SAE Aero Regular

Operation Manual

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Assembly

Molds

Assembly of the aircraft starts with creating the molds that will act as the positive shapes for the fiberglass to form from. These molds are made up of insulation foam, laser cut wood cut-outs, wood dowels, a strong noncorrosive adhesive, and body filler. The assembler will need a surform, a power sander, 220-grit sandpaper, and protective gloves and masks.

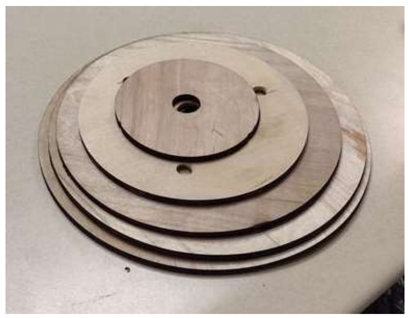

Figure 1: Laser cut plywood

Before starting any step in this entire process, the assembler or assemblers must wear protective gloves, masks, and safety glasses. There will be dangerous foam, body filler, and fiberglass particulates circulating in the air that can leave long term damage and effects in the body.

All the molds are made using the same basic methods, so all of the forthcoming steps will be performed on all parts unless explicitly stated. First, all the wood cut-outs should be categorized into their individual subassemblies, including the nose cone, the fuselage, the wings, the tail, the rudder section, and the horizontal stabilizers. All parts are labeled according to their subassembly and part number in the CAD package and DXF files. The numbers on the parts run from smallest to largest according to largest part of each subassembly to smallest part of each subassembly (1 – largest, 10 – smallest).

Figure 2: Cut parts for nose cone assembly

After categorizing all parts, they should be glued together with layers of styrofoam. The layers of styrofoam for the nose cone, fuselage, rudder section, and horizontal stabilizers should be two layers thick. The layers should be three layers thick for the tail. The layers should be four layers thick for the wings. All of the styrofoam layers should be cut about one inch oversize of their respective wood cuts. These layers can then be glued together with the noncorrosive glue according to the sizes and orientations indicated in the CAD files. The surfaces being glued together should be lightly dampened by adding the glue. All the holes for the wood dowels should line up along the wood cut-outs for each subassembly. While the parts are being glued together, they should be compressed by a large, flat, heavy surface to fully bond the subassemblies together. Depending on the glue used, the parts should take one to two hours to fully cure and be ready to cut.

Figure 3: Foam and airfoils cut out prior to glue up

After all the separate subassemblies are glued, they can be cut and shaped with the surform to cut most of the excess material off. As the parts start to shape up, a power sander can be used to remove more material and bring the parts closer to their final shapes. Final smoothing and shaping of intricate parts and corners can be done with the 220-grit sandpaper.

Figure 4: Glued together nose cone

Once the subassemblies have been fully shaped, they must be coated with body filler. If they are not coated with body filler, the styrofoam will be dissolved by the resin during the fiberglass layup process. No styrofoam should be showing after the parts have been layered with body filler. This may take one to two layers of body filler. After, the subassemblies should be smoothed down with the power sander and 220-grit sandpaper in the same manner as before. The should be sanded until the wood inside the molds starts to show. Be sure to sand the parts evenly until the full edges of each wood cut-out shows on each subassembly. These subassemblies should now be ready for fiberglass layups.

Figure 5: Molds for the fiber glass

Fiberglass Layup

The entire fiberglass layup process should be done in a heated, well-ventilated environment to most efficiently complete the process and effectively cure the material. The resign and hardener mixture are labeled with a 24-minute-long work time, meaning the assembler has about 24 minutes to perform one layup of fiberglass before the resin hardens too much to work with. The resin and hardener require about one hour to harden into a malleable state and 6 hours to fully harden into a cutting and sanding state. However, these times will shorten as the surroundings get warmer and lengthen as the surroundings get colder. The resin and hardener mixture will not cure properly below 55°F. The most effective temperature to work at to properly cure the resin and hardener and maximize the work time while shortening the total cure time is about 75°F.

The materials required for this process include fiberglass, resin and hardener, nylon peel ply, measurement labeled mixing cups, mixing sticks, a syringe, paint brushes, acetone, scissors, and 220 grit sandpaper. A razor blade is also recommended to clean up loose bits of fiberglass during the process. A space heater is also recommended to maintain a high heat during the curing process. The assembler must wear the proper PPE as stated before to protect against the adhesion of the resin and fiberglass air particulates.

Like the previous section, all the subassemblies will be done in the same manner, so all the forthcoming steps and their descriptions will apply to all of the subassemblies unless explicitly stated otherwise. To prepare for each layering of fiberglass, several (30 – 40) small squares (about 5in.) should be cut from the fiberglass and placed near the area where the layup will be performed for ease of access and quick application. When performing the fiberglass layup for the wings, large sheets of fiberglass slightly bigger than the tops and bottoms of the wings can be cut to fit the wings because these faces are a much simpler geometry than the rest of the subassemblies. The assembler should also cut the nylon peel ply to the approximate size and shape of whatever subassembly they are performing the layup on. For the nose cone in particular, the nylon peel ply should be cut into strips for ease of application along the round surface. The assembler should fill a mixing cup about halfway full of acetone to clean their tools. The mixing cup for the resin mixing and application, two paint brushes, the fiberglass squares, the nylon peel ply, an empty mixing cup (for dirty tool storage during the layup), and the acetone should be placed at an arm's reach from the assembler to maximize the work that can be done during the resin work time. The assembler should also fill the syringe with hardener at this time.

To mix the resin and hardener, the assembler will fill the resin mixing cup with the desired amount of resin. More resin should be prepared for larger layups, like the wings. The mixing ratio for hardener to resin is 10cc's of hardener to one pint of resin. To start the layup and hardening process, the assembler will mix however much hardener is necessary (depending on how much resin is desired) with the resin and mixed vigorously with the mixing stick in the resin cup. Keep track of which mixing cup holds which substance! After, use one paint brush to apply the mixture to the subassembly and start placing squares of fiberglass flat onto the surface of the subassembly. This brush is now the "wet" brush and should be kept in the resin cup. Squares of fiberglass should always be touching each other to guarantee coverage of the entire part. Use the other brush, the "dry" brush, to spread the applied resin throughout the surface and the applied fiberglass. Also use this brush to even out the surface of the fiberglass and eliminate bubbles. If the fiberglass hardens with bubbles, the bubbles can be sanded until smooth and patched with fiberglass at a later stage. Keep track of which brush is which for simplicity and ease of use. Keep applying squares of fiberglass one layer at a time until either the resin cup is empty or the work time has passed. Once this is all done, lay one layer of nylon peel ply on the subassembly and place the subassembly in front of the space heater. Designate a space for the space heater as well. If possible, surround the space being heated by the space heater with some flat surfaces to prevent heat dissipation throughout the room. The nylon peel ply will be peeled off once the part is entirely cured to remove any excess resin. Finally, clean the brushes and any other tools caught by the adhesive in the acetone and repeat the entire process until each individual subassembly has 4 layers of fiberglass. This entire process will take several days due to the lengthy cure time, so be prepared to wait for extended periods of time.

When finished, the parts should be hard, but flexible enough to remove from the molds. Mold removal will require the assembler to fully break the molds. It will take some time and force to do, but do not rush the process or else the risk of breaking the fiberglass will increase. After removing the fiberglass layups from the molds, simply seal the edges of each piece shut. For ease of assembly later down the line, do not seal the inside sections of the wings and horizontal stabilizers and do not seal the outer portions of the rudder section.

Figure 6: Fiberglassed nose cone

Circuitry

To simplify wiring the circuit throughout the plane later, the assemblers should create the circuit now after finishing the individual subassemblies. All the parts used in the circuit are purchased parts which include the battery, the power limiter, the safety switch, the electric speed controller (ESC), the motor, the receiver, five servos, a roll of servo wire, and a kit of servo connectors. The tools necessary to construct the circuit include wire cutters, wire strippers, and a servo wire crimper.

The circuit to control the plane is simple. The battery connects directly to the safety switch, which connects to the battery input on the power limiter. The power limiter connects to the battery input on the ESC. The motor leads connect to the motor leads on the ESC. On the power limiter, there is a female servo lead that connects to the servo lead on the ESC. The male servo lead on the power limiter goes to channel one on the receiver. From there, all the servos run from channels two through four on the receiver.

To lengthen the wire on any servo, the assembler must cut a length of wire from the roll of servo wire. To approximate the length necessary, estimate the length of the wire based off the length of the subassemblies depending on whichever control surface the assembler is cutting the wire for. There should be one servo for the rudder, two for the horizontal stabilizers, and two for the ailerons on the wings. The assembler will attach a male connector on one end of the wire and female connector on the other end. To do this, separate the wires on each end of the servo wire and strip about two millimeters of covering off each wire at each end. Crimp male servo leads on one end and female leads on the other end. Slide a male plastic cover over each end of connectors until there is an audible click sound. Facing the front of the plastic covers, the yellow lead should be on the top and the black lead should be on the bottom. Finally, slide a female plastic cover over the female end until there is another audible click.

The servo wire must be spliced to actuate two servos for both the wings and the horizontal stabilizers. To do so, follow all the previous steps for cutting the wire and attaching the connectors, but connect two different wires to the male end of the initial wire. Cut the wires where appropriate, separate the colors, and connect the stripped leads of each color to the same color on each other wire. Wrap the exposed leads with electrical tape (keep different color leads separated) and attach the female connectors to the spliced wires as desired.

Final Assembly

To finalize the assembly, the assembler should cut the control surfaces. It is the same process for all the control surfaces. Cut them to the desired dimensions with a jig saw, run some wood dowels through some thin wood blocks drilled out to the size of the dowels, sand the blocks to fit inside the control surfaces, cut the dowel to length, drill two more wood blocks about halfway, slide those blocks onto the dowels, and slide the whole assembly into the cutouts on the rudder, horizontal stabilizers, and wings. Screw the control surfaces in place and sand the edges as necessary.

Finally, fiberglass the rudder section, tail, and fuselage together, insert the circuitry and wire and connect the servos to the control surfaces. To insert the motor, attach the motor to a two-inch PVC cap, insert the cap into a small two-inch PVC coupler, and insert the newly made motor assembly into the top of the fuselage. Attach the propeller to the motor using the provided collet assembly. To firmly attach the wings, run two 1/4in. by one in. wood beams through the top of the fuselage as appropriate, slide on the wings, and screw in the wings into place. The assembler should bend a thin bar of aluminum into a circle slightly smaller than the large opening on the fuselage to give the fuselage more structure. Screw the landing gear into this ring through the bottom of the fuselage. Finally, the assembler can use a latch and hinge to attach the nose cone and allow the nose cone to open and close. Assembly of the product is now complete.

Disassembly

Since the aircraft is almost entirely fiberglass, it is not made to be totally disassembled. However, the wings can be removed relatively easily to make transportation easier. To do so, simply unscrew the screws holding down the wings, slide the wings off, and slide out the wood beams. The aircraft is now ready for transport or reassembly.

Maintenance

Body

Wear and tear is an issue on all moving parts. Due to the aircraft design the wear and tear on the airframe is almost nil. Our design used fiberglass as the structure of the system and for all control surfaces. Due to fiberglasses properties, the material should hold up for the service life of the aircraft. While the airframe is made with fiberglass and this material is strong and has the ability to take an impact with out deforming a sever crash will render the aircraft obsolete. Due to the design and the way the aircraft was assembled if a part was to get a fatal crack there is no simple way to repair it without adding extra layers of fiberglass to the aircraft. Because of most don't have these types of materials radially available the aircraft would be retired if this issue were to arise.

Propeller

In the event the aircraft crashes in an orientation to break the propeller or to severely damage the propeller the repair man can replace the propeller by simply unscrewing the bullet. The bullet has a hole though it which allows a small screwdriver to be placed through it to get more leverage to loosen the nut. In order to stop the motor form turning the repair man can grab the fitting behind the propeller with a pair or pillars. Once the nut is off the propeller can be replace and reinstalled with the nut being tightened to 15 inch pounds of force. **NOTE:** the propellers is a reverse orientation where the writing should face the nose cone of the plane. Failure to install the blade correctly will result in a nonfunctional aircraft.

Servos

The most common part that breaks on the aircraft are the servos, these take lots of abuse during a crash. In the event of a crash all control surfaces should be checked to make sure they are fully functioning before taking off again. Servos are easy to replace, they are zip tied into their pockets in the fiberglass. To replace all that needs to happen is cutting the zip tie pull out the servo. Once the connection on the wire is discovered you can separate the connector be pulling on opposite directions on the connector. Next you can get a new connect plug into the connector, push extra while back into the airframe and replace the zip tie that will hold the servo in its pocket. The aircraft is now flight worthy.

Motor

Motor that moves the propeller. This motor can be replaced by removing the old motor by disconnecting the wire connection and reaching inside the fuselage to unscrew the 4 screes holding the motor in. Once this is done you can remove the motor and replace a new motor, reconnect the wiring and turn the aircraft on to verify the motor was replaced properly.