Apogee Components

PEAK OF FLIGHT

NEWSLETTER

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Cover Photo: Mad Cow Rocketry's Hawk MIM-23B rocket kit blasts off from the launch pad. Get your own at: www.ApogeeRockets.com/Rocket_Kits/Skill_Level_3_Kits/Hawk_MIM-23B

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Multi-Staging Cluster Motors and Other Reader Questions

By Tim Van Milligan

We get great questions all the time from customers. Most of them are already answered somewhere on our web site. So if you are researching a topic, just type the query into the search bar at the top of our web page.

But occasionally, we get a question that hasn't been answered yet. That is where this issue's topic comes from.

Round Rockets?

Our first question comes from Brendan Gartland. He asks: *"Wondering if you had any idea how these round rockets are made http://laughingsquid.com/giant-round-homemade-rocket-fired-off-during-thai-rocket-festival/ Never seen them before and they look awesome" (see Figure 1).*

This is definitely a cool looking rocket that was launched in Thailand. They have quite the rocket festival over there.

Figure 1: Round Rocket flown in Thailand.

In simple terms, this is an example of a Monocopter type rocket. It is so big, that they've attached 6 rocket motors to it in order to spin it up and create the lift to get it in the air.

I have to say that I'm impressed at the engineering that went into this rocket. It is perfectly balanced and flies very nice. The wheel on the edge is actually the balance arm that give it stability.

What makes this particular rocket work so well is the long burn motors. If you put a stop-watch on it, you'll see that they burn for well over 30 seconds. That is impressive just by itself, considering that most model rockets here in the USA have burn times under 8 seconds.

If you'd like to know more about how to design a monocopter, we have a great book that was written by Dr. Francis Grahamn. You'll find it on our web site at: www.apogeerockets.com/Rocket_Books_Videos/Books/Monocopters.

Staging Cluster Motors

Donald Leaman asks us if we have any advice on multi-staging rockets with cluster motors in each stage.

Staging rockets adds some complexity to a rocket. It is easy if the motors are the simple black-powder variety, and you can use direct staging (see www.apogeerockets.com/Tech/How_2-Stage_Rockets_Work).

You can even use this direct staging technique with larger black powder motors, like the Estes 29mm Diameter F-15 rocket engines (www.apogeerockets.com/Rocket_Motors/Estes_Motors/29mm_Motors/Estes_Motors_F15-0).

Clustering these types of motors is relatively easy. You just have to have an equal number of motors in both the lower stage and the upper stage, so that you can vent the gasses easily to ignite the upper stage engines.

The only kit we have currently at Apogee Components that clusters and stages black powder motors is the US

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About this Newsletter

You can subscribe to receive this e-zine FREE at the Apogee Components web site (www.ApogeeRockets.com), or by sending an e-mail to: ezine@apogeeRockets.com with "SUBSCRIBE" as the subject line of the message.

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Multi-Staging Cluster Motor Rockets

Rockets Hi-Test 3100 (www.apogeerockets.com/Rocket_Kits/Skill_Level_5_Kits/Hi-Test_3100). However, because this rocket is so large and heavy, I wouldn't recomment that you use the F15-0 motor in the booster stage. The F15 is a low thrust motor, and even clustering four of them together, it doesn't produce enough thrust to get the rocket moving fast enough at launch for a nice straight ascent. When this rocket first came out decades ago, FSI was still producing the high thrust F100 black powder motor. That was a good choice, but unfortunately it is no longer available.

Run Your Simulations

This goes without saying, but whenever you are considering launching a complex rocket that has both multi-stage and clustering in it, you need to run your computer simulations. If you have RockSim already, you have an advantage. It has a great little editor to help you design your cluster engine rockets. See the article on how to use the cluster editor in Peak-of-Flight Newsletter #140 (www.ApogeeRockets.om/Education/Downloads/Newsletter140.pdf).

The thing you really want to pay attention to is the velocity at launch guide departure. If your rocket isn't leaving the rail at a speed of at least 30 mph, you need more thrust or a longer launch rail. This is how we know that the Hi-Test 3100 needs more powerful motors in the booster stage.

Staging Composite Motors

When you need more thrust, you have to switch to composite propellant rocket motors. But this presents a problem for staging, because there aren't specific booster motors for composite motors. See *Peak-of-Flight Newsletter #49* (www.ApogeeRockets.com/Education/Downloads/Newsletter49.pdf) to find out why.

In order to stage composite motors, you have to carry some sort of launch controller in the rocket to ignite the upper stage motors.

We've written a few articles on this subject here in this newsletter. See:

Newsletter #91 - Electronic Staging of Composite Propellant Rocket Motors (www.ApogeeRockets.com/Education/Downloads/Newsletter91.pdf)

Newsletter #289 - Tips for Constructing Electronically Staged Mid-Power Rockets (www.ApogeeRockets.com/Education/Downloads/Newsletter289.pdf)

Newsletter #364 - Staging Composite Motors (www.ApogeeRockets.com/Education/Downloads/Newsletter364.pdf)

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The question then, is how does adding cluster motors into the rocket change things?

Basically, very little changes as far as the concept of staging goes. You still have to carry up an ignition system in the rocket to ignite the upper stage motors. The difference is that it has to be capable of firing off multiple igniters at once.

To see which electronic payloads we offer that can support staging, see: www.apogeerockets.com/Electronics_Payloads/Staging.

People always ask me this question: "Does the X-brand electronic gizmo (controller or altimeter) have the capacity to fire off multiple rocket motors?'

I avoid this question for a couple of reasons. First, it is not the controller that fires the motors. It is the "IGNITER" that start the motors.

The correct question would be: "Does the X-brand electronic gizmo have the capacity to iginte multiple starters (igniters) as the same time?"

But to be honest, I don't know. The reason is that I'm not an electrical engineer. This question is out of my level of expertise, because electronic gizmos can be confusing to me too.

And truthfully, every rocket starter (igniter) is different. They all draw more or less power to get them to fire off. So you'll have to be more specific on which starter you are using with the device. There is a pdf document that explains the difference in the starters. You can download it at: www.gwiz-partners.com/igniters.pdf. Additional information on the starting current of Estes and Quest Starters can be found at: www.apogeerockets.com/education/downloads/Q2G2_Igniter_Report.pdf.

What I'm getting at, is this: a better person to ask is the manufacturer of the electronic device that you are interested in using. They are the experts in the products they create. And they do answer their emails too. So just ask them.

And when in doubt - TEST! Set up your electronics and fire off a bunch of starters (igniters). Yes... I know starters cost money. But if you're not bench testing your system, you're going to have lots of problems during the actual launch. So the money you spend burning off a bunch of starters is worth the investment.

Mechanical Considerations of Cluster Rockets

Designing cluster rockets has to be thought out, far in advance of the construction of the model. Don't just expect to take a kit rocket and slap a cluster engine mount into it. You have to consider where the electronics are going to be placed. This is probably the biggest challenge when building multi-stage rockets that have composite motors.

I like to put the electronics for staging as close to the rocket motors as possible (see Figure 2). The reason is that

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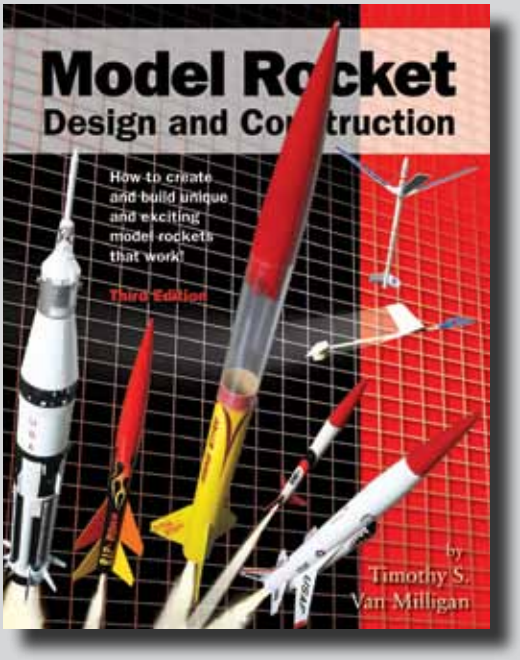

Model Rocket Design and Construction

By Timothy S. Van Milligan

The Expanded 3rd Edition

This massive, 328 page guidebook for serious rocket designers contains the most up-to-date information on creating unique and exciting models that really work. With 566 illustrations and 175 photos, it is the ultimate resource if you want to make rockets that will push the edge of the performance envelope. Because of the number of pictures, it is also a great gift to give to beginners to start them on their rocketry future.

For more information, and to order this hefty book, visit the Apogee web site at: www.ApogeeRockets.com

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Multi-Staging Cluster Motor Rockets

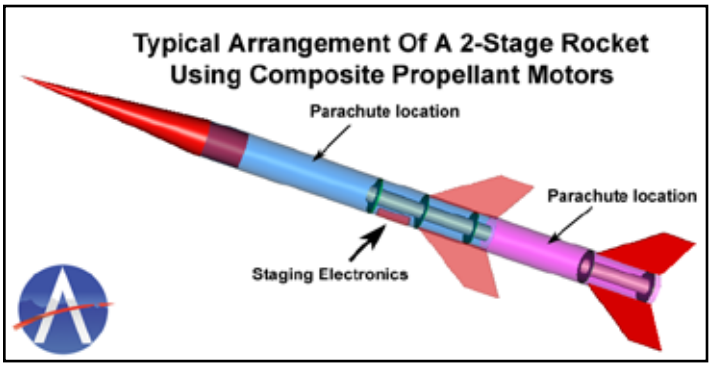

Figure 2: The typical location for the staging electronics is near the rocket motors.

it is easier to route the wires down to the rocket motors.

For large diameter rockets, there is usually room between the motor tube and the body tube for electronics and a battery. You can even sandwich it between the cluster tubes and the body tube, like shown in Figure 3.

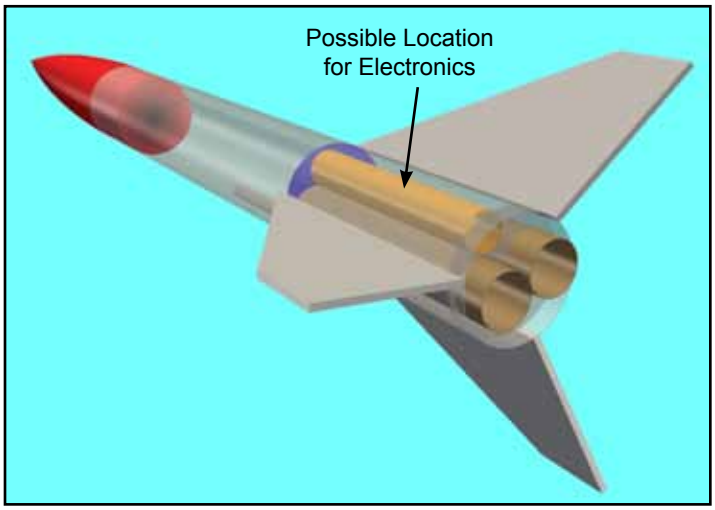

Figure 3: Clusters usually have room for the electronics surrounding the motor tubes.

The key thing to keep in the back of your mind is that you have to protect the electronics from the heat of the ejection charge. That is why it is behind a bulkhead in both Figure 2 and 3.

Sometimes it takes some creative routing of the ejection charge to protect the electronics bay. This is the situation I had with the the Cosmodrome Aerobee-Hi rocket kit (www.ApogeeRockets.com/Rocket_Kits/Skill_Level_5_Kits/Aerobee-Hi). I had to create a dog-leg in the motor mount tube in order to provide space for the electronics (see Figure 4). The plans for this special modification come with the kit when you purchase it from Apogee Components. The plans are also available separately at: www.ApogeeRockets.com/Rocket_Books_Videos/Pamphlets_Reports/Building_an_Electronics_Bay_in_the_Cosmodrome_Aerobee-Hi_kit.

Once you decide where to put the electronics, the next issue is where to route the wiring for the igniters. In Figure

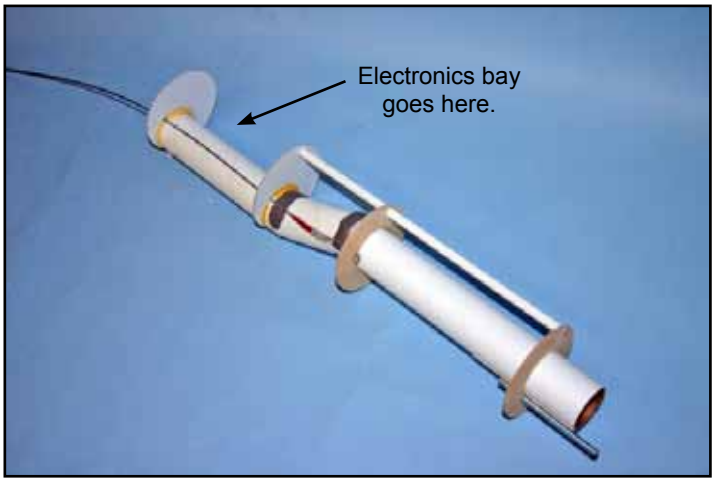

Figure 4: The ejection charge gasses may need to be ducted around the location of the electronics.

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4, you can see that I used a long straw-like tube for this purpose. It should be noted that real-life rocket engineers face these same issues. Sometimes they have to put the wiring on the outside of the rocket. You can do that too in a pinch.

Figure 5: The US Rockets HI-Test 3100 is about the most complex multi-stage cluster you'll see.

The US Rockets Hi-Test 3100 Kit

This particular rocket (see Figure 5) is about as complex a design to successfully stage that you might come across. I've never down it myself (yet), but I'll give you some of my thoughts on how it might be done.

You have to remember that this kit is literally decades old. The kit was designed around motors that no longer exist. And the instructions haven't been updated to allow it to be flown on available motors. In other words, we have to make some major modifications that aren't in the instructions. This is the kind of challenge that gives me goosebumps, because the payoff is going to be spectacular.

What gives this kit a unique look is the technique of fin wedging. This is where the motor tubes are exposed, and the fins are bonded in the gaps between the tubes. The advantage is that it is a lot like through-the-wall fins, so the joint is very strong. But is also why it is so complex to stage successfully.

First of all, this is a huge rocket. It is 3.1 inches in diameter, and over 90 inches tall. It is made from heavy tubes, so it weighs-in empty at over 67 ounces (1900 grams).

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Multi-Staging Cluster Motor Rockets

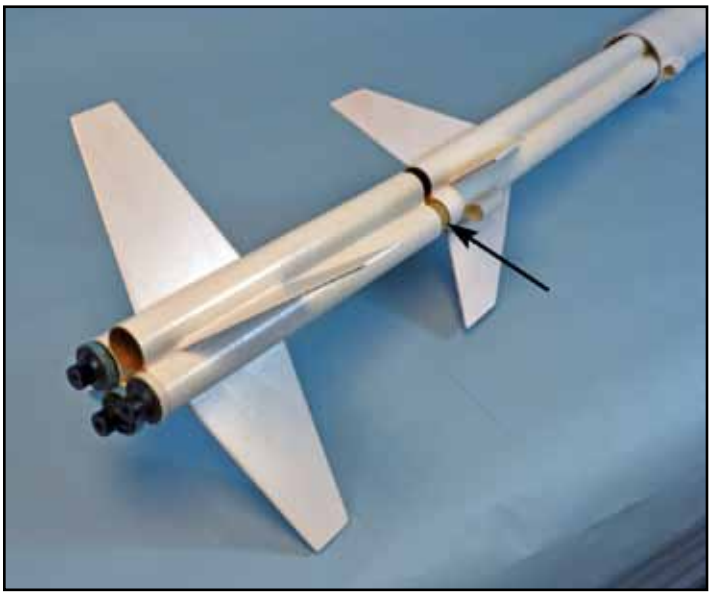

Figure 6: The engines act as couplers to keep the two stages together.

Once you put the eight 29mm diameter rocket engines in it, the rocket is a beast. Four F15 motors in the booster stage just don't have the grunt to get it moving fast enough at launch. It needs high-thrust composite motors in the booster stage to get it moving. The minimum size motors that I'd put in the booster stage are Aerotech F42's. But preferably something bigger, like G80's.

The reason it is complicated is because the stages are coupled together by the motors in the upper stage (see Figure 6). For starters, this doesn't give you any place near the motors to mount the electronics for staging. Essentially, the electronics have to be put in front of the engine tubes. Fortunately, there is plenty of room in the front body tube.

But remember the electronics have to be protected from the ejection charge of the motors. So an internal bay wth some sort of ducting of the ejection charge gasses will be needed. It probably wouldn't be as complicated as shown in Figure 4, but you get the idea.

Where do you put the wiring from the electronics to the motors in the upper stage? That was the first question we had too.

Fortunately, there is a cruciform channel that is formed between the four engine mount tubes. So the wires can simply be run down the middle of the rocket as shown in Figure 7.

The next problem took me a little while to figure out. That problem is: how do you do get the wires to the nozzles of the motors? It looks easy when you are just looking at Figure 7. You think they can just go directly into the motors.

But think for a second... The motors are the coupler that join the two stages together. They are going to go directly into the tops of the tubes on the bottom stage (like

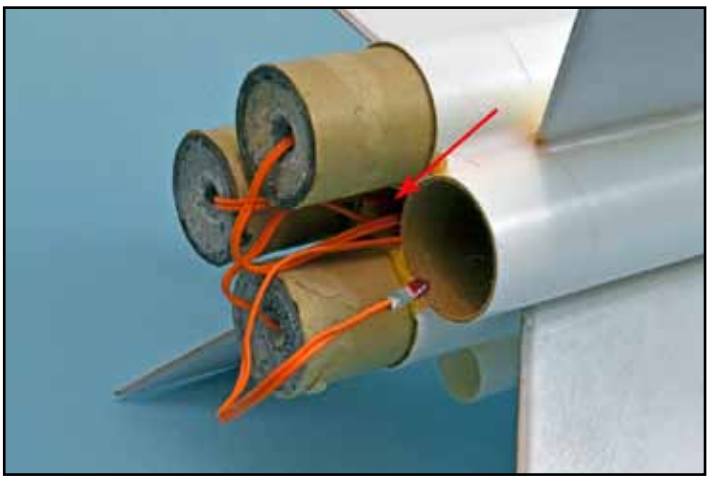

Figure 7: The igniter wires in the upper stage can be routed through the channel formed by four tubes.

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shown in Figure 6). There isn't room for them in the tubes on the booster stage because the motors are a snug fit. You want them to be snug too, because otherwise the rocket would flop around at the joint between the two stages.

How do the wires turn the corner and pass through the wall of the tubes on the booster stage?

The answer to this problem is to cut away part of the tubes on the top of the booster stage. We want them to look like Figure 8.

Once you have slots cut in the tube, you can route the wires around the bottom of the motor, and into the nozzle of the motor.

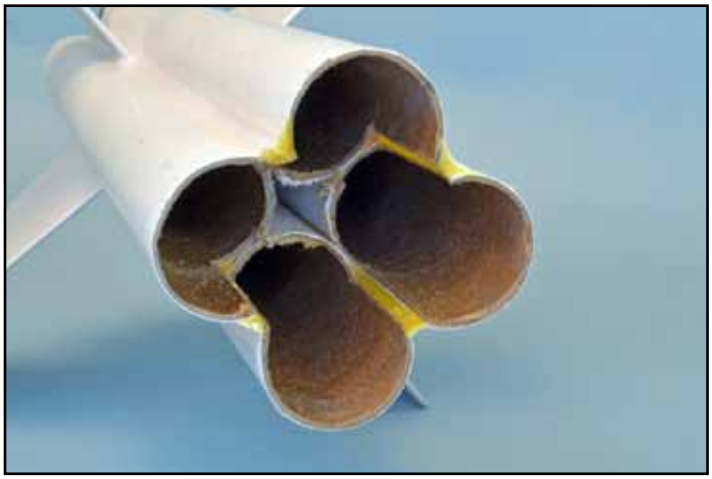

Figure 8: The inside of the tubes on the booster have to be cut away to allow the igniters to get to the nozzles of the upper stage motors.

There is one last issue that you'll eventually come to with this rocket. That is the thrust ring on the back of most composite propellant rocket engines.

That thrust ring is usually a great addition to the motor. It prevents it from sliding forward in the engine mount. Almost all composite motors now have this thrust ring molded on the back of the casing.

The problem is that this ring won't allow the nozzle end of the motor to slide into the front of the booster stage tubes.

There are two execptions to this. The first is black powder motors. This means you can use the Estes 29mm motors in the upper stage. But if you wanted more thrust, you might think you can't use composites.

Fortunately, there is an option available. The Cesaroni reload casings have an optional "tapered" rear closure (www.ApogeeRockets.com/Rocket_Motors/Cesaroni_Casings/29mm_Casings/Cesaroni_29mm_Tapered_Aft_Closure). This is typically used for low drag minimum-diameter rockets. But in this situation, they allow us to substitute composite motors in place of black powder motors.

The only concern I have, is that the motors would have to be restrained in the engine mount a different way. Typically, we'd friction fit the motor into the tube by wrapping it with masking take until it has a tight fit. Then we pray that at ejection the motor doesn't get kicked out the back. You

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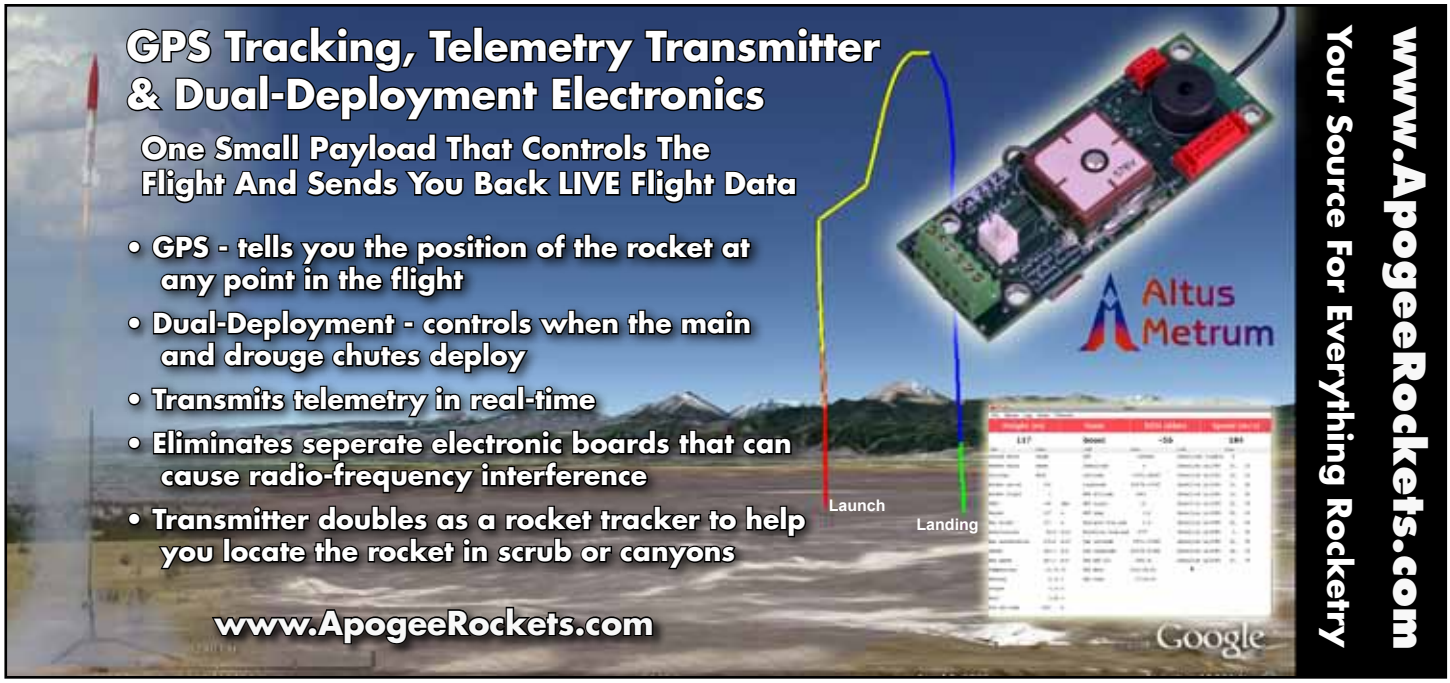

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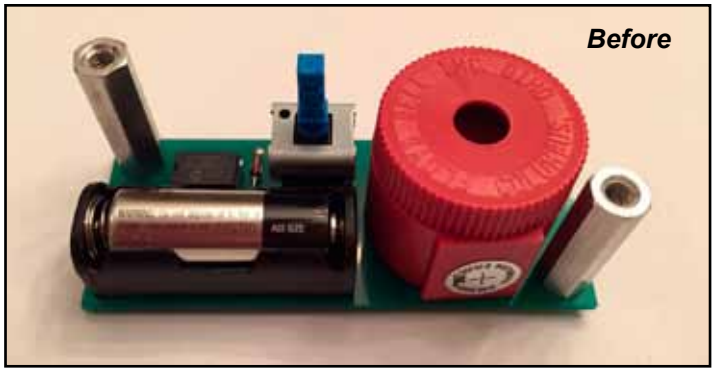
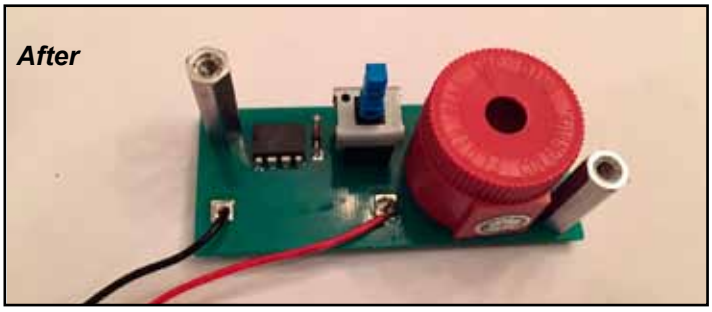
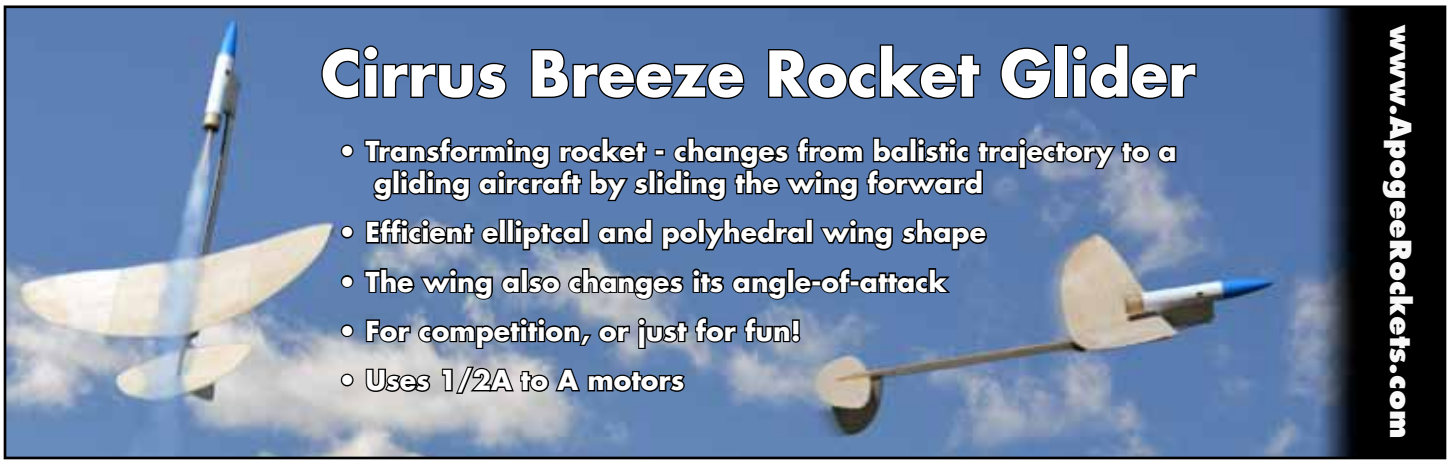
Figure 9: The aft thrust ring on the motor would prevent it from being used in the upper stage. You'll need a tapered rear closure, like the one shown in the foreground.

might want to utilize our service of laser etching your name on the casing if you want to get it back (www.apogeerockets.com/Customization/Motor_Casing_Engraving).

Modifying the Transolve BeepX

Rob Derstadt writes: *"Here's a simple mod I did to the Transolve BeepX (www.apogeerockets.com/Electronics_Payloads/Rocket_Locators/Transolve_BeepX). I wanted to mount it inside a nosecone so it was out of the way, but still allowed me to get to the battery. It was pretty easy to de-solder the battery holder and run some jumper cables so I could re-mount the battery on the opposite side of the bulkhead (in this case my Little John). The battery can be taped in for extra protection and will be protected by the chute/chute-protector. I didn't want the beeper to take up space and possibly interfere with the parachute in the model. It's permanent, but I think will work well."*

Cool idea Rob. I'm happy to share it with the readers of this newsletter.