F1D Construction

Last revised 7/9/2015

MOTOR STICK

Please study these resources for building a F1D motor stick. Although some of the techniques we use will be different, these resources provide much helpful information.

- 2010 F1D Build (HipPocketAeronautics) replies #90 to #170
- F1D Motorstick Construction by Steve Brown

ROLLING TUBE

We will not use an overlapped balsa blank as described in Steve Brown's article. The motor stick blank will be cut to a pre-measured size then rolled. The rolling process is the same, though.

If you haven't done this before, I encourage you test roll and glue on 1-2" long sections before committing a full sheet of wood.

Cut the .015" thick blank to 9" by .825". This blank will shrink slightly during baking and will result in a .240" ID motor tube. The .825" width is just right when I build at home in San Diego. The right width for a different temperature, humidity, or elevation may be different.

Before cutting, tape down one edge of the sheet. Using a heavy straightedge trim the opposite edge perfectly straight. Use the steel ruler with .010" gradation to measure .825" from the trued edge. You can mark the width of the blank at each end of the sheet by making a small cut in the balsa with a razor blade that has been smeared with a little ink from a felt tip marker. That creates a very fine marker line for aligning the straightedge. I use magnification to align a straight edge with these faint marks and then cut.

Soak the blank in cold water for 15-20 minutes.

Cut a piece of tissue to 4" x 10". Lay the tissue on a smooth, flat surface such as glass or laminate. I usually roll the motor tube on our granite counter in the kitchen. Use the .25" mandrel to roll the balsa. Use saliva or water on the tissue to first stick it to the mandrel while aligning the edge of tissue down the mandrel. Now wet the tissue thoroughly making sure that the wet tissue is smooth and wrinkle free. Roll the mandrel a complete revolution making sure the tissue is tightly and evenly attached. Wipe off excess water from the blank and place the

blank squarely against the mandrel. Roll the balsa/tissue assembly all the way through. The gap in the balsa should be straight. Re-roll until you are satisfied.

Bake in the oven at 170 F for 20 minutes. Let it cool for 30 minutes or more. Or, if you don't have access to the oven, let it air dry for 24 hours.

Carefully un-wrap the outer layers of tissue until the wood is exposed. Using a very fine-tip marker make 4 or 5 small marks across the seam along the length of the tube. These marks can later be aligned and will assist in gluing a straight seam. Remove the wood and the rest of the paper from the mandrel. In some places the wood will be stuck to the tissue or the mandrel. Be patient and proceed carefully. Weigh and record the weight of the tube.

GLUING TUBE

Use Duco or Ambroid mixed 50/50 with acetone. Apply the glue with a fine tip glue bottle or syringe. If using a needle, remove the sharp point and smooth it. I use a glue bottle with a 25 gauge tip.

With the tube removed from the mandrel, glue both edges lightly. This "pre-glues" the edges. Wipe off excess glue as you go.

Put the tube on the .240" mandrel. Start in the middle. Use the marks to align the edges. Hold the mandrel and tube in your left hand applying gentle pressure to push the seam closer together, apply glue to about 1/4" at a time. Press the tube together with the left hand and press gently down on the top of the seam with the right finger. You want the edges to meet flush. Once you get the first 1/4" glued and holding, work towards the ends. Move the mandrel in relation to the wood a little at frequent intervals to avoid the possibility of gluing the tube to the mandrel.

Allow the glue to dry completely, usually 1-2 hours, before removing the tube from the rod.

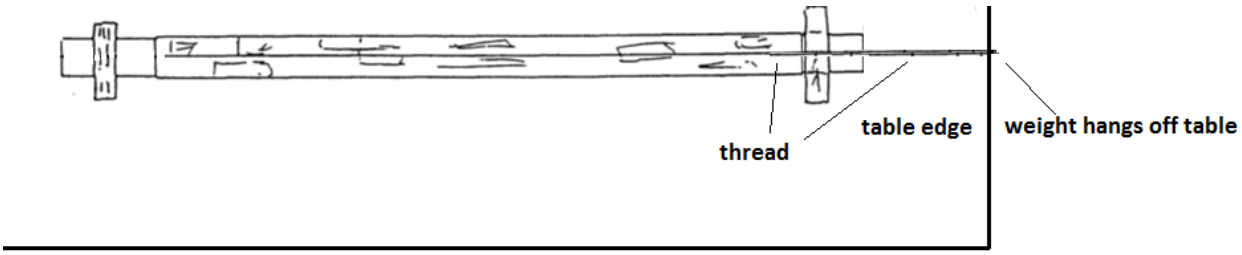
BORON

The motor tube has two .003" boron fibers at the 4 and 8 o'clock positions.

Now you have to decide which way is "up", or 12 o'clock, for your tube. Your tube likely will not be perfectly straight and will curve to one direction. Likewise, your seam may not be perfectly straight. We will define the orientation of the tube by calling the direction that the ends point to be "down", or 6 o'clock. Often, "down" coincides with the seam. At the front of the motor tube, mark the 12 and 6 o'clock locations. Also put marks at 4 and 8 o'clock.

Be diligent when working with boron. When a short-length fiber enters the skin, it is extremely painful and difficult to remove.

I like to first cut the boron fiber to the desired length. Actually, we don't "cut" the boron but "break" it in the right place. Use a surface that "gives", such as a hardwood building board or a rubbery cutting mat. Place the boron on a piece of masking tape, sticky side up. Use a single-edge razor blade (or equivalent) and press down on the boron. The boron will snap cleanly. If there are broken bits at the break, they will be stuck to the tape, safely captured. Return the unused length back in the boron container. Wrap the broken bits with the masking tape and promptly throw them way in the trash. Be diligent.



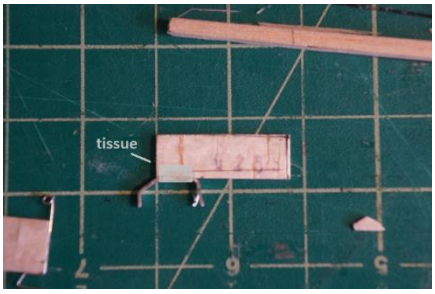
Put the motor tube on the mandrel. Tape the mandrel down to the worktable in two places. Take an 8.8" piece of boron and glue one end to the 4 o'clock position and .1" from the end. Position the tube so that the 4 o'clock point faces straight up. We will use a simple set up to keep the boron fiber taut. Tie a piece of weight (I use a ¾" steel nut) to 24" of thread. Glue the loose end of the boron to the thread, overlapping about ½". Hang the weight off the table so that it pulls the boron tight. Position the thread and the weight so that the boron lies perfectly straight on the motor tube. Next, put a small drop of glue every 1" of the fiber to keep it in place, then go back and put a small drop of glue every ¼". This tack glues the boron in position.

Gently slide the tip of the glue needle against the fiber and the wood to apply the glue to the boron. Do this 1" at a time. Press down on the boron fiber so that it embeds slightly into the wood. I use the side of the needle to and slide it along the boron while putting some pressure. It's important to press down on the boron because we don't want glue to build up and cure between the boron and the wood. Control the amount of glue by the speed at which the needle slides along the boron. When you finish gluing the boron along the whole length of the tube, unglue the thread from the boron using a brush dipped in acetone. The weight will drop to the floor unless you put it on the table. Then glue down the loose length of boron. Repeat with the next piece of boron.

An alternative method to gluing boron to the motor tube can be found in APPENDIX 1.

THRUST BEARING

Cut the web slightly taller in size in the vertical direction. Excess can be cut off after installation.



Abrade the top of the Harlan bearing with a file or rough sandpaper so that it has a rough surface. You want “teeth” on the metal. This will help to securely glue it to the web. Use full-strength Duco or Ambroid to attach the bearing to the bottom of the web. While gluing, I place the web and bearing on their sides so that one sides is flush, and the web and bearing are perfectly inline. Let dry for 30 minutes. Saturate tissue with glue and wrap it around the bearing and the web. Let the web tissue conform to the contours of the bearing and the web.

Measure and mark the location of the front web on the top and bottom of the motor stick. Cut a .020” wide slot on the top and bottom parallel to the length of the tube. Use fine grit sandpaper and widen to .025” to get a good fit against the web.

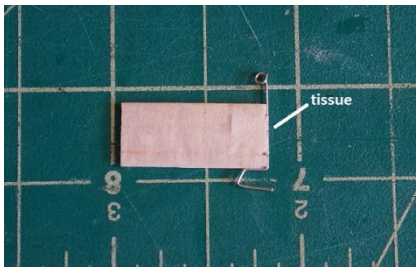
Alternatively, you can cut the slot width directly to .025” if you are comfortable.

Before gluing the web and bearing assembly to the motor stick, make a test fit. Make sure that there is 1 degree of down thrust. Insert 3” of straight .013” wire to visually verify the thrust line. 1.5 degrees is okay, too. Note that the Harlan bearing typically comes with 1 degree of down thrust. Don’t worry about side thrust now; it will be twisted into the Harlan bearing after the motor stick is completed.

Pre-glue all surfaces where the web and bearing will meet the motor tube. Glue the web and bearing to the motor tube. The bearing must be flush with the bottom of the tube, and the web should not extend below the bottom of the wood tube. Use a healthy amount of glue. Once the glue has dried and you're satisfied with the thrust line, put a glue fillet all around the metal/wood contact area. A "band-aid" of tissue can be put over the bearing and saturated with glue so that it conforms to the shapes of the metal and wood. The tissue patch needs to go 1/16" past each side of the bearing.

Don’t install the cap at this point. Keep the tube open so you can sight inside to a1lign the rear web and the bracing post.

TAIL HOOK



Abrade the tail hook where it will meet the web. Cut a web slightly taller than shown on the plan. Using full-strength Duco or Ambroid, glue the tail hook to the web. After the glue dries for 30 minutes, use a tissue "band aid" to strengthen the hold between the hook and the web.

The rear web must be aligned vertically to the front web. Like the front web, the rear web fits through slots on the top and bottom of the tube. Using a ruler to aid alignment, make a mark at the rear of the tube that lines up with the top of the front web. Insert a pin through this mark. Now look through the inside of the motor tube from the rear and sight both the front web and the pin. Move the pin to align it to the front web. The alignment is very sensitive to small movements of the pin, so take your time here. When aligned, poke the pin through the bottom of the tube. Re-align and re-poke until you are satisfied. The pinhole marks the location of the bottom slot.

Cut the top and bottom slots to the correct width using the same technique as for the front web. The web must fit snugly. Pre-glue all areas where the web contacts the motor tube.

Use a healthy amount of glue to secure the web to the motor tube. After the glue dries, put another tissue "band aid" to cover the music wire at the bottom of the tube. The whole assembly must be securely glued in place.

BRACING

Make the bracing post from a 1.5" length of .060" x .060" stick. The first .25" that sits inside the tube should be sanded round. The remaining 1.25" is tapered in both dimensions down to .040".

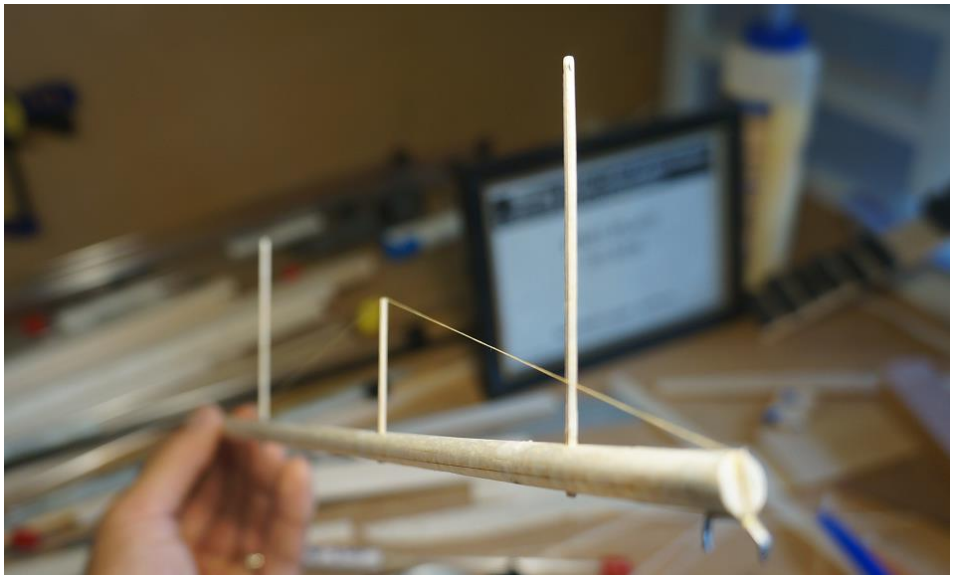
Mark a point on the top of the tube mid-way between the rear and front webs. Use a pin to puncture holes at the top and bottom of the tube making sure that the alignment is vertical.

Use a round toothpick and slowly worry each hole for a good fit. Keep the holes slightly undersized. Glue the bracing post in place.

Now cap the nose of the tube. Slice off the front end at a desired angle, sand, and cap with a piece of .025" C grain wood. Cut off excess and sand flush against the tube.

I use Kevlar thread for bracing. I find it much easier to use than Tungsten wiring, both because it is easier to see and handle. Make a tight knot at the kink at the top of the tail hook and glue it in place. Bring the thread over the top of the bracing post and over the nose. Tension the line with one hand so that the tube bends slightly away from its natural curve. With the same hand,

hold the line and the thrust bearing while keeping the tension. With the other hand, glue the line to the face of the cap. When the glue dries, wrap the line twice around the bearing, bring it up against the cap, and glue to the cap. Cut off the excess. Glue the line to the top of the tension post.



Note slight upward bow in the motor stick after bracing.

EXTENSION

The extension is a tapered tube made from .012” 4# to 4.5# C grain balsa. Four .003 boron fibers are used reinforce the extension.

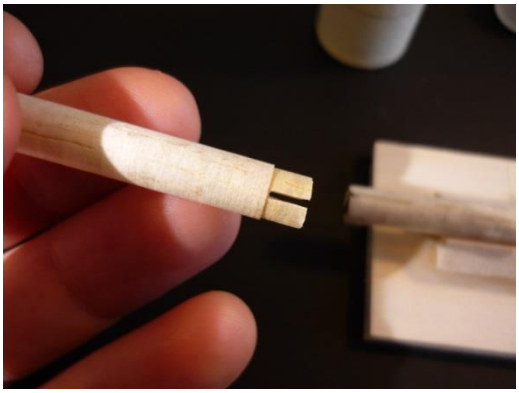
The tapered blank is 4” long and tapers from .850” to .750”. Prepare a piece of tissue 5” long tapering from 4” to 3.5”. The extension is rolled using the same technique for the motor tube. Use the wide end of the Harlan mandrel. The extension should be baked for 20 minutes at 170F or air dried for 24 hours.

Glue the seam over the wide end of the Harlan mandrel. Let the glue dry for 30 minutes. Mark the 12, 3, 6, 9 o’clock positions at the wide end of the extension. Prepare a piece of boron 4” long. Glue one end of the boron at the 12 o’clock mark. Position the boron so that it runs straight down the extension. You can move the boron by using a scrap piece of balsa or with a brush. The end of the boron may need to be unglued to position the boron straight. When you are satisfied with the alignment, add glue every ¼” to tack glue the boron in place. Then add glue in 1” intervals and gently press down on the boron. Glue all 4 boron fibers in place

The extension must be securely glued to the motor stick. We will use a sleeve inside the tubes to connect them. See photo. Make the sleeve from a scrap piece of tube .25” long. Slots are needed to accommodate the rear web.

Before gluing the sleeve inside the motor stick, make a test fit. It is critical that the edges of the motor stick and the extension meet flush. Slowly sand the edges. The seam between the motor tube and the extension must be tightly closed when glued.

Pre-glue the sleeve and inside the motor stick; then glue sleeve inside the tube. Use the end of a brush and press the sleeve against the tube to secure the joint.

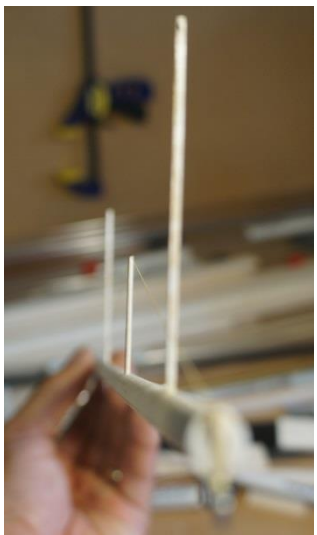


Next, pre-glue both the sleeve and inside the extension. Test fit the extension on the sleeve. Adjust as needed. Align the extension so that the boron at 12 o’clock is .030” offset from the rear web. Rotating the extension this way allows the rear wing post to be positioned vertically in the extension without interfering with the boron fibers at 12 and 6 o’clock. When you are satisfied with the fit, apply glue to the sleeve and glue the extension over the sleeve and keep everything aligned. Be sure the seam is closed. Brush acetone along the perimeter of the seam and work your fingers around the perimeter to help the extension to adhere to the sleeve. Apply a last coat of glue at the seam, and, again, be sure the seam is closed.

WING POSTS

Wing posts are .056” x .052” and 2.75” long. The wider dimensions of the post face forward and aft. Glue 2.5” of .003” boron to each face of the post, leaving .125” at each end. Slightly imbed the boron into the wood at each end of the post.

The wing posts are oriented vertically, in the same line as the bearing and hook. Install the front wing post first. Measure and mark the post position on the top of the tube. This mark should be at the center position of the post. Use a pin to puncture this point all the way through the bottom of the tube, AND make sure the holes are aligned vertically.



The holes must be enlarged and shaped rectangular to fit the wing post. To enlarge a hole, nibble at the edges with the pin. Use a toothpick that tapers from the tip to a rectangular cross section

slightly smaller than the post. Slowly worry the holes until the wing post fits snugly. Keep the holes slightly undersized. Sand a gentle taper at the bottom of the post – this will make it easier to insert the post from the top to the bottom.

Align the front wing post so that it barely touches the bracing line, while minimizing the tilt of the post. The post goes to the right of the bracing line, as viewed from the front. When you are satisfied with the alignment, glue it in place. Apply multiple coats.

The rear wing post is located on the tapered extension. The front of the rear post is 7.80” from the rear of the front post to fit a wing of 7.80” chord. Glue in the 4 x .003” boron fibers. Install the rear post in the exact vertical orientation as the front post.

SIDE THRUST

To put in side thrust, follow these directions from Ray Harlan:

> The design of my bearing is intended to permit bending the front section in both down thrust (up and down bending) and side thrust (twisting). To twist, you need a very narrow pair of needle-nosed pliers to hold the bearing close to the motor stick. Then hold the end of the bearing on the sides with another pair of pliers and twist to get side thrust. Be sure to check freedom of the prop shaft in the bearing. The little vertical front section may need some twisting to line it up perpendicular to the shaft to ensure that freedom.

I have found that twisting the bearing is a straightforward procedure, but bending it to change up/down thrust is more difficult. This is why we build in the down thrust during construction.

TAIL BOOM

ROLLING BOOM

The .010”, 4.5# to 4.8# wood will result in a sturdy boom. The blank will be 18” in length and taper from .840” to .385”. Thicker balsa, such as .011” or .012” 4.0# to 4.5#, would also work well, but the blank size would need to be increased slightly.

Prepare a piece of tissue 18.5” in length tapering from 4” to 2”. Roll the boom in a similar way as the motor tube. Because of the longer length, I soak the blank in the bathtub and roll it on the Corian® counter. There is some tendency for the balsa to move out of position as it is rolled. Roll the former 1.5 revolutions over the tissue before rolling the balsa. Reposition the balsa and re-roll as needed and until you are satisfied. Bake at 170F for 20 minutes, or air dry for 24 hours.

2010 F1D Build, replies #114 and #115 have good illustrations and hints to rolling the boom and positioning the balsa.

GLUING BOOM

The boom is glued in the same way as the motor tube. First pre-glue the edges. Begin gluing in the middle of the tube, aligning the edges to produce a straight seam. You might find that one part of the tube does not have enough width to close on the form. In this case, glue from the middle of the tube to this point on the form, then from the middle to the narrow end of the form. Then push the tube toward the narrow end until the tube will close over the form. Don’t force the seam closed as the balsa may split.

When complete, leave the tube on the former for 6-8 hours to allow the glue to dry completely. Weigh and record the glued boom.

All of my booms end up with a curve. Sometimes, there are curves in two directions. Make a judgment call and orient the end of the boom to curve to the left.

ADDING BORON

Two .003” boron fibers are glued to the boom at the 12 and 6 o’clock positions. Mark these positions at the wide end of the boom. Put the boom back on the former.

Boron can be glued to the boom in a similar way as it is applied to the motor tube. Some adjustments have to be made, though, as the boom former can’t be taped to the work bench.

Prepare a piece of boron exactly the length of the boom, or 18”. Glue one end of the boron the 12 o’clock marked location. Glue the other end of the boron to the weighted thread. With one hand, hold the boom and former at the wide end with the 12 o’clock position pointed up. With the other hand, hang the weight off the table. Adjust the weight and thread until the boron is aligned straight down the boom. Now use this same hand to glue down the boron, first tack gluing then the final application of glue, as described in the motor stick section. Repeat for the boron at 6 o’clock

Leave the boom in the former for 1-2 hours to dry.

STAB POSTS

(Note: It is better to install the stab posts after building the stab, so that the exact position and inclination of the posts can be customized for the stab.)

Next, install the stab posts. No boron is required on the stab posts.

The boron fibers will interfere with the front stab post. This is a pesky problem that needs a workaround. I suggest you move the boron fibers slightly out of the way, as well as decrease the width of the post where it sits inside the boom.

FIN

Glue fin to the right side of the tail boom. The fin should be installed to give 2 degrees left rudder. The curve in your boom may already set the right amount. If necessary, wedge balsa scraps at the glue joint between the leading edge of the fin and the tail boom to get the right amount of left rudder.

WING

The five wing ribs are of equal length. With a 7.80” wing chord (~198 mm) and .040” thick spars, the ribs should be 7.72” long. The rib blank I supplied has already been cut to 7.72”, +-.010”. Slice the ribs from this blank, and they are ready to be used.

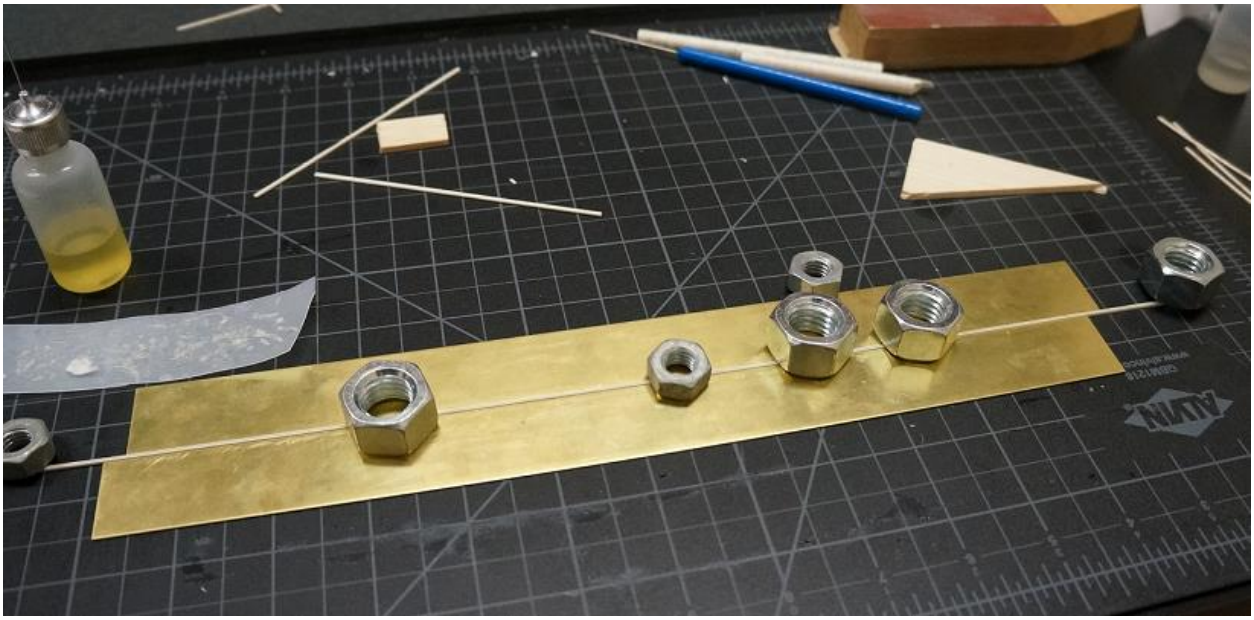
The two dihedral ribs are the “compression” ribs and are .070” tall. The middle 3 ribs take smaller loads and are .050” tall.

The center section of the wing is 15” long. Cut the spars to exactly 15.5”. On each spar, mark exactly the locations of the end ribs, which will be 0.25” from the end of the spar.

Gently bend the spar with your hands to remove excess curvature. The spar doesn’t need to be perfectly straight.

APPLYING BORON ON WING SPARS

Glue exactly 15” of boron on the top and bottom of each spar. Trap the spar between two pieces of straight brass strip. I use K&S .032” x 12” strips bought at Ace Hardware. Weigh down the brass strips. I recommend gluing on boron on “free hand” without the use of tension. Start at one end mark. Tack glue the boron ½” at a time with a small amount of glue and keep the boron fiber as straight as possible. After tack gluing the entire length, then go back and glue down 1” at a time. Unlike when gluing boron to the motor tube, don’t press down on the boron too hard. Use gentler pressure so that the boron does not embed into the spar, but use enough pressure to make sure that there is no glue gap between the boron and the spar.



After you are finished with both spars, trap both of them between the brass strips, and let the glue dry for about one hour.

The spars should be very straight in the vertical direction but slightly curved horizontally. This is okay. However, big curves in the vertical directions should be removed. Unglue a small section of the boron, about ¼", at the outer edge of the curvature. Trap the spar between the brass strips and glue the loose boron. Straighten the spars until you are satisfied.

WING CENTER SECTION

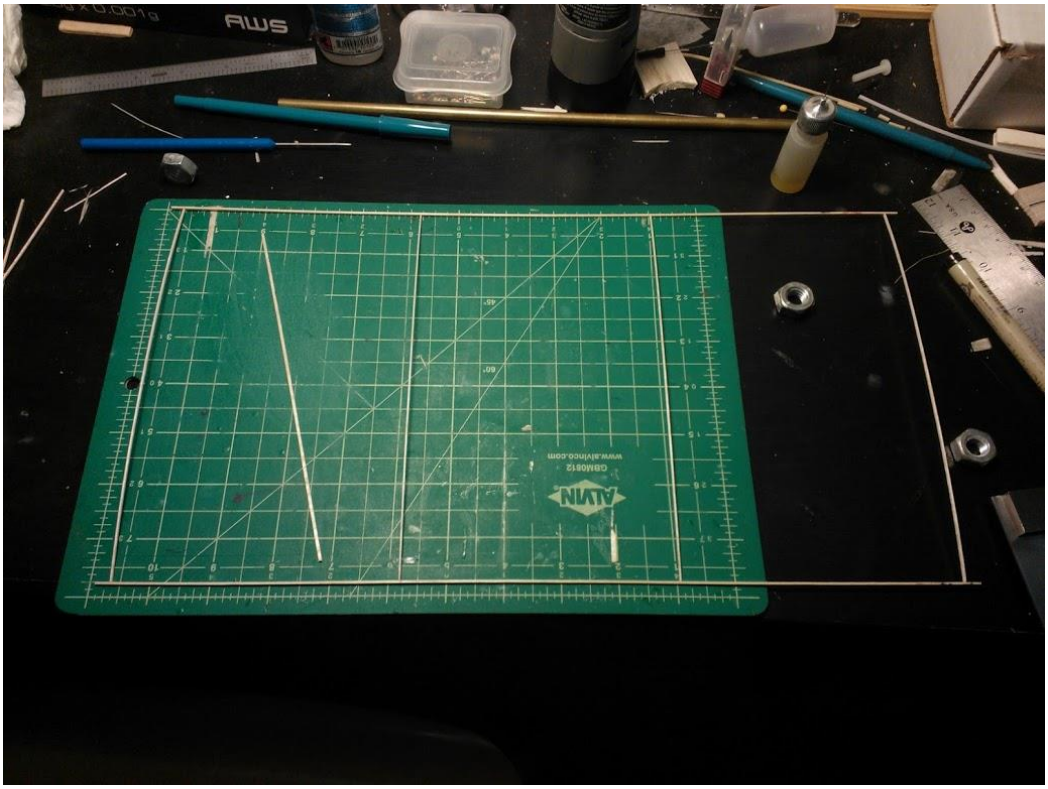
Most of you are familiar with building a wing over a full-size plan or penciled-in lines for the spars and ribs. Align the spars and ribs in the way that you are most comfortable. I'll describe how I build the wing over a cutting mat that has grid marks like graph paper.

Lay the leading edge spar against a straightedge (or use the brass strip) on your work table. The straightedge should be pinned or taped down. I use weights to keep the spar trapped against the straightedge, but you can use your own methods.

Mark with a fine-tip pen the locations of the ribs on the top of the spars. The end rib locations were marked earlier.

Glue the ribs to the leading edge spar. (Always double glue.) Keep the ribs vertical and square to the spar with weights while using the grid on the cutting board as guides.

Now mark the rib locations on the top of the trailing edge spar. Pre-glue these spots and the end of the ribs. Starting at the center rib then working outwards, glue the ribs to the trailing edge spar. Use weights to keep the spar in place.



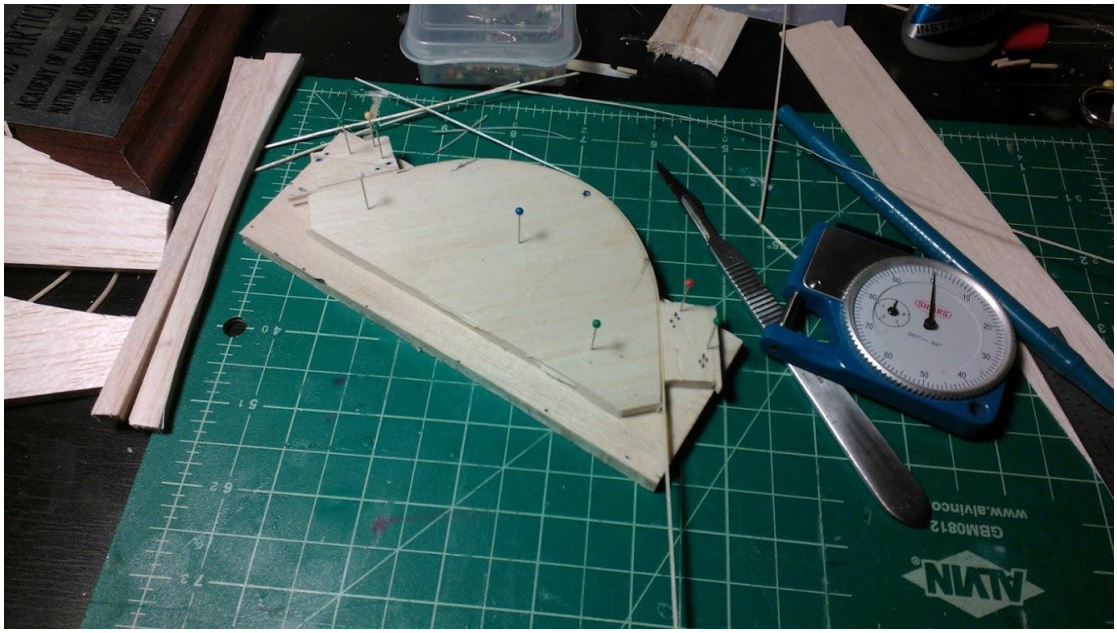
Wing Center Section (4 rib wing). Note spars are extended .25" past the end rib

The 7.720” length of the ribs regulates the chord of the wing. Using 0.040” thick spars, the wing chord will be exactly 7.80”.

WING TIPS

I form the tip from two pieces of wood. One piece forms the leading ledge and the tip. The second piece forms the trailing edge. The two are butt jointed. The curved leading edge and tip piece is baked on a balsa form.

Forming curved parts is straightforward. Read the article, Making Curved Parts the Easy Way to better understand what’s involved. You can use making tape band aids to hold the balsa in place against the template.



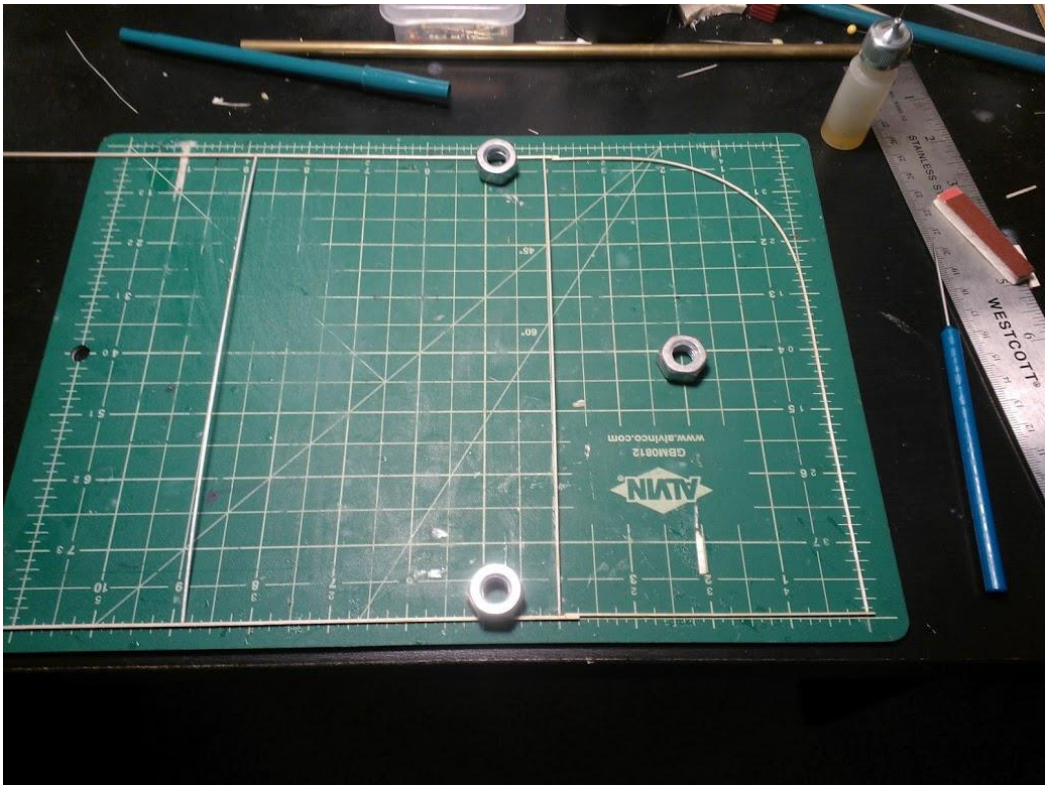
Forming wing tips. Baked 170 F for 20 minutes.

You can form the tip from one piece of wood, too, by using a small curve at the trailing edge of the tip. Or, you can form the tip from multiple straight pieces as done in Bernie Hunt's Big Square.

Shown are "band aids" for holding balsa against the baking template. The white is paper towel.

I encourage you to find a tip shape to your liking and build it in the easiest way possible. Keep the wing area about the same as what's on the plan. However, do not use a rectangular shaped wing tip. Not only is it ugly, it likely increases drag at the wing tip. The wing tip shape of Zoltan Sukosd's European Championship winning model is one good example.

The wing tip often takes a lot of abuse. When handling the model, it is easy to bump the tip. When the model is steered in flight, the steering line often hits the wing tip with a lot of force. The failure point is typically at the dihedral joint.



Overlap joint for dihedral break. Take wing tip spars all the way to the rib. In photo, the tip spars incorrectly do not go all the way to the rib.

I use an overlap joint to glue the wing tip to the wing center section, but there are many other ways. I like the overlap joint because it is simple in construction, and it's very strong. See photo. Cut the tip spars to exact length, and pre-glue the spars. Abut the tip spars against the dihedral rib. Add a small amount of glue to tack glue the tips in place.

COVERING THE WING

Use any method that you are comfortable with. I recommend wrinkling the film.

Weigh the wing frame before and after covering.

DIHEDRAL BREAK

The wing span must be 550 mm or less. Set up your work table so that you can carefully limit the wing's span. For example, set up two ¼" balsa "book ends" 2" tall that are separated by exactly 548 mm.

Loosen the overlap joint on both wing tips. The covering has to be cut at the joint so the tips will prop up. Use a sharp knife, soldering iron, or cautery. Center the wing between the book ends and prop up the tips with blocks. Lightly weigh down or trap with shims the center section of the wing. Work on one wing tip at a time. Prop up the tip so that it barely touches the balsa book end. Position the tip so that the center and tip spars in the overlap joints are touching, and make sure that there is no wash-in or wash-out at the tip. Put a small amount of glue into the two joints to tack glue the tip. After a couple of minutes, make sure the glue is dry, and the tip can hold its position. Repeat and tack glue the other tip. Repeat this process on both tips until you are satisfied that the wing span is correct and the tip has neutral wash.

Next, we will add more glue to the overlap joints to strengthen them. Apply glue to the overlap joint and squeeze the joint with a moderate amount of pressure. The joint is in an awkward spot to do this. What I do is first add more glue and wait until dry. I then pick up the wing in my hands so I can reach the dihedral joint with my fingers. I brush acetone all along the joint and squeeze the joint with my fingers. After a few minutes, I add more glue to the joint.

WING TUBES

The wings tubes are made from triple walled .064" ID polyimide tubing. Each tube is .400" long. Acetate glue cures slowly on these tubes. Their smooth surface has to be sanded rough to maximize glue adhesion.

With a pair of scissors, cut 0.4" length of tubing. Use medium grade sand paper and sand one side of the tube until it is no longer shiny. The sanded side will face the spar.

With the wing on the work table, put a small mark on the top of the leading and trailing edge spars (over the film) exactly 1.00" to the right of the center rib. As you look at the marks under magnification, be sure you can determine within .010" where the 1.00" point is. You will use these marks to line up the wing tubes.

Pre-glue the face of the spar at these marks where the wing tubes will be glued. Put a drop of full-strength Ambroid/Duco on the face of the spar. Next, attach the wing tube to the spar at exactly the 1.00" mark. The wing tube must be vertical and flush with the face of the spar. The top of the tube should be 0.050" above the top of the spar. When you are satisfied with the alignment of the tube, let the glue dry for at least 5 minutes. Then glue on the other wing tube.

After about 15 minutes, check that the tubes are secure enough to handle. If not, re-glue the loose tubes.

ALIGNING WING ON WING POSTS

Next, we will check the alignment of the wing, wing tubes, and wing posts. Check the fit of each wing post inside the wing tube. You will likely need to lightly sand the corners of the top ½" of the wing posts. Work a little at a time so the friction fit is just right.

When the wing is installed on the posts, the leading and trailing edge spars should be parallel. Adjustments can be made at the wing tubes or at the base of the wing posts. To adjust the alignment of the wing tubes, lightly brush acetone on both side of the glue joint, and gently move the spar against the wing tube. The adjustment is made with the wing on the wing posts, so the alignment can be seen at all times. To adjust the wing posts, brush the joint of the wing post and motor tube with acetone, then apply gentle pressure with your hands to reposition the post. When you are satisfied with the alignment, wait one minute for the acetone/glue to dry, then apply more glue to secure the joint.

Now we will strengthen the wing tube to wing spar joint. Use a thin piece of tissue and "band aid" the wing tube on the spar. Next, glue a strip of balsa to brace the tube against the spar. (See photo.) Don't glue the wing post to the wing tube. Let dry for 20 minutes.

Wing tube. Excess tissue can be cut away. Here, the tube extends too far above the spar. This is a critical joint.

STAB

The stab outline is formed from two pieces, a right and a left half. The halves are formed and baked on a half elliptical template. A separate full elliptical template is used for assembling the stab. The two halves are joined together using an overlap joint. The ribs are next installed. Lastly, boron is glued to the top and bottom of the leading and trailing edge spars.

FORMING THE OUTLINE

Bake each half of the spar using a half elliptical template. Make sure the center rib location is well marked on the template.

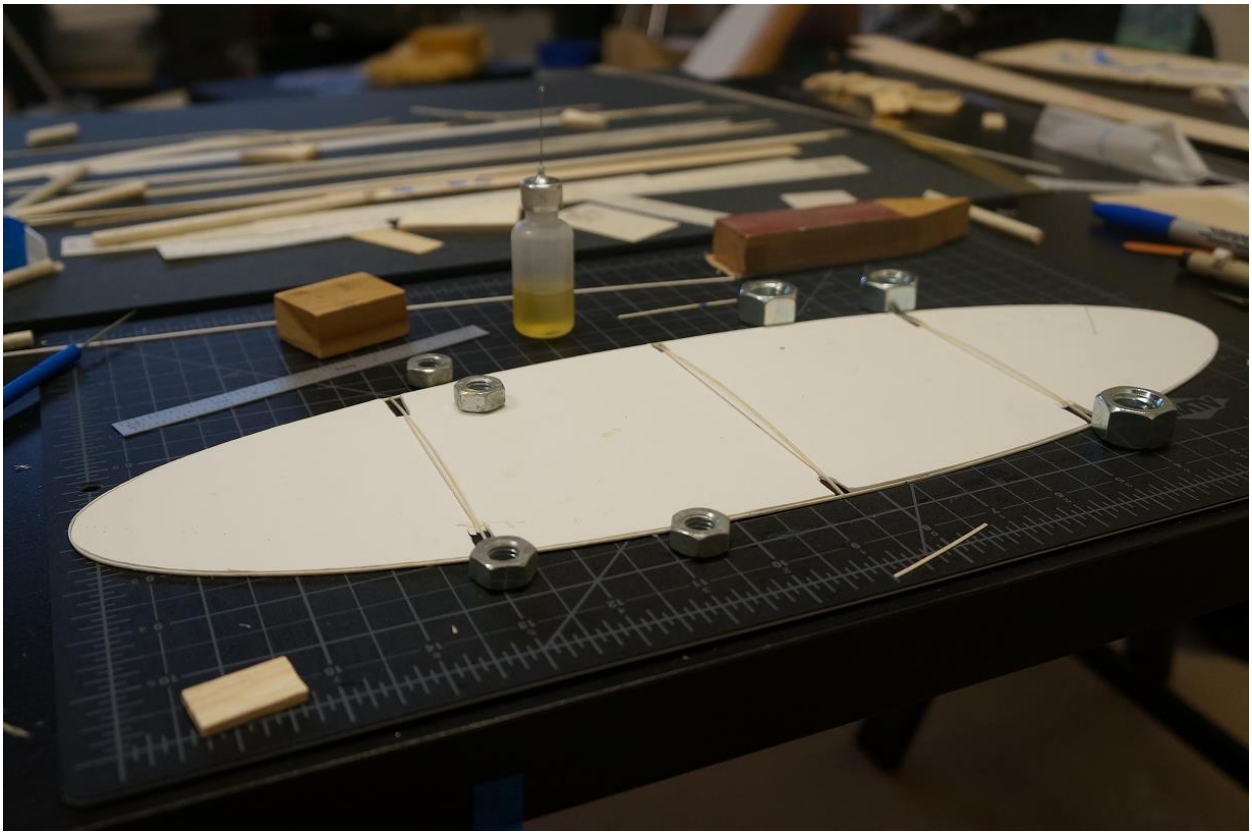
Each spar must be 20” in length. This will allow each spar to completely wrap around the half template with approximately 0.25” margin at each end. Increase the length of the spar by adding another short length piece of spar wood. Use a scar joint to join them.

Half Stab Baking Template.

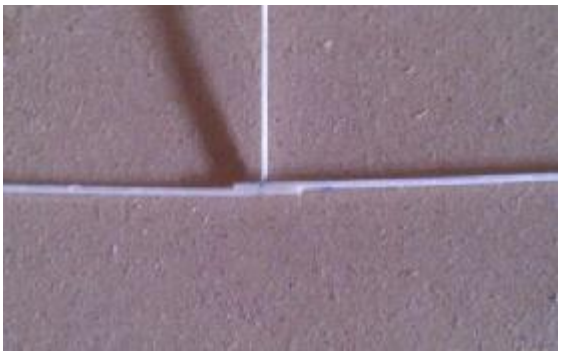
Soak the spars in cold water for 20 minutes. The two spars will be baked together. Position them side-to-side (.025 x .080). Make sure each end is .25” past the center rib location. Push (not pull) the outlines gently around the form, then around the tip. Shims or masking tape band aids are used to hold the spars in place. Bake for 20 minutes at 170F.

BUILDING THE STAB

Make a full stab template to assemble the stab. The template shown is made from 1/16” cardboard. Cardboard from a cereal box or balsa can also be used.



Place each half of the outline snugly around the template. The outlines should overlap at the center about 0.5”. Double glue the overlap joint.



The ribs are cut to an as-needed length during assembly. On my stab template, the center rib is exactly 5.5”, and the side ribs are 4.75”. Yours will be slightly different. Double glue all joints.

BORON ON STAB

I glue on the boron after the stab is built. The boron spans the center 10” and is glued over the top and bottom of the leading and trailing edges. In total, 40” of boron is used. If you use an overlap joint, the 10” of boron will have to be broken into two pieces and overlapped at the joint.

As on the wing, the boron is glued on using only a moderate amount of pressure. Gluing to the bottom of the spar is awkward because of the camber of the ribs. Go slowly to avoid damage.

COVERING STAB

The stab has low camber and should be covered snugly. This helps to stiffen the tips. Don’t cover the too tightly, though, as it may warp.

STAB TUBES

Follow a similar procedure used to install wing tubes. The stab tubes are .25” off center. The bottom of the tube should be glued flush with the bottom of the spar.

After the stab tubes are installed, install with stab tubes and align so the there is a hint of wash-in on the left stab.

After the stab tubes and posts are aligned, use tissue band aids over the tubes.

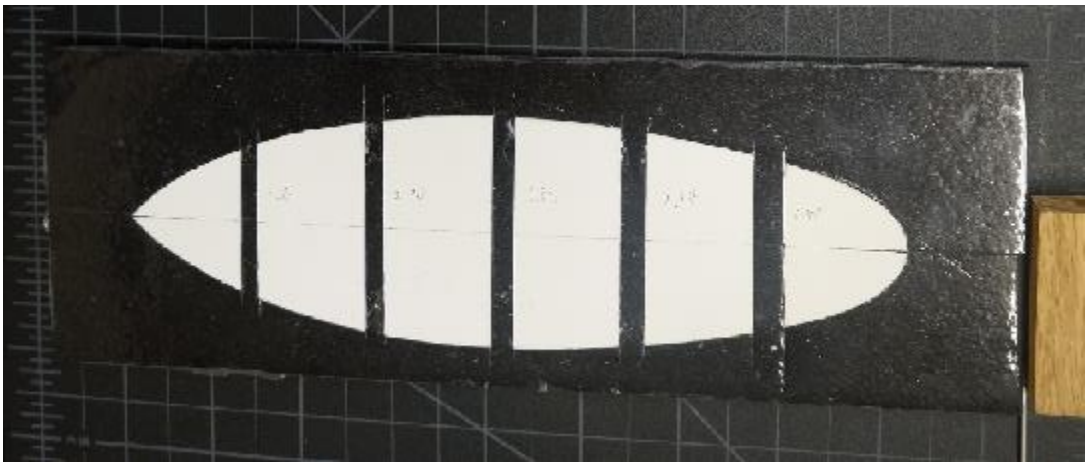
PROP

Refer to Steve Brown's F1D Prop Construction article.

We will build the two blades separately. The finished blades will plug into a fixed-pitch hub made from polyimide tubing to form the final propeller. The tubes will allow the propeller blades angles to be adjusted.

Build each blade to 8.15". The center of the hub will add 0.2" to the prop diameter for a total of 16.5".

The outline and ribs may be built exactly the way described in the Brown article. I suggest two slight changes from the article. Instead of assembling the outline and ribs over a penciled outline, I recommend using a cardboard template so the outline can be held firmly in place. Second, I suggest not gluing the ends of the outline together until a later step of the prop build.



Template for assembling outline and ribs.

PROP SPAR

The spar is the primary structural member of the prop, providing support for both bending and twisting forces. We will build spars that are very stiff to insure that the two blades stay within design specifications.

The tapered sheets you have don't have the exact taper that is needed for the spar. You will have to sand the sheet to get the .065" to .025" taper over 8.15". Use your micrometer to find the locations on the sheet where the thickness is close to .065" and where it is close to .025". From these locations, determine where the tapered sheet can yield the right taper after sanding. Sand slowly once the thicknesses come within 0.005" of target. When you reach your target thickness, draw two lines across the sheet at locations that are .065" and .025" thick.

Using a knife or a balsa stripper, cut off a strip .070” wide. At the .025” point, measure and mark .025”. Using a knife and straightedge, carefully make a cut from the .065” mark to the .025” mark. If you’re not comfortable with cutting the spar to its exact measurements, you may cut the resulting spar slightly oversized then sand it down.

Next, a .003” boron fiber will be glued to each face of the spar. Trap the spar between the brass strips used to trap the wing spars. As with the wing and stab spars, press down on the boron only moderately when gluing. At the root of the spar, the boron is pushed down to embed in the spar.

GLUING OUTLINE AND RIBS TO SPAR

Follow the directions in the Brown article.

Remember that the glue joints that connect the ribs to the spar hold the prop’s twist in place. Glue them together well.

Before gluing the ribs to the spar, I suggest that the outline be open at the root. After the ribs are glued to the spar, splice the end of each outline so each end joins flush with a face of the spar. Glue down. Then follow the directions in the Brown article wetting down the prop outline.

COVERING PROP

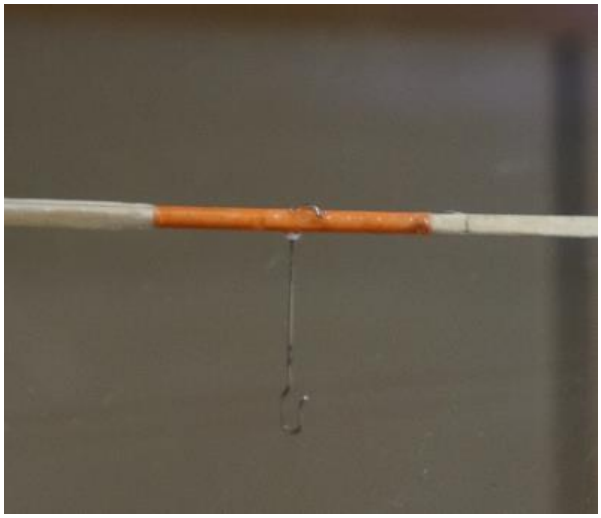
Use a covering frame as shown in the photo album.

Before you spray glue the blade, cover the spar between each rib with tape. Cover the root part of the spar, too. The spar does not touch the covering.

PROP HUB

The prop hub is made from .9” of .064” ID polyimide tubing. Start with a 1” section and cut it down to length after the hub is completed. Sand the center of the tube so that it will adhere to CA glue.

Sharpen the end of 1.5” of .013” music to use as a reamer. First, slowly ream a hole through the balsa insert, making sure not to crush it. Next, ream through the center of the polyimide tubing. Do not ream the polyimide tubing with balsa inside. Insert the balsa insert inside the tubing and line up the holes.



Bend the prop hook from .013” music wire. Insert the non-hook end through the polyimide tubing and bend back as shown in the photo. Apply CA through the holes and align the tubing and prop shaft square. Continue adjusting the prop shaft and add CA until the shaft is secure and square. Add more CA to the top of the hub where the u-bend touches the tubing.

Apply CA using an applicator for precision and to control the amount of glue used. Never use CA directly from the bottle.

Enough glue must be used. The completed hub should weigh less than 50 mg. This hub is a critical component, and everything must be square and secure.

ASSEMBLYING PROP

Slowly sand and round the root of the prop spar to fit inside the prop hub. A good fit has a small amount of friction but no wiggle. You should be able to rotate the prop spar to set the blade at the desired angle. Proceed slowly as you don’t want to take off too much of the spar.

Use a spot of glue at the junction of the spar and the tube to set the blade angle. Glue it at the same location on each blade. Use the minimum amount of glue necessary for the blade to hold its angle under the most aggressive launch conditions. You’ll have to experiment with what this amount is. Over time, as the prop blade is adjusted multiple times, there will be glue build up in the tube and on the spar. The prop blade will become more difficult to loosen and adjust. However, the most important thing is that the blade holds its angle during the many flights that you will make in a contest. Be patient when trying to loosen it for adjustment – it may take some time, but it will loosen with enough acetone. Check your blades frequently to make certain that their settings have not moved.

Apply a small spot of glue at circled point to lock the blade in place.

APPENDIX 1 JOHN TIPPER BORON METHOD

INAV 97 1999

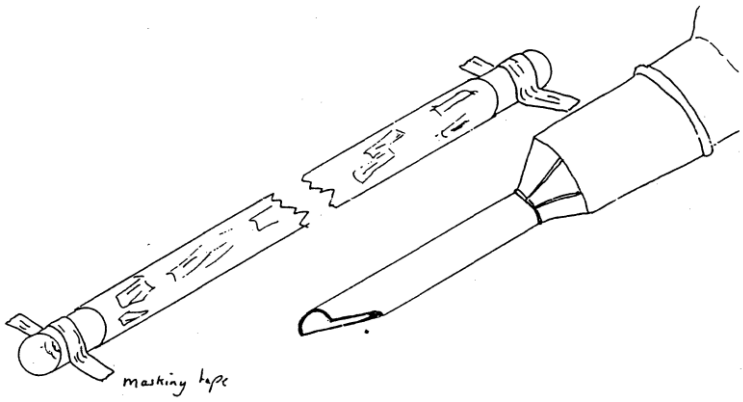
Applying boron to motorsticks by John Tipper (GBR)

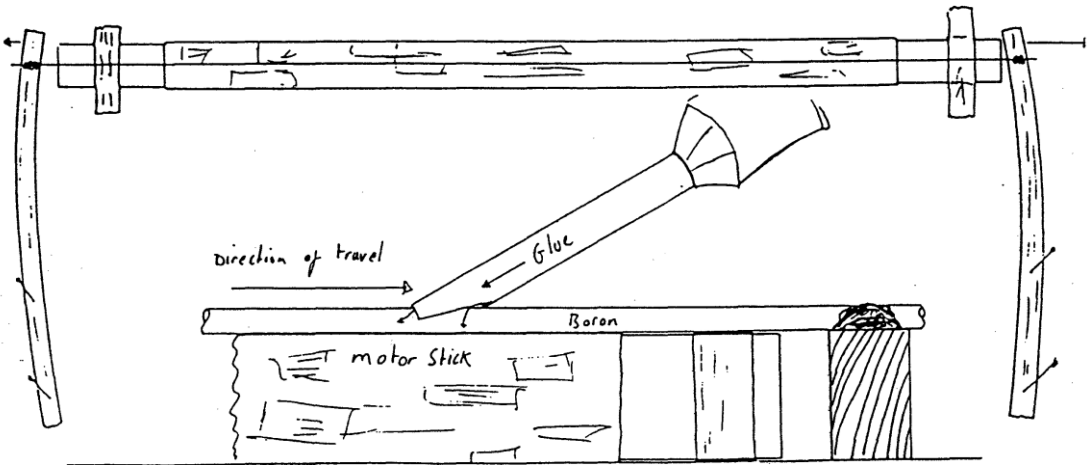
I have tried many different methods to apply boron to motor sticks and have found this one to be the best. The boron stays on straight and has never parted from the motor stick. The weight penalty is only about 2mg for 16 in of boron - a small price to pay for a much stronger motor stick.

1. Tape motor stick down to work bench by the mandrel.
2. Select two pieces of medium balsa 5mm wide x 120mm long, the depth to be the overall diameter of the motor tube.
3. Glue balsa sticks onto each end of boron and allow to dry. This joint needs to be very secure.

Carefully file off the point on a 24 gauge hypodermic needle (see drawing). This will leave a half round groove in the end of the needle. I use a small high speed drill and fine cut-off blade for this, so as to leave a clean edge on the needle.

4. Pin balsa sticks to work bench so that boron is under tension and in the correct place on the motor stick.
5. Apply about 8-10 dots of glue along boron to secure in a straight line and allow to dry.
6. Mix up a solution of 20% Duco and 80% Acetone and fill glue gun (glue guns available from FID Indoor Supplies).
7. Position the half round section of the needle onto the boron and run a bead of glue along the length of the motorstick. The needle will run along the boron like on rails. The glue will coat the boron and form a very small fillet along its length. Allow the glue to dry before cutting end of boron from balsa sticks, then repeat procedure as above for other boron positions.





REVISION

Updated 7/13/2015: Modified description of gluing the extension to the motor stick. Added section on assembling the prop.

Updated 7/9/2015: Added prop construction section. Stab spar length is increased to 20”. Added stab template for building stab. Added photo for gluing boron on wing spars. Described masking tape band aids to hold balsa against baking form.

Updated 7/5/2015: Added stab construction section. Added reference for making curved parts.

Updated 7/3/2015: Added details of using saliva to first attach tissue to mandrel when rolling the motor tube. Changed details for rolling tubes: for the motor tube, roll tissue 1 full revolution first instead of 2/3; for tail boom, roll tissue 1.5 revolutions. Added text to install stab posts after building stab. Removed text to apply two tissue band aids on the bearing. Added a complete section on wing construction. Added details on gluing the boom. Removed requirements on taping up the rolled balsa and tissue assembly.

Updated 6/17/2015: the wing tip wood size has changed to .039 x .040 4.6#.

Updated 6/17/2015: the tail boom blank size has been increased in size. Fat end is increased from .830 to .840".

Updated 6/16/2015: the extension blank has been increased in size. New size is 4" long, tapering from .850" to .750"

Updated 6/16/2015: the tissue sizes for rolling blanks have been modified

Updated 6/15/2015: added details about slots for rear web; added information on installing front stab post.