

Figure 2: Aerobee 350 Fin Assembly Scan 03

Aerojet Drawing 1105120, courtesy of Josh Tschirhart

Each sustainer fin had a root chord length of 50.00" with a tip length of 25.00". The perpendicular span, root to tip, was 34.15". The leading edge was swept 45-degrees; the wedge shape was defined by a 3-degree slope, leading to trailing edge, and a 3-degree taper, root to tip. The trailing edge was swept rearward 15 degrees.

Consistent with the overall skeletal construction, the trailing edge was defined by a channel spar (the Aft spar) to which the sheeting's trailing edge was riveted. The interior of the Aft spar was covered with a 0.15" thick layer of phenolic cork, holes punched at the rivet locations so that the cork insulation could be bonded flush to the spar. The open holes in the cork insulation were then potted with Armstrong Cork Company's J1156-E30 adhesive to seal each hole. Photo 1 highlights these features.



Photo 1: A350 Sustainer Fin Trailing Edge

Provided courtesy of Josh Tschirhart

Photos of Flight 17.01GT (Wallops Island June 18, 1965), taken while the round was undergoing integration and pre-test activities, provide other helpful views of the sustainer's fins.



Photo 2: FLT 17.01GT (NASA G-66-1698)

Provided courtesy of Al Pizzo/Josh Tschirhart

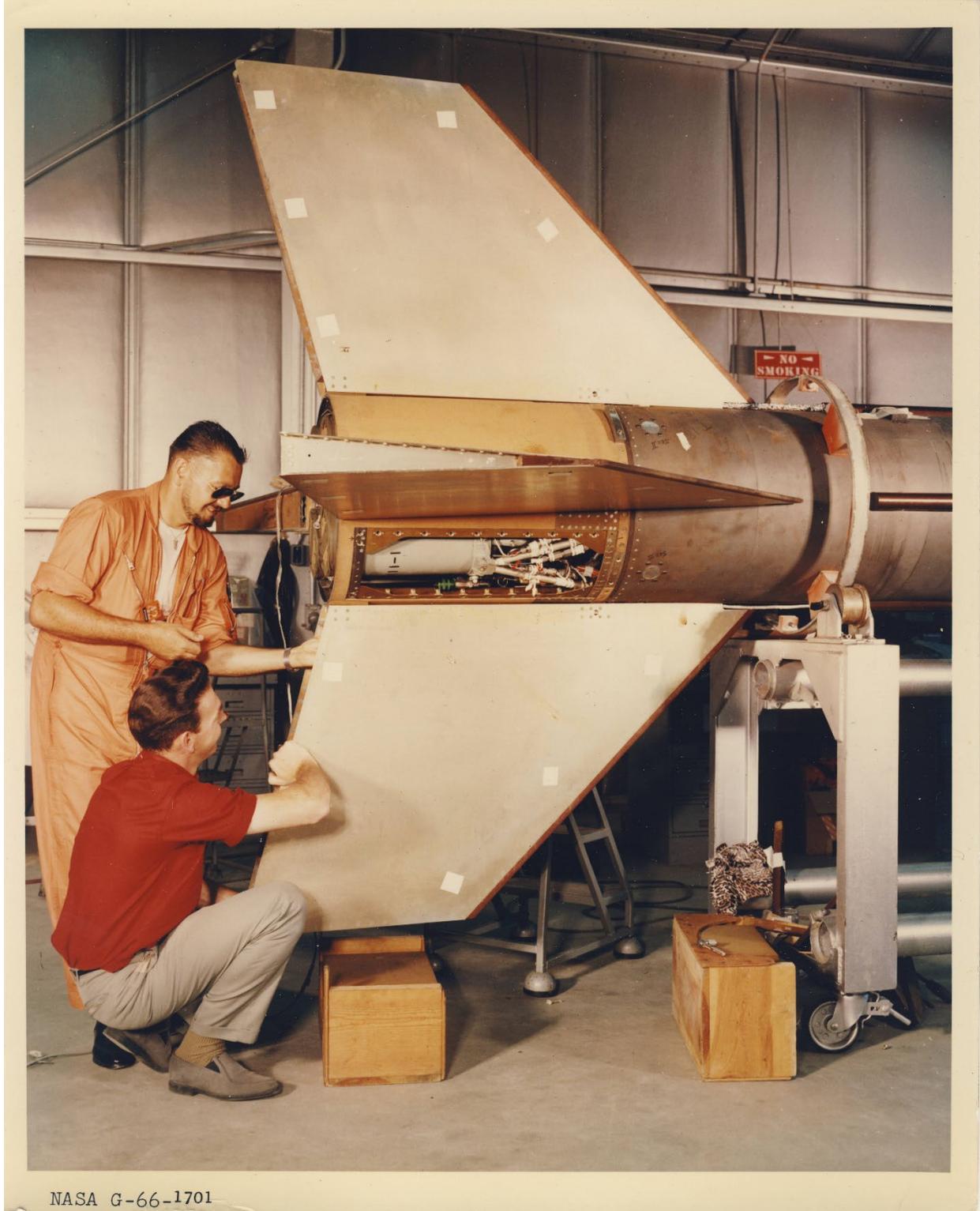


Photo 3: FLT 17.01GT (NASA G-66-1701)

Provided courtesy of Al Pizzo/Josh Tschirhart

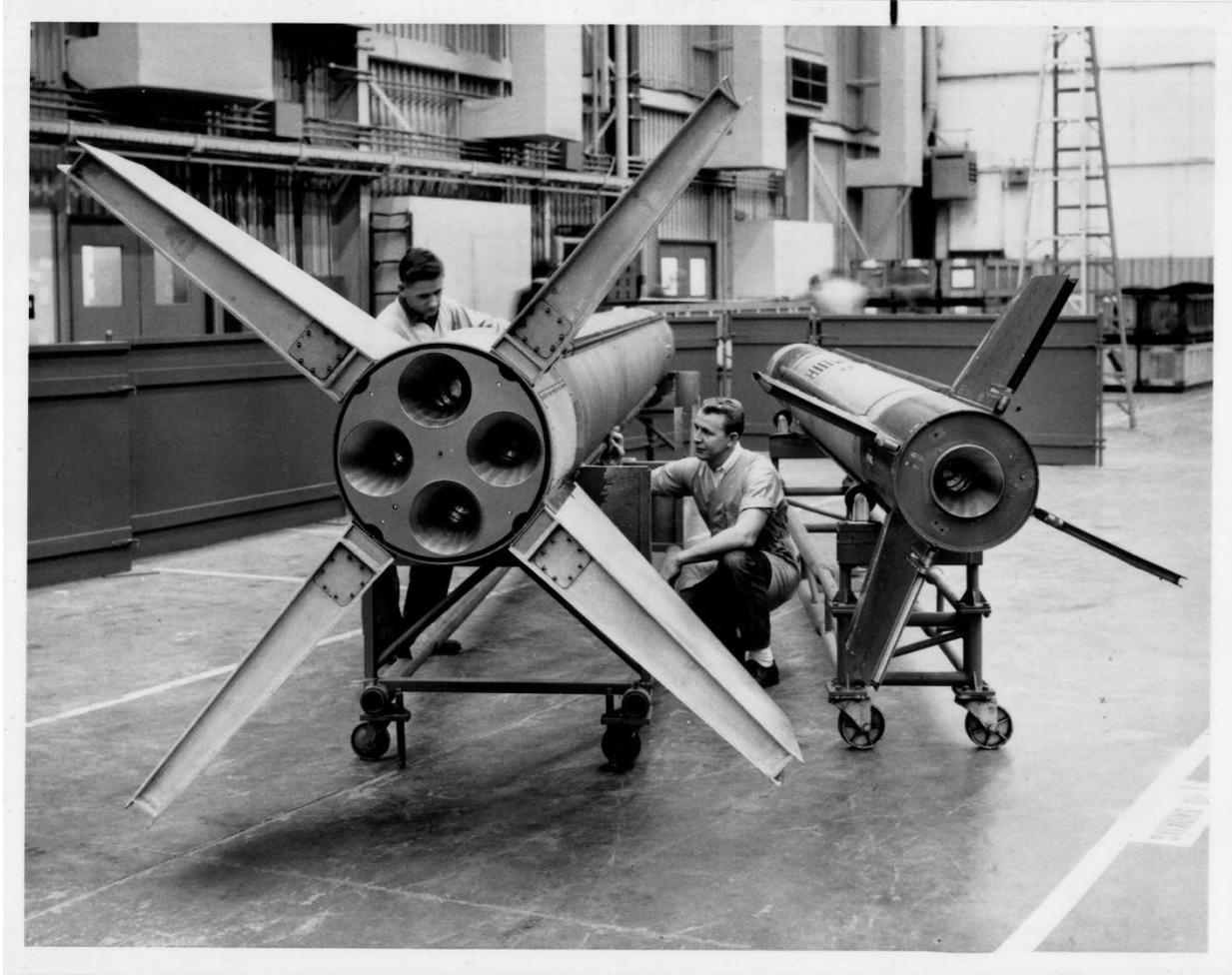


Photo 4: FLT 17.01GT (NASA Photo 65-H-1050)

Provided courtesy of Chris Timm/Josh Tschirhart

Like the prototype, the fins on our model will be built up with a set of spars to realize the distinctive wedge shape. But unlike the prototype, our model's fins will be based on nominal 1/16" aircraft plywood cores, with TTW tabs to secure each fin to the model's motor mount. Each built up fin will be sheeted with 1/16" balsa, and then covered with 0.010" Styrene fin skins.

The Model Fins

We'll start by creating a set of birch plywood cores. Our target is a nominal core thickness of 1/16", but as it's virtually impossible to purchase warp-free plywood these days, we'll make our own by gluing 1/32" blanks together with their warps opposed.



Photo 5: Nominal 1/32" Ply Blanks, Ready for Epoxy

Using 15-minute epoxy for this task provides adequate working time to mate, align, and then press and weight the native blanks together. Once cured we arrive at four very flat, warp-free core blanks, ready for processing.

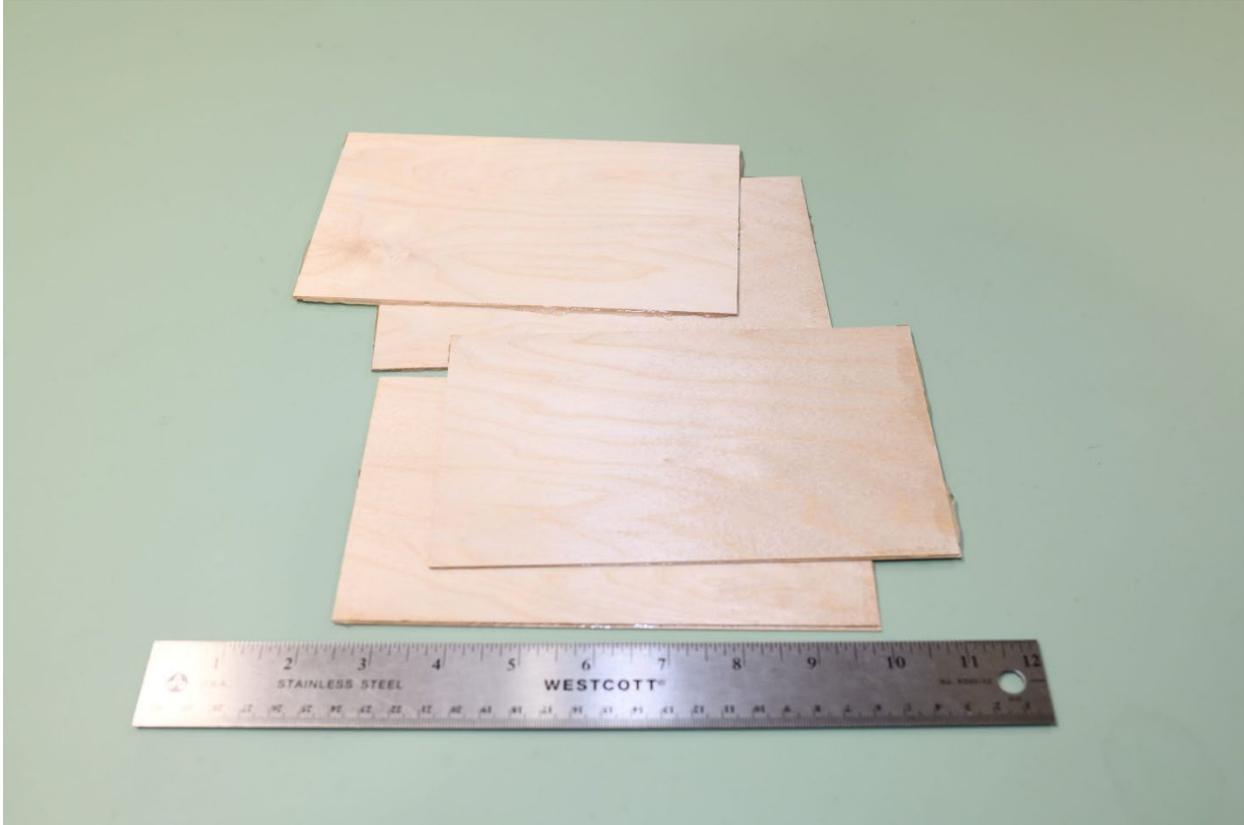


Photo 6: Fin Core Blanks

The final core thickness is approximately 0.070", partly due to variances in the thickness of the nominal 1/32" ply but also because of the adhesive layer that now resides between the 1/32" blanks. This final core thickness is accounted for in the model's fin design so that overall dimensional fidelity can be preserved.

Next, a fin core template was developed in CAD. The template was sized so that the plywood core's leading edge would sit just behind the tangent point with the outer converging fin skins. I picked this point to terminate the plywood core to obviate the chore of sanding/beveling the hard plywood out to the ultimate leading edge of the fin.

However, at the tangent line the core plus its balsa sheeting will have a combined thickness of about 0.10", about twice the width of the scale leading edge. So, we need a way to continue the 3-degree slope of the wedge from the front edge of the core to the ultimate leading edge of the fin, and we'll accomplish this with the addition of a shaped LE transition strip, as we'll see.

So with the core's features defined, designed and drafted, a set of fin cores was produced.

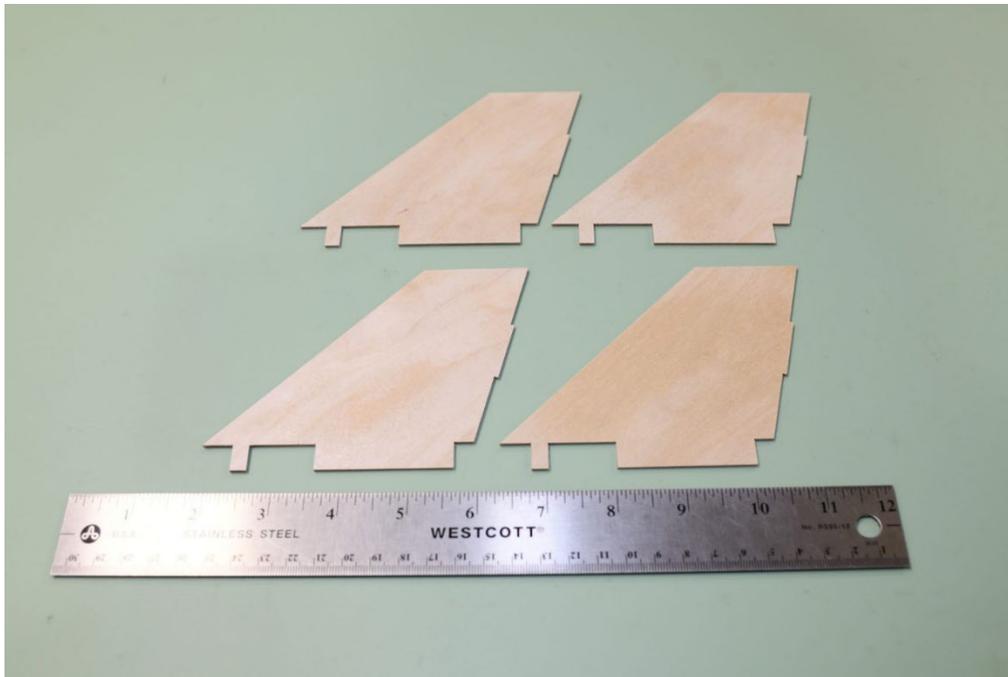


Photo 7: Fin Cores

Next, the fin base plates and aft spars were cut from appropriately scaled pieces of balsa. These components were slotted to accommodate the fin core interlocking tabs.

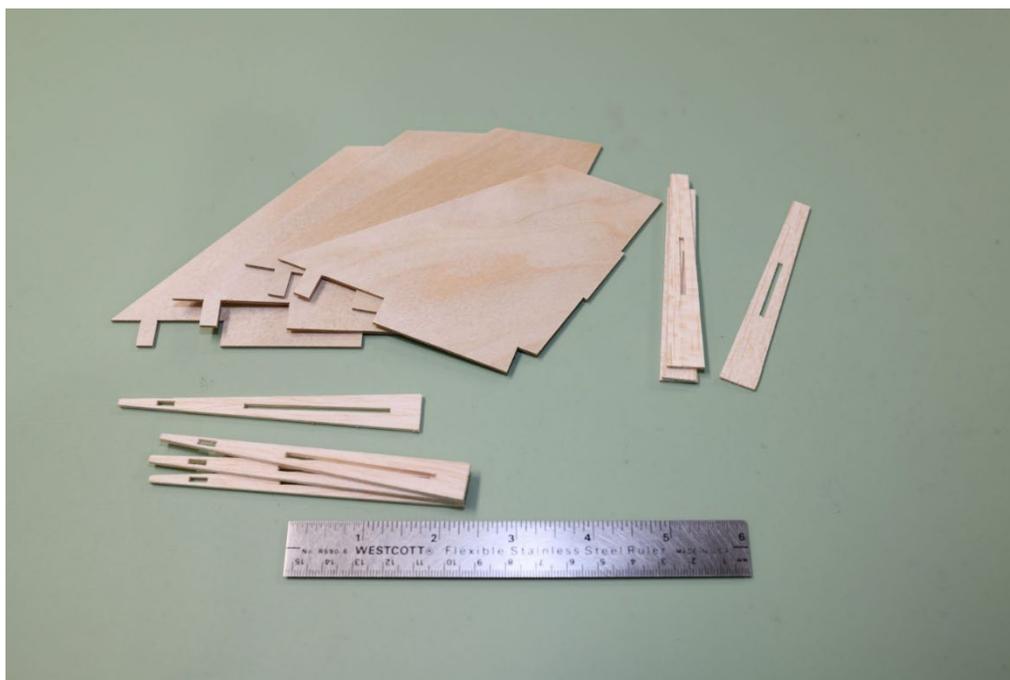


Photo 8: Fin Cores and Spars

A dry fit of the main parts gives us a glimpse of the fin's wedge shape.

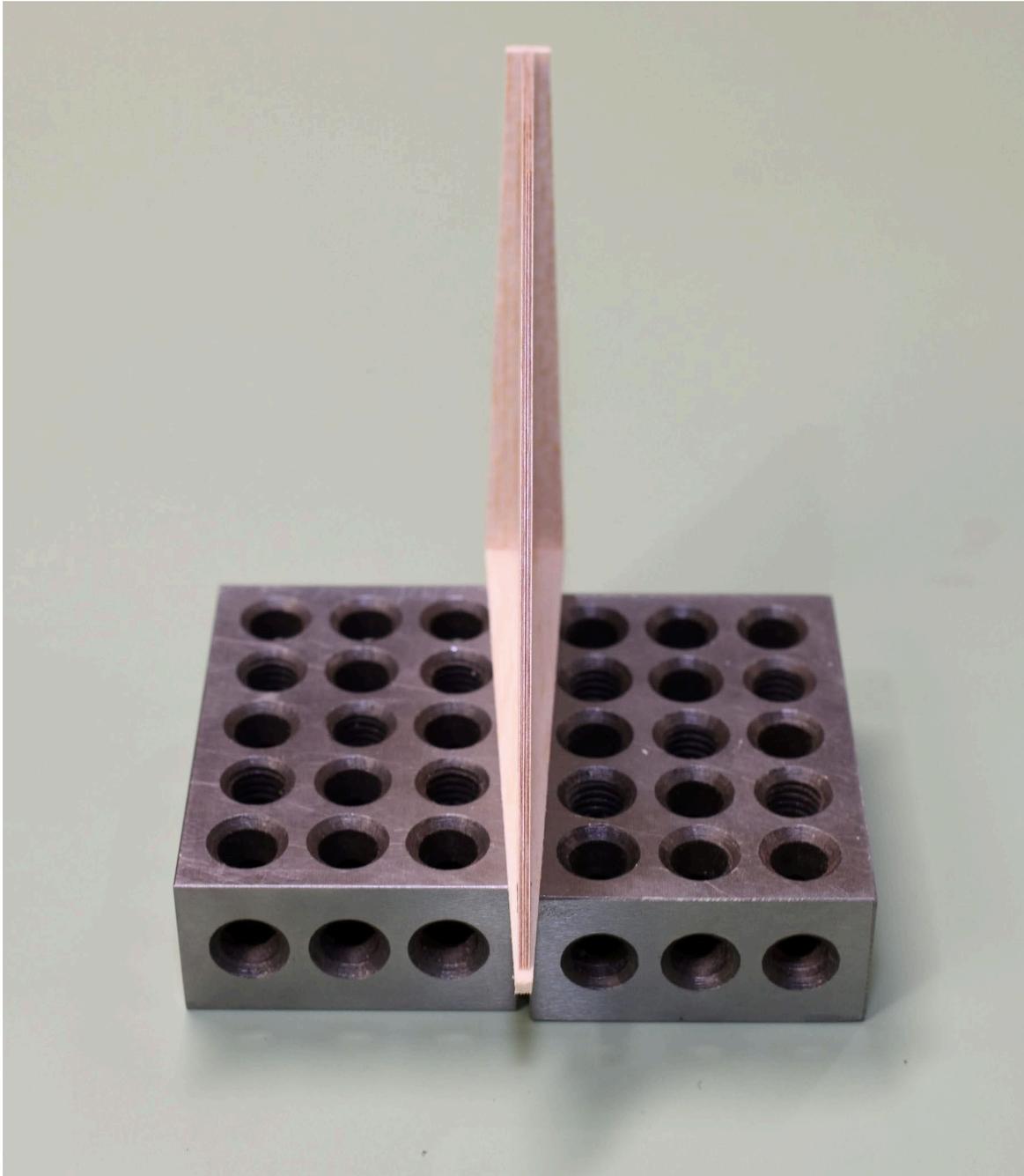


Photo 9: Fin Dry Fit

We'll set up to properly align the parts and with some thin CA we'll glue them together.

Up next – the fin chord ribs.

Fin Chord Ribs

Each fin core needs to be sheeted to complete the finished wedge shape. But just butt-gluing balsa sheet to the core spar edges makes for an unreliable construction joint, and given their wedge shape the fin sides will easily deform without internal support. To mitigate these issues, we'll add a set of lofted chord ribs that take the wedge slope and fin taper into account.

First, a pair of tapered supports are added to the fin core root base and aft spar – these provide the edge support for the nominal 1/16" balsa sheeting that will be used to cover the fin. The supports are sized to allow the balsa sheeting to sit flush to the outside edge of the root and aft spars.

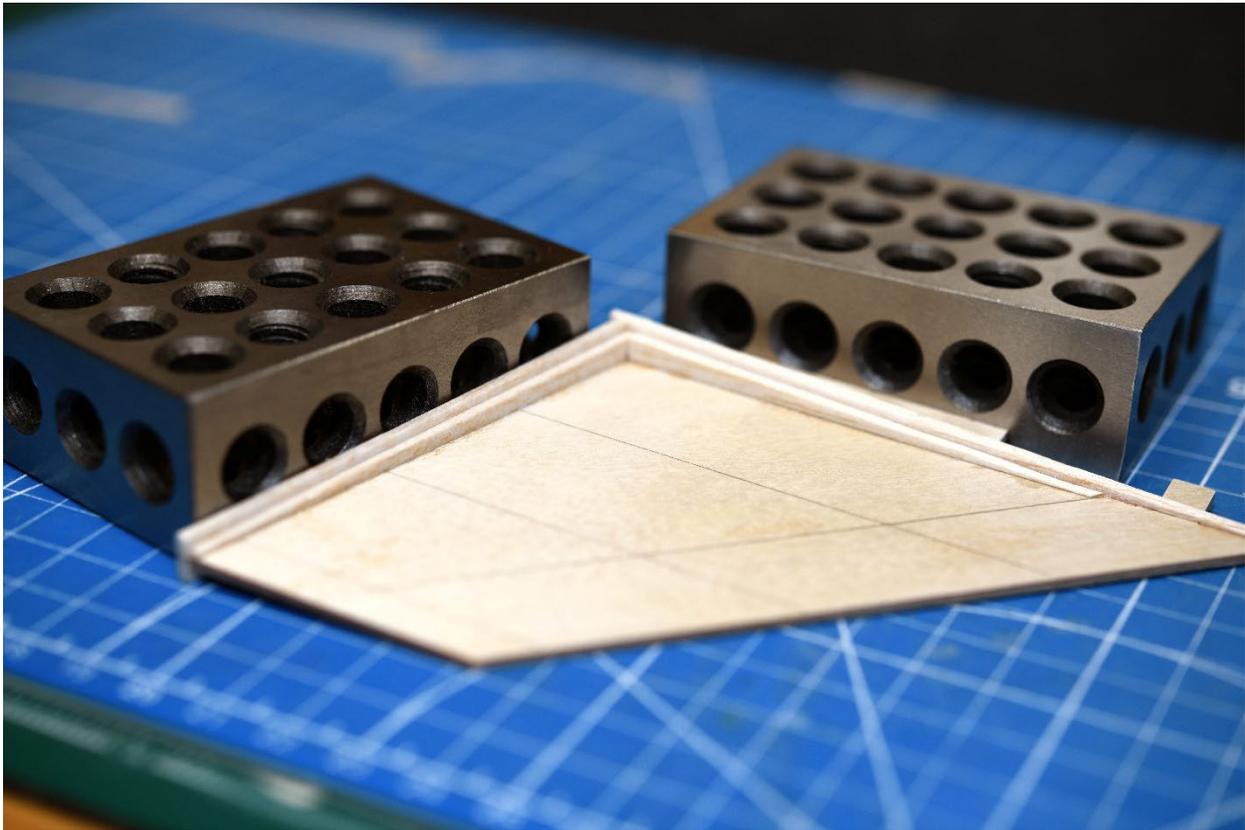


Photo 10: Fin Sheet Edge Supports

Next, a set of tapered chord ribs are added that will provide internal support to the sheeting. One will note how the ribs fall short of the leading edge; this is because the sheeting's inside leading-edge face must be beveled so that it will converge with the fin's leading edge when set in place. The chord ribs are designed and sized to meet this internal sheeting tangent line. One might also notice a tiny blue dot in the lower corner of each rib – this dot was added to denote the right angle of the rib. With the rib slope being only 3 degrees it's quite easy to confuse the base angle of the rib. The blue dot resolves this.

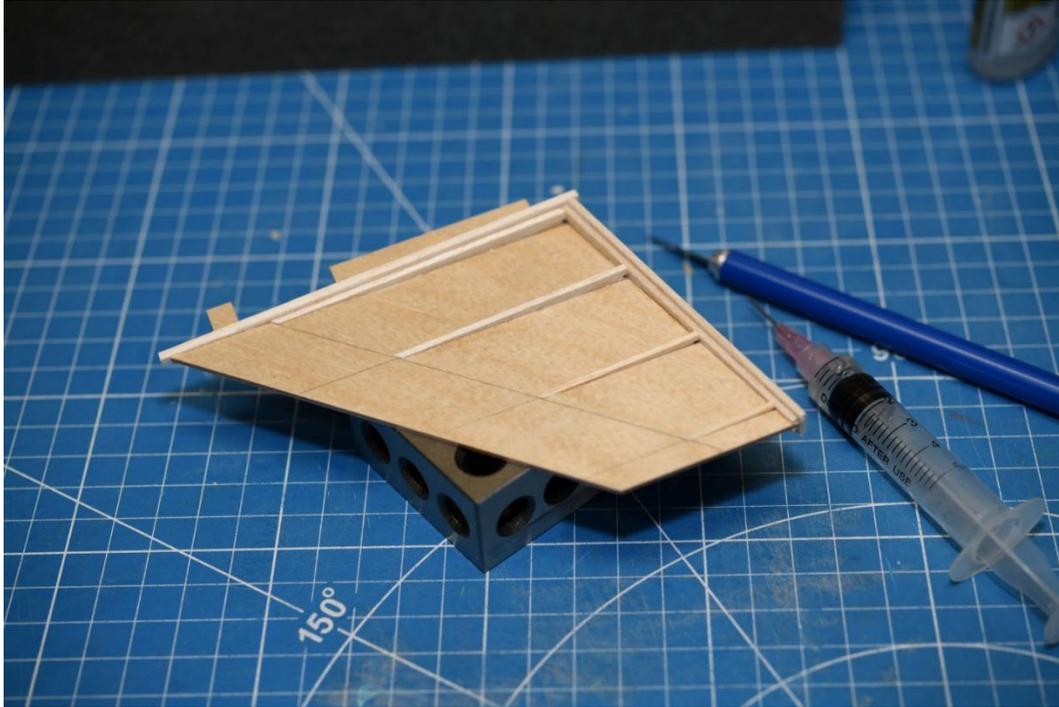


Photo 11: Ribs Glued in Place

Repeating this process we arrive at four skeletal fins, ready for their 1/16" balsa sheeting.

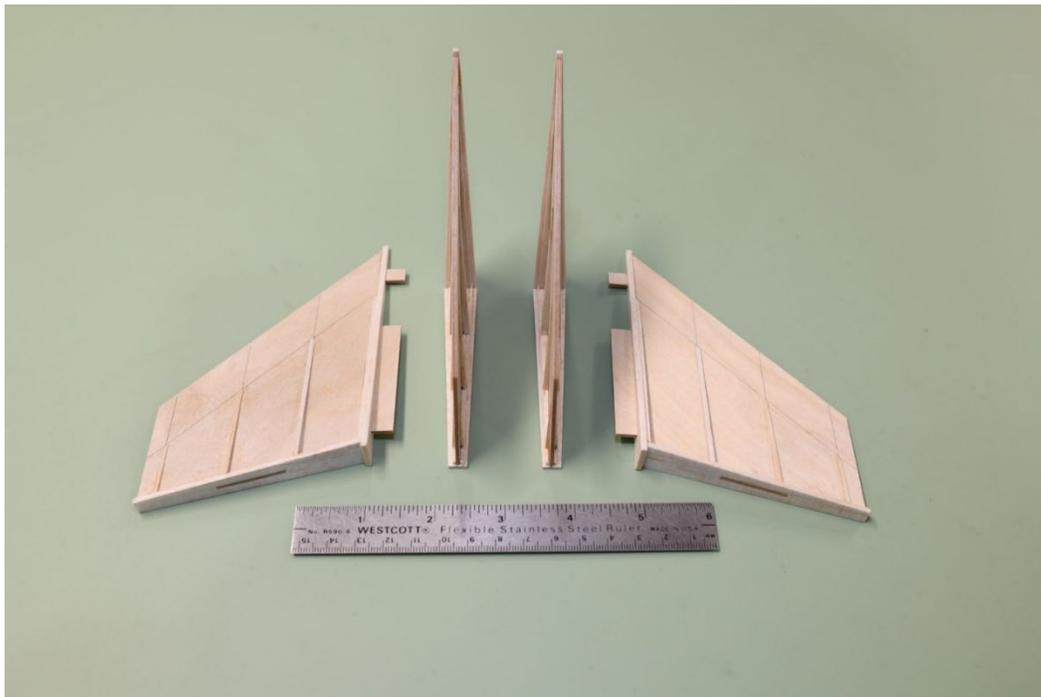


Photo 12: Ready for Sheeting

But first we need to sand the leading-edge bevel into each of the fin sheets in preparation for their installation.

Beveling the Sheets

One of the problems with hand-sanding bevels, tapers and wedges is exactly that – doing it by hand. Too much stock movement, or inconsistent sanding with the block (or both!) usually results in an inconsistent and unsatisfactory result. Here we need a rather shallow bevel along the inside face of each sheet – we can minimize the hand-sanding variables with a sanding fixture that holds the sheet in place while it's being worked.

A sanding fixture was fashioned from a flat piece of 1" pine upon which a pair of 3/16" square pine stops were added to prevent the stock from moving/sliding while being shaped. The stops were positioned such that the leading edge of the sheet sits flush with the edge of the pine board. Note that a lefthand and righthand fixture is needed.

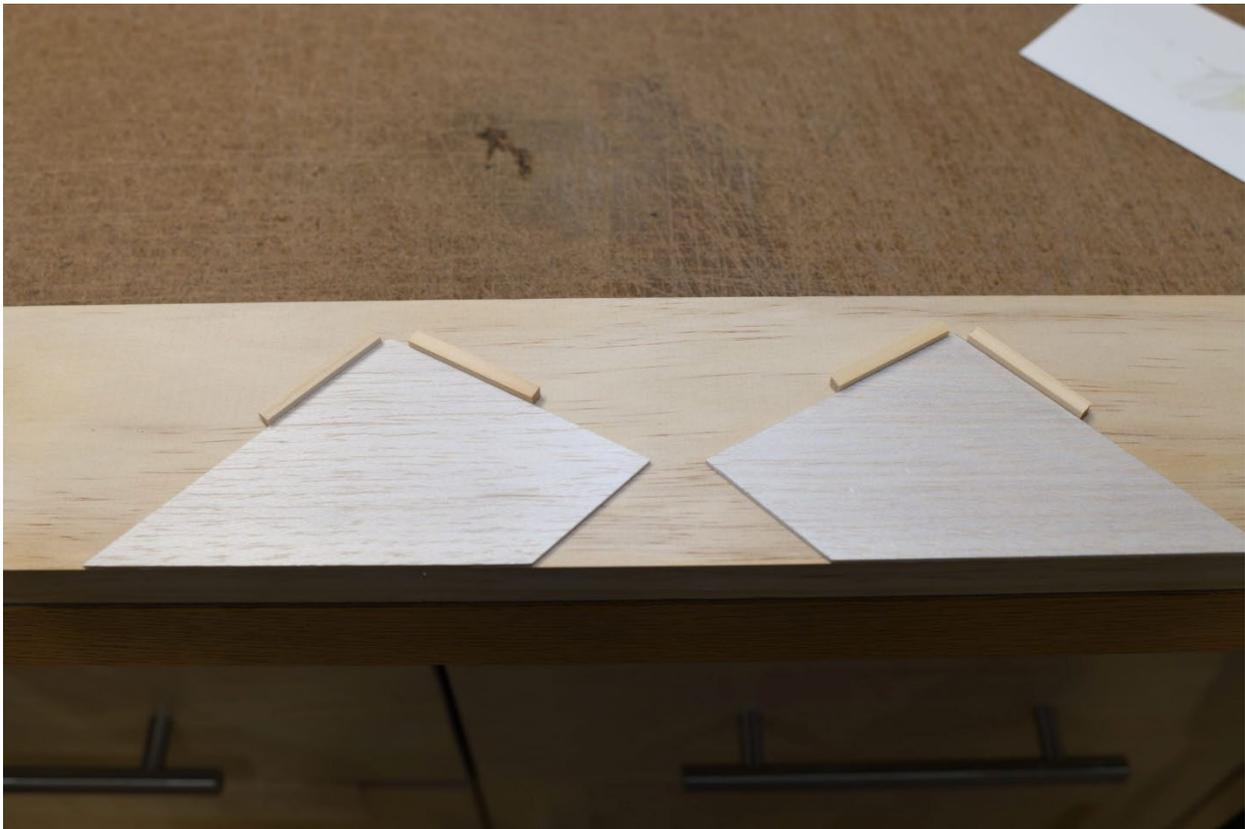


Photo 13: Sanding Fixture

The sheet to be worked is held in place with a strip of masking tape. The leading edge of the masking tape is placed at the bevel's internal tangent line.

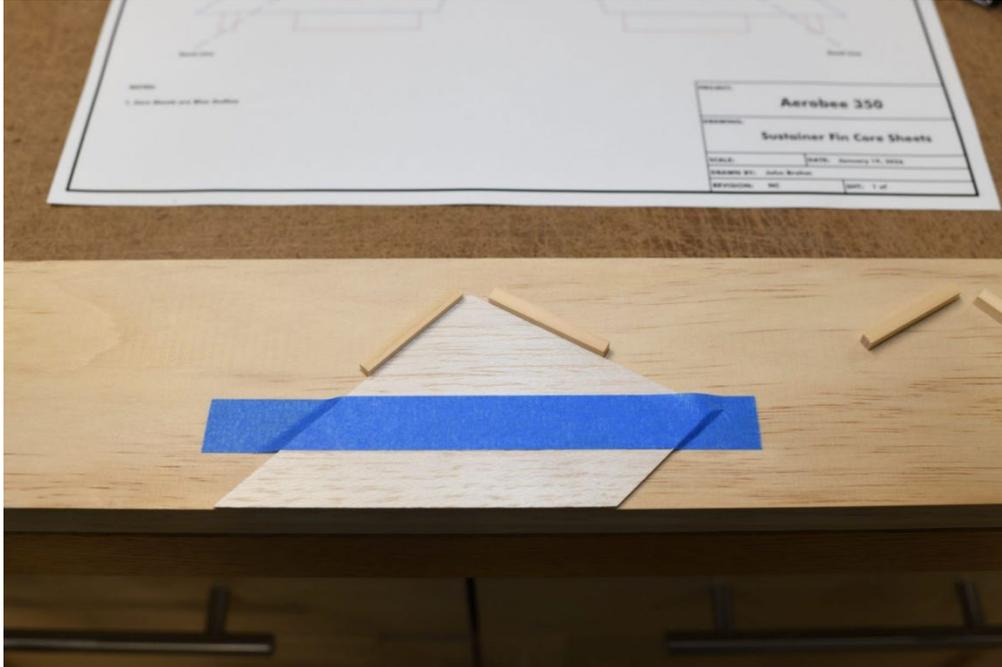


Photo 14: Taped in Place

With some careful, consistent sanding with a progression of grits, taking care to respect the tangent line, a smooth bevel is produced, with the front edge of the sheeting brought to a nominal thickness of 1/64". A straightedge confirms the work.

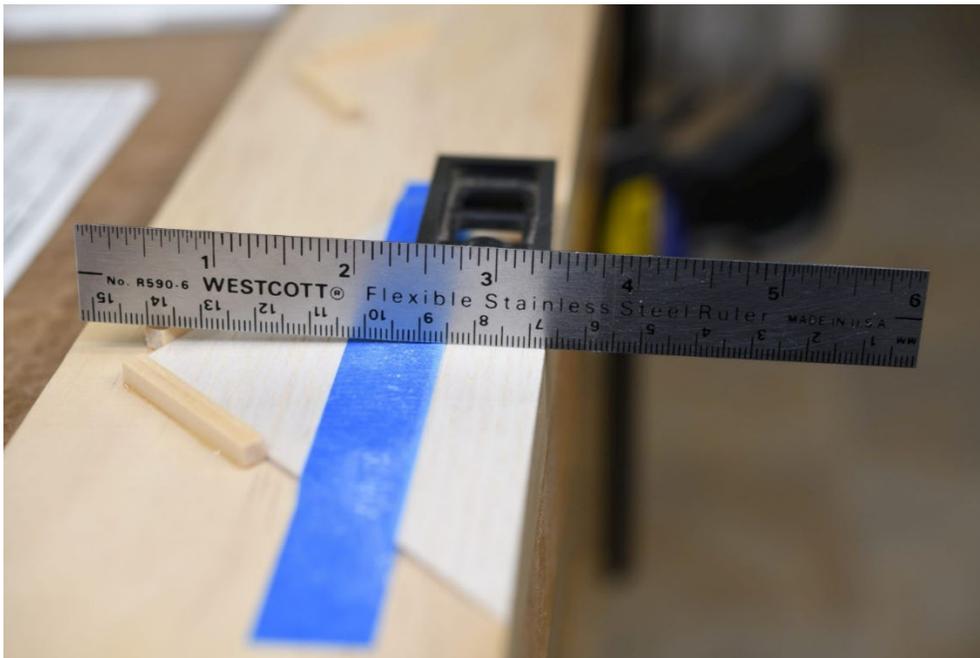


Photo 15: Finished Bevel

With a pair of beveled sheets, we can close up the fin core. Each sheeted fin undergoes a final sanding with some #320 grit. Care is taken while performing the final sanding so as to prevent erosion of the fin's wedge shape.

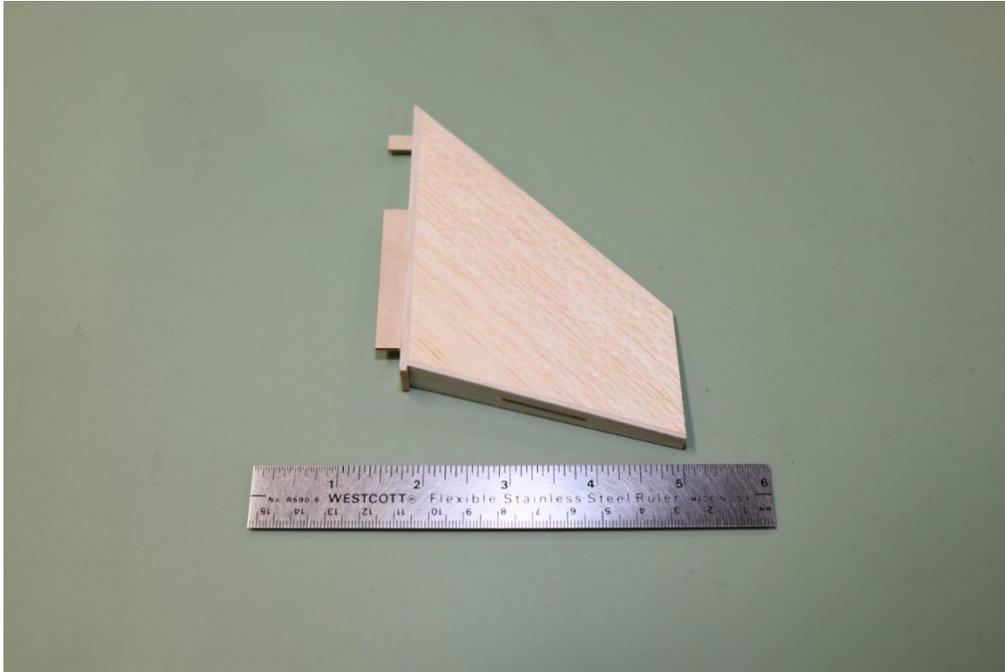


Photo 16: Sheeted Fin

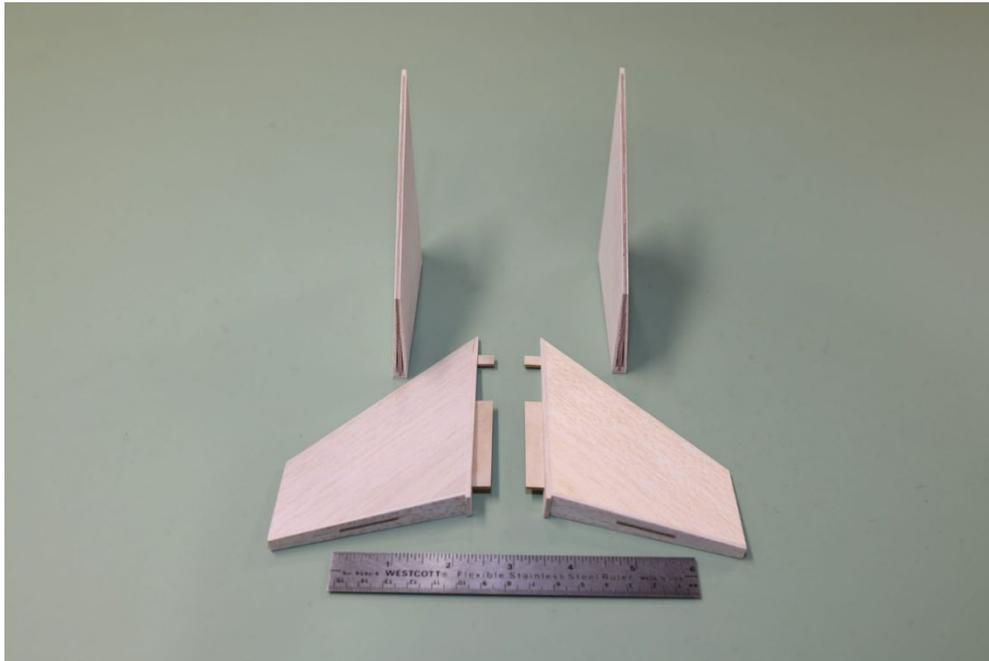


Photo 17: Native Fin Cores

With the final sanding complete, we have a set of native fin cores ready to be fitted with their leading edges. But just before we take that step, we'll close up the open fin tip. We'll do this with a mix of 5-minute epoxy and micro-balloons.

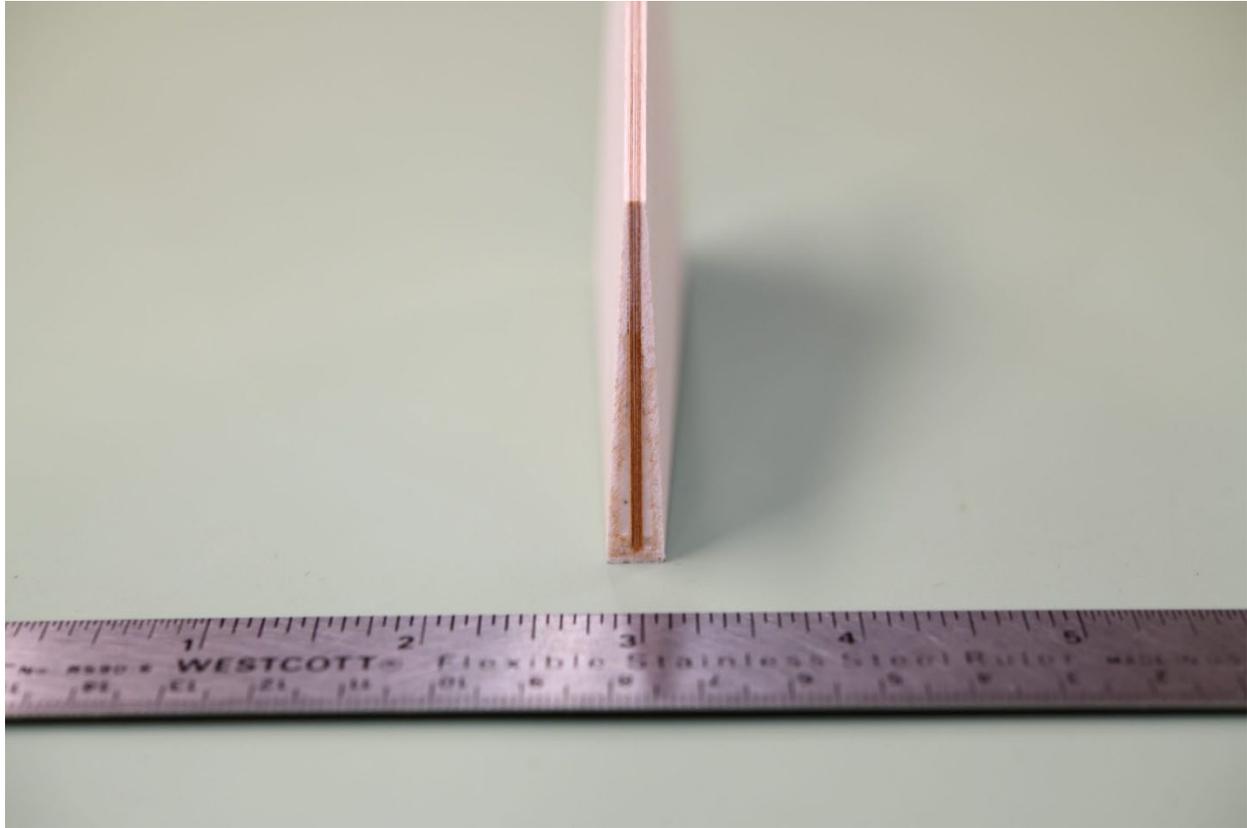


Photo 18: Filled Fin Tip

The Leading Edge

The prototype fin incorporated a solid leading edge molded from a mix of fiberglass and phenolic resin. The leading edge had an exposed chord length of 0.78", and had a milled mating surface designed to fit within the fin sheets as they converged at the leading edge. The fin sheets were then riveted in place.

At the fin's tip, a solid wedge-shaped block was installed to provide a robust tip support. The following photo highlights these features.



Photo 19: Fin Tip LE and Support Block

We'll size the model's leading edge strip such that the tip support block is included in the strip's chord length. Accordingly, the leading edge is fashioned from a length of 0.125" x 0.50" balsa, and will be butt-glued to the leading edge of the fin core.

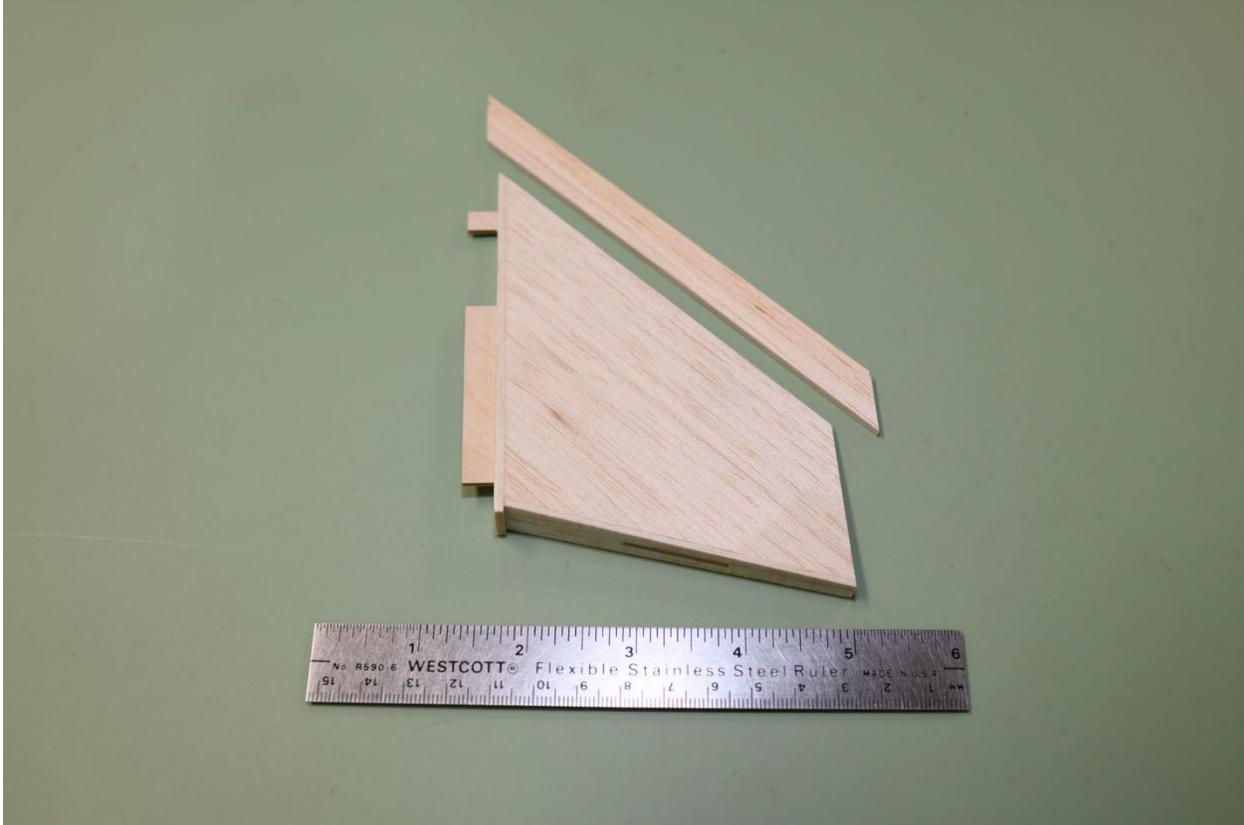


Photo 20: Leading Edge

But which glue should we reach for? We need to use an adhesive that will secure the joint but will be relatively easy to sand. Depending on the balsa's density, adhesives like CA and epoxy can cure too hard as compared to the surrounding balsa, leaving a hard ridge at the joint that could show through the outer 0.010" Styrene fin skins. Even a good aliphatic glue, like Sig's SIG-BOND, can present this risk. So here, we'll opt for an old-fashioned model airplane nitrocellulose adhesive, Ambroid, and we'll mate the leading edge strip with an Ambroid double glue joint.

Sadly, Ambroid went out of business quite a few years ago, so finding a useable tube is a rather challenging proposition. Sig's SIG-MENT was a good substitute, but unfortunately it too has been recently discontinued (although as of this writing it can still be found in some supply chains). But fear not - there are still some excellent substitutes available, such as Duco Cement and Indoor Free Flight Supply's NiCe! adhesive (<https://www.indoorffsupply.com/>). However, the best Ambroid substitute that I've found (or at least the one I prefer) is the Nitrocellulose Adhesive produced by 3Rivers Archery (<https://www.3riversarchery.com/>). This stuff looks and smells exactly like the old Ambroid liquid cement of yesteryear.



Photo 21: Nitrocellulose Adhesives

With the glue joint cured, we can carefully shape the leading edge in situ with a progression of grits until finally, we arrive at the finished sloped edge.

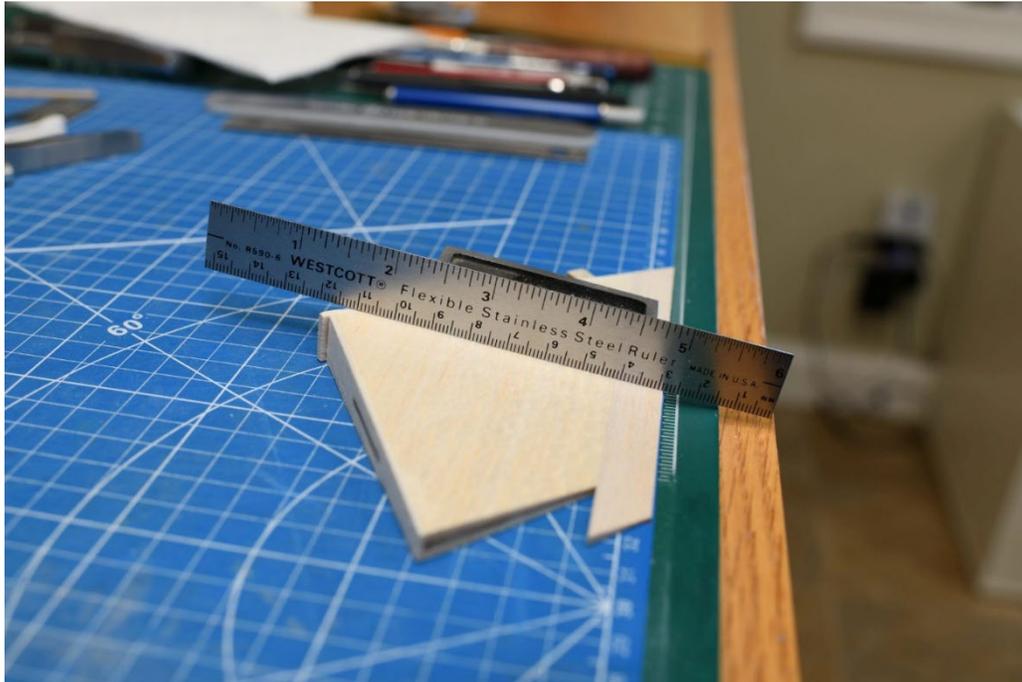


Photo 22: LE Sanding Complete

Provided we stayed mindful of the fin's slope while sanding, then the finished leading edge will have a width of about 0.030". We'll cap this with a length of 0.030" diameter Styrene rod. This rod rounds the leading edge and provides a perfect mating surface to weld the front edges of the fin skins with some thin Styrene cement.

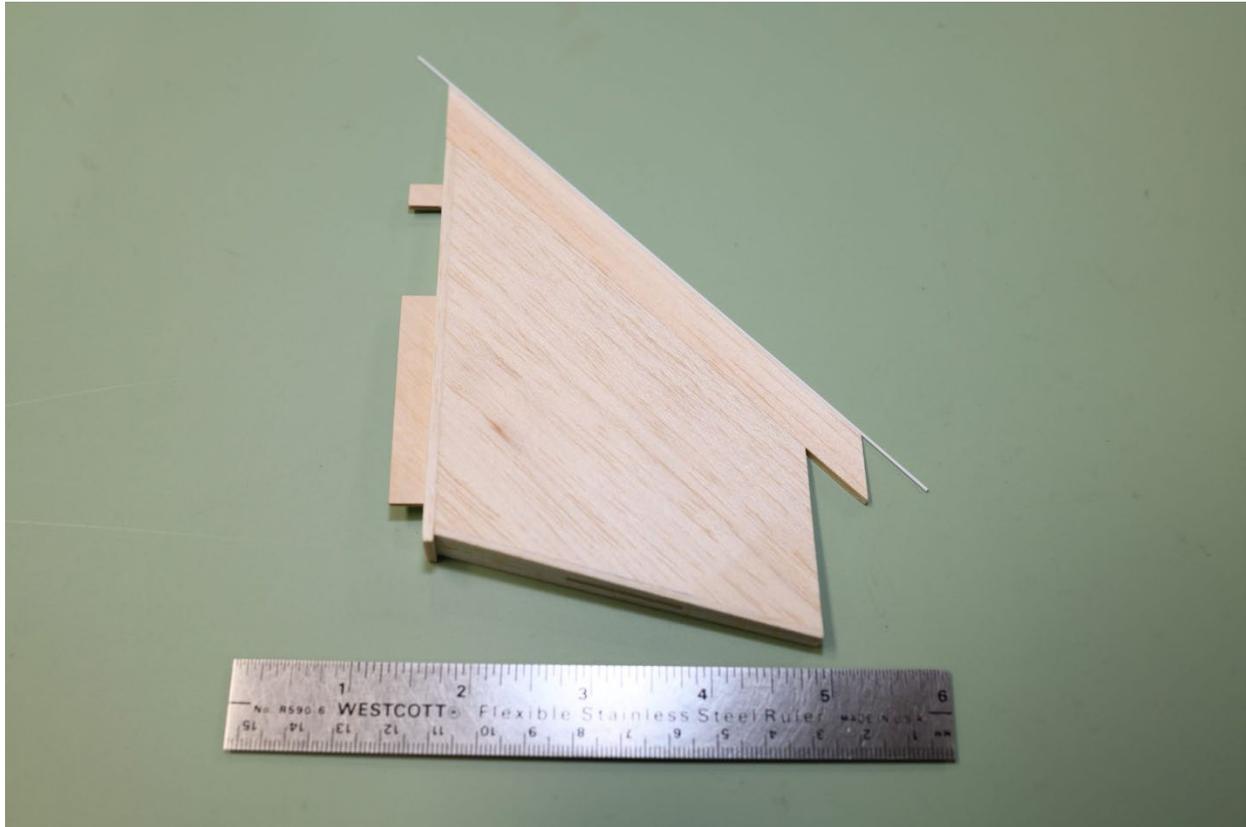


Photo 23: Ready for Fin Skins

The rod plus the two converging 0.010" Styrene fin skins provide the 0.05" LE width we're aiming for. The overhanging LE ends will be trimmed once the fin skins have been placed.

The Fin Skins

We'll begin by preparing a set of fin skins fashioned from 0.010" thick sheet Styrene.

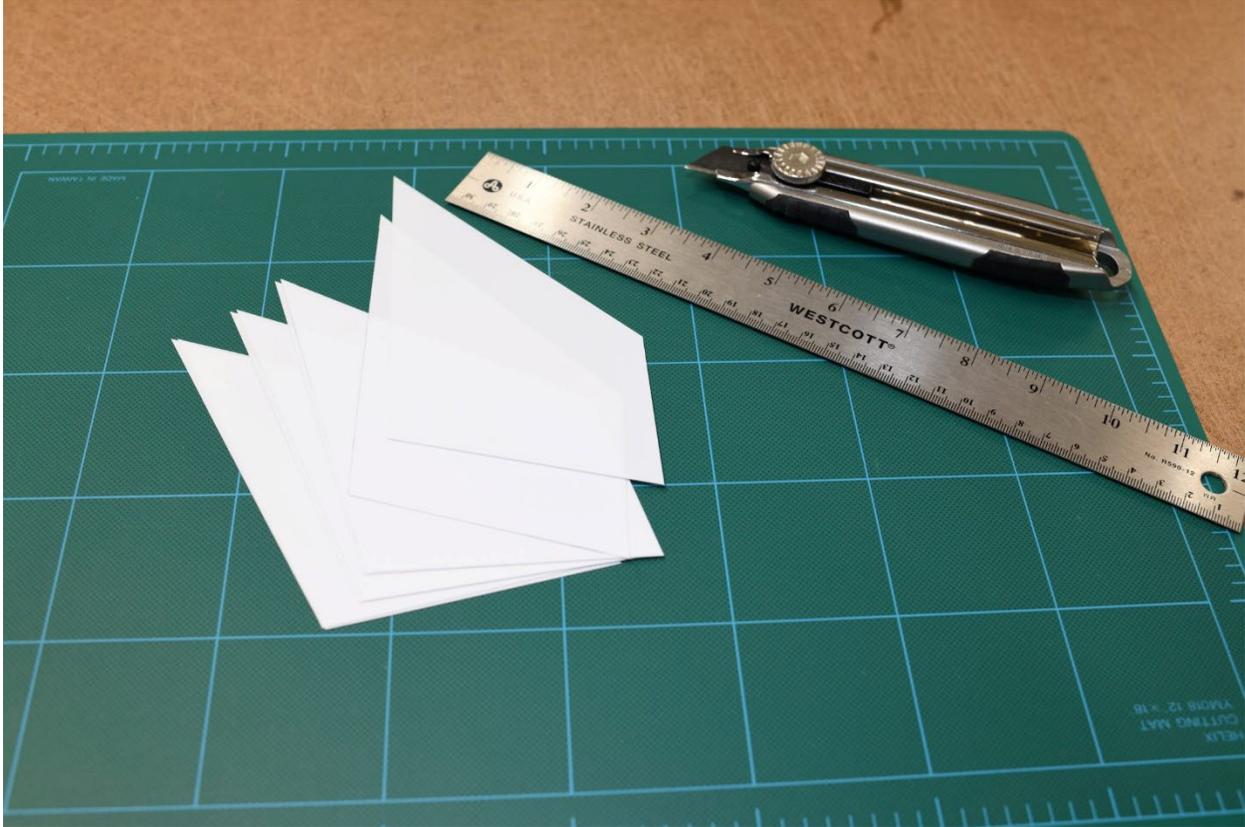


Photo 24: Styrene Fin Skins

But before we apply the skins to the sheeted fin cores, we must first decide how best to represent the surface detail found on the prototype fins.

Our earlier prototype fin photos make plain that the rivets used on the prototype fins were flush to the skin; while they are visible on the unfinished metal fin, they are not so on the freshly painted fins. They would have been partially obscured by the fin's primer, and fully covered by the paint, as the fins were hand painted.



Photo 25: Painting Fins

Provided courtesy of Al Pizzo/Josh Tschirhart



Photo 26: No Visible Rivets

So, we'll ignore the flush surface rivets on the painted fins but will attempt to account for them on the unpainted natural metal fin. This means we'll have two different finishing strategies for the fins – one for the three painted fins, and a second for the unfinished fin.

We must also account for the visible detail in the channel portions of the Aft and Tip spars. Recalling our earlier Photo 1 and considering the following photo, we can see several Aft spar features that must be addressed.



Photo 27: Exposed Root Base Channels

Provided courtesy of Josh Tschirhart

First, there are the exposed ends of the two channels that make up the root base plate (bottom and top). Just above is the access hatch, and then between the two photos we can see how the interior of the Aft spar is covered with phenolic cork, with the various rivet holes in the cork potted with the bonding adhesive, as mentioned previously. We can also see how the fin skin is riveted to the Aft spar channel sides, so we'll add strips of Styrene to build out these edges accordingly. The cork and potted rivet detail will be addressed during the paint and finish stage. So, with our skinning strategy set a Styrene fin skin is glued to each side of

the fin core with thin CA. The root channel ends are crafted from scaled pieces from 0.010" Styrene and are cemented in place.



Photo 28: Skinning a Fin

The access hatch (see Photo 4) will be crafted from a scale piece of Styrene but will be cemented in place once the main painting has been completed.

The interior edges of the Aft spar channel are built out with strips of 0.010" and 0.015" Styrene to arrive at the correct scale thickness (channel thickness + cork, each side). The forward edges of the fin skins are glued to the Styrene rod leading edge with Extra Thin Styrene cement. Time to tackle the Tip spar.

Our earlier Photo 19 and the following photo provide a good view of the Tip spar detail.



Photo 29: Tip Spar Detail

Provided courtesy of Josh Tschirhart

One can see how the prototype fin skins are riveted to the Tip spar channel sides, with the back side of the rivets being particularly visible. At our scale factor, Archer Fine Transfers (<https://www.archertransfers.com/>) G-Scale resin rivet heads (#AR88082) are a good match for this detail, and we'll place the appropriate rivets on pieces of sheet 0.010" Styrene.

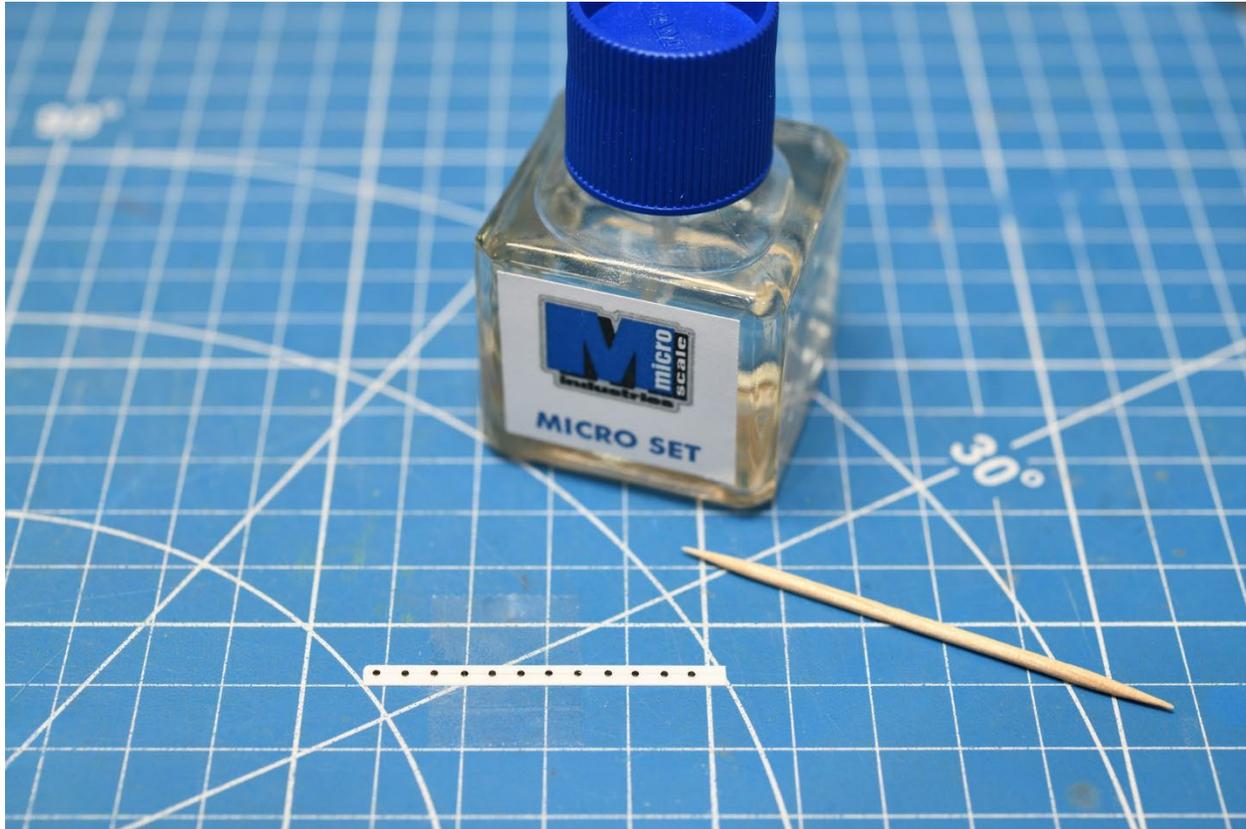


Photo 30: Riveting Stuff

These strips are then cemented in place, with the strip edges lightly sanded to ensure conformity with the fin skin edges.



Photo 31: Tip Rivets in Place

Finally, the leading edge separation line is scored into the fin skins at the appropriate location. And with this, our A350 wedge-shaped fin is ready for the Paint Shop.

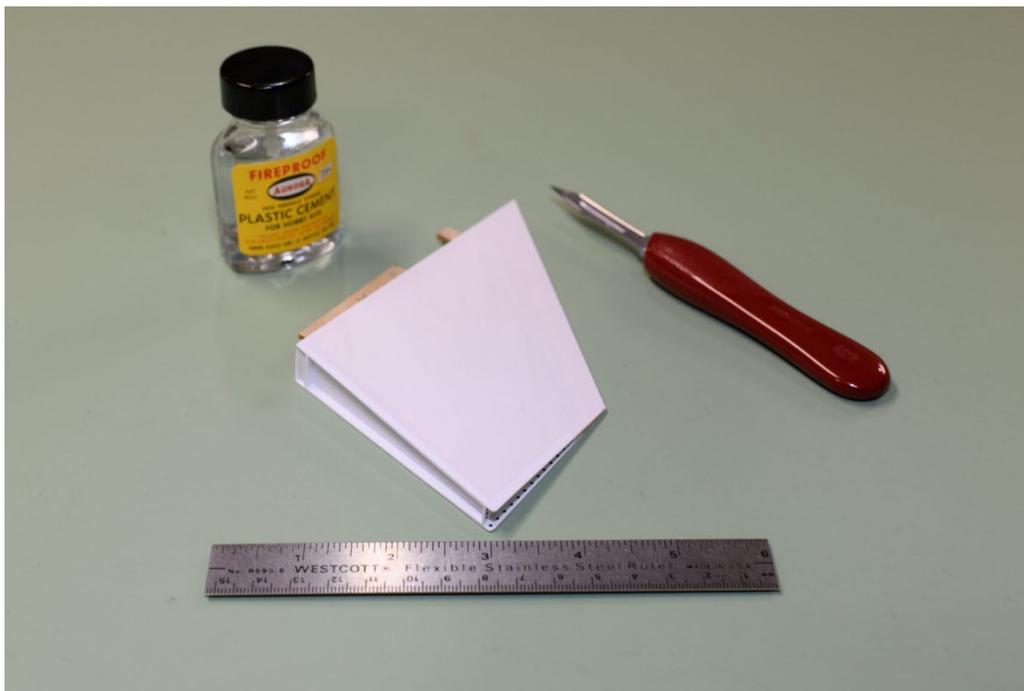


Photo 32: Finished Fin, Ready for Primer

Let's take a quick look at this fin on the Sustainer's motor mount.

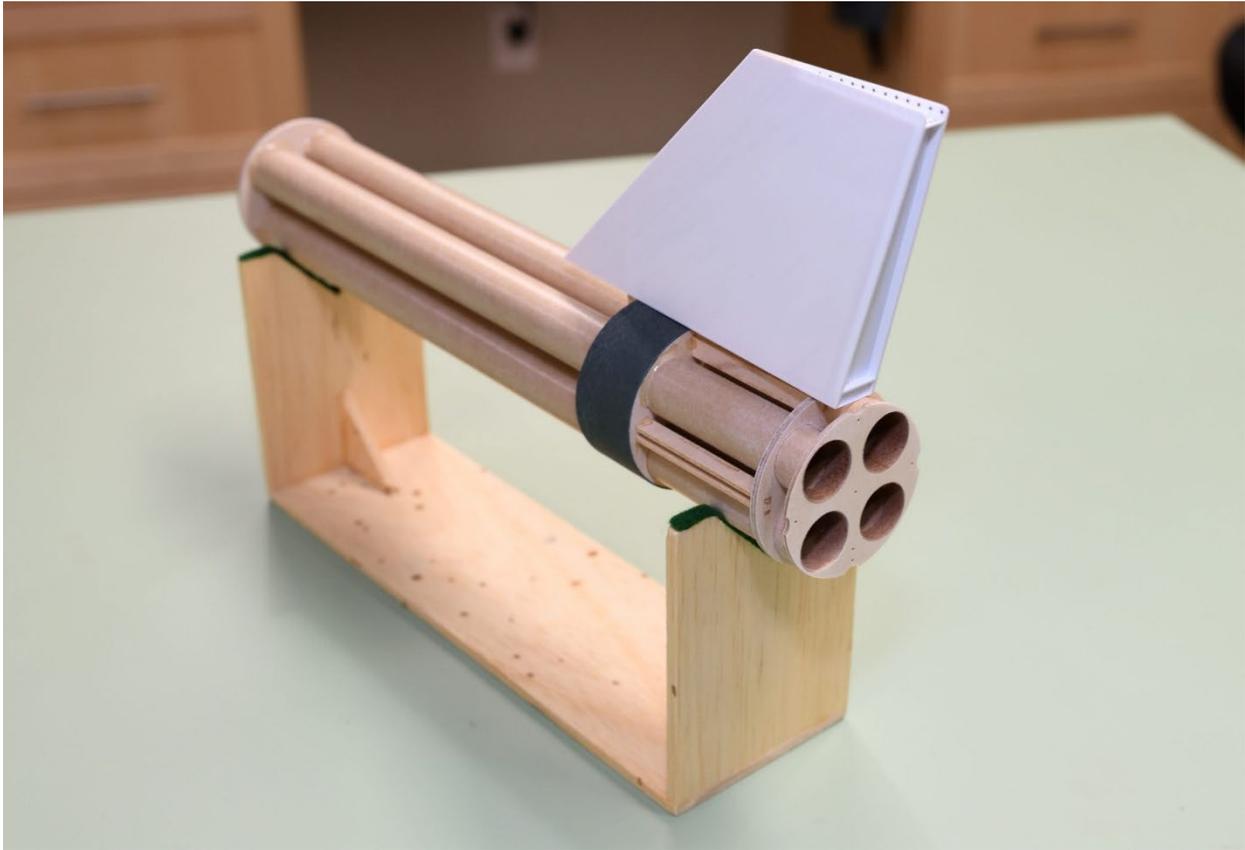


Photo 33: Fin and MMT Dry Fit

Seems to be coming along quite nicely. We'll finish up the other three fins, and then tackle the paint and finish process. Until then, I hope you found this article of interest, and as always, best of luck with your scale projects!