Aero Design East Competition

Introduction

The annual SAE Aero Design East competition gives engineering students across the nation an opportunity to demonstrate their knowledge, ingenuity, teamwork, and presentation skills. There are two classes for the competition, a highly-restricted regular class and an unrestricted open class. Our team will participate in the regular class competition, where our goal is to out perform our competitors by carrying the most weight. The University of Central Florida will host the competition in Orlando on the weekend of April 16-18th.

Background

Our team consists of seven senior members, four of which are returning members from last year's cargo plane team. This gives us a large advantage in experience to efficiently develop and execute our designs. The main obstacles we have to initially overcome are design decisions concerning airframe structure and material components. For last year's plane we were restricted to a six-foot wingspan, where we innovated a Tri-plane design to maximize lift. This year's requirements are quite the opposite; the wingspan must be a minimum of 10 feet and the cargo bay is restricted to a specific geometry.

Our primary obstacle is producing a lightweight wing structure capable of carrying all loads encountered in normal operation. Additionally, we will be concentrating on the development of a lightweight, low drag fuselage, designed with advanced composite construction.

Student Responsibilities

The students will be responsible for designing, acquiring the materials, building, and presenting the design at the Aero Design East competition and at the Undergraduate Research Symposium. To aid in the construction and design process, we have assigned two or more member sub-groups to each major task. Each team member will be a part of multiple sub-groups, but no one will be a part of every task. For the design tasks, the sub-group will do all of the necessary research, and then present their results to the main group at a weekly meeting. The group as a whole will make the major decisions, and the design sub-group will implement the group decision into the aircraft plans. The sub-group will likely also be responsible for writing a small contribution to the final report on that particular design decision.

PATRAN/NASTRAN:

One sub-group will use the PATRAN and NASTRAN computer programs to model the major structures of the aircraft, including the main wing and fuselage, in order to facilitate design. To simplify the process, all material strengths will be approximated as isentropic. This is an acceptable method, even for composite materials, given the small scale of our aircraft. The design group hopes to get results from the models such as the strength of the materials needed for the major structures and the material deflections under loading. This will allow us to build composite structures and test them with a greater accuracy, and it will eliminate unnecessary failures in testing by pre-determining load characteristics and structure behavior.

Fuselage:

This team will design and build the fuselage design of the aircraft. Components will include the engine mount, fuel tank mount, servo brackets, cargo bay, and attachment points for the wing and tail. All of this will be held together by the structure and skin of the fuselage. The fuselage team must decide which materials to use, and how best to build the fuselage in order to accomplish these goals, and save as much weight as possible. From our past experience, the best material to use for the body is fiberglass, stiffened from the inside with struts and bulkheads.

Empennage:

The empennage, or tail of the aircraft will provide it with aerodynamic stability, but in order to do so, must have adequate surface area, while adding minimal weight to the rear of the plane. The empennage team will have to design and build such a tail, taking into account these factors, considering the forces on the tail, and the materials available. From our preliminary calculations, using sizing ratios from similar aircraft types, the horizontal tail should be about 2.66 square feet, and the vertical tail should be about 2.40 square feet. The tail will likely be built with balsa ribs and a MonoKote skin, but foam core and fiberglass will be considered because it is rather large.

Wing Structure:

The wing is the most important component of the aircraft. The wing team must design and build the main wing. We have already narrowed down the basic layout and size of the wing, to an area of 16 square feet, with a span of twelve feet, and a chord of sixteen inches. However, the wing team still must decide on further details, such as twist, taper, and dihedral. As a general principle, the group has decided that the design should be as simple as possible from the outset, and any modifications must be proven to be advantageous before the will be incorporated into the aircraft. Using this principle, deviations from the rectangular wing, such as twist and taper must be researched by the wing sub-group before making it onto the design. We have two basic methods of construction to consider, either a foam core with fiberglass skin, or a built-up wing with a spar and rib structure. It must be considered that in order to transport the wing, it must be disassembled into no less than three sections. Also of importance is cost, as it can be expensive to build such a large and light structure, and we want to stay under budget. After laying out a detailed budget for each method, the foam core and fiberglass wing is about $100 cheaper, with our experience from last year; we should be able to do the fiberglass lay-ups with relative ease.

Controls:

This team's job is to plan the layout of the control systems for the flaps, elevators, and other aircraft systems. In addition, this team will set up the interface between the airplane and the controller. Last year, our design used flexible nylon control rods, and there were severe problems with the amount of flex in the control surfaces. This year, the aircraft design will include rigid control rods, so that the controls will be more precise.

Engine:

This team's goal is to identify the thrust vs. airspeed curve for our engine in order to determine the maximum level cruising speed. The cruising speed will determine the incident angle of attack for the main wing, given the amount of lift needed to keep the aircraft aloft. We will need to purchase an aircraft engine for the purposes of achieving empirical data.

CAD

We will need to produce accurate dimensioned drawings of the aircraft for the SAE presentation, and scaled drawings for our own construction purposes. In particular, accurate patterns for the aircraft parts will be generated using CAD. The task of generating these drawings will fall to another sub-group.

Funding and Report:

The final report will be compiled from the technical reports written about each design decision. As such, it will involve the work of the entire group. A major section will also be the dimensioned CAD drawings, which will count for a large portion of the points for the SAE competition. Also of major importance for the report are the aircraft performance calculations. We must accurately describe the maximum takeoff weight of the aircraft, because the competition requires a prediction of the maximum possible payload for the plane. Also, if we complete more advanced calculations such as trim diagrams and interference drag calculations, we will receive more points for our report.

Presentations:

As part of the SAE competition, our group must make a comprehensive twenty-five minute presentation to a panel of senior and retired Lockheed engineers. This requires much preparation, because the level of excellence of many of the teams approaches that of professional aircraft engineers. The presentation must detail the reasons behind each major design decision, and the calculations and graphs that our group used.

Also, we will give a presentation to UROP, which in the interest of time will likely be a poster presentation. Last year, our poster consisted of relevant aircraft performance statistics, as well as the findings of our development research. It was illustrated with pictures and diagrams of the plane, as well as performance graphs such as lift and drag ratios. We also brought physical examples of our work, such as the wind tunnel test section of our wing, and the mold for our fuselage. We our poster attracted quite a crowd and we usually had at least three team members answering questions at any given time for the duration of the poster presentations.

Timeline

October 17:

- Finish Preliminary Sizing
- Recruit new members
- Select Airfoil

October 24:

- Detailed Sizing
- Specific Length & Areas

October 31:

- Discussion of Specific Modifications to Design
- Simple Start - Upgrades must defend their way onto the design

November 7:

- Basic Plans
- Simple Drawings, Define Important Attach Points

November 21:

- Detailed Plans
- 3D shape views
- Wing
- Fuselage
- Empennage
- Controls

December 5:

- Redesign, plans for improvements
- Discuss weight reduction, simplification, etc.
- Begin Plan Instructions Process
- Construction Begins (fuselage)

January 5:

- Complete fuselage construction
- Start on wing construction
- Start landing gear construction
- Start on control surfaces

February 5:

- Controls installation
- Weight plates
- Start assembling components

March 5:

- Complete construction
- Flight tests
- Trouble shoot

April 5:

- Repairs
- Modifications

April 16-19:

- Competition
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Budget

Item	**Type**	**Unit Cost**	**Quantity**	**Total**
Competition Costs:				
Entrance Fee	Competition Entrance Fee	$400.00	1	$400.00
SAE membership		$10.00	7	$70.00
Controls Costs:				
Controller - 6 Ch FM	Airtronics	$200.00	1	$200.00
Servos - Standard	Airtronics	$15.00	4	$60.00
Control Rods	Steel/carbon fiber	$7.50	6	$45.00

Crystals - for transmitter	FM crystals	$12.00	2	$24.00
Construction Costs:				
Carbon Fiber	42" width; .007" thickness; per linear yard	$16.50	16	$264.00
Fiberglass	38" width per linear yard	$5.40	16	$86.40
Polyurethane Foam	2" thickness; 24"x48"	$14.70	8	$117.60
Epoxy Kit	5.25 Gallon Kit: 4.25 Gallon #105 resin; 121 oz. #206 Hardener	$325.00	1	$325.00
Epoxy Pump Kit	Epoxy Ratio Dispenser	$10.00	1	$10.00
Painter's Brushes	Applicator (Box of brushes)	$12.00	3	$36.00
Aluminum Foil	Lay - up material	$5.00	2	$10.00
Laquer Thinner	Clean-up material	$30.00	2	$60.00
Gel Coat Paint	Mold Building Material	$150.00	1	$150.00
Squeegee	Gel Coat Applicator	$5.00	3	$15.00
Mold Release Wax	Mold Release Agent (Male Plug)	$10.00	1	$10.00
Mold Release	1 Gal. Mold Release Agent (Female Mould)	$100.00	1	$100.00
Paper Towels	12 Rolls	$10.00	1	$10.00
Engine Costs:				
Engine	OS 0.61 FX	$159.95	2	$319.90
Gasoline	10% Nitrous Model Engine Fuel	$10.00	2	$20.00
Propellers	APC Scimitar	$6.00	6	$36.00
Transportation Costs:				
Airplane Ticket to Orlando	SNA to MCO; Travelocity Bid	$450.00	6	$2,700.00
Hotel	Local Hotel Near U of Central Florida per night	$60.00	3	$180.00
			Total	**$5,248.90**

Goals

Our goal is to produce a cargo plane that fulfills all competition requirements that carries the most weight at the Aero Design East competition. To do this, our group will need to produce an effective aircraft configuration, and build and test it accurately. We will also need to do extensive research on aircraft performance in order to predict the maximum payload of our plane, and to predict its behavior in the air

Benefits

Aiding our team will allow us to thoroughly research advanced composite construction techniques, specifically regarding lightweight structures. We achieved some of this last year, but our team members are looking to perfect their techniques. Our group also hopes to gain valuable experience in the design of aircraft, and the analysis of aircraft performance. In particular, we have an opportunity to make progress in the design and configuration of light unmanned aircraft.