Design for Manufacturing, Reliability, and Economics

EML4552-C Senior Design, Spring 2013, Deliverable

AIAA Design Build Fly Competition
Team # 16

Team Publisher – Lee F. Becker
Team Leader – Jordan Benezra
Meeting Coordinator – Terry Thomas
Team Treasurer –Will S. Watts

Sponsor:

FCAAP
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TECHNOLOGIES FOR THE NEXT GENERATION

Advisors:
Dr. Alvi
Dr. Shih

Instructor: Dr. Amin

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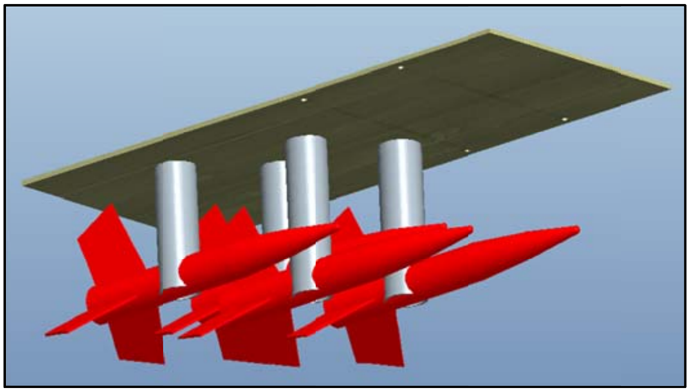
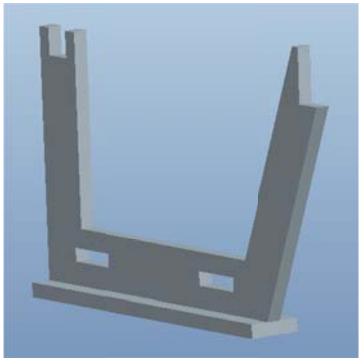
A-1

The Manufacturing processes for our fuselage, wing, landing gear, and stores attachment were all designed to save time and materials.

The fuselage was constructed byconfiguring rectangular strips of carbon composite. For each bond of the carbon composite strips, there was a rigorous regimen of abrasive finishing on the surface of the carbon composite. This was done in order to expose part of the surface which will accept the bond capabilities of the epoxy, which would be used to create the structure.The walls of the fuselage were formed independently.The floor and roof were then added to hold all parts together. The nose area was constructed in order to allow space for the propulsion system to be fastened to the unit. The tail area of the fuselage was constructed in order to securely fasten the tail connector to the belly of the aircraft.

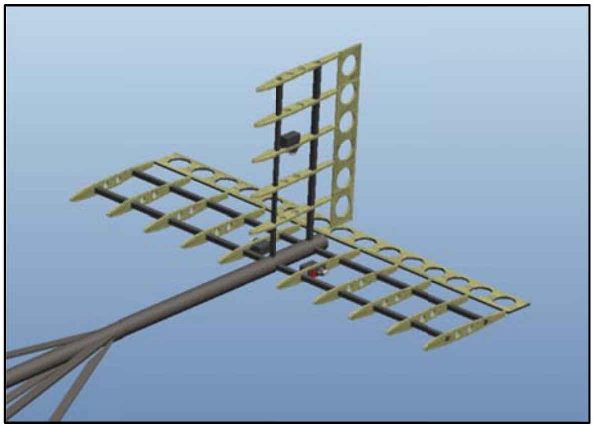


The internal stores attachment device is an integrated design. The roof of the aircraft is made up of a plank of 8x20 inch bass wood. On under-side of the basswood are the rocket attachment devices which have been arranged in a design optimized to minimize the internal rectangular volume of the fuselage. The rocket attachment devices are made up of thin-walled plastic tubes and were hand-cut using a dremmel. The design complies with the AIAA DesignBuild Fly 2012/2013 Competition rules that state that the internal stores may not touch one another.



The external stores attachments were made up of carbon composite strips. The geometry was determined by the spacing required to separate the rocket fins from the wing of the fuselage and from other components of the aircraft.

The wing was constructed by combining carbon composite spars and laser-cut balsa wood ribs. The carbon composite spars were made up of square .25inch by .25 inch tubes cut to 78 inches in length. For the forward spar, two tubes were bonded in a vertical orientation using a heavy duty epoxy. This ensured rigidity of the structure. The second spar was made up of a single square tube, this was to provide additional support to the wing, and act as a hinge point for the balsa ribs to connect. The balsa wood ribs were attached to their respective locations using a mid-duty small aircraft adhesive. This ensured that there could be no translation or extraneous vibration due to continuous displacement of the ribs in flight. The combination of these elements formed a very strong, very rigid wing. Servos were placed into their respective housings using supplied hardware. Control surfaces were made up of rectangular balsa sheets, tapered down to follow the profile of the airfoil, and holes were laser cut into them to save weight. The control surfaces were attachedinside of select ribs within the wing using lightweight plastic hinges. The linkages were designed to be simple crank rockers allowing full intended range of motion for the ailerons. A shrink-wrap finishing material called mono-kote, which goes over all of the ribs and actually forms the airfoil of the wing was then applied, completing the structure and providing the lift that the wing was designed to supply. The control surfaces were wrapped separately.



The tail section was made up of three components. The tail connector was made up of a very rigid carbon composite tube, which would transfer the moment induced by the control surfaces on the tail. The elevator and rudder were both constructed in the same fashion as the wing, but used a different laser-cut airfoil anddremmel-cut spar size. The elevator was constructed by running two single carbon composite tubes through equally spaced holes in each of the balsa wood ribs and adhering them in place.Servos were placed into their respective housings inside of select ribs within the rudder and elevator using supplied hardware. Control surfaces were made up of rectangular balsa sheets, tapered down to follow the profile of the airfoil, and holes were laser cut into them to save weight. The control surfaces were attached using lightweight plastic hinges. The linkages were designed to be simple crank rockers allowing full intended range of motion for the ailerons. Mono-kote shrink wrap was then applied to both the rudder and elevator independently. It was attached to the control surfaces separately so that there was no risk of tearing or damaging it in use.

The landing gear was constructed by first taking 5/32 inch steel piano wire and bending it to fit the specific geometry of the corners of the fuselage. The wire was bent specifically to fit through and around holes drilled into the fuselage. The piano wire acts as an independent rear suspension and rear axle for the rear wheels. The steel bars were bent and cut with hand tools. The wheel is a factory made light soft foam wheel with a plastic hub. The front end landing gear was made by joining a lexan sheet to the front carbon composite strip of the aircraft. A steel bolt was inserted into a hole in the lexan which was restrained by two stoppers at the ends. The steel bolt was oriented inward toward the center of the area underneath the aircraft and the wheel was attached to that.

A-2

The criteria used in the material selection process was based upon the weight, strength, availability, and machinability of each material.

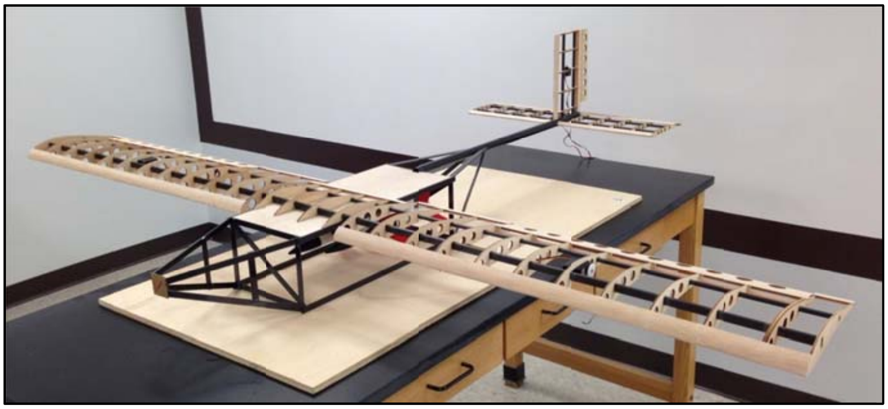
For the fuselage, a carbon composite strip was chosen as the base construction material because a very rigid box was required, but it had to be as lightweight as possible. These strips were bonded using a 30-minute epoxy. The wing was constructed of balsa wood ribs for its lightweight rigidity, and carbon composite spars for its length, uniformity, and strength. The rudder was made of the same material as the wing for the same reasons. The elevator is almost an exact replica of the rudder, oriented to be parallel with the wings, and scaled to a different length. The landing gear is made up of thin steel wire for its flexibility and durability. Plastic was chosen for the internal stores attachments because of its flexibility, lightweight nature, and ease of manufacturing. The external stores attachments were made of carbon composite strips.

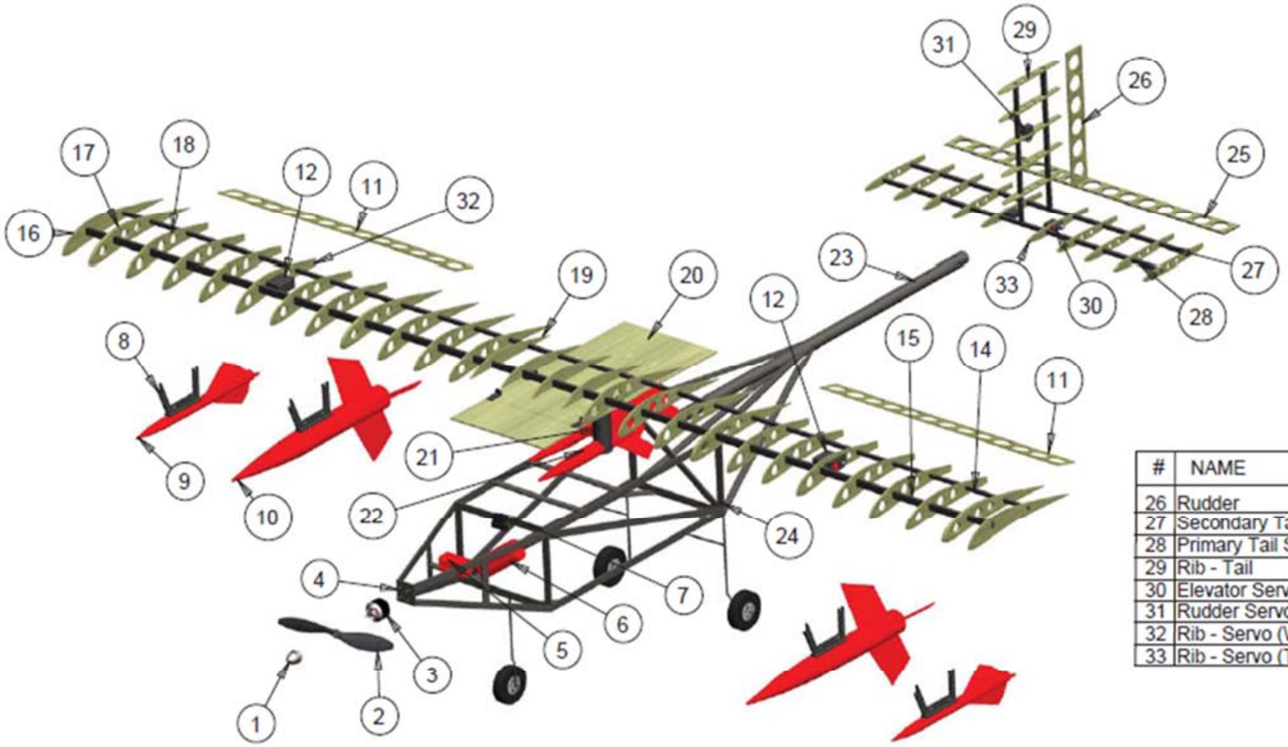
A-3

The wing was constructed in the senior design lab. The reason for this was simple. During the early late February 2013 weeks, the air temperature in Tallahassee, FL was below 40^{o}F at night. This was a problem for the epoxy. The epoxy chosen would not set properly in temperatures below 70^{o} F. Due to the undulating nature of day-night temperatures in the portable we had available, it was necessary to find a thermally stable location in which to do any bonding work. The wing was never moved back to the portable because the group suspects that there may be a bit of thermal contraction of the epoxy in the event of a cold night.

The fuselage was constructed in the home of one of the group members. This was done because the engineering school did not make the proper tools available for free use to our group. He did the epoxy work there because of the thermally stable nature of a personal residence. The tail section including the rudder and elevator was constructed in the same location as the fuselage because the two components had to be bonded together using an epoxy. Internal stores attachment device was created in the senior design lab because it was necessary to continuously consult with the 3d models while building.

The landing gear was constructed in the senior design lab. The reason for this is that a makeshift vice mount needed in order to bend the steel bars to the appropriate shapes.Manual bending was the only feasible way to achieve the proper geometry for the landing gear.





#	NAME	MATERIAL	QTY.
26	Rudder	Balsa	1
27	Secondary Tail Spar	Carbon Composite	1
28	Primary Tail Spar	Carbon Composite	1
29	Rib - Tail	Balsa	12
30	Elevator Servo	n/a	2
31	Rudder Servo	n/a	1
32	Rib - Servo (Wing)	Balsa	2
33	Rib - Servo (Tail)	Balsa	3

#	NAME	MATERIAL	QTY.	#	NAME	MATERIAL	QTY.
1	Propeller Chuck	Aluminum	1	14	Secondary Spar	Carbon Composite	1
2	Propeller	Plastic	1	15	Primary Spar	Carbon Composite	1
3	Electric Motor	n/a	1	16	Rib - Wing End	Balsa	2
4	Motor Mount	Carbon Composite	1	17	Rib - Regular	Balsa	12
5	Battery Pack (Servo)	n/a	1	18	Rib - Aileron	Balsa	14
6	Battery Pack (Motor)	n/a	1	19	Rib - Fuselage	Balsa	4
7	20 Amp Fuse Holder	n/a	1	20	Fuselage Top	Basswood	1
8	External Store Att.	Carbon Composite	4	21	Internal Store Att.	Plastic	4
9	HiFlyer Rocket	n/a	2	22	MiniMax Rocket	n/a	4
10	DerRedMax Rocket	n/a	2	23	Tail Tube	Carbon Fiber	1
11	Aileron	Balsa	2	24	Fuselage	Carbon Composite	1
12	Aileron Servo	n/a	2	25	Elevator	Balsa	1

NOTE: ALL DIMENSIONS IN CENTIMETERS	FAMU FSU COLLEGE OF ENGINEERING CESSNA-RAYTHEON-AIAA DESIGN/BUILD/FLY 2013		
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Comments on

Dimensions: The dimensions for the wing and fuselage were measured in inches, but the dimensions for the propulsion system component placement were measured in millimeters.

Geometry: The geometry of the aircraft was based simply upon minimizing the simple volume required to house all four rockets inside of the bay of the aircraft.

Holes: All holes were drilled by hand, laser cut, or added with the water jet. The water-jetted holes were
Surface Finish: All carbon composite surfaces that were to be bonded using epoxy were sanded very roughly in order to accept the epoxy and create a proper bond. All wood or otherwise porous materials were adhered twice; once for expected absorption, and again for bonding.

B -Design for Reliability

Certain features of our design had to be tailored specifically to a set of rules determined by the AMA (Academy of Model Aeronautics). The battery packs were required to be contained within a shrink-wrapped container so that no chance of exposed wire could risk igniting the whole unit. This was done by asking our battery maker to ensure that the shrink wrap cannot be easily punctured or damaged. The next feature of reliability is the fuse. The fuse box had to be designed so that the fuse could be inserted from behind the propeller. This is a requirement for AMA-sponsored competitions. The next feature of safety was the failsafe mode of the control system. In the event of lost radio contact, the competition requires that all competitors set their failsafe mode to. 1) Throttle Closed 2) Full Up Elevator 3) Full Right Rudder 4) Full Right Aileron. This helps to ensure that an out of control aircraft will have minimized risk of flying into any unsuspecting person or property that can take damage from a possible crash. The unit must also hold its internal and external rockets securely. This means that it may not shoot (or even drop) them from any hard point on the aircraft. This would be a beach of AMA regulation.

C-Design for economics

All of the prototype components were made by hand, or were cut by a laser cutter, CNC, or water jet. It was found that the most economical way to produce this prototype was would be to generate a 3-d model of the entire unit, while accounting for the proper dimensions and weights of each object within the unit. The center of gravity was found this way. After a full computer-generated image model, we began fabricating the individual components with the spacing considerations that we were able to make using the model. This helped to save material and minimize costly error. All product ordering that required shipping was recognized as a major cause of loss. The more individual shipping orders placed, the greater our shipping costs would be. The solution was to minimize the number of times that we would place an order by mail.

Conclusion:

This aircraft is a sturdy, relatively lightweight aircraft that was designed and built to carry rockets. It is expected to perform well, and be able to compete successfully in competition in mid-April 2013.