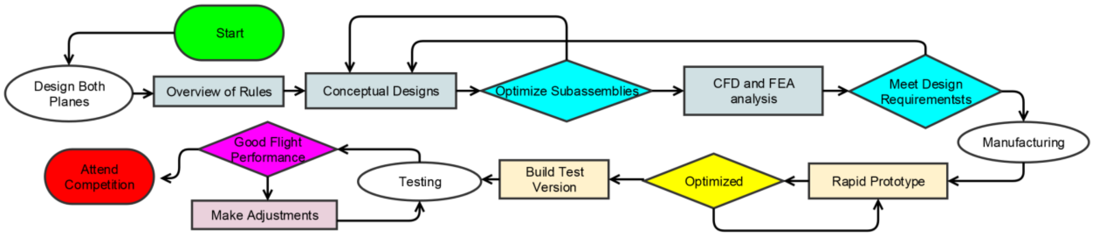


Figure 4: Shows the manufacturing flow chart.

Figure 5: Rapid Prototype Composed of Foam Board

The production plane will utilize poster board composites with reinforced carbon fiber spars and backbones. The poster board is desired as it will provide sufficient strength while keeping weight low. We plan to secure subassemblies to the front fuselage using lightweight pins and grooves. An iterative rapid prototype (Figure 4) was used to test these conceptual ideas as well as to help with sizing and avionics placement. Testing will be conducted in a 1,858m^2 airfield by our pilots and experienced PhD students.

6. Conceptual Aircraft Views

6.1 Production Airplane Design

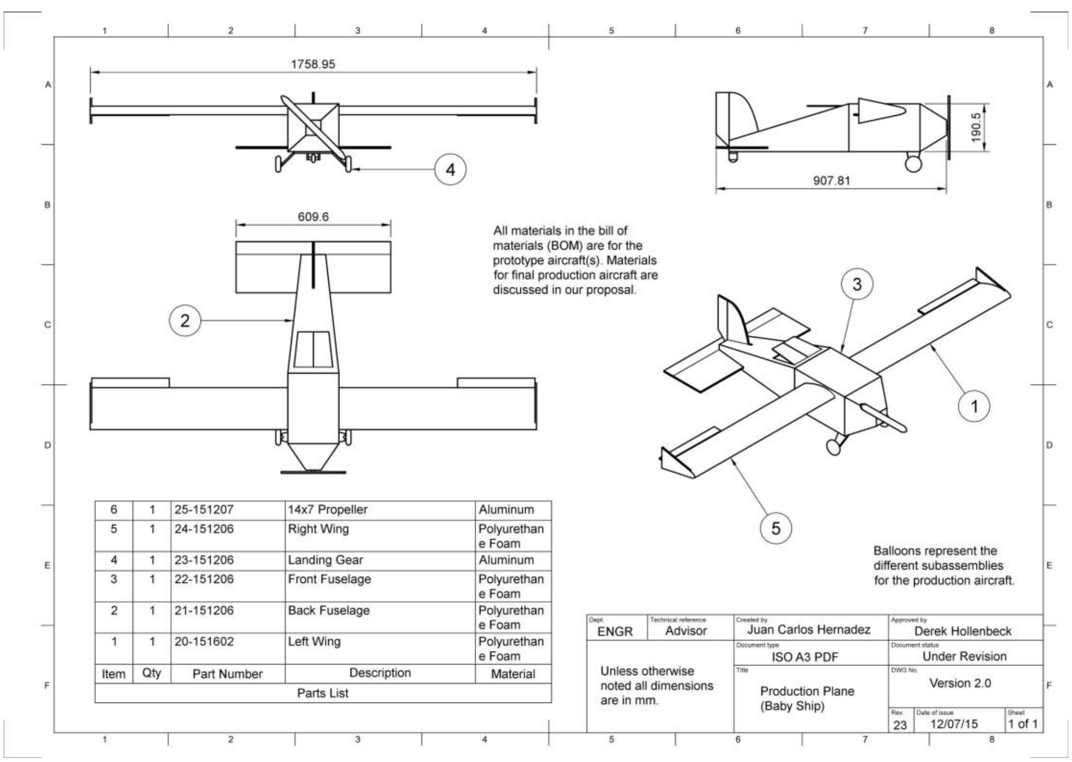
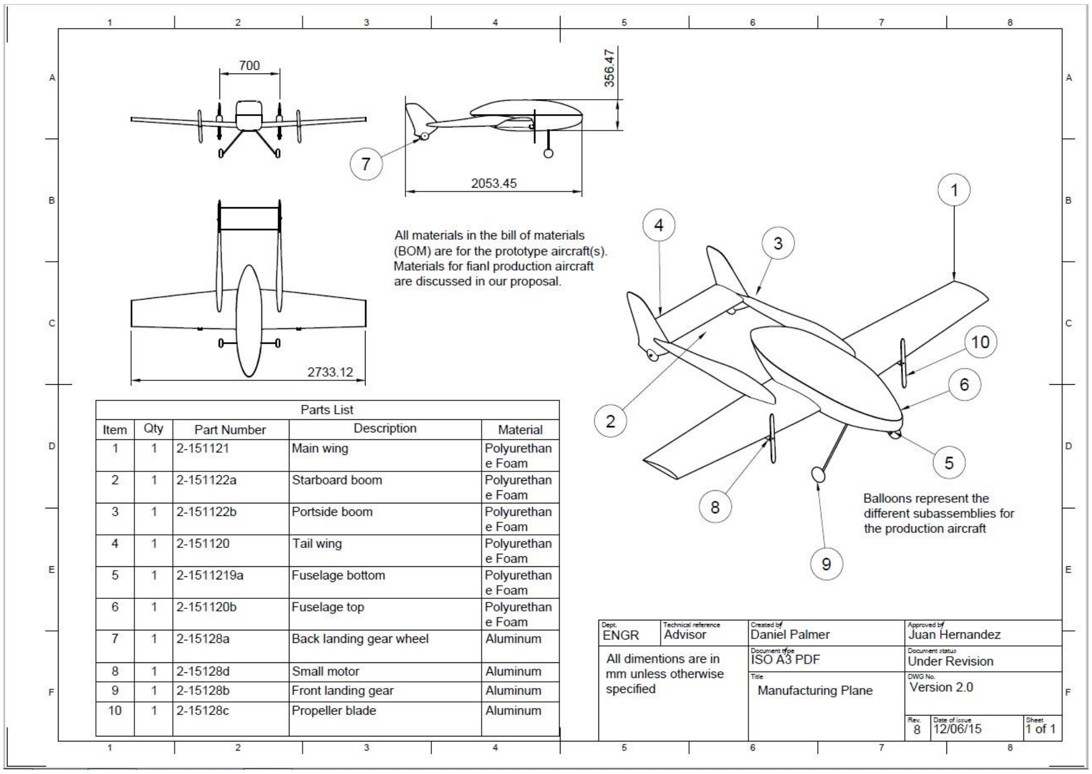


Figure 6: CAD Drawing of the Initial Product Aircraft

6.2 Manufacturing Airplane Design



Parts List

Item	Qty	Part Number	Description	Material
1	1	2-151121	Main wing	Polyurethane Foam
2	1	2-151122a	Starboard boom	Polyurethane Foam
3	1	2-151122b	Portside boom	Polyurethane Foam
4	1	2-151120	Tail wing	Polyurethane Foam
5	1	2-1511219a	Fuselage bottom	Polyurethane Foam
6	1	2-151120b	Fuselage top	Polyurethane Foam
7	1	2-15128a	Back landing gear wheel	Aluminum
8	1	2-15128d	Small motor	Aluminum
9	1	2-15128b	Front landing gear	Aluminum
10	1	2-15128c	Propeller blade	Aluminum

Figure 7: CAD Drawing of the Initial Manufacturing Aircraft

7. Summary

In conclusion, the team will be broken into four sub-teams (pilots, manufacturing, design/analysis, and electronics) to provide greater understanding in respective fields. Based on conceptual and preliminary considerations we will design the production plane to have six sub-assemblies (front fuselage, back fuselage, left wing, right wing, landing gear, and folding propeller). These sub-assemblies will be broken into three groupings (fuselage/landing gear, left/right wings, and tail assembly) to minimize laps in mission (2). For the manufacturing plane, we will be using a high aspect ratio low wing design, utilizing foam core fiberglass wings with carbon fiber spars and backbones as well as an N-22 airfoil for maximum lift and ease of manufacturability. The production plane is designed to have a NACA 2414 airfoil with medium aspect ratio and high wing configuration. We will be using fiber glass techniques as well as laser cutting technology to build the foam core fiber glass wings and basic shop tools to build the remaining components on both aircrafts.

Acknowledgements

We would like to thank: UC Merced's Mechatronics Embedded Systems and Automation Laboratory, the School of Engineering, and ASUCM for support knowledge, dedicated space to work, and committed financial support; Autodesk for offering free student software like Fusion 360 and CFD Motion; and Composites One LLC for material donations.