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How To Join A Cluster Of Tubes To A Single Tube

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Joining Cluster Tubes To A Single Tube

By Tim Van Milligan

Joining a cluster of tubes to a single small tube is not an easy task to do. But it looks cooler than you can imagine if you pull it off correctly. It has a couple of advantages, the first being reduced mass, and the second being reduced drag. But in reality, it is the coolness factor that makes it worth doing. You just don't see this very often, so it will be something that will make your rocket stand out from the crowd.

I started this article because of one of the NARAM contest events this summer here in Colorado. The event is 4-"A" motors, cluster altitude. That means you must use four A-size motors ignited simultaneously, and the object is to have the rocket achieve the highest altitude. Using this as a guide, I created a rocket that is shown in Figure 1.

For this article, I decided to simplify the rocket a little bit and instead of using four tubes connected to a single tube, I thought I'd use small 2-cluster tubes, and connect them to a single tube. It is sized so that the cluster of 2-tubes are made from 13mm diameter (BT-5 size), and it will connect to an 18mm tube (BT-20 size) on top.

While I'm using small tubes for the example in this article, I will try to write it in generic terms so that you pick up the imporant concepts, and not just a series of measurements. That way, you'll be able to scale this process up for whatever size rocket you're making.

The basic process reminds me of making Oblique nose cones (see Peak-of-Flight Newsletter 127 at: www.ApogeeRockets.com/education/downloads/Newsletter127pdf) or cutting tubes at an angle (see Peak-of-Flight Newsletter 121 at: www.ApogeeRockets.com/education/downloads/Newsletter121pdf). The reason is you have to start by making a precision drawing of the rocket side and top views. I

Figure 1: A four-engine cluster that connects to a single tube. The nose cones help reduce drag.

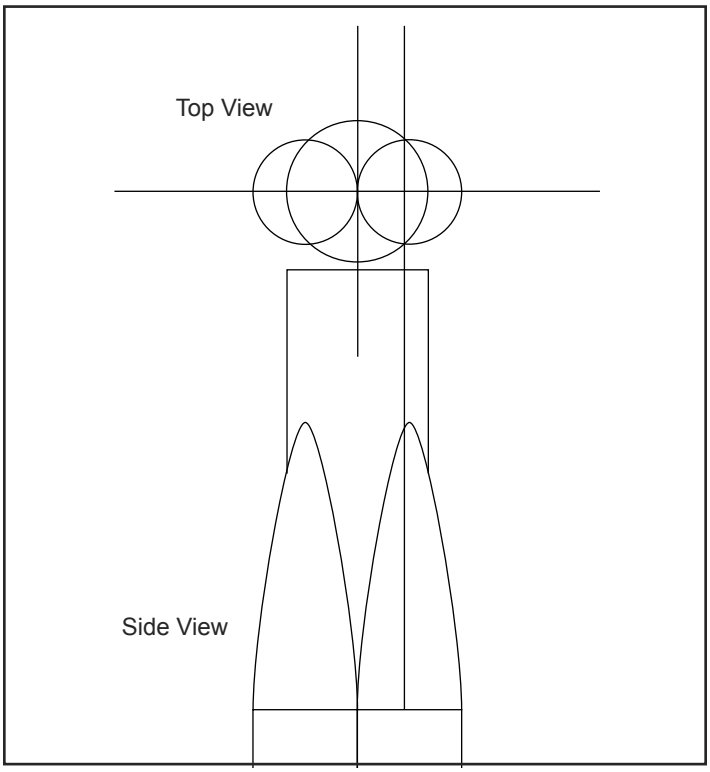

Figure 2: Full-size drawing of the top and side view of the rocket where the cluster joint the single tube.

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personally use the Adobe Illustrator program, but you can use a drafting program, or a free drawing program for you computer like InkScape (http://www.inkscape.org/).

Figure 2 shows the top and side view of the rocket where the tubes join together. What I did was to put nose cones on the cluster tubes. In actuality, a large portion of one side of the nose cone will be removed. So the illustration is not correct at this point, but it gives us something to start with.

Next, you'll want to mark the cluster body tubes where the single tube will touch them. In this particular case, there will be three places on the cluster tube that have to be marked. First, where each cluster tube touches the other. And then the two places where the cluster tube touches the single tube (see Figure 3).

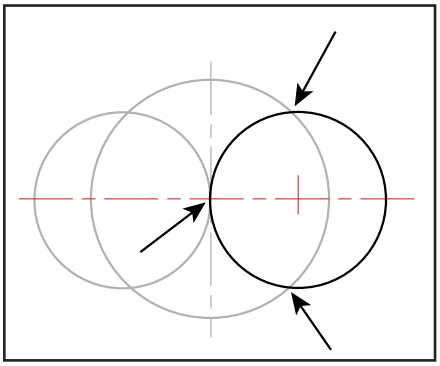

Figure 3: The cluster tubes are marked where they touch each other, and where it touches the single tube.

When marking the tube, what I found is simplest is to stand the cluster tube on the drawing, and just mark it with a pencil as shown in Figure 4. It is important to be as accurate as possible when doing this. When you're done, extend the lines along the length of the tubes.

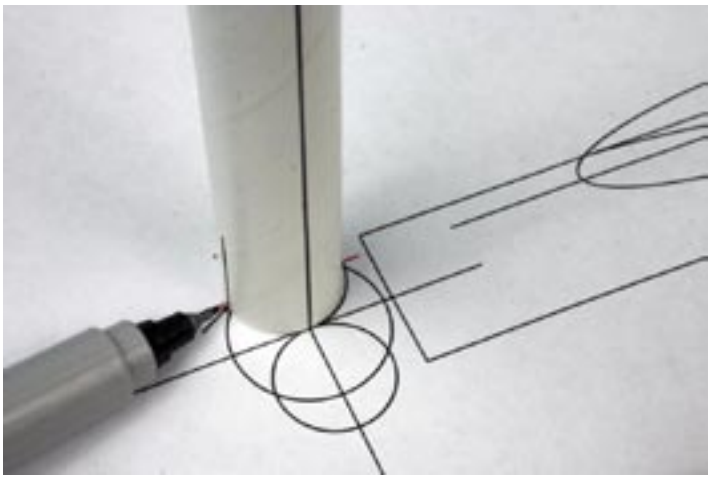

Figure 4: Be as precise as you can be when marking the tubes.

The purpose of extending the lines is because you will be cutting a notch out of the tube. Once the tubes are glued together, the notches will form a seat into which the single tube will sit. The longer you make the notch, the easier it is to get the tubes straight when you glue them together. But the disadvantage is the extra mass of the overlapping tubes. My recommendation is to make the length of the cutouts at least 1-1/2 times the diameter of the smallest tubes. But as I said, it could be longer or shorter depending on

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Figure 5: The tube will have a notch cut out (top). The bottom tube is marked and is ready to have to indicated area removed.

how you want the rocket to look.

Figure 5 shows the area that is removed. You'll do this to all the cluster tubes.

Figure 6: Glue the cluster tubes together.

When all your cluster tubes have their notches cut into them, you'll glue the cluster tubes together as shown in Figure 6. Make sure that they are aligned as straight as possible.

Slide the single tube into the seat created by the cut-outs in the cluster tube. The optimum is for the tube to go in with a nice snug fit. If the fit is sloppy, the tubes could end up crooked once the glue is dry. But don't glue yet, just test fit everything from this point forward until the very end when all the pieces are cut and shaped properly.

Mark on the single tube where the cluster tubes touch it, as showin in Figure 7. Remove the single tube from the seat, and extend the tick-marks to create lines on the single

Figure 7: Insert the single tube into the seat, and mark on it the location where each cluster tube touches it.

tube as shown in Figure 8.

You'll also see a perimeter line in Figure 8, which is positioned slightly lower than the top edge of the cluster tubes would extend. I'd say to keep this perimeter line at least 1/16 of an inch shorter than the length of the seat.

Now make two more lines, about 1/16th of an inch

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Joining Cluster Tubes To A Single Tube

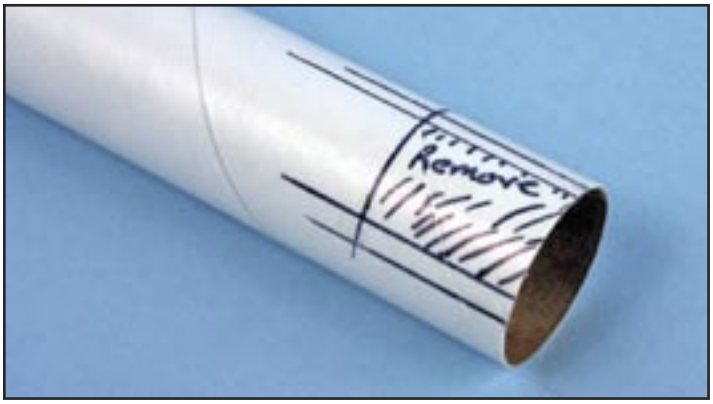

Figure 8: Mark a cut-out location on the single tube for each location where it is inserted into the cluster tubes. The purpose of these are to allow the exhaust gasses to easily pass through to the single tube.

inward from the two long lines. This will define an area, as shown in Figure 8, to create a notch in the single tube that you'll remove to allow the exhaust gasses of the cluster tubes to pass through to the single tube. We'll leave a little ledge along the edges to make sure the tubes still have an overlap to allow them to be securely glued together later.

Note that there is going to be several notches in the single tube, one for each of the cluster tubes. In Figure 9, the notches have been removed, and you can see that there are two notches because I'm joining a cluster of two tubes to the single tube.

Again, the lines that remain in Figure 9 are the locations where the cluster tubes will attach to this single tube.

Figure 10 shows how the two tubes will slide together and finally mate (remember, don't glue them yet).

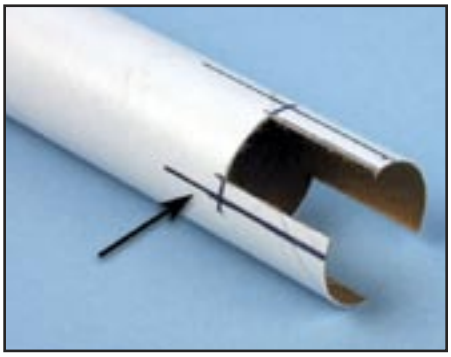

Figure 9: Cut-out notches made in the "single" tube to allow ejection charge exhaust gases to pass into it from the cluster tubes.

To reduce the aerodynamic drag on the rocket, we'll create fairings from plastic nose cones, and insert them into the tops of the cluster tubes. You can

Figure 10: The notches in the single tube allow ejection charge gasses to pass through to the single tube.

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Figure 11: Insert the nose cone on a cluster tube, and mark where it will touch the cluster tube edges.

use either plastic nose cones or balsa for this step. I will show you the plastic nose cones, since that happens to be what I had available when I wrote this article.

Temporarily insert the shoulder into the nose cone, but do not glue it since it will be discarded later. Mark both sides at the base where the edges of the cluster tubes will touch the nose (as shown in Figure 11).

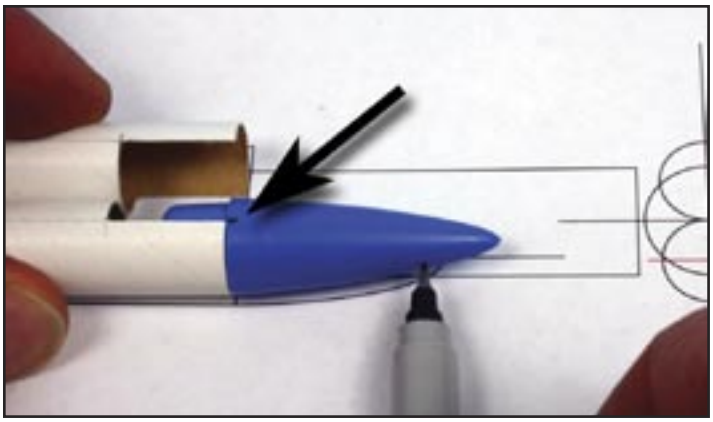

Figure 12: Mark the nose cone where it will touch the single tube.

Lay the cluster tubes on the full-size drawing, and using a pen, mark where the nose cone tip will touch the single-tube as shown in Figure 12.

Next, draw a rough outline of where you'll cut the nose cone so that it matches the contour of the single-tube (as shown in Figure 13. You'll probably be off quite a bit, but don't worry about that. We'll sand off the high points and fill any low points).

In Figure 13, I drew arrows on the nose cone pointing to the large section of the nose cone that will get discarded.

Now cut off the excess nose cone. Keep the knife blade

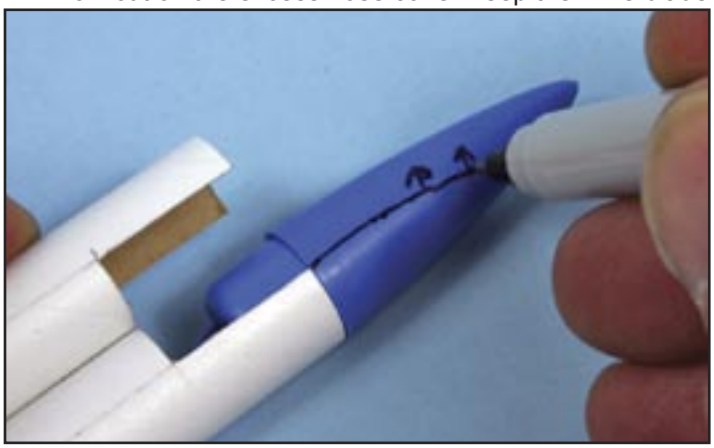

Figure 13: Mark the nose cone where it will touch the single tube, and where the edges of the cluster tube touch (as shown by the arrow).

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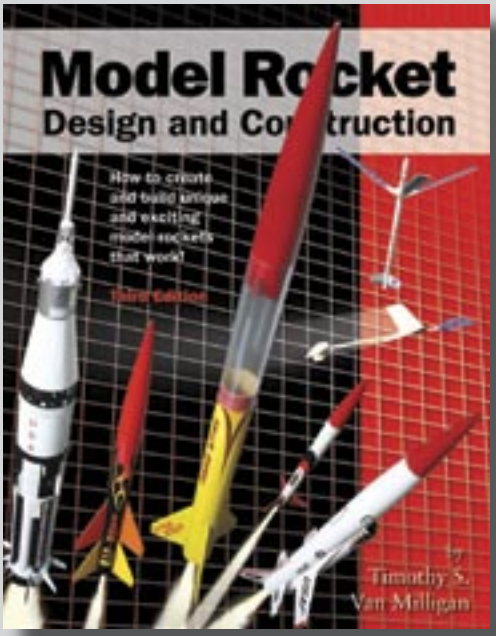

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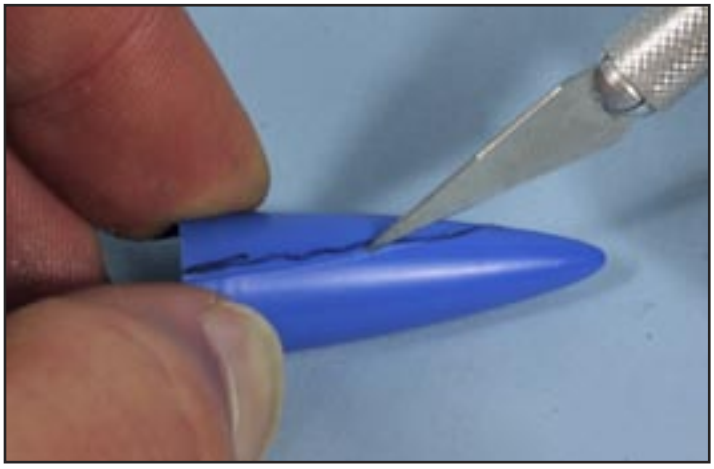

Figure 14: Cut off the excess nose cone to create the drag reducing fairing for each cluster tube.

to the outside of the line you just drew as shown in Figure 14. This will make the fairing a little large, but it will be sanded to a perfect fit onto the single tube.

To be honest, this is the hardest step of the whole process. Cutting the nose is tricky because the knife wants to wander all over the surface of the nose. So use many light passes with the knife so you have better control over it.When you're done cutting, you should have something that looks like Figure 15.

Figure 15: The nose cone after it has been cut.

To make a perfect fit, take a piece of sandpaper, and wrap it around the single-tube. Lay the fairing on it, and using a back-and-forth motion, sand down the edges of the cone so that it conforms to the single-tube (see Figure 16). Test fit it on the model often to make sure you don't sand off too much. If you do, don't worry, you can fill the gaps later.

To keep the nose cone attached to the cluster tube,

Figure 16: Sand down the edges of the cone to make it conform to the curvature of the body tube.

we'll create a custom shoulder from a sliver of centering ring. But you'll have to cut it to make it fit properly.

Start by laying the centering ring in the trough created by the cluster tube forward end. Hold the ring tight up agains the tube, and just use the edge to draw a line along the length of the centering ring (see Figure 17). Remember to do both edges and all the other rings for the cluster tubes in your design.

Then cut the rings and test fit them in the cluster tubes. Make sure that the single tube can still be inserted once you have the centering rings installed (Figure 18). I had to trim my centering rings slightly so that they would fit properly.

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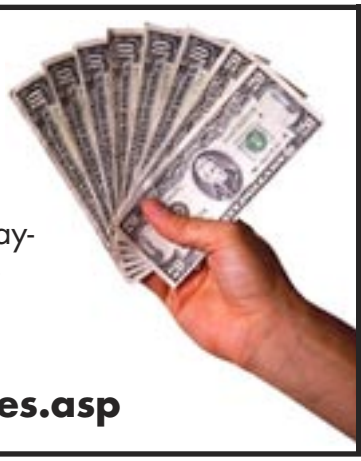

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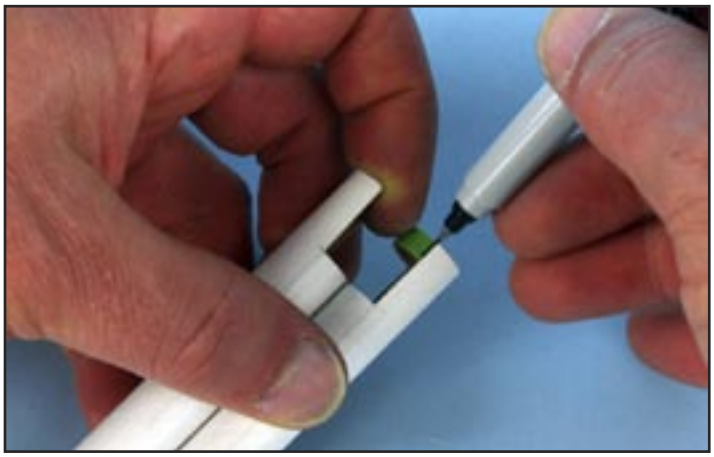

Figure 17: Use the trough in the cluster tubes to draw lines down the length of the centering rings. These will serve as short shoulders to hold on the nose cones.

Now it is time to start gluing everything up. You can start by gluing in the centering rings. Remember to leave a little bit sticking out of the tube to act as a shoulder for the nose cones (see Figure 18). The nose cones don't need much of a shoulder. Basically, it is to seal off the bottom edge of the nose cones to prevent exhaust gases from leaking out around the edges of the nose cone fairings.

Now glue the single-tube into the seat of the cluster tubes. Before you tack it in place, make sure that the tube is parallel to the cluster tubes. This is important, because you want the rocket to fly straight, right?

There should be a little slop in the joints to allow you to make sure everything is straight. When it is, tack it down. Now you can glue the nose cone fairings onto the ends of the cluster tubes.

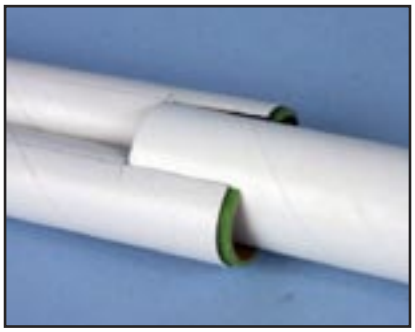

Figure 18. The centering rings must be trimmed to allow the single-tube to be inserted into the cluster tubes.

You will notice on my rocket, that I didn't do a good

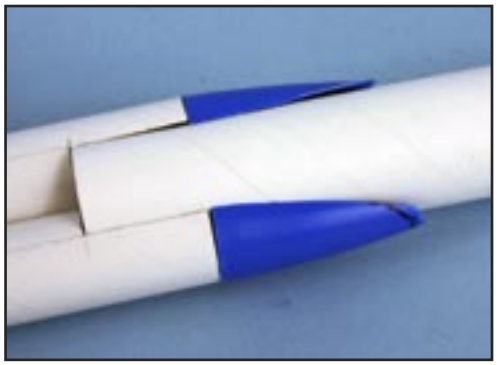

Figure 19: Glue the fairings onto the ends of the cluster tubes.

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job of sanding down the edges of the plastic fairings. If you have any large gaps, us the Fix-IT epoxy clay (www.ApogeeRockets.com/epoxy-clay.asp) to fill them. When it is hard, go ahead and sand down any excess.

Finally, the gap in the base where the tubes join needs

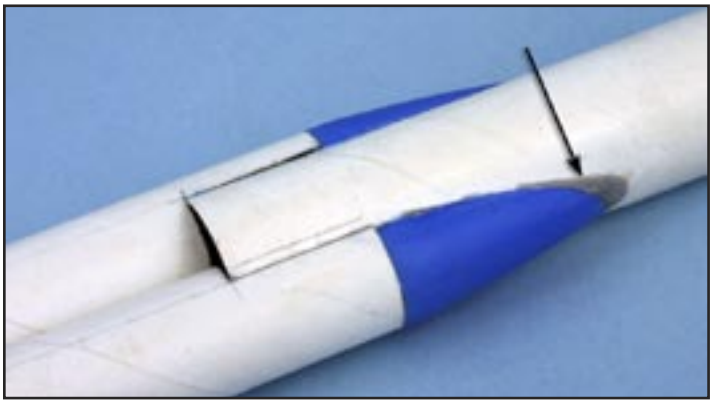

Figure 20. Use Fix-IT epoxy clay to fill any gaps under the edges of the nose fairings. Sand it down smooth when complete.

to be filled to prevent the ejection charge from leaking out instead of pushing the nose cone off. This can be done by cutting a piece of cardstock to fit the shape of the opening as shown in Figure 21. I used the base view on the full-scale drawing to get the exact shape. As can be seen, I used a hobby knife to position it properly so I could tack it down and then glue it securely in place.

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

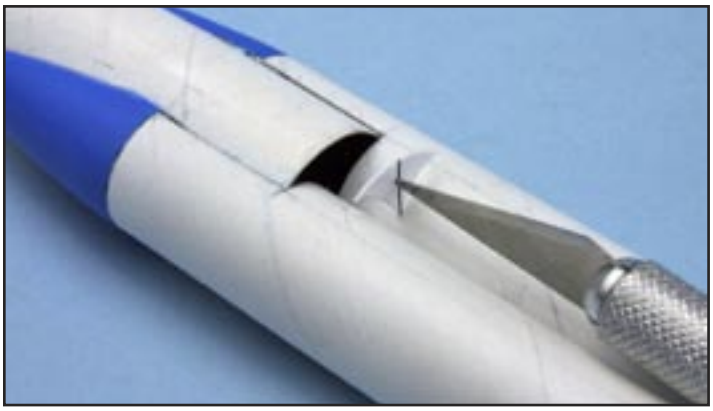

Figure 21: The gap in the base can be plugged with a piece of cardstock cut to fit the shape of the opening.

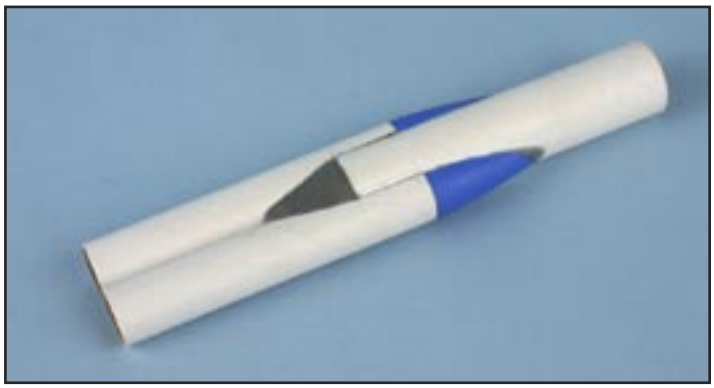

Figure 22. Use Fix-IT epoxy clay to create an aft fairing to reduce base drag on the rocket.

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. You can subscribe to the e-zine at the Apogee Components web site or by sending an e-mail to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.