Construction Guide for the X-31 Park Jet EDF

By Steve Shumate

This model can be built using the following types of adhesives:

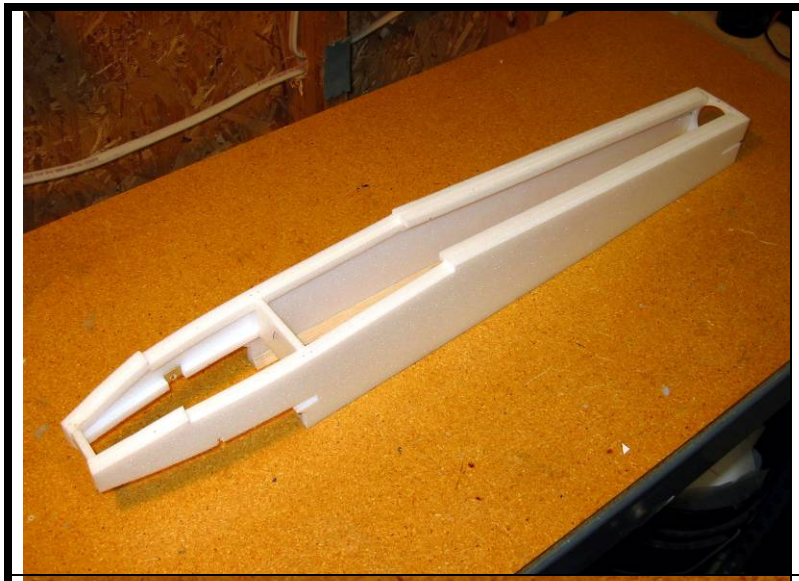
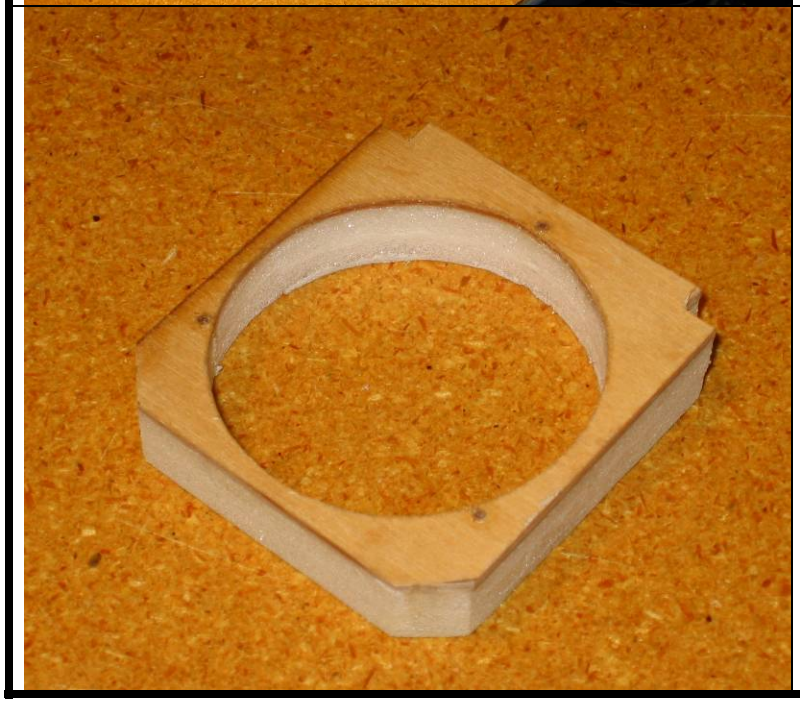
- Epoxy
- Odorless cyanoacrylate (CA) with accelerator
- UHU Creativ for Styrofoam (or UHU POR)
- 3M 77 spray adhesive
- Hot glue gun
- ProBond (or Gorilla Glue)

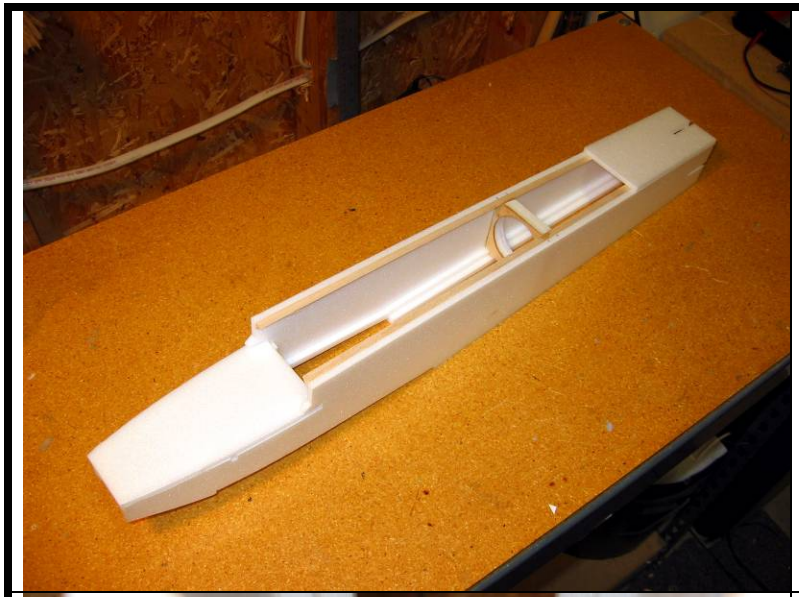
To minimize weight, try to use as little epoxy as possible on this model, saving it for only critical joints such as wing spars and motor mounts. The majority of construction should use a lightweight and quick-drying adhesive such as CA, UHU Creativ, or 3M 77. I personally use 3M 77 and UHU Creativ (picture at left) for the majority of construction.

1. Begin assembly with the forward fuselage. Start by gluing the small plywood canard pivot supports to each fuselage side. Once the glue is dry, stack the two sides together and drill a 3/16” hole at the location shown on the plans through both sides at once (preferably on a drill press).

Next, lay the two fuselage sides down flat on the work bench and glue the foam strips and balsa triangle to the locations shown on the parts templates.

Be sure to make two mirror image parts—a left side and a right side.

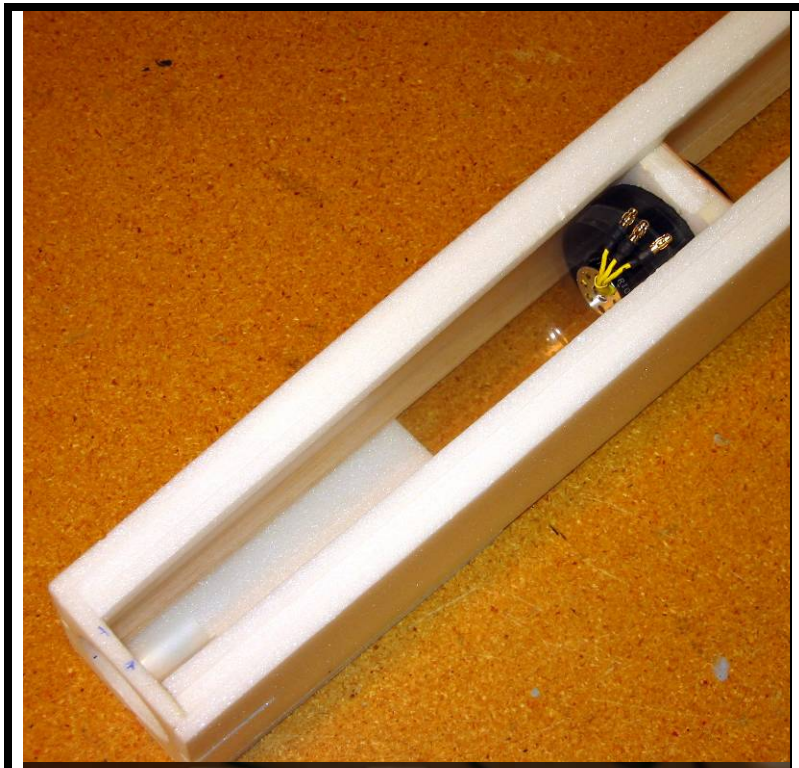
	**2.** After the glue has dried, glue the three fuselage bulkheads to one of the fuselage sides at the locations shown, making sure they are perpendicular. Next glue the two fuselage sides together. Set the fuselage sides upright and flat on the workbench, apply glue to the edge of the bulkheads, and push the sides together.
	**3.** Laminate the EDF fan mount pieces (2 foam and 1 plywood). Drill the mounting holes for the fan unit as shown and reinforce holes with CA glue and accelerator.



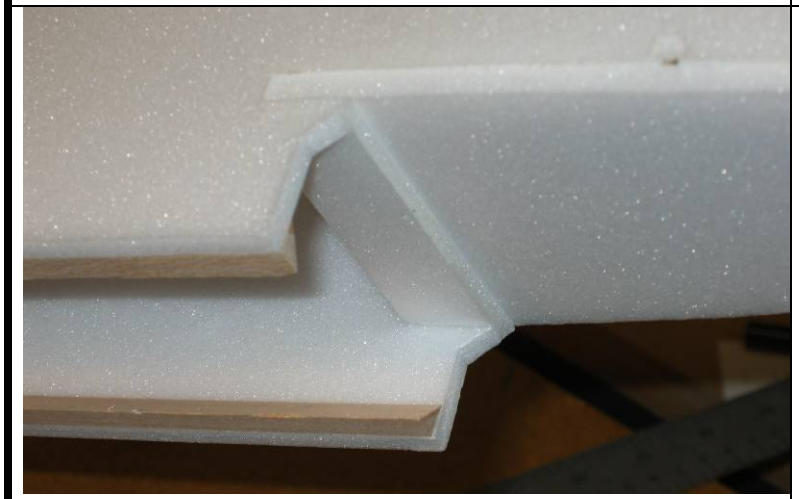
4. Install the EDF fan mount at the location shown on the parts templates, making sure it is aligned correctly.

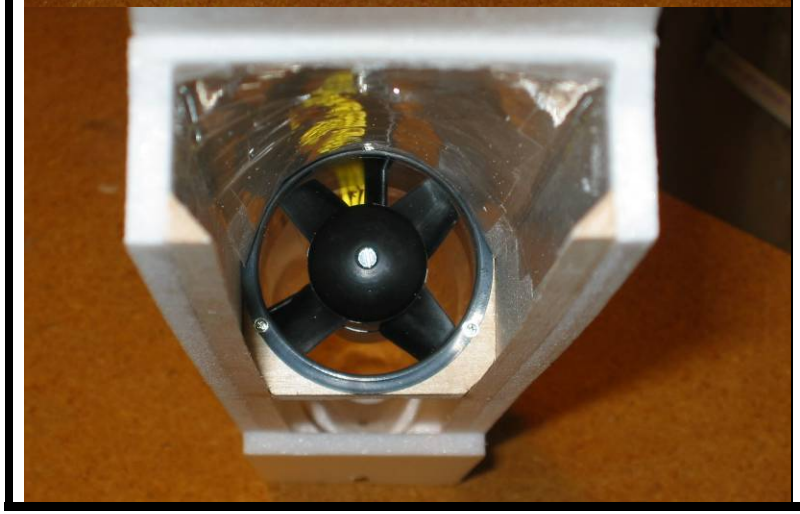
Glue on the forward fuselage bottom piece and aft fuselage bottom piece as shown.

5. Install the assembled fan unit into the fan mount using 3 screws as shown. Make sure the fan is properly assembled and runs correctly BEFORE installing it, since once the model is built it is VERY difficult to access the fan unit and motor!



6. Make and install the thrust tube. This is made from a rolled piece of viewfoil transparency material and simply taped around the fan unit and to the exhaust opening. Use the template provided for the Wemotec Microfan, or make your own if using a different fan unit. Note you'll need to cut a small hole in the top of the thrust tube just behind the fan unit to allow routing the motor wires up and out of the fan unit (see top picture at left).

	**7.** Glue in the foam and plywood pieces forming the inlet diverter. Note the aft end of the plywood piece (not shown in the photo) sticks out into the fuselage to form a small ledge, which you'll use in the next step when installing the internal ducting.
	**8.** Bevel the edges of the upper forward ducting piece as shown on the parts templates. Then immerse the entire piece in hot water (as hot as your hands can stand), let it soften a bit, and bend to form the shape shown. The aft end should conform exactly to the fan unit, while the forward end remains flat to butt up against the ledge formed by the inlet diverter piece. It will probably take a lot of bending and re-bending to get this right—take your time.

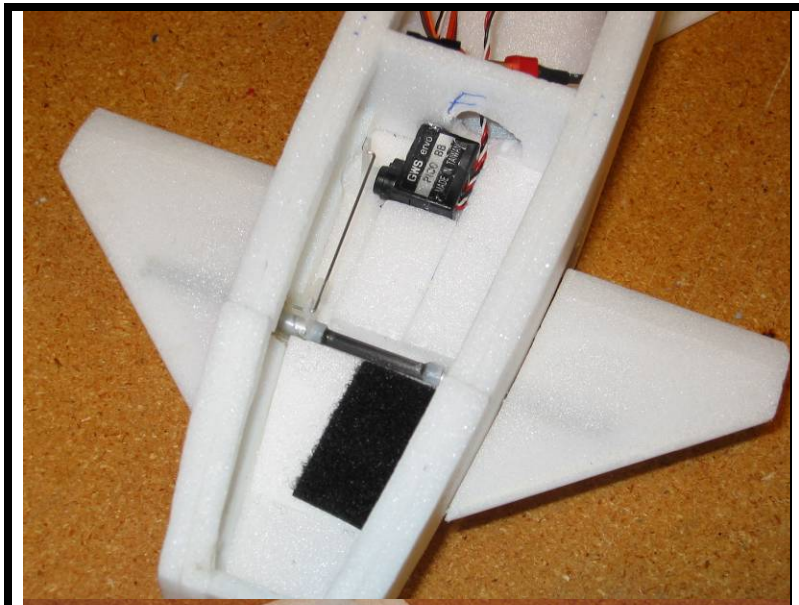


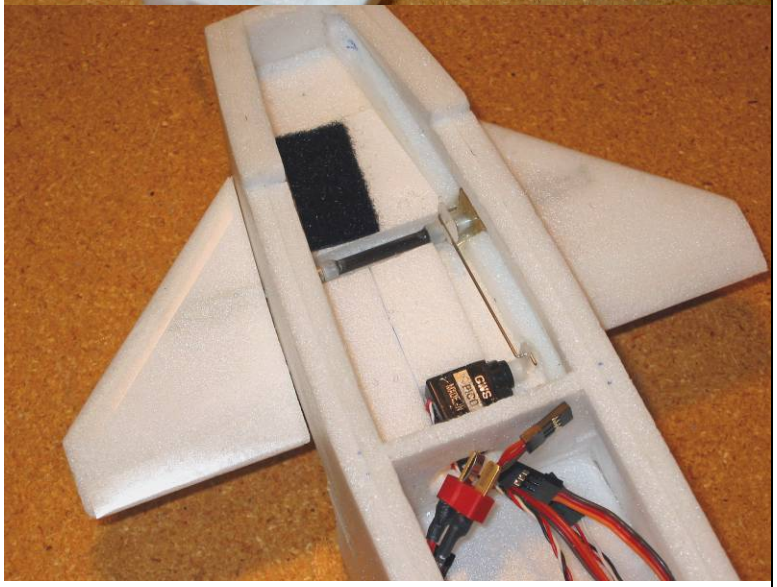
9. Install the upper forward ducting piece into the fuselage. Make sure the aft end wraps tightly around the fan, the forward end glues onto the ledge behind the inlet diverter, and the sides are flush against the fuselage. Lots of trimming and shimming and re-heating may be required, so take your time to get it right.

Once this piece is glued in properly, liberally coat the entire inner duct surface with smooth packing tape to create low friction surface.

10. Bevel and heat form the lower forward ducting piece using the same procedure as before, and then glue in to the fuselage. This piece should wrap tightly around the lower part of the fan unit and sit flat across the bottom of the fuselage (it will sit flush against the top of the wing once it's installed). Make sure to cut a shallow bevel across the forward facing end of this piece, to minimize the step it forms when it mates with the top of the wing.

Apply smooth packing tape to the duct surface as before (the entire inner ducting should be smooth and coated with packing tape).





11. Next install the canards. The 0.157” diameter carbon pivot rod pivots inside two 0.5” pieces of 3/16” diameter aluminum tube. The rod is held in place by the control arm on one side and an end stop on the other. Both butt up against the aluminum tube and both are made from spare nylon servo arms—just drill both out to fit the rod and snip the arm off the end stop side.

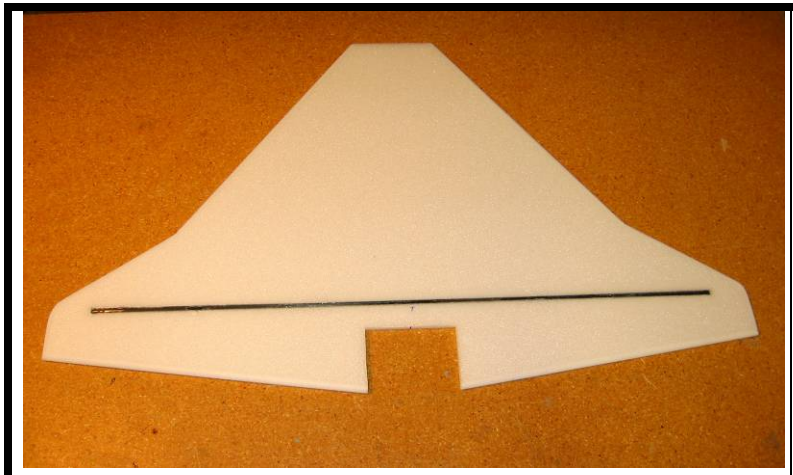
Begin by sanding the canard halves to give them a symmetrical airfoil shape, with a rounded leading edge and a tapered trailing edge. Wrap a strip of 3M Satin around both the leading and trailing edges to provide strength and smoothness. Cut a groove in each half to fit the carbon pivot rod, as shown on the parts templates

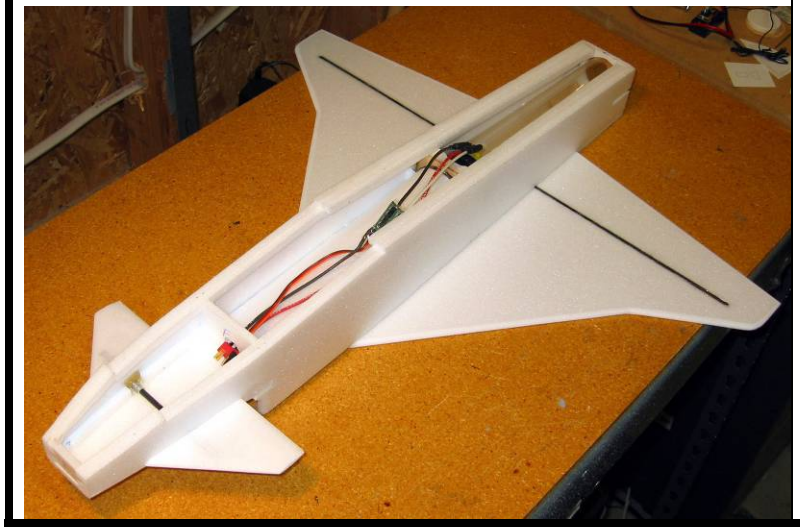
Test fit the aluminum tubes into the holes in the fuselage sides and slide the carbon rod into place. Adjust the fit as required until the carbon rod is perfectly straight and turns freely, and then glue the aluminum tubes in place using CA or epoxy. After the glue is cured, slide the rod out and then reinstall it while sliding on the end stop and control arm at the same time. Do not glue them onto the rod yet.

Now glue the canard halves onto the rod using 5 minute epoxy, making sure they are perfectly straight and aligned. You can do both sides at once, but it is easier to do each side individually so you can be sure everything is perfectly aligned.

After the glue is dry, push the servo arm and end stop up against the aluminum tubes until you get a nice tight fit, and then glue them in place using CA.

Now install the canard servo as shown and make and install the 1/32” music wire pushrod. I just used servo tape on bottom with a little foam-safe CA for extra strength. Use scrap foam to brace the servo as required to get a strong and stiff servo mount. I used Dubro micro pushrod keepers on the control arm side to easily allow connecting and unconnecting the linkage. Use a Z-bend on the servo side.



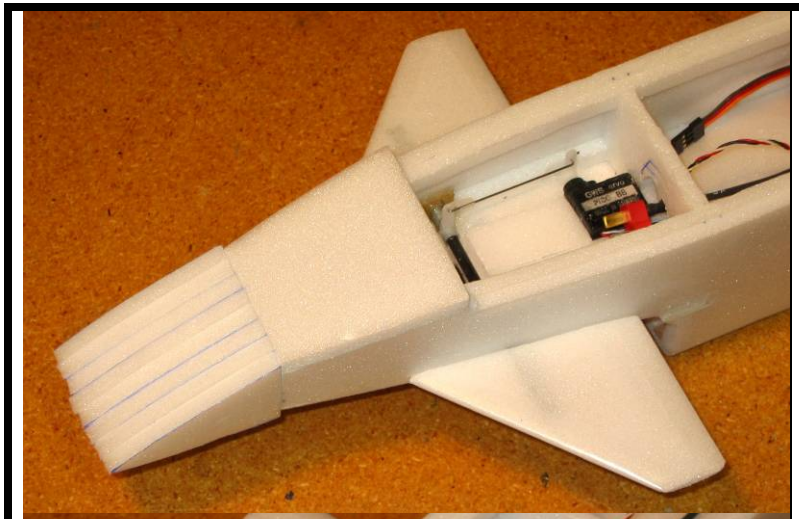


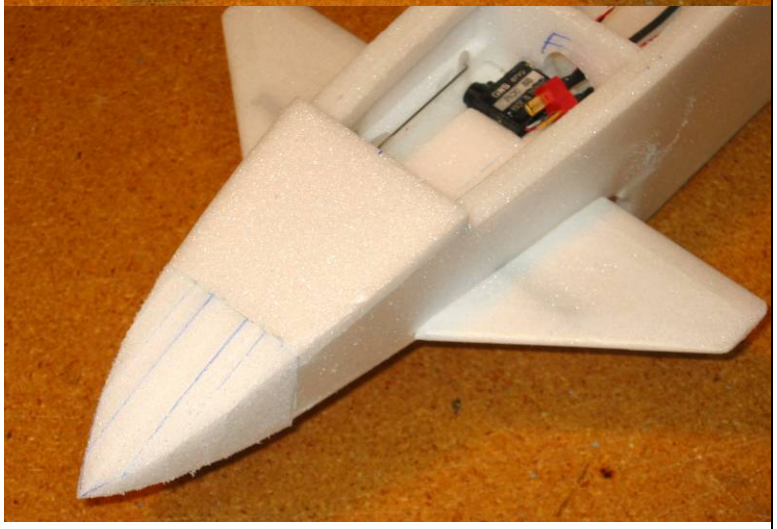
12. Sand the leading edge of the wing to a well-rounded shape, and sand the trailing edge to a gentle taper. Cut a slot for the carbon tube wing spar.

Lay the wing down on a flat surface and use 30 minute epoxy to glue the carbon wing spar in place. Place heavy books over wax paper on top of the wing to hold the wing perfectly flat as the glue cures.

After the glue has cured, cut the flaperons free from the wing. Then cut a 45 degree bevel in the leading edge of the flaperon using a ruler and a hobby knife. Hinge the flaperons with 3M Satin tape.

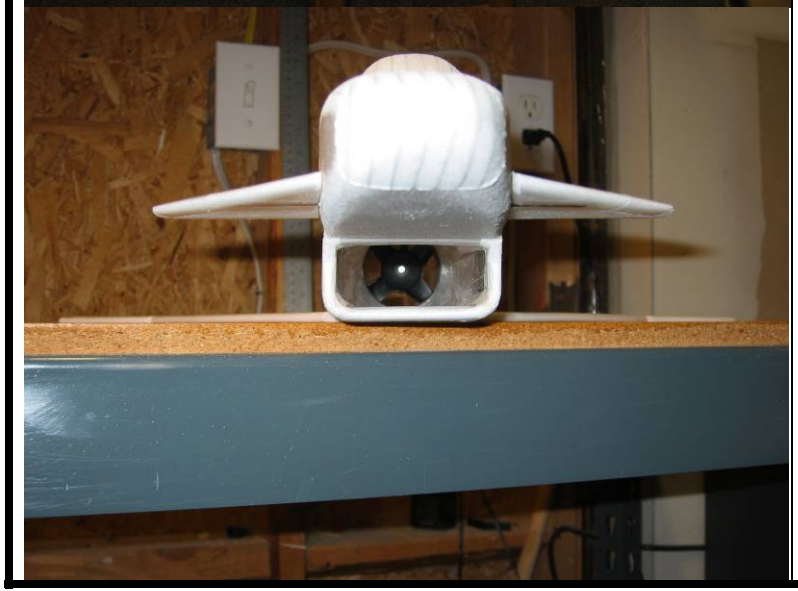
Draw centerline marks on both the wing and fuselage. Then glue the wing to the bottom of the fuselage, making sure the centerlines are perfectly aligned. Also put a little glue on the bottom of the lower internal ducting piece so that it is secured to the wing. After the glue is dry, apply a small piece of packing tape over the joint between the wing and the lower inner ducting piece to smooth it out.





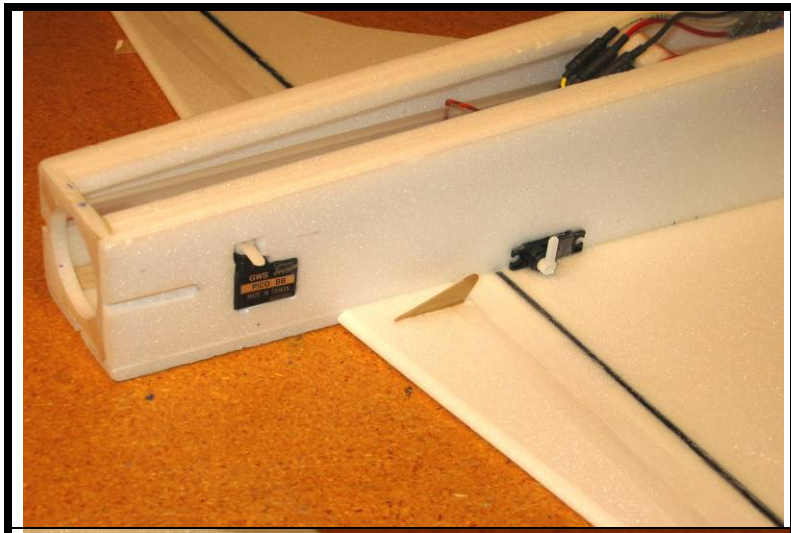
13. Laminate all of the nosecone pieces together using 3M 77 adhesive. Then glue the nosecone block to the front of the fuselage.

Once the glue has dried, sand the nosecone and forward fuselage to shape. Start by tracing the top outline of the nosecone onto the foam and cut to shape with a long knife or saw. Begin with coarse sandpaper (100 grit) to rough out the basic shape, then move to a finer sandpaper (220 grit) to do the final shaping. End with 320 grit sandpaper to do the final polish sanding and provide a very smooth surface.



14. Glue on the forward inlet bottom piece in front of the wing. Install a strip of packing tape down the middle inside of this piece before installing it.

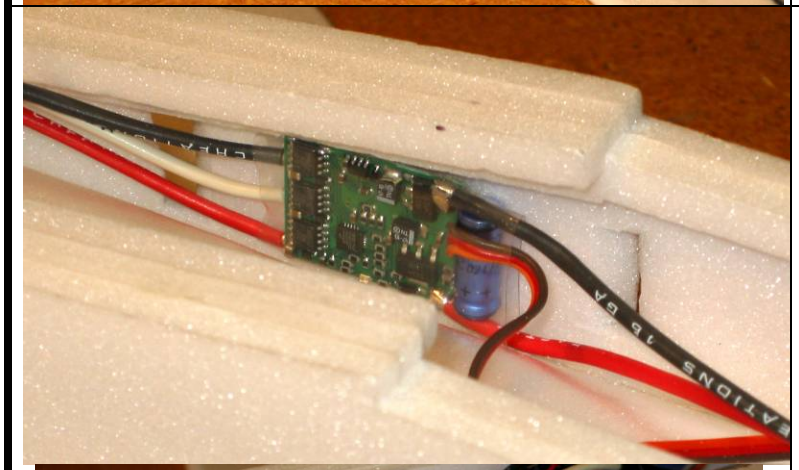
Now sand the entire forward fuselage to shape, rounding the corners of the fuselage and inlets as shown. Take care to round the leading edges of the inlet especially, to ensure smooth airflow into the fan at large angles of attack and sideslip. Put a strip of 3M Satin tape around inlet leading edge as well to provide durability and an extra smooth surface.

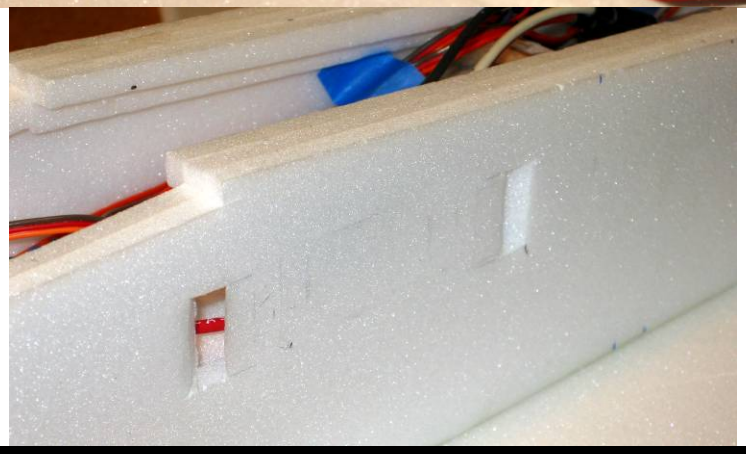


15. Install the flaperon servos, control horns, and pushrods. I simply cut a square hole in the fuselage and pushed the servos in, letting friction and a small dab of CA hold in them in place. Run the servo wires up over the top of the fan mount bulkhead and forward.

Install the pitch vane servo as well and run the servo wire forward over the fan mount as well. Note how this servo is mounted in the picture at left. This arrangement is necessary because of the limited amount of space between the fuselage side and the thrust tube inside. The GWS Pico servo shown just fit.

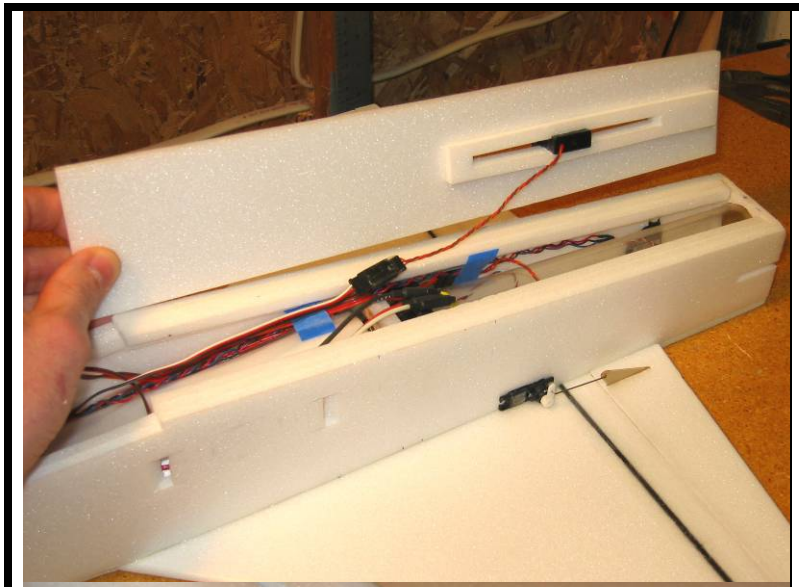
Extend the leads of all these servos as necessary to reach the receiver mounted in the forward fuselage (see the plans for recommended location).

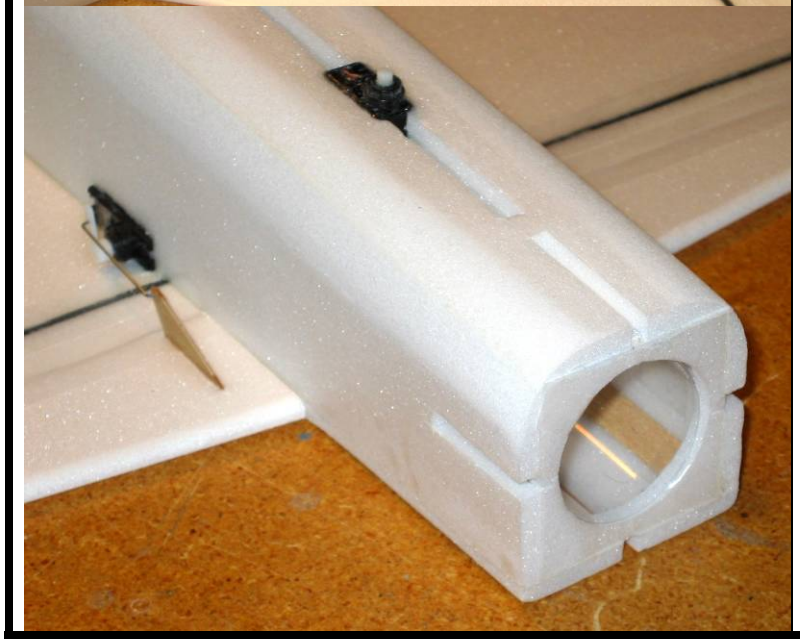




16. Install the speed control in the location shown on the plans. To ensure adequate cooling, it is highly recommended that you cut 45 degrees slots in front and behind the speed control as shown. Note that cooling is important not just because of the motor amps, but more so because of the BEC circuitry since this model requires 5 micro servos (and most speed controls are only rated for 3 or 4 servos). Cooling the BEC helps prevent premature shutdowns due to overheating.

It's also highly recommended to cut cooling holes in the forward fuselage to provide airflow to the battery. Choose a location that works best with the particular battery size and shape you use.

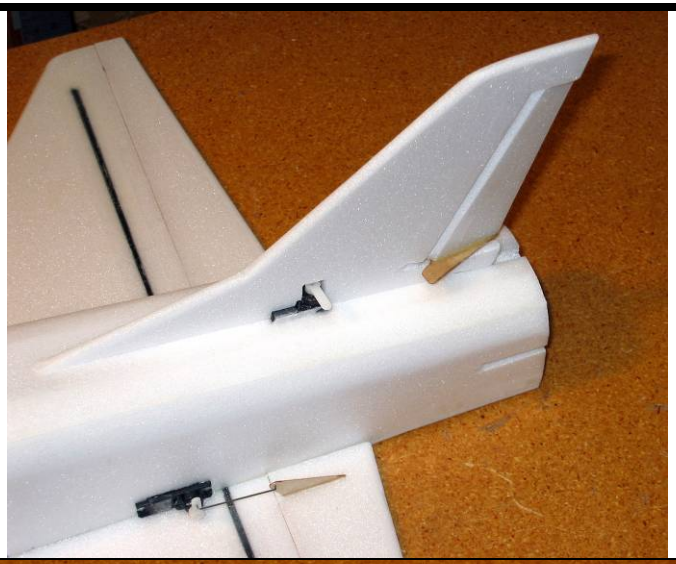




17. Install the vertical tail brace into the aft fuselage top. Then install the rudder servo into the aft fuselage top as shown, extending the servo leads forward and over the top of the fan unit mount as shown.

Make sure all the internal wiring is in place and secured with tape (see photo at left).

Glue the aft fuselage top and place. Once the glue is dry, sand the aft fuselage top to the rounded shape shown.



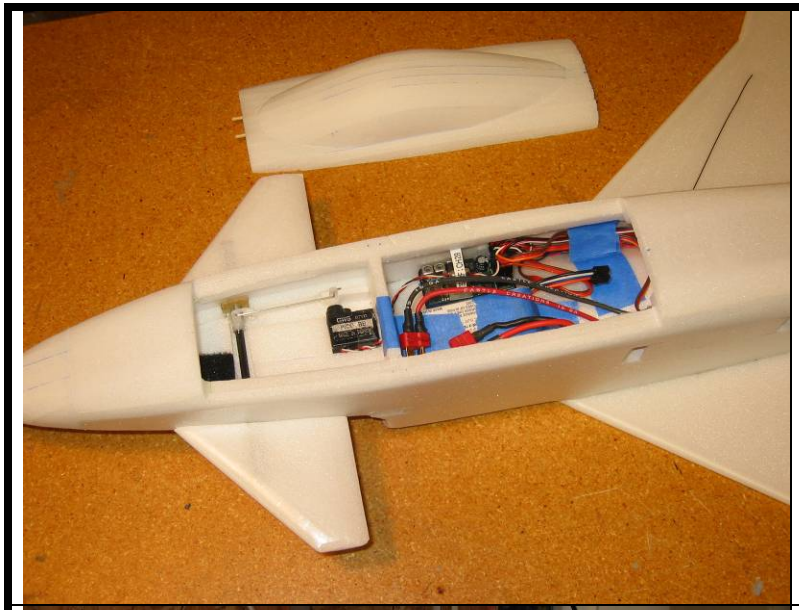
18. Sand the vertical tail to shape, rounding all the edges. Apply a strip of 3M Satin tape to the leading edge.

Cut the rudder free, bevel the leading edge, and hinge with 3M Satin tape. Install the rudder control horn as shown.

Glue the vertical tail in place with epoxy, making sure it clears the pre-installed rudder servo.

After the glue is dried, make and install the rudder pushrod.

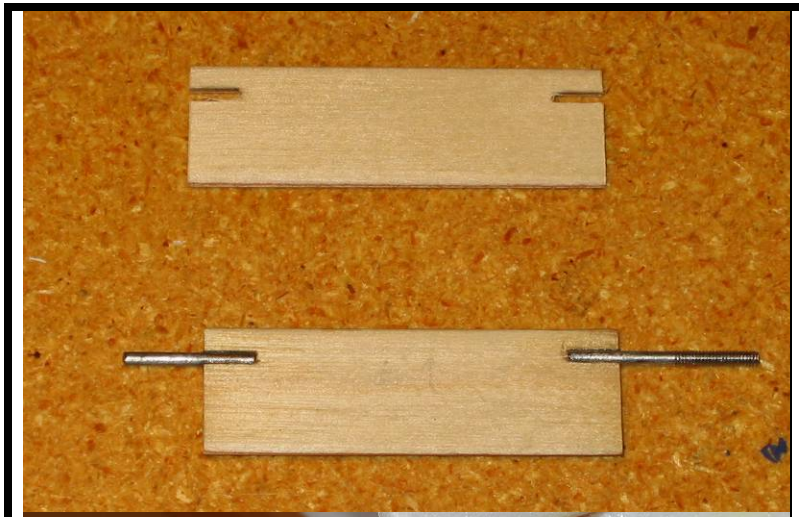
19. Laminate and carve the canopy to shape using the same procedure as the nosecone. Note there's a thin piece that goes on the bottom outside of the block. This piece allows forming the lower sill of the canopy.



20. Install the finished canopy. I used two toothpicks forward and 3M Satin tape aft to secure it in flight, but Velcro or small magnets could be used as well.

Install the receiver as shown and hook up all the servos.

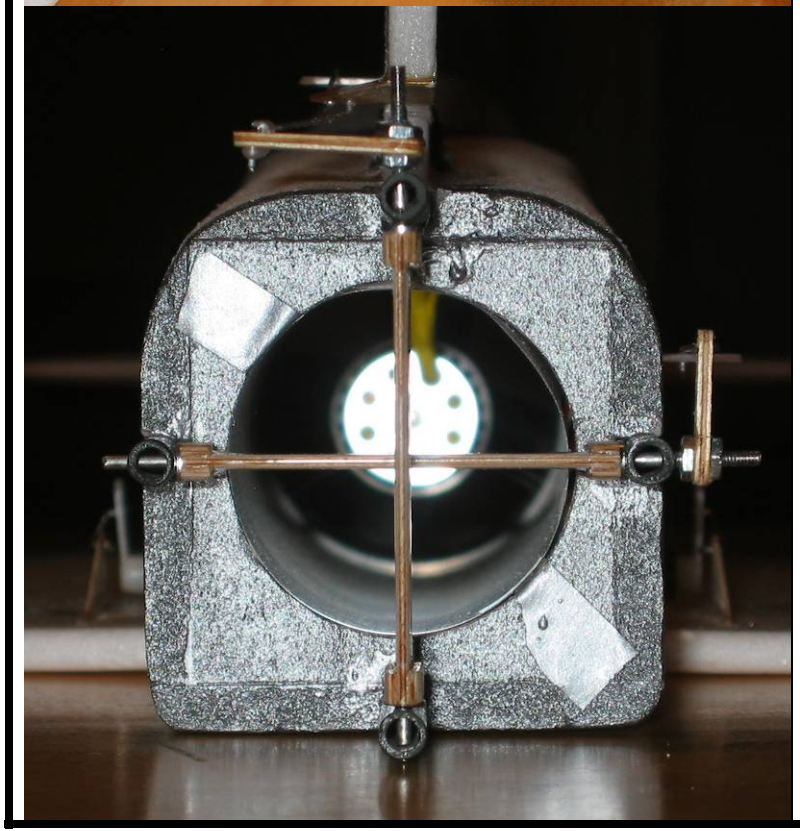
21. Final sand the entire model.



22. Next install the thrust vectoring system. Begin by assembling the pitch and yaw vanes. Sand the vanes to provide a very rounded leading edge, a tapered trailing edge, and a smooth surface on both sides. Glue the 1/16" music wire into the slots in each piece using CA as shown. Then glue on the 1/8" wide chordwise supports on both sides of both ends of each piece. Lastly, coat the vanes with a layer of smooth packing tape to provide a low friction surface.

Drill the carbon tube vane supports as shown on the plans to fit the 1/16" wire pivots. Assembly the pitch vane into both carbon supports and glue the assembly into place with epoxy (note the small washers that go between the vane and the support on each end). Study the photos and plans carefully to see how it's all supposed to come together. Make sure everything is properly aligned and that the vanes turn freely before the glue cures! Once the glue is cured, repeat this procedure with the yaw vane and supports.

Install the pitch and yaw control arms, sandwiching them between two nuts and secured with CA. Make and install the 1/32" wire pushrods. Note how the yaw vane is slaved to the rudder control horn, passing underneath it as the rudder is deflected.



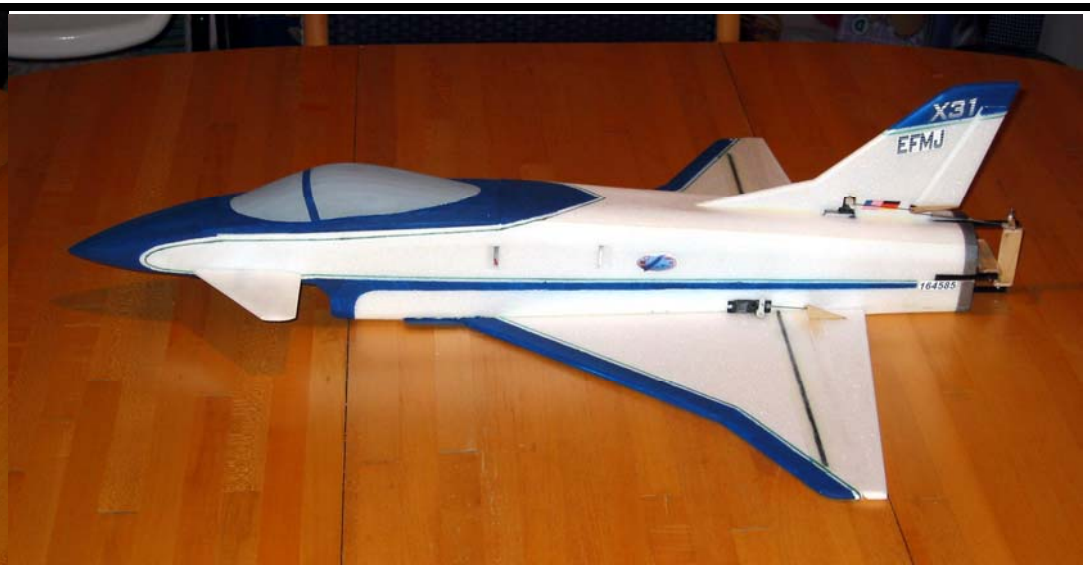
More photos of thrust vectoring system.

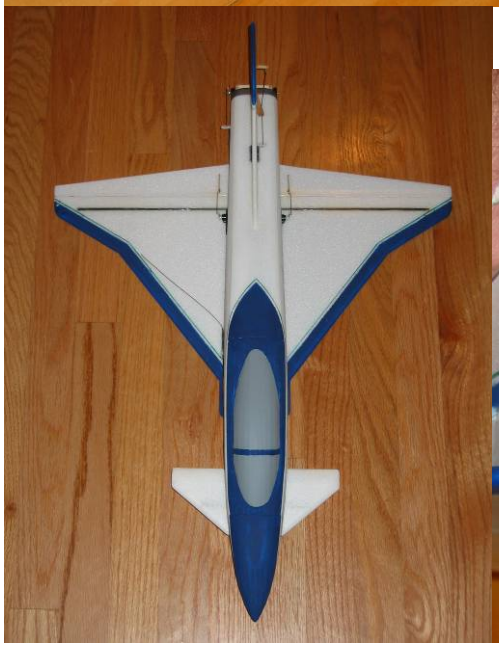
23. CONGRATULATIONS! Your model is now complete.

The model can be flown as is or can be painted using standard acrylic craft paint (available at most craft stores) applied with either a brush or airbrush. Remember to wipe the foam with rubbing alcohol before painting to remove any grease or dirt. Rough areas such as the canopy and nosecone should be filled with lightweight wall spackling compound thinned with water, which fills the holes and can be sanded to a very smooth finish (with minimal weight gain).

I hope you enjoy this model as much as I have!

Additional Photos





Flight Setup

1. Adjust the controls to provide the following recommended deflections (measured at the root trailing edge):
   Canard: +/- 7/16" (-40% expo)
   Elevons (pitch): +/- 9/16" (-40% expo)
   Elevons (roll): +/- 1/2" (-40% expo)
   Rudder: +/- 5/8" (-10% expo)
   Yaw Vane: +/- 1/8"
   Pitch Vane: +/- 1/8"

2. Note that mixing is required to actuate the elevons, canard, and pitch vane all together for pitch. The procedure I used to set up the flight controls with my Futaba 9CAP transmitter is as follows:
   - Plug the canard servo in channel 2 (elevator)
   - Enable flaperon mixing for the two servos on the wing (this provides roll control as well as flaps)
   - Enable elevator-to-flap mixing so that trailing edge down canard produces trailing edge up flaps (this makes the flaps function as elevators)
   - Plug the pitch vane servo in channel 5 (or any auxiliary channel)
   - Set up a custom mix to mix channel 5 with channel 2 so that the pitch vane deflects with the canard (canard trailing edge down gives pitch vane trailing edge up)

   Now all three pitch control devices (canard, flaperons, pitch vane) will work perfectly in combination with each other. You'll need to adjust the mixing ratios to achieve the recommended control deflections for each surface, but that's easy to do with a computer transmitter. I have the pitch vane set up so that I can turn thrust vectoring in pitch on and off, but in the end I've found you can leave it on all the time. I initially thought the model would be too pitch sensitive at high speeds with it on, and it is more sensitive, but it's OK with it on full-time. The yaw thrust vectoring is on full-time automatically since it's slaved to the rudder, but since you rarely use the rudder in jets this works fine.

3. Start with the CG 3.44" behind the wing leading edge (see the plans). To set the initial pitch trim at this CG, the canard should be 1/8" trailing edge down at neutral and the elevons should be 3/32" trailing edge up. The pitch vane should be at zero deflection at neutral.

4. To hand launch this model, simple give it full throttle and throw it moderately hard and slightly up. It should climb out easily. Belly landings are easy as well, just try to slow the model down as much as possible before touchdown. Always check in the inlets after landing and clean out any dirt or grass that gets in there (and it will). You don't want that debris going through the fan unit!

5. The overall handling qualities of this model are very good. It is VERY quick on the controls at medium to high speed as expected, but because of the thrust vectoring system it's also quick on the controls at low speeds. That's something that takes getting used to with a jet, though it's not at all unlike a foamie 3D ship. It's also very aerobatic, with blindingly-fast rolls and easy loops.

6. Note that the recommended power setup draws 20 amps of current, which pushes the TP 1320 PL batteries to their limit. The batteries will get very hot after the flight. Thus, be very sparing with full throttle on this setup! Limit full throttle use to just short occasional bursts. Cutting cooling holes in the forward fuselage to provide cooling air is also highly recommended.

7. Note the thrust vectoring system is optional on this model, and it will fly fine without it. But the TV system enables much improved slow speed control and also allows new maneuvers such as pitch pirouettes and the Herbst maneuver made famous by the real X-31 (similar to a hammerhead stall). The TV system will also allow AMAZING flat spins with easy recovery!

8. For even more information about this model see the website below:

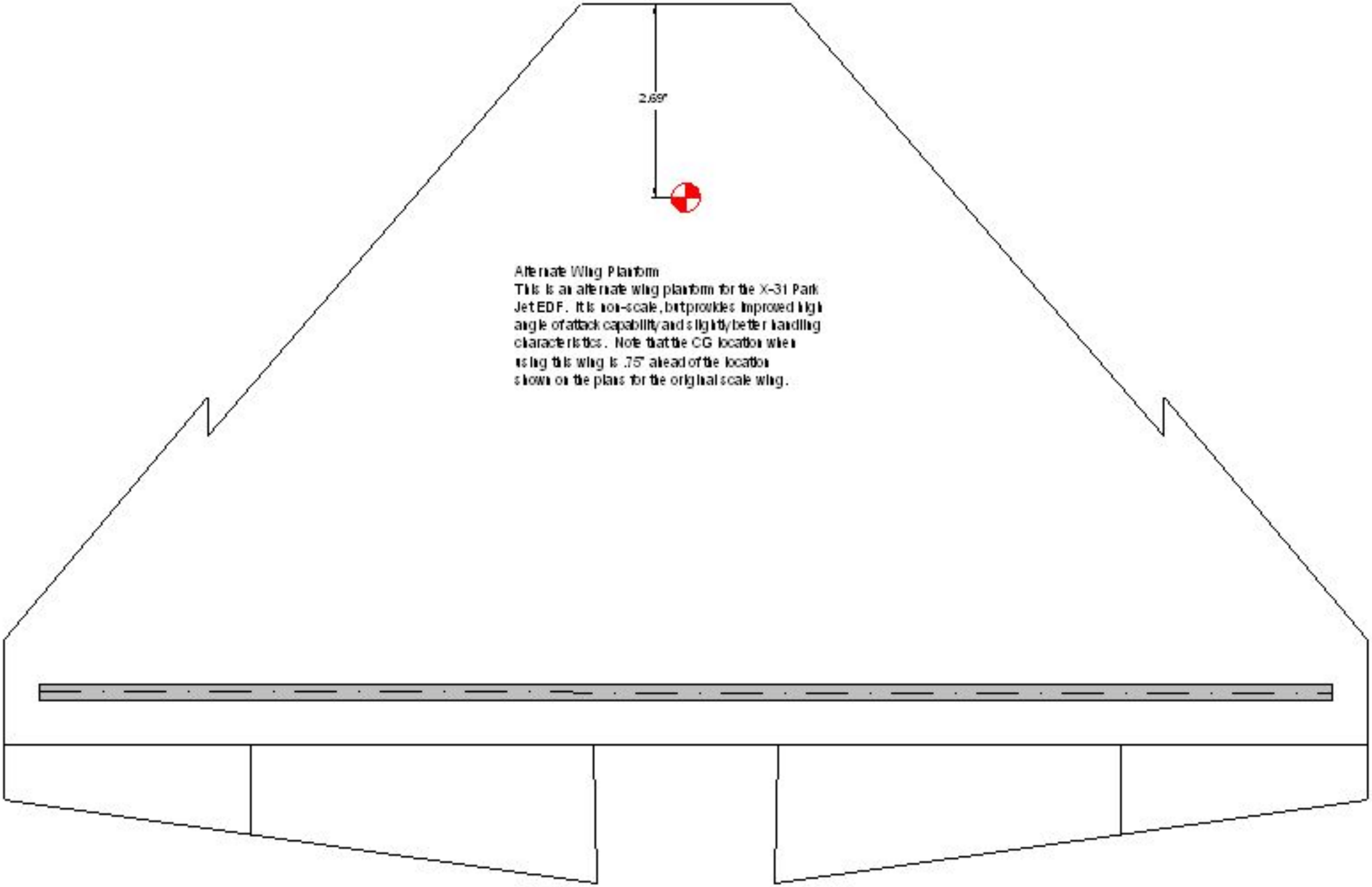
   http://www.rcgroups.com/forums/showthread.php?t=509363

Specifications

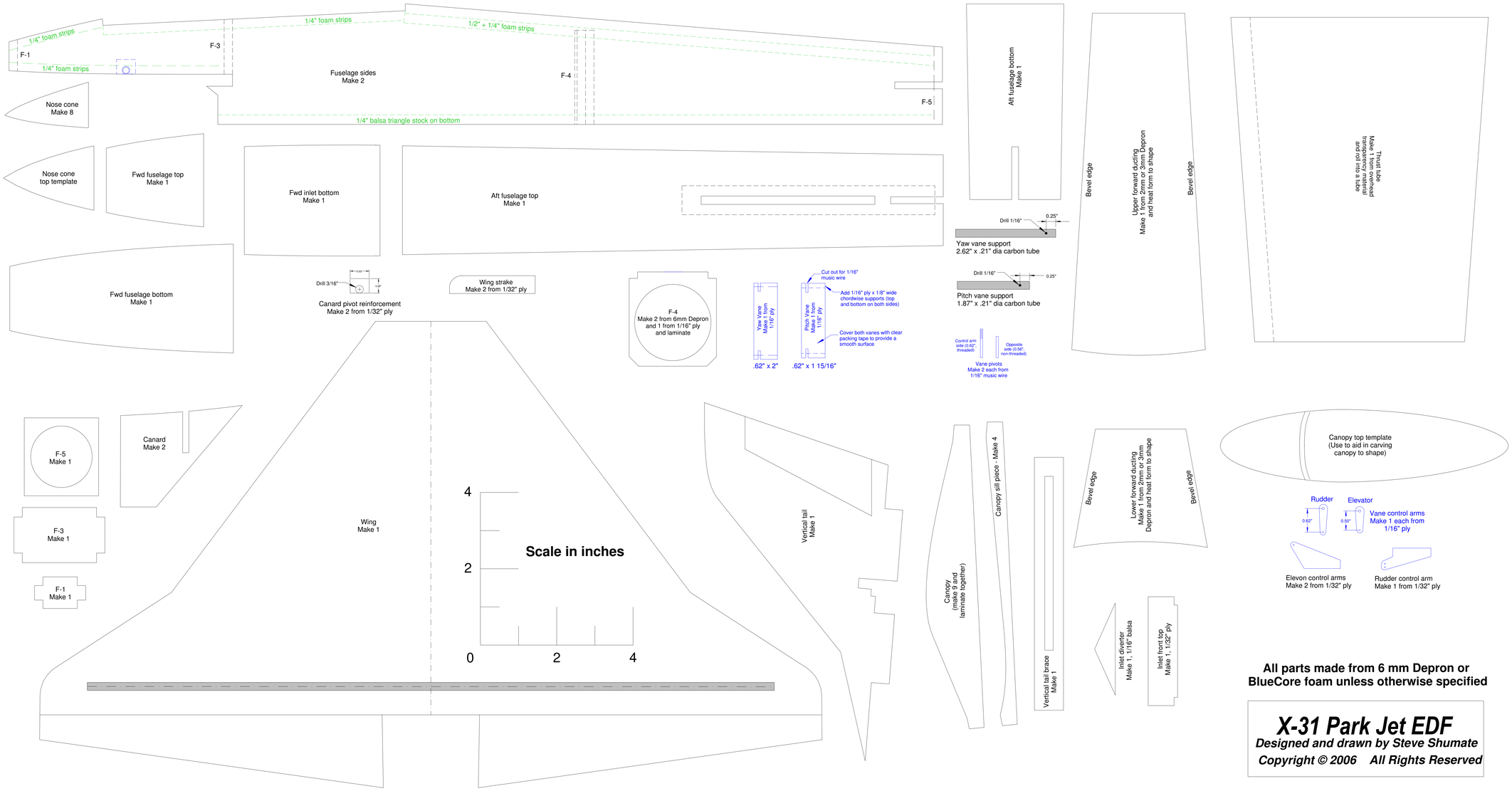
Wing area: 144 sq in
Span: 20.5”
Weight RTF: 13.5 oz as shown (with paint and thrust vectoring system)
Wing loading: 14 oz/ft2
Motor: Hyperion Y22S 5000 kV
Fan: Wemotec Microfan
Battery: Thunder Power 11.1V 1320 mAh Lipo
Current draw: 20.0 amps static
Power input: 200 watts
Power loading: 240 watts/lb
Electronics: Hitec Electron 6 Rx, Phoenix 25 ESC, 5 GWS Pico servos
Flight controls: Elevons, canard, rudder, pitch control vane, yaw control vane (5 servos total)

NOTE: Your kit includes some modifications from these instruction guides. Most notably, the shape of the wing has been modified slightly to provide more stability in flight. See attached picture to obtain correct CG.

If you are installing the Thrust Vectoring system, your kit comes with one threaded rod, which must be cut to the correct length.



Alternate Wing Planform
This is an alternate wing planform for the X-31 Park Jet EDF. It is non-scale, but provides improved high angle of attack capability and slightly better handling characteristics. Note that the CG location when using this wing is .75" ahead of the location shown on the plans for the original scale wing.



All parts made from 6 mm Depron or BlueCore foam unless otherwise specified

X-31 Park Jet EDF

Designed and drawn by Steve Shumate

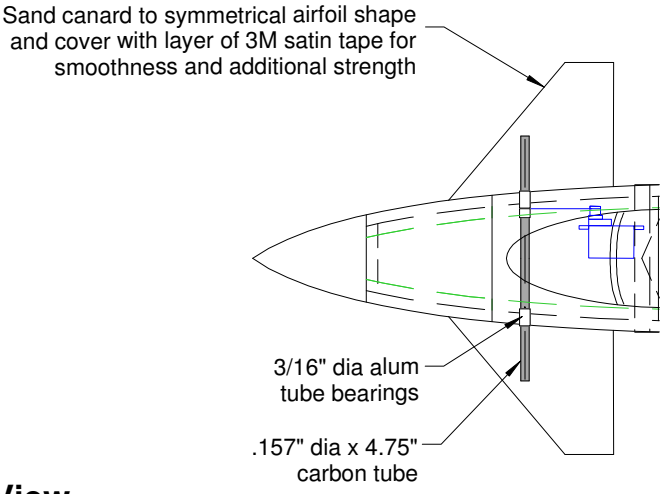
Sized for 50mm Microfan
Span = 20.5 in
Area = 144 sq in
RTF weight = 13.5 oz
Fan Swept Area (FSA) = 2.15 sq in
Exhaust area = 2.03 sq in (95% FSA)
Inlet area = 2.51 sq in (116% FSA)

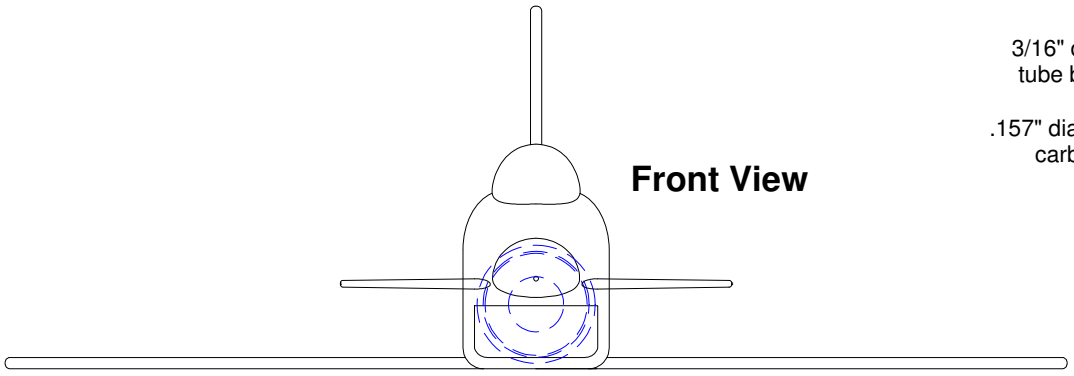
Recommended power system: Wemotec Microfan, Hyperion Y22S 5000 kV motor, TP 1320 11.1V PL batteries, Castle Creations Phoenix 25 ESC

Recommended control deflections (measured at root trailing edge):

- Canard: +/- 5/8" (-40% expo)
- Elevons (pitch): +/- 9/16" (-40% expo)
- Elevons (roll): +/- 1/2" (-25% expo)
- Rudder: +/- 5/8" (-10% expo)
- Yaw Vane: +/- 1/8"
- Pitch Vane: +/- 1/8"

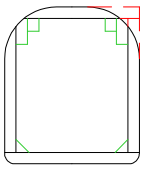
Initial pitch trim: At the CG shown, the canard should be 1/8" trailing edge down at neutral and the elevons should be 3/32" trailing edge up

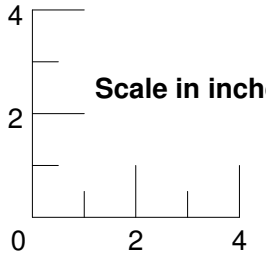


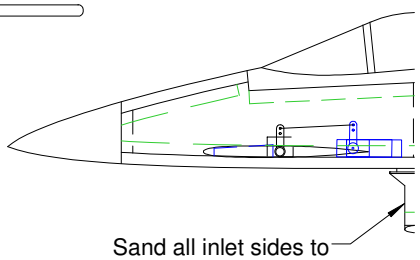


Sand all wing ar round and apply a pi the leading edge to a

Typical fuselage cross section

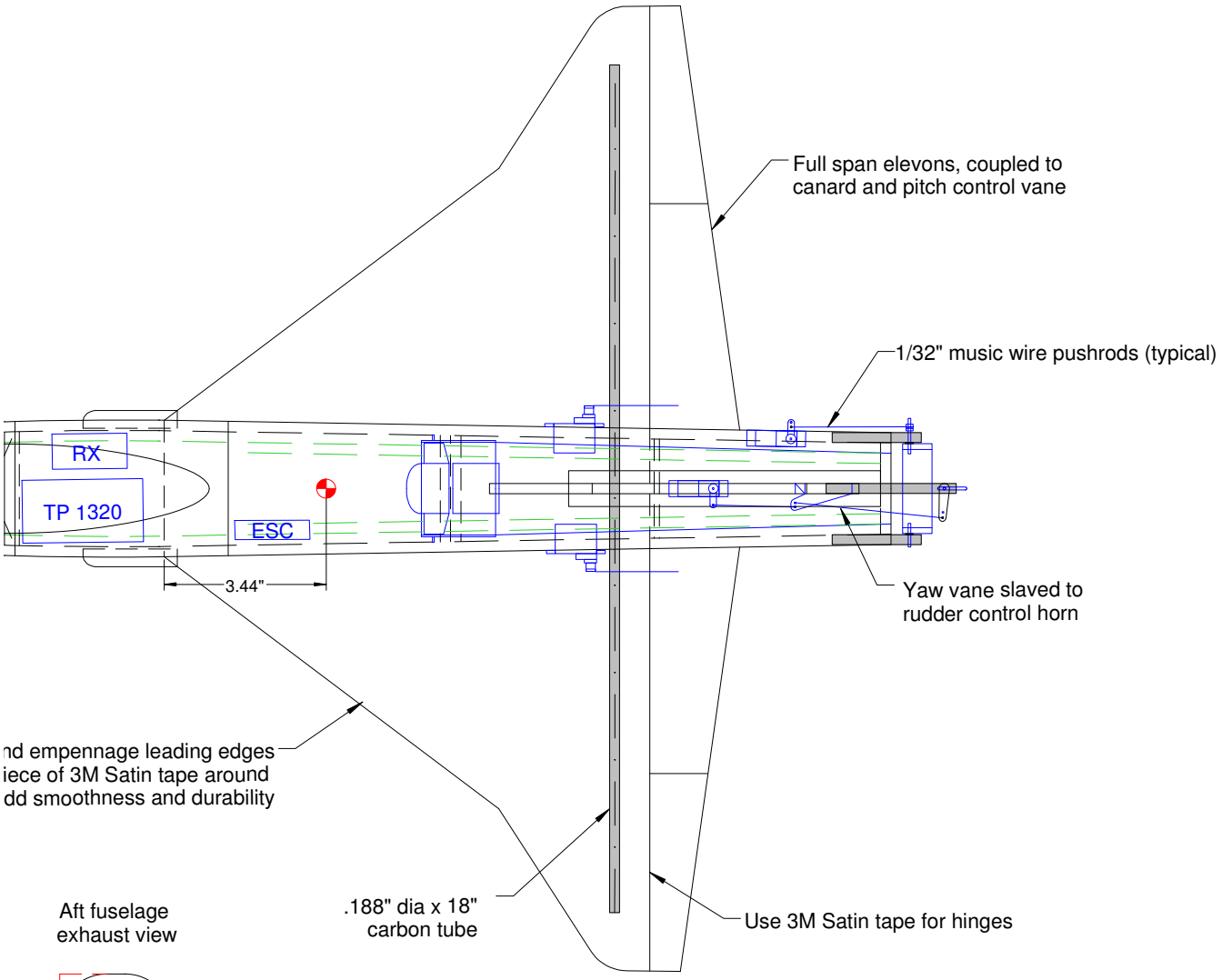






X-31 Park Jet EDF

Designed and drawn by Steve Shumate



Aft fuselage
exhaust view