Peak Of Flight

NEWSLETTER

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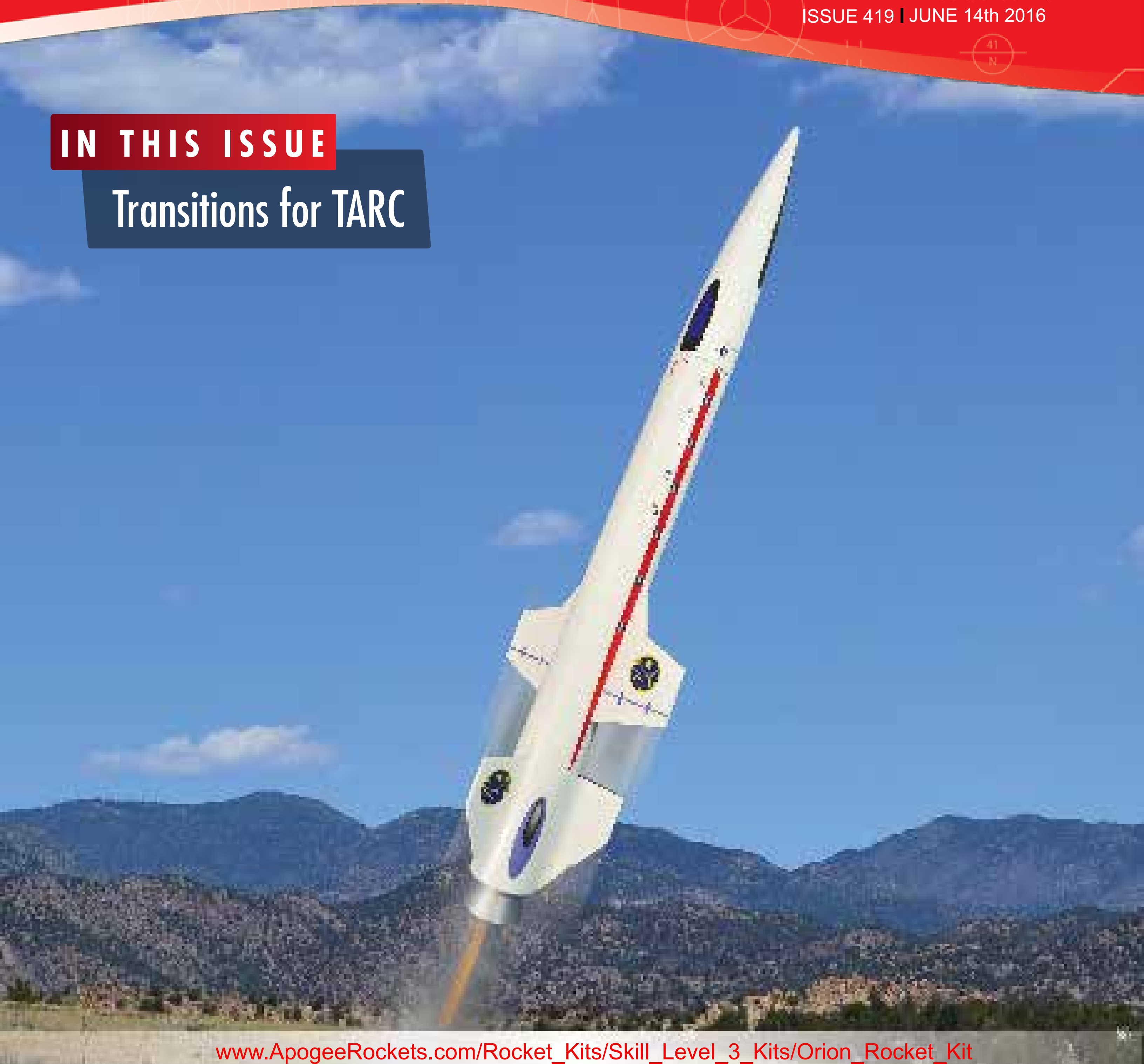

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Transitions for TARC

By Tim Van Milligan

When I read the rules for the TARC 2016-2017 calendar year and how you need transition to connect two tubes of different diameters together, I had the same initial reaction that you experienced. Namely, it was perplexion: "What are we going to do for the transition part?" I suppose it may be possible to create a rocket without a transition joining the two diameters together such as the one shown in **Figure 1**.

Figure 1: A simple rocket without a transition between the two diameter tubes.

The problem with this is that the discontinuity causes a lot of turbulence at the rear of the rocket. Not only does this increase the drag, but it makes the fins less effective. They have to be made larger (stick out from the tube further) in order to be in the smoother airflow.
Most teams, I suspect, will opt for a transition section between the two diameters, as shown in **Figure 2**.

Figure 2: The likely configuration of a TARC rocket that has a transition between the two tube diameters.

That gets us back to the question of what part can you order to construct your rocket? Right now, there are not a lot of options. One reason is that as a designer, you have a lot of choices for the tubes you can use. You can pick lightweight tubes, like the BT-70 that would nicely hold the egg. Or you can choose a bigger tube that would give you more room for extra padding to cushion the egg (https://www.apogeerockets.com/Building_Supplies/Payload_Protection). Additionally, you have many choices for the rear tube also. The maximum diameter is a BT-60 tube (https://www.apogeerockets.com/Building-Supplies/Body-Tubes/29mm-to-54mm-Tubes/33mm-X-18in-Slotted-Body-Tube-Estes-BT-55-Size). But you can go a lot smaller than that if you want to. My guess is that the minimum size that a team might use is the BT-50, which is the size that just fits the Estes D12 rocket engine.

There are so many tube options that, from my perspective as a supplier of parts, I'm freaking out too. I don't want to force a particular design by supplying just one size transition. I like the TARC contest, because it allows for ingenuity and variability from team to team. So in this article, I'll give you some ideas on how to make your own transition section, as well as some of my own thoughts from a manufacturer's perspective.

The Simplest Transition

I think the simplest type of transition is one made from balsa wood, like shown in **Figure 3** **(on Page 3)**.

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The nice thing about them is that it is a two piece solution: the wooden part, and the metal screw-eye that is used to attach the shock cord or the parachute.

Figure 3: A balsa wood transition is the most basic type of transition.

As soon as the rules were announced, we made inquiries with our own suppliers to try to get a few sizes of transitions. Hopefully they'll come through for us and for you.

The one thing that concerns me from a supplier standpoint is the availability of balsa wood. Based on my past experience, balsa supply is somewhat finicky. Sometimes the raw wood blocks are available, and sometimes they aren't. It would concern me to find out we couldn't supply our customers and their needs.

Molded Transitions

What would be even better than a balsa wood transition is a plastic molded part. It could be either injection molded (**Figure 4)** or blow molded (**Figure 5)**.

Figure 4: An injection molded transition would have the smoothest surface of any of the options.

Figure 5: A blow molded transition.

What makes a plastic transition ideal is that it is hollow. So if you needed to pass an ejection charge from the bottom to the top tube, it could easily be achieved by cutting off the base and the top of the part. Then you'd be left with the outer shell of the transition.

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The difference between the two types of plastic transitions is the way they are made. Injection molded gives the manufacturer the option of putting details on the inner surface of the part. The downside of injection molded parts is that the tooling is expensive. Blow mold tooling is cheaper, and for a part like this, it would probably be the way to make it if you wanted a smooth outer surface.

However, from my perspective as a manufacturer, tooling up to make a transition is still very expensive. And it takes a long time. The last injection molded part I had made took about a year from conception to release to customers. It is faster now, but still has a long lead time.
The other thing is that making multiple sizes of transitions would be extremely expensive. So much so, that in a practical sense, a manufacturer would only make a single size. And that locks TARC teams to a specific size and configuration rocket. As mentioned previously, I want to open up design choices for teams, not minimize them.
One of the things that has sped up the process is the ability to 3D print a prototype. And that opens up to a new method of making a transition. Instead of making one tool, it is possible to print any size or shape a customer wants.

I truly believe that 3D printing is going to revolutionize the hobby of model rocketry (**Figure 6**). And this might be the impetus to push that revolution forward. Instead of buying from Apogee or another supplier, you can simply make your own on a 3D printer that you have available. Many schools already have 3D printers, so be sure to check your own school first. If not schools, many public libraries also have 3D printers. That is where I personally go to have parts printed for my own use. And finally, the internet has listings for hundreds of businesses that would love to print a part for you.

Figure 6: An example of what a 3D printed transition might look like.

All you need is the design file to send to the printer. It is really similar to printing a piece of paper. Just select the file you want, and hit the print button. The only hold-up is a file to print. To solve that, I've created a simple file that you can download and use for free. The only thing that I ask is that you send us a photo of your rocket that uses the part so we can share in your success.
Here is the link to the file to download and send to a 3D printer: https://www.apogeerockets.com/downloads/transition_BT-60_to_BT-70.stl

This part is for joining a BT-60 to a BT-70 tube. You'll also need a piece of Kevlar™ shock cord to attach the parachute. But

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Figure 7: The mesh of the 3D transition.

I'll let you figure out how to do that. The downside of 3D printing is that the parts are not typically strong. That is changing because of new technology. But if you have the original filament type of printer, the layers can sometimes separate. So if you print it out, you should reinforce it before putting it into a rocket. Fortunately that is easy. Simply coat the inside of the part with some epoxy. When cured, the transition should be plenty strong for use in your egg-lofting rocket.

Resin Transitions

Another idea I had for making transitions was to make a solid resin transition, like the one shown in **Figure 8**.

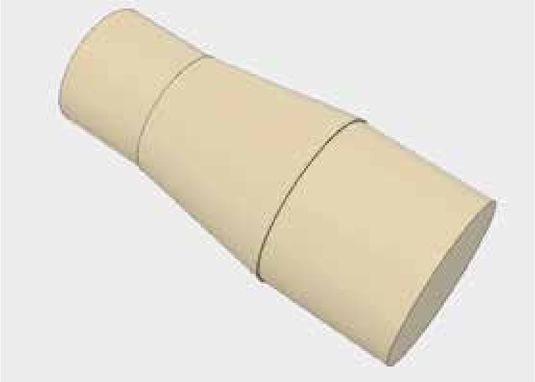

Figure 8: A cast resin transition would be heavy, but easy to use.

It was a fleeting thought, because it wasn't a "good" idea. The reason is that it would be too heavy. But I was thinking of options, using the capabilities that we have here at Apogee Components. I can make resin parts, because that is something we already do. We make things like the Saturn V fins which are cast resin (https://www.apogeerockets.com/Building_Supplies/Rocket_Fins/Saturn_V_Fins). If you want to learn more about how to make cast resin parts, see Apogee Technical Publication #12 (https://www.apogeerockets.com/Rocket_Books_Videos/Pamphlets_Reports/Tech_Pub_12).

Modify a Nose Cone into a Transition

One suggested way to make a tough and durable transition is to modify a plastic nose cone. The BT-70 and BT-80 size nose cones that we sell are designed to be easily modifiable to turn into a transition. The steps are easy:

Step 1: Cut the base and the tip off the nose cone

Figure 9: Cut the base and the tip of the nose cone off.

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The tricky part is marking the location where to cut the tip off. What I recommend is to slip the tube you want to pass through the transition over the tip and use that to mark the cutting location. In this particular case, I recommend using a tube coupler for the tube you will be using for your design, as shown in **Figure 10**.

Figure 10: Slide a tube over the tip of the nose cone, and use the edge to draw a line around the perimeter. This will be the cutting line for removing the tip.

After cutting it off, try inserting the coupler into the transition. It should just slip out the smaller diameter end. If you marked it as shown in **Figure 10**, the coupler won't slide through. You'll need to sand the small end a bit. Work carefully when sanding the end, because you don't want the fit to be too loose. You'd like it to be tight when it slides through.

If you'd like to see a video of the technique, we have one on the Apogee web site at: https://www.apogeerockets.com/Advanced_Construction_Videos/Rocketry_Video_194.

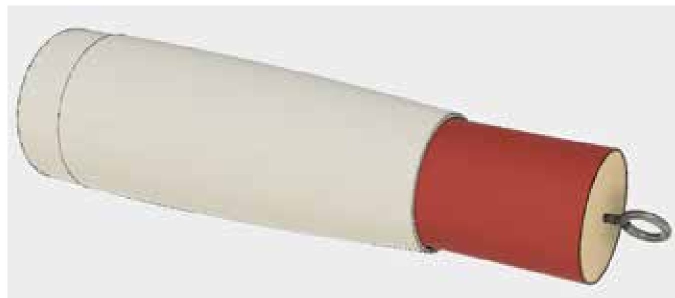

Figure 11: The completed transition that was made from a nose cone.

Step 2: Center the coupler into the cut-off nose cone.

The transition needs a shoulder to insert it on top of the smaller diameter tube of the rocket. This shoulder is made from a tube coupler (shown in red in the illustra-

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tions). To keep the coupler from being canted to one side, a small ring is glued to the front end. Then the coupler is slid into the wide end of the cut-off nose cone. Slide it in until the ring touches the inside of the transition. The coupler should extend out the rear end to make a shoulder like shown in **Figure 11 (on Page 6)**. This is where it will be glued into place.

Figure 12: The centering ring aligns the coupler inside the cut-off nose.

Figure 12 shows a similar view to **Figure 11**, except the opacity of the plastic nose cone piece was reduced so you can see the centering ring on the inside. If the shoulder doesn't stick out far enough to make a good connection into the smaller body tube, you'll need to reduce the outer diameter of the centering ring. You can either cut a new one that is smaller, or sand down the outside of the ring until the coupler extends further out the tip end of the nose cone.

The exploded parts view of the transition is shown in **Figure 13**. The final two pieces of the transition are a bulkhead disk to fit into the end of the coupler, and a metal screw eye so that you can attach a parachute or shock cord to the small end of the transition.

Figure 13: An exploded parts view of the transition made from a nose cone.

A Paper Transition

Probably the most versatile method of making a boattail, due to all the tube sizes possible, is to make a transition out of paper. This is the old school method, and one I use a lot. It is cheap too, because most of the components are readily available. **Figure 14** shows the completed transition, but I'll walk you through the steps on how to make one. You'll find a video that shows you the construction of this type of transition at: https://www.apogeerockets.com/Advanced_Construction_Videos/Rocketry_Video_10.

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Figure 14: A paper transition made from commonly available components.

Step 1: Glue the Coupler into the body tube (**Figure 15**).

Figure 15: Glue the coupler into the body tube.

The tube in this case is the same diameter as the smaller tube on the rocket. It is a separate tube from the lower section of the rocket. The purpose of this tube is to center the transition into the larger tube. The coupler is used as the shoulder, so that the transition can separate from the lower section of the rocket.

Step 2: Cut out the transition pattern.

This is the hardest step in making this type of transition, because you have to have a template to use. I have described this technique before in previous issues of Peak-of-Flight. The basic equations are found in **Newsletter #136** (https://www.apogeerockets.com/education/downloads/Newsletter136.pdf). There is also the option of using RockSim to create the pattern for you. The instructions for using RockSim are found in Peak-of-Flight **Newsletter #355** (https://www.apogeerockets.com/education/downloads/Newsletter355.pdf.)

Once you have the paper transition cut out (use thick cardstock or "index" paper), your next step is to roll it and glue it up. Again, see the two newsletter issues or the videos for instructions on how to make a perfectly rolled transition.

Step 3: Glue a centering ring into the wide end of the transition (**Figure 16 on page 9**).

For this step, I like to use the thick "foam-core" centering rings (such as: https://www.apogeerockets.com/Building-Supplies/Centering-Rings/For-56mm-BT-70-Body-Tubes/Foam-Core-Centering-Ring-41-6-56).

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The reason is that when you put it into the transition shroud, half of the ring will stick out, like shown in **Figure 16**.

Figure 16: Glue the centering ring into the wide end of the transition. Half of the ring should extend out the end.

The purpose of this ring is to act as a little shoulder for when you insert and glue the transition into the wider tube on the rocket. If you don't have this little shoulder, you'll need a third centering ring to help align everything properly.

Step 4: Glue the transition onto the body tube.

Figure 17: The transition is slid over the tube from the coupler side.

Slide the wide end of the paper transition over the end of the coupler and onto the body tube. The small end of the shoulder of the transition should just reach the end of the tube where the coupler extends. Glue it into place at this location. Next, you'll glue the remaining centering ring on the far end of the tube as shown in **Figure 18**.

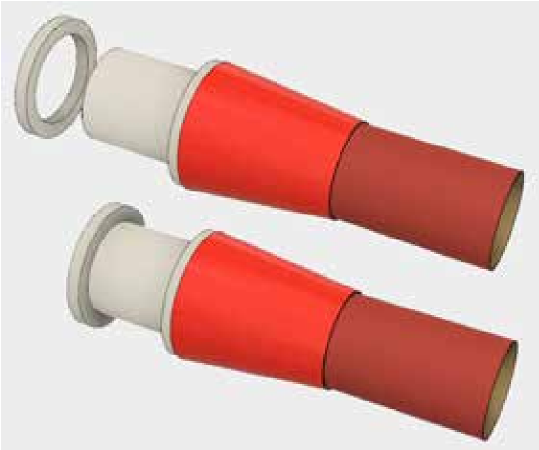

Figure 18: The forward centering ring is glued on the front end of the body tube.

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Figure 19: A bulkhead and screw eye are added to complete the transition.

Step 5: Glue in a bulkhead and add a screw eye. To complete the transition, you next need to add a bulkhead into the end of the coupler and add a screw eye (**Figure 19**).

The bulkhead seals off the coupler so that the transition can be ejected out the rocket during deployment. And the screw eye allows you to add a shock cord or a parachute to the base of the forward section of the rocket.

At this point, the transition is done. The whole thing is then glued into the base of the larger tube. It is not glued into the smaller tube.
An exploded parts-view of this transition is shown in **Figure 20**.

It should be noted that the paper transition is non-structural. All the tubes and the internal rings carry the forces of flight and ejection. The paper shroud is only to smooth the airflow between the two different diameters of the rocket. So you'll notice that the transition feels a little squishy. That is fine, and doesn't hurt anything. But if you don't like how it feels, you can reinforce the shroud. See **Newsletter #229** (https://www.apogeerockets.com/education/downloads/Newsletter229.pdf.)

Figure 20: An exploded parts view of the paper transition section.

Vacuum-Form Transitions

In this article I mentioned a number of different choices that you can use to make a transition. As I was thinking about this problem and comparing it to the production capabilities here at Apogee, I came up with one additional alternative. That is a vacuum-formed transition, like the one shown in **Figure 21 (on page 11)**.

A feature of this transition is that it will be lightweight. Not that weight is an issue in this contest, but it does allow a team to use smaller motors that are cheaper than the bigger ones. This coupler is not available yet,

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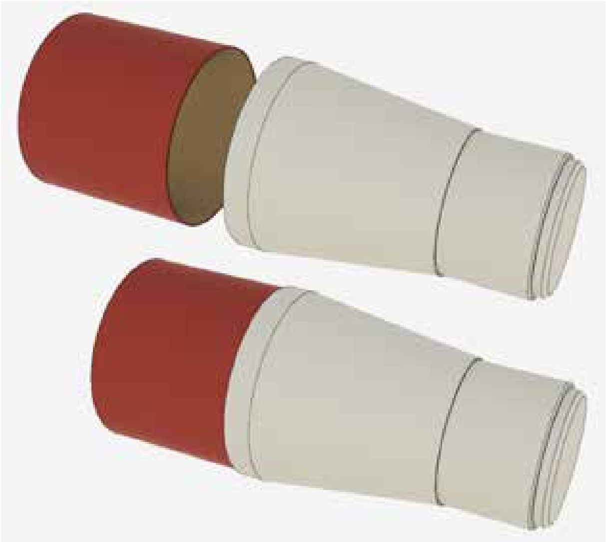

Figure 21: A vacuum-formed transition with a paper coupler.

because I have to do a little research yet. I have to figure out how to make it strong enough to survive the stress of an egg-lofter type flight. But we are getting better at vacuum-forming components and this one should be doable with our current equipment. It does require some investment in tooling, but it isn't as much as a blow mold. If everything goes well, my goal is to have it available at the beginning of September 2016.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. He is an avid rocketry competitor, and is Level 3 high power certified. He is often asked what is the biggest rocket he's ever launched. His answer is that 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 also the author of the books: "Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics" and publisher of the "Peak-of-Flight" newsletter, a FREE e-zine newsletter about model rockets. You can email him by using the contact form at: https://www.apogeerockets.com/Contact.