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PEAK OF FLIGHT

NEWSLETTER

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Aligning A Structural Paper Transition

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ISSUE 355 DECEMBER 31, 2013

Aligning A Structural Paper Transition

By Tim Van Milligan

In *Peak-of-Flight Newsletter 136* (www.ApogeeRockets.com/Education/Downloads/Newsletter136.pdf), I showed you how to make a transition section. The type of transition in that newsletter is what I call a non-structural transition. The actual paper shroud part of the assembly isn't meant to take any forces during the flight. All the forces are carried by the tubes underneath the shroud. The shroud is only meant to smooth out the air flow to reduce the drag.

The harder paper transition to make is the pure structural one. In this case, there are no tubes inside the paper transition to carry the forces (thrust). All the forces through the rocket must be carried by the paper shroud.

The advantage of the structural shroud is that it gives a lot more room inside the rocket to carry a bigger parachute. Normally, for typical model rocket, having the extra room isn't needed. The one case where it might be needed is in

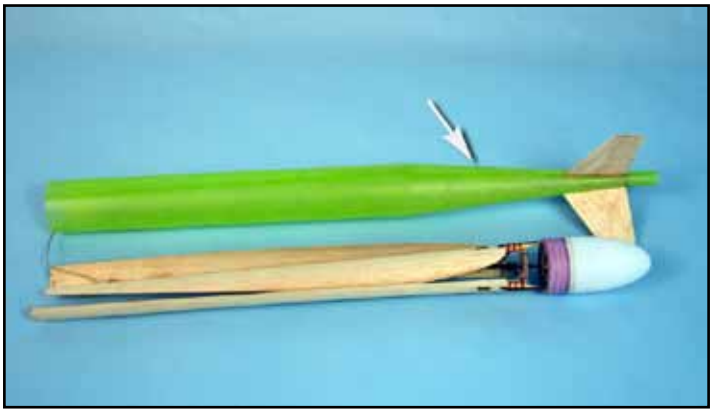

Figure 1: A structural transition has no internal support, and allows more room inside the rocket for the recovery device. Here the helicopter blades of this FAI style helicopter will slide into the transition.

competition rocketry. Here a larger internal volume means you can put in a larger parachute so that the rocket hangs in the air longer. Or, instead of using a larger chute, you might use the space to loosely pack the chute, which increases its chances of opening. In other words, it increases reliability. Figure 1 shows a helicopter model where the blades are housed inside the tube of the rocket. The long transition adds length for longer blades.

The typical solution in rocketry is to use a molded plas-

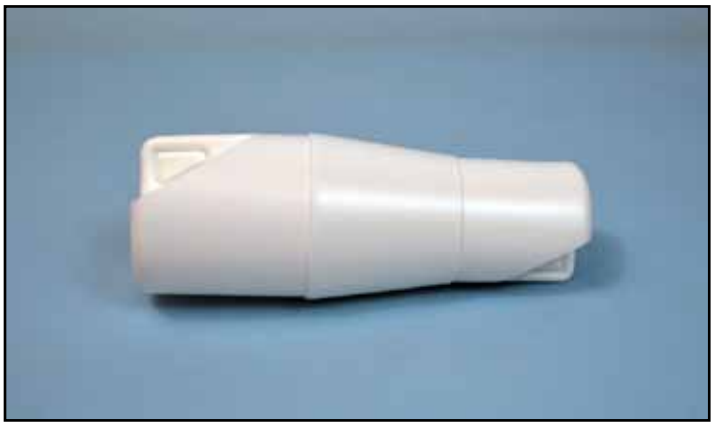

Figure 2: A blow-molded transition can be used for a hollow transition. The end caps can be cut off to allow space inside.

tic transition, such as the ones that Estes produces shown in Figure 2. The advantage is ease of assembly, as you just plug it in between the two tubes you want to join. The disadvantage is that you are limited on the sizes of plastic transitions that are available. So you may not find one for the sizes of tubes you want to join.

The other disadvantage is that plastic transitions are heavy. So if your application is a competition rocket, then you give away in mass what you make up in volume.

In international competition such as in F.A.I. events, hardcore competitors will make a single piece tube and transition out of thin fiberglass. This creates the optimum

Figure 3: FAI models are made by wrapping fiberglass over an aluminum mandrel.

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situation, as the tube and transition are lightweight and strong. But the disadvantage is that to make the fiberglass tube, you need a mandrel to wrap the fiberglass around. These mandrels are available through the NAR's technical service (http://www.nar.org/NARTS/). The mandrel and the layup of the fiberglass can be expensive, so changing the design is rare.

In this regard, paper has an advantage in that it is cheap and you can modify your design easily. You can easily make any length you want, with whatever tube sizes that you have available. And the forces on the transitions aren't really that bad. Even if they were large, it is easy to strengthen a transition by putting an extra shroud over the first one to double the wall thickness of the paper.

But there is one big issue that you have to overcome. That is getting structural paper transitions aligned properly. As shown in the video on the Apogee web site (*Transition Section Construction – Part 1* www.apogeerockets.com/Advanced_Construction_Videos/Rocketry_Video_10), it is easy to get the tubes misaligned. If the tubes are misaligned, then your rocket will have a kinked look to it, and it won't fly straight.

The solution is to build a temporary structure inside the transition to make sure it is aligned. It is then removed after all the glue is dried, to reveal the large internal volume. The only downside of this is that it will take some extra work, and you'll have an extra fixture that will probably be tossed out after you're done with it.

Designing The Transition

I typically use RockSim to generate the shroud pattern, because I find it is fast and accurate. But the dimensions on the transition shroud are critical on a purely structural piece. The reason is that if there is any slop or gaps around the tubes, it makes it harder to get perfect alignment of the tubes. Therefore, you'll need to know the exact dimensions of the tubes.

If the tubes aren't in the database of RockSim, you'll need to get the measurements to three places after the decimal point. For example, if you look on the Apogee web site for body tube dimensions, we list them all to three decimal points for the tubes we carry. Here is what I do when I specify the dimensions of the shroud:

1. The small diameter of the shroud must fit snugly over the smaller tube. This is the most critical dimension of the shroud, so you may have to print out a couple of shrouds until you get the fit correct. I usually start by adding 0.004 inches to the outside diameter of the small tube. So if you're using an AT-13 tube (a BT-5 size) which has an outside diameter of .544 inches, you'll want to specify the rear diameter of the shroud to be .548 inches. This should give you a snug fit of the paper shroud over the small tube.

2. The large diameter should be set at the exact diameter of the outer tube. So if the outside diameter of the big tube is 1.585 inches, then that is the diameter you should type into RockSim to create the shroud.

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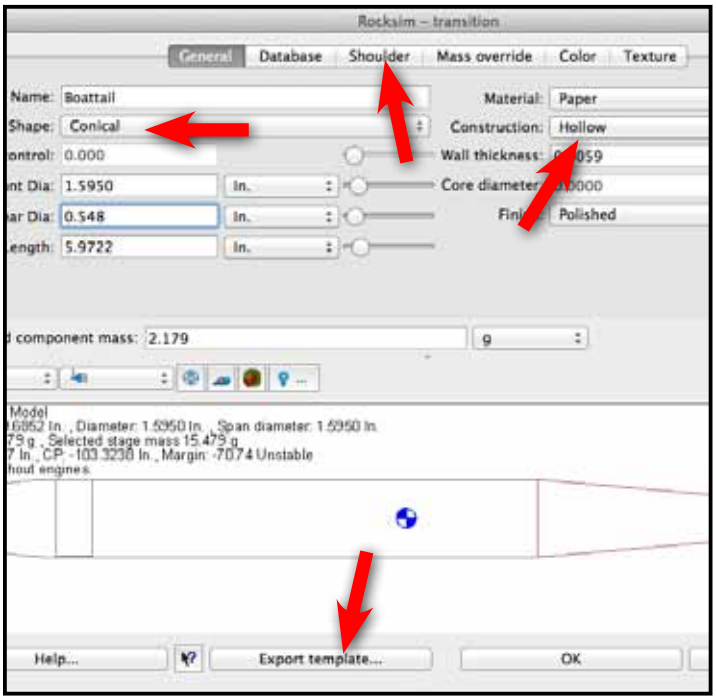

Figure 4: To create a pattern sheet in RockSim, the shape must be conical, the construction set to hollow, and the shoulders removed. Then you can either export or print out the pattern sheet.

In the past, I would set the diameter slightly larger than the diameter of the big tube so that the shroud hangs over the edge a little bit. I did this thinking that it would be easy to sand off the overhang so that you'd get a perfect fit. But I've never found the look to be satisfactory. The end result was that it had a rounded look to it, or if you sand too deep, you sand through the paper and you have a gap around the tube to fill.

Recently, I've been playing with slightly undersized shrouds, and I like the look much better. I found it easier to get a better appearance by filling the gap than by sanding off the overhang.

This will require a little bit more work initially, but it more than makes up the amount of work saved in sanding later.

In RockSim, in order to export a paper shroud pattern, you must set up three conditions.

1. There can not be shoulders on either end of the shroud, so you'll need to click on the shoulder tab and set everything to zero.

2. The shroud must be set to hollow.

3. And the shape of the shroud must be conical.

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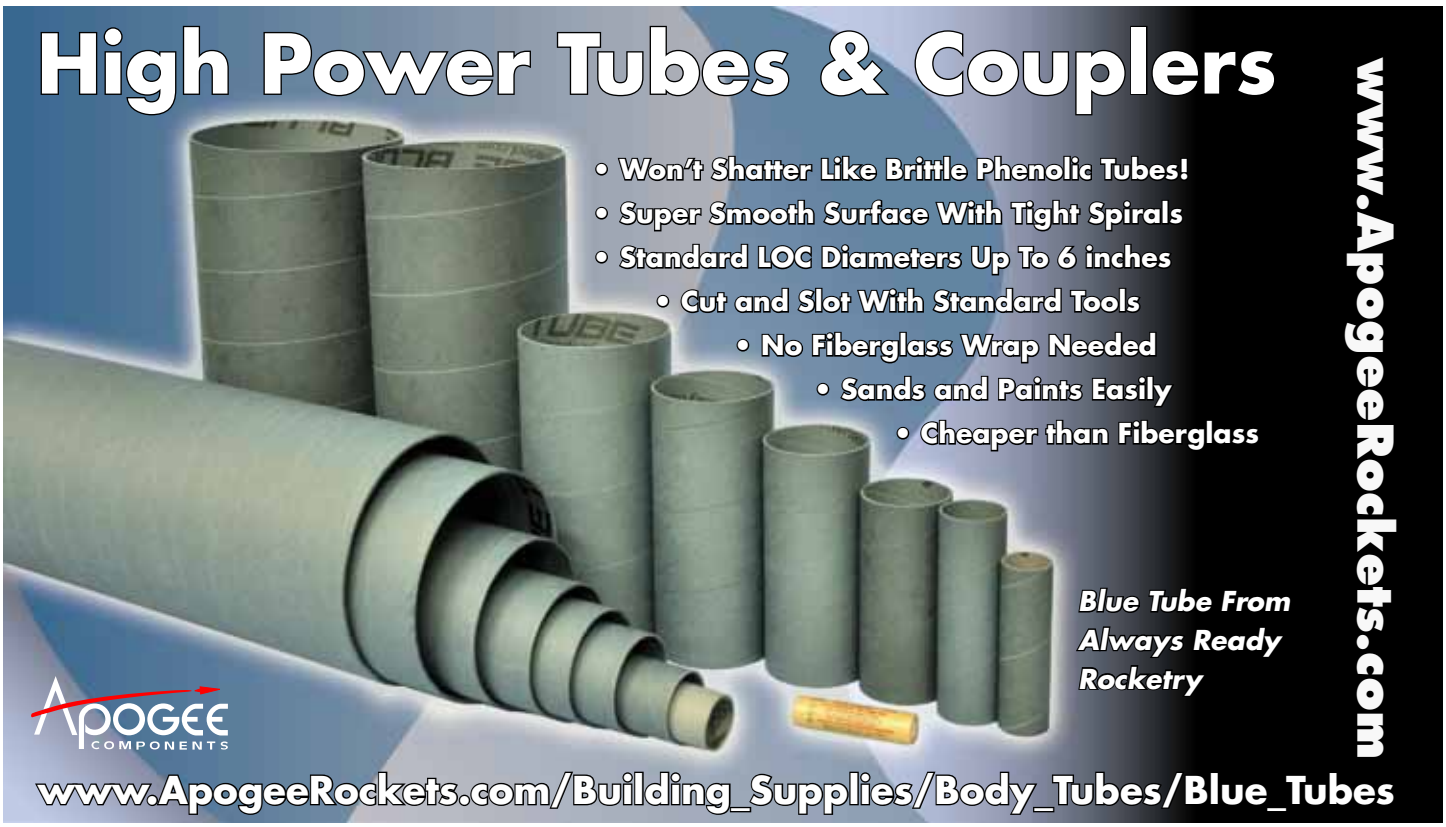

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Once you have these conditions set up, you can now print out or export out a shroud pattern.

Rolling the paper shroud is the hardest part of the entire process. And for this, I recommend watching my video on the Apogee Components web site (www.ApogeeRockets.com/Advanced_Construction_Videos/Rocketry_Video_10). It will walk you through the basic technique of rolling the shroud and joining the edges together.

The small tube must be inserted into the paper shroud first. But before you do that, you'll need to add a ring to the end that will be inside the paper shroud as seen in Figure 5. The larger the diameter of the ring, the better, as it will make sure that the small tube comes out of the paper shroud straight. But a large ring will also mean more weight inside the paper shroud and a heavier rocket.

If you need a shock cord attached to the small tube, such as it is a motor mount, then you'll want to have two rings on the tube as shown in Figure 6. I like a thick ring for securing the shock cord, so it can't yank out of the rocket.

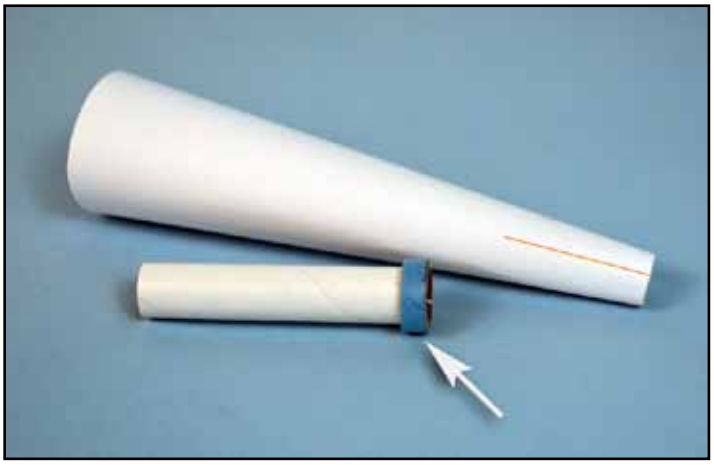

Figure 5: A ring on the front of the small tube will center up the tube inside the transition.

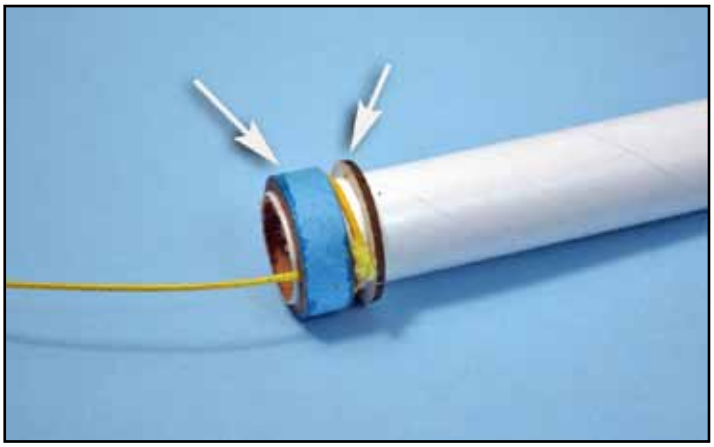

Figure 6: If you need a shock cord, then use two rings as shown. This prevents the shock cord from misaligning the tube in the transition.

But the shock cord will interfere with the fit of the ring touching the inside surface of the paper shroud. So the second ring is needed. For this ring, I recommend a cardstock ring to minimize the weight.

Also, don't add an engine block to the tube yet, as you'll need to have an unrestricted tube for assembly. You can always come back and add an engine block to the tube once you finish aligning the tubes.

To make it easier to slide the small diameter tube inside the shroud and to ensure alignment of the tube, you'll need a long tube the same diameter as the small tube. For convenience, we'll call this long tube the "alignment tube." You'll put a tube coupler into the alignment tube so that you can temporarily join this with the small tube on the rocket. I recommend that the tube coupler be glued inside the long alignment tube so that the coupler doesn't accidentally get stuck in the small tube of the actual rocket (see Figure 7 on the next page).

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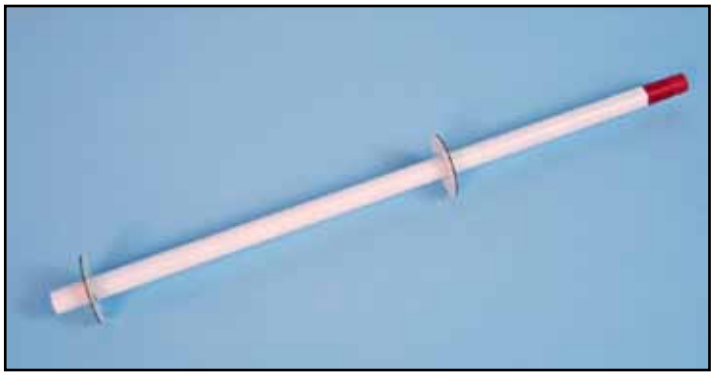

Figure 7: The alignment tube is a tube the same diameter as the smaller tube in the rocket, with rings on it that center it into the larger tube. There is a coupler on one end so the tube can be temporarily mated to the small tube.

On the other end of the alignment tube put two centering rings. These need to fit over the alignment tube and into the big tube. You may have to adjust the position of these rings along the length of the tube, so at this point don't glue them down. You just need them to make sure the small tube will be aligned with the transition once you glue it in.

You can test fit the small tube into the shroud to see how it fits, as shown in Figure 9. As mentioned before, you want a snug fit of the paper shroud over the small tube so that there are no gaps around the perimeter where it slides over the tube. You can also see where the ring glued to the end of the small tube will touch on the inside of the shroud.

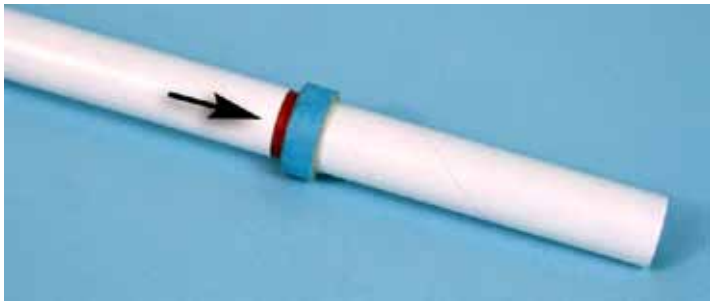

Figure 8: Temporarily insert the coupler into the front end of the small tube.

Figure 9: Slide the small tube into the transition using the alignment tube to push it so the centering ring contacts the inside of the transition.

Roll the alignment tube on its two centering rings across the table, and make sure the small tube doesn't look like it is wobbling. If it is, then the alignment is off. Try pushing the small tube deeper into the paper shroud to center things up. This is a test-fit to make sure you know how it should work once you add glue to the parts. Now pull the small tube out of the paper shroud so you can apply glue to the right spots.

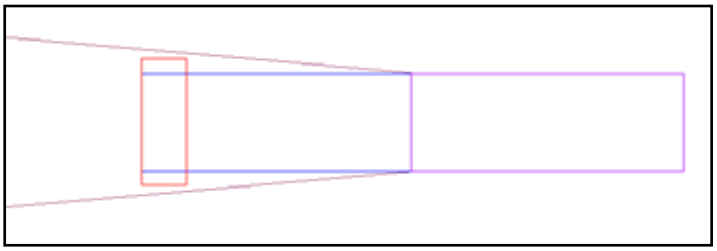

Figure 10: The ring and the end of the paper shroud will align the tube perfectly.

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Put glue on the edge of the ring and where the paper shroud meets the small tube (see Figure 10). Push it into the shroud using the alignment tube. Don't push too hard, or you'll make a bulge in the paper shroud where the ring touches. But make sure that the small tube is aligned straight by rolling the long alignment tube along the table.

If everything works right, the small tube will now be straight out the small end of the shroud. Remove the alignment tube from the assembly and allow the glue to dry.

While that is drying, you'll need to build the shoulder on the large diameter tube that will mate inside the big end of the paper shroud.

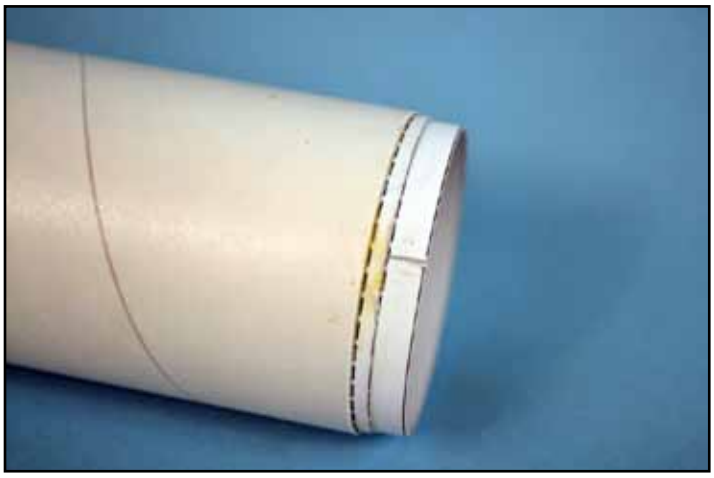

Figure 11: Two short shoulders sticking out of the big tube help align the paper transition.

You can use a short length of tube coupler for this protruding shoulder if you are using a standard diameter tube. If it is a non-standard diameter tube, then you'll need to make up a shoulder using paper. You can simply glue strips of paper into the end of the tube, so a little bit hangs out of the tube. Test fit the shroud over this shoulder.

Here is a little trick I discovered that makes it easier to get the lip of the paper shroud over the shoulder of the big tube. That is to add a second shoulder to the one already in the tube. With a stair-step approach seen in Figure 11, the shroud should slide over the shoulder easier, and you'll have more area for making a strong glue joint.

If you sized the shroud properly when you designed it, the paper should not overlap the tube. Ideally, it should butt right up against the edge of the big tube. If there is a

Figure 12: Insert the alignment tube into the big tube so you can then slide the paper transition over the shoulders of the big tube.

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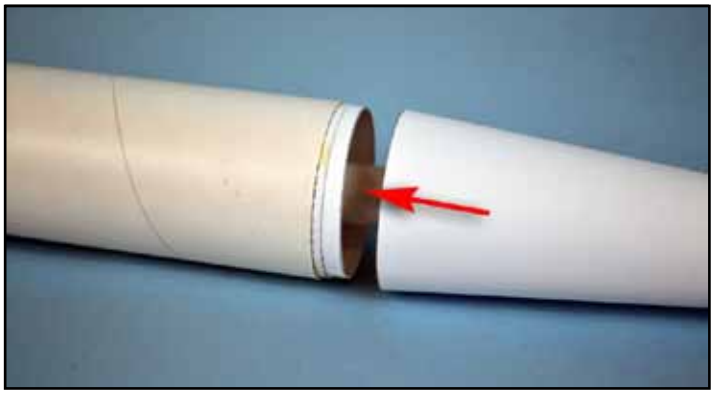

Figure 13: Slide the transition over the shoulders sticking out of the tube.

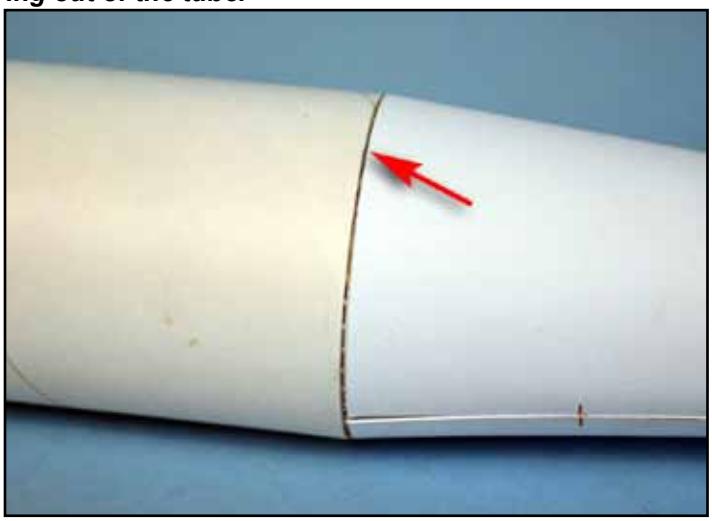

Figure 14: The final joint shouldn't have any overhang.

gap between the paper transition and the edge of the tube, then sand the length of the exposed portion of the shoulder down. That way, the shoulder is shorter. When you have the length of the shoulder to allow a perfect fit, it is time to glue everything together.

Insert the long alignment tube into the large diameter tube (as seen in Figure 12) and then into the shroud. It may be a bit tricky to get the tube coupler into the end into the small tube, but it needs to go into it. This will make sure that the large tube is aligned with the small tube.

If the position of the centering rings doesn't allow both of them to be inside the large tube, you'll have to pull the tubes apart and readjust the rings' positions. Tack them to the long alignment tube once you have them in place. Ideally, the farther apart the rings are, the better the alignment of the tubes will be once you glue them all together.

When you are satisfied with the fit and the alignment, you can add glue to the exposed end of the shoulder, and slide it into the paper transition.

Keep the long alignment tube in the assembly while the glue dries on the transition. When it is dry, you can remove the alignment tube.

You'll be left with a hollow transition section that adds a lot of space inside your rocket. A completed FAI style rocket is shown in Figure 15.

If you have any questions or comments on this pro-

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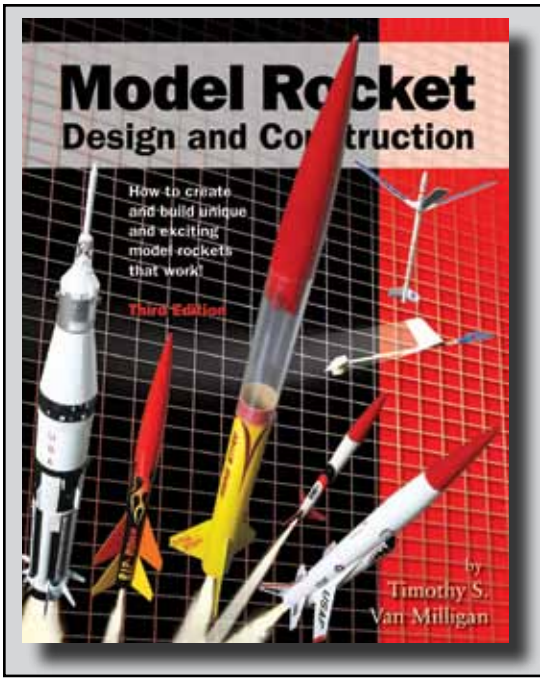

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By Timothy S. Van Milligan

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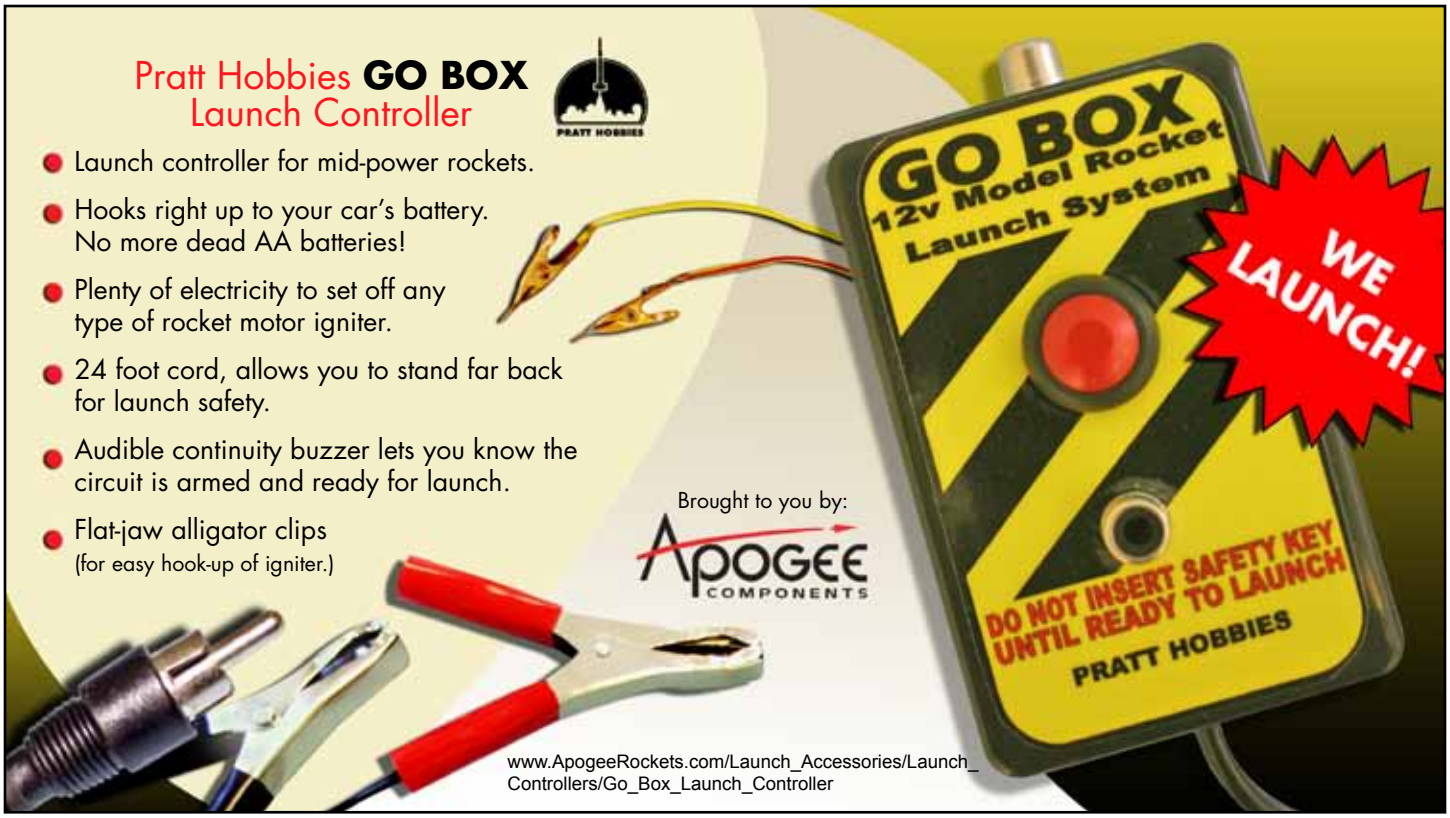
Aligning A Structural Paper Transition

Figure 15: A completed rocket with a hollow structural transition section.

cess, please let me know.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. Before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit. He has a B.S. in Aeronautical Engineering from Embry-Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward a M.S. in Space Technology from the Florida Institute of Technology in Melbourne, Florida. Currently, he is the owner of Apogee Components (http://www.apogeerockets.com) and the curator of the rocketry education web site: http://www.apogeerockets.com/education/. He is also the author of the books: *"Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics"* and publisher of a FREE e-zine newsletter about model rockets.

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