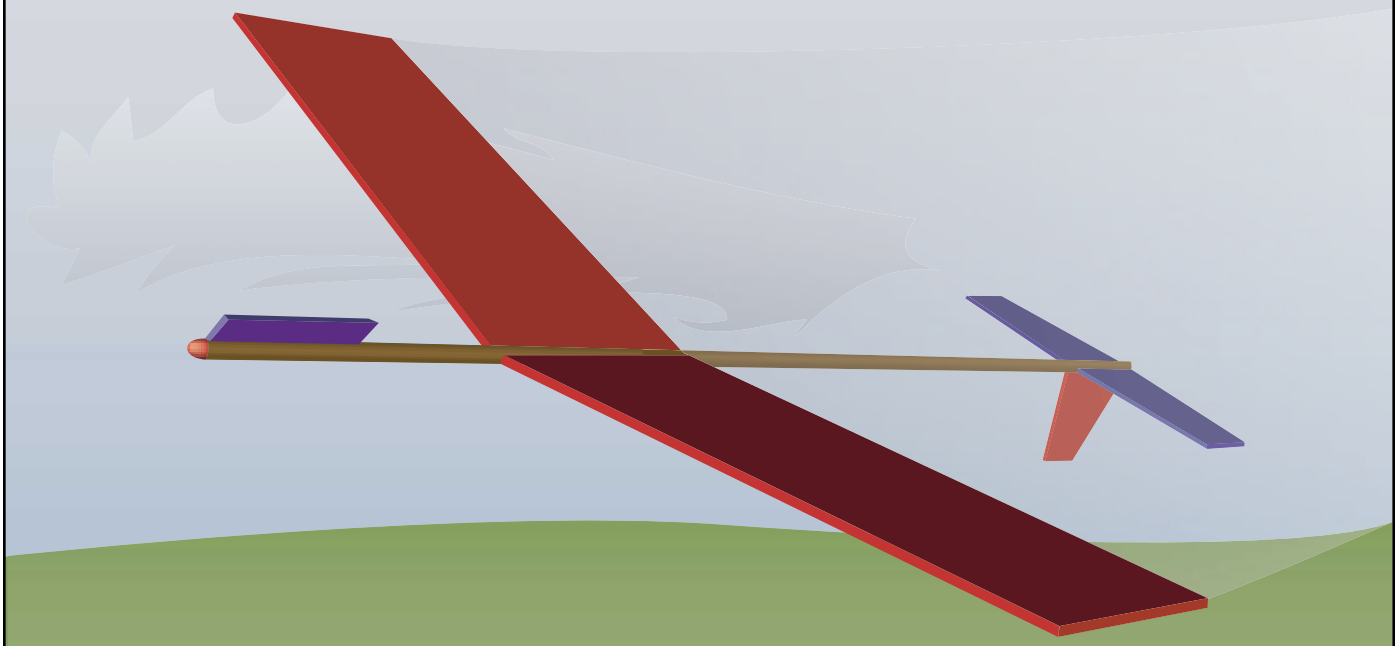
ISSUE 115, NOV. 21, 2003

APOGEE PEAK OF FLIGHT NEWSLETTER

Designing A Simple Glider Using RockSim 7.0



Mini-Poster

How Composite Propellant Rocket Engines Work

APOGEE COMPONENTS
1130 Elkton Drive, Suite A
Colorado Springs, CO 80907 USA
www.ApogeeRockets.com
orders @ApogeeRockets.com
phone 719-535-9335 fax 719-534-9050

ISSUE 115 - NOVEMBER 21, 2003

APOGEE

PEAK OF FLIGHT

Designing A Simple Glider Using RockSim 7

By Tim Van Milligan

RockSim 7's ability to allow assymetrical fin arrangements has opened up a whole range of rocket designs. The question that pops up often is: "can I design gliders?"

In this article, we'll take a look at this subject, and discuss the abilities and the limitations of RockSim. I'll show you one way to design a simple glider using RockSim 7. But there are other ways too. The other method will be presented in the next issue by Bruce Levison, as he shows you step-by-step some tricks he uses to create pop-pod boost gliders. He'll even discuss how to run a simulation to get RockSim to estimate the glide times of the glider after the pod falls off.

As you can see by the above introduction, it is possible to use RockSim to design gliders. Figure 1 shows the type of simple glider designs you can create. Cool, huh?

The key feature in RockSim 7 that allows glider type models is the ability to place each fin/wing individually on the rocket, and to specify its position radially along the centerline of the model. In the past, the minimum number of fins that could be placed on the rocket was three. And the spacing of those three fins had to be 120 degrees apart. One fin, was always "up," which defined the top view of the rocket. The top was defined as zero degrees.

In RockSim v6, you could rotate those three fins around the body. In other words, you didn't have to have one fin at the top (zero degree) position. But you couldn't change the spacing between the fins. They still had to be 120° apart.

In the new RockSim v7, both those design rules were eliminated. Now you could specify two fins, or even a single fin in a "set" of fins. This is called Assymetrical fins. For more information about this feature, see Peak-of-Flight newsletter issue #105 (http://www.ApogeeRockets.com/education/downloads/Newsletter105.pdf).

This is the feature we needed to add wings to the rocket, and to add dihedral to them.

I won't bore you with the step-by-step details on creating a simple glider. I'll just try to give you the important elements

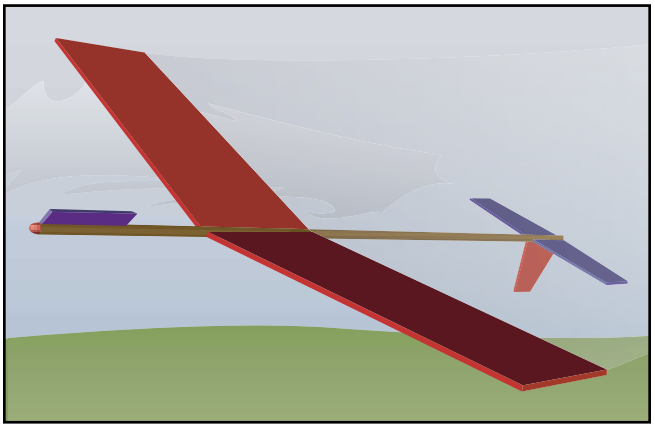


Figure 1: This is the type of simple design we can create using RockSim 7.

that it takes to create one. As you can see in Figure 2, the simple glider is created using just seven individual components.

In a typical boost-glider type model, the boom is made

Continued on page 3

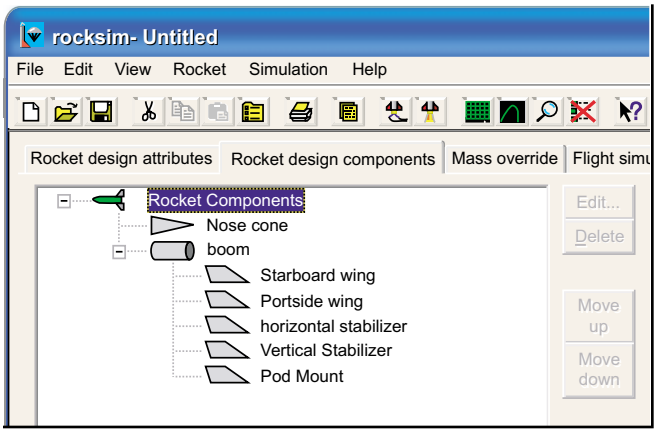


Figure 2: The basic layout of the glider is created using just seven components. The main wing is split into two parts.

About this Newsletter

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

Simple Gliders

Continued from page 2

from a single piece of hardwood. This is where I cheated a little bit. In my design, I created the boom out of a skinny body tube. That way, I could simply attach the wings and the stabilizers directly to it. When I actually build the model, I'll weigh the real boom, and then come back into my design and override the weight of the skinny tube.

I also put a tiny nose cone on the tube. I really didn't have to, but I thought the design looked better with a rounded tip.

The main wing is split into two, with each wing panel being a seperate "fin" in Rocksim. Why? Because the have dihedral of 10 degrees.

This dihedral is added using the radial position feature that is new in RockSim version 7. See Figure 3.

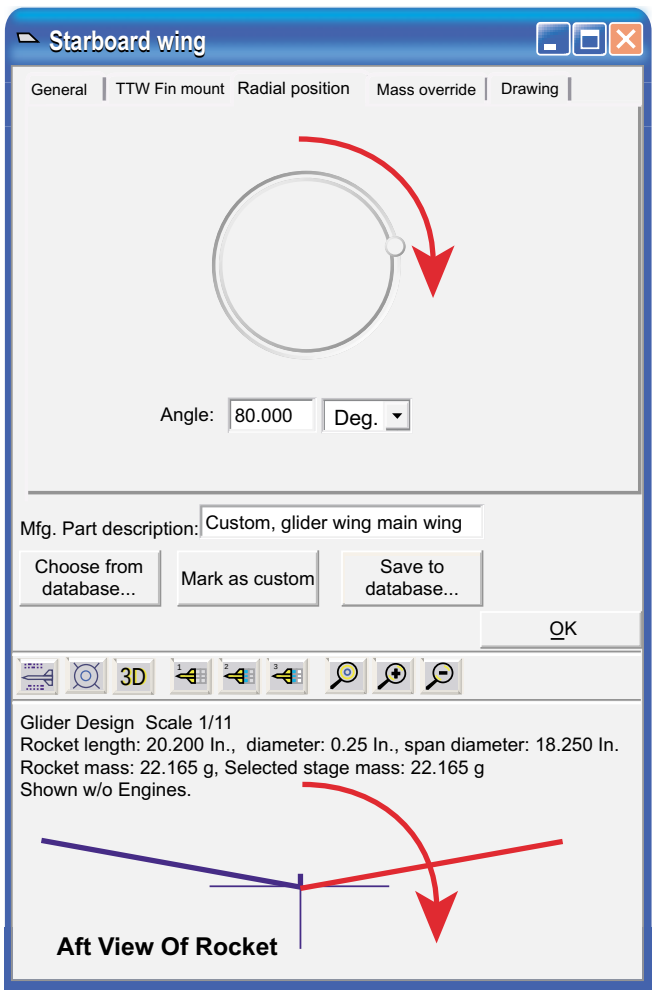


Figure 3: The dihedral angle of each wing is set individually. In this case, it is 10 degrees.

One thing that I'd like to point out is that I made sure to give each part in the design a distinctive name. Such as "Starboard wing" and "Portside wing." This really helps you later when you come back and edit the design. And it really helps other people decifer your design when you share the rocket file with them. *I guess this is a pet-peeve with me... I get so many designs to look at, and when everything has default names, such as trapazoid fin, trapazoid fin, trapazoid fin; it is difficult to determine which is the aft fin versus a forward fin. It only takes a few seconds to change the part names; so I urge you to do this.*

The horizontal and vertical stabilizer fins are pretty easy to add to the design, that it isn't worth talking about. I added a glider pod hook (called a pod mount) to the front of the model. I used a small fin to represent this part of the rocket. This is an optional part to add. I probably should have used a mass object instead of a fin; but the piece might affect the aerodynamics of the model, so I decided to use the fin.

Why Design Gliders In Rocksim?

Now we come to the crux of this whole article.

Why is this even an important question? Because there is one thing that RockSim does not do. It does not track the descent of the glider. In other words, it will not tell you how the model will fly when you toss it into the air.

Knowing this setback, why then is it worth designing gliders in RockSim?

The answer is that RockSim can estimate something very important about your glider. That is, the position of the glider's CP (Neutral Point).

The point where all the aerodynamic forces on a rocket balance is called the CP (you already knew that...). On a glider it is called the *Aerodynamic Center* (AC).

The CG location on a glider, which would result in exactly neutral stability (such that if the glider where disturbed, there would be no resulting pitching moment), is called the Neutral Point. On our gliders, if we position the CG exactly on the Aerodynamic Center (AC), we have located the Neutral Point.

In other words, the neutral point is thus equivalent of the Center of Pressure (CP).

Why is the Neutral Point critical? Because it allows us to trim the glider properly for balanced flight.

Most modelers that get started in glider type models trim the glider by hand tossing. It is a by-guess, by-golly method that I've used in the past too. It is frustrating, because you start by guessing where the CG should be for a proper glide, and then you wing the model into the air, and hope it flies.

If it doesn't glide, and if it doesn't crash and break, you

Continued on page 4

Simple Gliders

Continued from page 3

shift the CG (by adding weight), and hurl it into the air again. You repeat this process until you get something that resembles an adequate glide.

The question becomes: "is this the best CG and trim for the glider that yeilds the slowest rate of descent?" Or is it just a good point where the glider doesn't crash? The answer to these questions is that you really don't know. It is just a guess afterall.

For the competition modeler, or the person that just wants to get the longest duration glide out of the aircraft, they want a better way of trimming the glider. They want to make sure the glider will come down slowest (so it stays aloft the longest).

This is done by finding the neutral point, and then positioning the CG location. Once the CG is selected, the glider is trimmed by warping the flying surfaces to get a good flight profile.

Does this "neutral point" method work? Yes! Competition modelers swear by it.

How Do You Calculate the Neutral Point?

There are three methods. Obviously, since this is an article about RockSim, we know that RockSim can give us a good approximation. We'll talk more about it below.

There are also quick-and-dirty calculations in an article that appeared in *American Spacemodeling* magazine (see bibliography at the end of this article). While it is a fairly easy equation, it does take some time to calculate. For the most part, these equations are adequate even if they are a rough approximation.

For a more accurate location of the Neutral Point, you have to do a lot more calculating. This is described in an article that appeared in the Journal of the M.I.T. Rocket Society.

But, we're in the computer age. Why do the calculations long-hand?

With RockSim 7, we can get a good approximation of the CP (where the neutral point is), and then we can shift things around to get the CG point in the right place.

The beauty of RockSim is that it is "visual." As you design the model, you can actually see what it will look like. And if you want to make a modification, you see the results instantly, without having to recalculate the neutral point.

Where Should The CG Be Located?

This is a topic of much debate.

Mark Bundick (President of the NAR) likes to position his neutral point so that the glider has a 10% static stability. I've seen other people say 20% static stability.

The lower the number, the closer the CG will be to the CP point. That means the glider will take a little bit longer to recover from a disturbance in the glide.

By the way, what does 10% static stability mean? Here's how you calculate it. You'll find this pretty simple.

1. Take the length of the root chord, and multiply it by the static stability margin you wish to use. For example, say your glider has a root chord of 3 inches, and you want a static stability margin of 10%. So 3 inches multiplied by .10 is 0.3 inches.

2. Now find the CP location of the glider. This is where RockSim comes in...

3. Finally, you want to balance the glider so the CG position is 0.3 inches in front of the CP position.

The RockSim CP Location

As you design your rocket in RockSim, there will be a summary on the bottom of the main screen showing you where the CP is located (see figure 4).

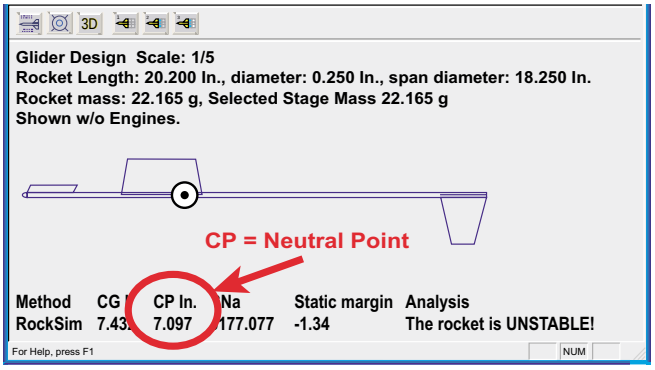


Figure 4: RockSim will find the Neutral Point.

There is something to be aware of...

RockSim was designed for rockets, not gliders. So you have to make sure the CP in the summary is the right CP location. To double check, use the Rocket Stability screen from the "Rocket" pull-down menu (see figure 5).

There are CP's around the entire rocket. This was discussed in Peak-of-Flight newsletter #105. We want to have the CP location that is on the TOP side of the glider. In other words, if you were looking down on the wings.

Once you know the CP location, you can add weight to the glider's nose to move the CG into the correct location to give you the right static stability margin.

If you want to keep the glider as light as possible, you can also adjust the positions of the wings, or the length of the fuselage boom. What I like to do is reference the wings to the base of the boom tube. So if you make the tube longer, it auto-

Continued on page 5

Simple Gliders

Continued from page 4

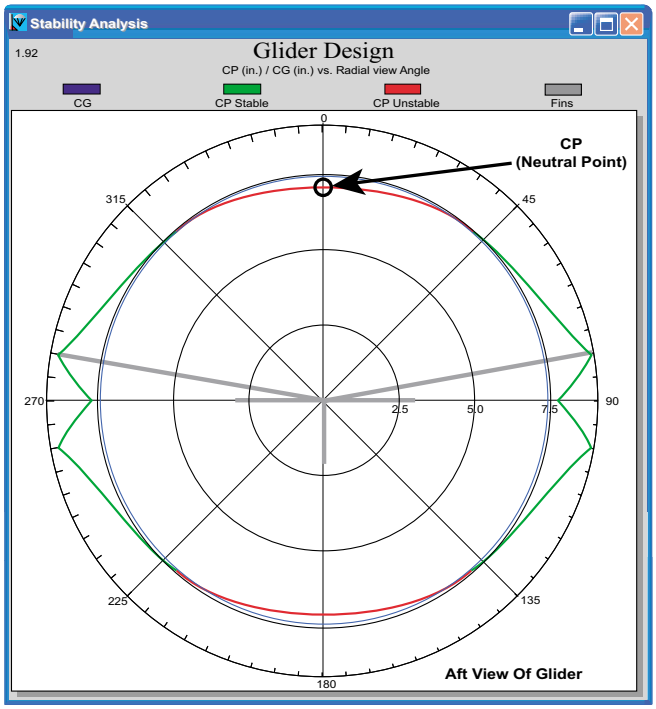


Figure 5: Look at the Rocket Stability chart to make sure you have the correct CP location.

matically moves the wings backward. It is really slick. If you want to see a sample glider that I used in this article, you can download the .rkt file from the Apogee Components web site at:
http://www.ApogeeRockets.com/education/downloads/glider.zip

How to Trim The Glider?

Once you build the glider from the RockSim design with the CG in the correct spot, will it automatically be trimmed? In other words, can you take if off your workbench and go out and launch it with a rocket? Of course not.

You'll still need to trim the glider. But instead of sliding the CG back and forth, you'll tweak the control surfaces. For example, you may need to add more decalage in the horizontal tail to get it to pull up a bit more.

The topic of trimming a glider is beyond the scope of this article. But you can find out more information in the book: Model Rocket Design and Construction. It can be ordered from Apogee Components at:
http://www.ApogeeRockets.com/design_book.asp

How Accurate Is This Proceedure?

I did compute the neutral point using the quick-and-dirty calculations from *American Spacemodeling* magazine, and compared it to the RockSim design I referenced earlier.

The quick-and-dirty method put the neutral point 6.55 inches from the tip of the nose cone. RockSim calculated it at 7.097 inches from the tip of the nose.

Why the difference?

There are two reasons. First, RockSim is actually calculating the forces on the flight surfaces. That should make it more accurate than the quick-and-dirty calculations. That's the good news.

For example, because the wings have dihedral, they produce less "up" force. RockSim does take this into account. But it isn't taken into account by the quick-and-dirty calculations.

On the other hand, RockSim does overestimate the force of the horizontal stabilizer. In real life, The tail feathers are in the wake of the wing. As the air flows over the wing, it leaves the back edge with a slightly downward direction. This is called *downwash*. The horizontal tail flies through this deflected air.

What this means is that the horizontal tail is actually flying at an angle of attack instead of being streamlined to the airflow (See Figure 6).

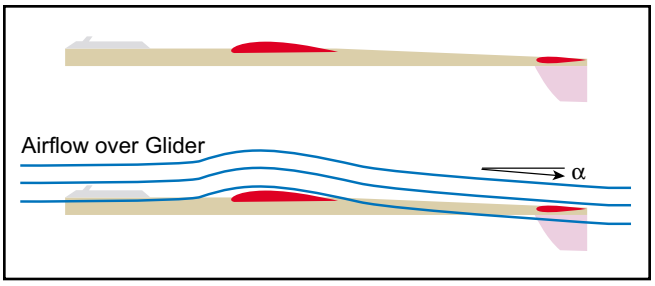


Figure 6: The tail is in the wing's downwash. So it flies at a negative angle-of-attack.

Because of the downwash, the tail becomes less effective. There is an efficiency factor in the "full" neutral point calculations to account for this downwash. It can mean that the tail is between 65% to 85% efficient. However, RockSim assumes it is 100% efficient.

If you want to account for this in your RockSim design file, you should reduce the size of the horizontal tail to the percentage of its efficiency. If your tail is 85% efficient, reduce the size in RockSim 85%.

What about the Boost Phase & Glide Phase?

As said earlier, RockSim doesn't track the glide phase of the model. Again, RockSim was meant to be a "rocket" de-

Continued on page 6

Simple Gliders

Continued from page 5

sign program, not a glider design program. We're just able to use it to find the neutral point because it calculates the forces on each wing.

At the same time, RockSim wasn't originally designed to track the launch phase of boost gliders. But then again, many users of the software have found ways to trick RockSim to perform all sorts of odd-ball designs and complex simulations. And in the next issue of the *Peak-of-Flight* newsletter, Bruce Levison will show us a way to simulate the launch phase of a boost glider.

Conclusion

In conclusion, RockSim can be used to help design a simple glider. In particular, it helps you approximate the neutral point of the glider. Once you have this, you can set the glide CG and begin the task of trimming the model for flight.

While RockSim wasn't specifically created to do this task, it does have a lot of versatility, which is becoming more apparent as new uses are found for this spectacular software.

Bibliography:

"Boost Glider Stability" by Geoffrey A. Landis. *Model Rocketeer*, November 1980. Pages 24 & 25.

"Calculation of the Neutral Point" by Guppy (Harold Youngren). *Journal of the M.I.T. Rocket Society*. April 1980. Pages 45 - 47.

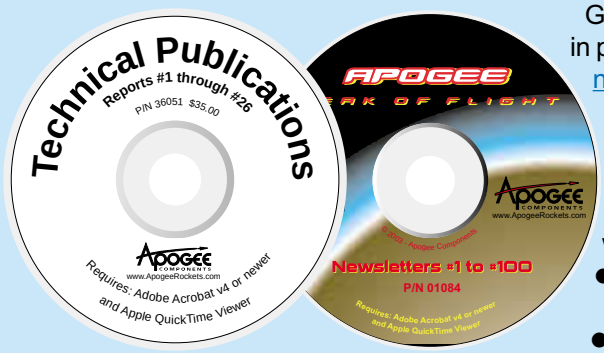
"Basics of design and trimming of a conventional hand-launched freeflight glider" by Kevin McKiou. March 5, 1998. Posted on the internet.

"Glider Hints & Kinks" by Mark Johnson. *American Spacemodeling*, Mark 1989 page 3-6.

About the Author:

Tim Van Milligan 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 the FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site, or sending an email to: ezine@apogeerockets.com with "SUBSCRIBE" as the subject line of the message.

Newsletter Archive On CD-ROM - *FREE!*



APOGEE PEAK OF FLIGHT

Newsletter #1 to #100
Order Today, and also receive #101-#112

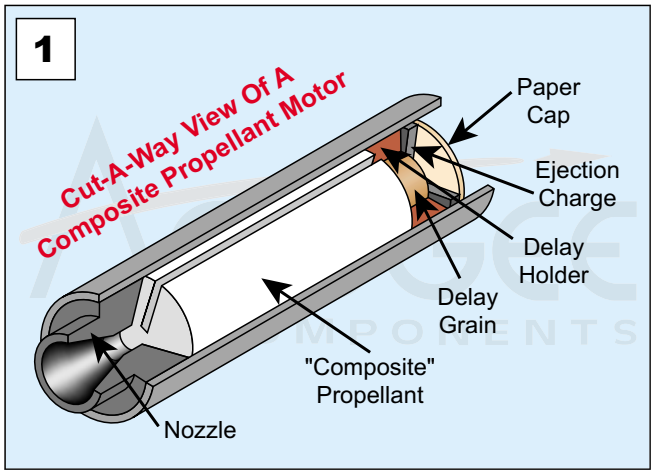
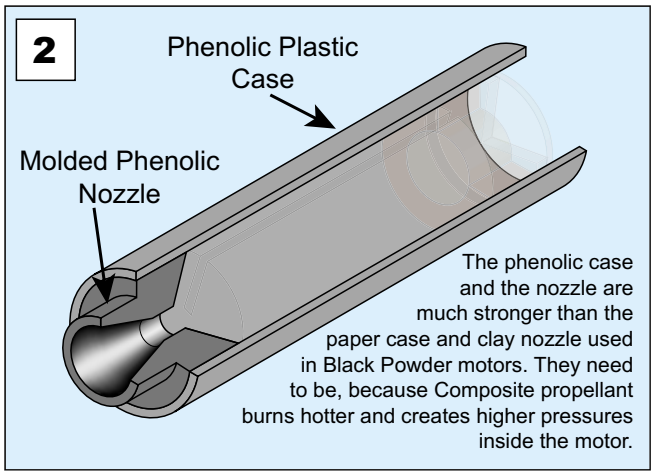
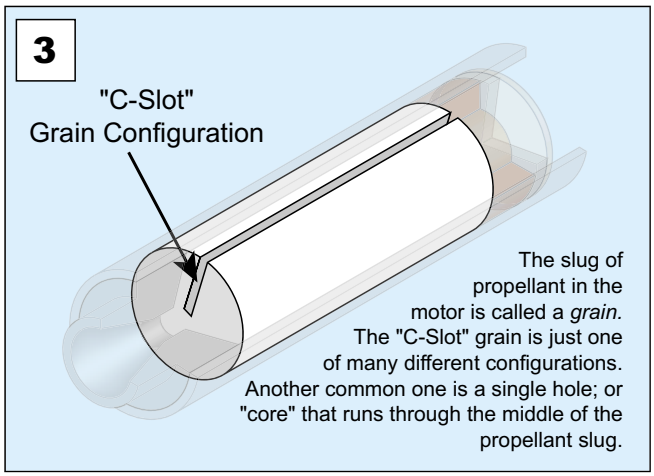
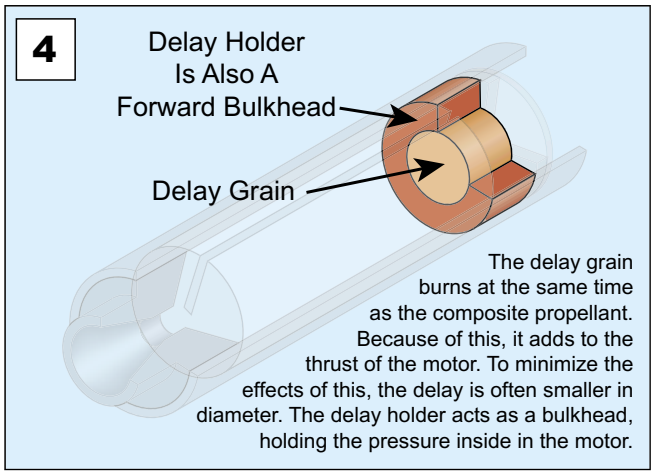
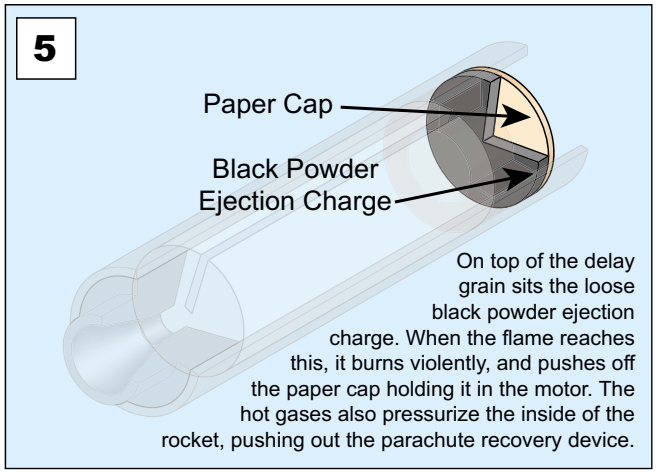
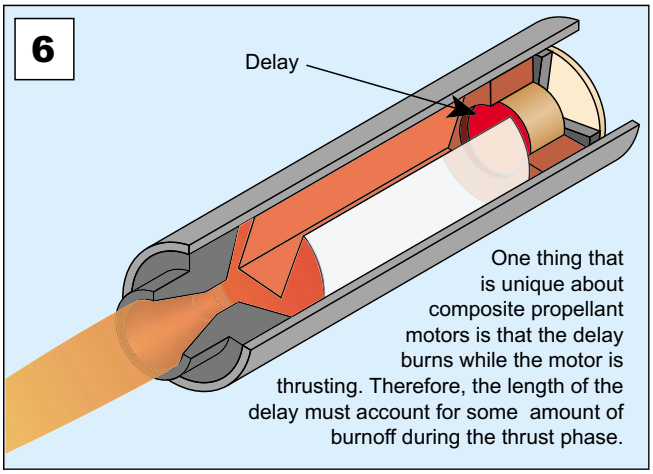
http://www.ApogeeRockets.com/technical_publications.asp

Get the entire collection of Peak-of-Flight newsletters on CD-ROM in pdf format. It's absolutely FREE when you buy the Apogee Technical Publications (#1-#35) set.

Not only do you get the great technical reports, you get all of the first 112 issues of the Peak-of-Flight newsletter on a seperate CD-ROM for no extra charge.

The Peak-of-Flight CD-ROM gives you much more than the web-site archives. You also get:

- All issues are in PDF format. This allows you to print them out quickly so you can share them with your friends.
- Images are high-resolution, so they print out great.
- Many of the earlier articles have been re-written and updated with new information and illustrations.
- QuickTime videos have been embedded into many issues to show action sequences (11 movies total).
- Many extra reference articles included - So you don't have to download them from the internet.
- Shrox plans, decals, and RockSim design files included.
- Plus excel spreadsheets, programs, and much more...

Advertising is available for this newsletter - Call (719)535-9335 for Info.

How Composite Propellant Rocket Motors Work