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Avro Vulcan

Written by Larry Kruse Build your own park-ready delta wing Free plans and bonus content Read the full tutorial in the October 2015 issue of Model Aviation.

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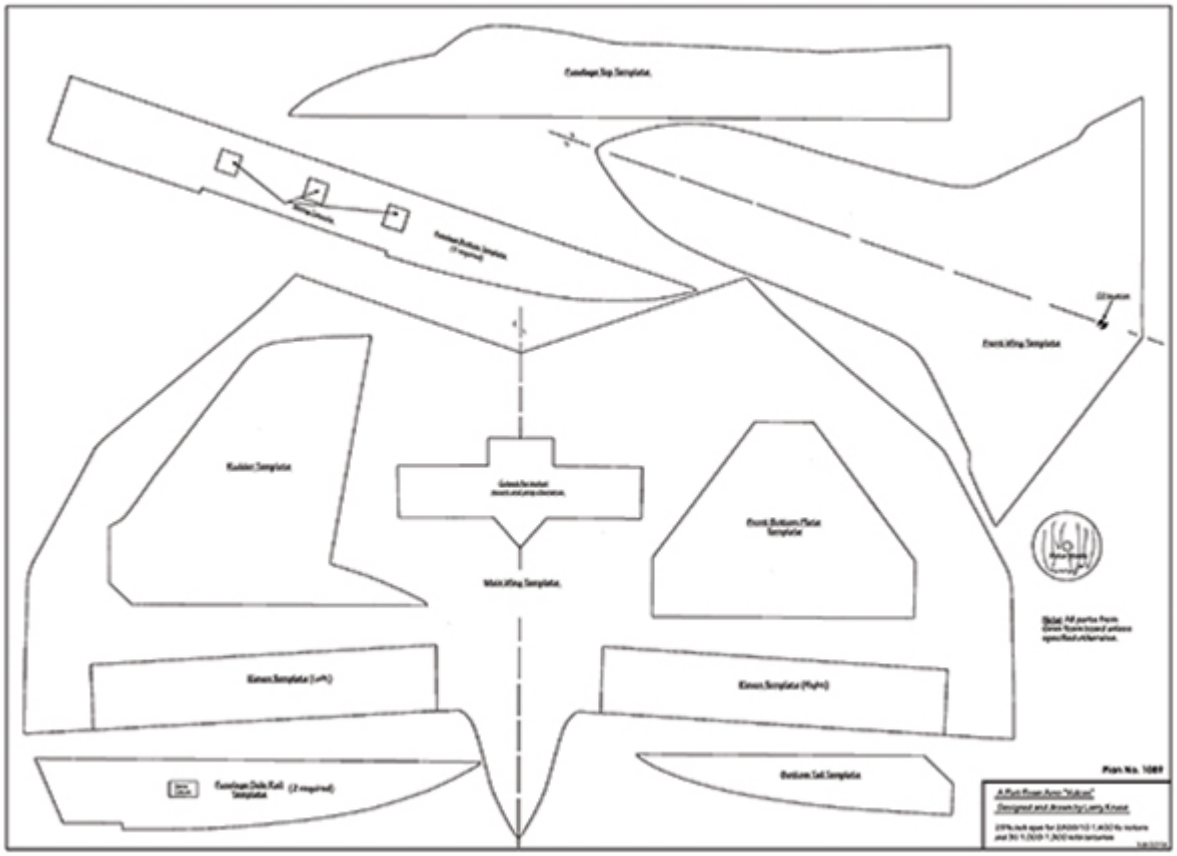
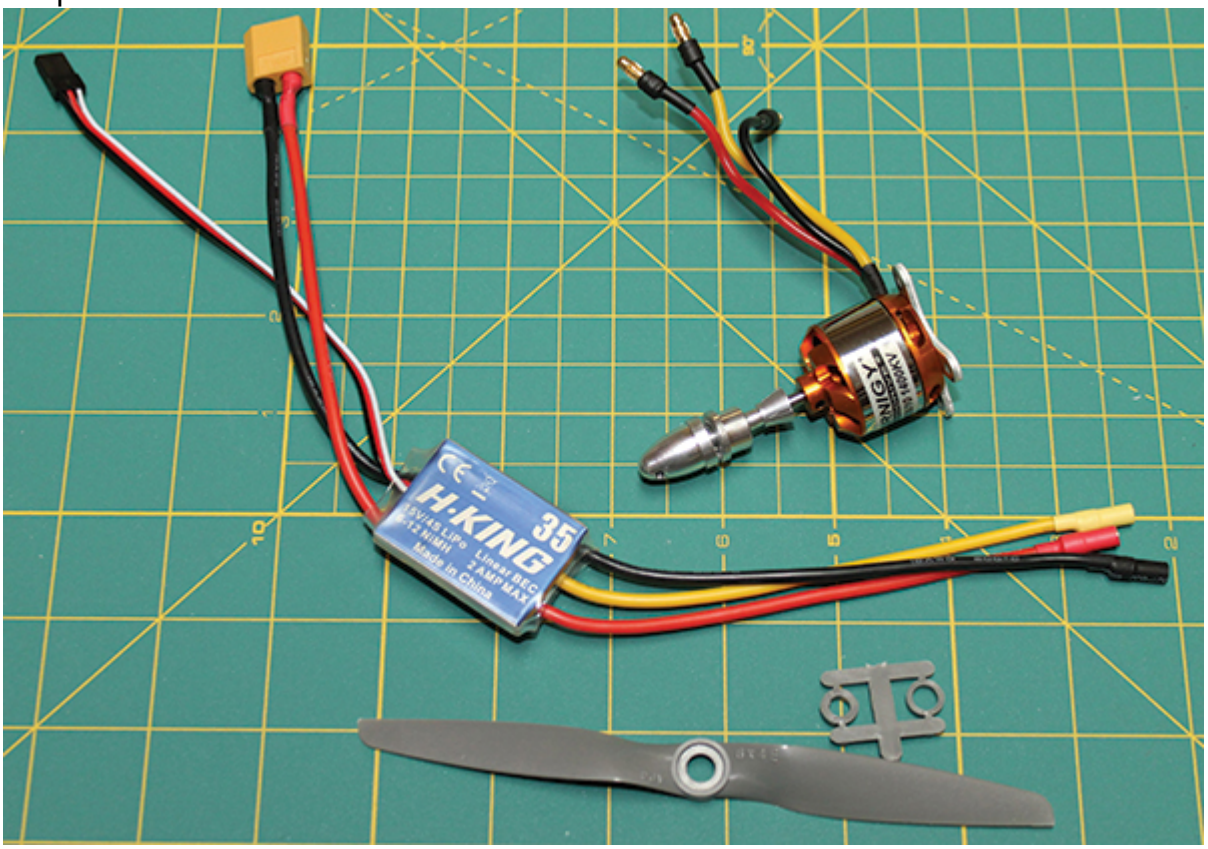


Introduction

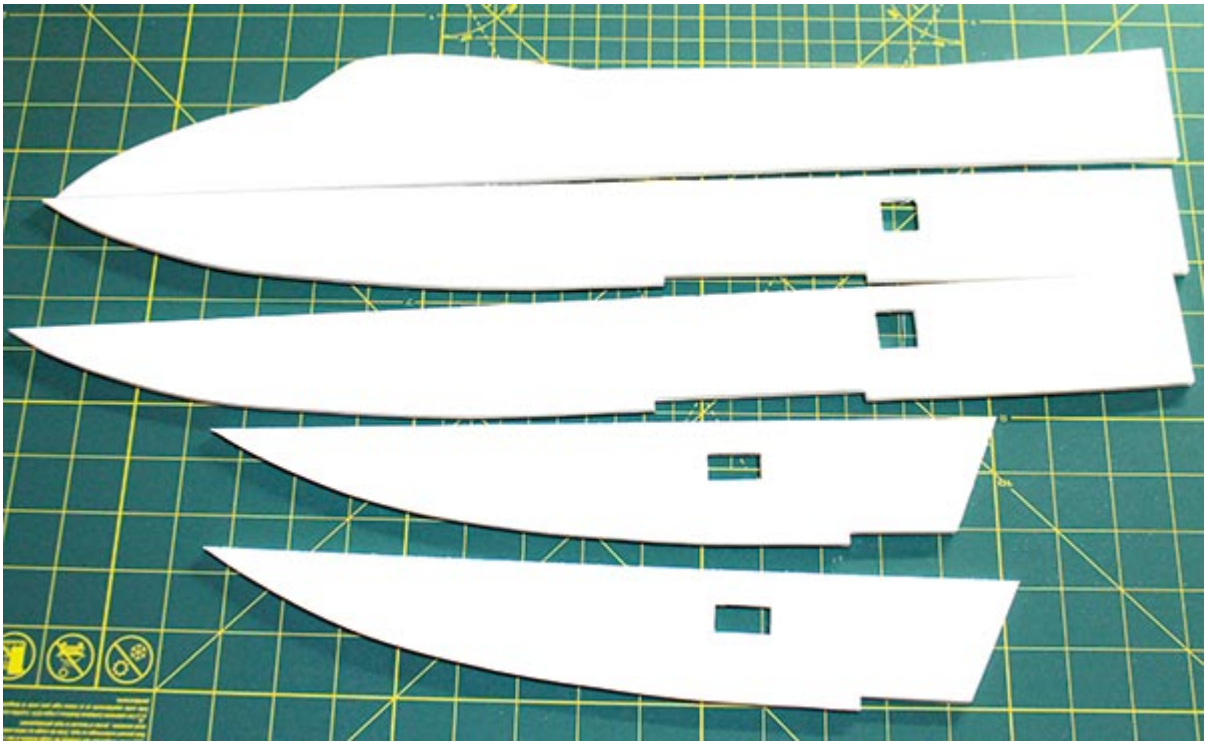
With simple and economical construction, the Avro Vulcan has a high enjoyment-to-cost ratio. Little time investment is needed to get it from a flat foam board to a good-flying model. I was recently introduced to the world of flat-foam flying, and I've found it much like trying to eat just one potato chip. After constructing and flying two manufacturer-produced flat-foam airplanes (one Depron and the other foam board), I wondered what else might lend itself to a flat-foam presentation. Noting that many flat-foam jet-like models take their inspiration from modern-day fighter aircraft such as the F-22 Raptor, the F-15 Eagle, and the Russian MiG series, I began looking at an earlier era of jet aircraft—particularly those designed during the Cold War era, spurred along by the new nuclear age. Scanning the aircraft of that time brought me to the Avro Vulcan (now called the Hawker-Siddeley Vulcan) and its delta-wing planform that lends itself well to mid-fuselage motor placement in a pusher configuration. Development of the full-scale Vulcan began back in 1947, shortly after World War II. The nuclear age required an entirely different platform for high-altitude delivery of nuclear ordnance. Built to mission specifications, the Vulcan went through several iterations before arriving at the "kinked-and-drooped" wing shape of the production version. Using several three-views and photos of the prototype, I sketched a model that would fit a 99-foot wingspan onto two 30 x 20-inch sheets of 3/16-inch polystyrene foam core board. I used inexpensive paper-backed foam board rather than the more costly Depron. This generic 6mm foam board could be purchased for roughly $1 per sheet at Dollar Tree or craft-supply stores. The airplane could be powered by an inexpensive outrunner motor and ESC, making it a low-cost project with a minimal time investment that still provides the illusion of a jet aircraft in the air. Although the word scale and the phrase "flat-foam construction" are not mutually exclusive terms, their relationship can be described as loose at best. Flat foamies provide a scalelike impression in the air, achieved with a minimal investment of effort, time, and money.

Construction Sequence

Free plans for the Avro Vulcan can be downloaded at www.ModelAviation.com. Two sheets of 6mm foam board, a 2826/10 size motor (or similar), a 35-amp ESC, a 7 x 4 electric propeller, two 9-gram servos, a hot glue gun, and 5-minute epoxy will get you on your way to putting your own Vulcan in the air in no more than a couple of evenings. Any radio with elevon mixing capabilities will work as the control unit for the airplane. All foam parts should be carefully cut out before assembly begins. A disposable #11 scalpel was the perfect tool for cutting cleanly through the foam board laminate, but a sharp #11 hobby knife blade will suffice. Make sure that you make all cuts with the knife held vertically. If you happen to cut an edge that ends up slightly slanted, it can be quickly squared using a T-bar sander faced with medium-grade sandpaper. Two characteristics of foam board that make it attractive are that it cuts like butter, and if you mess up a piece, you can easily and economically cut another one! Use the following sequenced assembly process as a checklist as you complete of your Avro Vulcan. 1) You will need to back each template with lightweight poster board. Any type of rubber cement or spray adhesive can be used to attach the patterns to the poster board. After they are glued down, the final template shapes can be cut out with scissors and a hobby knife. After the templates have been made, trace all of the parts onto the foam board using a soft lead pencil. A pencil is recommended for tracing around the parts because you can erase it if you stray from the template lines.

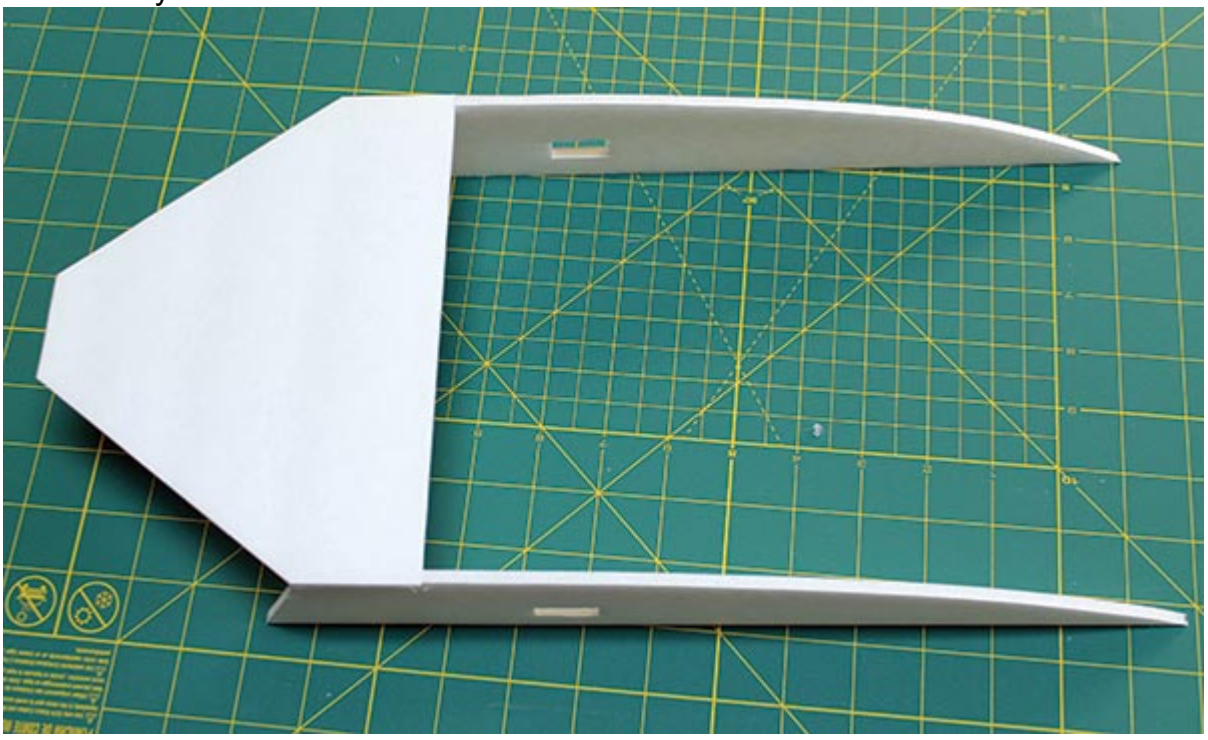


The modestly priced powertrain chosen was a Turnigy 2826/10 1,400 Kv motor, a HobbyKing 35-amp ESC, and an APC electric propeller. The 6 x 4 propeller shown was later change to a 7 x 4 for greater efficiency. The 3S batteries, ranging from 1,000 to 1,300 mAh, require only a slight shifting of position on their hook-and-loop mounts to achieve the required CG.



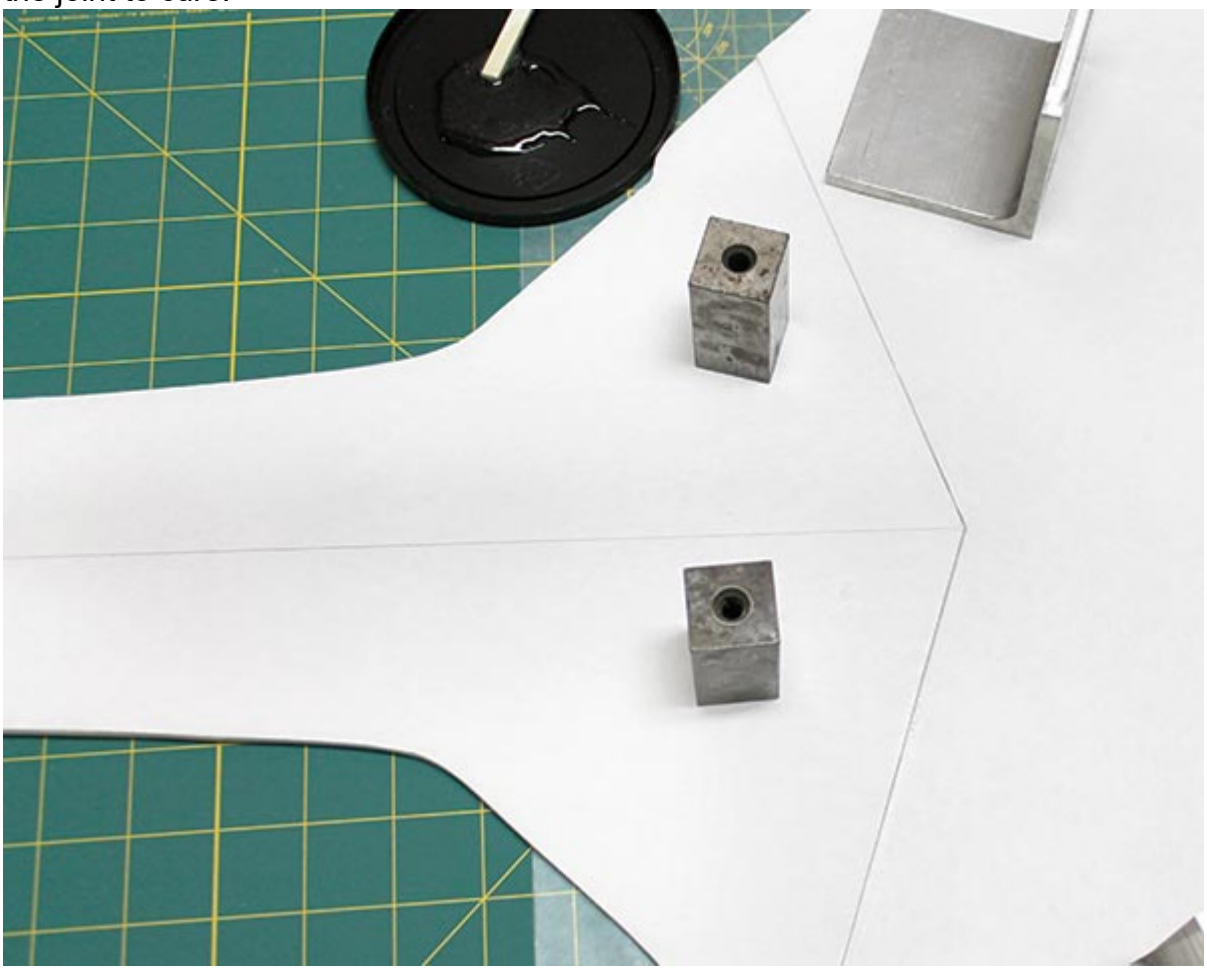
There are only five fuselage pieces. Use 5-minute epoxy to laminate the bottom fuselage center pieces. Although only one wiring hole is shown in the photo, the plans template has additional wiring crossover holes.

2) Place the bottom front plate flat on your work surface and apply a bead of hot glue to the top of one outside edge. You need to work quickly before it sets up. Stand one of the fuselage side rails on edge and attach it to the bottom front plate at the notch. Repeat for the other rail. The rails should be squarely installed so they will align with the outside edges of the propeller clearance slot in the wing. You might want to use a scrap piece of foam board as a spacer at the back of the rails to ensure they maintain a constant width from front to back.



Step 2 The fuselage front bottom plate is hot glued into the notches of the two fuselage side rails. An extra bead of hot glue will increase its strength.

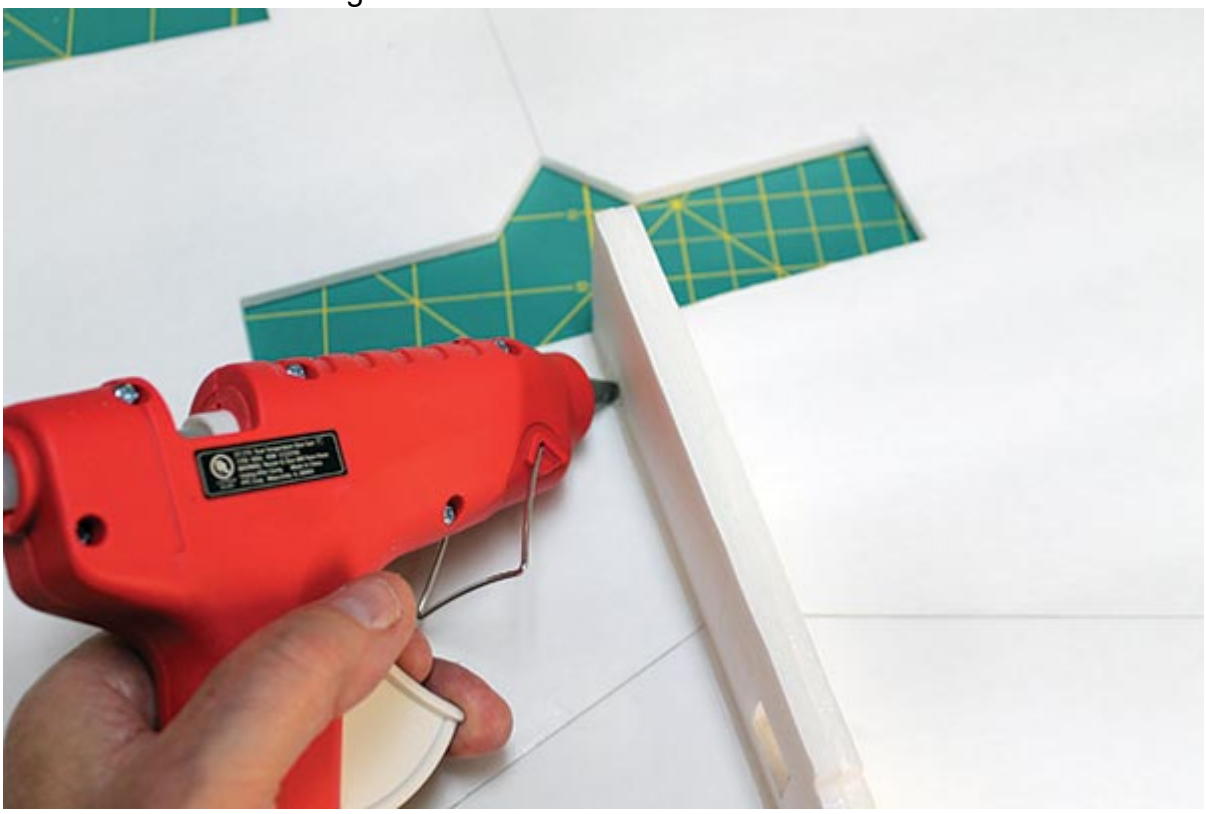
3) Epoxy the bottom curved fuselage center pieces together to make a double-thickness laminated fuselage former. Apply a thin coat of epoxy to one side and keep the two pieces aligned while the epoxy cures. 4) Place a piece of waxed paper on your work surface large enough to extend beyond the joint in the two wing pieces. Spread a thin bead of 5-minute epoxy on the rear of the front wing piece and slide it into contact with the main wing panel. If any epoxy oozes out of either side, wipe it off immediately using a dry paper towel. Weight the two pieces down to keep them flat, and allow the joint to cure.



Step 4 The wing is constructed from two pieces epoxied together and weighted to maintain a flat, warp-free flying surface. Sheets of 6mm foam larger than the 30 x 20-inch foam specified in the text will allow you to cut out the wing in one piece.

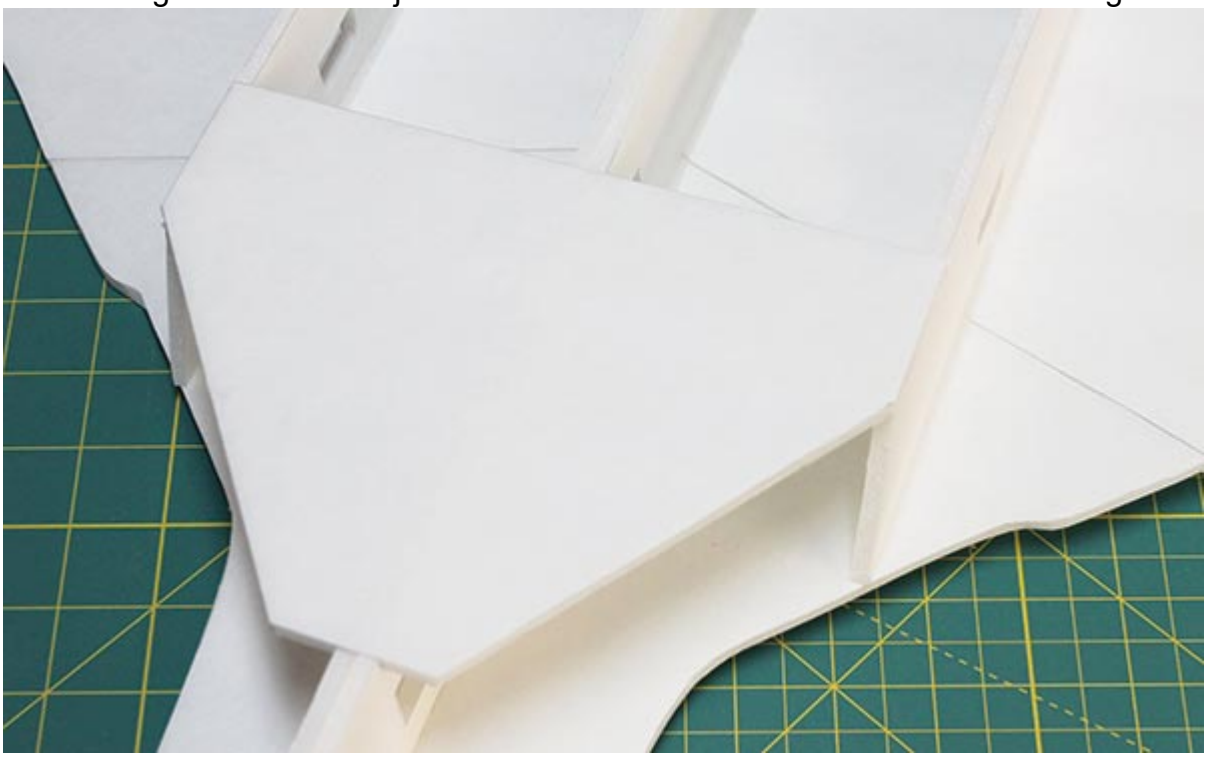
5) Mark a centerline in pencil on the top and bottom of the wing, using a long straightedge. These two lines will be the reference points for joining the remaining parts to the completed wing panel. If you need to enlarge the cutout to use a larger motor and firewall, now would be the time to do it. 6) Glue the laminated fuselage former to the bottom centerline of the wing with hot glue, reinforcing it

with additional beads of glue on both sides.

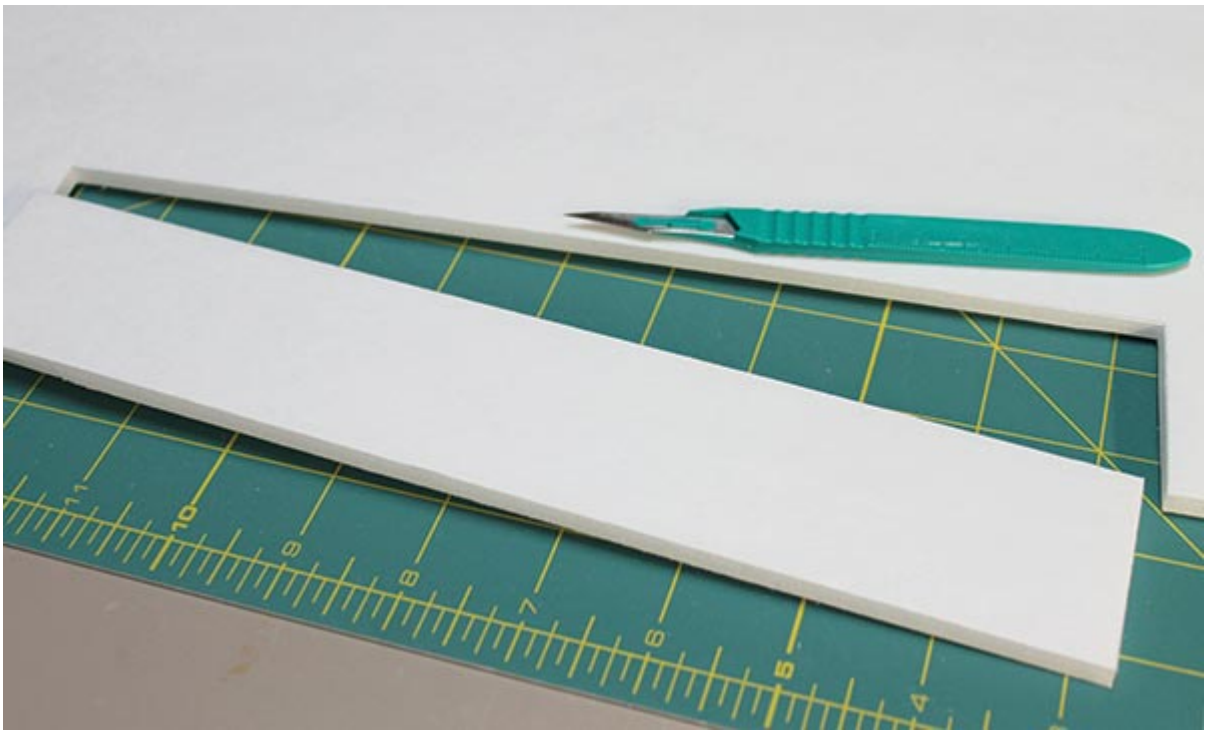


Step 6 The bottom fuselage center laminate is glued to the bottom of the wing using a centerline drawn as suggested in the construction notes. A bead of glue should be applied to the full length of the joint on both sides.

7) Place the fuselage side rails and bottom front piece unit over the bottom of the wing and mark a line on each side for their respective locations. Glue the unit in place by running a bead of glue down the lines you marked and placing a bead of glue into the notch in the laminated fuselage former. Reglue the side rail joints on the inside and outside for additional strength.

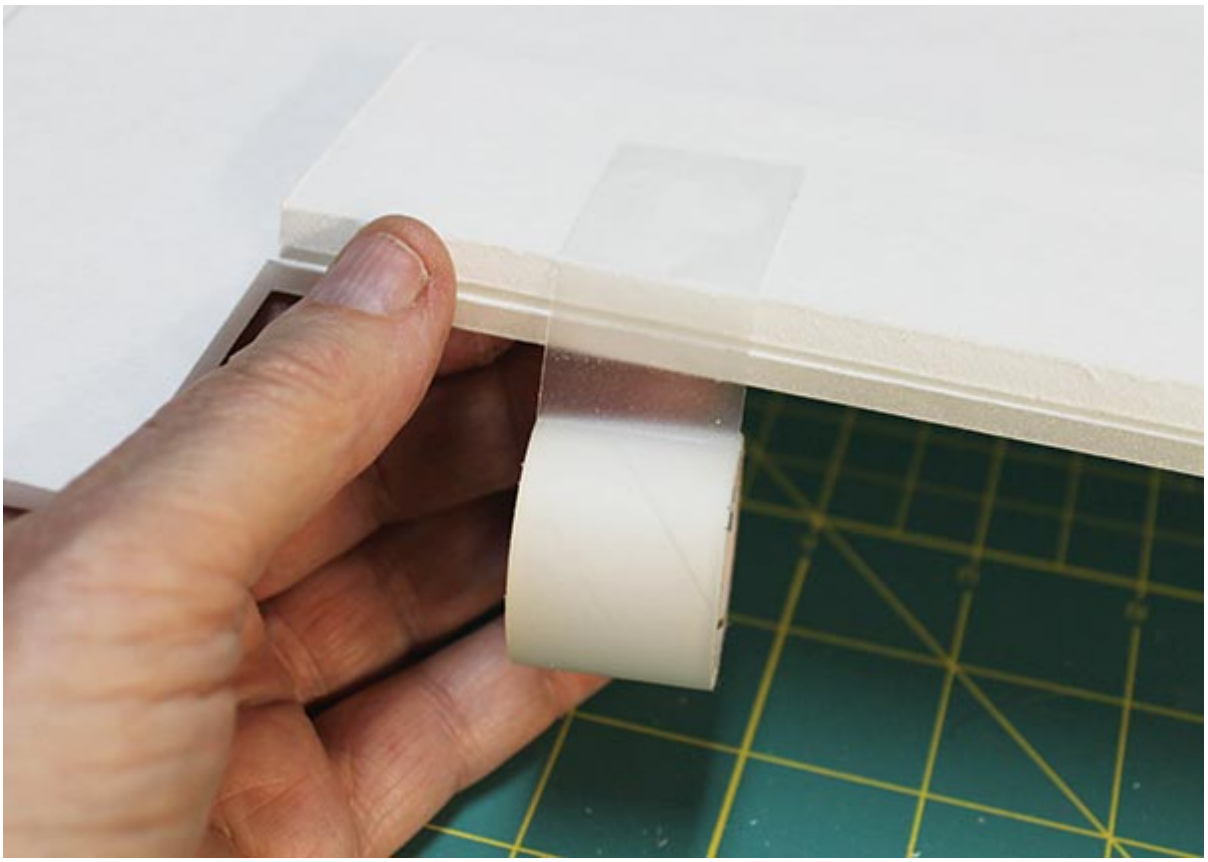


Step 7 The front bottom plate and fuselage side rail assembly fits into the notch in the fuselage center laminate and the rails are glued to the bottom of the wing. An extra bead of glue should be added to the wing/rail joints on both sides.



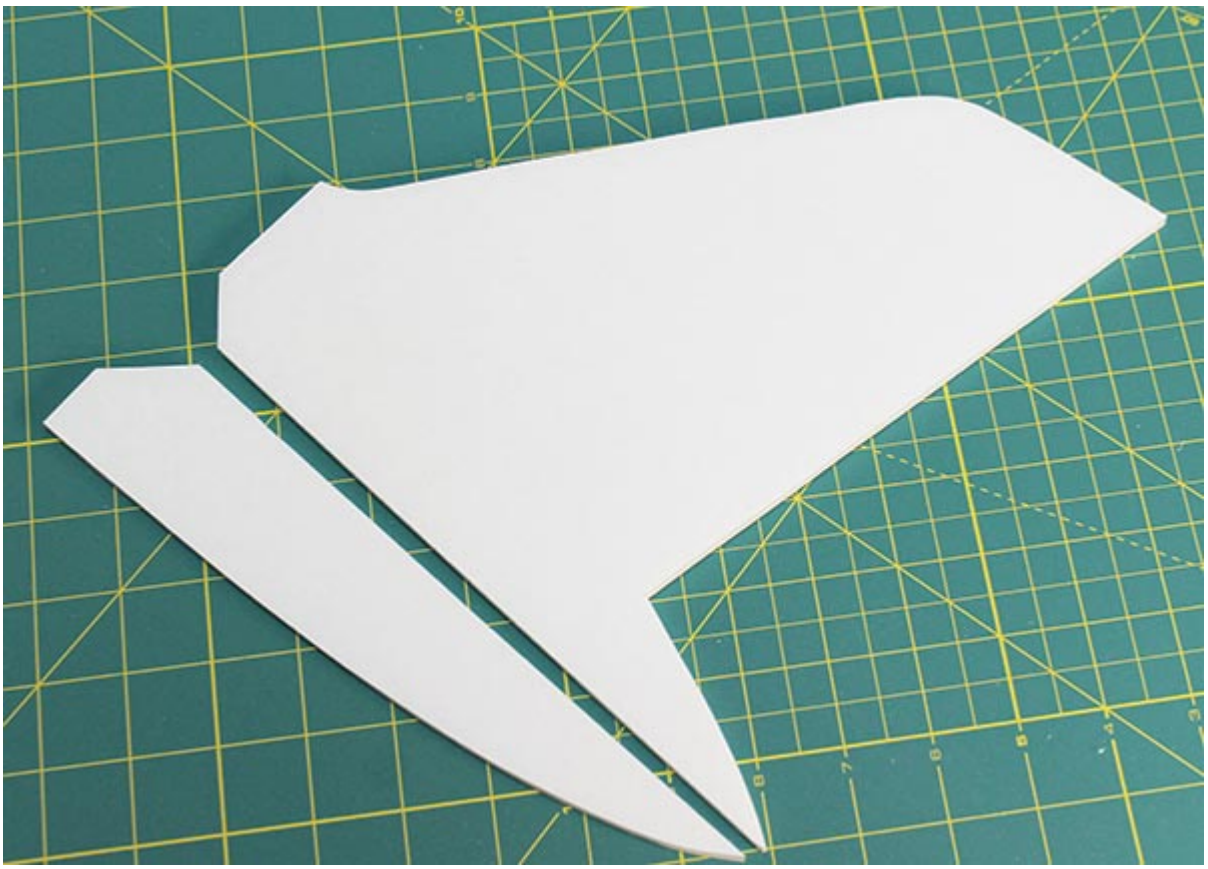
Step 8 After cutting out the main wing panel, the ailerons can be separated using a steel-edge ruler and a scalpel or sharp hobby knife with a #11 blade.

The top of each elevon is hinged with a strip of Blenderm tape across the full length of the piece.



The elevon is then bent flat over the top of the wing and two pieces of Blenderm tape are placed 90° to the wing/elevon joint, spaced at an even distance from each end. Note that the elevon's LE has been sanded to a triangular or chisel shape to allow the joint to bend and not bind against the back edge of the wing.

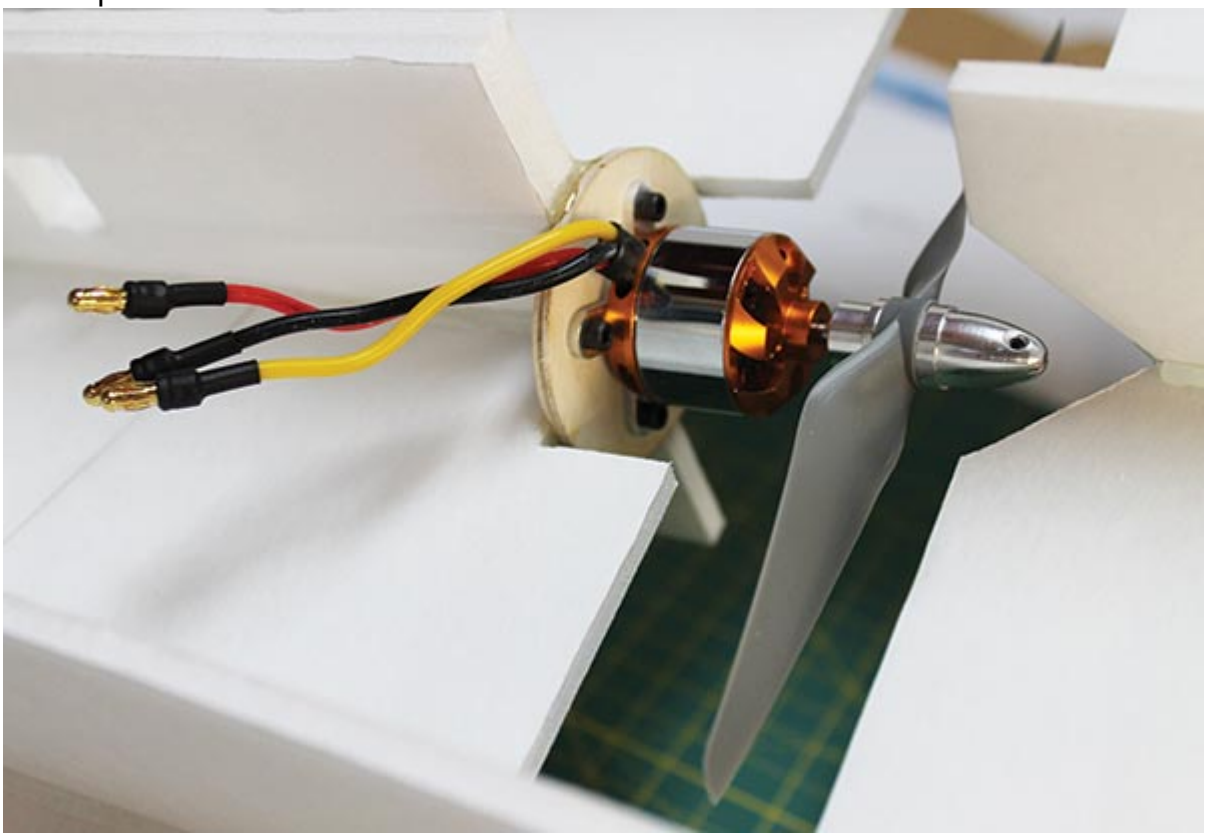
8) Turn the wing over so the top side is facing up. Sand the bottom of each elevon to a wedge shape to taper the leading edge (LE). Hinge the pieces with a piece of 3M Blenderm tape or Scotch Magic Mending Tape placed over the top seam of each elevon and wing joint. Fold both elevator/aileron pieces back flat against the wing surface. Put two pieces of tape at right angles to the elevon and wing seam on each side, spacing out the tape for strength and flexibility. 9) Glue the front top piece (cockpit area) of the fuselage in place, reinforcing it with additional beads of glue on the side. Now glue the rudder piece in place in back of the propeller clearance slot. Make sure it is both vertically and horizontally straight, and then add an additional bead of glue along each side seam. 10) The final fuselage piece is the bottom fairing aft of the propeller slot and directly beneath the rudder. This piece adds strength to the aft fuselage tail cone. Because it is well away from the propeller, it can be used as a grip for launching the airplane. It should receive an extra bead of glue on both sides.



Step 10 The rudder and the bottom fuselage piece both have a notch at the front to clear the propeller spinner. The tapered tail cone shapes add strength to the aft end so it can be gripped to launch the airplane.

11) I found it easiest to bolt the motor to the motor mount and then install the entire unit to the cruciform mounting surface using 5-minute epoxy. The epoxy allows tweaking during the curing process to make sure the thrustline remains at 0-0. After the epoxy sets up, I used a second coat to

build up fillets between the back of the motor mount and the foam board cruciform.

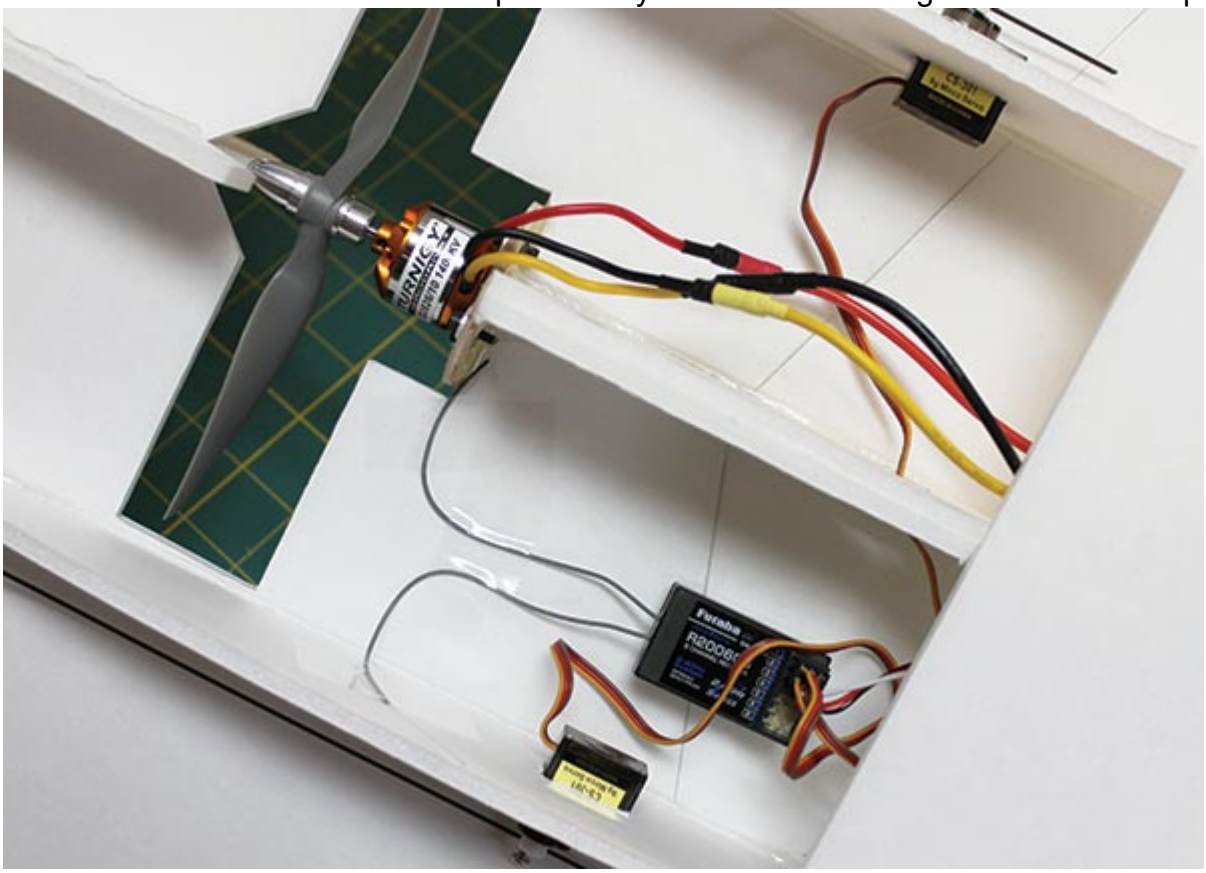


Step 11 The motor mount is glued in place using 5-minute epoxy. A second coat is applied to build up a fillet all around the back of the motor mount where it joins the fuselage/ wing juncture. It's easiest to epoxy the complete assembly in place in order to assure a 0-0 thrust angle.

Radio Installation

The area between the main laminated fuselage former and the fuselage side rails on both sides allows ample space to mount the receiver, ESC, and battery using industrial-grade hook-and-loop

material. It’s easiest to do a mockup of the layout before attaching the hook-and-loop material.



Radio Installation This view shows the placement of the receiver and servos. The ESC is mounted under the front bottom plate, with the battery attached to the side of the fuselage as far forward as necessary to achieve the CG.

Hot gluing it to the foam board works better than trying to use the self-sticking variety. The cutouts in the main fuselage former allow the wires to be moved to whichever side of the fuselage is required. It’s wise to move the ESC as far forward as the length of the motor wires allows, to achieve proper center of gravity (CG) without needing to place the battery too far out on the nose area. The two 9-gram servos are slipped into their respective cutouts and hot glued in place. Center the servos before attaching the pushrods to them and to the control horns. GWS servo keepers, along with Du-Bro Micro Control Horns and Micro E/Z Links, work well with the .047-inch music wire pushrods. The control horns should align with the servo arms. I drilled pilot holes for the control horn pins and used foam-safe CA glue to lock them in place. Because I was using my trusty Futaba T6J transmitter and R2006GS receiver, it was simply a matter of going through approximately five screens to set up the elevon mix. My starting point for initial test flights was 80% control throws and

40% exponential.

Servo Installation The servos are hot glued in place and the control horns are glued in place using foam-safe CA. A Dubro mini-keeper is used to lock the pushrods to the control horns.

Preparing for Flight

After the electronics were installed, I finished the model in the color scheme and markings of the prototype high-altitude Avro Vulcan—an easy task because the airplane was all white with few markings! I did a Google search for “Royal Air Force roundels” to find the fuselage and wing roundels. I printed them on plain paper and used spray adhesive to attach them to the foam board. All other markings were cut from MonoKote trim sheet and adhered to the foam board as you can

see in the photos.

Markings for this version of the Vulcan are minimal. The cockpit markings are from a MonoKote trim sheet and the RAF roundels were printed and attached with Elmer's spray adhesive.

Foam board does not like moisture—including high humidity—so you might want to seal it. Some modelers have found that Minwax oil-based polyurethane (not the water-based formula) works well.

The delta-wing planform is distinctive in the air, providing the in-flight illusion of a complex, scalelike Vulcan bomber.

One of our club members had success with brushing Minwax on and wiping it off with paper towels before it dried. He then sprayed his airplane with rattle-can paint without causing any warping. Sealing in such a manner would have to be done after the airplane is constructed because hot glue won't stick to Minwax polyurethane. Although the model presented here doesn't have any finish on it, the later low-altitude version of the Avro Vulcan has a striking green and gray camouflage scheme that could be applied after sealing the foam board. I used a 3S 1,000 mAh battery for my first flights with the prototype, moving the battery forward as needed to attain the CG, and checking all of the control throws to make sure they were equal and moving in the correct direction. Make sure the motor is turning in the right direction by removing the propeller and attaching a small piece of double-sided masking tape to the motor shaft. Slowly run the throttle lever up. If it's rotating

backward, simply switch any two of the motor wires in their ESC sockets. When reinstalling the propeller, the pitch numbers on the front of the propeller should be facing the motor case to achieve the greatest efficiency.

The Avro Vulcan in Flight

Control surface deflections were set to 1/2 inch up and down, and the airplane was launched with roughly four clicks of up-elevator to indicate which way it needed to go. That proved to be the right amount, with some of the up-elevator removed when the desired airspeed was reached. The tailcone in back of the rudder was intended as a convenient object to grip to launch the Avro Vulcan with your hand aft of the propeller and out of harm's way. Using that technique, the model can be pointed upward at approximately 45°. When the motor is brought up to nearly full power, the model will simply leave your hand with no need to throw it.

The Vulcan's glide is slower than walking pace with no tendency to tip stall. Note the nose-up angle of attack and the position of the elevons as it sets up for a landing.

From the first launch, it proved to be a stable, fully acrobatic model capable of achieving high speeds and less-than-walking-speed landing approaches. It never showed a tendency to tip stall. When it was throttled back to stall speed in the air, it dropped its nose slightly and mushed straight ahead. It is a comfortable, visually exciting airplane while in the air. I want to thank fellow club member Paul Phillips for his steady hand at the controls so I could capture flight photos, and Chase Watkins for his construction techniques that I adapted to the Avro Vulcan to make it a lightweight, but sturdy design. I'm pleased with this foam-board project. Given its minimal cost and quick construction, I think you will be, too. —Larry Kruse