Javelin – Building the Honest John Booster

By John Brohm, NAR #78048

In this, the final chapter in our 1/10th size Javelin construction series, I'd like to share with you the approach taken to model the Javelin's 1st stage Honest John booster. It may seem odd that we end the story with the 1st stage, but we must recall this series was sparked by the loss of the 3rd stage and payload section of the original model. So somewhat unusually, this is a model that has been built from the top down.

The Honest John booster is the largest and most complex part of the model, the prototype rich in detail, and incorporates the unique adapter that mates the Honest John booster to the 2nd stage Nike. That unique HJ-Nike adapter also serves as the nest for the staging package that fires the 2nd stage Nike, and so our planning must take this requirement into account. We will also cover the construction of the HoJo's big diamond fins.

References

Once again, we'll draw upon the very extensive Javelin data archive made available by our good friend Josh Tschirhart. In the archive we find a very comprehensive drawing of the 1st stage booster, prepared by Jon Randolph, and as shown in Figure 1. As can be seen, some parts of the drawing are barely legible, but fortunately Josh has prepared a clearer and more precise version, as shown in Figure 2.

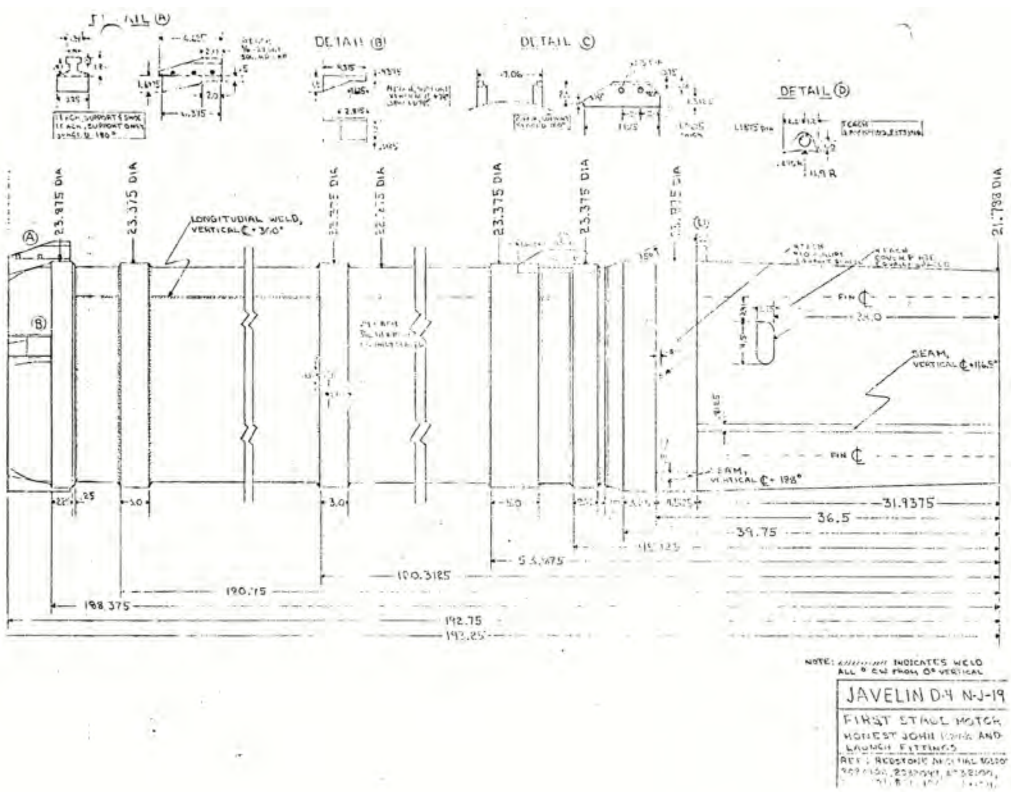

Figure 1: Honest John Booster

(Jon Randolph Drawing)

Note that the Randolph drawing ends at the forward limit of the HoJo motor case; Josh's drawing in Figure 2 goes a step further, and provides an outline of the HJ-Nike Adapter. When we get to that section of the model, we'll pull in a more detailed drawing of the adapter to guide our construction decisions.

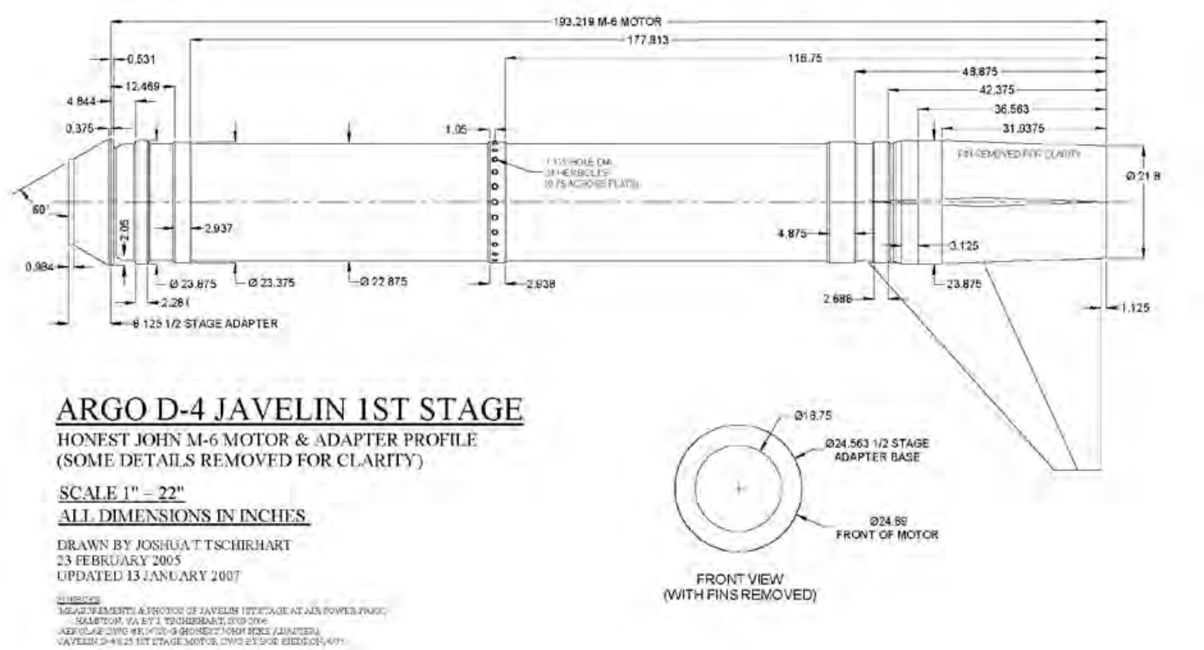

Figure 2: Javelin Honest John Booster

(Josh Tschirhart Drawing)

The Javelin archive also makes available a number of photographs taken of several actual prototype rounds; these too will be pulled in as needed as we confront the various details that characterize this part of the vehicle.

Build Considerations

Setting details aside for a moment, our first decision is airframe choice. We recall that our Scale Factor is 10.32, which returns a model slightly less than 1/10th size. The prototype has a bare airframe OD of 22.875"; at our scale factor that equates to 2.217". A quick check of available tube specs shows that this is precisely the OD of BT-70, and so this tubing forms the basis of our Honest John booster.

Looking at the aft end, we see a rather complicated arrangement of case bands followed by a tapered tail cone. In the Randolph drawing we see a broad overlap weld that closes the tail cone, and a fin mounting access panel; that access panel appears in each of the four fin quadrants, and was used on the prototype to access the bolts that mate each fin to the nozzle section of the motor. Photo 1 shows these details more clearly.

Photo 1: Honest John Tail Cone Arrangement

(Photo by Josh Tschirhart)

To close the point, we offer Photo 2, which highlights the fin installation process on the prototype:

Photo 2: Honest John Fin Installation

For the model, we desire a tail cone that captures all of these details, but one that also provides for the motor mount and for the fin mounts.

One choice would be a turned balsa tail cone – sturdy, and reasonably easy to finish, but an approach that might make the representation of those four fin mounting access panels a bit difficult. On the prototype, those panels are flush with the tail cones' outer surface, whereas on a solid balsa tail cone one would be tempted to surface-mount the panels. That wouldn't be prototypically accurate.

Another choice might be a built-up transition with an outer transition shroud as a cover. Conceptually this would work, but my concern with this idea was with the integrity of the shroud at the fin interfaces, the propensity for the shroud to dip in open spaces, and generally the sturdiness of the assembly upon landing. Those big HoJo fins can leverage large loads should the booster land at an angle.

Given all of these concerns, I elected to design the tail cone in CAD and have it 3D-printed. This then set the starting point for the model.

Construction

Carl Campbell of DFR Technologies was kind enough to print the tail cone for me, and so we begin the build with a very precise part.

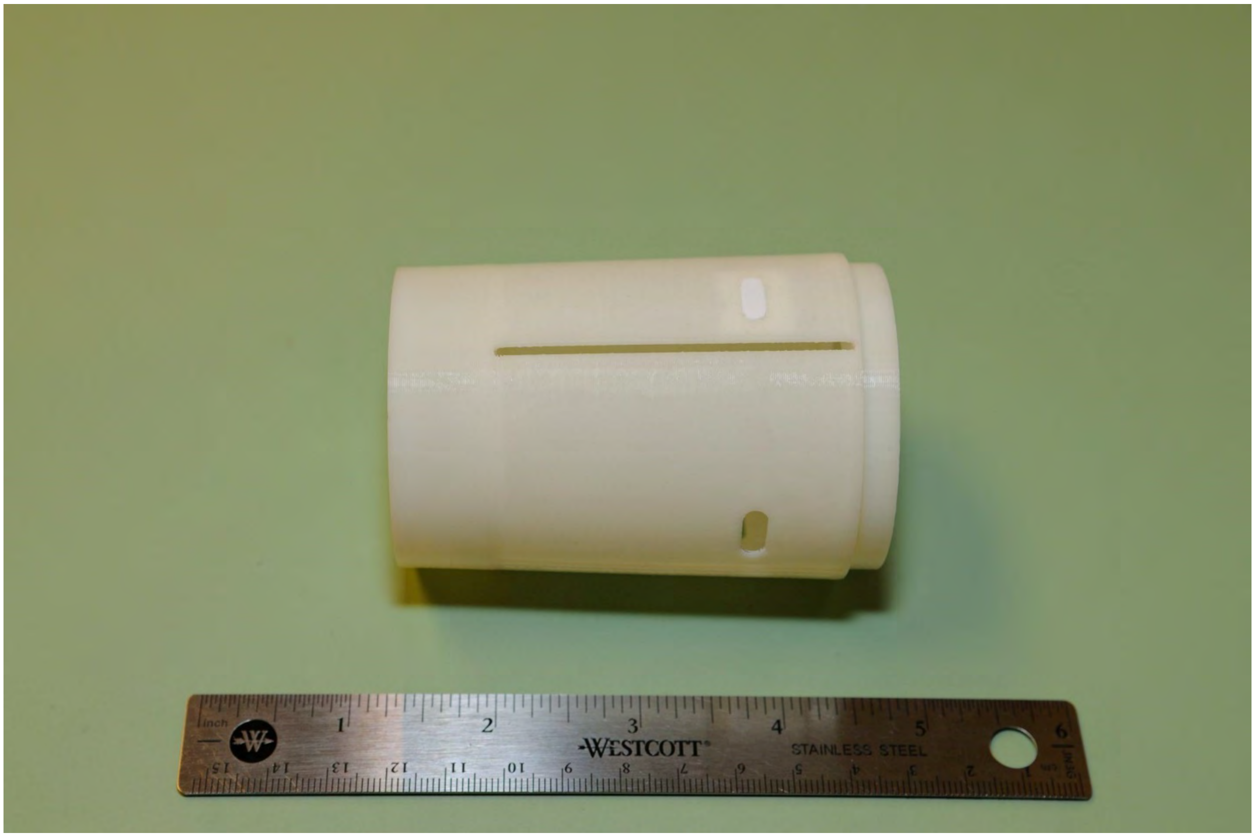

Photo 3: Native 3D-Printed Tail Cone

In Photo 3, one can see a fin tab slot, an open fin mounting access port, and a hint of the integral, internally printed aft centering ring that forms part of the motor mount. The internal forward ring is located just below the coupler at the forward end.

Photo 3 also shows a fin mounting access panel already installed in the top side of the part. To do this, I first backed the hole with a piece of sheet Styrene. Given that the cone's wall thickness is 0.040", I placed in the hole, and on top of the backing sheet, a pair of 0.020" square strips to support the panel. Then I placed the access panel itself, shaped from a piece of 0.020" thick Styrene. This brought the panel flush to the outside surface of the tail cone. A Styrene strip was then added to represent the overlap weld.

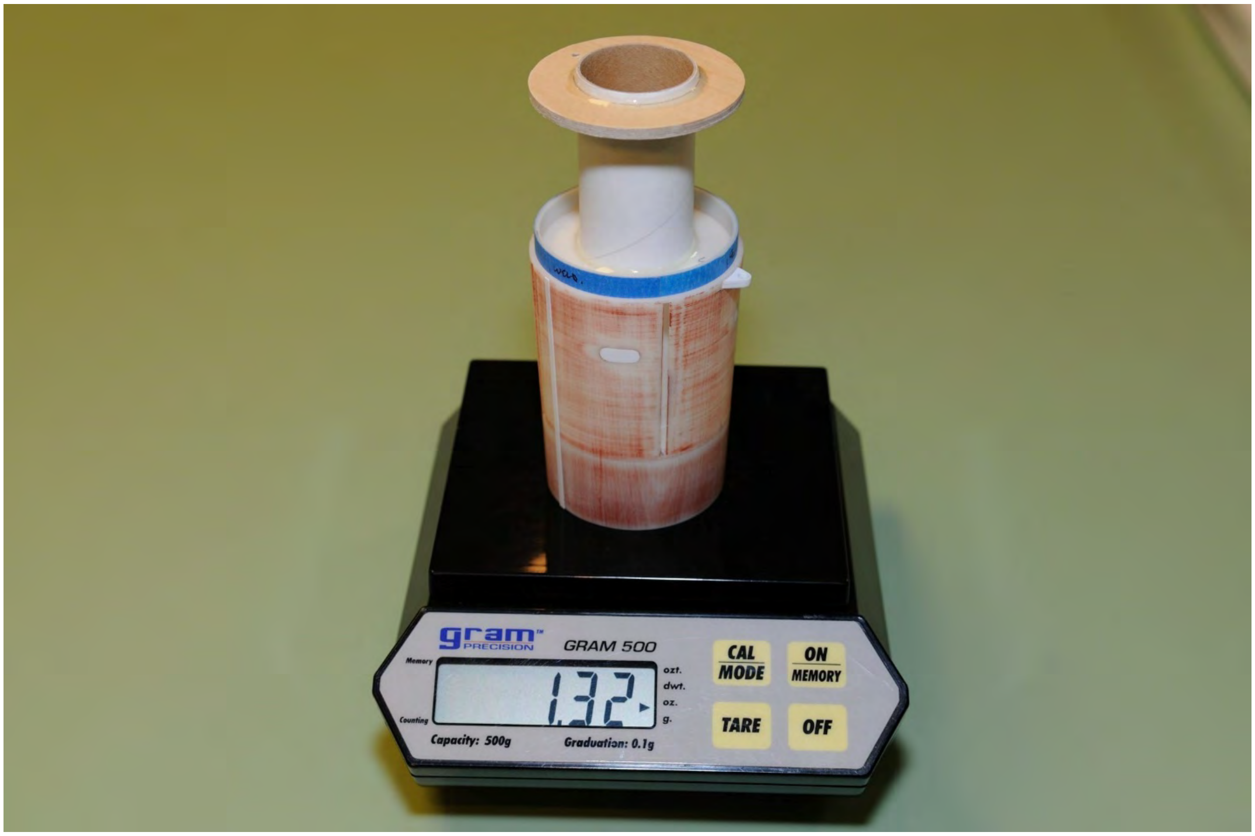

Photo 4: Tail Cone Assembly

Photo 4 shows the tail cone assembly – the motor mount tube has been installed together with a forward centering ring, and the tail cone overlap weld can be seen on the left side of the cone. Note that the tail cone has been filled and sanded, a step taken before the surface detail was added.

Photo 4 also shows a lug protruding from the top of the tail cone; that lug was used on the prototype to support the vehicle on the launch rail when placed in launch attitude. This lug can be seen as "Detail D" in Figure 1, above, but we also have a clearer view in a sketch provided by Josh Tschirhart.

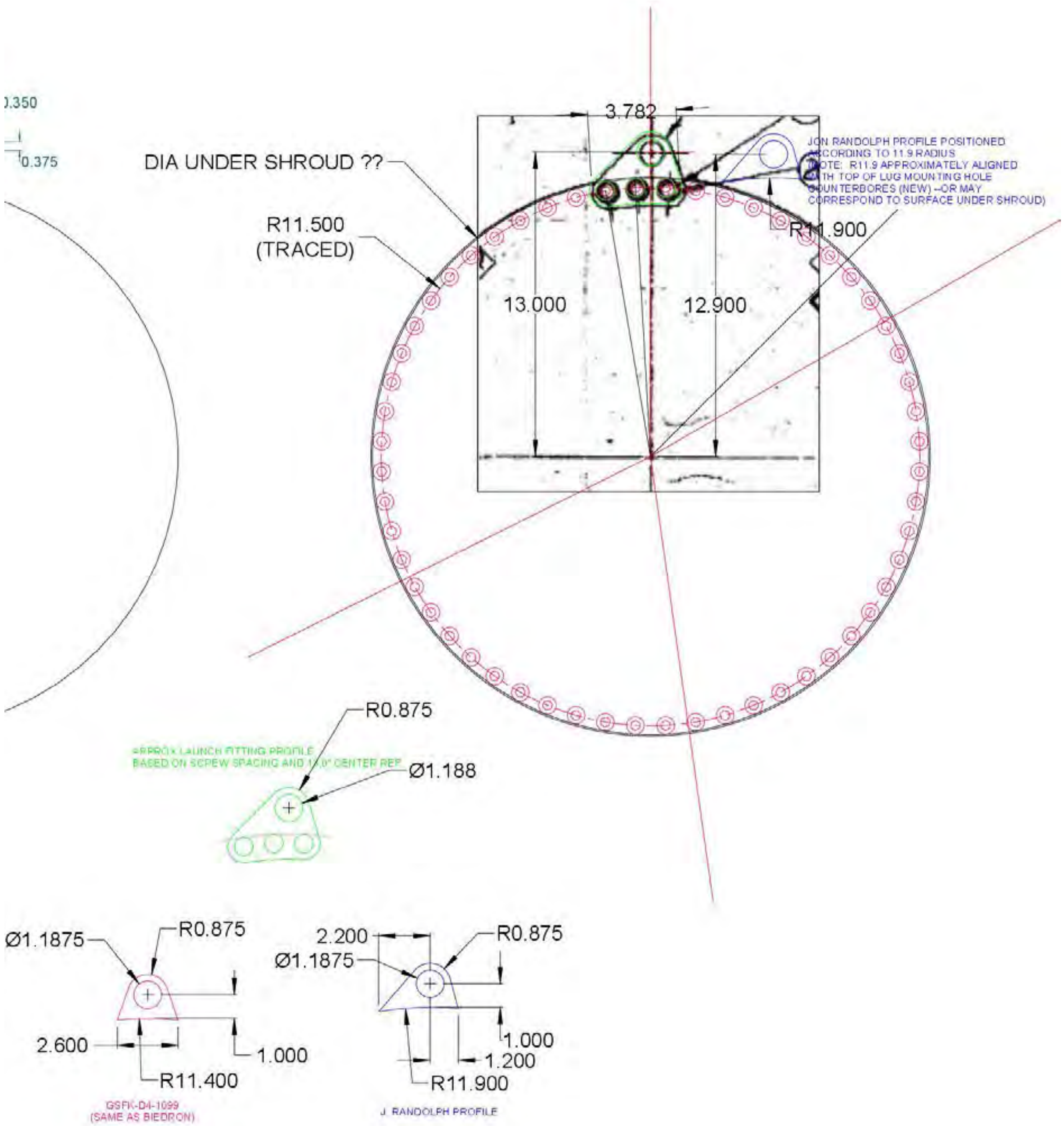

Figure 3: Tail Lug (Viewing Forward from Aft End)

(Drawing by Josh Tschirhart)

Josh's drawing cleans up the detail from the Randolph drawing, and highlights the dimensions of the lug. Note there were at least two versions of the lug – we can't know which version was used on the specific round we're modeling, as we have no photo (so far) that shows this detail on our round. We'll use the Randolph version, staying consistent with our main reference drawing.

The lug was built up from layers of Styrene to arrive at a blank slab of the correct scale thickness. The rail mounting hole was then located and drilled with a #32 bit for scale diameter.

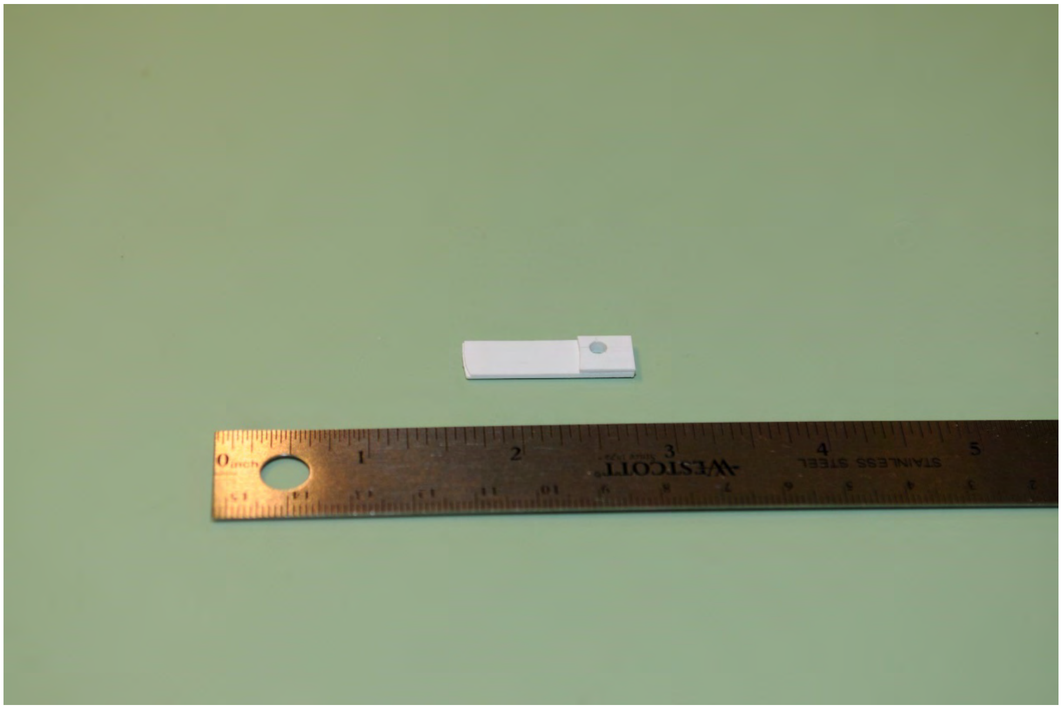

Photo 5: Blank Lug Slab

The slab was then carved and sanded to final shape.

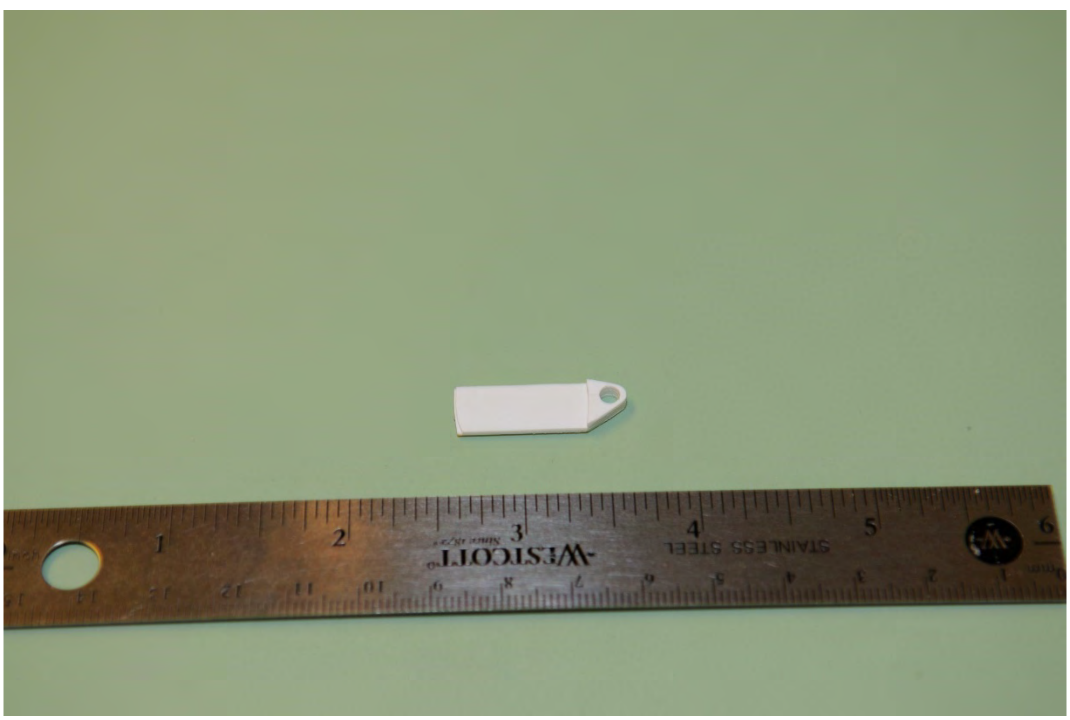

Photo 6: Tail Lug, Ready for Installation

The mounting position for the lug was located on the tail cone, which was then slotted, and the lug cemented into place.

Photo 7: Tail Lug Installed

Later on, when we view the finished model photos, you may notice that the lug has been repositioned further forward on the booster. That's because at this stage of construction I wasn't paying attention closely enough, and located the lug incorrectly. This error was caught, and the lug properly repositioned.

Returning to our build, the scaled airframe is then added (making sure not to forget to install the shock cord anchor on the forward centering ring beforehand), and then using the Randolph and Tschirhart drawings, the various aft case bands were added using scaled pieces of sheet Styrene.

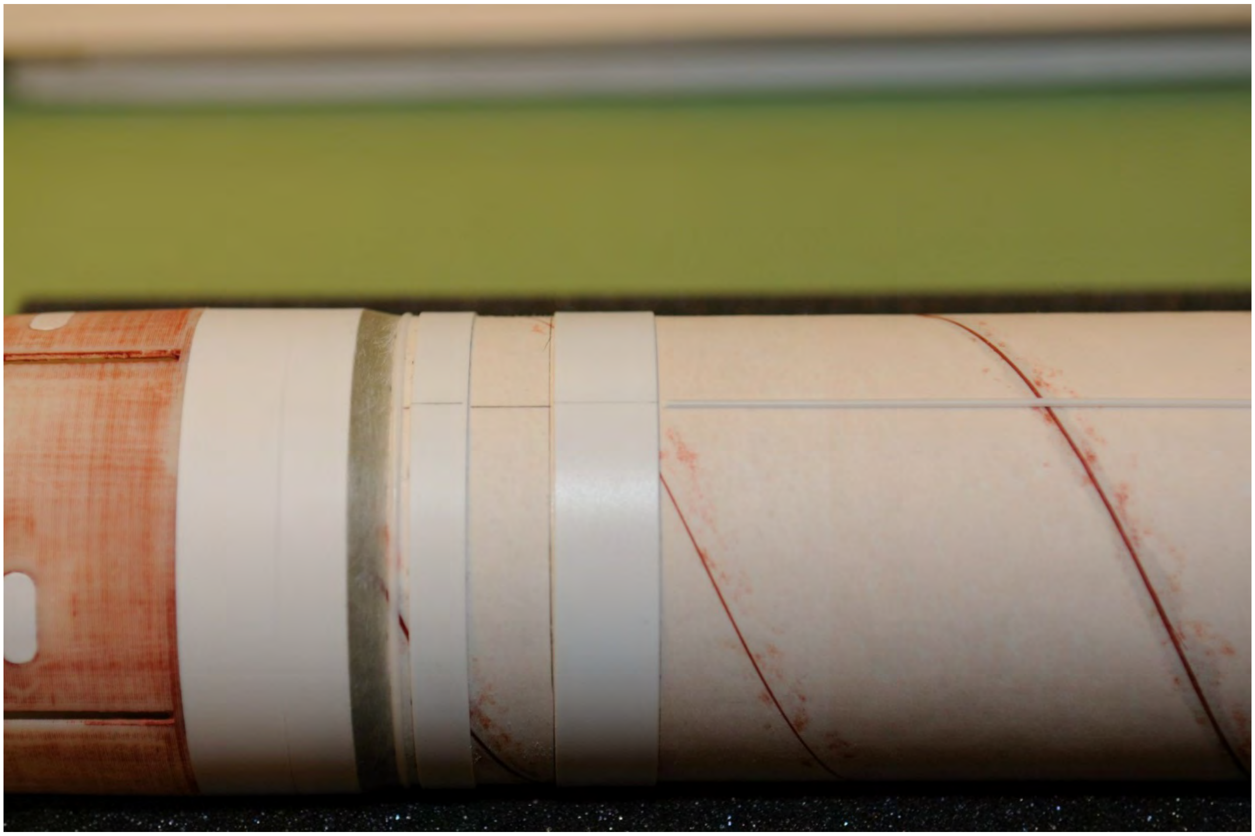

Photo 8: Case Bands

Note the small forward transition in the left of the photo; this was formed from Apoxie Sculpt, shaped while soft, and then filed and sanded to final shape once cured.

Next, we tackle the aft launch rail lugs – these can be best seen in the following photos 9 and 10.

Photo 9: Aft Launch Rail Lug

(Photo by K. Johnson)

Photo 10: Rail Lug, Longitudinal View

(Photo by K. Johnson)

There has been some debate whether the lugs used on the round we're modeling actually had the bolted-on ears; our reference photos just aren't clear enough to make a solid determination. I elected to model the whole affair for completeness, and for the added detail.

For the model, the lugs were built up from separate pieces of scaled Styrene, and then cemented into place. Photo 11 shows the finished result on the model. Note that a second set of lugs are mounted on the other side of the round, 180 degrees opposite.

Photo 11: Aft Rail Lugs

Moving further forward, we see one of the most distinguishing features of the booster – the bolted mid-case band. This is illustrated in Figure 2, above, and can be clearly seen on the prototype, as shown in the following Photo 12:

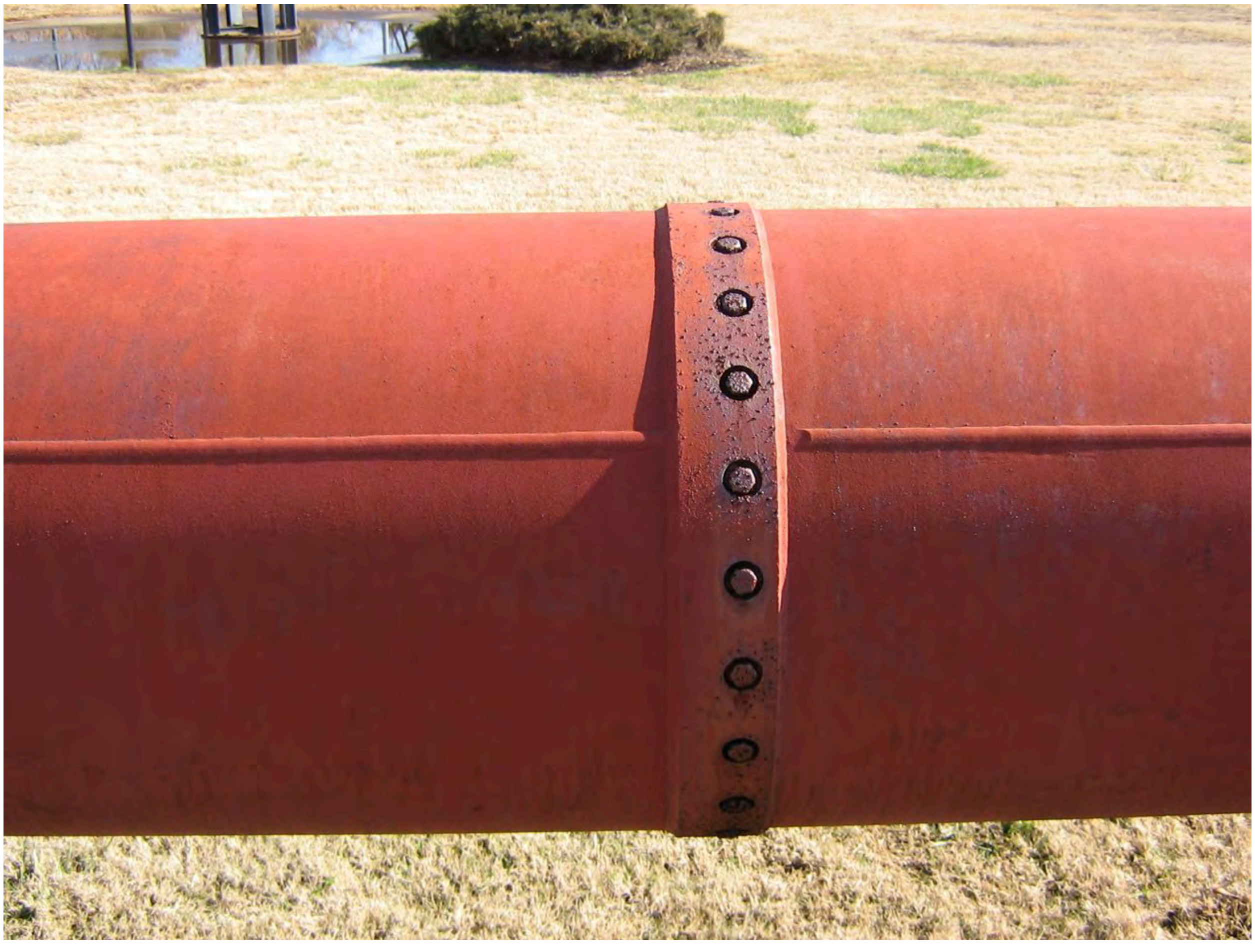

Photo 12: Bolted Mid-Case Band

(Photo by Josh Tschirhart)

Note that the bolt holes are located just forward of the center of the band. To create this detail, I drew the pattern to scale in CAD, printed the pattern and then taped it to a scaled piece of Styrene. This was then punched in a jig to form the correct size holes at the correct spacing, as shown in Photo 13. Photo 14 shows the completed strip, ready for application.

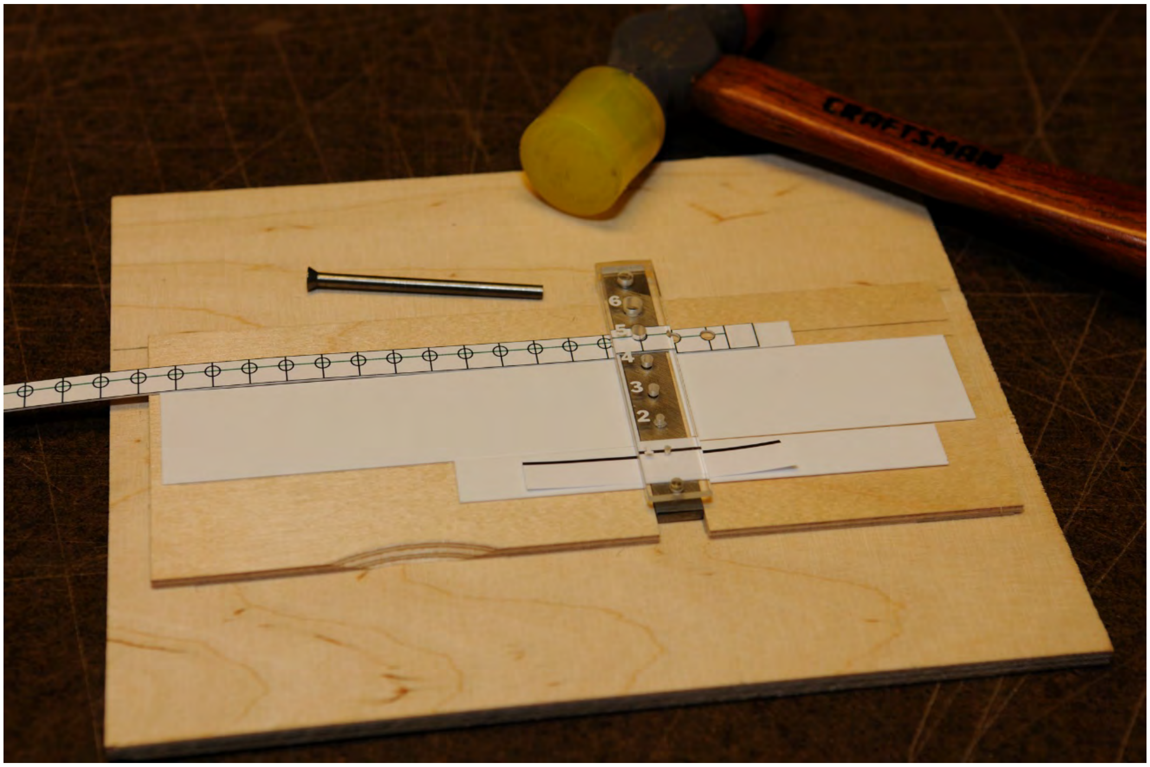

Photo 13: Mid-Case Band Punch Jig

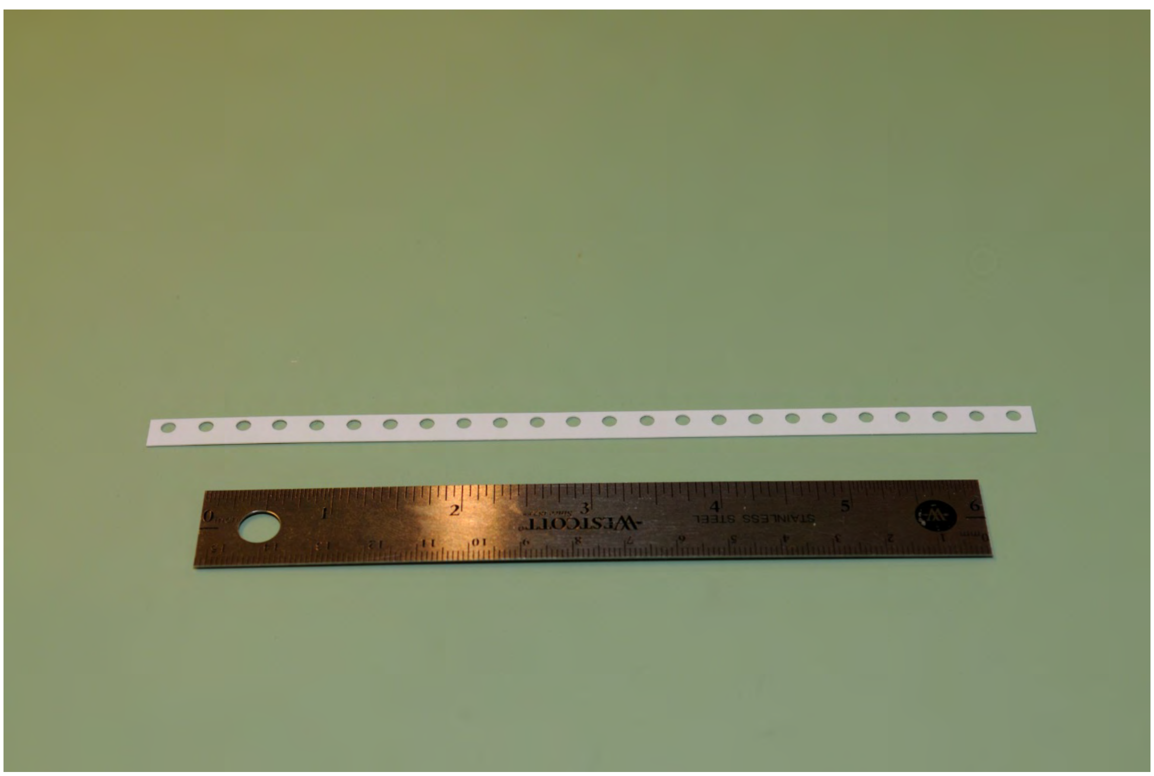

Photo 14: Mid-Case Band, Ready for Application

The band is applied with contact cement, and once cured, we have a completed airframe, ready for priming. The bolt heads that are placed in the mid-case band won't be applied until the airframe is fully primed.

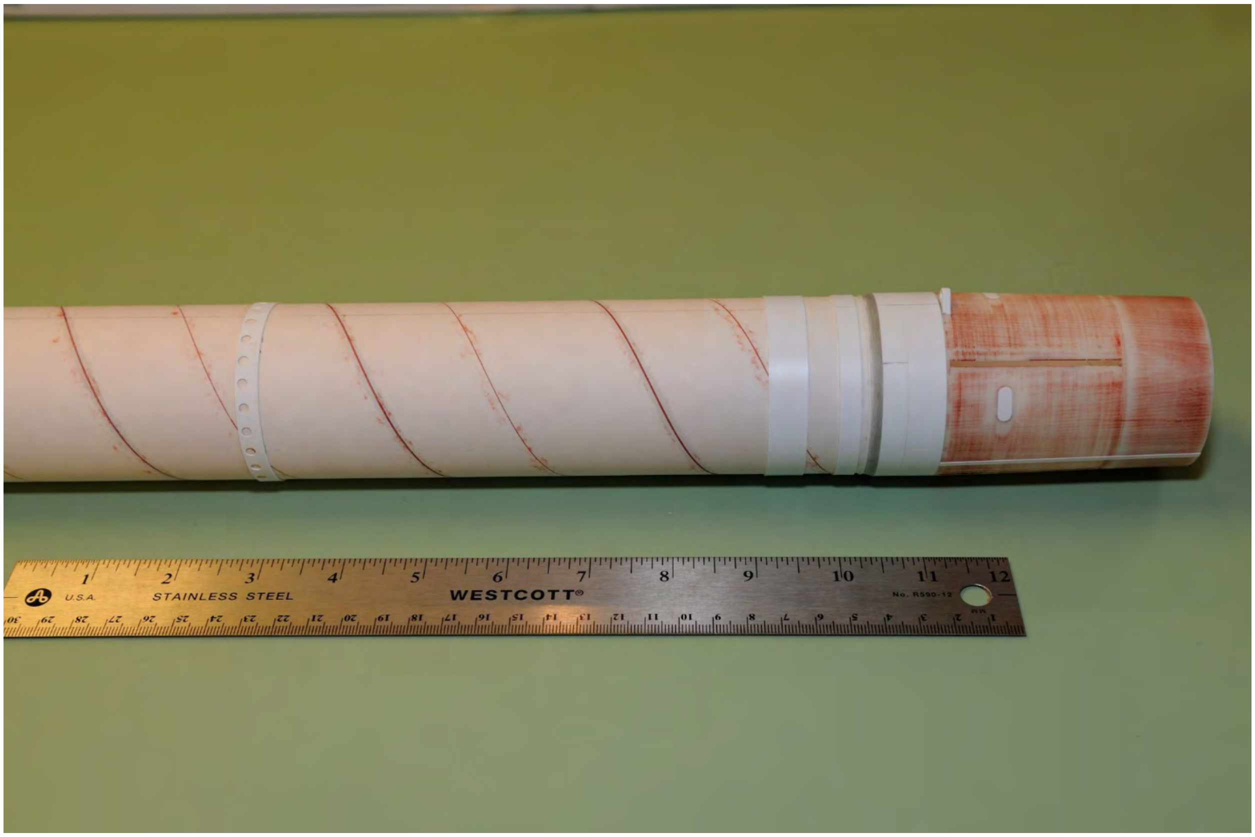

Photo 15: Completed Airframe

To wrap up the aft end of the booster, we turn our attention next to the HoJo fins.

Crafting the Honest John Fins

We have an accurate drawing of the Honest John fin, provided by Jon Randolph.

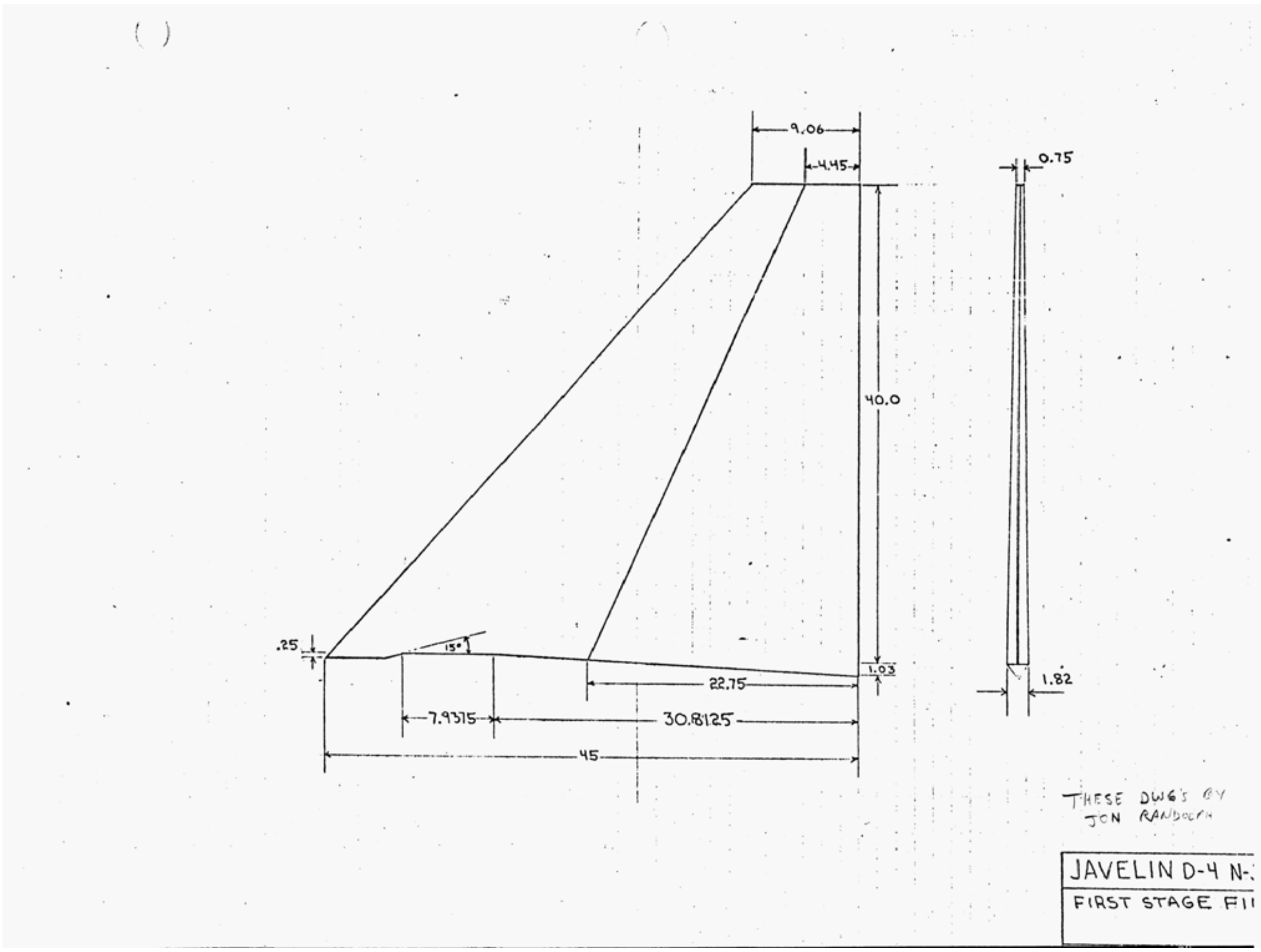

Figure 4: Honest John Fin

(Drawing by Jon Randolph)

If we look closely, we see a few important details. Starting from the left root end, we note there is a flat area, marked by the 7.9375" dimension. This flat area corresponds to the wide band on the booster, just forward of the tail cone, and this flat area is the main reference point for the root. To the left of that flat area, we see that the fin protrudes beyond the flat area by 0.25"; this corresponds to the narrower diameter of the booster further forward of the wide band, the 15-degree slope corresponding to that short forward transition we saw in our early Photo 8.

To the right of the flat root area, we see the root of the fin slopes in conjunction with the taper of the tail cone. At the far right, we note that the sweep of this taper, relative to the flat area, is 1.03". The following photo highlights these features on a prototype round.

Photo 16: Prototype Honest John Fin

With these points in mind, we begin the crafting of our fins, starting with a 1/16" aircraft plywood core. Photo 17 shows this core, to which we've already applied a tapered balsa strip to support the diamond face of the fin skin. Note the odd shape of the core – with a bit of trigonometry, I worked out the internal tangent point of the core's edge relative to the inside face of the skin; doing so allowed me to arrive at a fin core that fully supported the fin skin while preserving the overall scale taper and thickness of the fin.

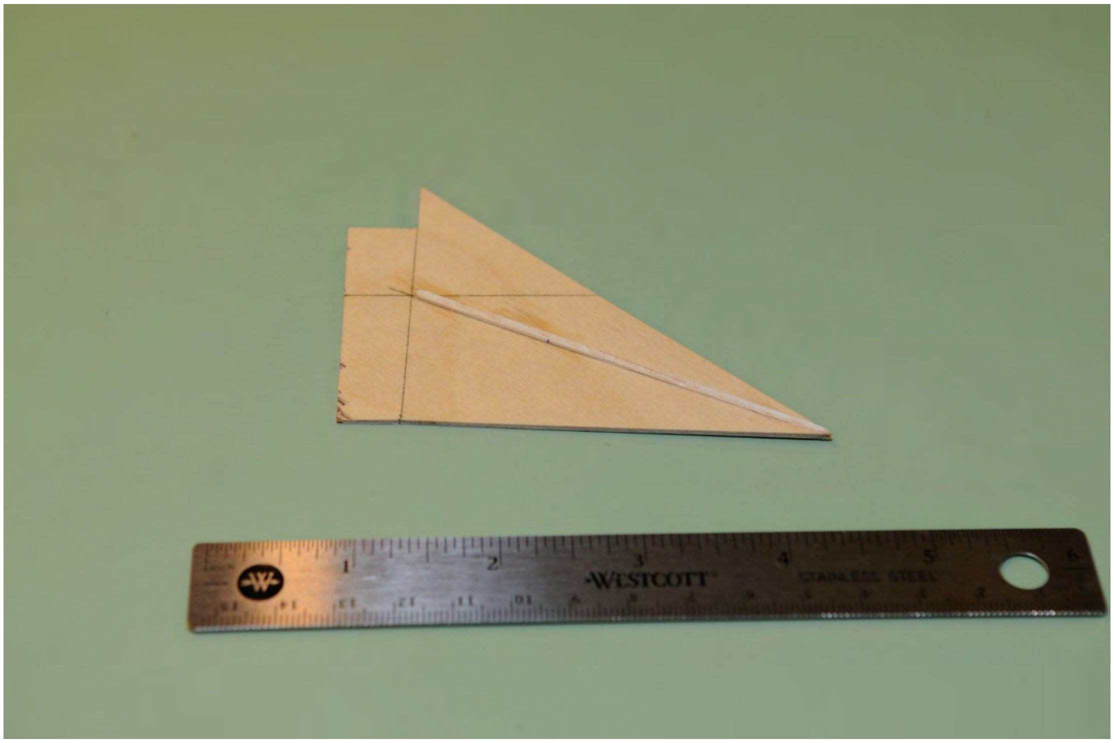

Photo 17: HoJo Fin Core

We cut our set of fin skins from a sheet of 0.015" thick Styrene, and apply them to the core with medium CA.

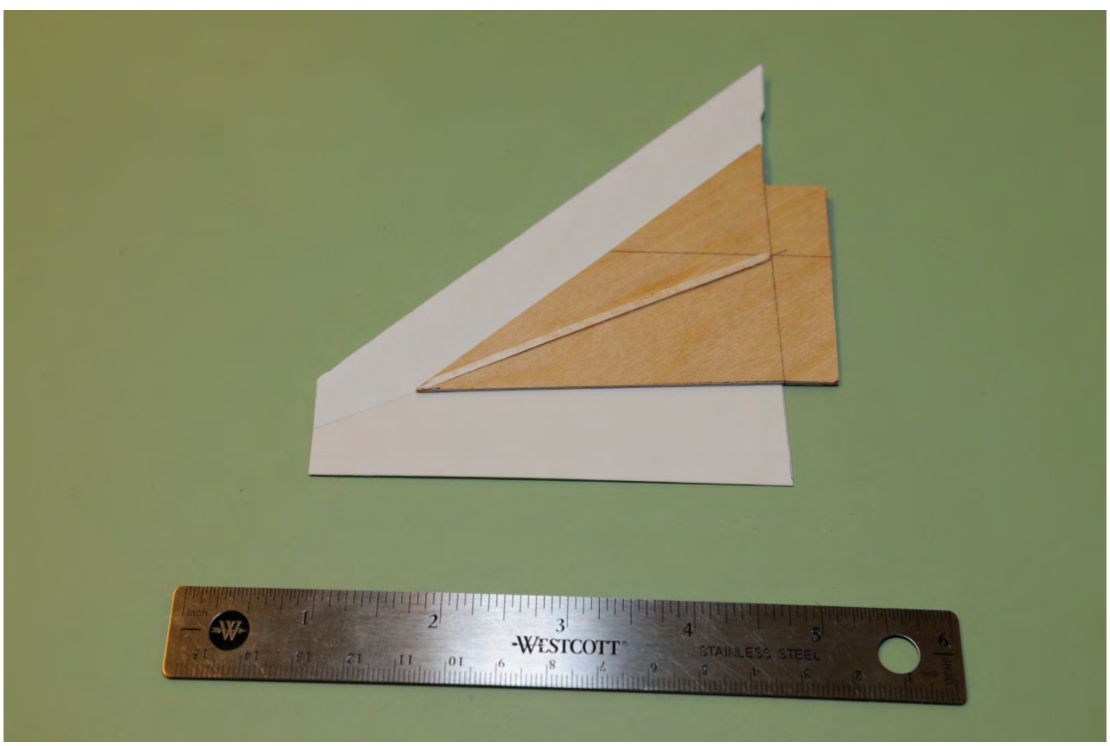

Photo 18: Applying the Skins

We reinforce the leading and trailing edges, and the fin tip, apply some glue, and with some sanding we arrive at a completed fin.

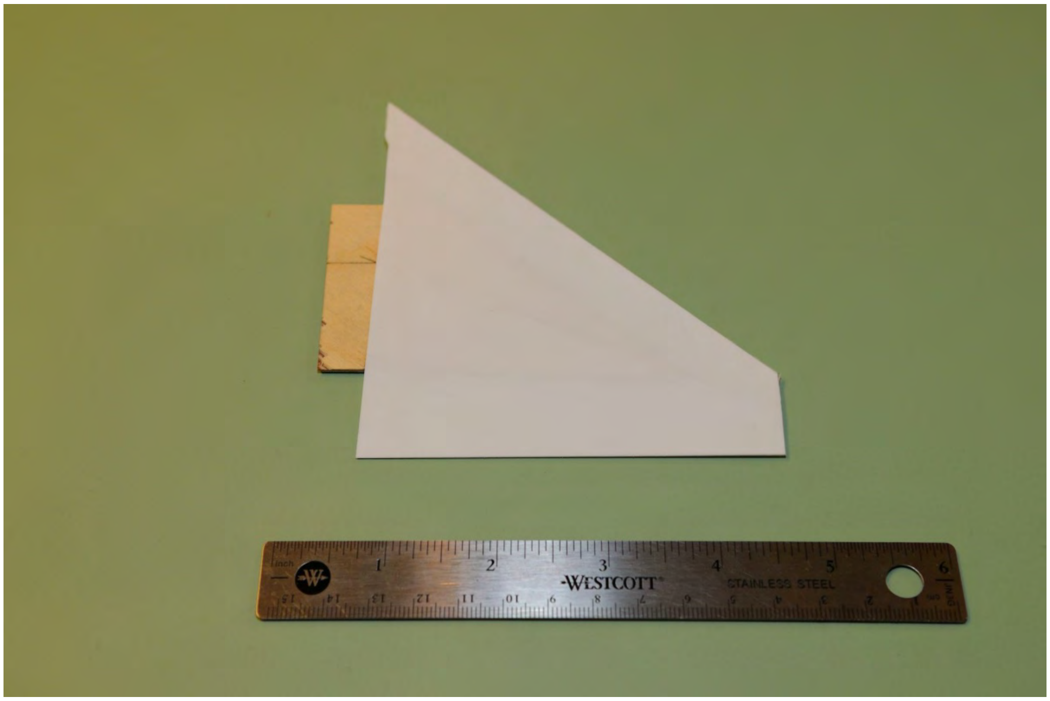

Photo 19: Completed HoJo Fin

A trial fit:

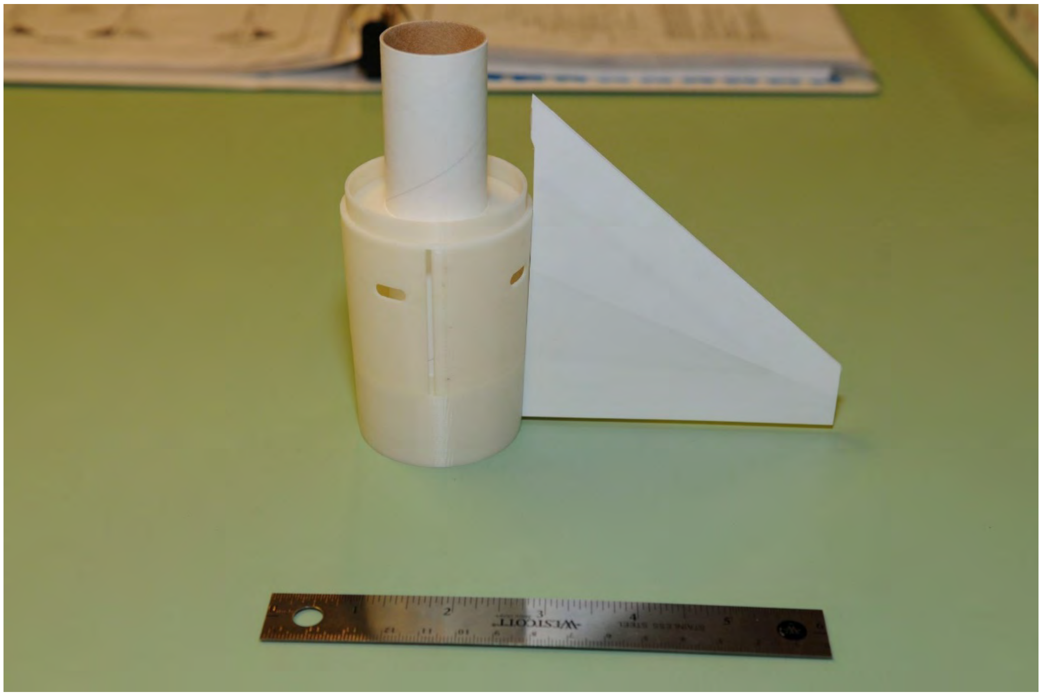

Photo 20: Trial Fit

Seems to fit well; we'll repeat this process to create the other three fins. Each of the fins will be primed and painted separately before installation onto the model. With that complete, we now confront the Honest John-Nike Booster Adapter.

Crafting the Honest John-Nike Booster Adapter

We'll start with a close examination of our reference material, starting with an actual drawing of the assembly.

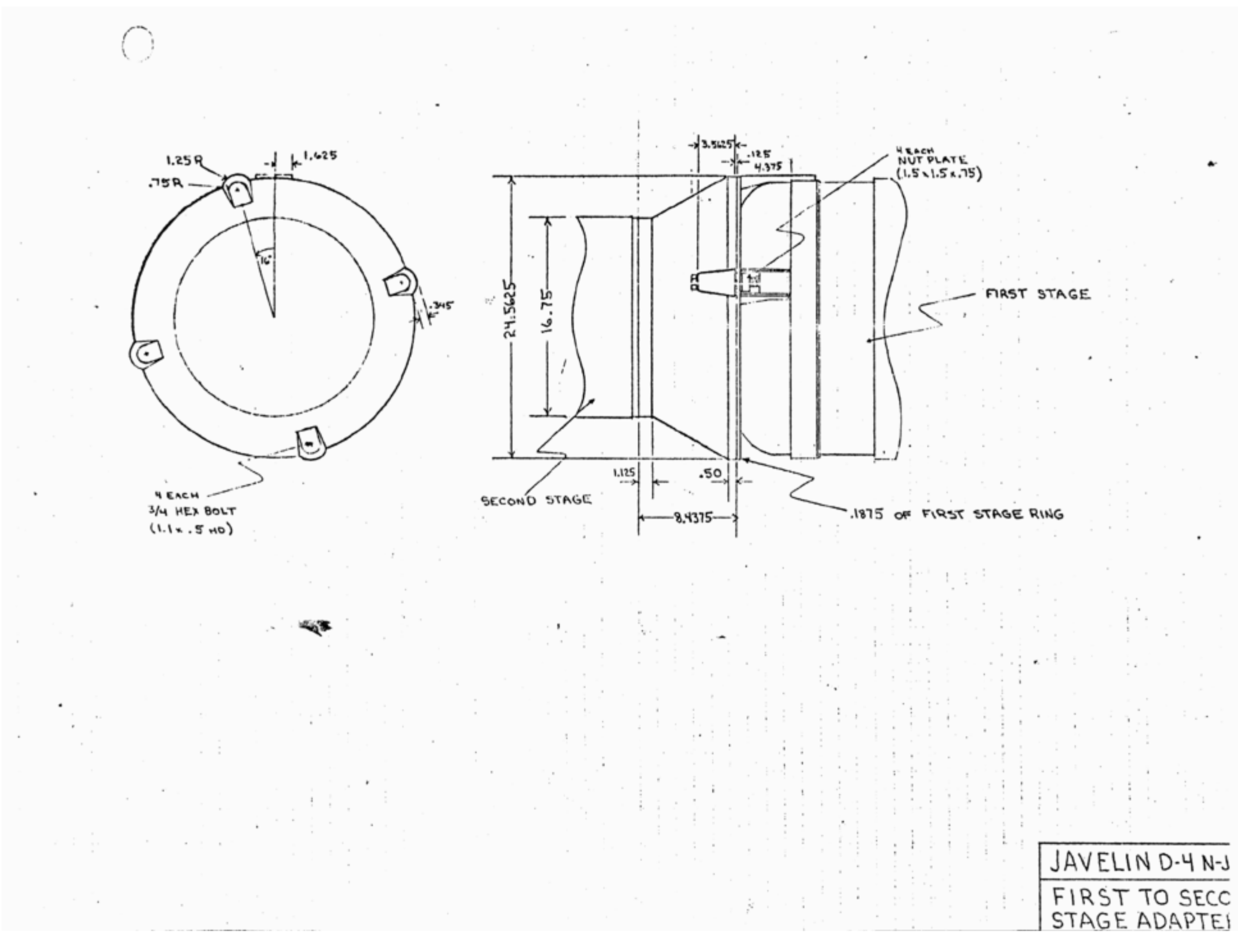

Figure 5: Honest John-Nike Adapter

(Drawing by Jon Randolph)

We'll also take a close look at a set of photos of the real thing; each of the following photos were taken by Josh Tschirhart.

Photo 21: HJ-Nike Adapter

In Photo 21, we can see the forward launch rail shoe located at the top of the adapter. We see a wide circumferential weld just ahead of the most forward band. We can see the end of the motor case, capped by a flat plate (also called out in Figure 5, above). We can see the separate conical adapter, secured in place by means of four bolts, each of which pass through an integral mounting boss, and which are then mated to a corresponding nut on the underside of the motor case interface plate. Note how the motor case interface plate is reinforced at the mounting boss location with some welded metal pieces, creating a box which includes access to the mating nuts. We disregard the long, skinny straps we see welded in place; these are used to secure the assembly as part of the horizontal display, and are not part of the actual adapter.

The following photo highlights the adapter's integral mounting bosses.

Photo 22: Adapter Mounting Boss

We also get a clearer view of the forward launch rail shoe in this photo. Exactly opposite of this view (the underside, in the case of this horizontal display) we see a second mounting plate for a launch rail shoe; our round did not have a second opposing shoe installed, just as we see here in this display round.

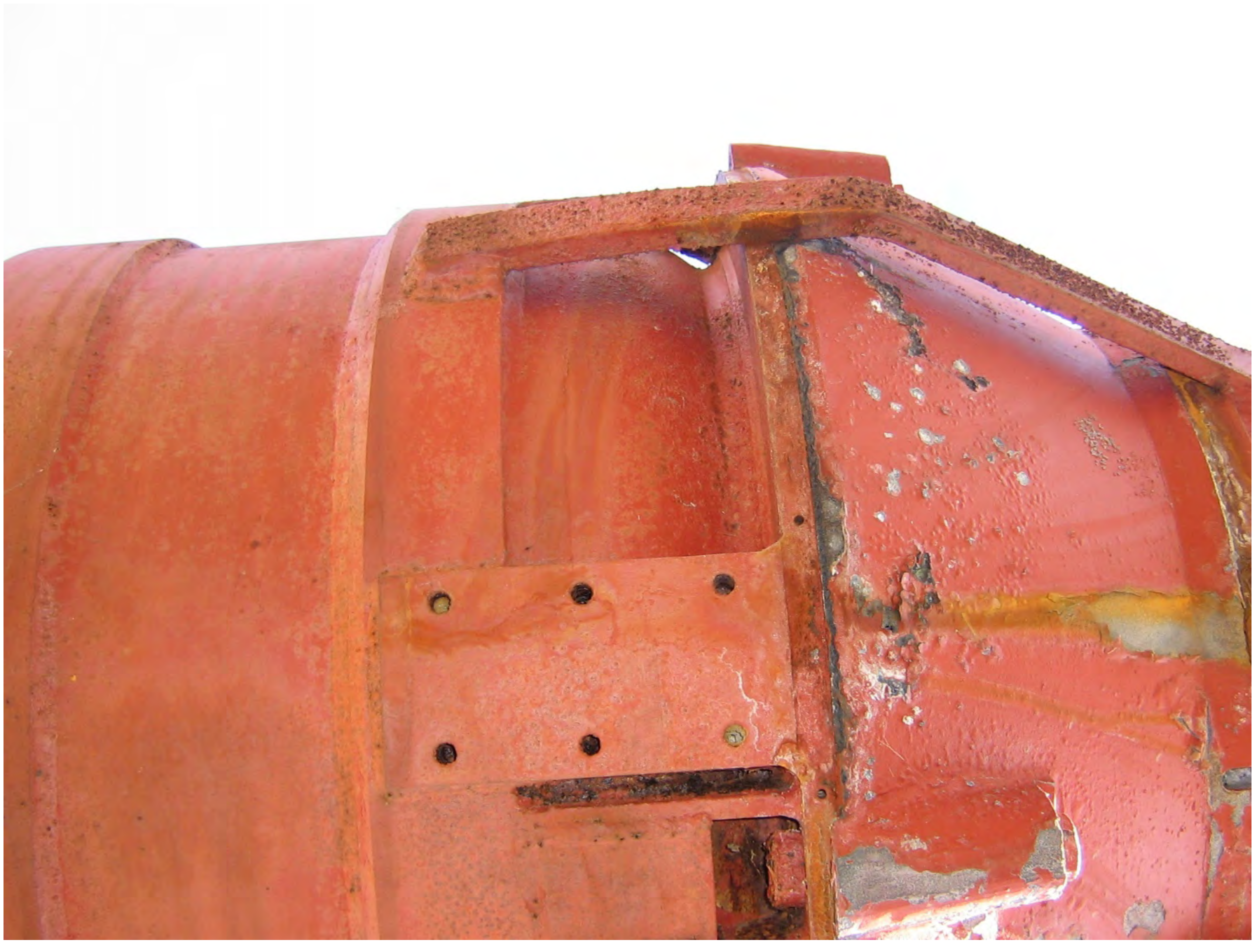

Photo 23: Adapter, Opposite Side

Photo 23 also highlights the weld fillet that binds the end of the curved motor case to the adapter interface plate.

Considering our build strategy, we must keep in mind that this assembly will also house our staging package. So, we will build up this assembly around a coupler tube that will mate to the 2nd stage Nike, and adapt the aft end of this coupler to a JT-70 coupler that will mate the adapter to the booster airframe. Let's get started.

Adapter Construction

In our model, we will make use of the JT-70 coupler as the housing for the staging package. To create enough room, we'll set the separation point at the aft band we see in our earlier Photo 21. That means a portion of the motor case will be part of this assembly, so we must make sure we shorten the booster airframe by this amount so that we arrive at the correct overall length for the booster assembly.

Accordingly, we start with a JT-70 coupler, add the appropriate section of BT-70 motor case, and a bulkhead to support the staging package. The following photo shows a dry fit of these components.

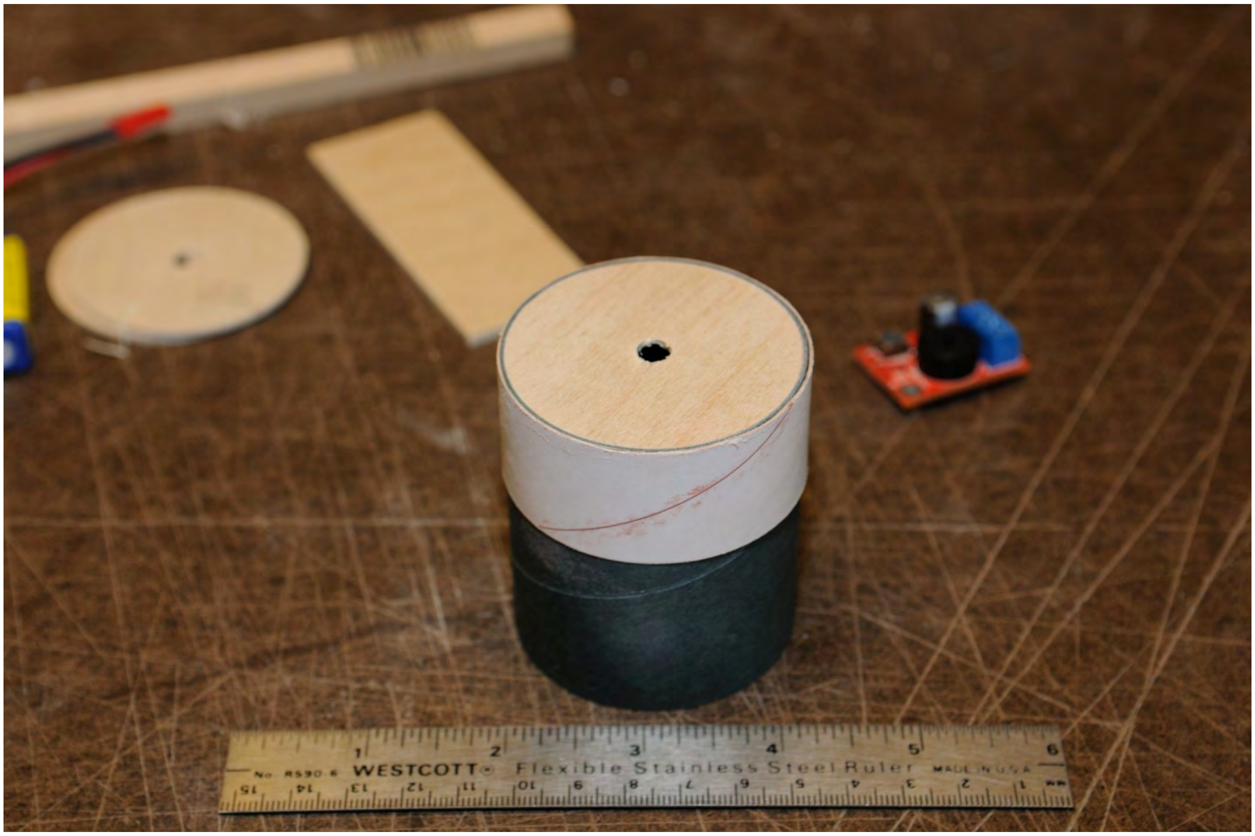

Photo 24: Coupler Assembly

We now attack the staging package, again making use of the very reliable MiniTimer4 timer. We'll use the largest LiPo we can reasonably fit into the space, in this case a 400 mAhr battery.

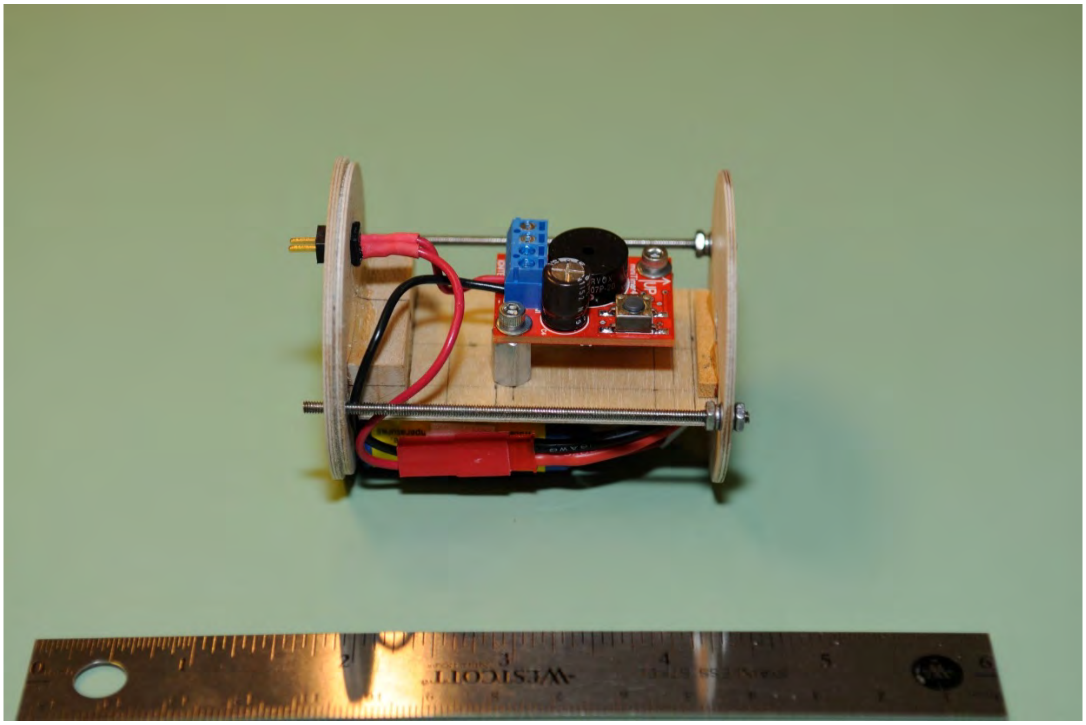

Photo 25: Staging Package

We add the aft Bulkhead, which includes our recovery system anchor and the Deans connector for the shorting plug that turns the timer on.

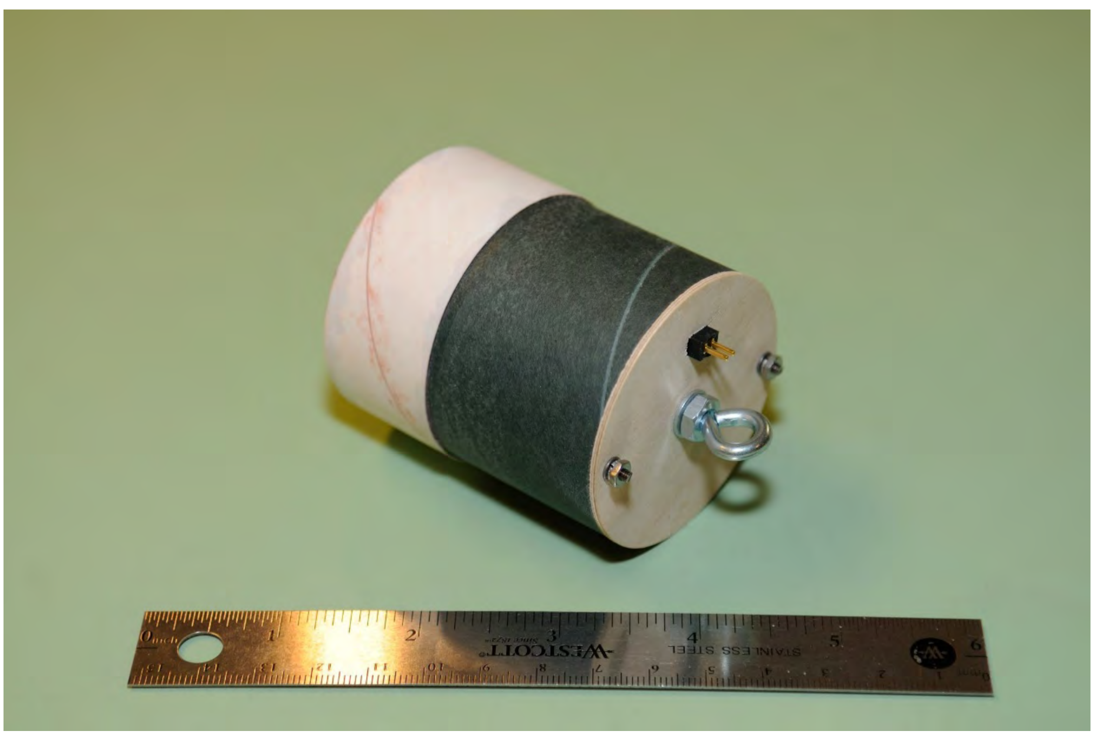

Photo 26: Aft Bulkhead

Now we turn our attention to the forward end. We start by adding the igniter lead extension, mounting this to its own bulkhead, which is then glued to the bulkhead that will center and seat the forward Nike coupler.

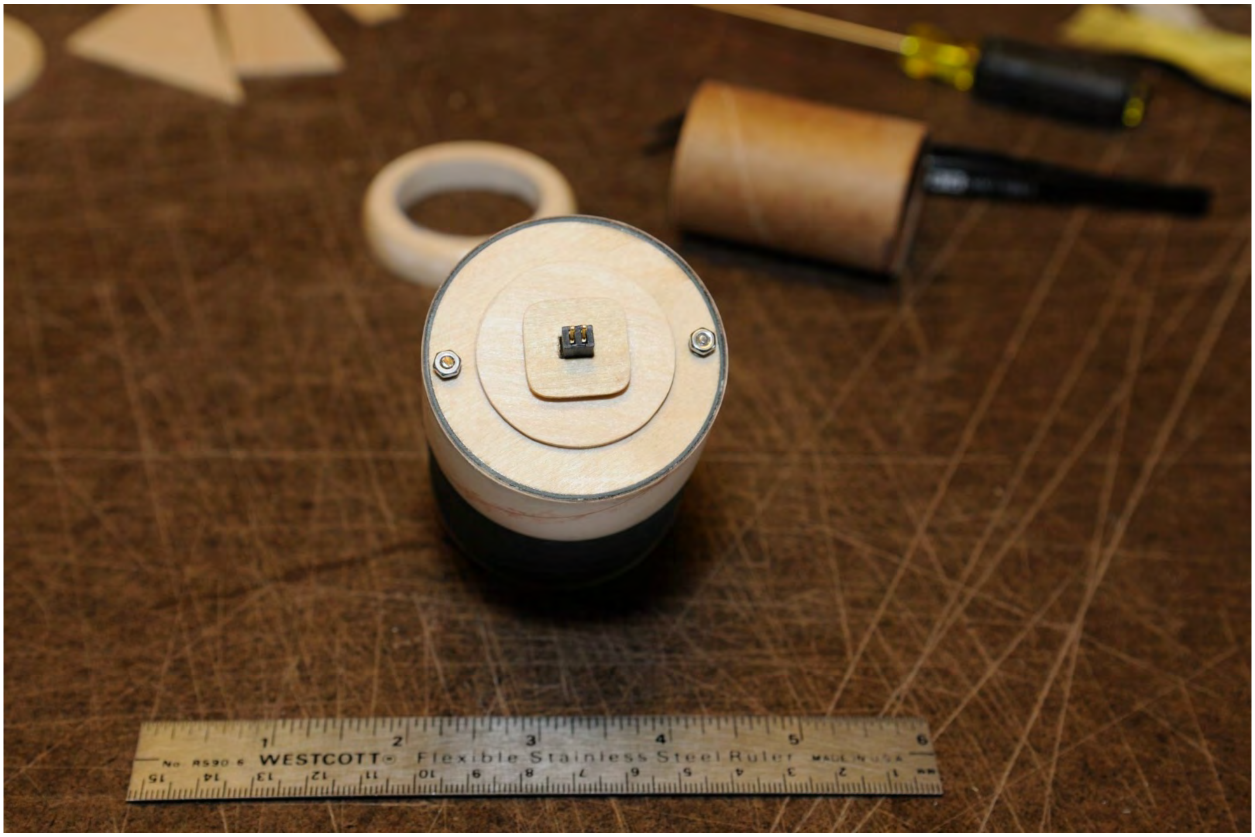

Photo 27: Forward Bulkhead

Now we begin the process to build up and detail the motor case end and adapter. Using our drill press, we turn a scaled curved motor case end, bored to accept the Nike coupler that will slide just inside. In the following photo, we show this turning, already sanded, sealed and filled, ready for installation.

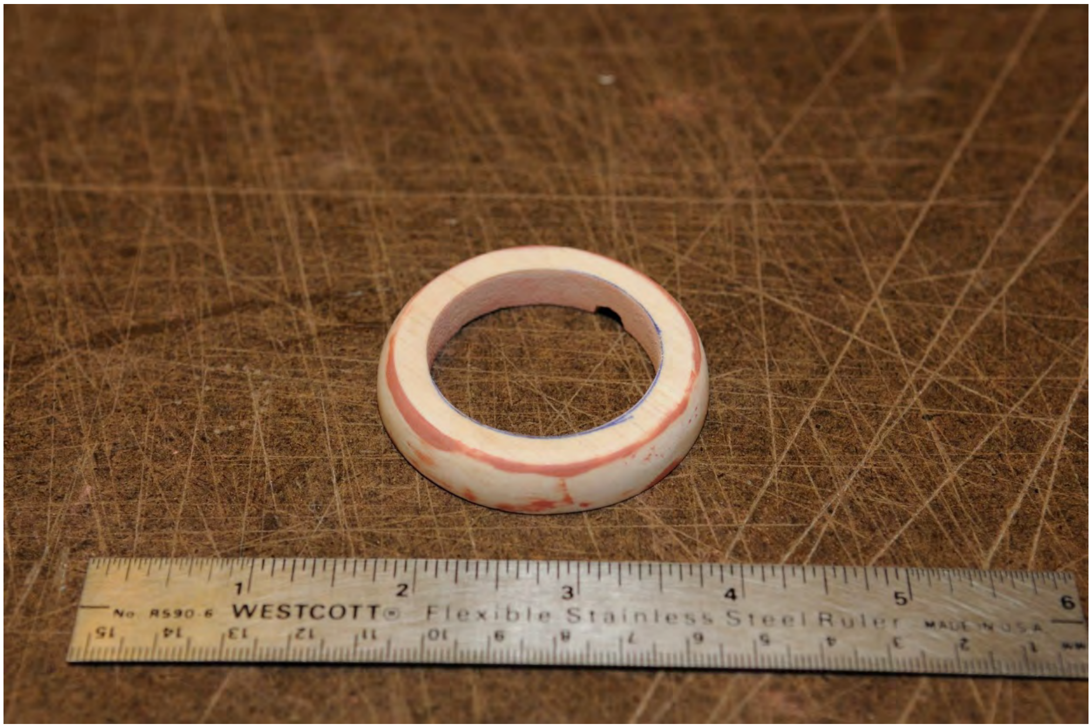

Photo 28: Balsa Motor Case End

On the Nike coupler we place a couple of layers of Styrene, forming a band located so that its forward edge is at the Adapter-Nike booster interface.

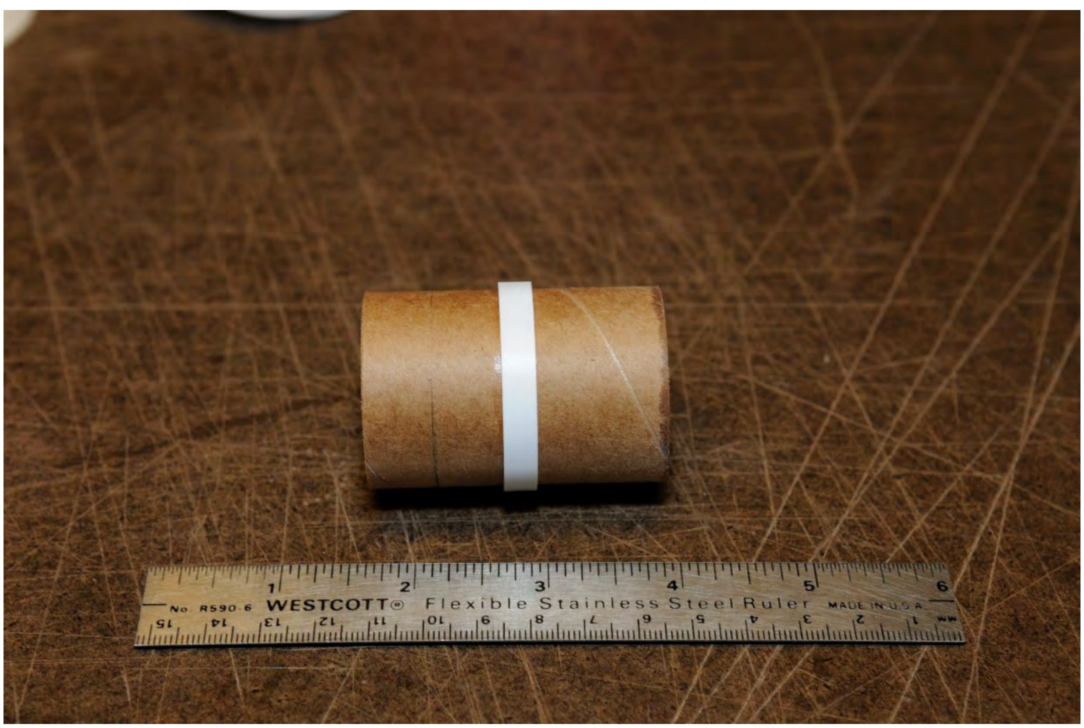

Photo 29: Adapter Forward Band

If we revisit Figure 5, we can see there is a band forward of the adapter that interfaces to the Nike. This is a thrust load bearing surface, so on the model I chose to use wide Styrene strips to maximize the gluing surface. We can also see this band quite clearly in Photo 22. Let's do a trial fit.

Photo 30: Case End Trial Fit

In Photo 30, I've also added a Styrene disk just ahead of the balsa case end; this disk represents that thick under-fillet weld we saw earlier in Photo 23. Following that is a Styrene disk that represents the flat case end interface plate, and then sitting on that is the support ring for the aft end of the transition shroud.

Photo 22 shows that the adapter transition's aft end flares to a flat plate; that's fortuitous, as we like to have a plate or ring to support the aft end of our transition cardstock shroud. So we size the shroud to rest tangent to this plate, with the forward end sized to the diameter of the adapter forward band that we installed in Photo 29. As is our practice, we will use 67# cardstock to fabricate the transition shroud, a photo of which follows in Photo 31.

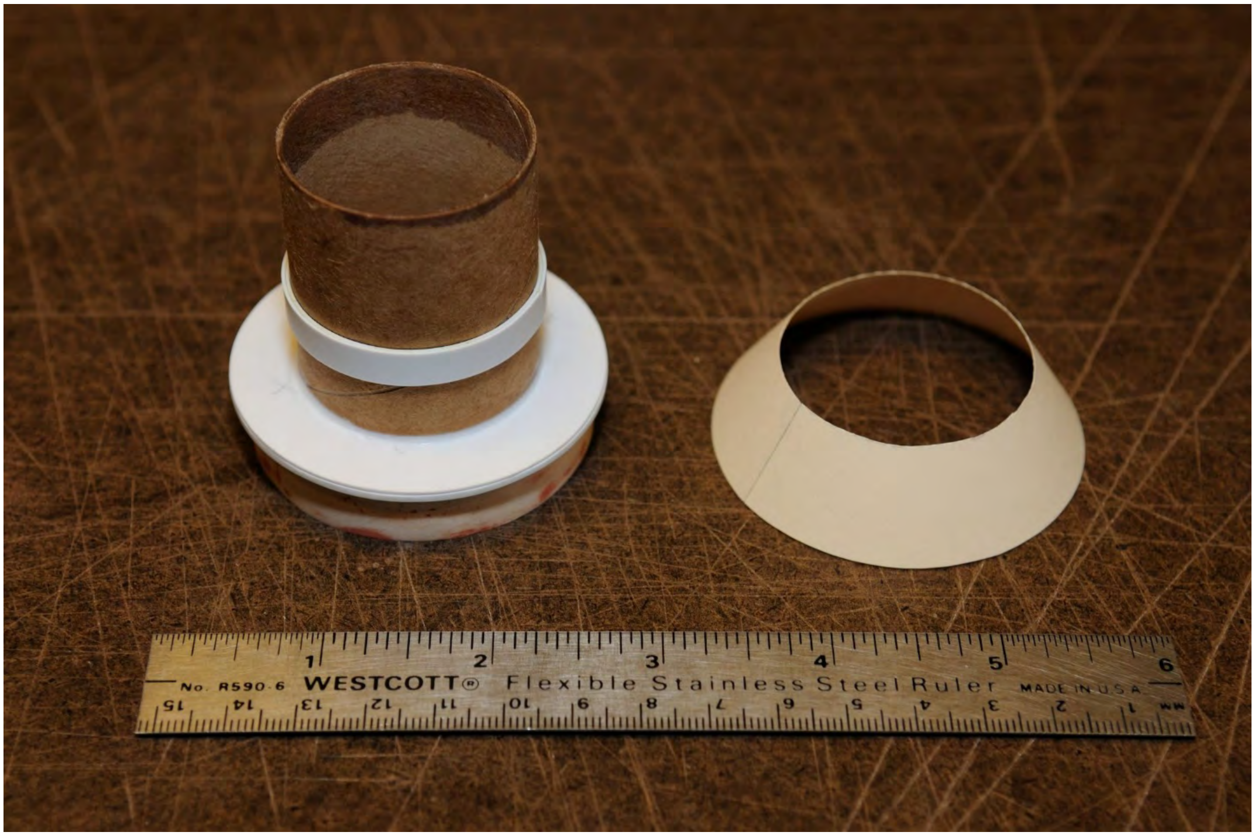

Photo 31: Transition Shroud

Looking closely at Photo 31, we can see a fillet of Formula 560 Canopy adhesive to glue the transition base plate to the coupler; this is a good adhesive to bond these dissimilar materials. We'll also use this adhesive to mate the transition shroud as well. Let's do another trial fit.

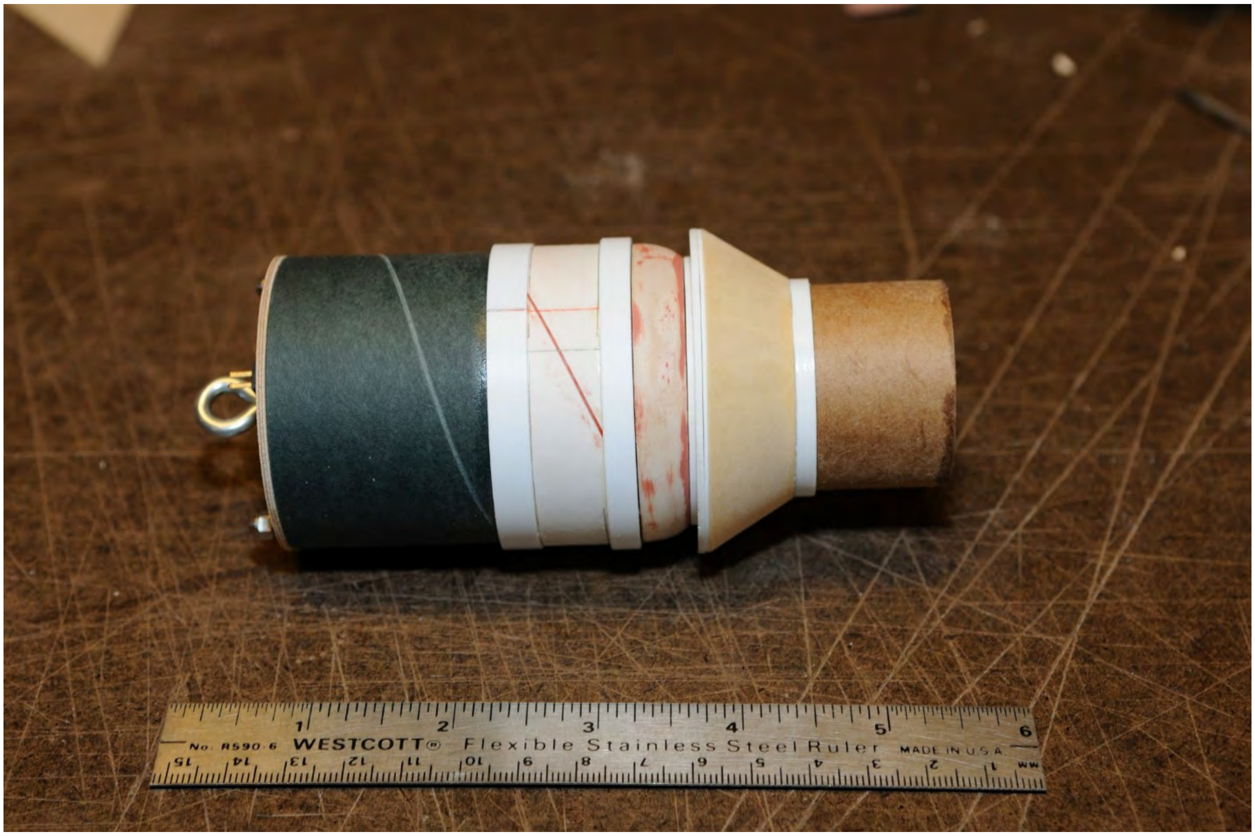

Photo 32: Another Trial Fit

Comparing to the earlier Photo 21, it would seem our adapter assembly is starting to look recognizable. But before we permanently mate the forward Nike coupler assembly to the aft coupler assembly, let's take the opportunity to detail that adapter. We'll start with the mounting bosses.

The mounting bosses begin life as a short, scaled length of Styrene tubing, of the appropriate scale diameter. These are glued to the adapter, with their forward ends offset with a short length of Styrene strip to ensure the bosses are set at the correct angle.

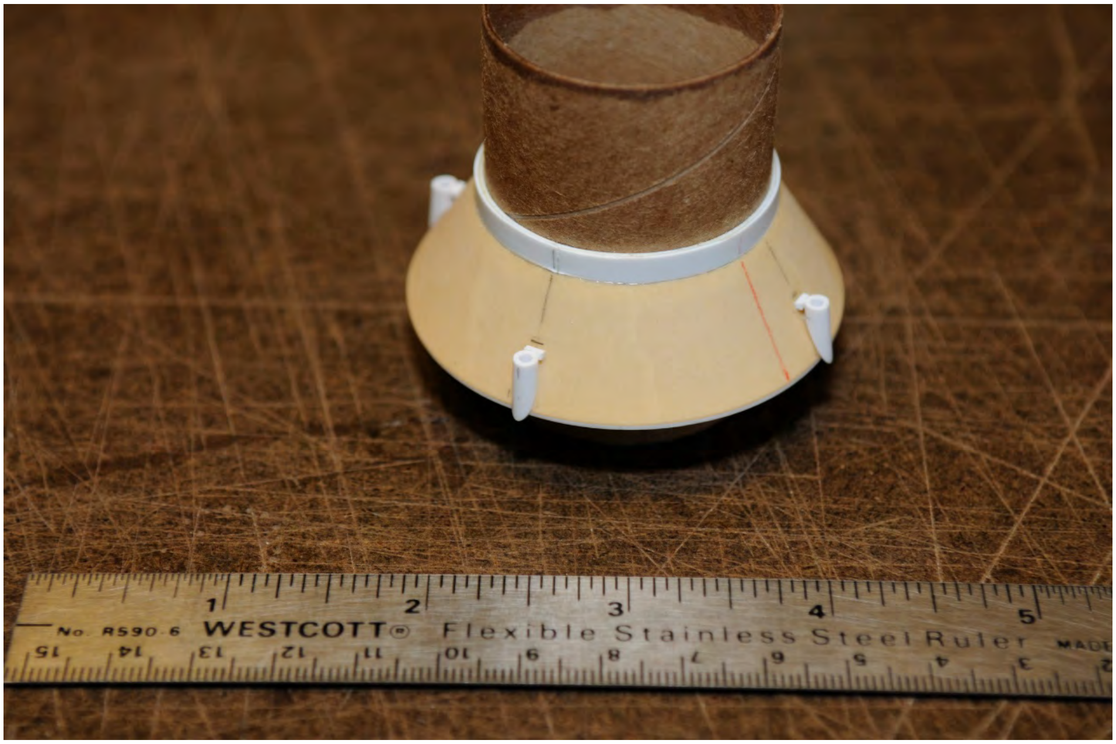

Photo 33: Native Mounting Bosses

Next we add some flat side pieces, and with some filleting to smooth things, we arrive at a completed boss.

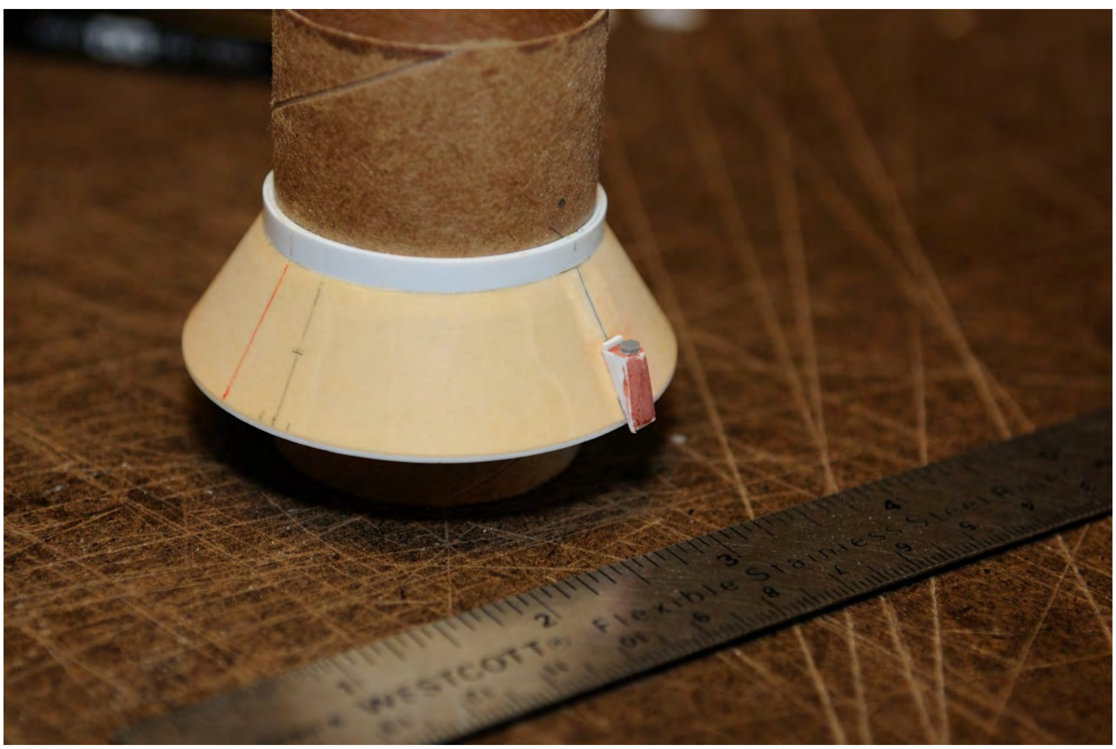

Photo 34: Mounting Boss Details

We repeat this process for the other three bosses.

The two assemblies are now brought together, and we can now add the final remaining details, starting with those four mounting boss boxes on the motor case end. These are pieced together with separate Styrene parts.

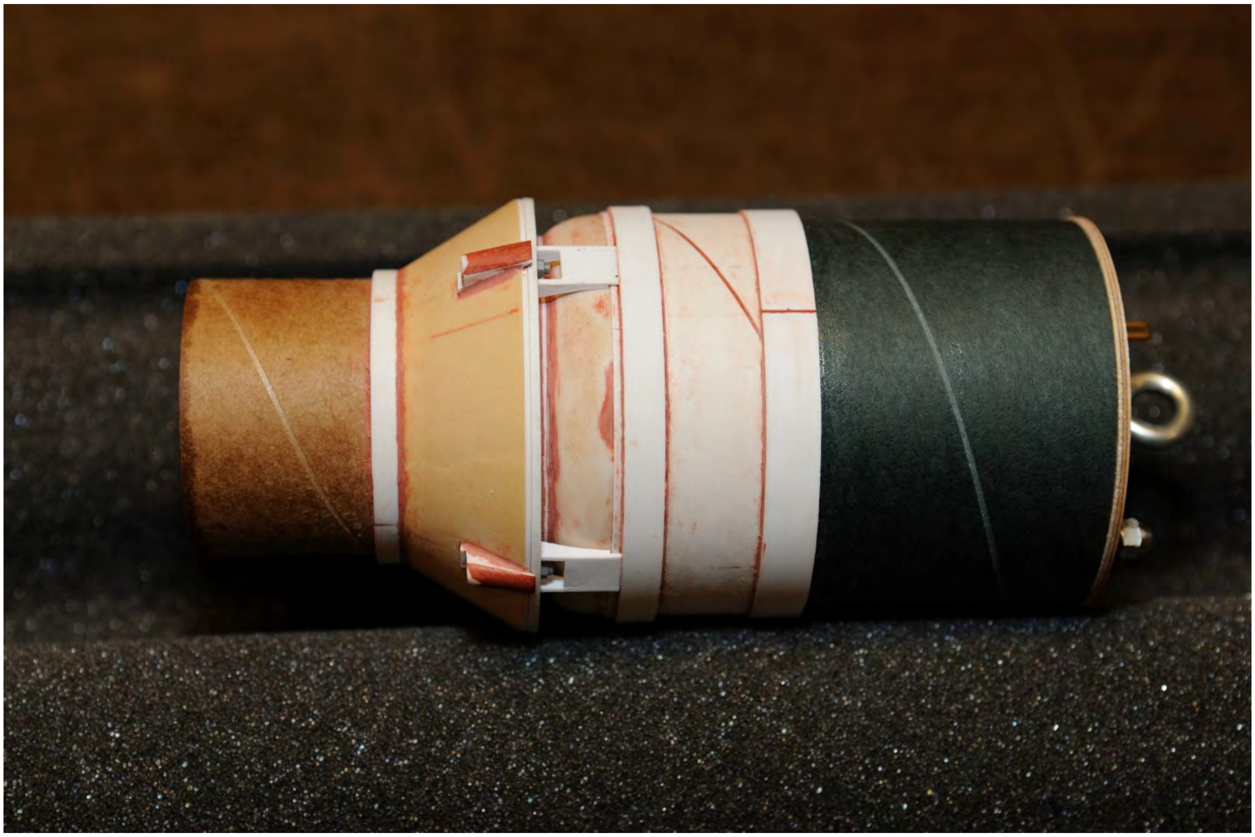

Photo 35: Mounting Boss Boxes

Next, the forward launch rail shoe, which itself is made up of a series of separate Styrene pieces. It will be filleted, smoothed and detailed before final installation.

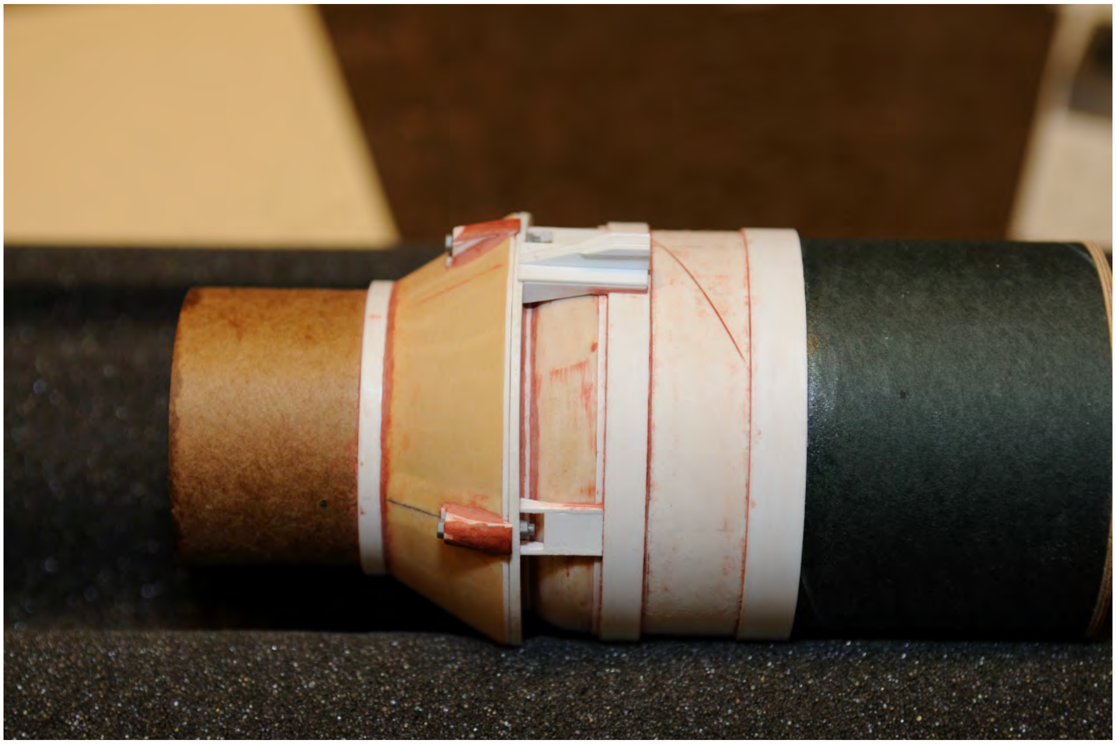

Photo 36: Forward Launch Rail Shoe

Let's not forget that opposing rail shoe mounting plate on the other side.

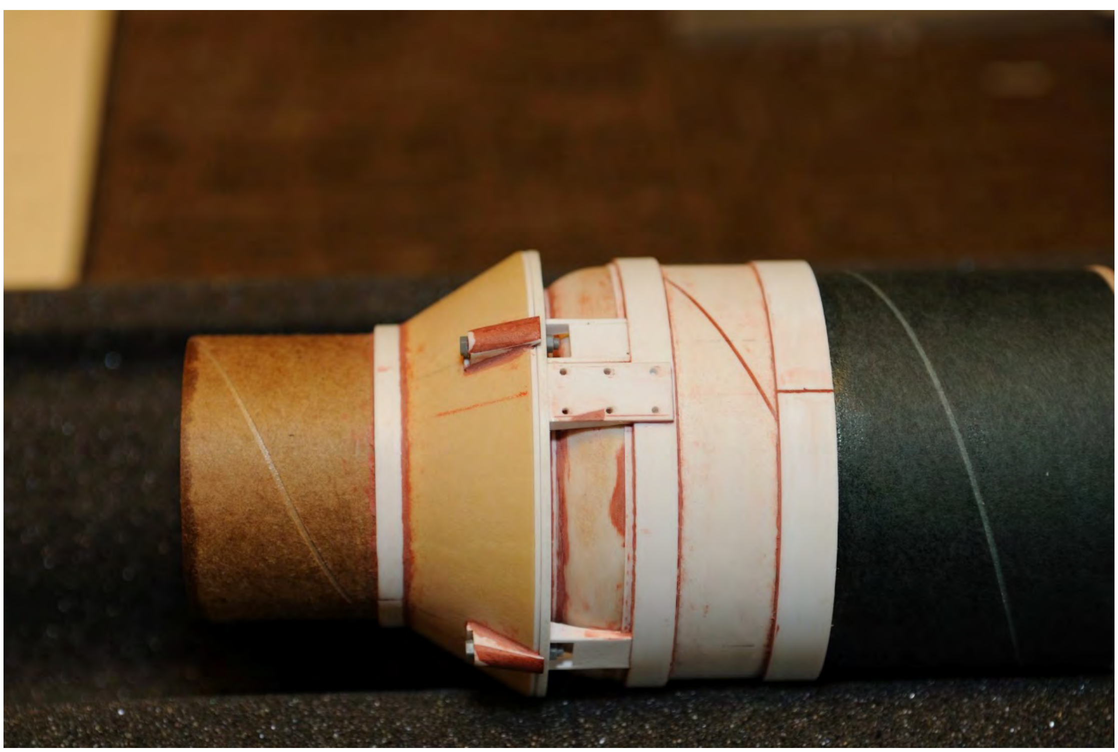

Photo 37: Opposite Shoe Mounting Plate

And with this, the adapter is complete, and ready for the paint shop. As is our practice, we'll prime with Rustoleum Automotive Grey Primer, correcting defects as needed with Squadron White Putty, finally arriving at the white color coat – here, we're using Dupli-Color Perfect Match Arctic White lacquer.

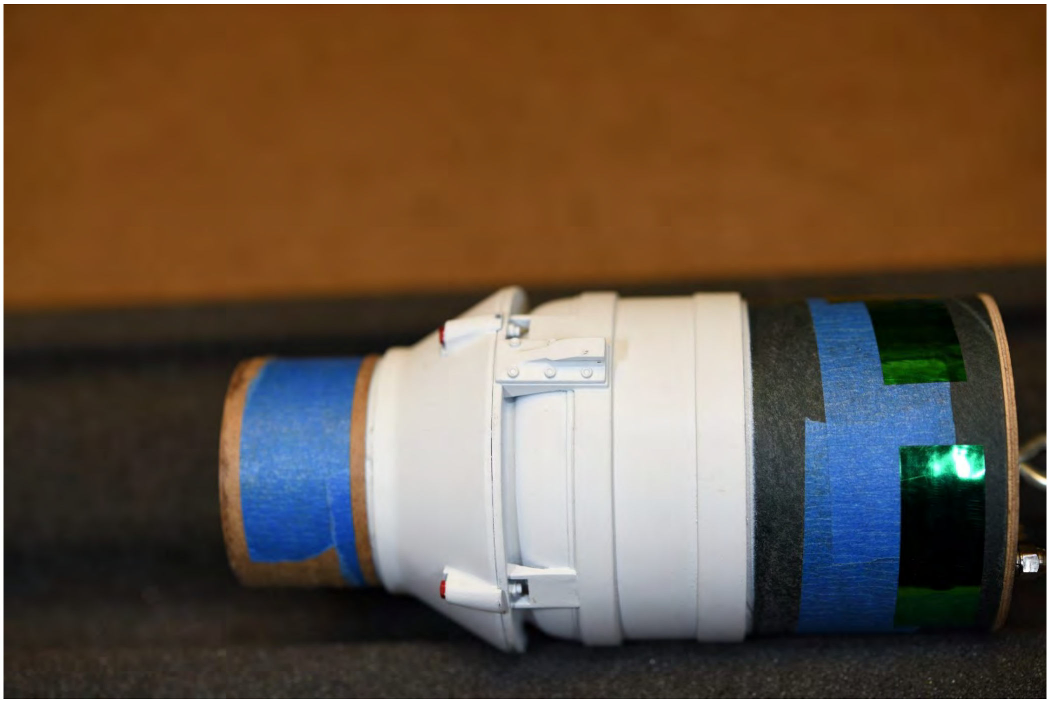

Photo 38: Painted Adapter

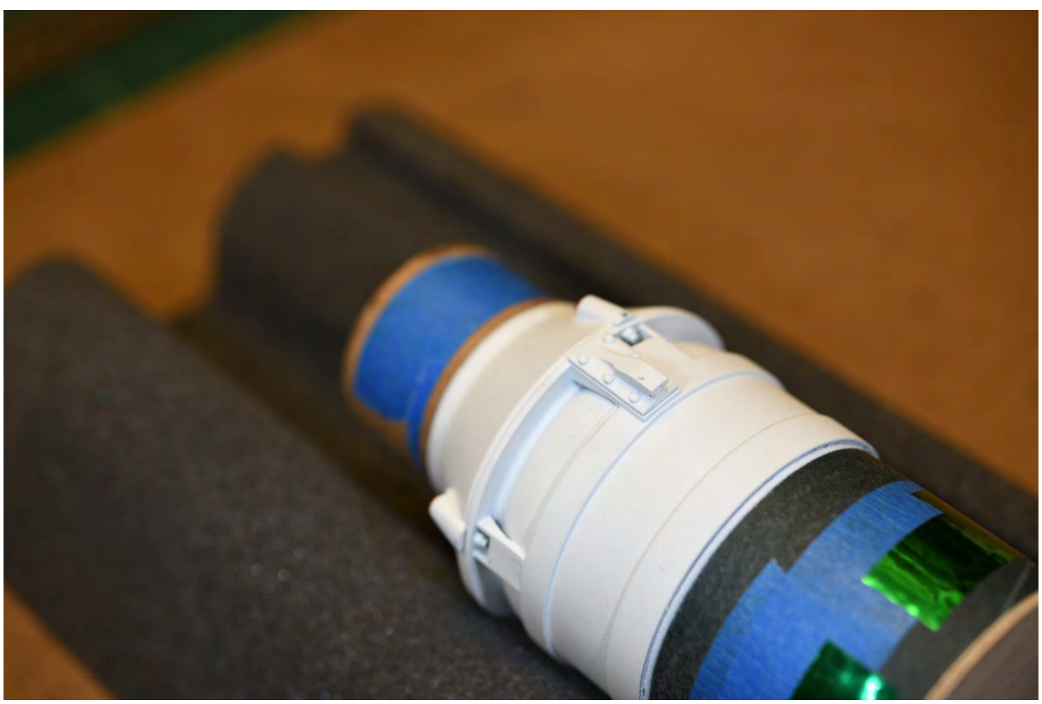

Photo 39: Completed Adapter

Remaining Details

Time to install those bolt heads in the mid-case band. Once done, we can paint the booster, decal it, and overspray it with Testors Lusterless Flat.

Photo 40: Booster Details

We install our painted fins, and perform our final assembly. And so, we arrive at our completed, 1/10th size Argo D-4 Javelin.

Photo 41: 1/10th Size Argo D-4 Javelin

Before we wrap this project, I thought I'd include a couple of photos of the payload section and nose. These components were fairly straightforward, the payload section just a length of tube, and the nose a solid balsa turning provided by BMS. The nose is tipped with Testors Model Master Chrome Silver, as seen in NASA Photo 71HC362.

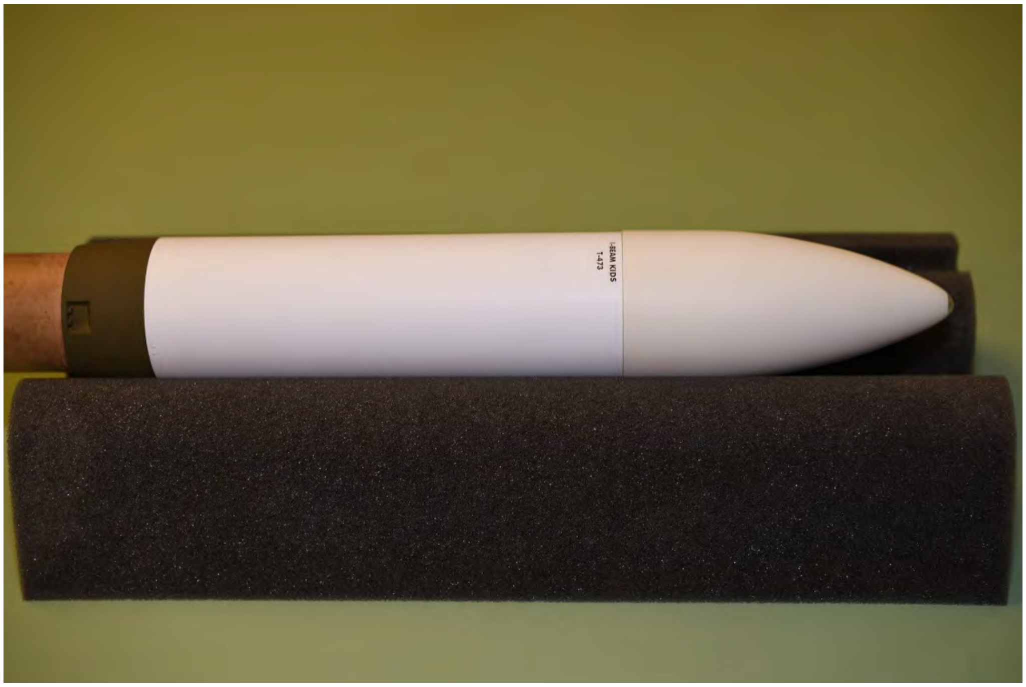

Photo 42: Payload Section

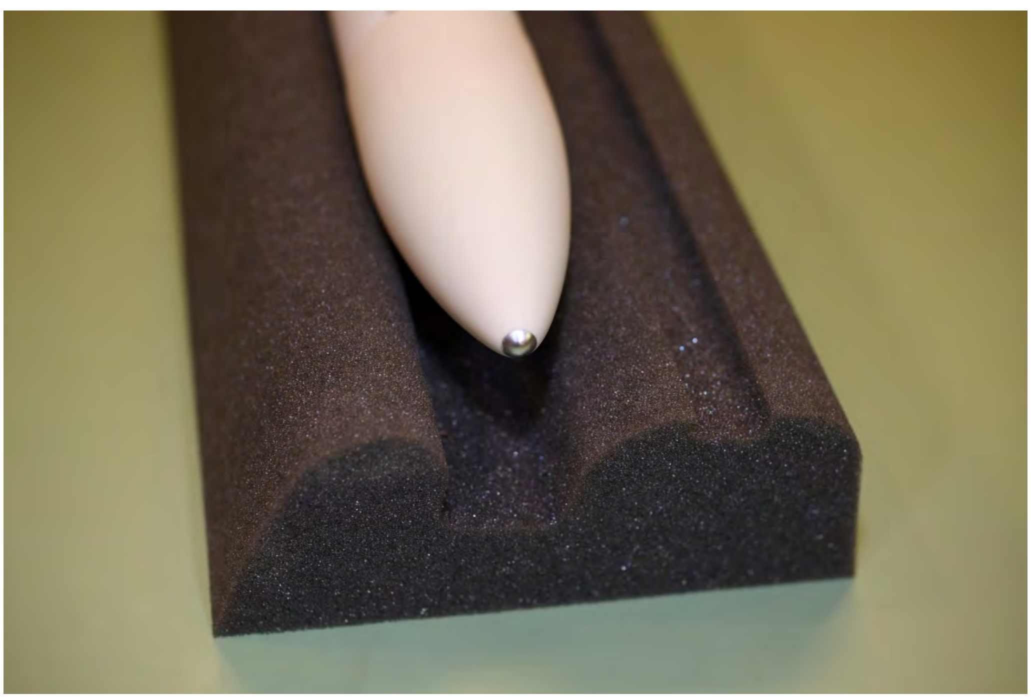

Photo 43: Nose Tip

Photo 44: Argo D-4 Javelin

(NASA Photo 71HC362)

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The Javelin has been a very satisfying project for me, both in its research and in its build. But it wasn't possible without the gracious and kind support of Josh Tschirhart of Meatball Rocketry, and the ongoing support of my teammates, Rod Schafer and Steve Foster of The Flying I-Beam Kids. Thank you, one and all.