Welcome to the

Jet Street Fighter
Construction Guide

By

Ace Sim RC

www.acesim.com/rc

Image 1 - JSF in action

Introduction:

Thank you for purchasing the JSF construction guide. These step-by-step instructions will allow you to build the amazing Jet Street Fighter using common supplies (and sources for the not-so-common ones if you choose to do it by the book) with only standard hobby tools and crafting skills.

This electric powered foamie fun flyer RC aircraft can be built for about $20 (less electronics) using carbon fiber (CF) or graphite tubes. The cost will be even less if you choose to use wood dowels instead of the more expensive CF tubes and do a little scrounging for some of the other supplies.

An experienced builder can probably build a JSF in less time than it takes to read this guide. If new to building, take your time, follow every step carefully, and you'll be rewarded with a plane that not only flies great but will give you a big dose of pride when everywhere you go people will ask: "Wow, that's cool! What is it and where can I get one?" Of course you'll have to tell them the JSF is not available in any store and you made it yourself. (Then of course we won't mind if you send them to our website!)

Design, Photos and Text by Ken Hill

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=JSF=

Jet Street Fighter

Image 2 - fly-by

Specifications:

- **Wing Area = 288 sq in (2 square feet)**
- **Span = 30 inches**
- **Length = 23 inches**
- **RTF weight tested = 10 to 16 oz.**
- **Wing loadings = 5 to 8 oz per sq. ft.**
- **Motors tested and proven:**
- **GWS IPS "A" w/ 9x6 & 10x4.7 APC sf**
- **IPS "S1" drive w/ 8x6 & 9x4.7 APC sf**
- **Homebuilt dual motor IPS "A" w/ 10x7 APC sf**
- **Batteries for all IPS motors above - 7 cell 700mah NiMH Maxell AAA packs**

Motors Tested:

- **Johnson 250 w/ MJ 5:1 BB GB - 9x6, 10x4.7 & 10x7 APC sf - 6 cell 600AE's & 7, 8 cell 700 Maxells**
- **Simprop "350+ Power System" - S300 w/ 5:1 Horst drive - 8x6 APC - 8 cell 600AE's**
- **Transmitter used - JR-652 (3 channels with mixing required)**
- **Recommend programmable transmitter for limiting control travel.**
- **Receiver used - GWS R4PJ (limited to 1000 foot range - other mini receivers like HS-555 are okay and the case can be removed to reduce weight)**
- **Servos used - 2) Hitec HS-55 servos - (similar to GWS Naros - Picos okay with IPS drives)**
- **ESC used with IPS drives - GWS GS-100 (has brake - recommended for stopping prop for landing and better gliding but not required)**
- **ESC for performance drives - 10 A or higher with brake recommended**

Model Versions:

You can build your JSF in three different variations plus fly it with a number of different power systems.

Image 3 - TT - Taileron Trainer

TT

Start with the 3 channel, 2 servo mixed Taileron Trainer no matter which version you "really" want to fly. The reason is that all the advanced models can be easily adapted from the TT version. You can't however start with an advanced version and always go the other way.

Image 4 - SC - Super Cutlass

SC

Then make up some smaller fins, hang elevons on the wings and try it configured as the Super Cutlass stunt wing. Just remove the tailerons, stick in your new fins, reconnect the same two wing servos to the elevons and fly.

SS

Make your TT into an A/E (aileron/elevator) Super Sport three channel flyer for some serious stunts by adding a third middle servo for the ailerons, a Y connector to the wing servos and use the tailerons as elevators. If you have four channels or more, leave the tailerons stock but mix them as ruddervators and have a full house setup.

Other Options:
Any of the above can use fixed tri-gear, single center wheel with rear skids, or bicycle LG for ROG ability, but why not add retractable landing gear with yet another channel and throw in some night flying lights while you are at it for even more fun. Obviously you won't be flying this final version with a little IPS drive, but once you get that "need for speed" you'll graduate beyond slow flyers anyway.

With the different power systems, control and wing modifications you can adapt your JSF to, it can effectively bridge the gap between slow flyer IPS planes all the way up to speed 400 screamers with just one basic design and for a large variety of power systems.

Truly a multi-role fighter you can grow with!

Construction Guide

These instructions are written so that a complete novice to model building should be able to complete the model and have it turn out accurately if they take their time, follow all directions carefully, and have reasonable crafting skills. This means I have added a lot of construction and method details that an experienced builder might find obvious. Sorry about that, but I feel it is better to have more info than you need than the other-way-around.

Must Read Notes:
The first rule of building is to measure twice, get ready to cut, and then measure again! Everyone makes mistakes and there is nothing worse than to find you cut something the wrong size, don't have any more of that material left, and have to start all over again. Besides just building the planes here, you will learn the techniques needed for building just about any plane you can imagine using the same materials.

Be sure to see the REFERENCE SECTION at the end of this guide before starting if you are new to building, just starting out in R/C aircraft or just want more information in general. You will find a list of abbreviations as well as a picture index there also.

No matter what level builder you are, please read through the entire manual before buying materials, starting construction, etc. There are options along the way that you may elect to try. If so, you won't want to order your parts first just to find out you wanted something extra later and have another wait and another shipping charge. Also you may be able to scrounge some of the parts using the noted substitutions that can save you some time and money.

Notice:
The pictures used for these plans are not necessarily indicative of the recommended order of construction or what you should be seeing when looking at your plane in a given step. They were compiled from many multiple builds and design revisions along the way. So don't think you missed something or messed up, just follow the order in the text and get what you need for that specific step from the picture. If you want or need to, refer back later for other details present in the picture once you reach that step.

Materials:
Since the other planes from the Wally Works are made from toy foam gliders that you can purchase at Walmart (thus the "Wally" name) for their durability and availability, the "Sturdyboard" brand foamboard that Walmart carries was a logical choice for the lightweight construction of the JSF. It is cheap, durable, ridged, and easy to work with ONCE you remove the paper it is sandwiched between. This isn't difficult, but is the hardest part of the entire build! If you don't have a Walmart in your area, arts and crafts stores usually carry it as well as picture frame and stationary stores. If you find some elsewhere, look for the size where the foam itself is about 3/16" thick as other brands use foam that's only 1/8" thick.

Parts List:

Note: Below are the minimum parts needed for the standard taileron trainer (TT) version.
Other model versions require a few additions and/or substitutions that are listed separately.

Wing:
2 sheets - 30" x 20" by about 3/16" thick (the foam thickness itself) foamboard without the paper, or the equivalent Depron or ¼" thick fan-fold Dow/Corning "Blucor" residing insulation foam.

Fuselage:
2 pieces - 5" x 16" by about 3/8" thick packing foam for fuselage. Thickness is recommended but not required.

Optional materials can be "Foamies" brand soft foam sheet found at craft stores, other dense soft foam used for upholstery, thin-walled pipe insulation foam, even stiff Styrofoam packing material that you can carve to shape will work.

If none of the above are available, you can always make the fuse from the remaining foam from the second foamboard sheet but it will not be as crash resistant unless covered over with packing tape for strength.

Hardware:
1 set - Du-bro Micro Pushrod System #847 (2 sets needed for aileron version)
Optional pushrod set(s): Du-bro Mini NY Steel Pushrod Assembly #113 for standard servo and 1/2 A control horn sizes for large motor use.

1 set - Du-bro Micro Control Horns #848 (2 sets needed for aileron version)
Optional horns can be any small 1/2 A type, cutout thin wood, plastic or other material, but must need to fit the mini linkages or be adapted. For example: add a tiny piece of wire insulation to fill the oversized hole for 1/2 A type horns for the mini wire pushrods. #113 set above uses 1/2 A size horns.

2) 14 inch length of .157" diameter CF (Carbon Fiber) or graphite tubing for tail booms. Available at kite stores and on-line through a number of suppliers
Optional booms can be 5/32" diameter wood dowels or thick 12" long bamboo skewers that slip fit just fine into the 3/16" plastic straws used as holders.

2) 15 inch length of .157" CF or graphite tubing for motor rails (same stuff as above - note: some suppliers only have it in 29.5" lengths but it's okay to use anyway, just cut it in half)
Optional motor rail can be hard balsa for very light flyer gear or any spruce/basswood round, square, or flat stock you can get to fit tight in the GPS motor mount slot. Watch the weight on the lighter models. Larger motors need dual dowels, tubes or wood rails for the extra strength, torque prevention, and to support their heavier battery.

1) 14 1/2 inch length of .080-.098 CF rod for taileron pivot - size for the sleeve you can find - I just used small (1/8"=.125") diameter heat-shrink tubing partly shrunk for a slip fit. If you use the .098 diameter rod, a 1/8" diameter stirring straw makes a nice fit. A tape sleeve can be made as a last resort if you can't find the right size cocktail straw or other sleeve by wrapping the tube with packing tape wrong side out and taping over it to the surface. A 1/8 inch dowel or a thin 12 inch long bamboo skewer would probably work for this piece.

CF & Graphite Notes:

Remember carbon is forever. When cutting this material, always wear a painters dust mask. Also, clean your work area right afterward still wearing the mask due to the dust you'll kick up. The best saw I've found to cut CF tubes is a Dremel tool with rotory saw bit (looks like disk of stiff sandpaper). Second is a Zona brand fine tooth hacksaw with the 52 teeth per inch blade. A regular hacksaw with the finest tooth blade you can find will work also but will be more brutal to the tube ends. Rotate the tube as you cut it to keep it from splintering. Use a fine tooth file to taper the edges after you cut. The fibers in the tubes are prone to catch at the edges and peal back, weakening the tube. This can be repaired with a drop of CA if it happens to you.

Supplies:

2 inch wide clear (and/or colored) packing tape – we recommend Scotch 3M brand due to its extra holding power.

1/4 inch or wider transfer tape (also called double-sided and seam tape), used for holding down photos, sticking together fabric seams, etc. It's the kind of tape that once you peel off the backing only the goo remains. Available at framing, craft, sewing, hardware, kite supply and office supply stores plus on-line. If you can't find the 1/4 inch width size, you can cut down the wider sizes to make your own.

A few inches of 3/16 inch outside diameter by 1/8 inch inside diameter vinyl, rubber, or flexible plastic tubing that fits VERY snug on the motor and boom tubes. The size you'll need may vary depending on manufacturer or how it is measured and whether you use CF tubes or wood dowels. Take your boom with you to the hardware store to be sure it fits good and tight. You should have to work it back and forth firmly to get it on. If it just pushes on, it's too loose.

2) Plastic "flex" or standard drinking straws for tail boom holders. The ones that fit the recommended diameter CF booms measure about 3/16 inch diameter. We found a pack of 100 of them at a 99 cent store. It turns out that there are many different size straws available. Some are 1/2 inch on down to about 1/8 inch diameter so you'll have to look around although they "seem" to be a fairly standard size. I believe they are 5 mm since these were made overseas.

1) Large paper clip for the IPS motor hanger.

3" of about 1/2 inch wide (measured flat) heat shrink to fit over motor tubes for snug fit into the gear drive mounting slot. You could just use some tape but it may soften and loosen over time.

15 inches of either 1/8" diameter heat shrink or a couple very thin cocktail or stirring straws that are a slip fit on the thin CF rod listed above for the taileron pivot axle.

Some #64 (about 1/4 inch wide) rubber bands to hold the motor rails to the wing.

A few inches of hook and loop "Velcro" type fastener. Get the sticky backed kind about 3/4 inch or wider.

Some masking tape

And be sure to save all your excess parts, pieces, and scraps from everything! Many will be needed.

Optional:

1) Short servo extension – use to ESC so you can leave your receiver in the wing when disconnecting your power systems

.047 music wire for aileron torque linkage and/or landing gear on advanced version.

Sleeve to slip fit .047 wire - can use hollow plastic Q-tips, empty ball-point-pen refills or the tape sleeve mentioned earlier.

3) 1.25 inch or 1.5 inch Dubro "mini lite" wheels for optional landing gear.

Part Sources:

Graphite tubes and rods, 1/4" transfer tape, many fittings and kite supplies.
http://www.intothewind.com/cart/supplies.html

CF tubes and rods:
http://www.cstsales.com/catalog.htm

CF tubes and rods, transfer tape, Bu-bro hardware, lots of parts, even foam sheet! (but only 12 x 24 inch size so you'll will have to piece the lower wing together) Get their thickest "type 1" Zepron or ask for the availability of Depron if you don't mind paying a little more.
http://www.airdyn.com/main.htm

Motors, gear drives, hardware, props, and anything else you can think of:
http://www.hobby-lobby.com

Distributor for GWS IPS park flyer gear and lots more:
http://www.horizonhobby.com

Electric Goldmine surplus - Source for Maxell AAA batteries and Johnson 250 motors for $1 each! Note: since this is a surplus outlet, items go in and out of stock all the time. Also, check in the motor section to links to the specific items mentioned.
http://sales.goldmine-elec.com/

Schrock's International - a crafts supply that carries the "Foamies" brand soft sheet foam that can be used for the fuselage. It comes in different colors, sizes and thicknesses so order the 3mm x 12"x18" size sheet if you can't find it or other foam locally. 1-800-426-4659

Note: there are many great dealers that carry the systems, hardware and other gear you'll need. These are just a sampling of some. Since we don't want to recommend any specific ones, check around the web for prices, availability, and personal recommendations as well as at your local hobby shop.

Alternate Materials:
If you are lucky enough to have Depron foam available to you, then you can skip the next prep section. Another alternative material is residing insulation know as Blucore foam. It comes in 2 x 4 foot 1/4 inch thick sheets that are fan-folded in a bundle by Dow-Corning and is available at Lowes and other building suppliers. It is used under house residing so check with siding suppliers if the others don't have it. There are different thicknesses and types, so be sure you get the Dow/Corning .23" thick HP type. A bundle should cost around $30 but you'll have enough for an entire air force of planes! Cut a sheet to 20 x 30 inches and you're ready for the layout. Be sure it is cut square by measuring diagonally from corner to corner for equal distances and that the "grain" runs along the 30" cut.

Foamboard Prep:

Throw a couple of the 20 x 30 inch foamboard sheets in a bathtub of hot water, weight it down at least beneath the surface with a shampoo bottle or whatever is handy. Be careful that the corners don't bet bent or crushed. Come back in an hour or so and shuffle them so the sides that were in the middle are now on the outside, flip both of them over and replace in the water. If they curled on you, you should now have the hump up so when you come back in another hour they will be flat again. If not, don't worry about it, as they will straighten out by themselves later. It seems to loosen the paper easier from the bowing from each direction back and forth.

Once thoroughly soaked like this a few times, lay them out on a towel and start peeling. You'll get a thick sheet of paper off each side at first in one big peel but a thinner layer will remain adhered to the foam. This can be removed by using the heal of your hand to gently roll it off. Be careful that the rolled up paper you're dragging along doesn't mar the bare foam from too much pressure. Remove the excess pieces often. The remaining spots can be softened again if necessary with a damp sponge and worked off with your thumb. Once both sheets are done on both sides and clean and dry, you're ready to begin.

Layout:

Pick out the best sheet with the squarest corners, and lay out your wing. Position it with the 30 inch length laying horizontally. You'll measure the centerline at 15 inches in from each side, both at the top of the sheet and at the bottom. In case the sheet isn't exactly 30 inches wide, your marks won't match up. That's okay since you can just split the difference to be sure the wing halves are of equal length. Once the exact center is found, connect the dots with a straight edge and a soft, blunt pencil. Don't press real hard, as you don't want to crease the foam, only mark it. With the centerline now drawn, measure up 14 inches from the bottom and put a mark. Now measure up 6 inches from the bottom outside edges and mark these on the edges. Connect the dots and we have our leading edge (LE) lines.

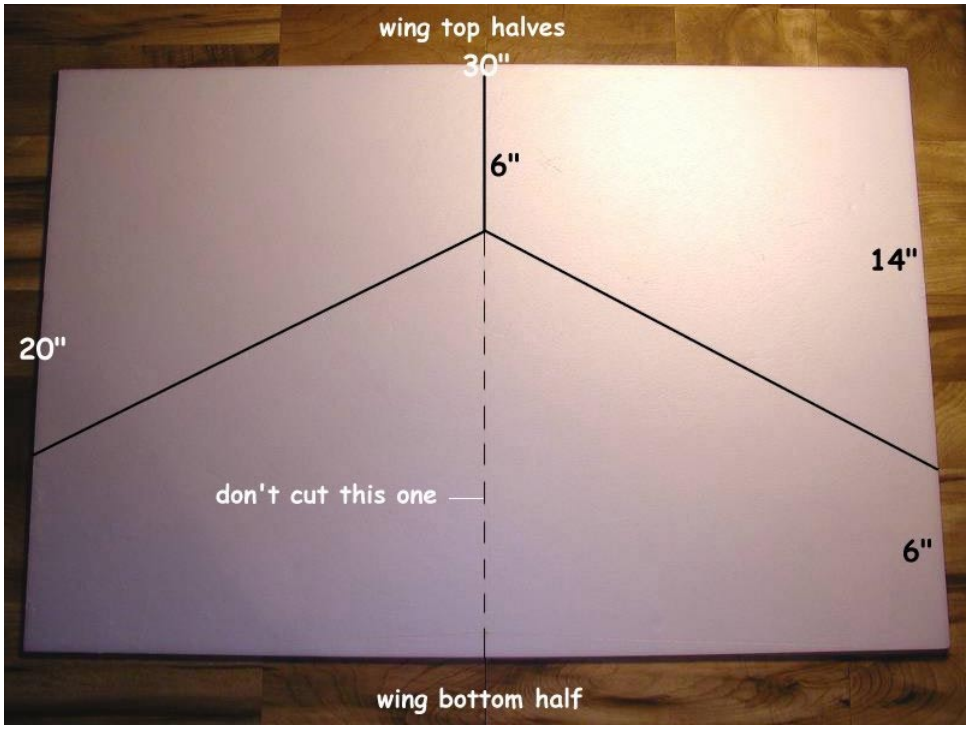


Image 5 - layout foamboard

Since the sheet is 30 x 20, 14 from 20 equals 6 so the upper half of the sheet once cut on it's 6" center line becomes equal sized pieces for the wing top half. (The bottom is one piece with the upper being 2 pieces.) Use a good straight edge and a brand new single edged razor blade or sharp hobby knife. If it is dull, it will bunch up the foam on the bottom of the cut as you go along. Do your cutting over an expendable, flat, preferably hard surface. (No, not your wife's new oak dining table!) Only cut the LE lines and the upper center 6 inch line.

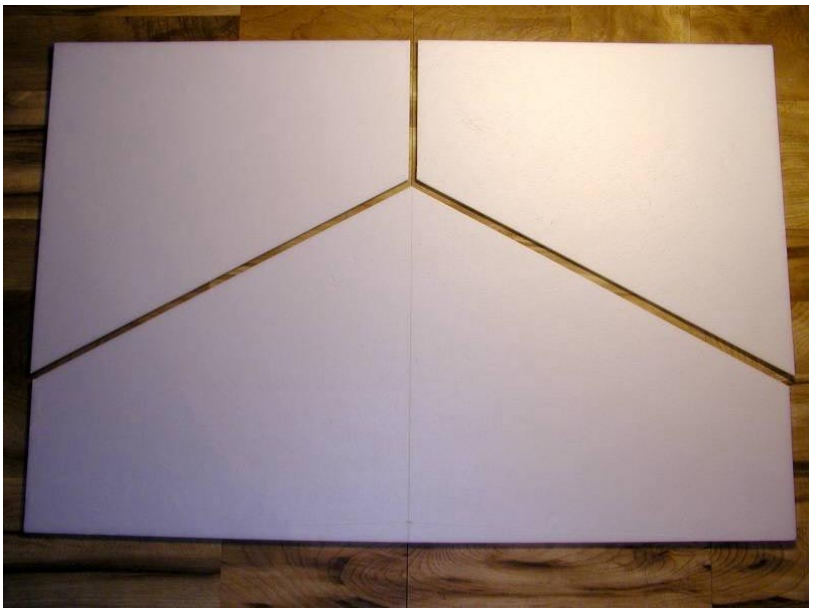


Image 6 - wing pieces

Put the top pieces on top of each other and trim if necessary to match. Now put them over the wing bottom with their LEs lined up. If the sheet was cut square to start with, they should match up at the tips and the TEs. If not, trim the lower wing tips to match the tops. You'll end up with a symmetrical, perfectly equally cut wing once you trim the TEs later.

Image 7 - relocate top pieces

Dart:

The airfoil you will create is a semi-symmetrical section so when completed, the lower wing LE at the root center will want to pucker from it curving up at the front. We can avoid this by putting in what is called in sewing circles a "dart". To do this, just slice the lower wing back to about 3 inches on the centerline from the nose. Now trim out just the smallest amount off the sides tapering wider out to the point. A total of no more than 1/16 inch width at the point will be needed to do the job. Trim a little at a time from each side and test by raising the nose about 1/2 inch up from the table to see if the edges meet nicely.

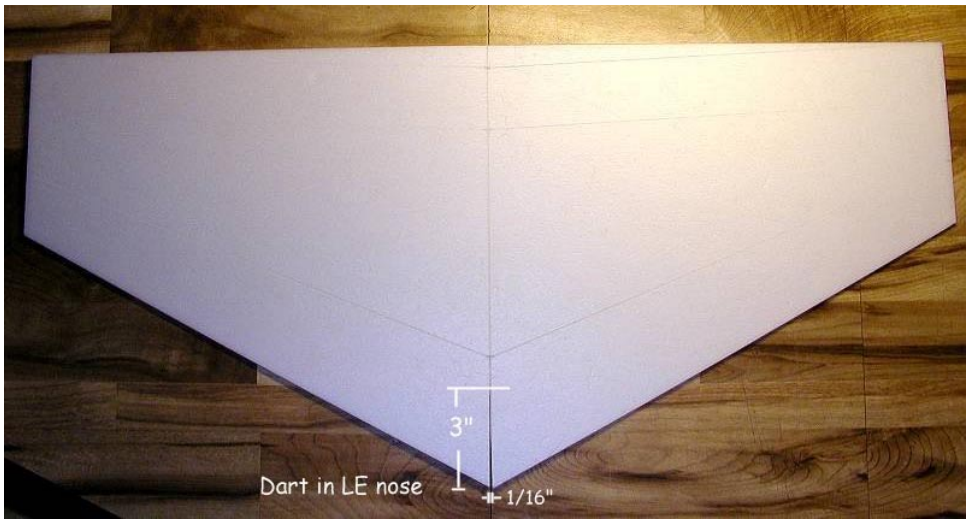


Image 8 - dart in nose

TE Cut:

Measure up 3/4 inch at the center root line of the lower wing panel TE. Mark this location and draw lines from it out to the wing tip TE corners being sure that the tips remain equal chord at 6 inches long each. Cut this piece off.

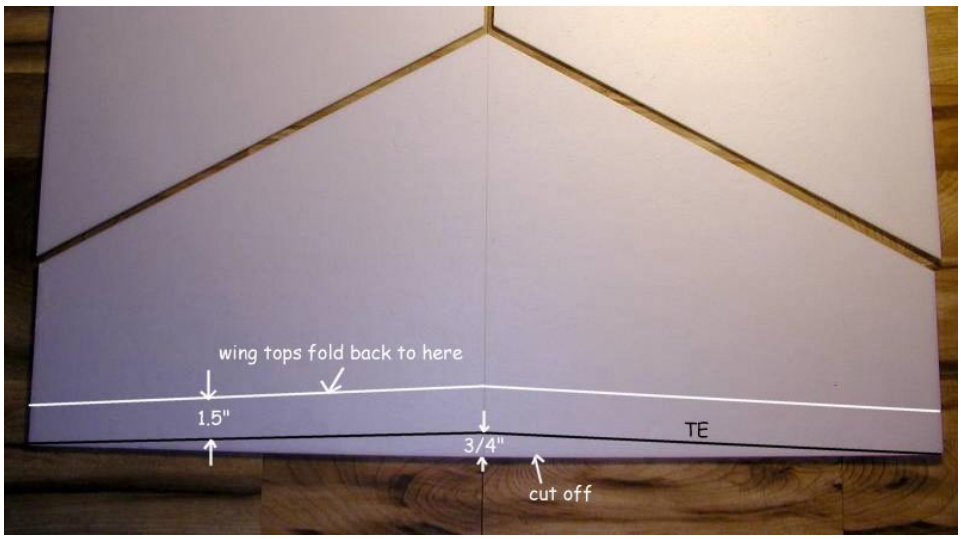


Image 9 - TE cut and reference

Wing Assembly:

First, here are some facts about taping this type of foam. You can only do it once! If the tape needs to be relocated for ANY reason, take it completely off, throw it away and start over with a fresh piece of tape. The reason is that a thin amount of foam will come off with the tape and it will prevent it from ever sticking again properly. Trust me on this!

Assemble the wing by first taping the LEs of the wing halves together. Do one side then the other and be sure the tip corners and root match up on each piece. This must be done on a perfectly flat surface. Attach your 2 inch wide packing tape to the table with the sticky side up by using another little piece of tape at the end to hold it down. Roll out enough to more than cover the length of the LE on one wing half and keep the tape tight. I use the seam in the table for a center reference line.

Start with the wing bottom first. Line up its leading edge with the center of the tape and set the foam down on it. Then remove it from the table, turn it all over and smooth and seal the tape some more. If you keep the tape tight, it works quite well.

Image 10 - tape wing 1

Once on, press it down real good working from the middle out. Now position the proper wing top half over the extended tape. Leave a 1/8 inch gap evenly spaced between the two. Don't forget to line up the corners or you'll have to start all over!

I found it easiest to hold the panel up at a very shallow angle and just touch the LE top edges together assuring end-to-end alignment and proper gap. Once the bottom edge of the panel's LE is touching on the tape straight, then just lay it down.

Image 11 - tape wing 2

Again, press firmly on the foam over the tape on the top pane. Trim the tape leaving it about an inch long on the ends. Slice these in the middle and fold them over the edges. Now flip the entire wing over and from the center, press the tape down on the outside. Flip it over again to the inside and using your finger along the inside seam, press the foam down along the LE length. This compression helps greatly strengthen the LE.

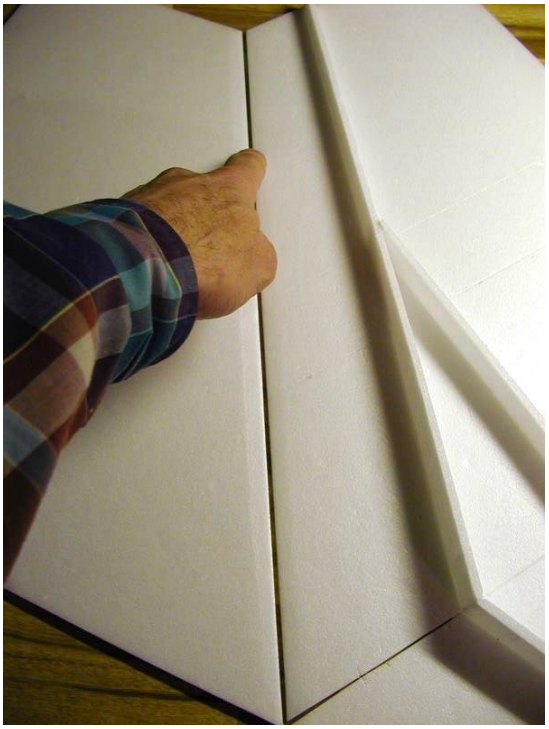


Image 12 - compress seam

Gently test fold the top half back over the lower. You'll have to work at it a little but it should end up only wanting to go back at about a 45 degree angle without excess pressure. This is ideal. Now do the other wing half the same way.

Image 13 - test fold

Score For Airfoil:

On the insides of the top and bottom wing pieces, measure back from the root LE one inch and mark. Then on the top panels only, measure back another two inches from that spot and mark. Now measure back 1/2 inch from the tip LEs on both upper and lower wing panels. Also measure back from that mark another 1 inch on the top wing panels only and mark. Connect the dots along the LEs with lines and you should have divided the front of the top and bottom wing panels back to the sub-spar line in half. The other line on the top panels should be half way between the sub-spar and main spar and will give the top surface more curvature than the lower to help shape our airfoil.

Image 14 - score locations

Now take a pizza cutter, a dull butter knife, or just even your blunt pencil and carefully score (not cut) the lines you marked on both the upper and lower wing panels with your straightedge. Do not mix up the spar location lines with the score lines on the lower panel as these you do not want scored! You should hear a nice crunching sound as you go along but be careful not to press too hard. It's better to have to go over it a couple times than to ruin your wing!

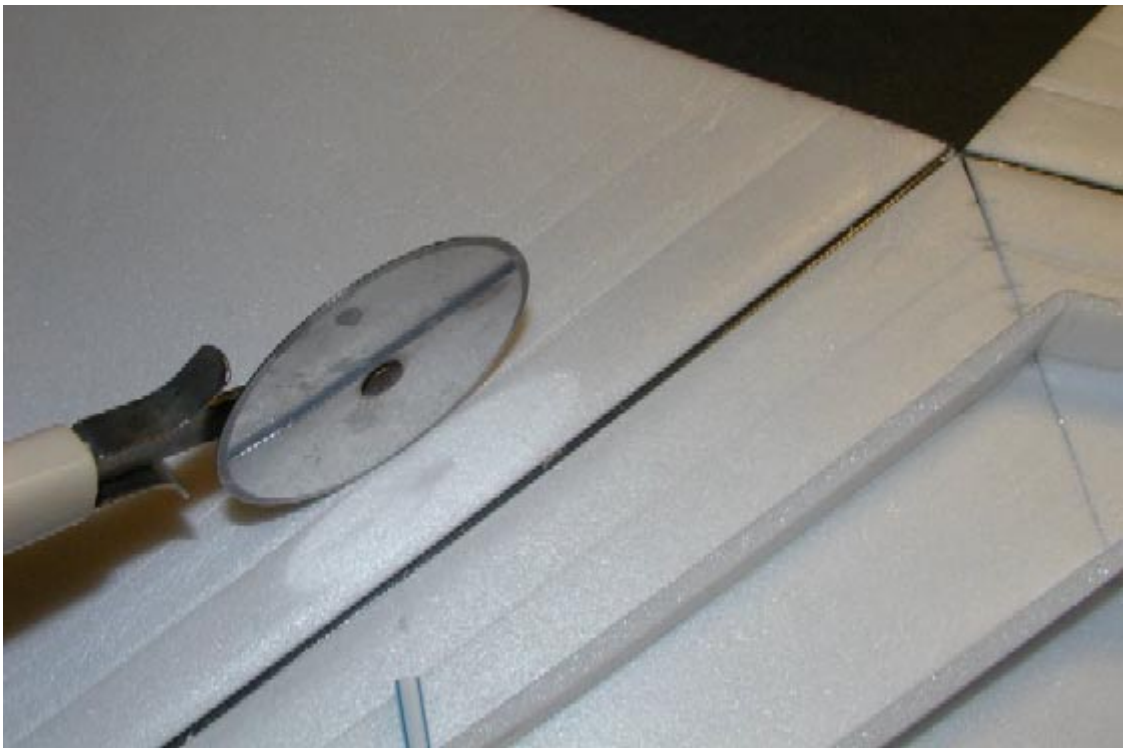


Image 15 - score LE

Run your finger hard along each score line against the table compressing the foam as you go. Now pick up the wing panels from the back at an angle off the table with the LE resting on it. Work the LE down against the table to form the airfoil shape with your fingers along the scores trying to get a nice gentle curve and not a fold. Be careful since you can crack the foam if you apply too much pressure too fast. All we want is for the foam to "relax" in this area to be easier to shape, so don't worry about getting too precise here. This scoring is just to help the airfoil along, not to define it.

Be careful not to loosen the tape while working with the wing. If this is wing is only for a heavier model you might want to add another piece of tape along the inside LE for added strength, but it's not necessary.

By the way, the reason we didn't do this step before we attached the wing panels together is that it is much easier to get a nice straight LE if we are dealing with flat pieces while taping.

Spar & Booms:

Layout:

Measure out the spar locations on the inside of the lower panel. Draw very visible lines for these, maybe using a fine tipped marker but don't score the foam in the process. The tips of the sub-spar are spaced half way between the LE and the main spar.

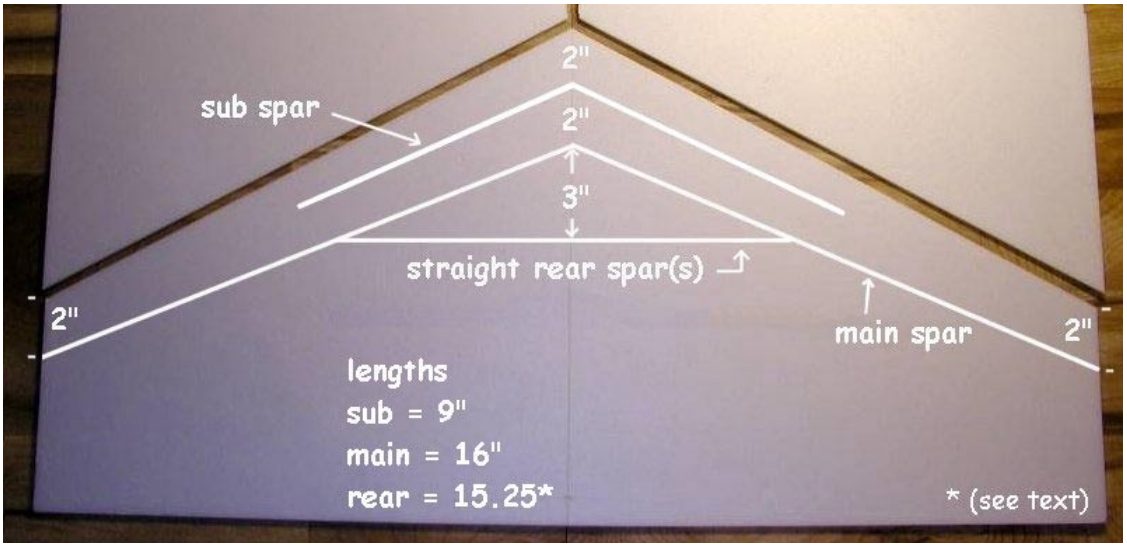


Image 16 - spar locations

Measure, mark and draw the tail boom location lines from LE to TE checking to be sure they are equal distance at each end from the wing root centerline.

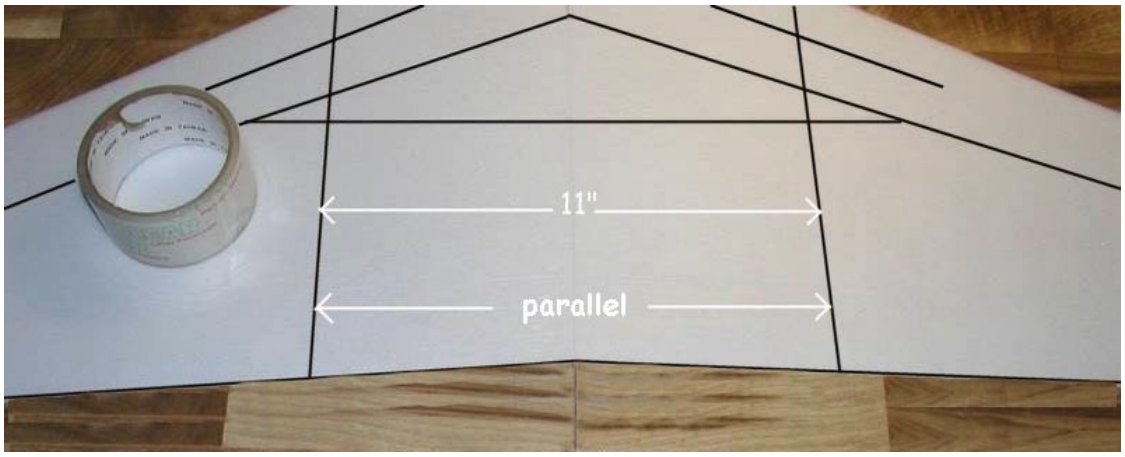


Image 17 - boom locations

Cut Spars:

From the other sheet of foam, cut a straight strip 3/4 inch wide from the 30 inch edge. Measure and cut it almost in half, having one piece 15.25 inches long and the other 14.75 inches. This is our dual rear straight spar. Make your spar length and end cuts as square up and down as you can.

This foam has "grain" in the long direction that resists bending more than in the narrow direction. It's just like in wood except that you can't see it! Any long pieces need to be along this grain for strength. If in the process of cutting out parts you forget which was the long direction of a piece, flex the piece in your hands and it should become apparent. The length direction will be the one that doesn't flex as much. Be aware that if the piece in question isn't nearly square then its shape will affect this flex test. Keep this in mind so you don't accidentally waste a lot of foam.

Cut your angled sub spar (short one) and the angled main spar (the long one), laying them out lengthwise again along the 30" side of the sheet. Make a separate left and right half of each so you can stack the pairs up and easily check for equal dimensions.

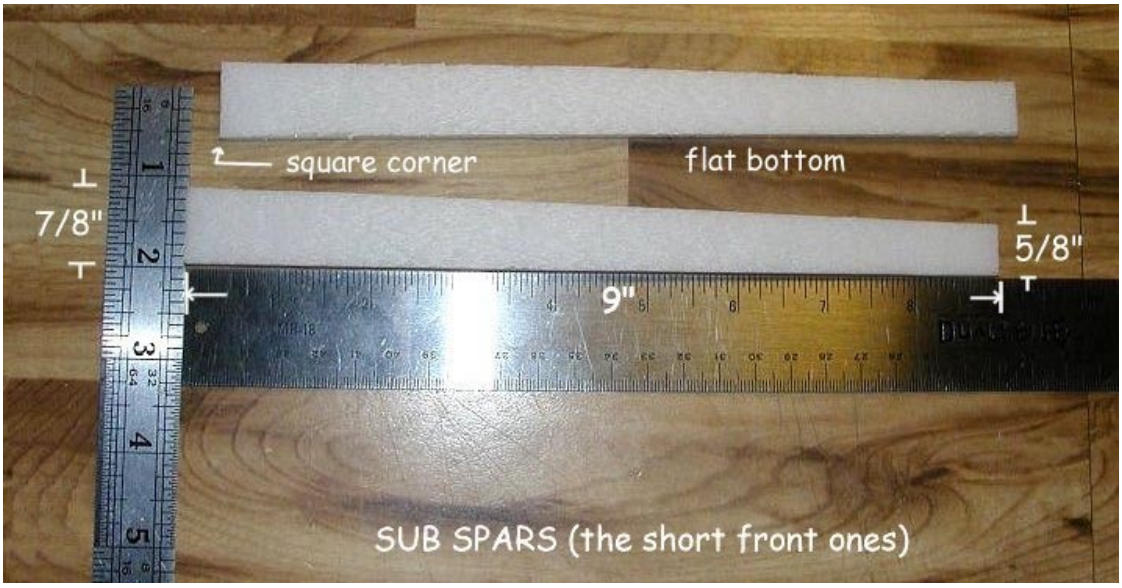


Image 18 - sub spar parts

Image 19 - main spar parts

Align your left and right pieces for the sub and main spars so with their centers together they sit flat on the wing. We don't want any dihedral developing from having the spars upside-down! For the rear straight spar, mark a straight line in the center, square with the flat bottom.

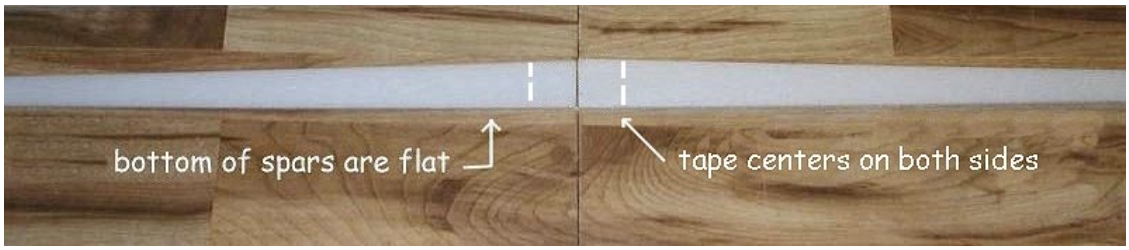


Image 20 - main spar

Tape the main and sub spars in the centers with a single layer on each side of 2 inch packing tape and trim off flush any excess instead of wrapping it around the edges. Now crease and bend the spars back on their centerlines to the angle needed to match the position marks on the wing. Place your main and sub spars on their lines and test position them with the flat sides down.

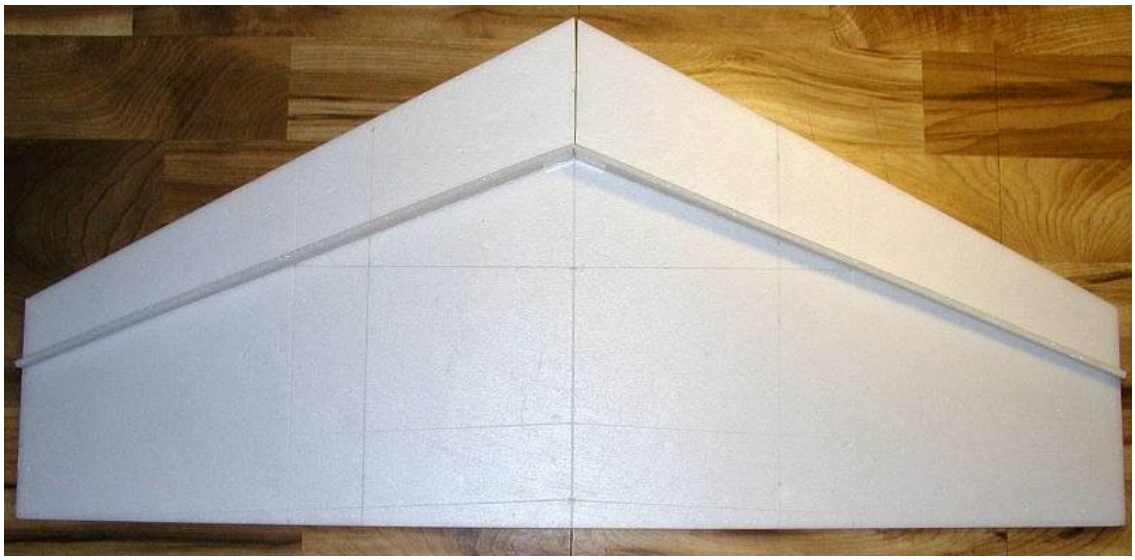


Image 21 - main spar position

Mount Spars:

If you didn't get the special 1/4" seam tape but have one of the wider types, you'll need to cut some thin strips for attaching the spars. Cut it on the roll since once unrolled it will be vulnerable to collecting dirt, skin oil, etc and reduce its stickiness. If not contaminated and applied correctly by pressing the parts together firmly, it has amazing holding strength on the edges of this foam. I destroyed a wing trying to disassemble it so I know from experience!

On the straight bottom edges of the angled spars, apply the thin tape full length pressing it firmly onto the foam. Remove the backing from the tape and position each spar over its line starting with the shorter sub-spar. With the wing bottom on a flat surface, start in the center lining up the center marks and keep the "tips" of the spars tilted up away from the wing. Press the center in place and continue on out staying on the line as you go and keeping the spar square with the wing. Once installed, go back and press evenly straight down firmly working along the spar's entire length to insure good contact. Do the same for the main spar.

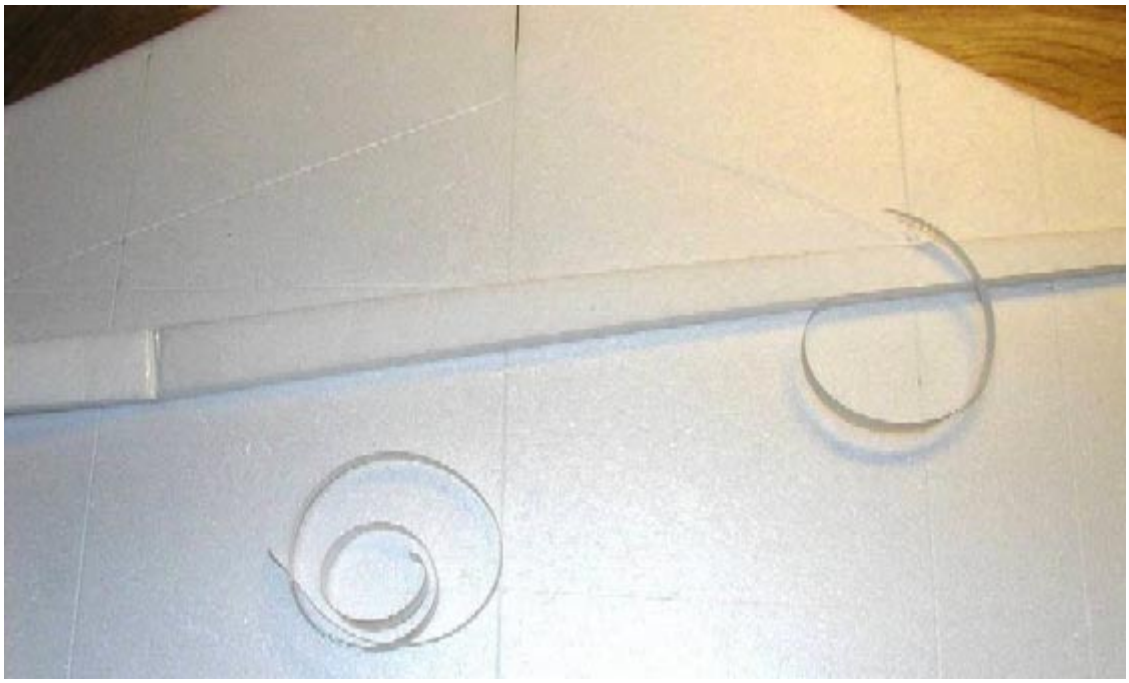


Image 22 - tape on spar

Note: If you don't have any transfer/seam tape, you can use white glue, yellow wood glue, 5 minute epoxy and others. (Some glues attack foam so test on a scrap first) Use sparingly and think light so you don't overdo it. If using a type of glue that has to dry overnight, be sure to somehow not only keep the spars square to the wing bottom, but held down tight against it also. A little masking tape in a few places over the spar tops and angled down to the lower wing on each side should do it.

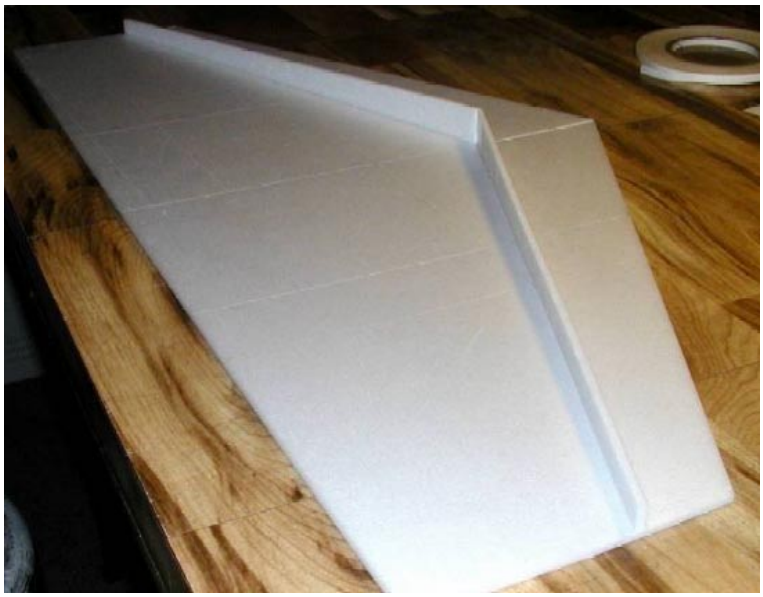


Image 23 - main spar mounted

Assemble the two straight spar pieces by using transfer tape or glue in between them full length. Be sure they are nice and evenly lined up along the top and bottom. (Note that some of the pics only show a single piece spar. This is fine for IPS weight models, but if you even plan to pump up the power, add it now since it doesn't weigh anything anyway.)

Image 24 - rear spar

We want to trim the ends of the twin straight spar to match the main angle spar where it meets. Measure and mark the spar's center and place it on the wing as close to the line as you can, just butting the ends up to the main spar for now.

Note: Before trimming and mounting the rear spar, put a servo in position over the spars with the horn about 1/8" from the inside of the boom line. The straight and main spars will get notched out for the servo mounting ears later but depending on the length of the body of the servo you use, you'll want to adjust the location of the rear spar for it. If using a very small servo, you can fill the excess space with scraps of foam sheet later so if this is the case, just size the spar to fit on your line.

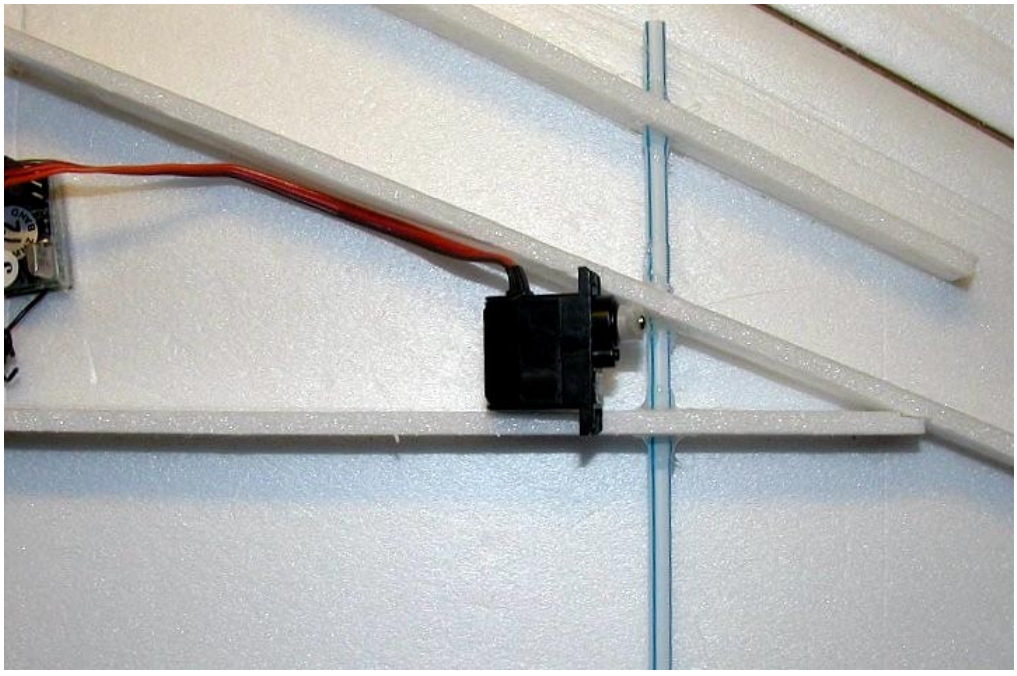


Image 25 - servo size spar

Once the desired rear spar location is found, (should be near or only slightly behind the line originally drawn) trim the ends equally by using the rear corners of the spar ends as a starting guide and slicing the ends at the needed angle down these corners. Allow for the fact that this step will cause the spar to end up further forward than it did with just the corners butted up against the main spars. Test fit the spar checking that the centerlines match up and that you are staying straight along the line. You want a snug fit at the ends for strength. Once in place, mark the main spar at the rear spar ends for easy reference and measure the main spars from this mark to the center to assure they are of equal distance.

Apply 1/4 inch wide seam tape to the bottom of the rear spar covering both layers and also apply some to the ends as well. Attach to the wing as above pressing the ends firmly into the angled spar also.

Fold over the wing tops and press the centers down onto the spars to check for shape. You should have a nice looking wing developing. Notice that the wing's LEs will lift up off the table. Putting pressure down on the spars should keep the rest of the wing flat on the table with the LEs nice and straight and evenly lifted. We don't want any warps or twists to develop during these steps so check it carefully.

Wing Alignment Jig:

To help align the wing for the final steps, cut a couple 1/4 inch high sticks that are about 16 inches long and equal in length. Don't worry about the width, only the height, and even it's not that critical. You can use square, rectangle, triangle or half-round (interior trim molding works well) as long as it's not much thicker than 3/8 inch.

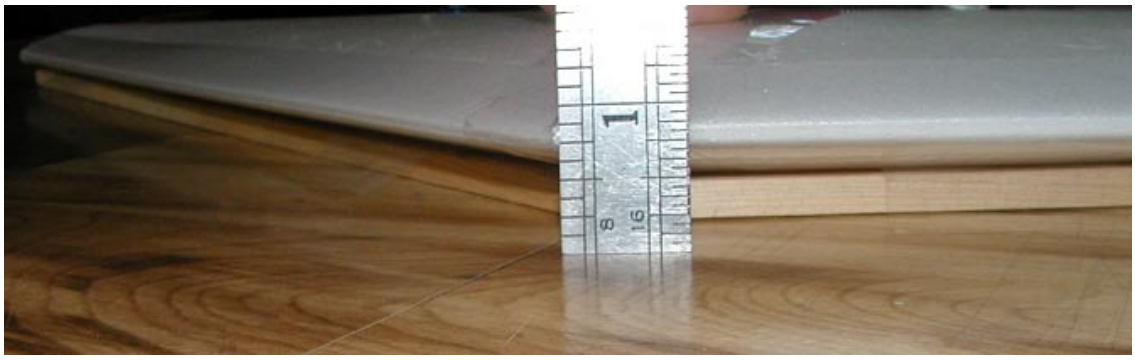


Image 26 - root height

These fit snug under the LEs of the wing with it held down on a flat surface. We want the LE raised 3/4 inch in the center and 1/2 inch at the tips with the middle and back of the wing held down flat.

Image 27 - tip height

After finding where one stick needs to be located under the front LE for the correct heights, put a piece of masking tape on the table at the root TE as a reference to the centerline of the wing position. Now tape the stick flat to the table.

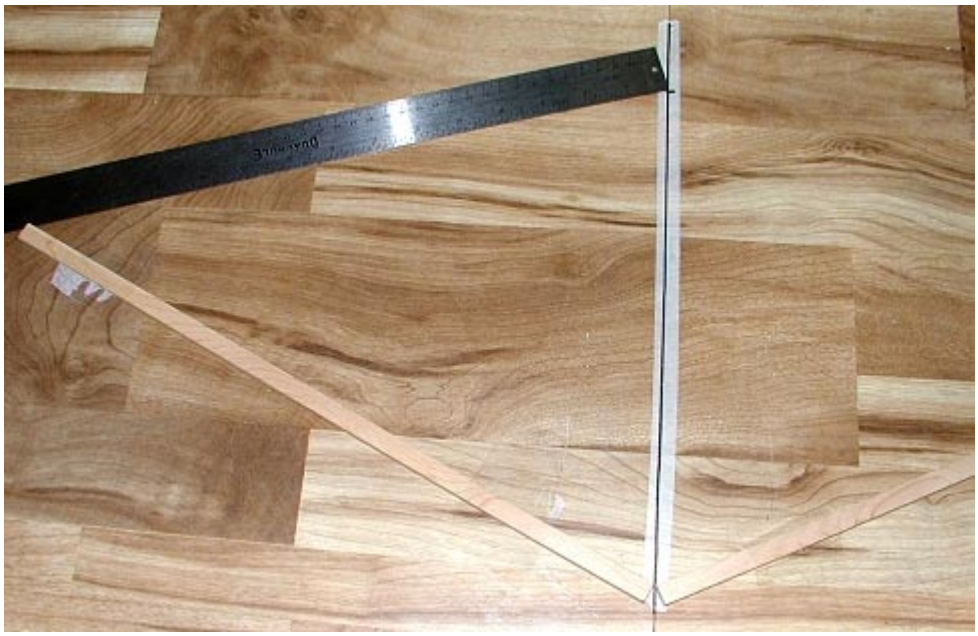


Image 28 - wing jig layout

Now add a long strip of masking tape to the table down the center from in front of the stick's point to your position marker at the back making it longer than the wing root chord so it extends out the back with the wing in position. Draw a centerline down the tape. Measure from the end of the first stick to a mark on the back of the line to compare to the distance to the second stick. Once it is equal then tape the second stick down. Position the wing and double-check the LE heights. If not correct with the TE and center of the wing pressed flat to the table, then adjust as necessary until it is.

Note: since the LE heights are not equal from the tip to the root yet the sticks are, you need the sticks to form a shallower angle than that of the LE of the wing. In other words, the nose of the wing will extend out over the sticks at the root to achieve the 3/4" height, but the stick may be partly out in front of the wing tip LE to get the 1/2" height there. How much depends on the shape and thickness of the sticks you use.

Once this position is found on the table with the wing center matching the tape center line and both tip heights equal, put a couple of pieces of masking tape on the table at the wing tips and mark the TE location on the tape. This is so you know just where to position the wing over the sticks for proper alignment anytime needed. Now you can just put the wing on your jig and when held down flat in the middle and back, the LEs will be forced up to the correct height.

Image 29 - wing on jig

Boom Holders:

Measure up the sides of the main and straight spars where the boom line crosses about 3/8 inch and make a dot. Put your wing in the jig and line it up. Take a fat skewer or finely pointed 5/32 inch dowel and from the rear with the wing bottom held flat on your jig, work it through the straight and main spars at the dots. Eyeball straight down as you go to be sure it isn't running off the line. Using the pointed stick works better than drilling or punching since it compresses the foam as it opens the hole thus adding strength. Being sure the wing is still down flat, continue on through the sub-spars.

Image 30 - holes for boom

The straws you'll use are a little bigger in diameter than your punch, so you'll have to work the holes a little with the pointed stick until the straws fit nice and snug. Insert the straw with your boom inside with the flex ridges of the straw (if any) toward the front. Note: If you are using a shorter boom than the 14" length (bamboo skewer, etc.) then locate the flex part at the back so it will grip the shorter boom.

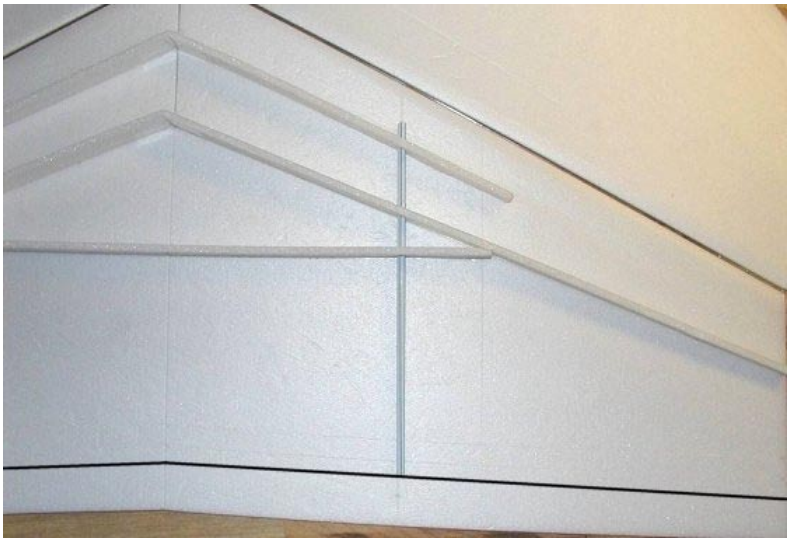


Image 31 - Straw in position

Work the straws in and stop once the straws rear ends meet the top wing TE junction line. Put the wing in the jig to keep them straight and glue or tape the straws to the spars. At the rear of the straw you can either glue or transfer tape it down to the lower wing flat area where it will rest at the last couple inches against the wing bottom.

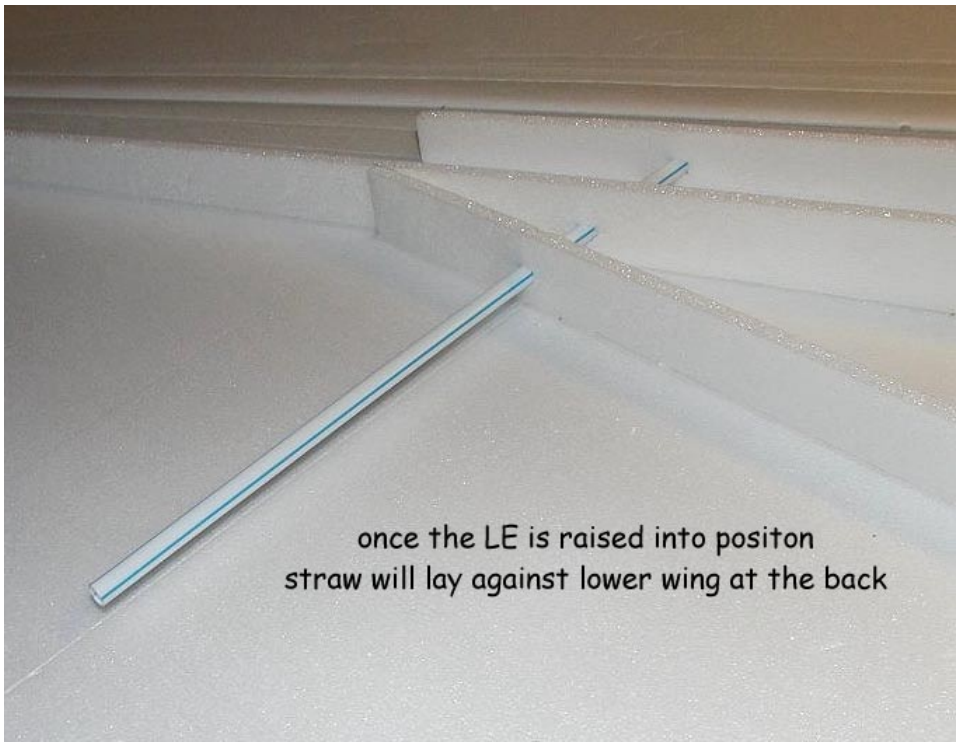


Image 32 - straw secure

Top Wing TE Cut:

While holding the lower wing flat in position on your jig, fold back one side of the upper wing surface and hold it down over the lower wing panel TE line you drew earlier. While holding the upper panel in place, mark where the TE line that's drawn on the lower wing comes out from beneath the top surface at the root.

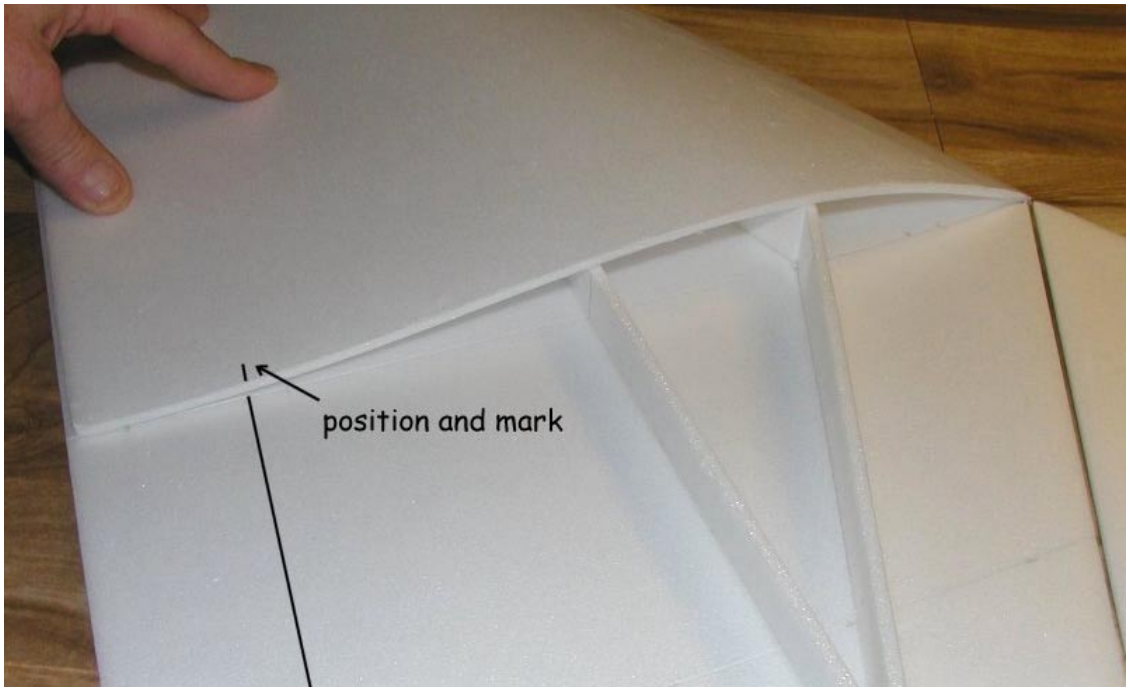


Image 33 - position wing top

Do the same at the tip holding it flat also. Unfold the top and draw the line on the upper panel between the dots. Instead of doing the same on the other side, to assure an equal wing, you'll measure the piece getting cut off and use it's dimensions for the other side. Just measure the top root TE mark to the edge and the tip TE mark to the edge and duplicate it on the other half. Once the line on the other side is drawn, fold both tops over to check your results with the wing still in the jig and held flat down. The lines should match up with each other and with the reference lines on the lower wing. If not, you are either holding it crooked, didn't measure a line correctly, have a warp, twist, or other problem causing the wing defect. Find it and fix it. This is a very important step so get it right. If you seal up the wing and it's warped or twisted for any reason, you might as well scrap it and start over. There is just no easy way to fix it properly. Once satisfied of a true and symmetrical wing, open the tops up and cut the excess TE pieces off both panels.

Airfoils:

Here's our airfoil shape over three spars. Above shows it over two spars. The camera warped the three spar picture but they are about the same shape, just not as pointed in the front third.

Image 34 - wing shape

Here's why the jig is needed and how careful you need to be when closing up the wing.

Image 35 - flat bottom

By letting the top roll forward or back, the entire airfoil changes. Get one side different and you've got a real mess.

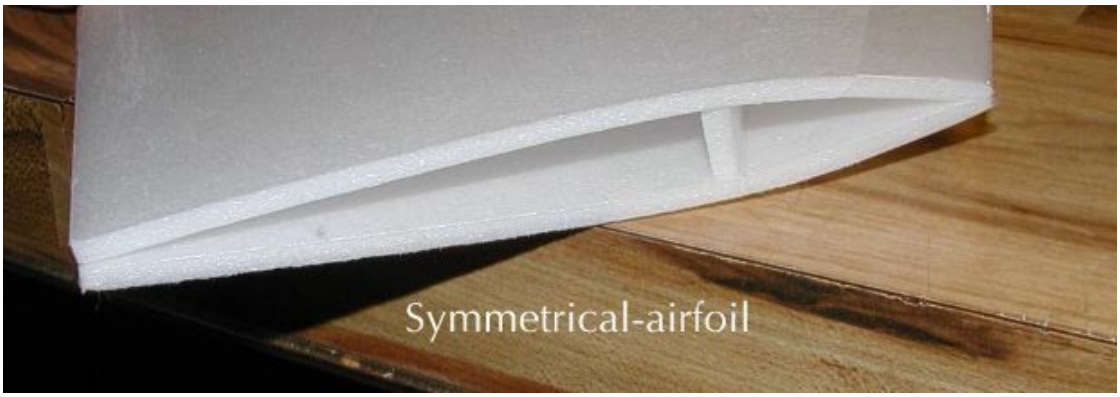


Image 36 - symmetrical

Notice how little the top actually had to move to change the airfoil that much? You can see it from how the two TEs line up in the two pictures above. Those two wings fly entirely different.

Image 37 - semi-symmetrical

This is what we're looking for. Learn to eyeball your wing now prior to sealing it up so you'll know what to look for.

Image 38 - head-on view

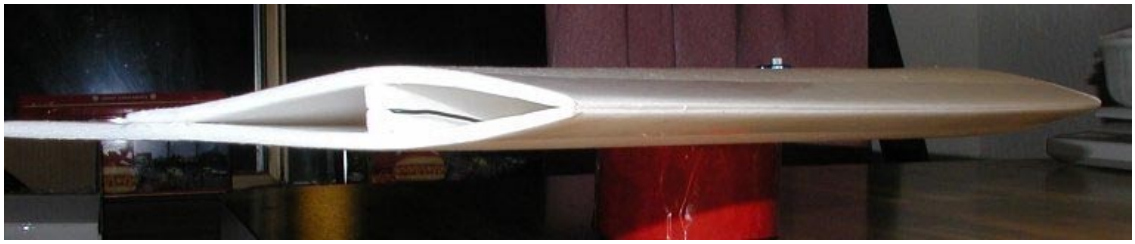


Image 39 - end view

Again, the camera warped the wing, but it should be straight and true, not curved and twisted like it looks in the picture above.

Wing Option:

An option for all the models presented here is to trim the mid-section TE (between the fins) of the wing forward to the junction of the top wing panels. This allows the motor to be mounted further forward. This mod is mostly for heavy motor and/or light battery pack use. It allows for a stronger mount point for the heavier motors as well as allowing light battery packs to be positioned further back from the nose and still achieve proper CG position.

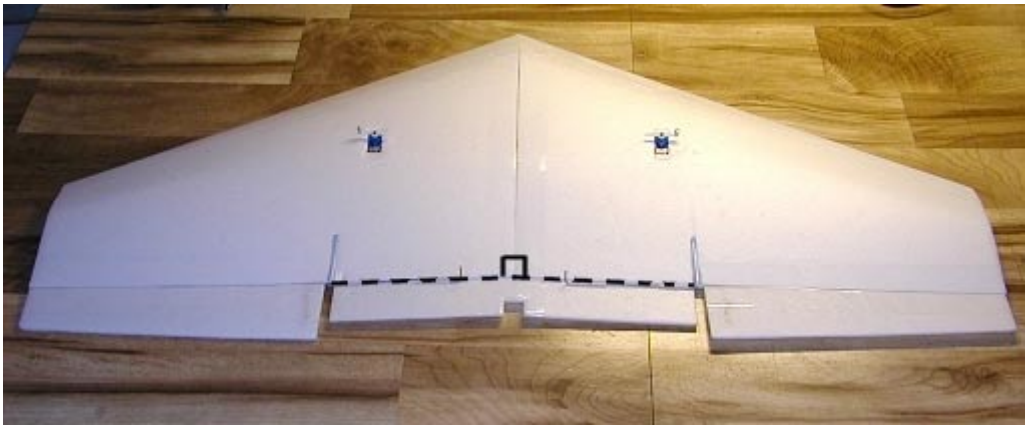


Image 40 - wing mod - aileron version

For a slightly faster and stronger speed 400 class SC wing, consider cutting the lower wing TE back to the upper wing TE line along the full length of the wing. (Cut as above but using elevons)

Image 41 - Top TE compress

TE Treatment:

With the tops still unfolded, place the now up-side-down top TEs on the edge of the table. With a roller, broomstick, or whatever, flatten the TE as thin as you can with a shallow angle. You can then run your thumb down it for further compressing the very edge.

Straw Exits:

With your booms in the straws and the wing in the jig in position held flat, press the wing tops down in place compressing the foam over the straws at the back. This will leave dents inside that you can use to notch out a slot for the straw to protrude through.

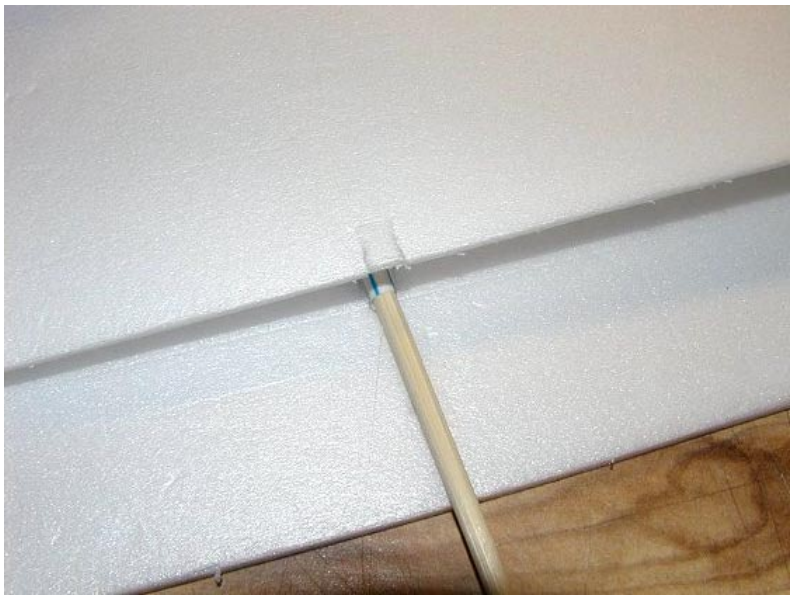


Image 42 - locate straw exit

Start narrow and short and only cut forward until the wing top starts to lay flat and snug around the straws. Then press the remainder down compressing the front edge of the slot into a taper for a nice tight fit. About 1 inch long should do it.

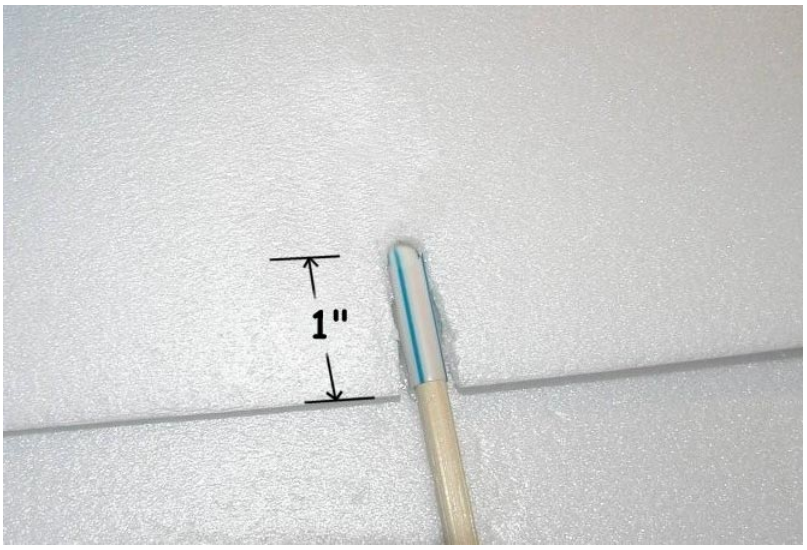


Image 43 - straw exit cut

Fin Cuts:

With the booms in place, mark lines down both sides of them on the foam between the straw and the TE. Keep the width undersized slightly and centered for a snug fit so the fins stay vertical. Cut out this slot under the boom from the straw edge all the way back off the TE and make it no wider than your foam stock.

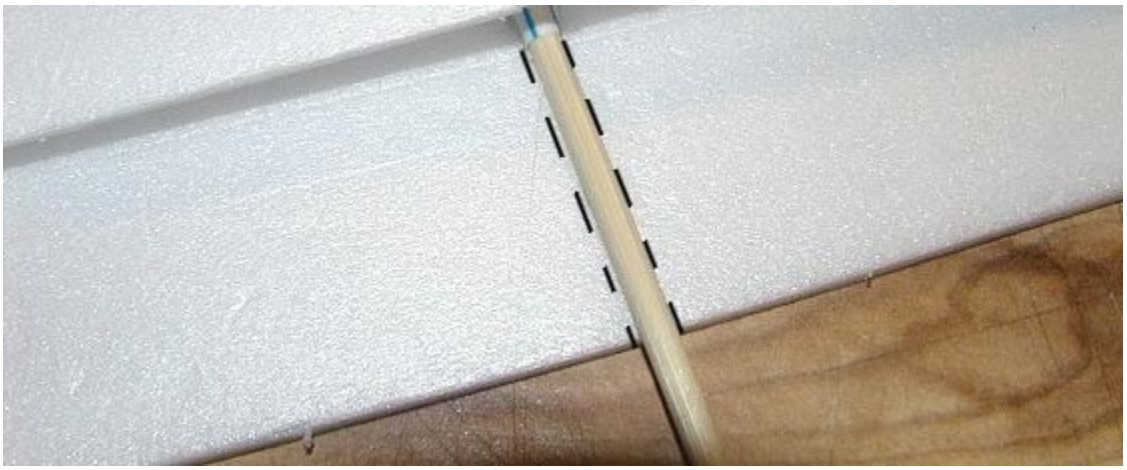


Image 44 - slot for fins

Servos:

You can locate the wing servos either upright for easy removal or on their side flat buried in the wing for a cleaner and slightly easier installation. You can also mount them flat but flush with the surface for removal as needed later if desired and cover them with some tape to hold them in.

Before anything else, hook up your radio and with a receiver battery connected, setup your mixing and test servo travel. You want the right wing servo horn to move forward with up and forward also with right stick input. The left horn should also move forward with stick up and move forward with left stick as well. Locate the side of the servo that has the wire to the front of the plane for ease of mounting. Use the longest servo arm you have that fits your linkage. DO NOT cut off one half of your long dual arm horn to make it a single one yet!

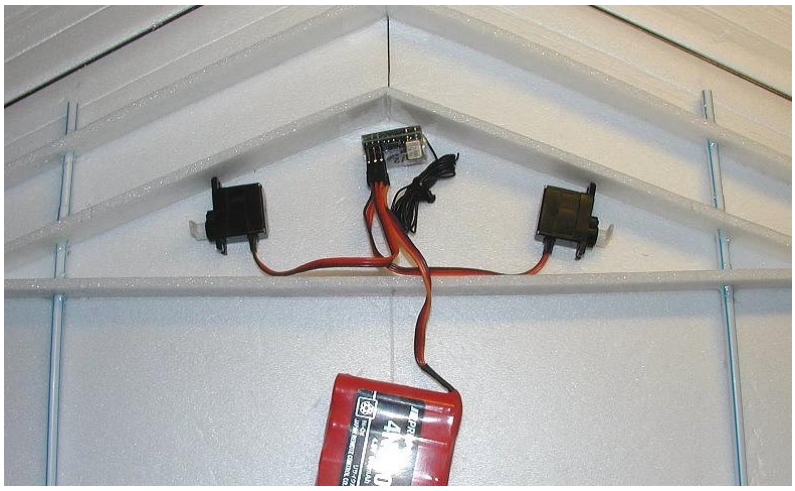


Image 45 - system test

Once all this is established by switching around the horns, swapping sides with the servos, etc. mark one of the servos for later reference. They will get mixed up on you.

Note: If you can't get equal centered trim on the servos when using the dual arm horns, try swapping the ends of the horn around on the servo and check again. They are molded so that the spline is not symmetrical from one side to the other, so just switching its position may be all that's needed to line them up. THEN you can cut off the opposite arm.

Keep in mind that this plane relies on a no slop control system. Since the foam surfaces can flex anyway, this becomes even more critical especially at high speeds.

As to orientation of the servos in the wings, you want the horn to operate as close as you can get it to the inside of the boom line to reduce binding since the push wires need to run straight back along the fins. These wires are just supported with a couple pieces of the plastic sleeve that comes with them that is taped to the insides of the fins.

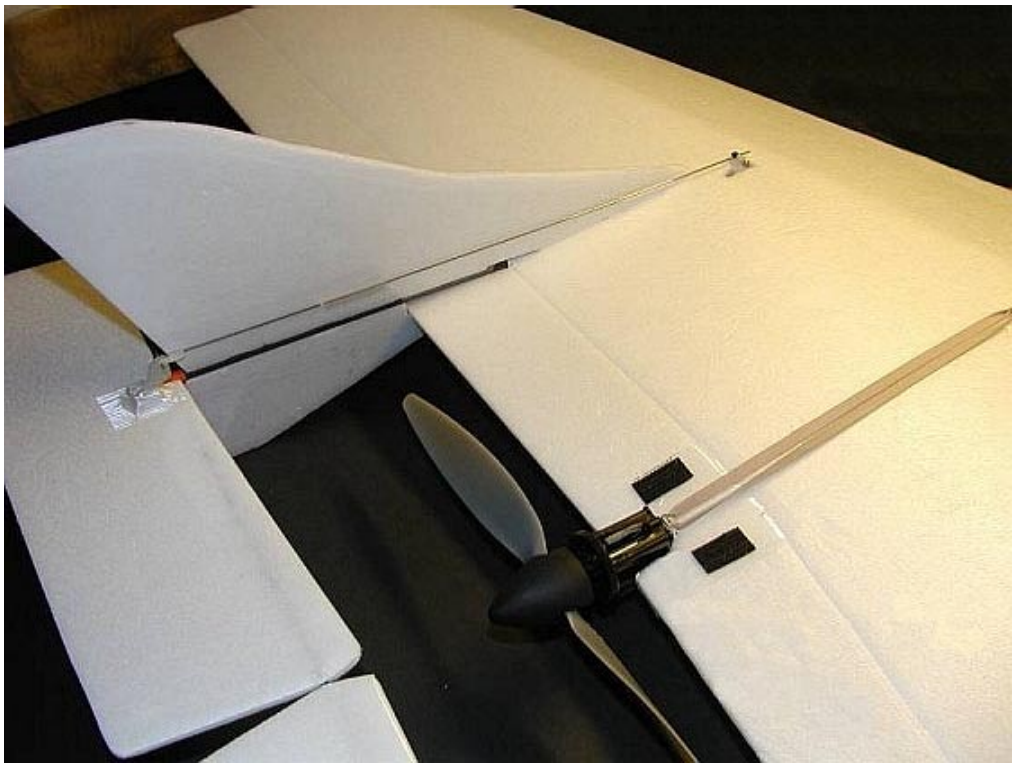


Image 46 - control linkages

Upright Mount:

For the stand-up mounting, you should position the servo so its wires exit forward. Note the opening that allows the servo lead to pass through to the receiver for installing/removing.

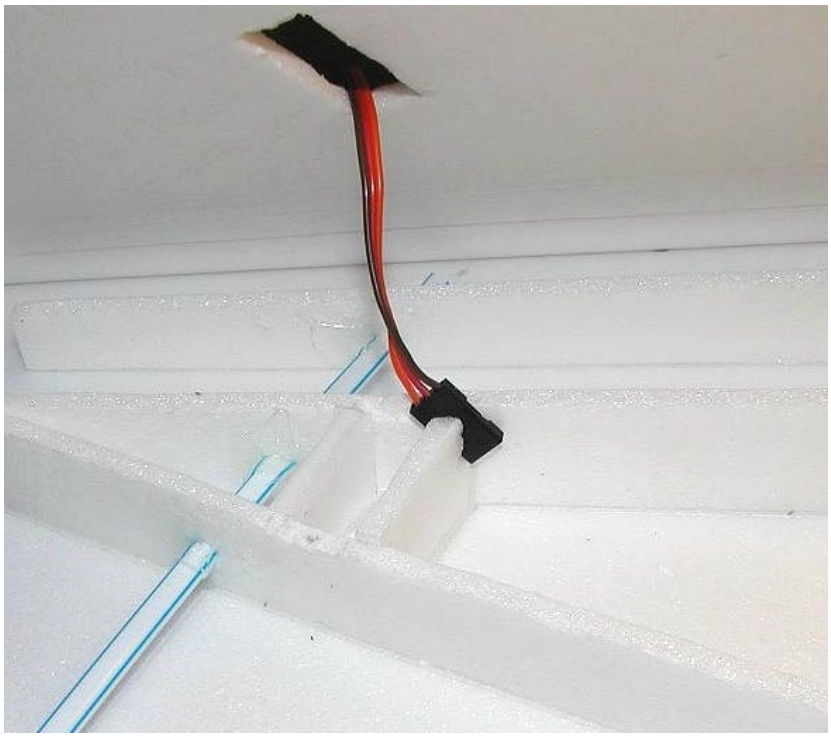


Image 47 - servo lead access

Build tight sidewalls between the main and rear spars from foam scraps, and shim the front and bottom of the servo as needed to achieve the proper fit and height.

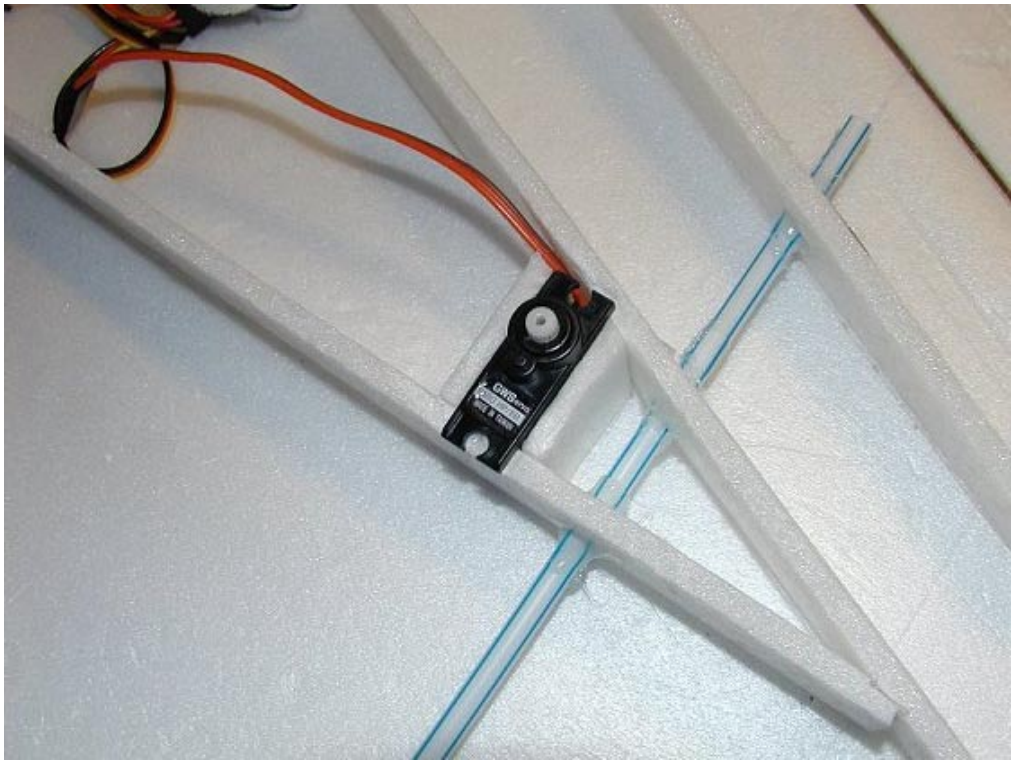


Image 48 - upright mount

You can find the proper cutout location in the wing top by putting the servo in place without a horn, pressing down on the top over it to mark the foam on the inside. Then take out the servo and use it with the top open to locate the cutout. Cut it way undersized at first and reinstall the servo to check the location. This will help you not to get the opening too big. The servos can then be taped over or you can use transfer tape to attach a couple foam plugs to snug it in and clean up the appearance some, but recess them as flush as you can either way and keep them tight.

Image 49 - upright cutout

Image 50 - upright servo installed

Flat Mount:

There's a couple ways to mount the flat servos. You can bury them inside the wing with just the servo arm sticking out the top through a slot. This is the cleanest but makes them inaccessible for service, horn position adjustment, etc. unless you cut an access panel in the wing. You can also cut them in through the wing upper surface leaving the case flush with the surface and secure them with a piece of tape. This is the preferred method if removal is needed often and you want a flat mount. It doesn't leave the upper wing surface quite as clean as if you bury them however.

Image 51 - flat mount layout

For either method you will need to notch out a little of both spars for the servo case attachment tabs. With the wing open, mark their locations on top of the spars. Make the cuts slightly under-sized for a tight friction fit for the tabs. Check your depth often and stop just before you get it either flush for the buried style, or raised 1/4 inch for the surface mount. You can compress it in the remaining bit later. Now build up some foam scraps under the servo to fill any gap there, and transfer tape the servos to it and into the spar slots for the buried method. For the flush removable method, do not attach internally but keep everything tight and if need-be add some support walls between the spars (see upright mounting) for a tighter fit. For the buried method, double check that you have the correct servos in place, connect your gear and retest the operations and trims now since it won't be possible to change anything later without hacking up your wing.

To find the location of the horn slot for the buried method, have the servo installed and its horn attached and sticking straight up, and then carefully fold the wing top panel over onto it. Press gently to make a mark inside the upper wing panel. Open the wing top back up and cut out just enough for the horn to stick through. Refold the wing over onto the horn and notice that you need to enlarge the slot to get the top down flat. Lengthen the slot and trim it slightly wider for clearance. Close and test again, etc.

Don't make the mistake I did at first when using a buried servo. I accidentally left the horn with the bigger holes attached and then tried to install the mini linkage. Here's what I had to come up with to get it to work without cutting the servos out to replace the horns. It works fine, but I have to lose my trim settings every time I remove the tail. By using the adjustable screw connectors on the control surfaces instead, you can use the quick disconnects at the servos to remove the entire tail for transport or storage without losing your settings.

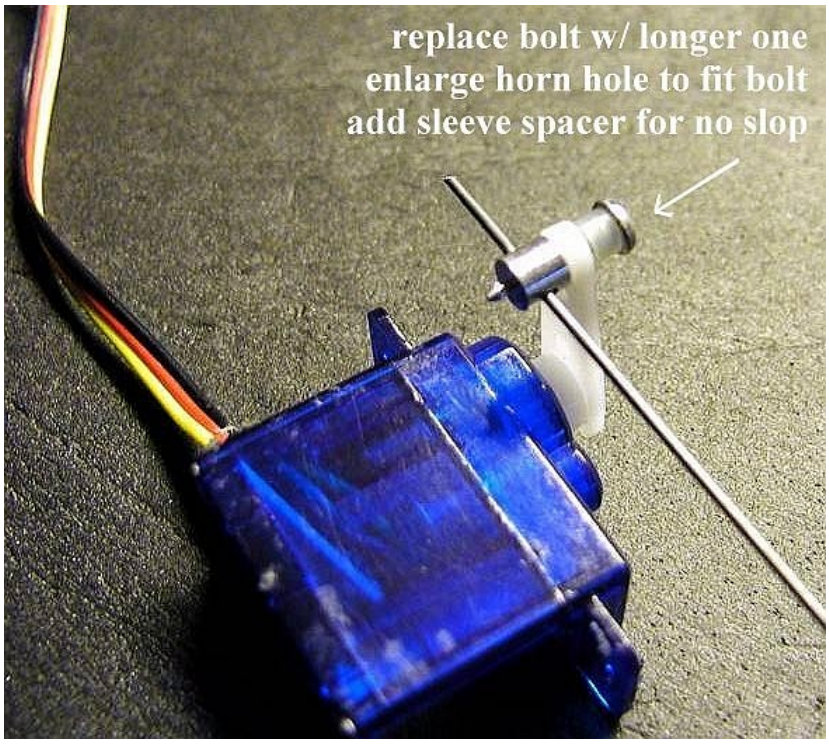


Image 52 - modified servo connecter

For the flush surface removable mounting, leave the arm off the servo and put the servo in place. Close the top and press down slightly over the servo enough to indent the inside top but not push the servo deeper into the wing. Open the top and find the impression. This should be enough to start a hole that you can look through to find the servo edges with the wing top over the servo. Keep enlarging it until close and then remove the servo and fit it down through the top. If you get it tight enough, a piece of 2" packing tape over it should be all you need to keep it from moving. If not, you can add some transfer tape under the servos.

Receiver Cutout:

Locate, size and cut an access hole for your receiver near the front of the wing bay. Just make the hole big enough to stuff in the receiver with a little thin soft foam wrapped around it.

Lightly rubber band the foam on so if you need to remove the receiver later, the foam will come off inside first allowing easier exit of the radio. This way the hole won't be so large that the receiver wants to fall out on its own.

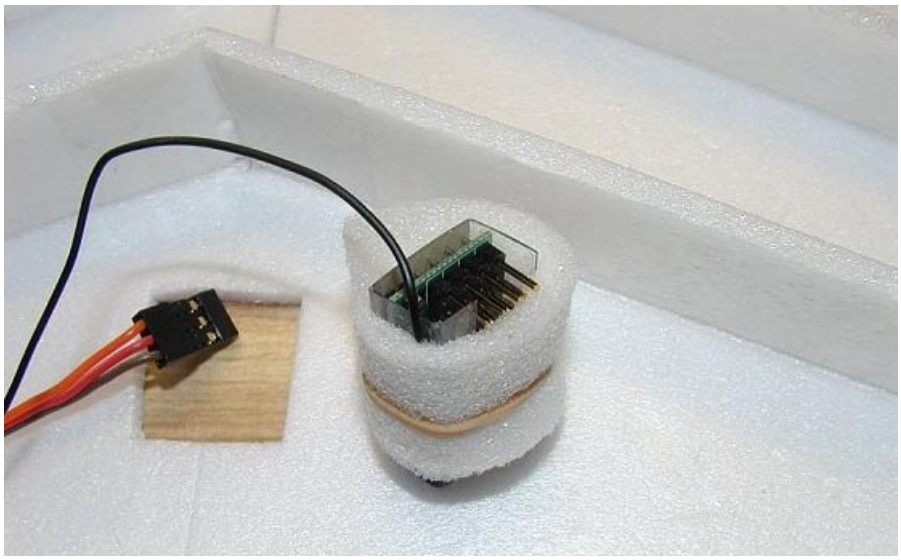


Image 53 - receiver access hole

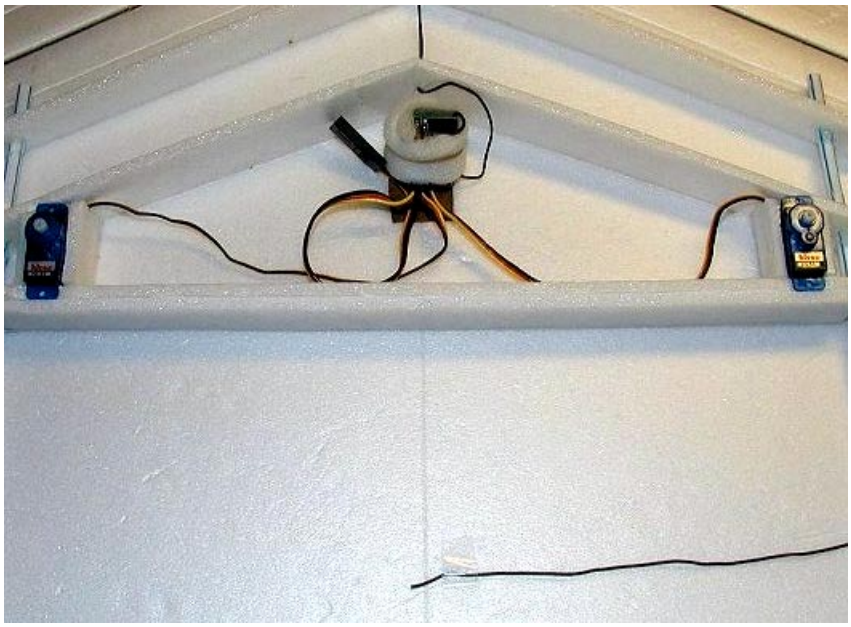


Image 54 - completed system

Antenna:

If you're like me and hate that ugly dangling wire, you can lay out the antenna as shown loosely and barely tape the end down for ease of removal later if needed.

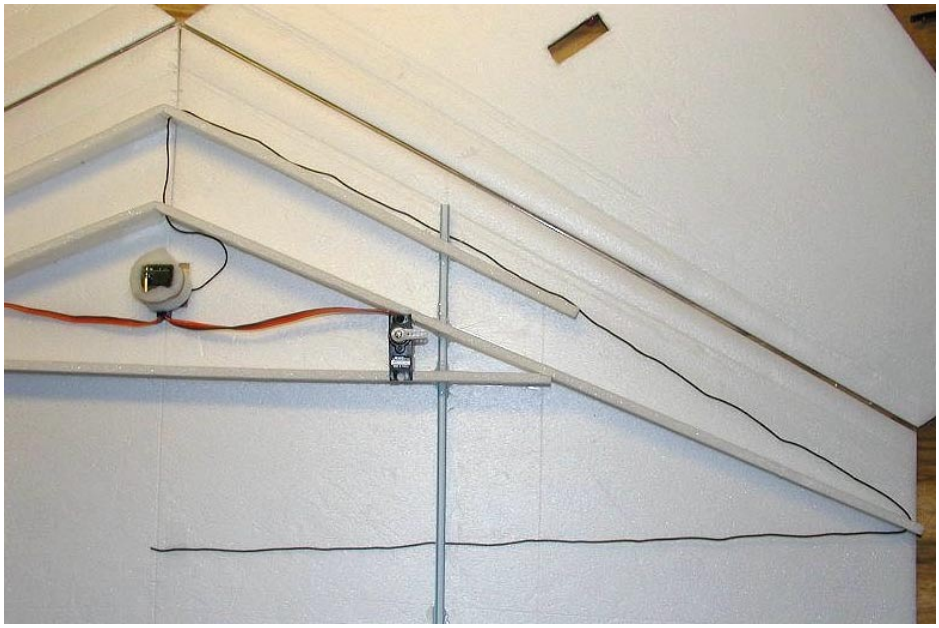


Image 55 - antenna layout

Here's some things you can't do with your antenna. Don't leave it wrapped up, coming in contact with metal or CF, cross itself, be parallel to itself, or let it get near the motor, ESC or prop. You can just run it along the spar and leave it hanging out a wing tip through a small hole in the tip plate. This way you can easily remove it with the receiver and replace it by snaking a wire back through the hole to the receiver bay and fishing it through again.

Another method is to add a single shrink wrapped servo connector near the receiver in the wire and have a separate antenna wire in each plane that uses that receiver. Just be sure they are the correct length and remember to range test religiously in case one should ever come loose or you forgot to connect it!

Close Wing:

Apply your thin seam tape to the tops of all angled spars. Cover the double thick straight spar completely. Also cover any servo walls you may have.

Do not remove the backing paper until instructed. Press well straight down on the spars all along the entire lengths. Now run at least a 3/4 inch wide strip of the seam tape just in front of the TE reference line on the lower wing full length skipping the straws as you go. Press this down good onto the foam also. You can also add a small piece of seam tape on the inside wing top panels at the straw exits for good measure if you want.

Image 56 - wing ready to seal

With the wing aligned on its jig, hold the tops down as if completed and double check alignment with the table by measuring the 1/2 inch tip and 3/4 inch root distances again. Eyeball the entire wing carefully for any twists or warps. If you find any, fix them now, as you won't be able to later without a mess.

Get a helper to hold the wing in position on the jig if necessary for the final closing, as this is the big one and your last chance to get it perfect.

With the wing back open, start with just the spar tape and remove all of it's backing off all spars.

Image 57 - spars taped and ready

Seal just the spars first. Start in the middle and keeping the root edges of the tops together as you go, press them down together firmly onto the spars. They will want to pop back up so continue to hold pressure in the center and work out to the tips all along all spars. Check it for symmetry by looking it over. Remember, until the entire wing is sealed, it won't have the shape we want so when checking, keep it tight down on the jig. If you missed the mark, just pull it up, replace all the tape and start over. Again, you just can't reposition it after it has touched the foam.

Finally remove the backing from the TE hold-down strip and the straw exit pieces and again with the wing in the jig and held down flat over the spars, start in the center and work the upper panels down onto the lower wing panel. Work the edge very firmly into the tape trying to compress it as you go. Go back over the spars and top TE a couple times insuring everything is stuck down firmly.

Now pick up your wing and admire your work! As they say, if it looks good it will probably fly good.

Wing Tips:

Use the wing tip itself over some lengthwise grain foam as a pattern. Draw around it and cut it out slightly oversized.

Image 58 - draw tip plate

Take the cut out tip and trace it on another piece of foam and cut this one out too.

Image 59 - copy tip plate

Check to be sure the wing tips are flat and straight. Install them with thin seam tape onto the wing tips edges being sure you press it on all around for good contact. Carefully trim each flush with the wing profile.

Image 60 - attach tip plate

You can then sand the last little bit to smooth it out and round it slightly to taste.

Image 61 - finishing tip

Motor Cutout:
Cut out a 1/2 x 1/2 inch square centered in the trailing edge as shown next.

Tape Root:
Stretch out a length of 2 inch tape up toward you attached to the table and place the wing beneath it with the nose toward you and evenly centered under the tape.

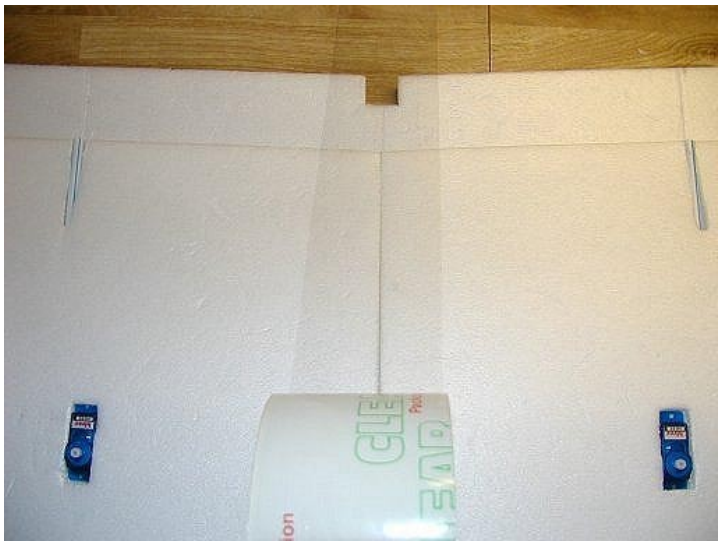


Image 62 - tape top

Start at the TE and press the tape over the top of the wing working from the center out as you go. When you reach the nose, stop and cut the tape off 2 inches extra long. Then slice a slit in the middle of the excess piece back to the nose. Take each of these pieces and individually wrap them around the LE and tight onto the bottom.

Image 63 - tape nose

Trim the tape a couple inches long on the back and wrap it around the TE right over the motor cutout. Slit the tape that covers the opening and being careful that the two sides don't touch each other, trim one and wrap the other around the edge of the cutout for added strength.

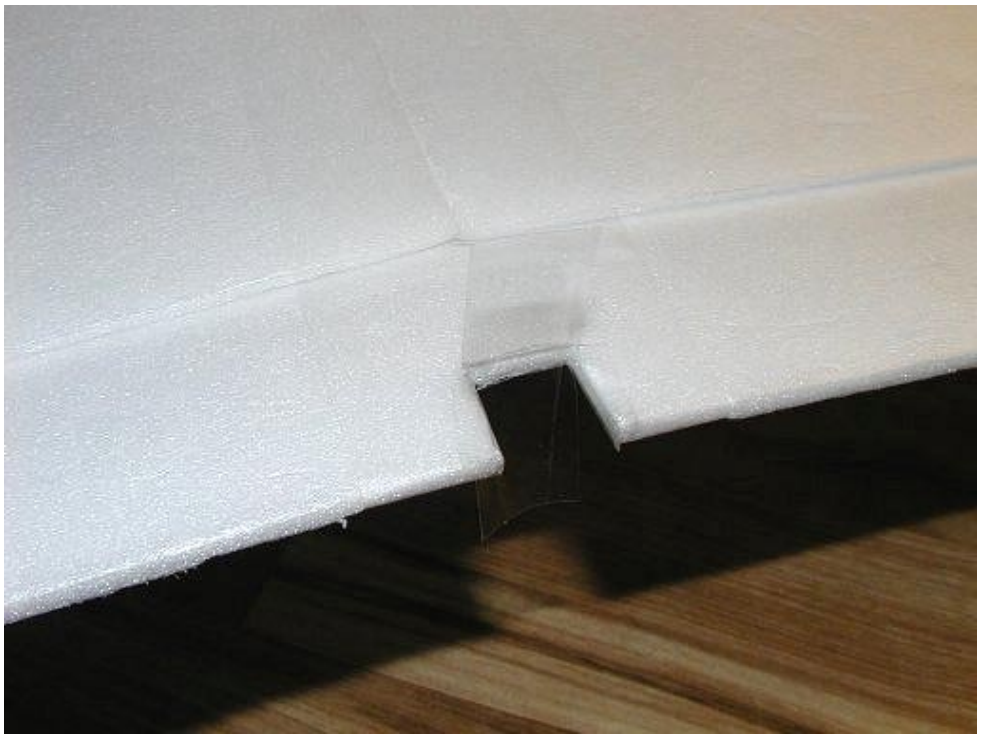


Image 64 - tape TE

Flip the wing over and add some tape to the front 1/3 bottom of the wing to seal our "dart" cut. Then slit and wrap the excess tape edge around the LE again. Add another couple inches also under the root TE to reinforce the motor cutout from the other direction as you did from the top.

Vertical Stabilizers:

We need a way to keep the fins from pulling out of the wing. You might have gotten lucky and have a snug fit with your booms but any movement will change your trim adjustments! By adding a slot in the wing and a tab on the fin, you can press down on the wing back near the slot and have a simple, effective catch to lock the fin in place. Keep the slot real tight as the foam will compress and want to loosen your lock with time. If this happens you can just add some tape around the tab and/or slot as needed to tighten it back up.

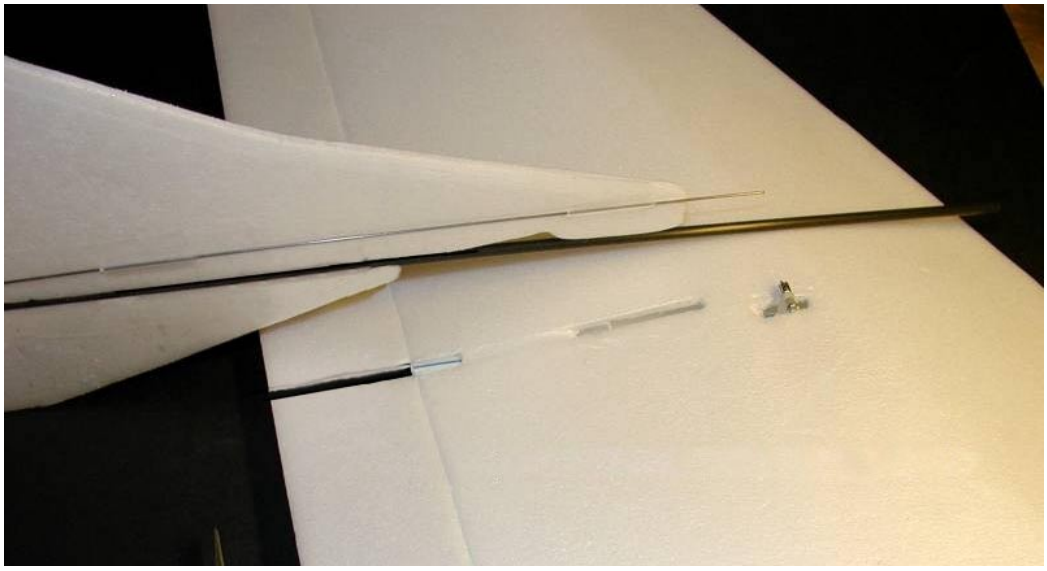


Image 65 - fin alignment

Cut out the fin parts with all straight cuts as shown. You will cut the tab next and can shape the fins to taste later. The bottom fin is mostly just for looks and for the plane to sit on so don't worry much about it's dimensions. The upper fin dimensions need only to match the other side and not allow the boom to be able to shift fore and aft. The critical measurements are the correct distance the boom extends past the TE of the wing and how much the boom extends past the fin out the back.

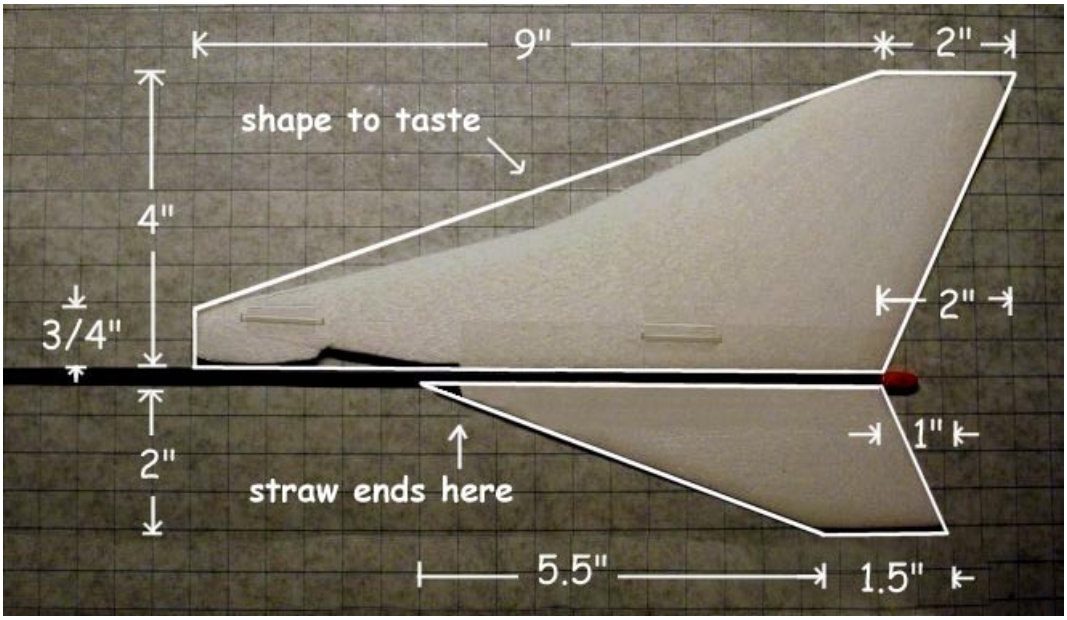


Image 66 - fin layout

If you mounted the straws exactly on the upper wing panel junction lines, then when installed the booms need to extend 5 1/2 inches back from the straw or 4 inches back from the wings TE. Position them now and mark this location on the spar. A little piece of masking tape shows up better on CF tubing than a pencil or marker. Tape will also act as a physical stop to keep the boom from going in too far while it's being fitted.

Measure back from the front of the fin 1 3/4 inches and place a mark on its bottom. This is the back edge of the tab.

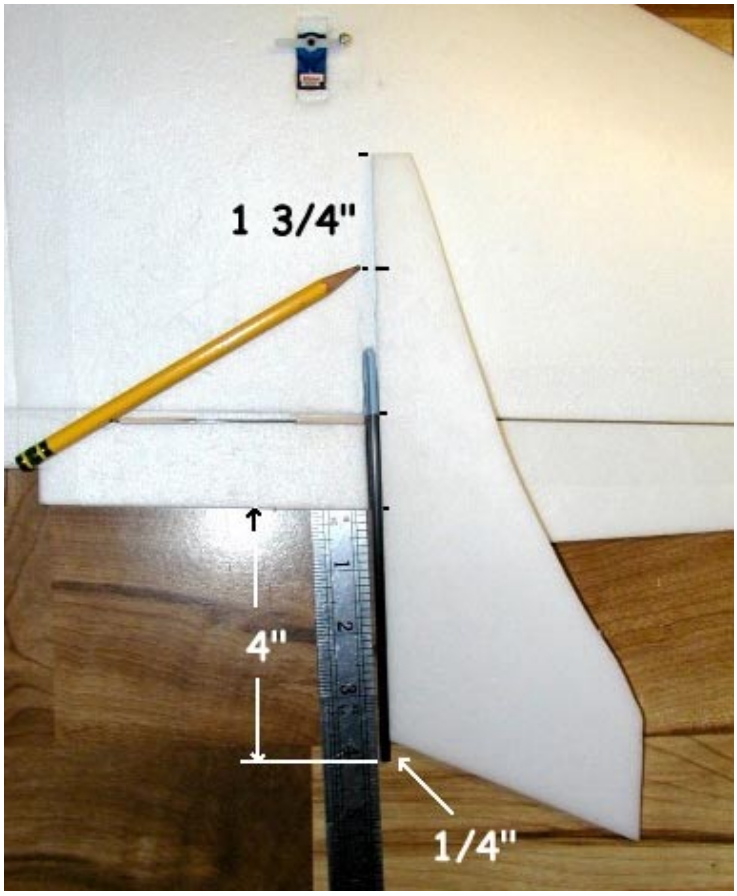


Image 67 - layout slot location

Leaving 1/4 inch of boom sticking out the back past the fin bottom, lay it flat on the boom line and mark the straw end location on the fin for reference. Next mark the wing at the front and rear of the tab location.

Line up the fin in the vertical position along the boom. Sight down from the top to make sure you have it in line with the boom and mark the slot side locations.

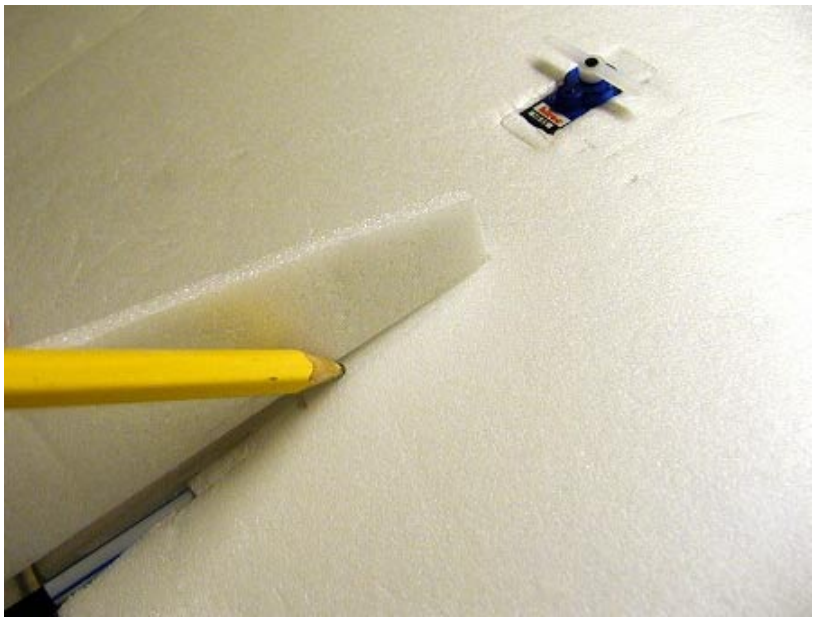


Image 68 - mark sides of slot

Start to cut the slot from the middle very undersized at first and check to see that you are directly on the boom line by looking in to see where the straw is located underneath. Compress the edges of the tab by pinching it for strength and ease of entry.

Image 69 - fin slot

You will need to trim a little notch behind the tab in the fin for this final fitting. The first time you attempt to custom fit something by eye may be intimidating so if that's the case, just cut a fin from card stock and trim it to fit. Then you can use it as a template for the foam fin.

Keep trying to fit the tab in the slot as you widen and lengthen it in the directions needed to keep it centered. When you get it open enough that it looks like if you forced the tab in it would go without breaking anything, don't cut anymore. Once you work it in the first time, it will compress the foam edges of the slot and the tab some and the next time it will not be quite as tight.

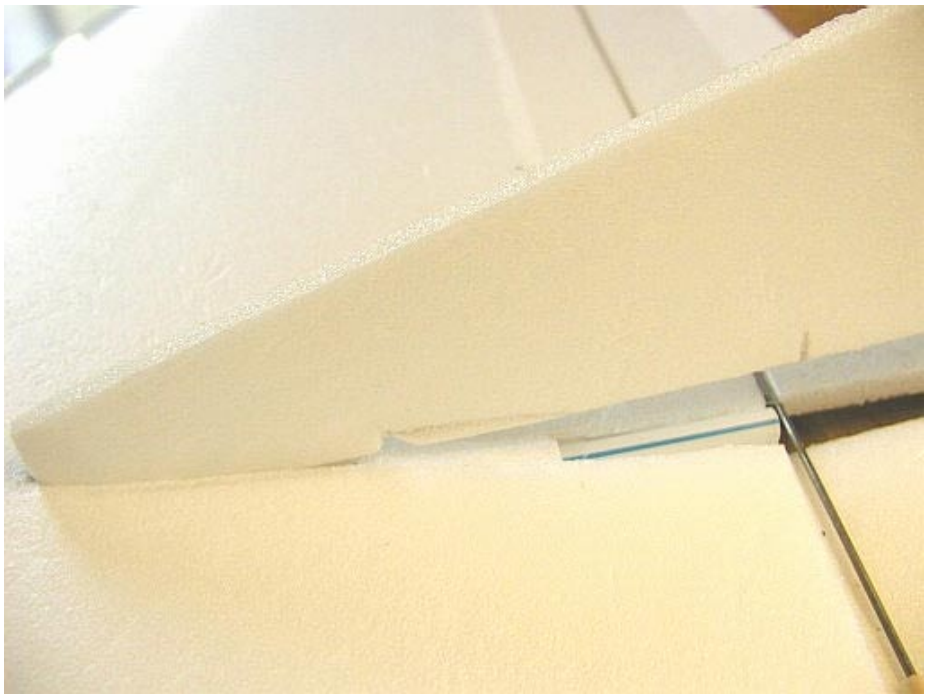


Image 70 - fit fin tab

Notice the mark on the fin from the notch we made back to where the straw exits the wing top. Gradually remove this until the tab inserts fully and the bottom of the fin lines up with the boom. You'll also need to remove just a sliver of foam where the fin goes over the straw.

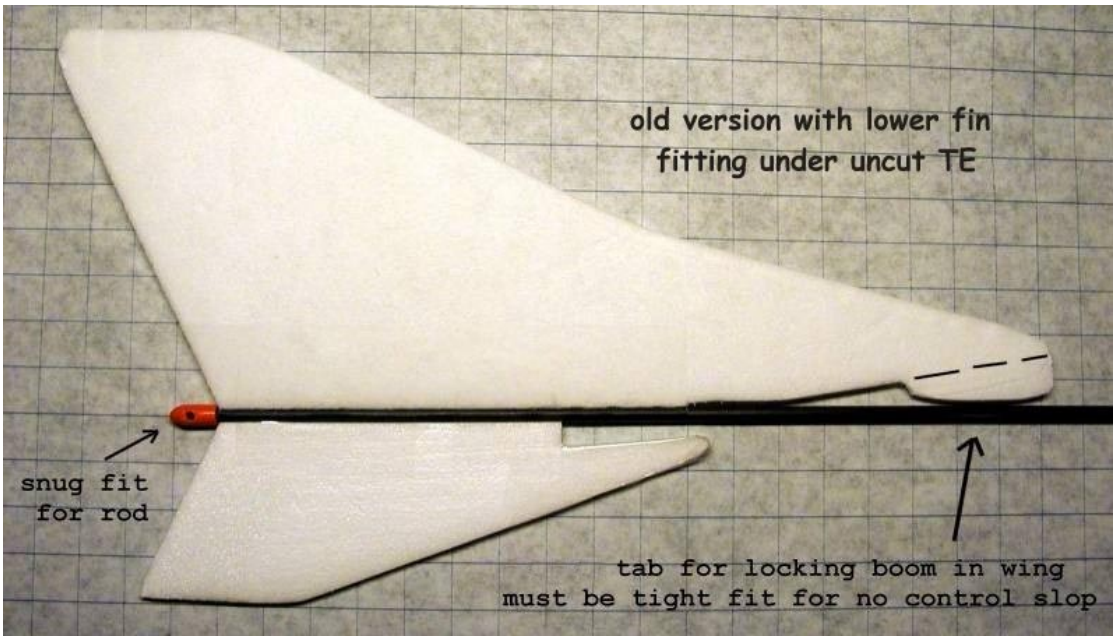


Image 71 - tab reference

You may have noticed some pictures with a slot in the lower fin on an un-notched TE. This method worked fine but that point on the front of the lower fin always seemed pretty flimsy. With it solid as instructed and the cut in the TE instead, the fin is easier to make, stronger, and if the TE slot is tight enough, helps hold the fin vertical.

Once you get the upper fin fitting nice and snug and flat against the boom, assure your marks on the boom and fin still line up with the straw exit. Test fit the lower fin against the mounted boom and wing. Round the front of it enough to allow the lower fins front edge to butt into the straw and have its back edge 1/4 inch from the end of the boom.

Remove the boom and lay it flat on the table with the upper and lower fins in position lined up with the marks. Holding all three pieces together tightly, apply a length of 2 inch packing tape along the boom half covering both fins. You could first attach them together with thin transfer tape to help hold them for you or maybe get a helper.

I found that I could do this step easier one fin half at a time by applying the tape to one fin, flipping it over and adding the boom in position. Then roll the boom tight up against the edge and add the other fin by pushing it into the boom as I dropped it onto the tape. However you do it just get them all tightly pressed together and flat. Flip it over and tape the other side flat on the table. You can just trim the tape ends flush with the edges in the back and end them on the straw line at the front.

Image 72 - fin fitted

Do the other side fins the same way. They can be shaped to taste if you want to round the corners, add some curves, etc. Once done, compress the edges together all around on both sides against the table or by pinching for strength and streamlining. You can lightly sand the edges round also.

Tailerons:

Find your vinyl tubing size that fits real tight on the ends of the booms. Cut two pieces 1/2 inch long. Insert it on to the back of the fins and leave 3/8 inch off the back of the boom.

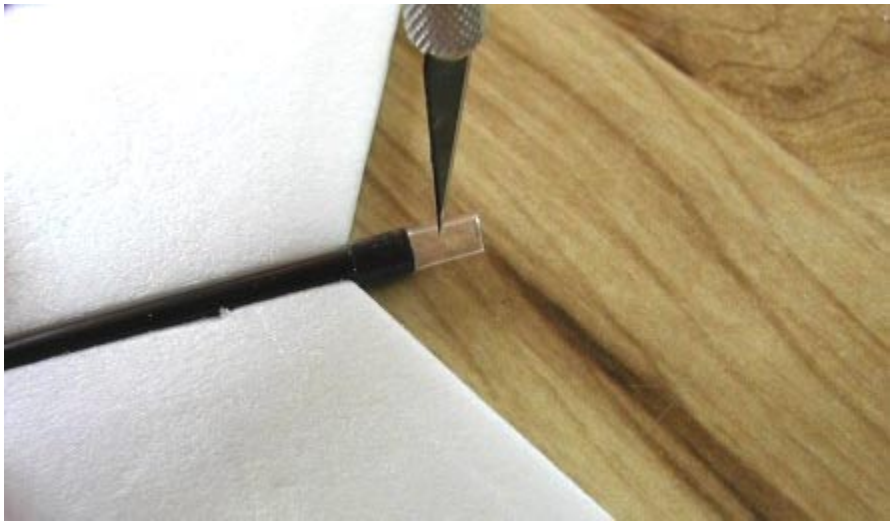


Image 73 - axle rod fitting

Just past the end of the boom and with the fins laying flat on the table, bore a tiny hole in each side of the vinyl tubing straight down with a long point hobby knife staying centered on the tube and even on both sides. We want the taileron hinge rod to fit very snug in these holes yet be able to be pulled out for transport as needed.

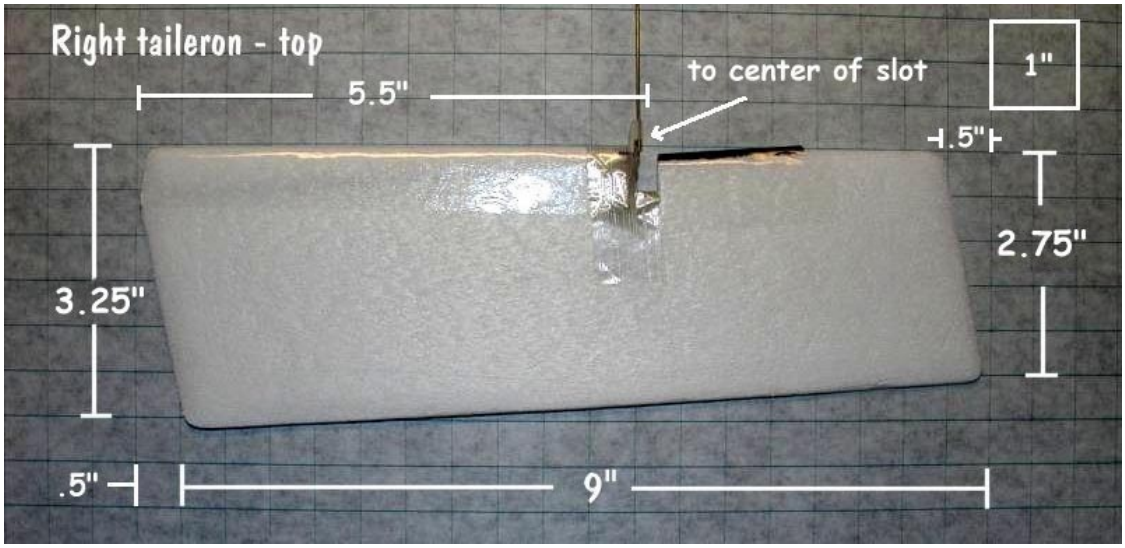


Image 74 - taileron layout

Cut your control surfaces remembering to keep the length along the grain. Compress the edges on both sides with your fingers against the table to strengthen and streamline the foam. Figure out what will work as a slip fit, no slop sleeve for the axle rod you're using and cut lengths to match the plan.

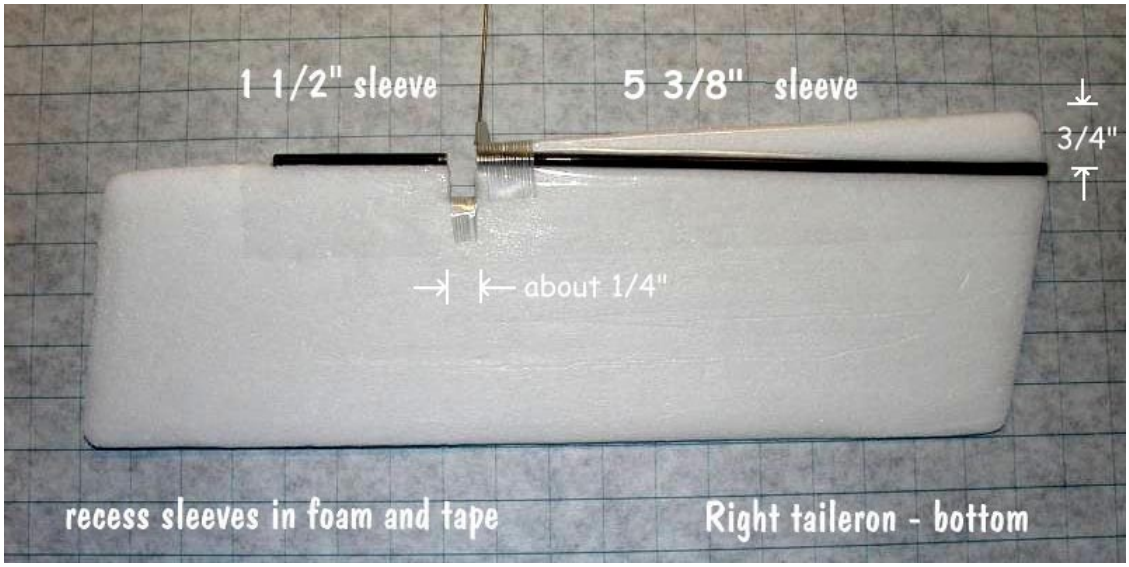


Image 75 - taileron pivot sleeve

Take the pivot rod and press along the line into the foam as well as you can. Rocking it a little back and forth will help indent the foam. Cut your sleeve to the required lengths and then tape the pieces to the surfaces with the axle rod in place. Don't tape the rod to it anywhere however, as by pulling it out of the sleeves and booms the entire tail assembly comes apart for flat storage.

If real meticulous and using a ridged sleeve, you can slice the foam on the line and tape the pieces around the sleeve as you did with the upper and lower fins around the tail booms.

Image 76 - tail bottom view

Assembly of the tail is to start the rod in the outer sleeve on one surface, work it through the boom tube holder and continue on through the rest of that surface's sleeve. Then add the other tail surface to the rod, position it in line with the boom fitting, work it through that fitting and finally ending about flush with the end of the last sleeve section.

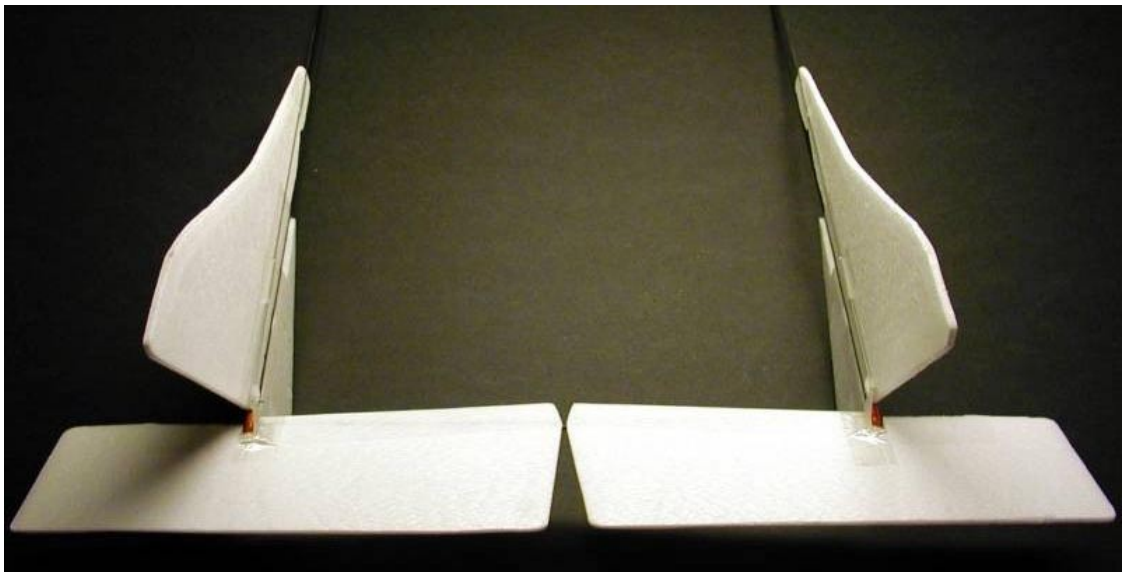


Image 77 - tail removed

Once assembled the surfaces should be free enough to just drop without any rubbing anywhere. Check for freedom of movement all around. Be sure there is no binding at the slots around the booms and enlarge slightly if needed.

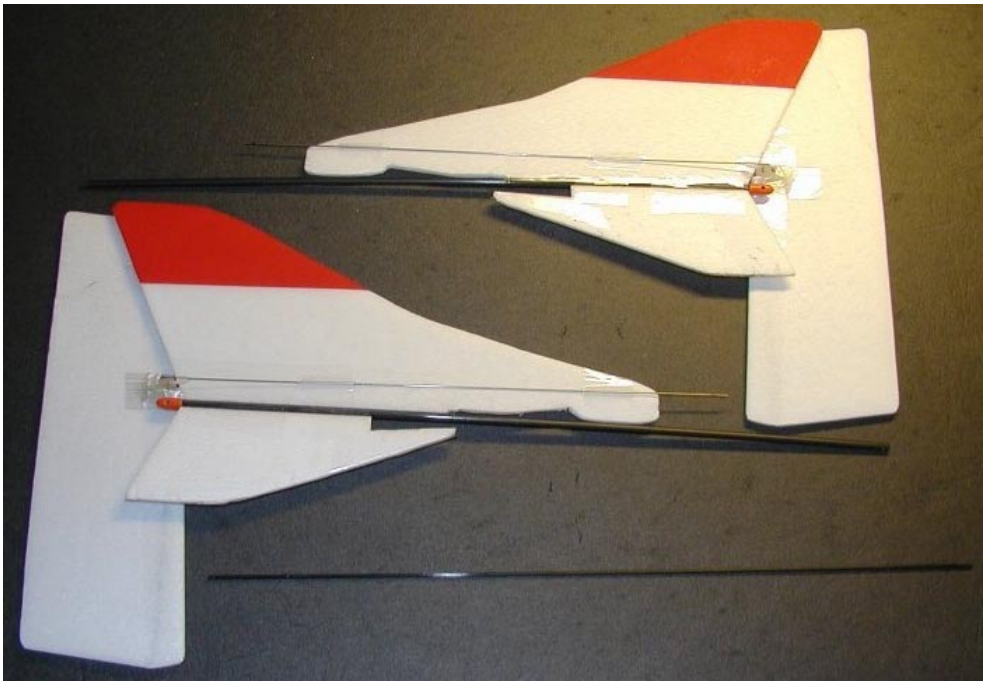


Image 78 - tail disassembled

The centers of the two surfaces should have a thin clearance between them and the ends of the sleeves at that location should be straight and smoothed in case they get together and rub. This is usually not a problem since the tail booms are spaced a tad wider, but check there after any hard landing or crash just to be on the safe side. Also check for any fore/aft movement either from the booms moving or slop in the taileron hinge. If a boom even slightly dislodges from a hard landing, your trims will be way off.

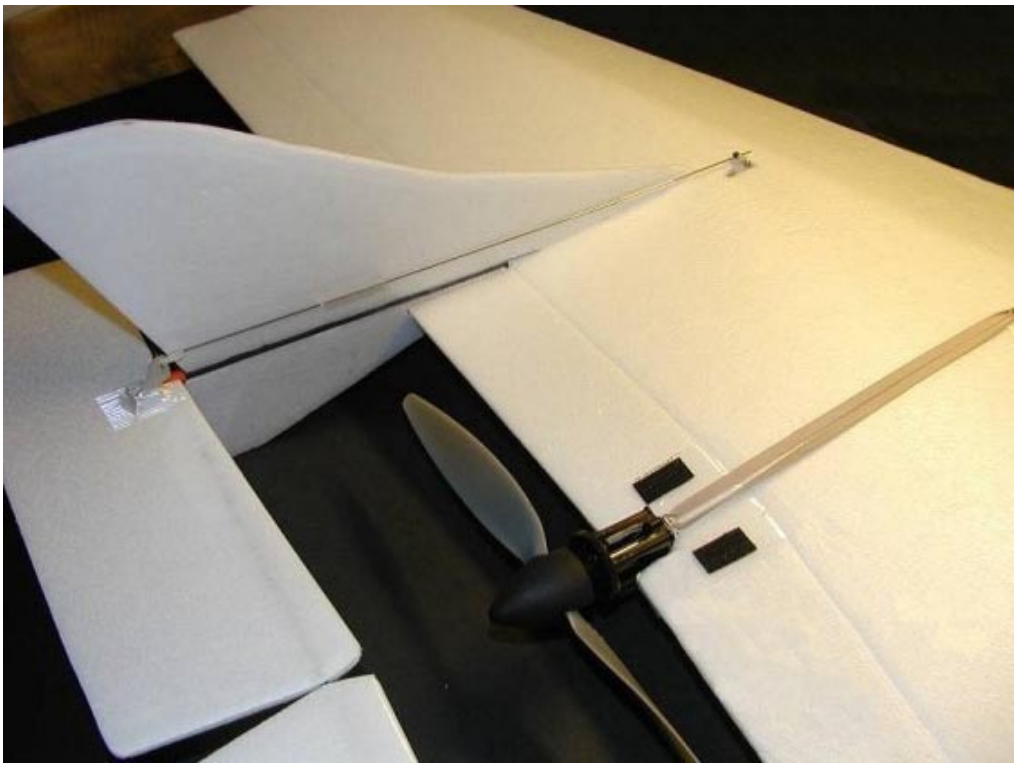


Image 79 - completed tail

Control Horns:

Depending on the type of control horn you are using, mount them securely into position as close to the inside of the notch in the control surface as you can. Be sure the linkage holes are dead center over the pivot rod on both sides with the control surface laid flat. If you are using the tiny micro horns, you'll want to reinforce the area around the spike that goes through the foam. You could epoxy on little squares of some thin stiff material on both sides like very thin ply or even some clear plastic you cut from some packaging would do. Tape over that if you like for extra security but think light.

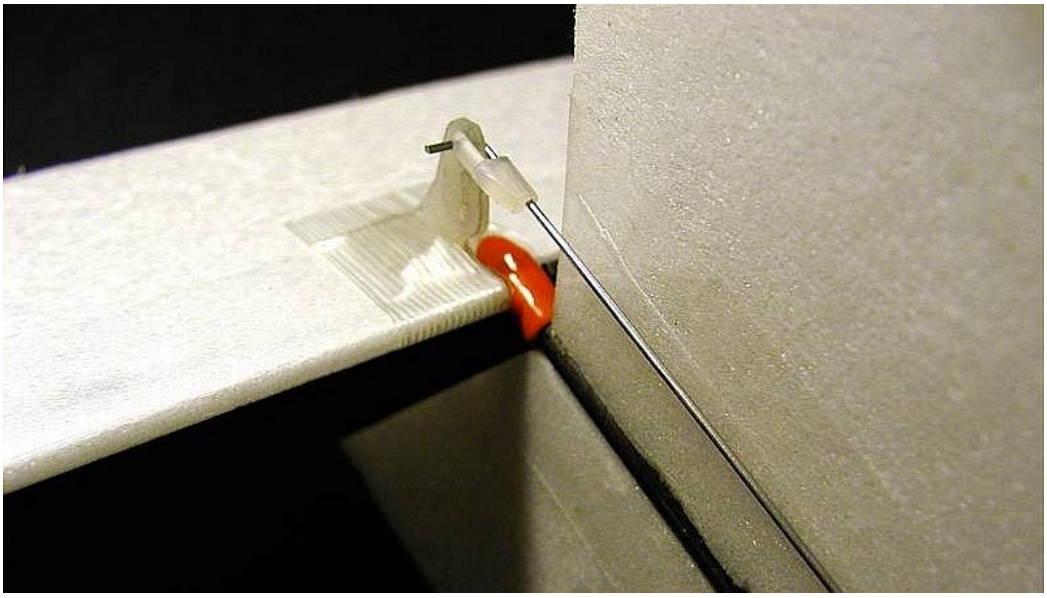


Image 80 - control horn

I've been thinning and shaping Dubro 1/2 A horns and seam taping them on plus covering them with strapping tape through a slit in the tape. They seem to be holding up so far, but sitting in the sun on a hot summer day may be a different story! Some people are using thin ply cut out horns and even shaped plastic bread wrapper closers and gluing them in with epoxy. Whatever you use, it can't be loose or have any play in the connection. No slop allowed, period!

Linkage:

Now cut four 1 1/2 inch pieces of your pushrod sleeve and slide two on each wire. Connect both ends of the linkages and see where the push wire lines up on the fin. Tape the sleeves to the front and rear areas of the fins being sure that you don't have them so close to the ends that the horns cause binding with full control travel. The fin layout picture shows the placement. Connect them to the outer hole on both servo and control horn. Use the screw connector on the control horn and the quick link on the servo arm for easy tail removal if using the Dubro micro pushrods.

Fuselage:

Here are your fuselage templates. Click on each image to open them in your editor or viewer:

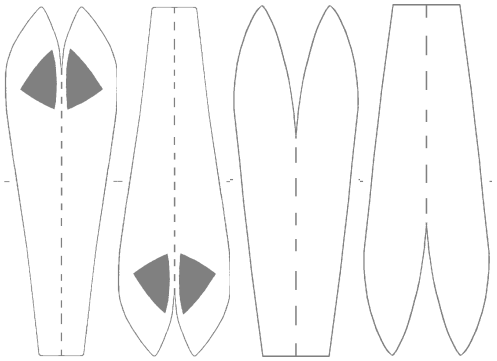


Image 81 - fuse templates

There is an upper and lower fuse template as well as a up and a down position print version of each. Since they need to be printed full size and are 16 inches long, unless you have a printer that can print this long, print all four of them to get both halves of the upper and lower templates. You'll want to print them out full size on standard 8.5x11 paper in portrait mode.

In your page setup for printing, be sure that there are no scaling or reduction settings applied. Also make sure the "fit page" and "centered" boxes aren't checked either. This way you will retain 100% size even though each image runs off the paper. When the top and bottom half of each template is overlapped to the reference marks, the overall length needs to end up close to 16 inches.

If your program for some reason changes the DPI (dots per inch) of the files or for whatever reason scales them differently, then you'll have to compensate by using the programs reduction or enlargement capabilities to end up with the required 16 inch lengths.

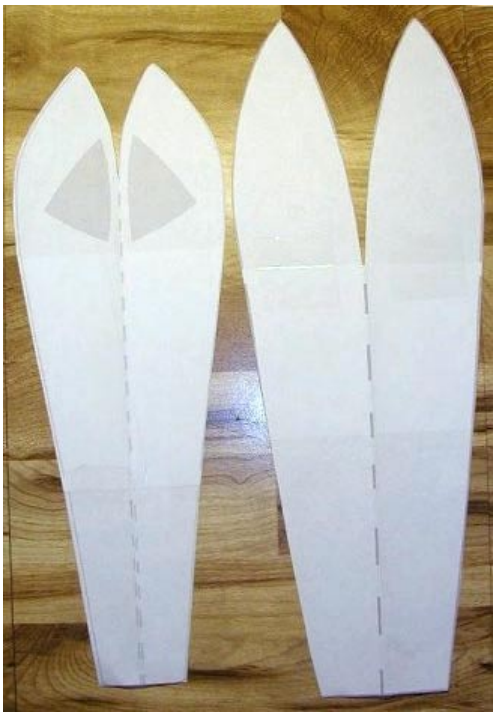


Image 82 - fuselage templates

Tape the halves together for both patterns lining up the marks by holding them up to the light and seeing both pages marks at the same time. Keeping them in this position, tape across the seams on both sides and cut them out. Now place them over the foam and cut the foam to match cutting straight down the sides.

Image 83 - cutout foam

Next, layout a center line on both. Measure out and mark or eyeball 1/4" on either side of the centerlines and with a single-edge razor blade, slice a V down the center only going about 1/2 way through the foam. This can be done all at once if you're good freehand with two angled cuts or by starting with a straight cut down the middle at the proper depth and then slicing out the side triangles with separate cuts.

The last method gives you more control over the operation as you can open the center cut up on the edge of a table and see where the blade should come out for the proper depth. Make the side cuts at about a 45 degree angle. This notch isn't too critical since it will be glued back together and won't show since it's on the inside anyway.

Image 84 - beveled and center notched

Using a hot glue gun, 5 minute epoxy or other glue that you have tested to work on the foam you are using, run a thin bead down the middle and hold or jig to dry in position.

You don't need a lot of glue here, just enough to hold the shape. For heavy epoxy and hot glue, just tacking it every so far will be good enough. Note the bevel edges explained in the next steps are already done in this picture.

Image 85 - center glued

Next bevel the front center dart edges being careful you don't change the exposed edge pattern line since if not straight and even, it will show up as poor seams on the outside. Do these at about a 45 degree angle also getting as close to the outside edge as you safely can but not into it. Glue them also. You now have a couple of foam boats.

Image 86 - top half inside

Image 87 - top of top half

Now you need to bevel the outer edges all around except for the backs following the same caution as for the darts. Once done, your fuse halves edges should allow a straight edge to be laid across them anywhere along the lengths and it should lay fairly flat and even. Finally we'll join the two halves at the nose. Measure back five inches from the point and make a mark on each side of the insides of the top and bottom fuse halves.

Image 88 - wing location mark

You can position them now on the wing to verify that this location will fit nice and that the back of the fuse reaches to about an inch from the TE.

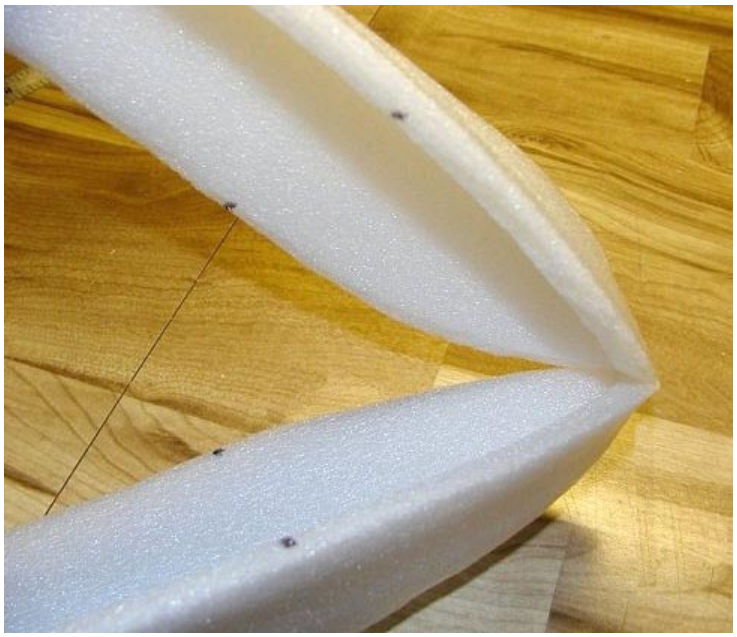


Image 89 - glue together

By the way, this last seam is the only place we've experienced any damage from hard nose-ins. When the wing continues moving forward on impact it wants to open this seam up. If this happens to you at the field, just throw a rubber band around the nose until you can re-glue it back home. If you are a novice pilot that might nose-in a lot, you might consider gluing thin strips of Velcro pieces every so far around the nose to make your JSF even more crash proof.

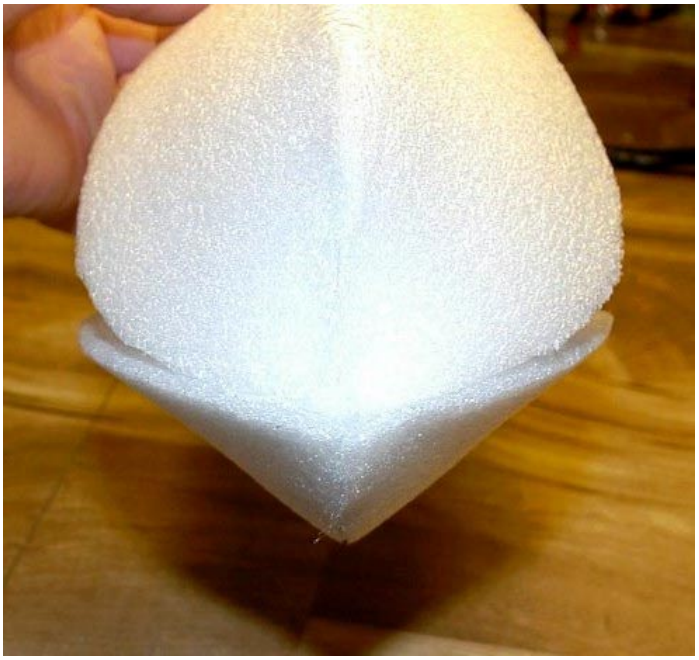


Image 90 - nose job

Start at the two nose points and tack them together getting them to come to a nice point. Work your way back each side seam keeping it even at the edges and symmetrical as you go. Stop at your marks. Don't use excessive glue at the marks to make it "stronger" as a crash will then rip the foam and not the glue. I'd rather re-glue a seam that opened than remake a new fuselage!

You can cut out some contact shelf paper or colored label paper to your liking for the cockpit windows. Use the template windows for a pattern if you want.

Image 91 - completed fuse

Finally, fit the fuselage on the wing pulling it snug and centered over the nose and mark where you'll need to put some Velcro squares on the TE of the wing top and bottom. They pull off the fuse foam pretty easy, so consider gluing or even sewing them on it.

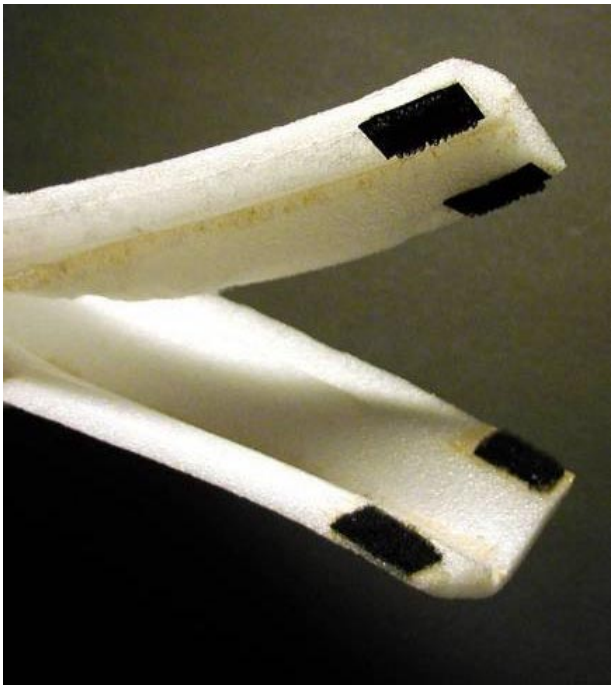


Image 92 - Velcro attachments

Add a couple cooling inlets on the bottom about 3 1/2 inches forward from the back. These also double as finger holes for launching.

Image 93 - air inlets

By putting your index and middle finger in the holes and balancing the plane on the thumb and remaining fingers at about the CG, you'll have a secure grip for a controlled launch.

SC Elevons:

To make your TT into an SC wing, construct a pair of new fins as shown. Use your original fins as a template for the tab and wing contour shapes.

The booms only need to be about 10 inches long since the back of the boom must end at the TE of the wing. The overall length (fore/aft) of the fin bottom will be no longer than from the front of your fin slot to the TE.

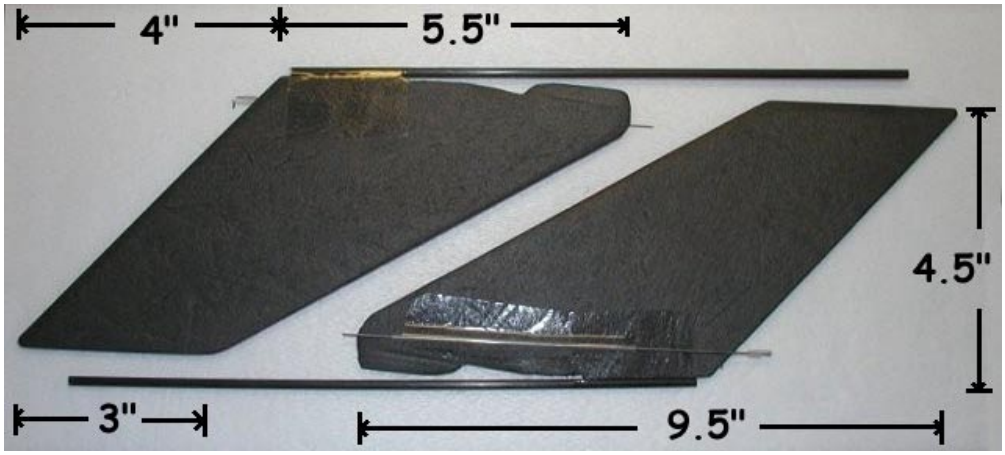


Image 94 - SC fins

These fins have to be short enough to not restrict the elevon movement that hinges beneath them. Tape the fin to the boom at the straw end location back to the boom end. Since we don't have a lower fin, just wrap the tape around the boom onto both sides of the fin.

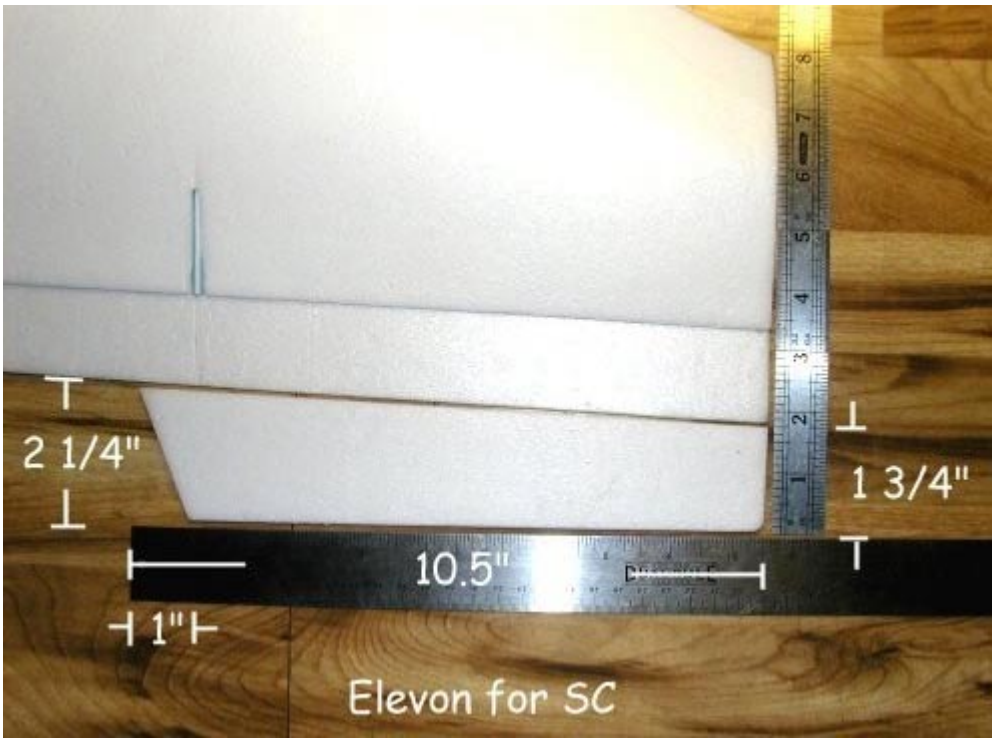


Image 95 - elevon layout

Cut out the elevons as shown and hinge them with packing tape to the TE of the wing. See the aileron section for details on making a tape hinge. Be sure your control horns are good and solid even if you have to reinforce around them. Control slop is even more unacceptable with this model so be careful. Use the same type linkage as on the TT but since the distance is shorter to the control surface, just use one piece of sleeve taped to the fin.

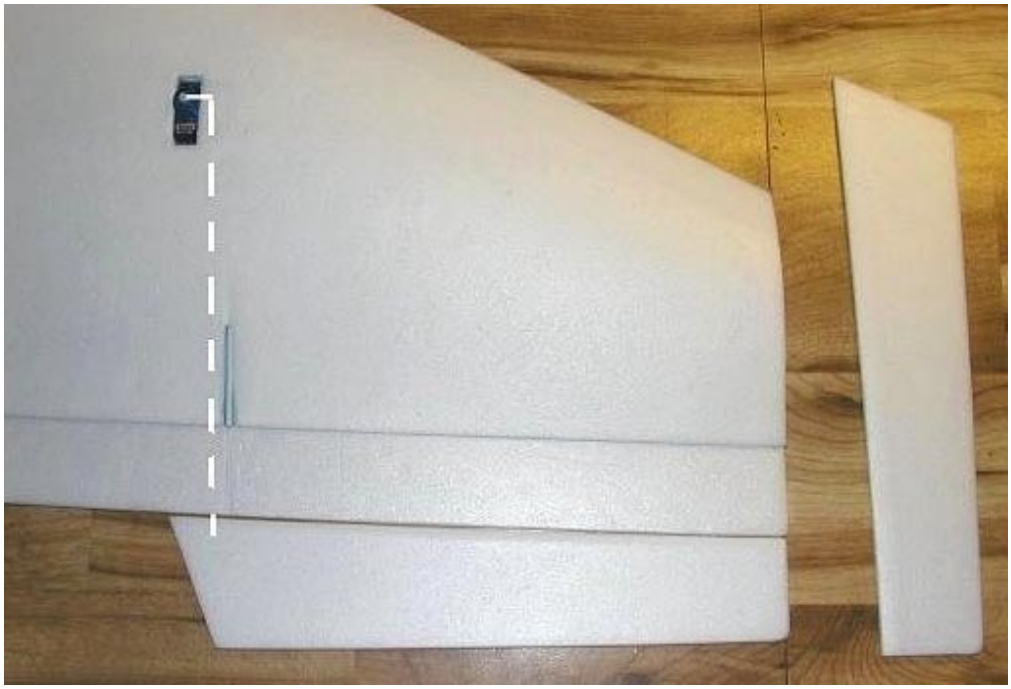


Image 96 - elevon control layout

You should be able to use your same settings as for the TT model, but you won't need near as much travel. If you don't have a programmable radio, set your linkage on the outer hole on the elevon and drop in to the second or third hole on your servo horn. Work your way out on the servo arm as you get proficient controlling it. See the flying section for more notes on setup.

Image 97 - completed SC

SS Ailerons:

Once you've mastered the TT and SC models, you're ready for the SS model. Don't try to just connect the elevons on an SC as ailerons since they are far enough back to effect pitch as well as roll. Cut them off if installed and cut back the single foam area of the TE of the outboard sections of the wings.

Image 98 - TE cut

Cut your ailerons to shape or use your elevon pieces trimmed at the root. The TE pieces you cut out could be used also, but for style, you can't beat the tapered look.

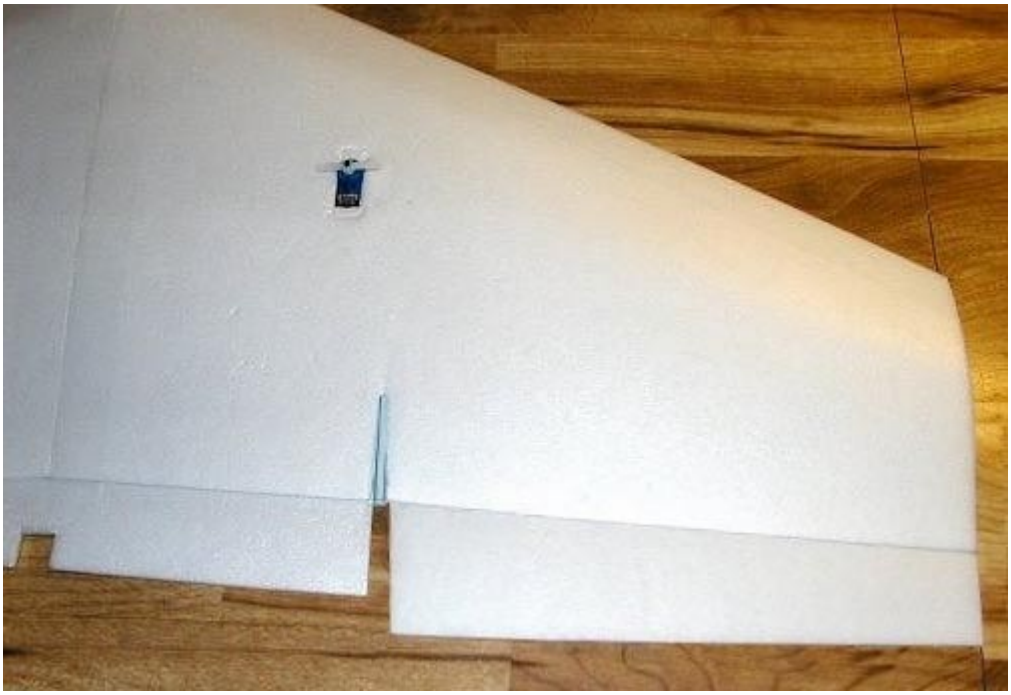


Image 99 - aileron layout

They are simply 2 inch wide at the inside and 1 1/2 inch wide at the tip. Make them square to the TE and about 9 3/16 inches long (or whatever is needed to clear the fin). As always, cut them along the grain.

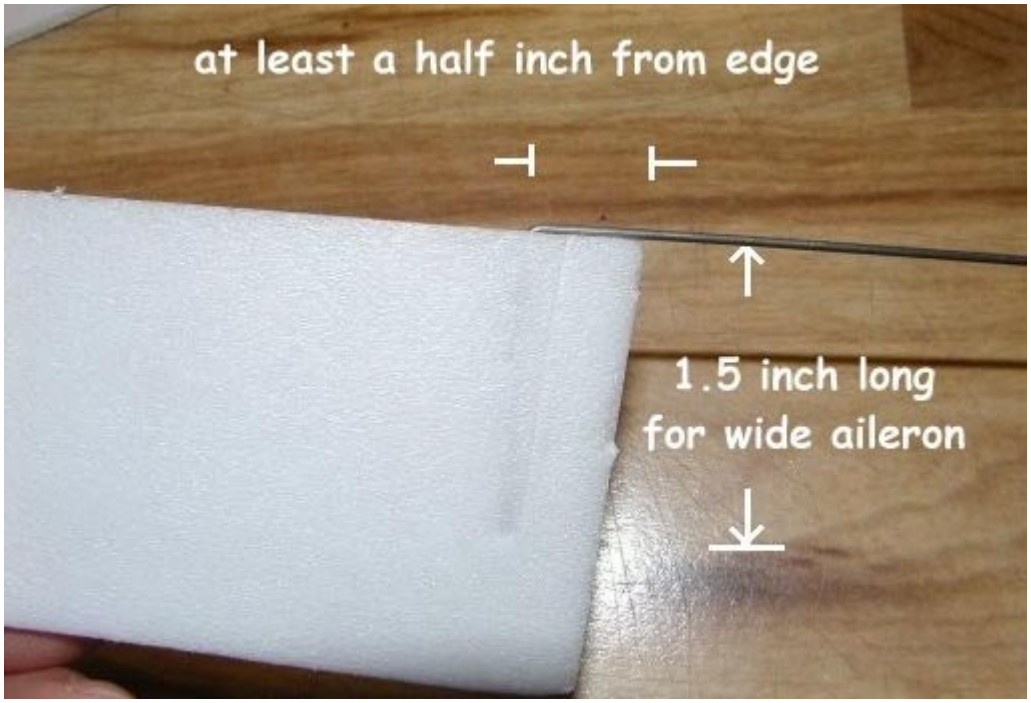


Image 100 - torque wire

Construct wire torque linkages from two 7 inch lengths of .047 spring wire by starting with the bend that goes in the aileron. Make this leg 1 1/2 inches long (or 1 1/4 inch if you are using the existing TE piece). This bend should be a sharp 90 degrees.

Image 101 - aileron hole

Take a large needle (not the wire itself) and pierce the hole centered in the root hinge edge of the aileron at least a half-inch in from the edge. Using the wire bunches up the foam but a needle compresses it first. Be careful that you stay centered in the foam and that your hole stays parallel to the aileron edge.

Image 102 - fit wire

Carefully work the wire in and once seated, press it in some more to recess the edge the wire rests on.

Image 103 - recess wire edge

To strengthen the foam in the hole, add a couple drops of white or yellow glue (no CA on foam!). Reinsert the wire and tape tightly over the edge to hold it in place securely. Let dry overnight.

Image 104 - tape wire in

Tape Hinges

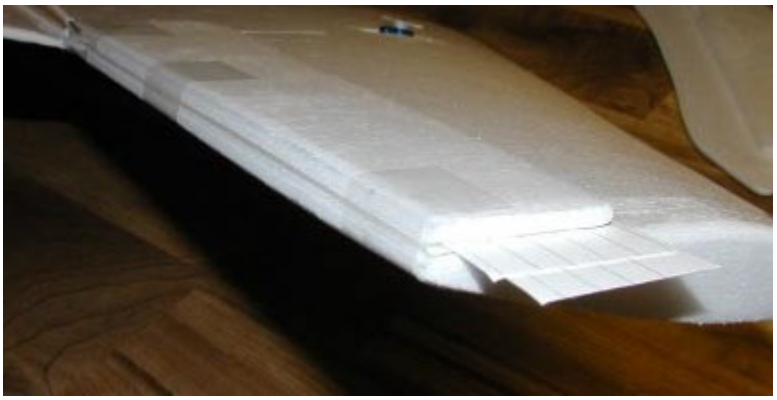
The best way I've found to install tape hinges on ailerons or elevons is to lay the surface in position with the wing flat on a table. You want a nice even gap of about 1/6 inch between the wing and control surface. While maintaining this gap, run 2 inch wide tape centered down the hinge line on the top. Trim flush at the ends and press on well.

Image 105 - top tape - down aileron

Now flip the wing over the edge of the table. Using a hard and flat "tool" compress both edges on an angle to allow the surface to drop down far enough for freedom of movement as shown above.

Image 106 - bevel edges

For the bottom tape, flip the surface all the way up and over on it's back on top the wing. Put about a 1/16 inch thickness of card stock under it to the edge against the tape as a spacer to hold your gap.



Be sure you don't overdo it and have your tape start pealing off. Then just add some strips of tape all the way from the bottom of the control surface (now up), around the edges, and under the wing. Press these well into the foam and at the gap against the top tape and you should get something that looks like this.

Image 107 - lower tape

Fold the surface back down and check for binding and freedom of movement to the down position. If binding is present, you can compress the inner edges some more until free.

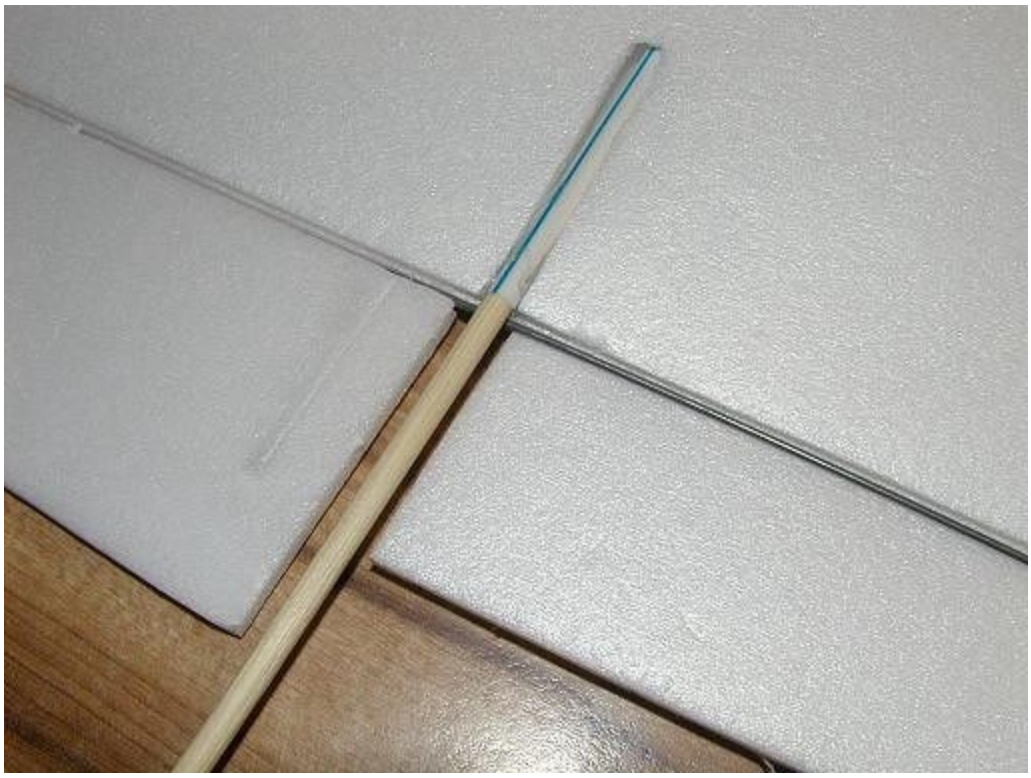


Image 108 - torque wire

Torque Linkage:

The torque wires runs under the booms. This can be a problem area so insert one and test the motion range again. Since the surface is hinged from the top and the rod wants to rise with the surface we need to make some room for it. By compressing the wire into the TE next to the boom, we can get enough clearance.

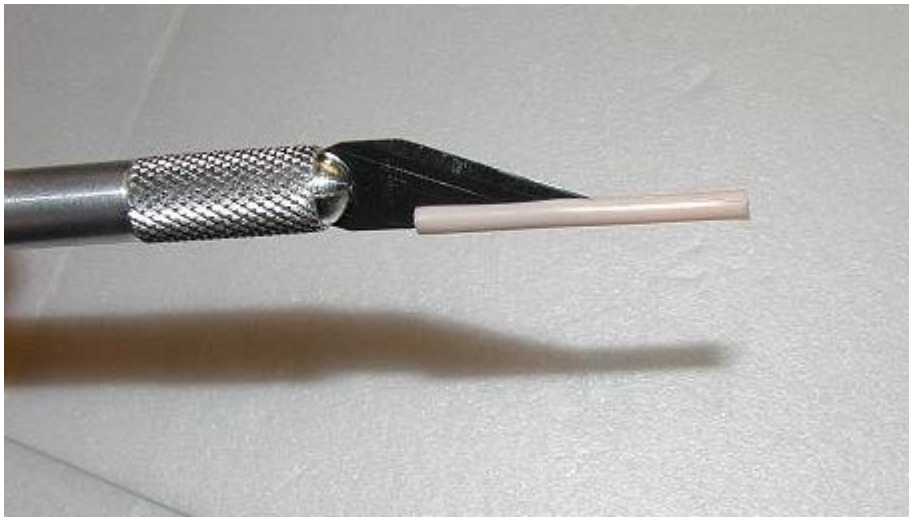


Image 109 - thin sleeves

You'll need two 1 1/2 inch long slip fit sleeves for these wires. If the ones you find are slightly oversized, you can trim them down by slicing lengthwise and taking out a thin sliver. Since they will be taped or glued down, you can hide the slot underneath.

Tape sleeves described earlier can be used if you can't find a suitable material. Locate them as close to the horn as possible without any binding. Be sure that you get a slip fit and not a sloppy or tight fit. Some pictures show an extra sleeve next to the boom but I found it wasn't really needed.

Image 110 - ailerons installed

Before attaching the sleeves to the wing, we want to bend our "horn" up for the servo pushrod connection. With the sleeves in place, measure in from the boom line 4 inches on the wire. With the control surface flat, bend the remainder of the wire straight up at a hard 90 degrees. Do this with the boom inserted to aid in leverage during bending and reduce the tendency to loosen the wire where it attaches to the control surface. Trim the upturned lengths to 1/2 inch long. Now you can hold down the sleeves and test their operation with them over the edge of the table. We want no binding, and no slop.

Image 111 - make horn

Find some of your left over control sleeve from your mini pushrod linkage. This sleeving fits nice and tight on .047 wire. Cut a couple lengths of it 3/4 inch long and stick them on 1/2 inch over the end of some scrap .047 wire. Take some pliers and smash the extended tube end flat. Now with a long point hobby knife, carefully bore a very tiny hole just above the end of the wire from both sides. Take your .023 linkage wire and work it through the hole. If it has any slop, just make another one as we need a nice fit here.

Image 112 - pierce tube

If you are careful you can mount your adjustable screw connectors on these fittings. You need to press both sides of the tubing over the little peg on the connector being sure that they get down past the barb. I used thin needle-nose pliers to straddle the peg to do this.

Install these tube fittings on the ends of the torque wire horns. They need to be very tight. A drop of CA or Loc-tite on the wire couldn't hurt if in doubt, but do it later so you can line up the angle correctly for the linkage to the servos.

Third Servo:

By installing a third servo in the top center of the wing just in front of the rear spar, we can hide it under the fuselage top, easily access the wire to the receiver, and not effect the CG.

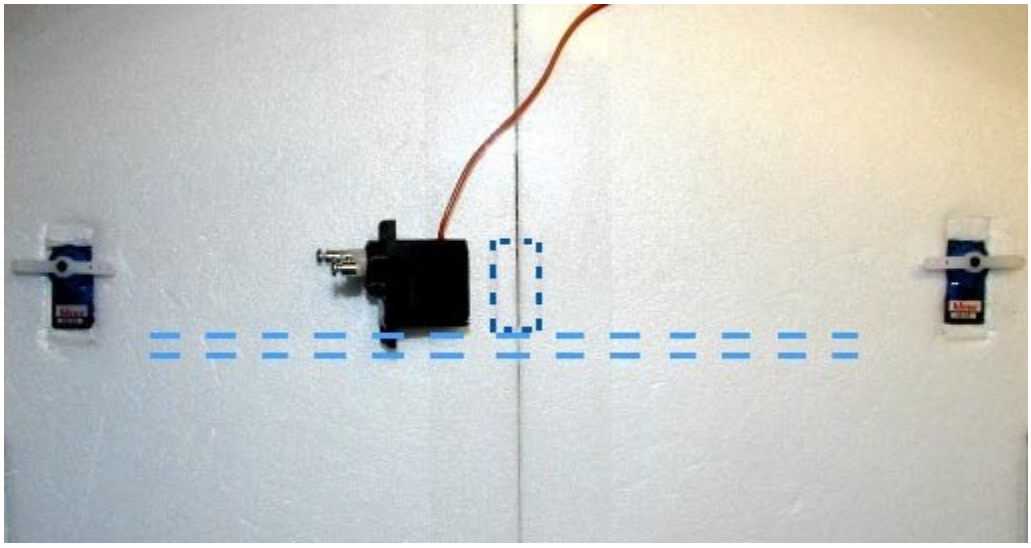


Image 113 - third servo

Use your servo to mark the dimensions of the cut. If you can't see the spar through the seam in the top wing panels you can hold it up to the light and find it.

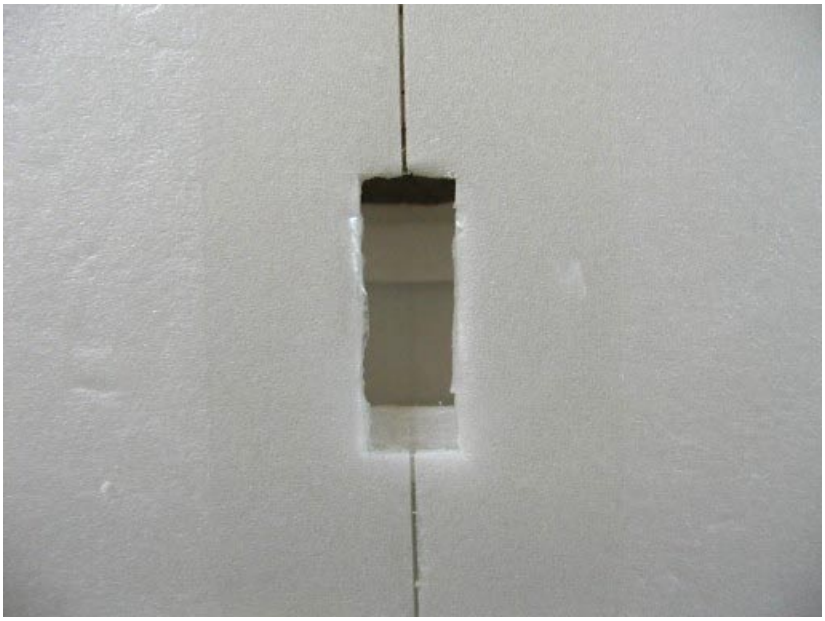


Image 114 - servo hole

We want the servo as low in the wing as possible so trim out the servos rear mounting tab location over the spar to recess it. The GWS servo I used bottomed out this way in the rear but needed the foam shim under it in the front to seat even that can be seen in the hole above. Transfer tape the servo in tight onto the spar and shim, hook up your lead to the receiver and we're about ready to go.

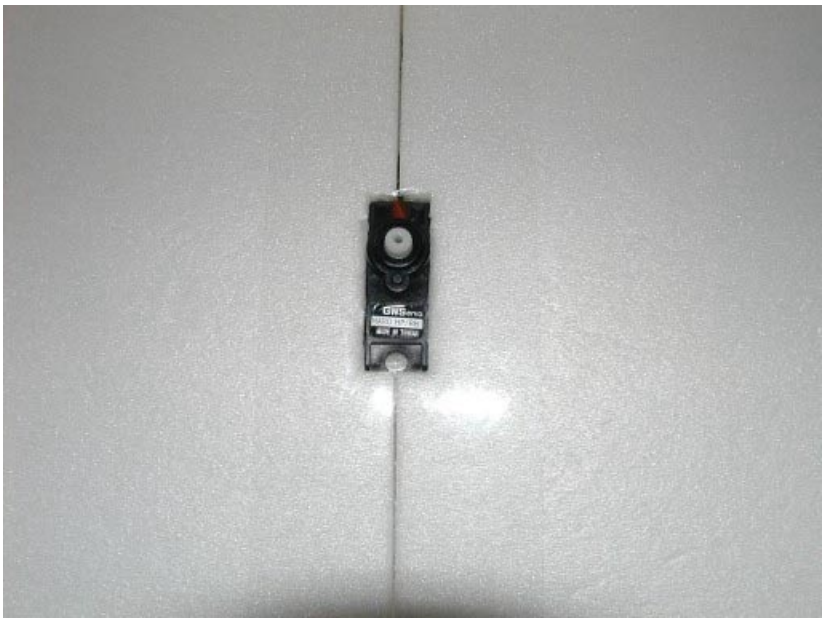


Image 115 - installed servo

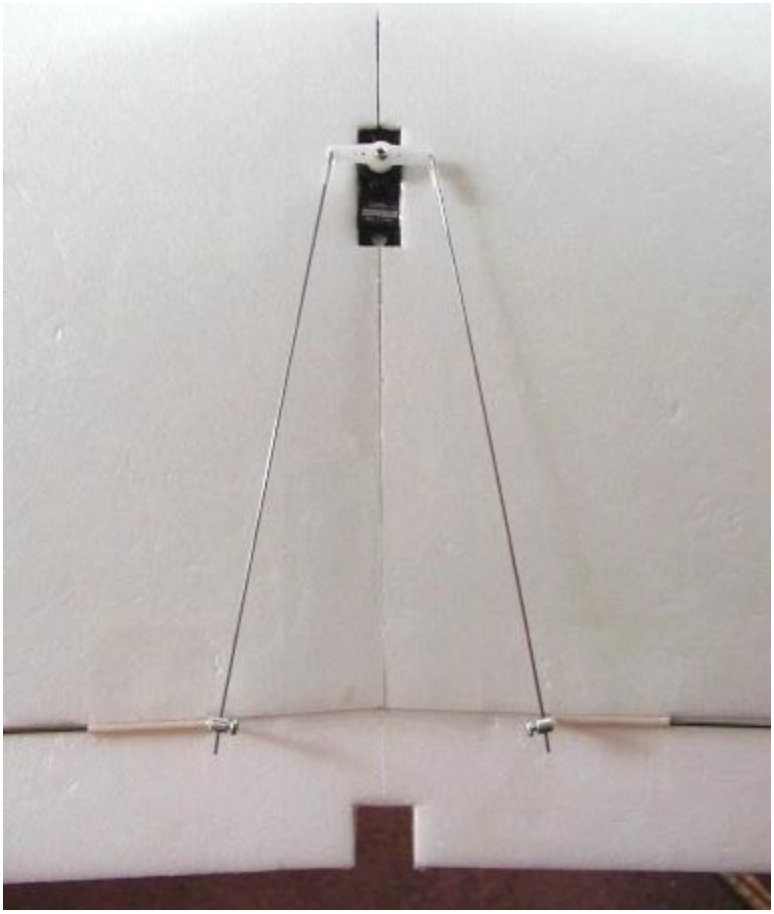


Image 116 - completed linkage

You'll need to thin out the inside of the top of the fuse above the servo as well as add a couple slots for the pushrods to run out.

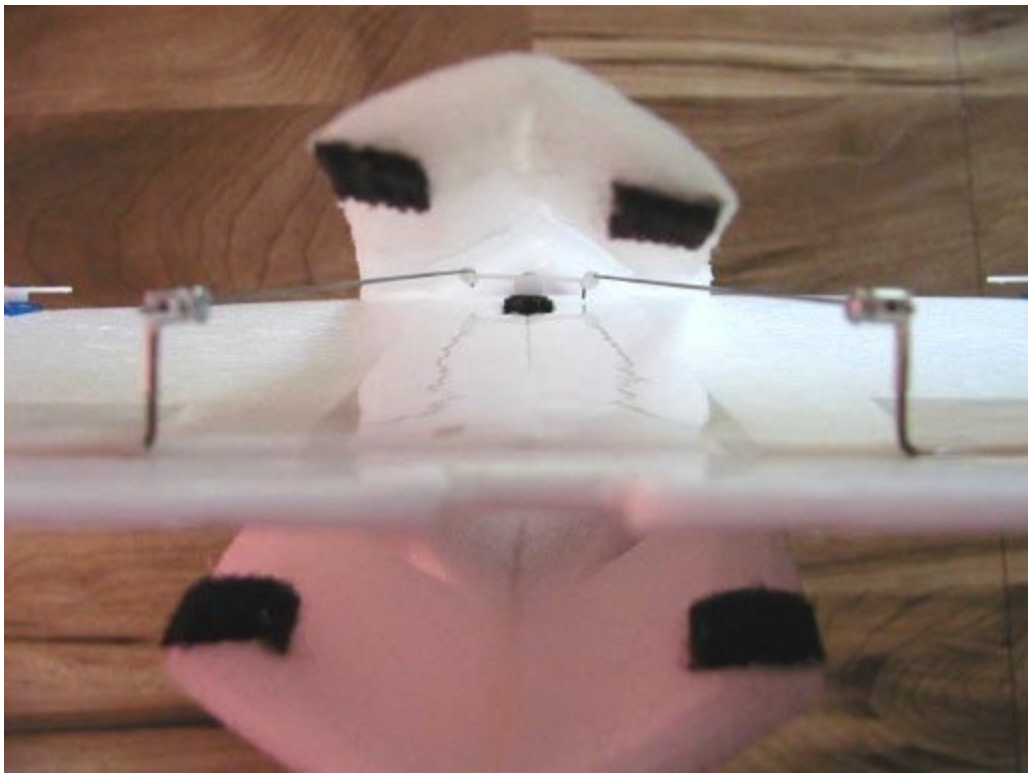


Image 117 - fuse fit

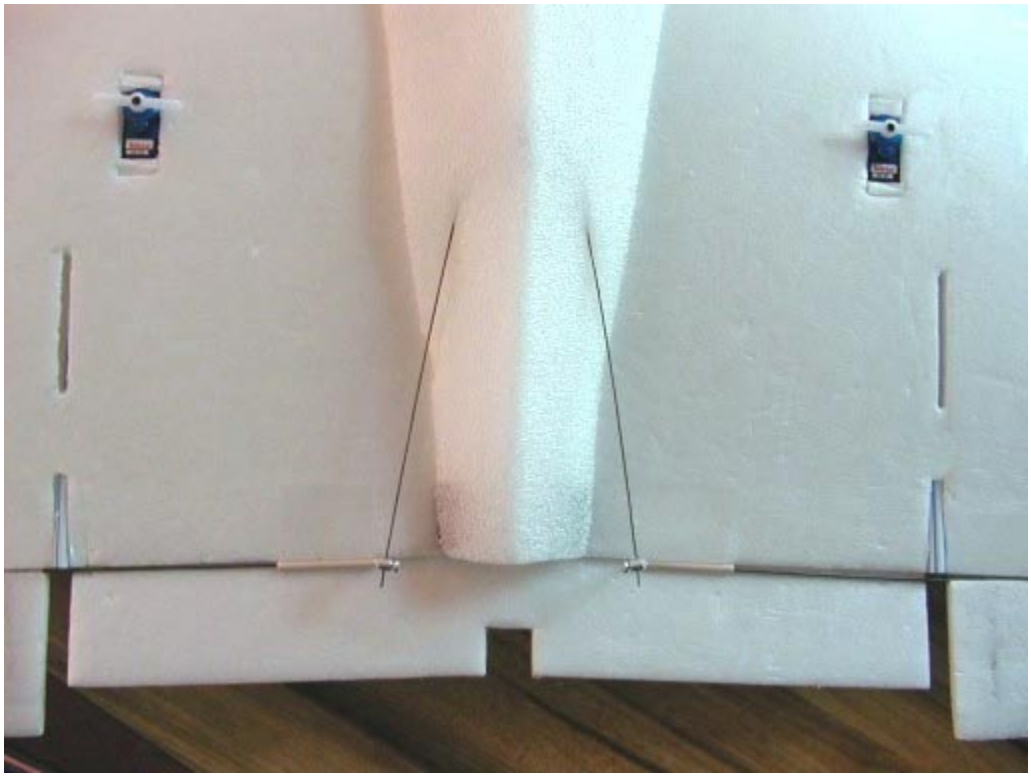


Image 118 - linkage slots

You'll also have to deal with the motor mount rubber bands wanting to go through your third servo. Without taking the linkage loose each time to change bands, here's one solution. Just make sure they don't restrict the servo movement.

Image 119 - servo location fix

Motor Systems:

GWS IPS:

First we need to modify the gearbox a little for use as a pusher and relocate the prop. VERY carefully remove the tiny cir-clip from the back of the drive shaft. Keep your hand over it the entire time because it will make a leap for freedom once it pops loose!

Image 120 - remove cir-clip

Note the location of the prop from the writing on it. This is the correct way for pusher operation which is opposite of the normal mounting that it is used as a puller.

Image 121 - disassemble drive

Now remove the washer there and slide the shaft out of the bearings.

Image 122 - put washer on shaft

Put the washer on the shaft up next to the drive gear and reassemble. This washer normally takes the thrust from the pulling load on the back of the shaft. We will need it to take the pushing load of the motor so it needs to be relocated.

Image 123 - reverse polarity to motor

Also, when connecting to the ESC, switch the motor plug (and only the motor plug!) backward (red to black) so the motor runs in the opposite direction.

Motor Hanger:

You'll need to make a little wire hanger for the motor to hook the rubber band on. You could loop it through the frame but every way I tried it, it resulted in rubbing the drive shaft, which is not a good thing. Start with a spread open large paper clip. With the motor of the drive facing down, stick one end in the little back hole on one side at the bottom of the drive near the end of the motor and bend it up.

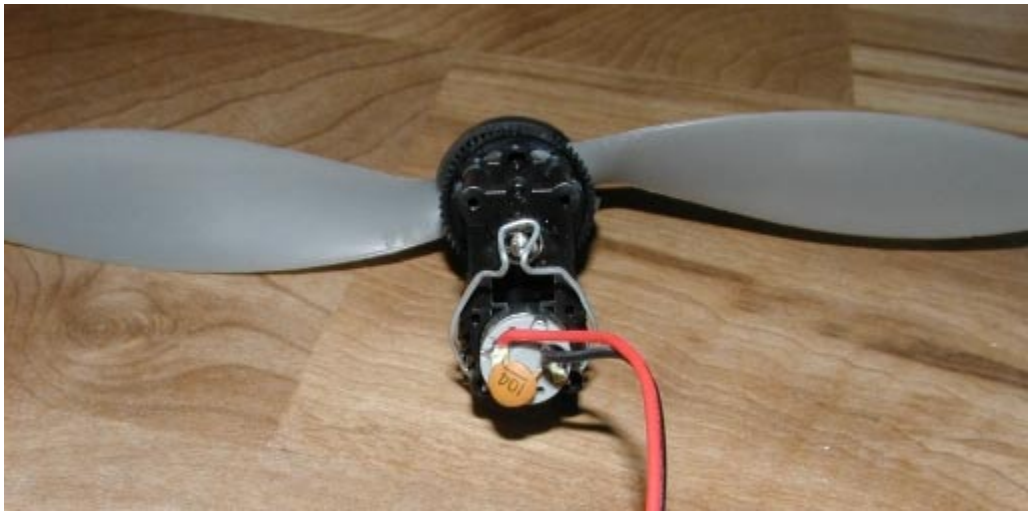


Image 124 - hanger back view

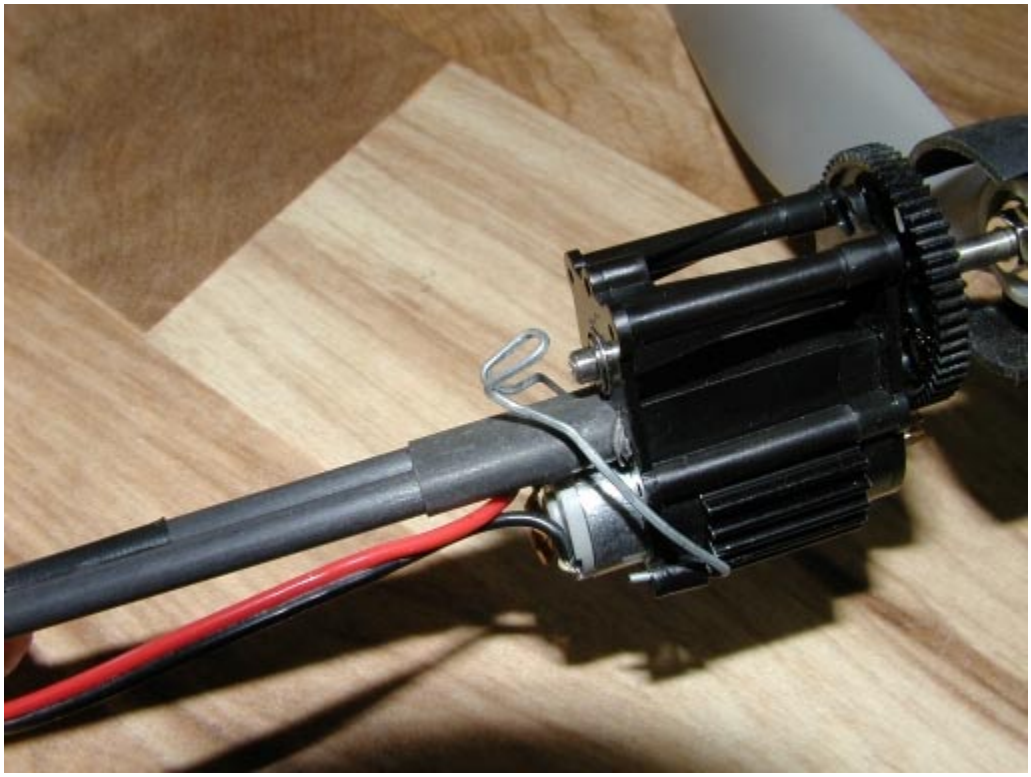


Image 125 - Motor hanger complete

Shape it up and around the back side of the drive and once about a 1/2 inch above the drive shaft, do a 180 degree turn with a pair of needle nose pliers and follow it back down to the other hole. Bend the leg on it for the hole and cut off the excess. Now work it into the hole, shape the whole thing tight against the drive with the top tapering together, and curve the top loop into a hook for the rubber band to hang on as shown.

Image 126 - hanger removed

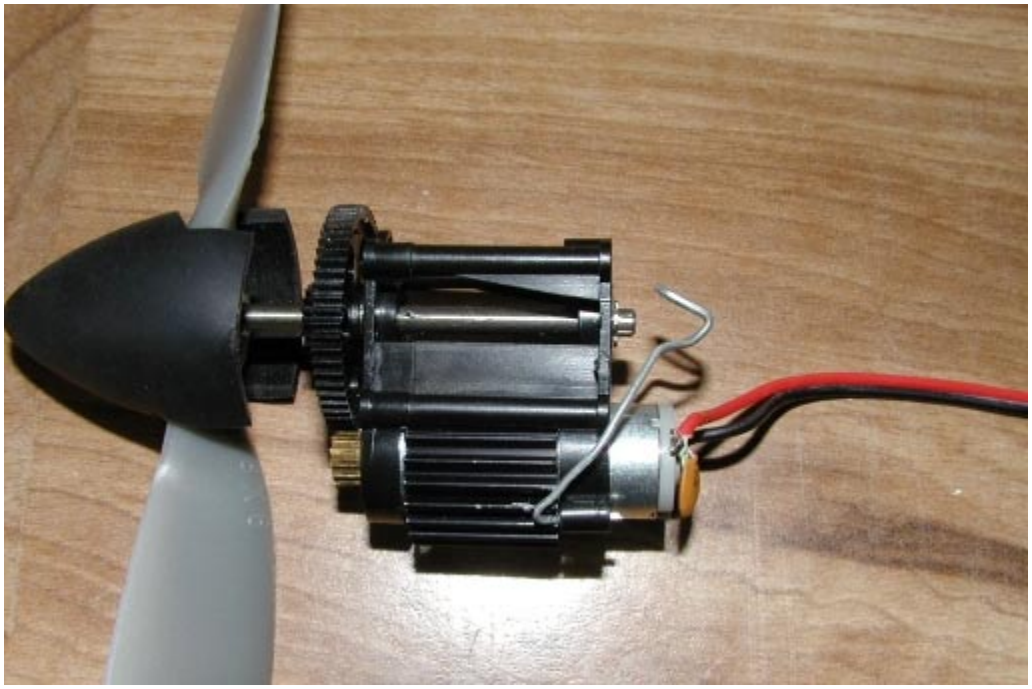


Image 127 - hanger side view

Motor Rails:

Cut your two 15 inch motor tubes and add an inch and a half long piece of 1/2 inch diameter heat shrink tubing and leaving a little extra over the ends, shrink it on over the ends of both tubes held together. You could just add a single wrap of clear tape on them instead but it may loosen up in time and need to be replaced. Test fit the tubes into the slot on the drive frame and be sure to achieve a tight fit.

Image 128 - motor mount

It's been said that since CF and graphite tubing are conductive, you shouldn't let them touch together to prevent possible radio interference. I can't confirm this but just to be safe, add a couple small pieces of tape in couple spots along the length between the tubes to prevent them from rubbing.

Image 129 - frame front top

On the front of the tubes, use your vinyl tubing to connect the ends together. It doesn't take much; just enough to stay on tight or you can use some more heat shrink.

Image 130 - hook and loop side

Take a 3 inch piece of hook and loop tape and stick it to the front of the tubes starting just behind the end. If you already have some on your batteries for other planes, be sure to use the opposing side tape for the motor rods of course.

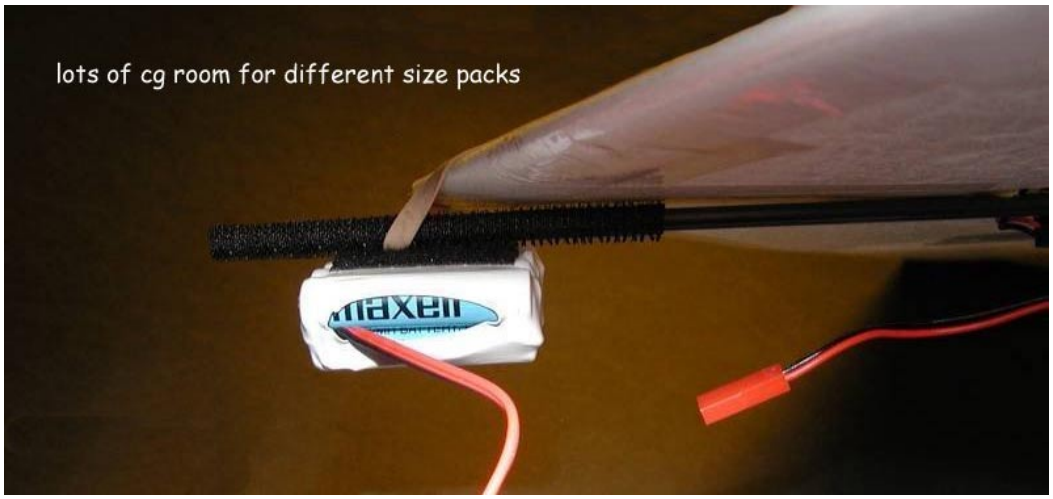


Image 131 - battery location

I put about an inch and a half long piece on the pack and it holds fine.

As for the batteries, the 7 cell 700 mah NiMH AAAs we use weigh 3 ounces. Fewer cells are okay, but more cells are not. NiCads packs usually use one less cell that NiMHs packs. I make my own packs of Maxell brand AAA cells from Electric Goldmine surplus for $1 each:

http://sales.goldmine-elec.com/prodinfo.asp?prodid=3952

I routinely get 20 minutes duration per flight at full throttle. They are a little heavier than their equivalent NiCads, but I don't notice it in flight.

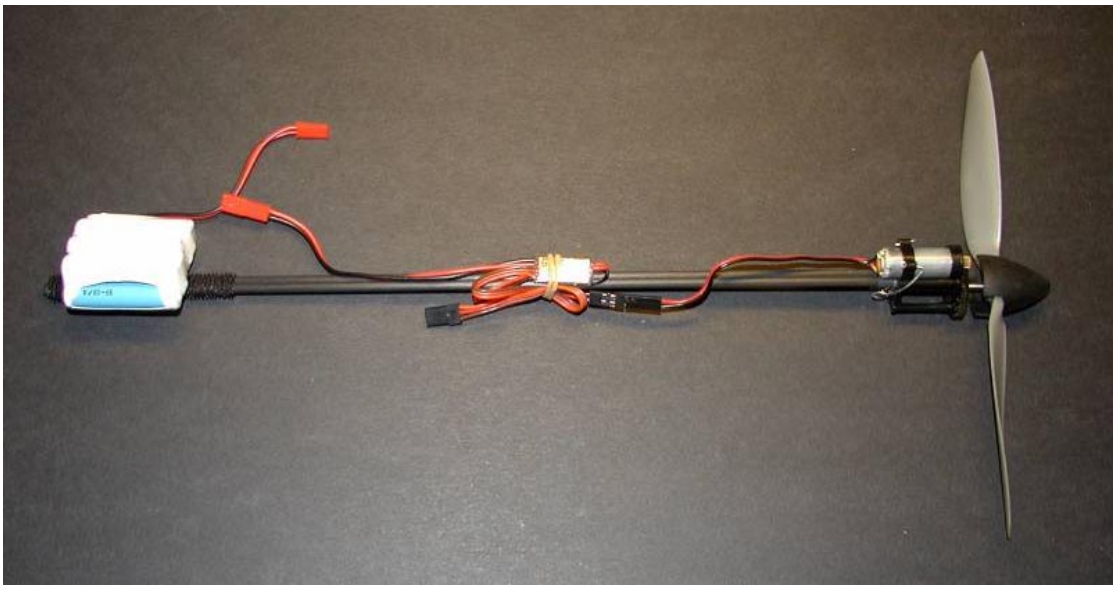


Image 132 - complete IPS system

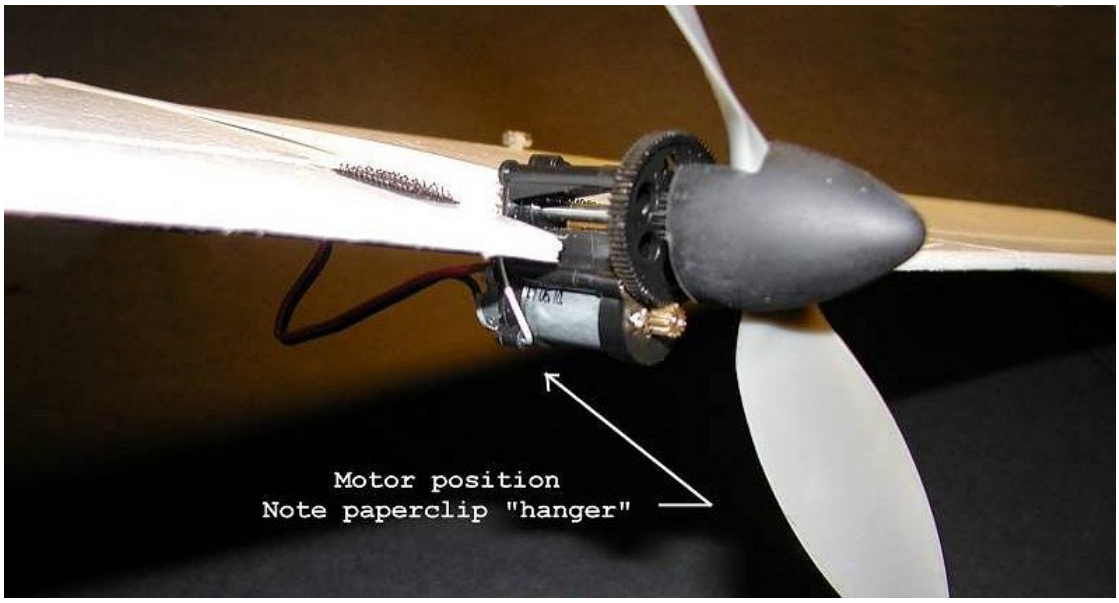


Image 133 - motor attached

Power Options:

Upgrades we've tested or know will work range from a dual IPS, Johnson 250, S280 drive, and even a S300 drive for ballistic performance. The wing itself is strong enough for a S400 direct drive with light cells, but you'll probably want to use larger servos (HS-81s size) and/or stronger control connections for the higher speeds it will reach. Since the JSF will be able to cover ground very rapidly, you'll want to use a full range, dual conversion receiver like the Hitec Micro 555 or equivalent.

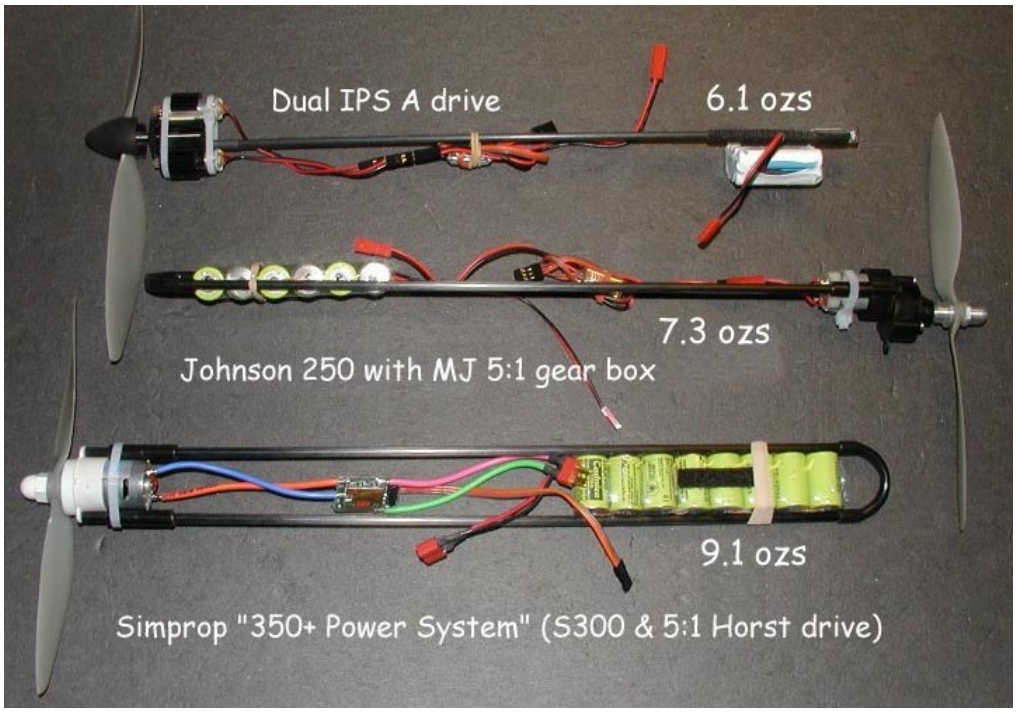


Image 134 - motor options tested

The Johnson 250, S280, and S300 drives with Horst (Simprop) or MJ 5:1 drives can be easily setup for the JSF. These systems can use the same 7 to 9 cell NiMH packs (depending on motor requirements and prop) mentioned above or 6 to 8 cell 600mah AE NiCads for more thrust but less duration. Here's the link to the MJ drive shown used with the cheap Johnson motor. There are also other brands that you can see and compare their specs at the Hobby Lobby website:

http://www.hobby-lobby.com/gear280.htm

They come in many sizes and some with or without ball bearings. The Johnson 250 motor is the same diameter as a S280 so get the correct one if you want to try one of these. The motor is available at Electric Goldmine surplus for a $1 each:

http://sales.goldmine-elec.com/prodinfo.asp?prodid=3009

The MJ box is a little heavy compared to the Horst drive like the Simprop system uses, but it is enclosed, quiet, and more durable by design. Both it and the Horst can be mounted the same way to your motor frame booms.

Image 135 - Johnson 250 & MJ drive

Here's how to deal with the ends of the tubes for any larger motor that mounts this way.

Image 136 - motor mount tube ends

I found some very thin stiff nylon tubing that could be fitted in the end. Be careful you don't split the CF tube. I used a very small machine screw that I pre-threaded into the nylon. Wood screws will split it every time. If this happens to you, you can wrap thread around the end and add a drop of CA (super-glue) to it. For wood dowels, undersize drill a hole in the end for a thin machine screw. Again, watch out for splitting from too fat a screw for the hole. Better to tap it to size first by screwing it in a little, backing it out to clear any shavings, screwing it in a little more, backing it out, etc.

Image 137 - motor mount front

Connect a length of vinyl tube for the front and I just use a couple rubber bands to hold the battery pack since the AE cells I like with these motors fit snug between the tubes.

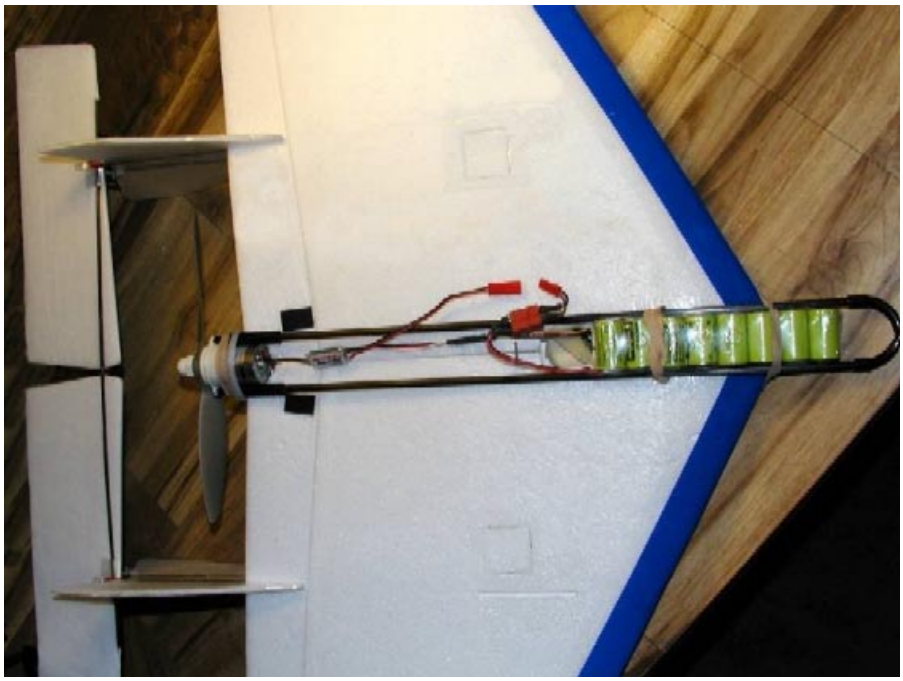


Image 138 - Simprop "Power System"

The motor rails simply rubber band over the top of the wing. Use two laced together for the proper length and double that for safety. Hook them under the gearbox and up through the slot. The wire tie lock sticks up through the slot for alignment.

Props:

I've tried a lot of them and for this plane I'd recommend (besides being in the correct range for the drive of course) using a size that has a pitch of more than half the diameter to get the full speed range from it. It will still fly nice and slow for you with these. Also, in the IPS class, try other drives such as the S1. This is a lower ratio than the "A" drive and uses a smaller diameter prop. I like the 9x6 for the "A" and an 8x6 for the S1.

I don't like the GWS props due to the thin hub that promotes breakage but I love the APC slow flyer and “E” props for the bigger motors. Use a thin slice of rubber fuel line to fill the gap between the adaptor ring that comes with them and the skinny GWS prop shaft. Also tighten the prop on very well since as a pusher, they have a tendency to loosen instead of tighten as on a puller due to the reverse direction of rotation when used as a pusher. This has the advantage of saving props however if you inadvertently drive the plane into the ground with the motor running. Instead of breaking it, it just comes loose on the shaft or unscrews altogether!

Image 139 - climb-out

Flying:

If you already know how to fly at least rudder and elevator slow fliers, you should be able to jump right in with the TT model and quickly advance your skills. Pitch is more sensitive than you'll probably be used to so keep your servo travel reduced to start. Always keep your planes attitude in check as it can change fast especially in turns. You'll need plenty of up once banked to turn as the nose will want to slide off. You'll then need to immediately add full opposite control and some down elevator and hold it until it's level again. This is fairly typical of aileron/elevator planes so get used to it if you want to advance up from simple rudder ships. The big difference with them is that unlike the JSF-TT, you can't take your eyes off them for an instant or it could get away from you fast. The reason is that for a plane to roll well it needs to be neutral in roll stability so where you put it is where it stays. Unfortunately a gust or thermal can displace it and if not watching it constantly, you'll be out of control quick. The JSF design isn't quite neutral in the roll axis so it's more forgiving to bumps and gusts. This combined with the inboard style "ailerons" makes it much less snappy in roll response so you have to lead your turns a lot. Once banked, feel free to pull it around as tight as you want with the elevator. A few laps and you'll be right at home and loving it! Skip the beginner section if you are experienced, but read the rest to insure you have everything setup correctly.

Beginner Tips:

As forgiving as the JSF is to fly, I'd still recommend you get some stick time on a conventional rudder/elevator trainer to have a benchmark flight reference at least. The reasoning is that you just might get spoiled to other planes once you've learned to fly the JSF! Have an experienced pilot help you into the sport as opposed to going it alone. It's much cheaper that way and makes for a faster learning curve if you have someone to tell you what you are doing wrong. Once you have a feel for it, give the JSF a go. In fact, have your instructor set it up and test fly it up for you. Be sure you relay the information below so it gets set up correctly and not left to the instructors best guess.

The biggest problem I've found with first time pilots is that they expect the plane to drive like a car. Move the stick to turn, it starts turning and they release the stick back to center expecting the plane to return to level. This just won't usually happen. The best balanced planes will hold a bank with the stick centered. Others will continue to steepen their bank and you will need some opposite stick just to hold it at the bank desired. To level this kind of plane, you have to give and hold full opposite stick for as long as it takes to bring it back. Still others like the JSF will hold the bank with a center stick but need constant up elevator to maintain the turn attitude.

Beginners also don't realize that a plane doesn't turn from its turning surfaces alone, but usually requires up elevator once the bank is established. It's just the opposite leveling out again as the nose will want to balloon up so you need a little down elevator as well as opposite control.

Always fly with the plane in front of you (viewing it from behind) to start and into the wind if any, but try to avoid any wind during the learning phase if at all possible. If you have no choice, then always make your turns into the wind and try not to let the plane turn more than 45 degrees off the wind line so it will not get blown downwind. Keep track of what the nose of your plane is doing at all times.

I highly recommend beginners get one of the current R/C simulator programs to “train” on. These are a great help in mastering the mind-set of flying from an outside visual reference. Even real pilots get confused at first when the model is flying toward them and suddenly their controls become reversed. My trick for this is to imagine yourself in the cockpit at all times. Then you just fly the plane and don’t think about which control does what and when. If you have to think about it, you are probably already in trouble.

There is even a great free RC simulator you can download and use with a joystick called FMS (Flight Model Simulator). Note: The link to this site seems to keep changing and has multiple entries. Do a web search for it if it’s dead.

CG:

Measure four inches in from the wing tips along the LE and make a mark on both wings. This is your CG for most purposes assuming you have the tailerons or elevons set slightly up at the back as instructed.

Image 140 - CG location

I find that this location is much better to check the CG at than marks under the wing you have to balance on your fingers with the plane over your head. Just catch the edges of the LEs on your finger tips with the plane pointed toward you and let it balance there. If it tilts back, move the battery forward. If it tilts forward, move it back. Get it balanced level at the marks and it's safe to fly. You can put marks on the motor sticks to locate your battery once you find the correct position for the best CG. This way you'll know right where to put it every time. Before I started doing this, there were times I had forgotten to check it and it was way off. You'll know if it's too far back when the pitch sensitivity is so extreme that you can hardly keep it level. If it’s to far forward it will want to dive out of your hand and need lots of up trim to stay level. This causes excess drag and performance will suffer greatly.

In general, a plane will fly more stable with a slightly nose heavy CG and more unstable with it tail heavy. If you just rubber band your battery pack to the motor frame, a hard throw can shift it back and you're in trouble. Velcro keeps this from happening and you can still add the bands for heavy packs to help hold them on if needed.

Setup TT:

If you've flown R/E planes, you're aware of the lag time between feeding rudder and when the wing starts banking. The tailerons on the JSF are similar, and the slower you fly the more pronounced this effect becomes. Also, cutting power reduces control authority even more so keep your glide speed up until level and close to the ground. At normal speeds, you'll find that a hard over stick initiates a nice coordinated turn. At real slow speeds with power, you can give full turn stick and horse it around with the elevator almost within a wingspan. Really lead your turns and recoveries from turns and you'll get the hang of it fast. If you are used to aileron roll rates, you'll be disappointed with the tailerons at first, but appreciate the stability and relaxing flying they offer as they grow on you.

Adjust the linkage so you have about 1/4 inch up tailerons at the rear of the surface at center trim. Do this with the wing flat on the table and the tail hanging off the edge.

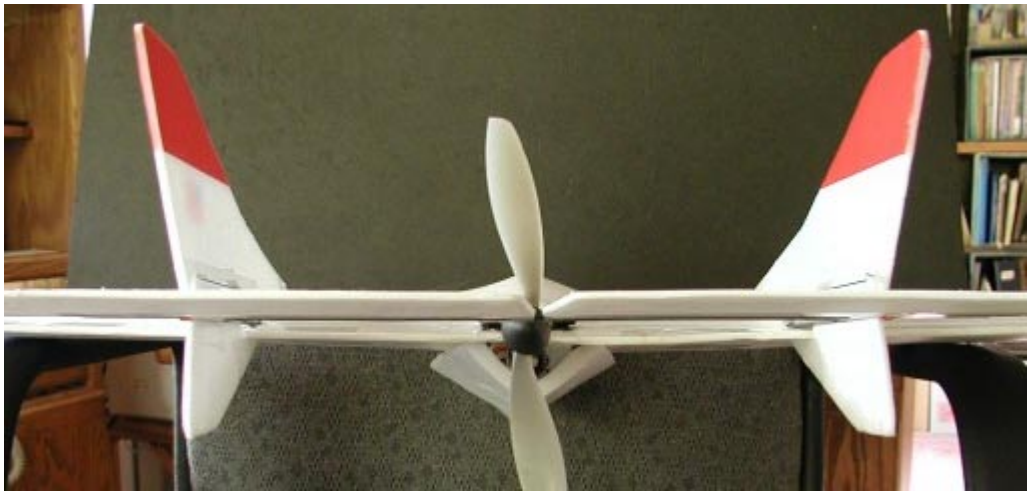


Image 141 - neutral trim

Get to know the centered trim angle of the tails so all you will have to do to preflight is glance at them and the gap in between and you'll know you are good to go. Of course this is in addition to your usual range check, control motion and direction check, etc.

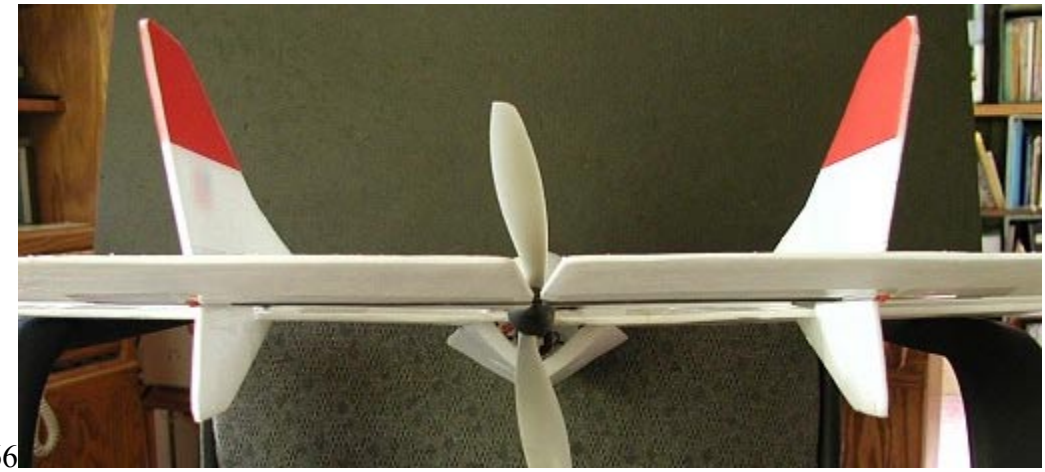
66 

Image 142 - full up elevator

As you can see, you don't need much travel with the elevator channel since the tail is so short. At the most use only about half the travel of what you use for the ailerons. Set your programming to about 70% aileron travel to 30% elevator. That gives you 100% total travel so you don't have excess travel adding from the mixer and forcing the servo arms around so far it bends the wire or digs into the wing. If using a separate mixer or radio that mixes but isn't programmable, you will just have to use the elevator stick very very sparingly. If you have a Hitec non-programmable with mixing, there is a modification you can do to your radio to reduce the elevator travel. It's not for the faint-of-heart, but not hard to do if you can solder and don't mind voiding your warrantee. It's at the Bird Works website.

Image 143 - full down elevator

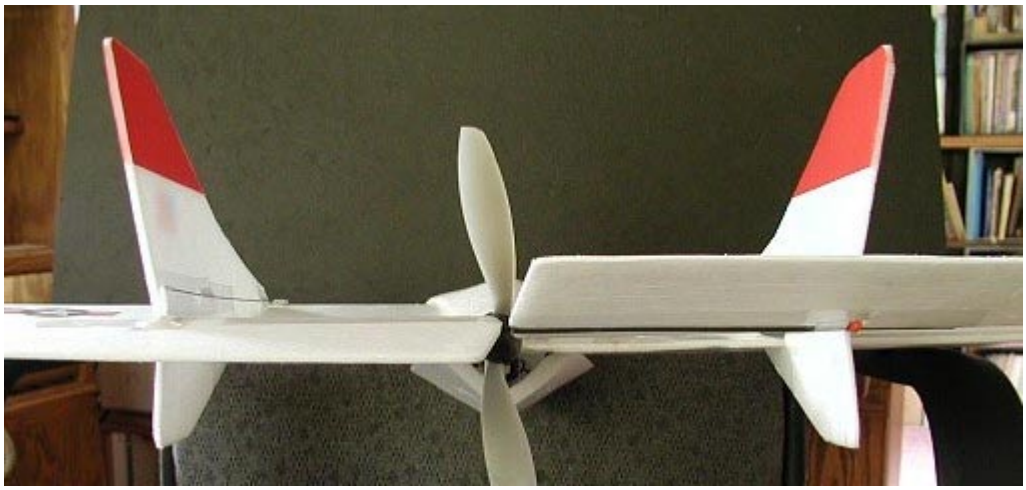


Image 144 - full right stick

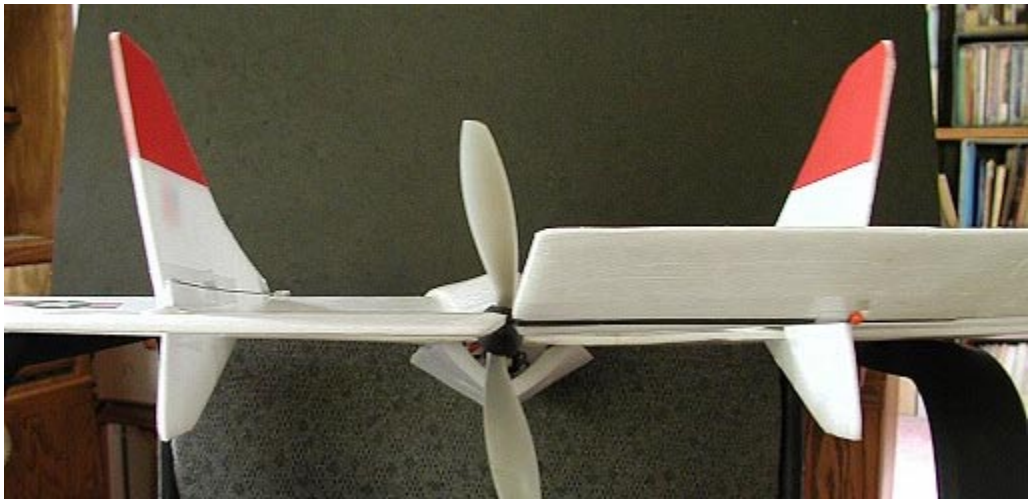


Image 145 - full up & right stick

And no, the fins aren't tilted out (although they could be). That's lens warp again. Also, it doesn't look like it but the full down elevator is angling down a little. Since we need slight up trim (remember, we don't have a horizontal stabilizer onboard) at neutral trim, there won't be much down deflection to see, but it's effect will be there.

Setup SC:

The elevon controlled SC offers the roll rate you A/E and flying wing pilots crave. Use the outer horn holes for your linkage and set your trim for about 1/4 inch up at the back of the elevons to start, with the CG at about four inches in from the tips on the LE. Set your throws for 100% total travel mixed between 60% ailerons and 40% elevator. For dual rates, try 30% ailerons and 20% elevator as a mild setting. Use this setting to learn on, and then switch to the increased travel once comfortable with the bird. Move the CG back a very little at a time and re-trim the elevon as needed to optimize performance. Reduce the up elevon adjustment a bit to re-center your trims as you lower the elevons. This reduces drag and increases control response also.

Don't exceed moving your CG back further than 3 1/2 inches in on the LE reference distance on the SC model. That's about the point of no return. Without a tail, a flying wing has much less tail moment and pitch damping so the CG range is reduced a lot from what you can get away with on a conventional model.

Setup SS:

For the SS version with ailerons, adjust the travel to about 1/4 inch up and 1/4 inch down on the ailerons with no differential. Set up the tailerons the same as for the TT model but mix in the rudder channel with the elevator instead of the ailerons. Don't use the radios stock ruddervator setting unless you can reverse the rudder channel since we still want the tail to function as a delta or flying wing the same as elevons and not like a V tail. If using them as only Y connected elevators, a 1/4 inch up and down travel is about all you need. You can also mix the tailerons with the ailerons for one stick control. This can be a great trainer option since you can setup dual rates for the ailerons and start by flying it normally as an aileron assisted TT. Once you get the hang of aileron control then kick in the higher rate for some real snap.

Test Flight:

For your first flights, leave your prop off and test glide it with a level and steady toss using the cooling cutouts for finger holes. Don't let the nose balloon up on you by trying to throw it. Do this into the wind if any, but it's much better to test in no wind conditions.

If it seems to just want to mush to the ground, even if you lower the nose, your CG is too far back. If it wants to dive for the ground, it's too far forward. Once you get it to consistently glide nice and flat, then and only then add the prop and fly with power.

Safety Notice!

Many have asked about the dangerous looking prop sticking down below the plane bottom. As bad as it seems, there are only two minor problems with it. First is launching with power. DON'T - PERIOD! There's no need to as a gentle toss will get it out of your hand and then you can power-up and be on your way. Second is when landing. Just get in the practice of totally cutting power anytime you get below your pre-established safety altitude. You already know the plane will glide just fine. It may be 10 feet if you are a beginner, or 10 inches if you are an expert. Whatever it is, use it. You may end up doing some real damage if you try to mow the grass with your plane, but that's usually the case with any plane, not just this one.

On landings after you kill the power, usually the prop will just go horizontal when it plops to the ground. Having a braking ESC helps here also because you can blip the throttle until the prop stops level if you like. I like using the brake to get a better glide ratio. That windmilling prop really adds drag. If you do drive it into the ground under power, kill the throttle immediately since you can do lots of expensive damage if sending current to a motor that can't turn!

Conclusion:

I think you'll find as I have that once set up properly, the JSF will fly nicely at all speeds without any vices. Even with high power systems installed, its slow flying characteristics are very predictable and at speed the JSF tracks rock solid. Remember that with its short tail length, pitch is more sensitive than a conventional design. This is one of the unique characteristics of the design that enhances its maneuverability. Nothing good comes without a price however, and you'll find this added sensitivity takes a little getting used to. All standard maneuvers can be performed with very little elevator travel. Use your expo function on your radio to soften the center of the control range in pitch if needed until you get used to it.

Visual Trim:

You can use colored packing tape to dress up your JSF or water based paint. Don't go overboard as everything adds weight. Using different colors for the front and back helps you keep your model orientated in flight. Using different color schemes for the top and bottom let you know if you're inverted or not.

Here is a graphics sheet that you can print out, cut up and clear tape on. Or you can print it to a full size white or clear label sheet for stick-on application:

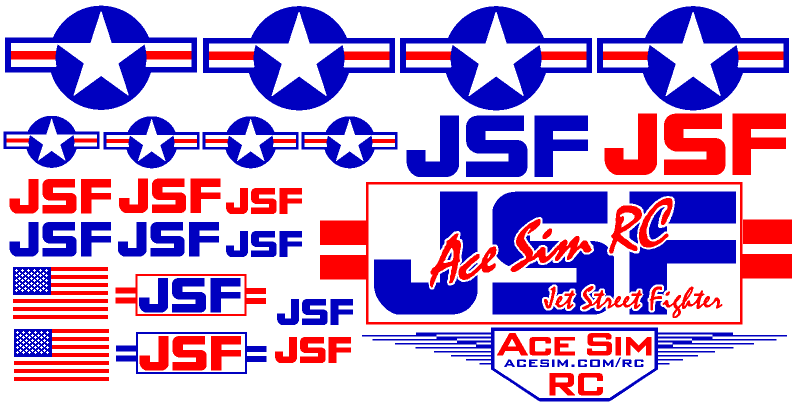


Image 146 - graphics sheet

Click on the image above to go to the full size graphic. It is left large to retain its resolution so before printing, preview it first and rescale it to the size you want.

Reference Section:

Image 147 - where is that runway again?

Definitions:

A of A = Angle of Attack of the wing to the airflow
A/E = aileron/elevator
ARF = almost ready to fly
CA = otherwise known as super-glue
CF = carbon fiber - material used for strong and light tubes and rods
CG = center of gravity - location at which the plane must physically balance for proper flight
Chord = width of the wing section from LE to TE
Dihedral = an up angle that the wing halves make to each other on some planes
FAQ = frequently asked questions
Fuse = short for fuselage - in our case, the foam nose pod
GB = gear box
Incidence = angle difference between fuselage (in our case the wing) to horizontal tail or elevons
L/D = lift to drag ratio
LE = leading edge = front edge of a wing, wing section, tail or control surface
LG = landing gear
ROG = rise off ground
Root = inner-most edge or wing section, control surface or centerline of a completed wing or surface
R/E = rudder/elevator
RTF = ready to fly
RTF = ready to fly
Semi-span = length of wing from root to tip
Span = length of the wing from tip to tip
Stall = when the wing stops flying either partially or entirely
TE = trailing edge = rear edge of a wing, wing section, tail or control surface
Tip = outer-most edge of a wing, wing section, tail or control surface
WL = wing loading

Image 148 - prototype #1

Image Index:

A Little Theory:

It's all about wing loading! Two things primarily determine how a plane will fly. Wing loading, which is how much weight is being carried by the wing's area, has a direct relation to stall speed or how slow a plane can fly. The JSF is easy to figure since it has an even two square feet of area. If it weighted 2 lbs RTF then it has a wing loading of 1 pound per square foot, or 16 ozs per square foot as it is more commonly used. That loading is okay for hot-liners and pylon racers, but it sure won't be a slow flyer! If it weighed only 1 pound RTF then 16 ozs divided by 2 sq ft = a WL of 8 ozs. This is more in line with most park flyers, but still on the high side for indoor slow flyers. They are down closer to 3 oz per square foot of area. Of course, many other factors come into play such as airfoil shape, drag, etc, but figuring a plane's wing loading is a fast and easy way to compare models and estimate how they will fly. The lower the WL, the slower it will fly before it stalls. I can almost figure that a plane's wing loading IS the stall speed with the planes I fly. It's not accurate, but gives me a good overview of the design in question. Higher WLs allow better wind penetration and aren't effected by gusts as much, so if it's windy out, add some weight right on the CG (or use a heavier power system for the JSF) and you won't be grounded as often.

The other big factor that affects flight (or lack of) is the power to weight ratio. Much has been written on the subject so I'll spare you, however I will say that the power to drag ratio is a big factor as well. Since lift squares with airspeed, a little drag reduction can add a lot of performance to an otherwise mediocre design since drag squares with airspeed also!

So, think light if you want it to fly slow, and think clean if you want it to have a good performance on any plane. Every little bit of drag and weight add up.

Additional:

Many people are building totally scale electric flying models of everything from vintage biplanes to military jets the same way you're building your JSF. Almost all that is needed are scaled down 3 view drawings of the project plane you want, parts cut from foam from the drawings, a few added internal foam parts for strength or support, and maybe some light ply glued in for a firewall, LG mount, etc.

If interested in finding out more, you'll want to go to online to E-zone Magazine and start reading the threads on the subject in the Foamie section of the discussion groups. There is a wealth of great information there, plus plenty of sources for just about anything you need from the start of a project to its completion. You can use the search feature there to lock in on just the information you need as well. There are links to online CG calculators, tools for picking the correct motor, prop and batteries, and tons more. And if all else fails, you can always ask hundreds of seasoned experts that are more than willing to help you out. If you are totally new to electrics, RC, or flight in general, please go to E-zone and first read the FAQ there before you even read these instructions. Also read up on any subject you're unsure of in their training section. The knowledge you gain will help you more fully understand what we're doing here and also why we are doing it.

Authors Note:

We hope you get as much enjoyment from your new JSFs as we are. We also hope that from this guide you not only learned to build a plane, but you learned the "skills" to maybe design and build your own creations!

I've checked and double-checked this guide for errors, but mistakes can always get missed. Please let me know if you find any errors in this guide so I can fix them in future revisions.

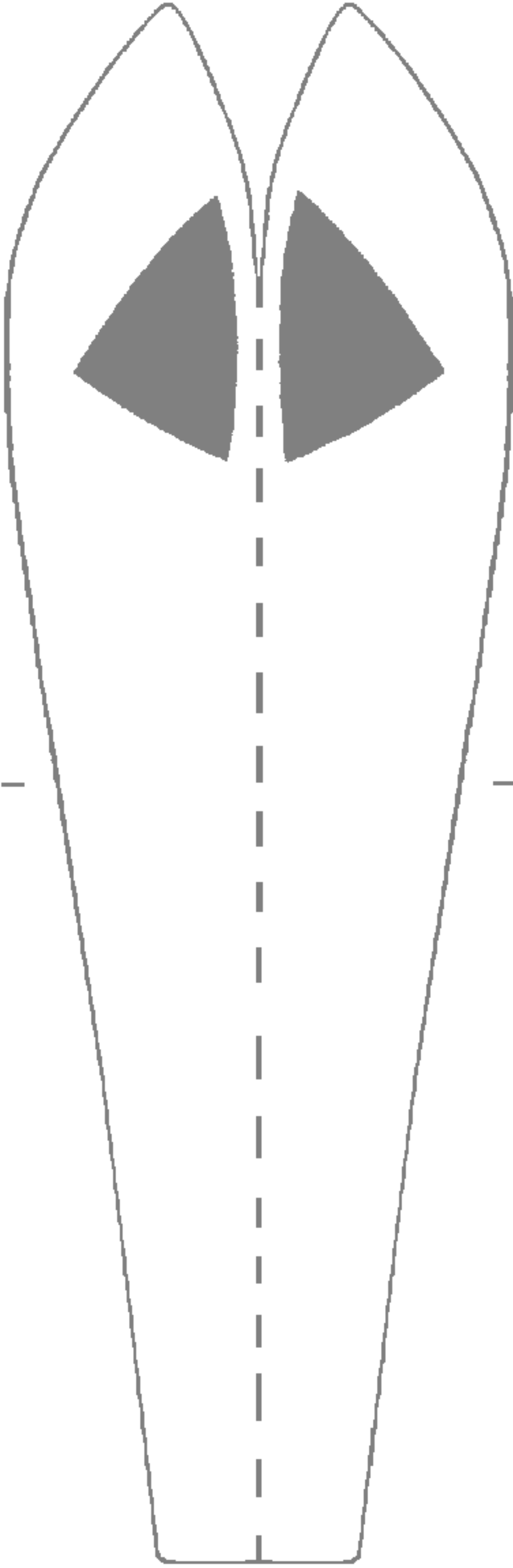
As always, I want you to succeed, so if you get stuck building your JSF, have honestly researched the issue and can't find the answer either within this guide or elsewhere, email me and I'll see if I can help. If I don't reply, it's not that I don't want to help, it's that you are probably asking a question already covered here, or that the information you need is not specific to the design.

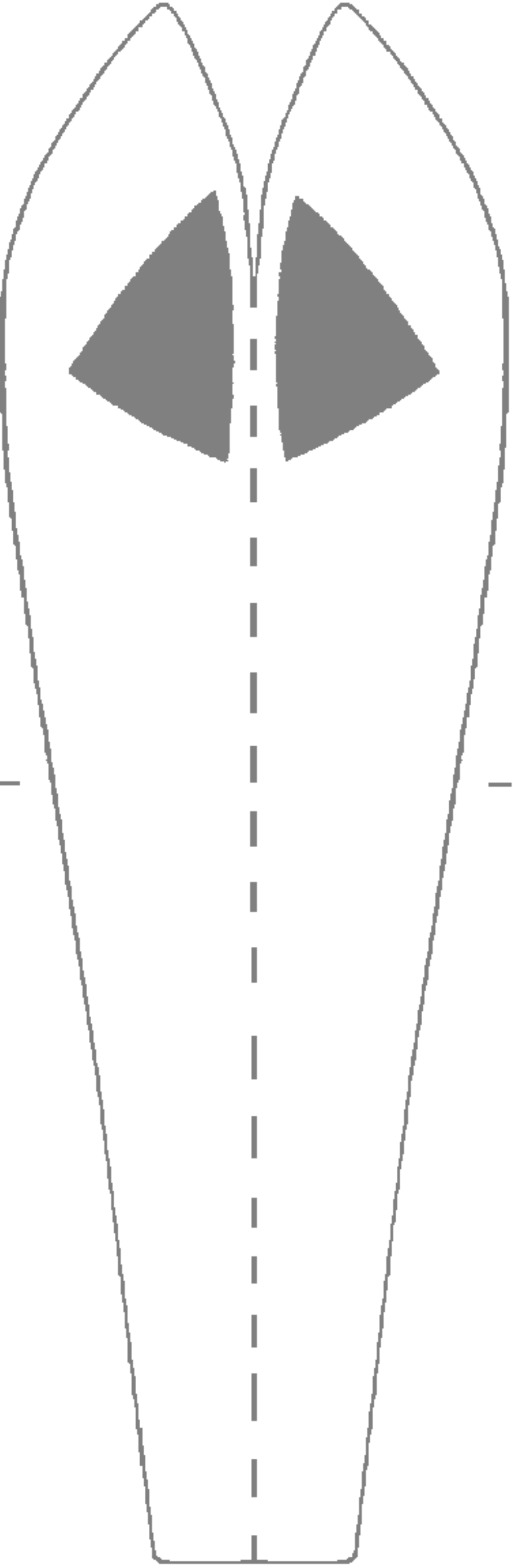
With the overwhelming numbers of emails I receive, even though I read them all, I just simply cannot reply to questions like "where can I buy battery packs?", or "do you think this idea would work if…." etc. After all, if I do get any free time, I'll probably either be out flying or figuring out one of dozens of other new designs I still have on the back burner!

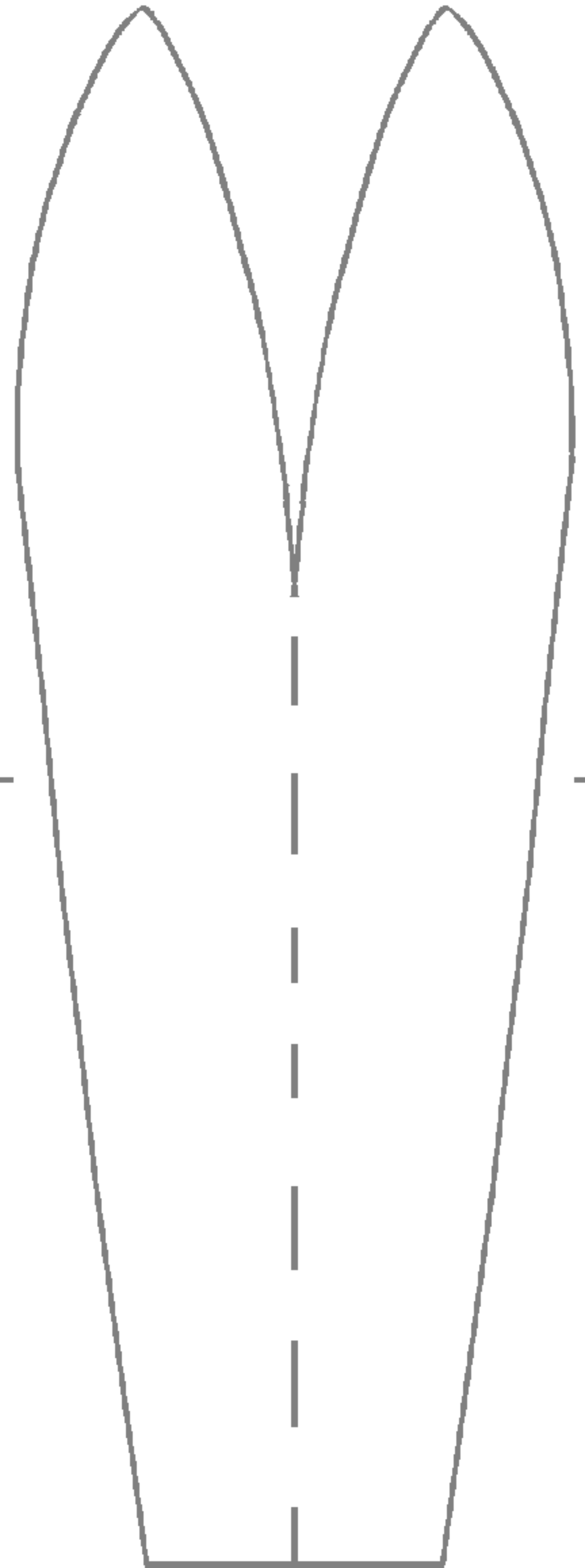
Sincerely,

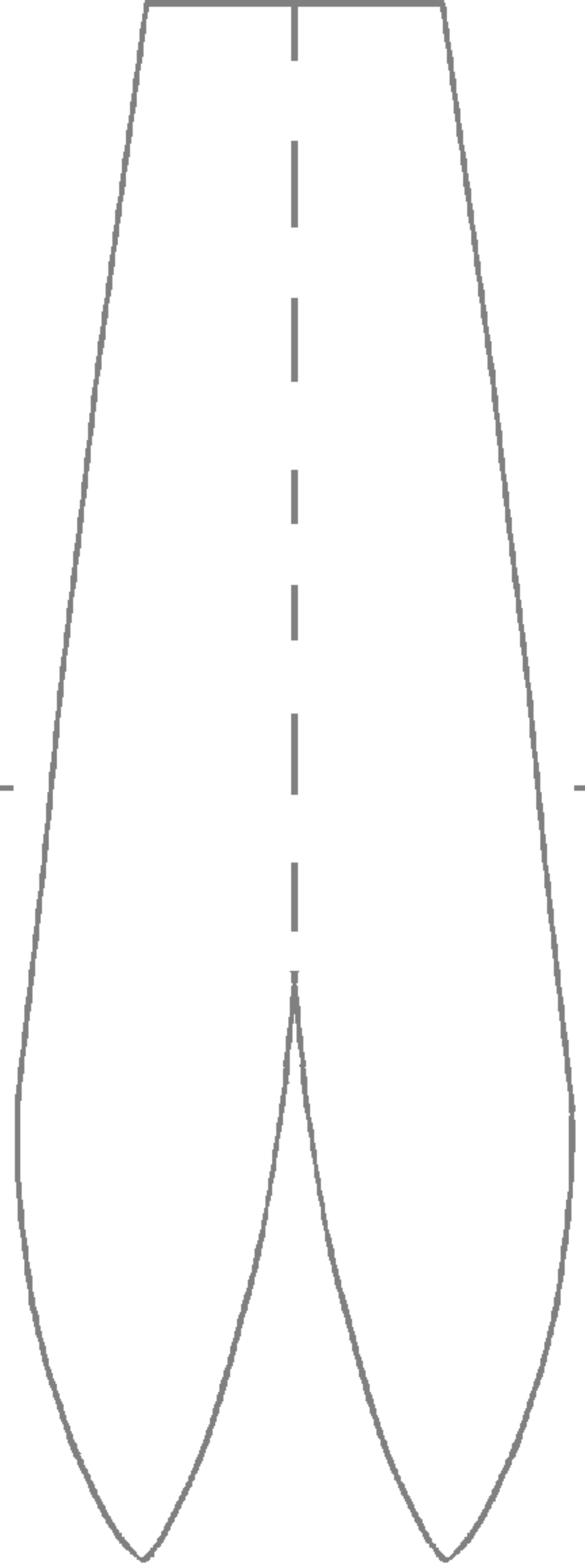
Ken "hardlock" Hill
"Keep wingin' it!"

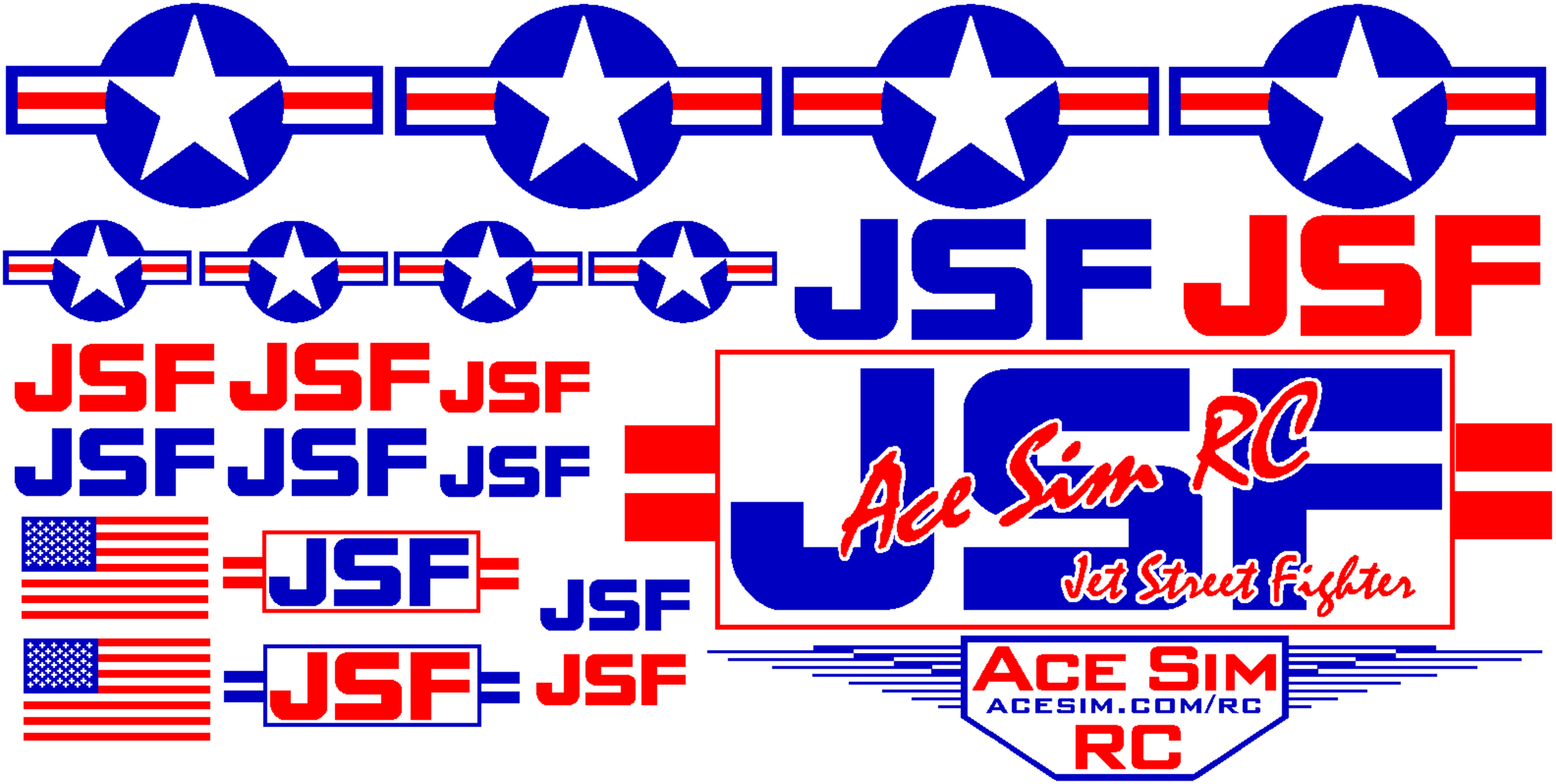
Image 149 - total package







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