PEAK OF FLIGHT

NEWSLETTER

In This Issue

Simulating Rack Rockets in RockSim

Cover Photo: NewWay Space Models N-20 Demon just starting its flight. Get your own at: www.ApogeeRockets.com/Rocket_Kits/Skill_Level_2_Kits/N-20_Demon

Apogee Components, Inc. — Your Source For Rocket Supplies That Will Take You To The “Peak-of-Flight”
3355 Fillmore Ridge Heights
Colorado Springs, Colorado 80907-9024 USA
www.ApogeeRockets.com e-mail: orders@apogeerockets.com
Phone: 719-535-9335 Fax: 719-534-9050

ISSUE 383 JANUARY 27, 2015

Simulating Rack Rockets in RockSim

By Tim Van Milligan

I had a customer ask me if RockSim can simulate a unique type of rocket that is called the “rack rocket,” or sometimes called a “train rocket.” The rocket is shown in Figure 1. Essentially, it is a multi-stage rocket for black-powder engines, but has only one set of fins.

The only advantage this style rocket has over a traditional multi-stage rocket is that it is slightly lighter weight, because it has fewer parts. The fins are attached to stiff wooden rails that extend off the rear of the rocket. There is usually a ring near the bottom, just so the rails don’t flex outward and allow the motors to drop out. I just didn’t put that little ring in the bottom so that you’d understand what the rocket typically looks like.

Figure 2 shows what the rocket looks like with the motors installed.

As mentioned, this is a multi-stage rocket where the black powder motors fire off in sequence, from the back towards the front. It requires direct staging, so it can’t use composite propellant type motors.

When a motor is done firing, it simply ejects rearward out of the rocket. And that is the bad aspect of this type of rocket that I particularly don’t like. Having free-falling motors dropping out of the sky is a safety hazard. Even though they are burned out, they are still very hot, and if conditions are right, they could cause a fire. So if you fly this type of rocket, please tape a streamer to each of the motors, so that as they are ejected, they are slowed down and have a longer chance to cool off.

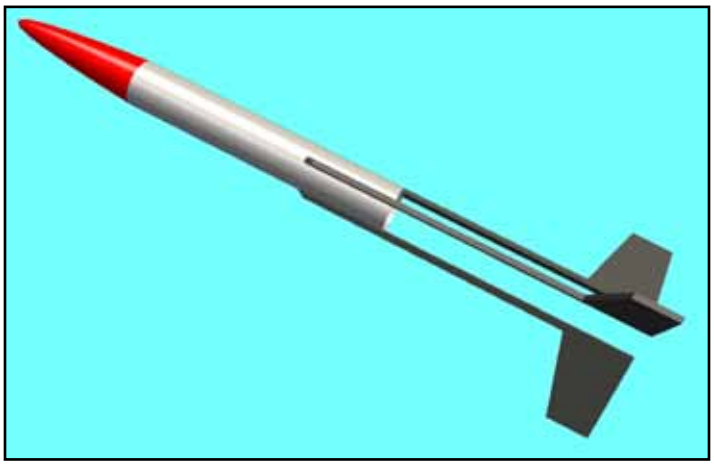


Figure 1: A rack rocket is a multi-stage rocket, but has only one set of fins.

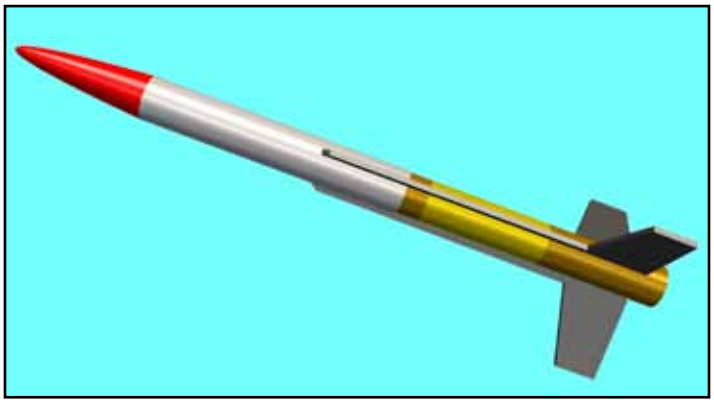


Figure 2: The motors installed in the Rack Rocket.

The second issue with these rockets is that the exhaust plume of the top stages strikes the rails where the fins are attached. It is because the upper stage motors are so far foward in the rocket. Essentially, the rails have to be made extra durable and stiff so that they don’t fall off during the flight. Usually, the damage on the flight is very significant, and the rockets don’t last very long.

The third issue is that these rockets are really prone to weathercocking into the wind. They seem to travel more horizontally than they do vertically. The reason is that they are very over stable by the time the upper-most motor is burning. We’ll discuss that more further on in this article.

Getting back to the original question, the answer is “yes.” RockSim can simulate these types of rockets without

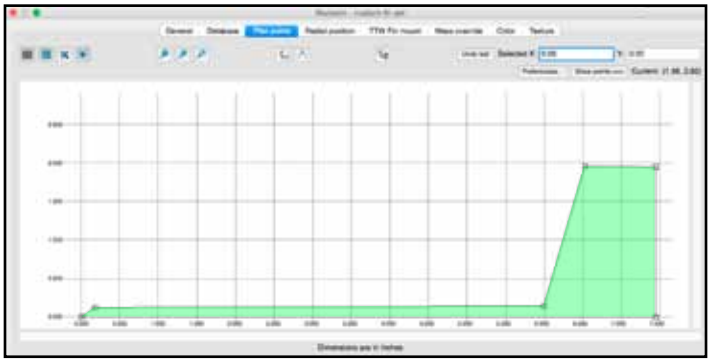


Figure 3: The elongated fins used on the rocket.

Continued on page 3

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.

Newsletter Staff

Writer: Tim Van Milligan
Layout / Cover Artist: Tim Van Milligan
Proofreader: Michelle Mason

Continued from page 2

Simulating Rack Rockets in RockSim

too much of a problem.

If the rocket uses just three motors, the RockSim design file is surprisingly simple. In that case, you'd design a rocket that looks like Figure 1. It would have just basic parts like a nose cone, a body tube, and a fin set.

The only thing that might be considered unique is the shape of the fins. This is where RockSim's free-form fin editor comes in really handy. Figure 3 shows what the fin would look like in RockSim's free-form fin editor.

To add the lower stages, your design will need a tube in each of the stages in order to add a rocket engine. In real life, these tubes wouldn't exist. But RockSim needs them in order to know where to place the motors for the simulations. So we absolutely need tubes. And this is probably the confusing part for designers, because in real life, they won't exist.

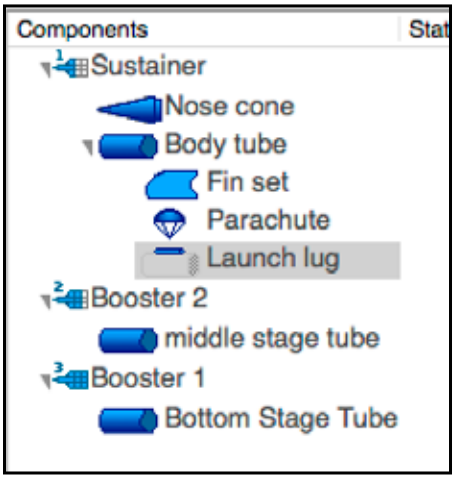


Figure 4: The parts tree for the Rack Rocket.

But the simulation can be fudged to make it work. In this case, we're going to add tubes. However, we can make them so wafer-thin that they have near zero mass. If they have low mass, they might as well not exist.

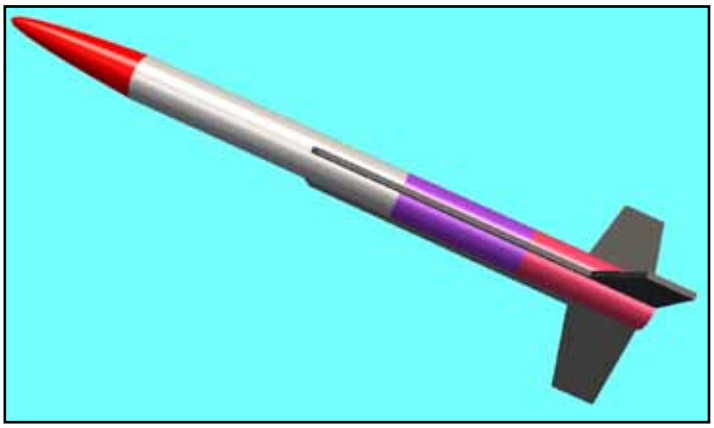


Figure 5: The colored tubes are the lower stages of the Rack Rocket.

To make the length of the rocket come out right, the length of the engine mount tubes is the same length as a real rocket motor. Since my design is built around the Estes D12 motor, I made the engine tubes 2.75 inches long.

The parts tree in RockSim now looks like Figure 4. It looks pretty simple doesn't it?

In Figure 5, I colored the two extra tubes so you can see what they look like. If you don't want to see the tubes, then open up the tube editor, and change the opacity of the parts to be 0%. In actuality, Figure 1 is the same rocket but the tubes were made transparant.

Continued on page 4

Continued from page 3

Simulating Rack Rockets in RockSim

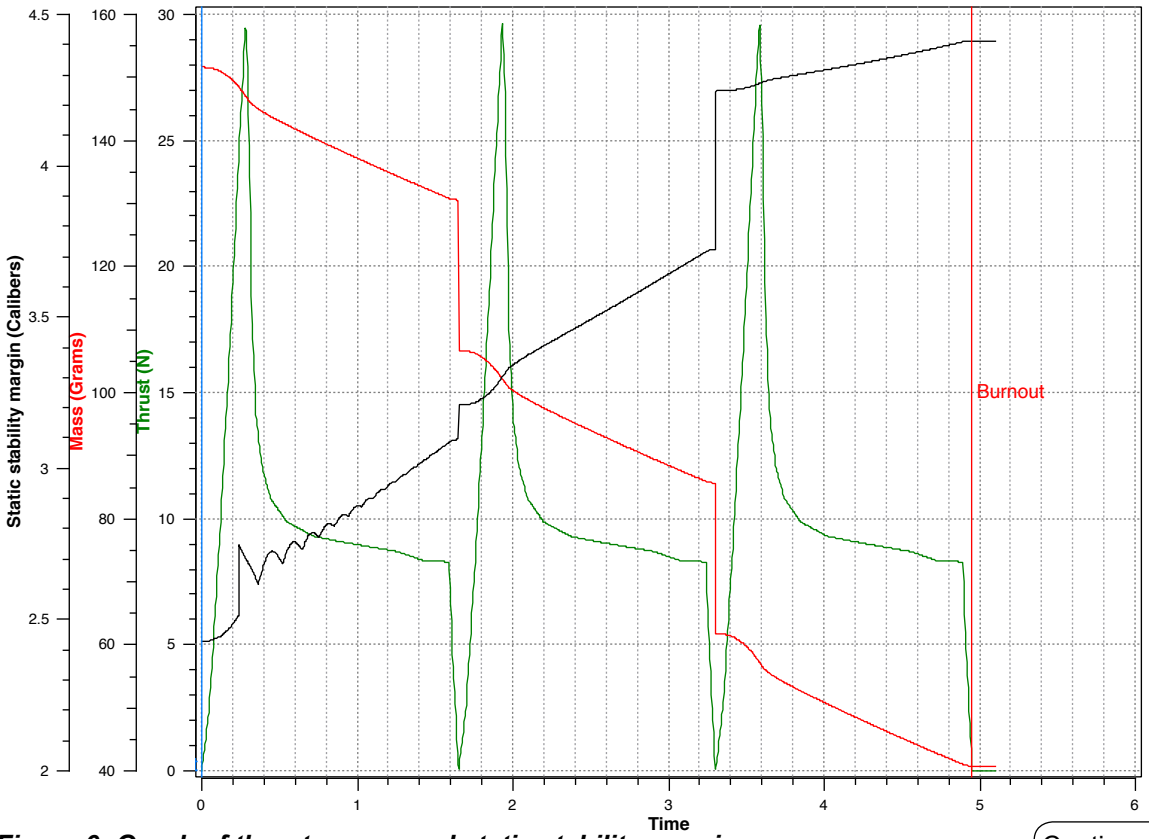


Figure 6: Graph of thrust, mass, and static stability margin.

Before you run your launch simulations, be sure to check the 2D view and note the stability margin of the rocket.

At this point, you can run a launch simulation to see how well it did during the flight.

I like to look at the graphs to verify that everything in the simulation looks correct.

The first graph I want to look at is the thrust of the rocket. It sets a time-line for the flight. Since there are three identical D12 motors in the rocket, I should see three identical thrust curves.

Continued on page 5

Looking For A Fun Rocket Kit?

Roam In Our Forest of Over 190 Different Types

- Unique and exotic kits from over 20 different manufacturers
- Skill Levels range from "easy" to "fiendish"
- Sizes from 1/4A motor to level-2-high-power
- We build & fly them to find out what they're like, saving you grief
- More new ones arriving all the time
- Educational bulk packs available too

www.ApogeeRockets.com

www.ApogeeRockets.com/Rockets_By_Manufacturers

Continued from page 4

Simulating Rack Rockets in RockSim

This is shown as the green line in Figure 6. The first time I ran the simulation, the thrust curves looked different. There were different peak values for the initial lift-off spike. The reason for this has to do with the default step-size that RockSim uses as it performs the iterations of the simulation. By default, it is set at 800 samples per second. What this means that it calculates all the flight parameters 800 times for every second the rocket flies. This sounds like a lot. But during the portion of the flight where things are changing fast (like at lift-off), then it can miss seeing points.

Later on in the flight, where things are going more slowly and smoothly, like as the rocket nears apogee, the 800 samples per second is overkill.

So for this particular flight, since I am more interested in what is happening at lift-off than how high the rocket is flying, the step size is too large. I can change it in the "Simulation Controls" tab when entering the rocket motors into the design. So I changed it from 800 samples per second to 1500. That was plenty to capture the peak thrust point of the motors. So now the thrust curves look identical. Just remember to turn it back down to 800 samples per second, or it will take a lot longer for your simulations to run, and you'll be using up a lot of memory because of all the information that Rocksim generates and has to store.

The next piece of information I want to look at in the charts is the mass curve. This is the orange line in Figure 6. You'll notice that at each time a motor burns out, that the mass of the rocket takes a giant step down. This is what I want to see, because it confirms that the entire motor casing is ejected out of the rocket; just like in real life.

I'm convinced, by looking at these two pieces of information, that the simulation is set up properly. With this in mind, my trust in the other data is very high.

One thing that I want to point out is the Static Stability Margin of the rocket, and how it changes during the flight. This is the black line on the graph shown in Figure 6.

When the rocket just takes off, the Static Stability Margin is around 2.4. What this means is that the Center-of-Gravity (CG) of the rocket is 2.4 times the diameter of the rocket forward of the Center-of-Pressure (CP). For the rocket to be stable, this number has to be positive. Typically, we want this number to be greater than 1.0.

By definition, the greater the value, the more stable the rocket is. This is a good thing.

But if the number is really large, the rocket will weathercock strongly into the wind. That means, it turns faster into the wind, and ends up travelling more horizontally than vertically.

Having an overstable rocket is NOT a bad thing. I'd rather it be overstable than unstable (where the Static Stability Margin is a negative number).

If it is greater than 2.0, you just need to be aware of it, and be ready to chase your rocket a further distance. You also need to double-check when the ejection charge will

Continued on page 6

Continued from page 5

Simulating Rack Rockets in RockSim

go off during the flight. If the rocket is arcing into the wind, you'll need to select a motor with a shorter ejection delay than if it went straighter up. So instead of selecting a D12-7 motor, which would be typical of an upper stage rocket, I would pick a D12-5 for the top-most stage.

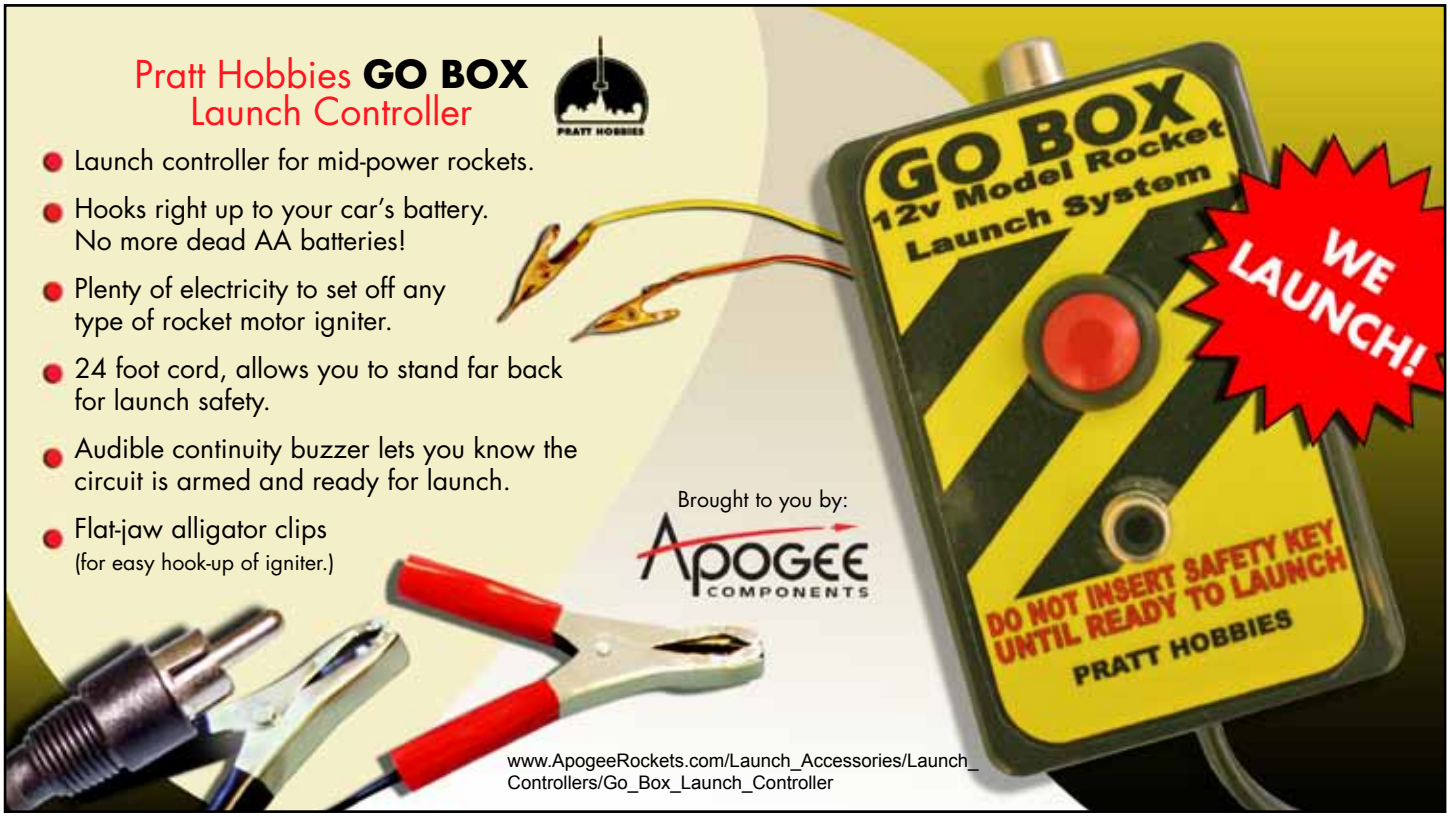
Also notice in Figure 6 that the Static Stability Margin takes giant steps upward as the rocket progresses. Again, this is caused by the motor cases being ejected out the rear of the rocket as the motors stage. Essentially, the back end of the rocket is getting lighter in weight as the motor kicks out. That means the CG shifts forward at staging.

What this means in practical terms is that the rocket is getting more and more stable as it burns. That makes it more and more prone to weathercocking into the wind as it ascends. By the time the last motor burns out, the Static Stabilty Margin is close to 4.4, which is considered over-stable.

This is why these Rack rockets almost always go horizontal during flight, and why you should be very careful when flying them. They won't go nearly as high as you'd expect compared to a traditional three-stage rocket. Selecting the delay is even more important than ever, because you don't want it ejecting when it is already on the ground. That is a major fire risk.

Coming Next Time

In the next Peak-of-Flight issue (www.ApogeeRockets.com/Education/Downloads/Newsletter384.pdf), I'll show you how to take this 3-stage rack rocket, and turn it into a 4-stage rocket in RockSim.

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-