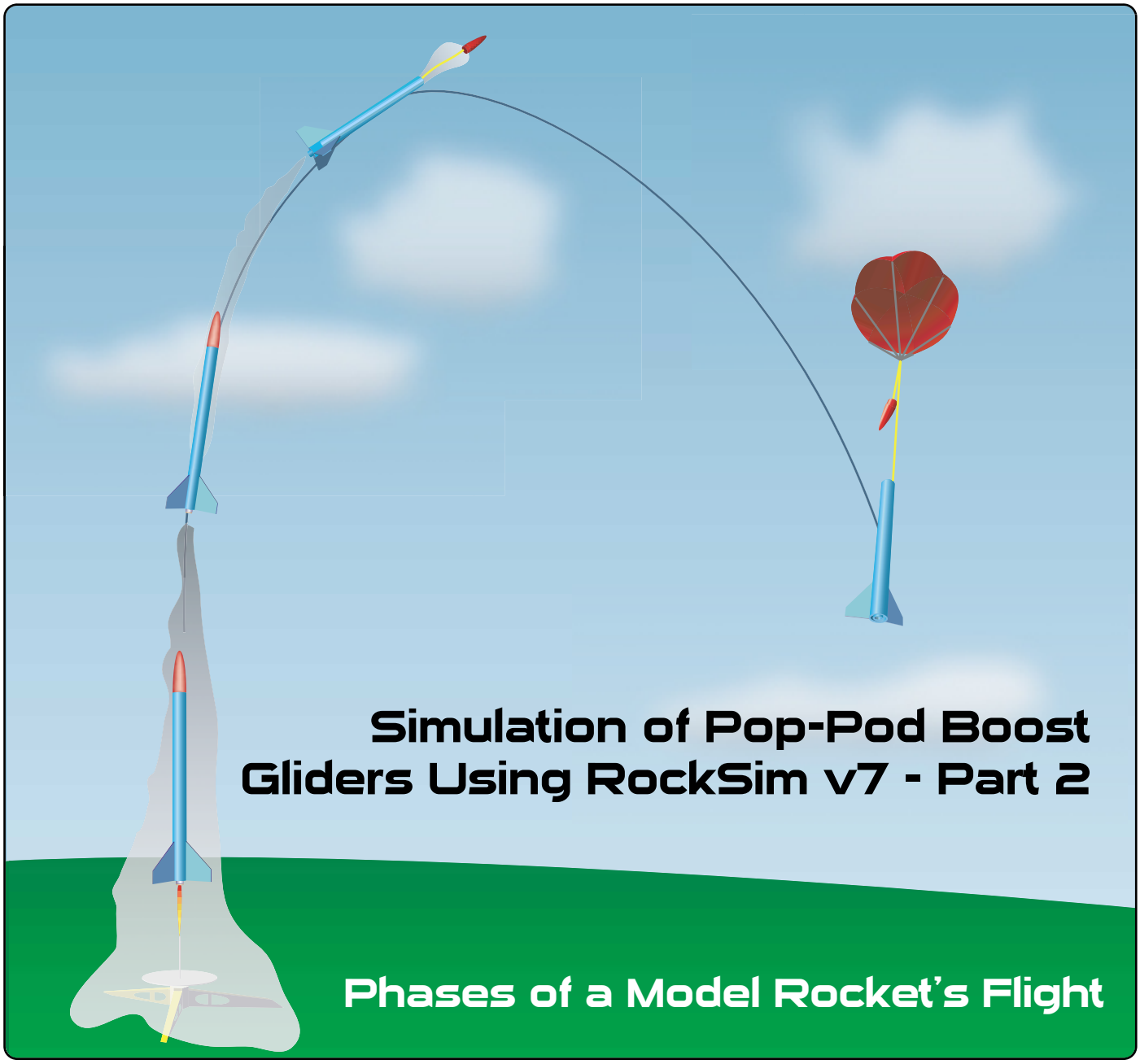
ISSUE 117, DEC. 19, 2003

APOGEE PEAK OF FLIGHT NEWSLETTER



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Simulation of Pop Pod Boost Gliders Using RockSim Version 7. Part 2

By Bruce S. Levison

Bruce has asked us to share this article with other RockSim users. It describes a method that he feels will help to simulate the fight of a Pop Pod Boost Glider in RockSim. Bruce feels that the CP will be in the right location on the boost glider. For the previous article, see Apogee's Peak-of-Flight newsletter #116 at http://www.apogeerockets.com/education/downloads/newsletter116.pdf. *Please note: The user assumes all risk for the information obtained with this method.*

This article contains links to download the RockSim version 7.01 designs. After downloading, place these files in the Design folder within the RockSim Folder on your hard drive. These files cannot be viewed using the demo or older versions of RockSim software. You can purchase the newest version of RockSim at: http://www.ApogeeRockets.com/rocksim.asp

Introduction

Part 2 of this article describes how to use RockSim to simulate pop pod boost glider rocket designs where the motor (pop) pod separates from the glider at apogee and the glider flies back to the ground. The motor pod is typically recovered separately. A word processing program (such as Microsoft Word or WordPad) is used to edit a RockSim version 7 .rkt file to simulate the glider design. Be sure to read part one of this article as well as my previous work on the Simulation *Fins on Fins with RockSim 7* by Bruce S. Levison in issue #113 of the Apogee *Peak-of-Flight Newsletter*, October 27, 2003 http://www.apogeerockets.com/education/downloads/Newsletter113.pdf . The glider is actually simulated as a boosted dart, boosted dart simulations are described in Apogee Technical Publication #14 *Software Simulation Tricks* by Tim Van Milligan http://www.apogeerockets.com/technical_publication_14.asp and in the article on *Strap-on Boosters* by Tim Van Milligan in issue #109 of the Apogee *Peak-of-Flight Newsletter*, August 22, 2003 - page 5 http://www.apogeerockets.com/education/downloads/Newsletter109.pdf also talks a little bit about boosted darts. It is a good idea to read over and become familiar with the simulation tips these articles before attempting your own pop pod boost glider simulation.

Motor Pop-Pods

A peculiarity of this boost glider simulation is that the motor pod, which actually behaves as a booster stage, is located on top of the dart (glider) opposite how RockSim wants this relationship to be in a simulation. The program can even be made to place a nose cone on top of the booster section. The descent rate of the glider is simulated using a square parachute with a surface area equivalent to that of the projection of the wing and stabilizer surfaces on to a horizontal plane. The lift of the glider wing can be augmented with thermals available on the "Launch Conditions" tab of RockSim version 7, this is one of the new software features. The C_d of the glider is estimated using the C_d analysis tab under the Rocket menu in the RockSim program.

Now that the glider has been simulated and its trim has been accounted for in part one of this article, the next step is to use RockSim to account for the glide phase of the recovery. Part two of this article covers the simulation techniques required to fly this glider with its pop pod.

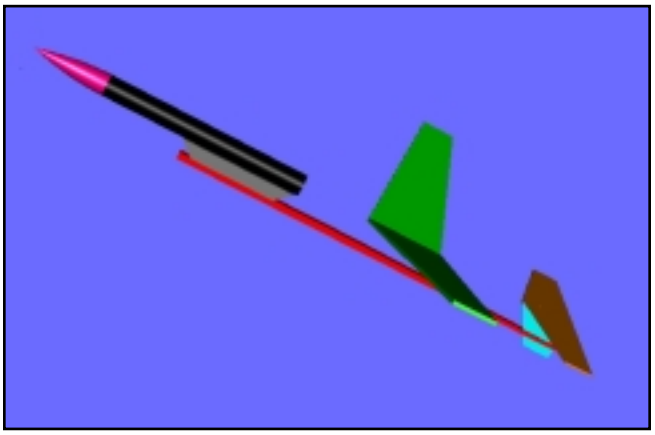

Figure 1: Quest Flat Cat RockSim 3D Image.

This is done by creating a square parachute for the sustainer (glider) in the simulation that has the same surface area as the horizontal surfaces of the glider. Thus each side of the wing and each side of the stabilizer has a surface area of (cos D)*1/2 (tip cord + root cord)*(semi span). The Quest Flat Cat has a 14-degree dihedral angle (D) for the wings and no dihedral angle for the rear stabilizer. So the calculation becomes.

Area of horizontal surfaces on the glider = 2(Cos14)*1/2(2.75+1.3)*7.75 + 2(Cos0)*1/2(2+1)*3.25 = 40.2

Area of the parachute = 40.2 square inches for a square 'chute the length of the sides is then 6.34 inches or the square

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Pop-Pod Gliders

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root of 40.2 since the area of a square is the length of its side squared.

The cos D can be left out of the calculation if desired since the Cosine of a 20 degree angle is about 0.94. Thus, the wing surface area will only project 6% less area to the horizontal plane for at a 20-degree dihedral angle.

This parachute will simulate the descent rate of the glider with no forward motion or lift. Open the Cd analysis screen in the under the rocket menu in the RockSim simulation.

Be sure to select the sustainer see Figure 2.

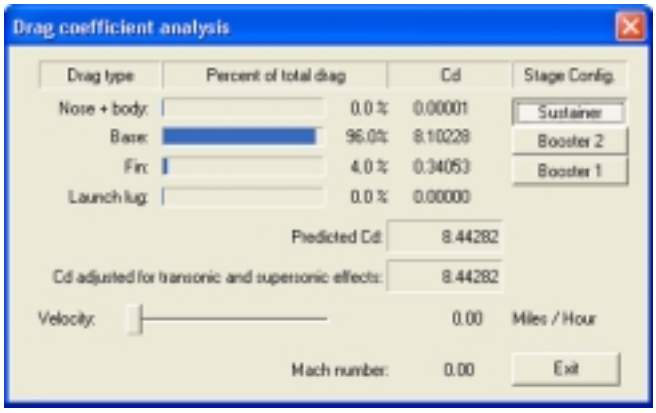

Figure 2: Drag Coefficient Analysis for the glider shown in figure 1.

Note the C_d value of 8.44 at 0 mph, this value is large due to base drag as you would expect. Create a square shaped parachute that is 6.34 inches on a side and has one shroud line of the shortest length and type in the C_d value of 8.44 for the C_d of the parachute. For minimum weight the parachute material was selected as Polyethylene LDPE, 0.001 mm thick. Notice that RockSim gives a descent rate of about 2.9 mph You can adjust this rate by increasing or decreasing the C_d value based on hand launched experiments of the fully trimmed glider. Actual flight data could also be used to get a better estimate of this C_d value. RockSim's C_d analysis menu might also help, open the C_d analysis menu and increase the glider (sustainer) velocity and look at the C_d value. If the average forward speed

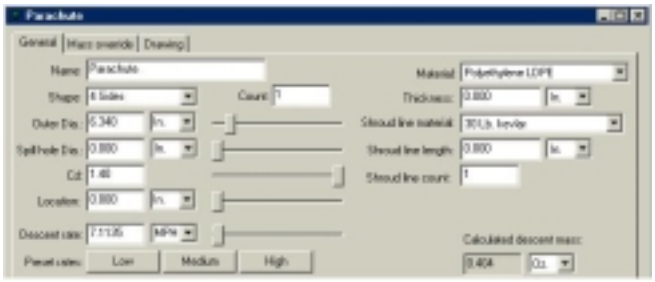

Figure 3: Create a parachute with a surface area equal to the wing area of the glider.

of the glider is known from a hand launched flight, move the velocity slider to this value and program the resulting C_d value in for the parachute C_d see Figure 3.

Note; if you reopen the parachute screen you will have to reset the parachute C_d value back to 8.44 since RockSim automatically resets the value back to 1.4.

Designing the Pop pod.

Construct the pop pod starting with a transition in the booster stage that will serve as a nosecone for the booster. Specify a minimal front diameter (0.001 mm) and make the transition the shape and length of the actual nosecone. Give the transition a rear diameter the same as that of the rear of the nose cone and specify the rear shoulder for the transition to be the same as the shoulder on the actual nose cone see Figure 4.

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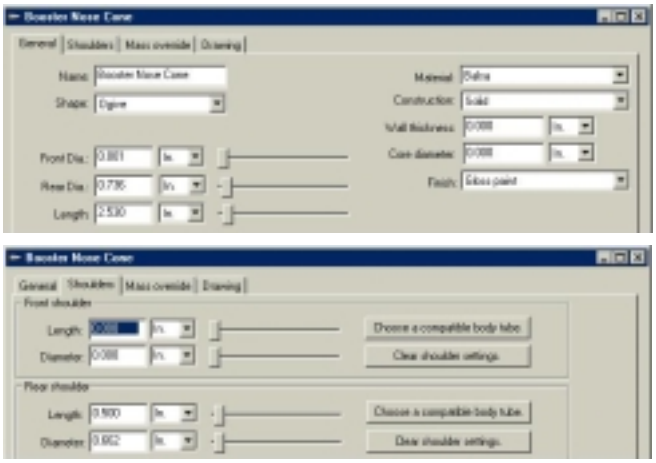

Figure 4: Create the nose for the pod.

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.

Pop-Pod Gliders

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Specify the pod body tube, 7 inches of BT-20 in this case. Select this tube as an 18 mm motor mount, see Figure 5.

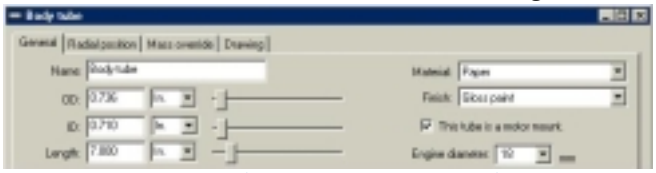


Figure 5: Create the motor mount tube.

Simulating the Pod mount

Design a single fin that is the size and shape and thickness of the pod mount using one of the selections on the fin set menu see figure 6.

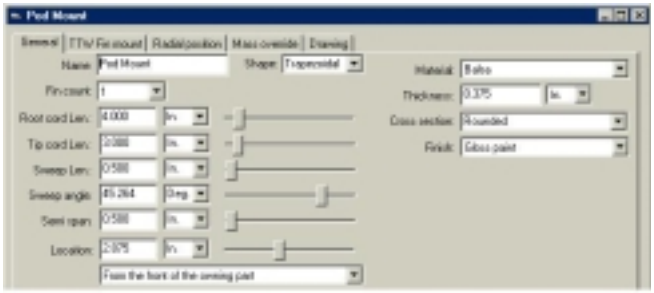


Figure 6: The pod pylon is made from a fin.

Include any other internal poop pod details such as thrust rings and shock cords. Use a mass object to simulate the mass of the pop pod recovery device. This completes the design of the pop pod booster stage. The parts tree for the booster should look like see Figure 7 below.

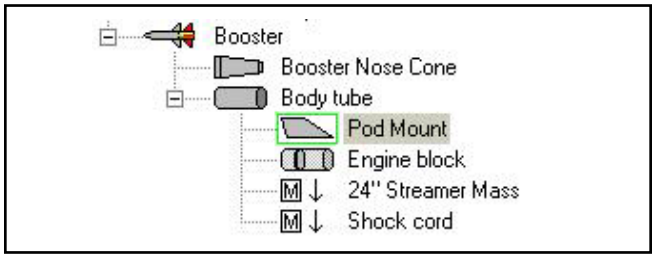
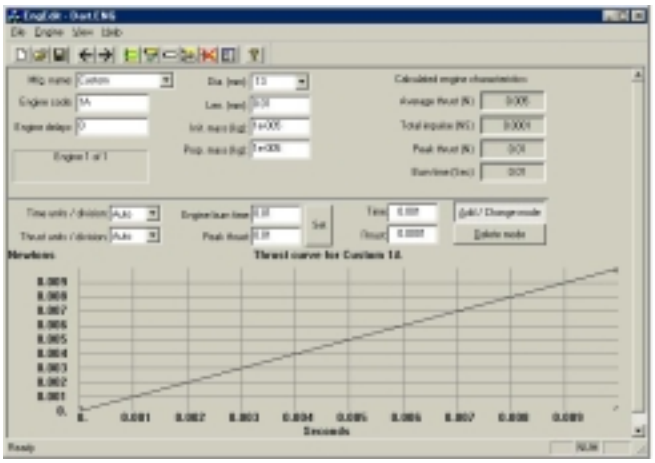


Figure 7: The parts tree for the pod.

Note a recovery device is not necessary for the pop pod since you are mainly interested in the gliders flight and recovery. If you must know details of the recovery flight of the pop pod, create a new simulation with the roles of the glider and pop pod reversed. Set the boost glider as the booster stage flying on the booster motor and the pop pod as the sustainer stage flying on the dart motor.

Creating a dart motor for the Boost Glider

Open the motor editing program that comes with RockSim, ENGEDIT.EXE and create a dart motor with essentially minimal mass, thrust, and time. Be sure to give this new motor a name you can remember and note the location of where it was saved. Below is the example I used for the dart motor. This motor is 13 mm in diameter, which corresponds to what was specified for the phantom body tube of the boost glider, see Figure 8a and 8b.



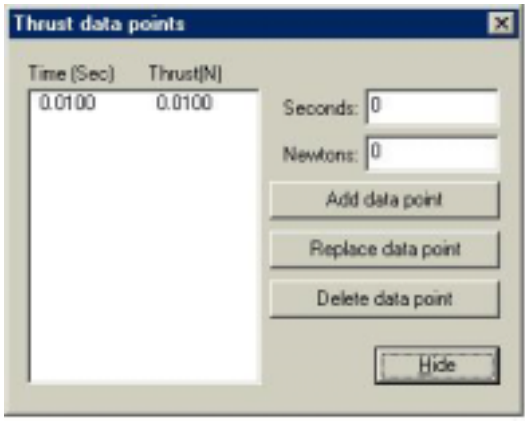


Figure 8a & 8b: A new phantom motor is made that goes in the sustainer stage of the model.

Save the motor file and compile all the motor files using the COMPENG.EEX program that comes with RockSim. More details on how to create the boosted dart motor can be found in Apogee Technical Publication #14 *Software Simulation Tricks* by Tim Van Milligan http://www.apogeerockets.com/technical_publication_14.asp and in the article on Strap-on Boosters by Tim Van Milligan in issue #109 of the *Apogee Peak of Flight Newsletter*, August 22, 2003

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Pop-Pod Gliders

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- page 5 http://www.apogeerockets.com/education/downloads/Newsletter109.pdf

Now its time for a pop pod boost glider virtual flight!

Load the dart motor in the sustainer select zero delay and enter zero for the engine overhang from the motor mount tube. Select a motor like a Quest B6-2 for the pop pod booster and set the engine overhang 0.25" in this case see Figure 9.

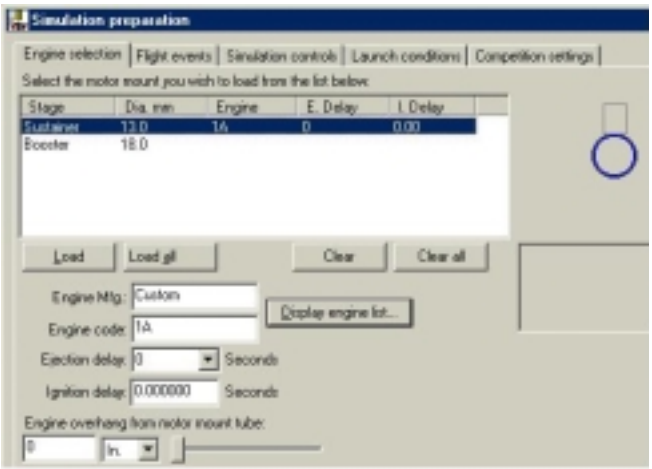

Figure 9: Load the phantom motor in the sustainer stage of the design.

Under the Flight events tab make sure to set the sustainer for Parachute deployment at *Max. Engine ejection.* Under the "Simulation controls" tab, end the simulation when the rocket returns to the ground. On the "launch conditions" tab, initially set up with *No thermals* and some fairly typical conditions and launch the simulation see Figure 10.

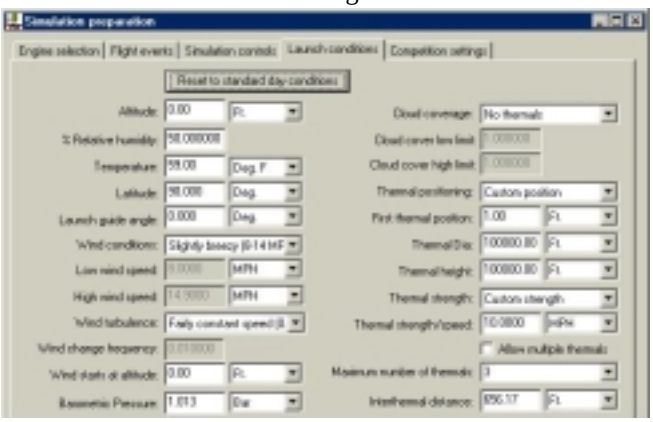

Figure 10: Set up the launch conditions.

Under the Simulations open the 2D flight profile and move the slider bar all the way to the right. The Profile screen now displays the Time and Range of the glide, which would be the length of glide if the flight were perfectly straight see figure 11.

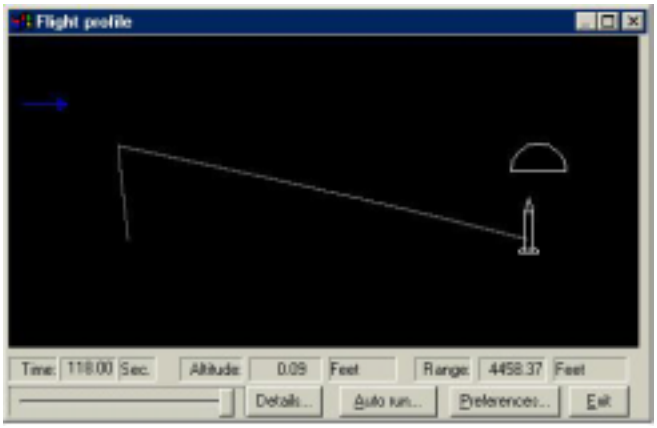

Figure 11: The flight profile of the glider.

Switch the Launch conditions to one where thermals are present such as in the example below and again view the 2D flight profile see Figure 12.

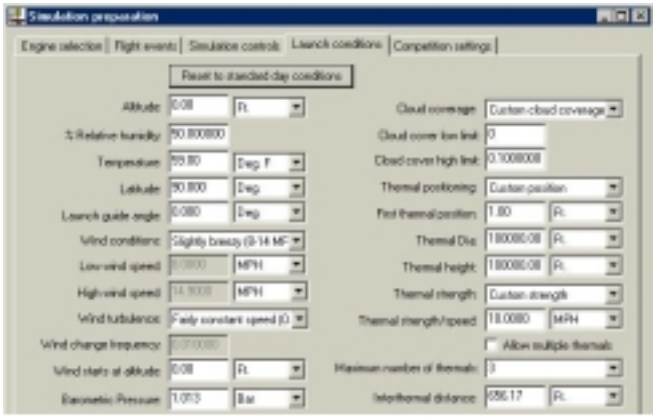

Figure 12: Add thermals to the next simulation.

Note that the added lift of the thermal added 45 seconds to the flight time (see Figure 13 on the next page).

The simulation can be tailored for a better fit to real world flights by adjusting the boost glider parachute C_d higher or lower to match the flight time, provided all the other ambient conditions are known and have been entered correctly.

On a Quest C6-3 motor the flight time increases to 216 seconds with no thermals, this seems to be in line with what is expected from a higher altitude flight.

Also note where RockSim places the CG in the model

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Pop-Pod Gliders

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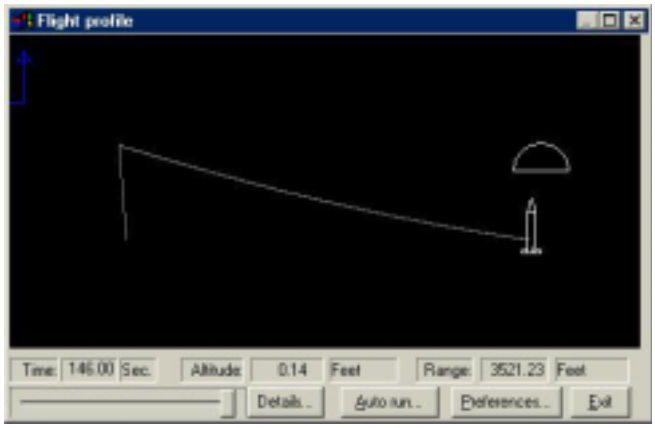


Figure 13: When thermals are added, the descent takes much longer - as expected.

containing the motor. The CG is now ahead of the CP, static margin = 2.27 for as would be necessary for a stable flight coupled to the booster pod see Figure 14.

The RockSim simulation file for the Quest Flat Cat boost glider can be downloaded by http://www.ApogeeRockets.com/education/downloads/Quest_flat_cat.zip

In closing I must again mention that this simulation work is only a theoretical approximation that has yet to be confirmed with real flight data; use this unproven technique at your own risk.

I welcome any comments and criticism on this work.

Bruce S. Levison, NAR #69055

Send Mail to: teflonrocketry1@yahoo.com

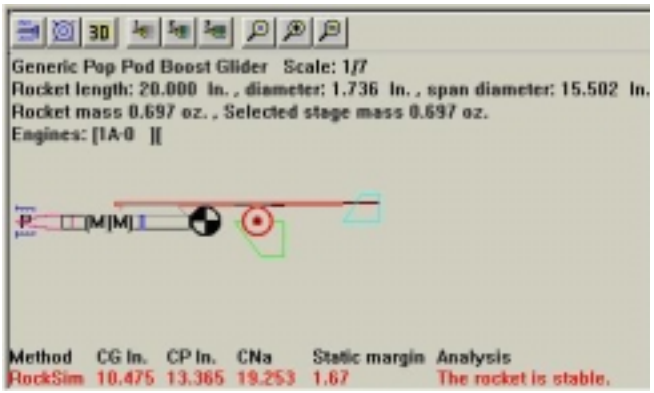
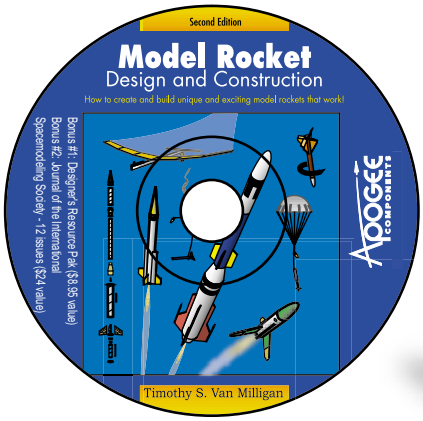


Figure 14: The CG is now ahead of the CP, indicating a stable launch configuration.

About the Author:

Bruce S. Levison (NAR #69055, MTMA #606), A.K.A. Teflon Rocketry, is a rocketeer from Ohio, a member of the National Association of Rocketry (NAR), and NAR section #606, the Mantua Township Missile Agency (MTMA). He has published articles on ejection charge proof expanded Teflon recovery systems (hence the nickname), camera tripod mounted launch pads, ablative blast deflectors, a horizontal painting swivel for model rockets, a method for the simulation of tube fin rocket designs, a RockSim method to determine how far away from the launch pad a parachute recovered model rocket will land, the simulation of ring fin designs using RockSim and the simulation of fins on fins using RockSim. Bruce earned an advanced degree in chemistry, and works as a research scientist at the Cleveland Clinic Foundation.

I Goofed... So You Win!



I didn't watch my inventory close enough, and I ran out of the printed versions of the book: *"Model Rocket Design & Construction."* I've ordered more, but they won't be in until late January. In the mean time, I'll distribute the book on CD-ROM as a pdf document. Everything is included!

And you'll also recieve $45.90 in free bonus items! One of them is the *"Building Skill Level 1 Model Rockets"* video book. To see the others, visit:

www.ApogeeRockets.com/design_book.asp

Phases Of A Model Rocket's Flight

By Tim Van Milligan

Are you new to model rocketry? Do you know what to expect when you build and fly a rocket kit? This article will try to help you by explaining what happens when you launch a model rocket. It will also point you in the right direction where you can find even more information to help make you into a rocketry expert.

Begin by looking at the picture on the next page. I've sized it so you can print it out as a mini-poster. If you are teaching others about rocketry, having a poster to hand out will be helpful. Please feel free to share it with your friends.

Phase 1 - Ignition and Liftoff

A model rocket is always ignited by "electrical ignition." That means that you need to have a device that starts the motor burning. This device is called a "launch controller." Basically, it consists of a battery, a switch, a safety key, and some wire. You can make your own if you have some basic electrical skills. There are plans for several different launch controllers in the booklet: *Electronic Model Rocket Launcher Construction Plans*. You can order this booklet at: http://www.apogeerockets.com/elect_launcher_book.asp.

If you want to save time, you can buy a launch controller. They are usually sold as a set along with the launch pad. You can find a good one at: http://www.ApogeeRockets.com/Quest_launch_pad.asp.

Why electrical ignition? This is a common question. The answer has to do with "safety." Many new people think a fuse would be simpler. But that would sacrifice safety. Once a fuse is lit, there is no stopping it. If the rocket should tip over, or an airplane suddenly appear in the sky, you couldn't halt the launch.

The other item shown in the picture is a launch pad. Again, many new modelers don't understand the need for a launch pad that includes a luanch rod. After all, the Space Shuttle doesn't have a big launch rod...

The purpose of the launch rod is to guide the rocket until it reaches sufficient speed where the fins take over and keep the rocket moving in a straight path. This is approximately 30 miles per hour.

By the way, the reason the Space Shuttle, and other large rockets don't have launch rods is because they have rocket engines that are steerable. In other words, the direction the rocket engine pushes controls the path of the rocket. Our model rockets have a fixed nozzle. They will only move in one direction. So we need a rod to keep the rocket moving in the "upward" direction. Without a rod, the model can easily tip over at lift-off, and come screaming right at you. So for safety, we have a launch rod that keeps the rocket pointed up.

The rest of the launch pad is needed to hold the rod, and to keep it from tipping over in a breeze.

Igniters

The actual device that starts the motor burning is the "igniter." It looks like a match with wires coming off the tip. These wires are hooked up to the launch controller that we discussed earlier.

When the electrical current passes through the igniter, it heats it up and causes it to burst into flame. This flame is what actually starts the propellant burning in the rocket motor.

Where do you get igniters?

They come with the rocket motors.

How do you hook them up? It's pretty simple. And instead of me telling you, I think it would be better to show you with a little Quicktime movie. By watching it, you can see how to insert and hook up the igniter. The movie is at: http://www.ApogeeRockets.com/copperhead_igniter.asp

The Rocket Lifts Off

Once the motor ignites, it begins to generate thrust. It is this thrust force that pushes the rocket into the air.

While the motor is making thrust, you'll normally see a flame coming out the back of the motor. Sometime it is hard to see because the rocket moves so fast. At the same time, the rocket motor is making a loud roar and a lot of thick dark smoke.

Phase 2 - Engine Burnout

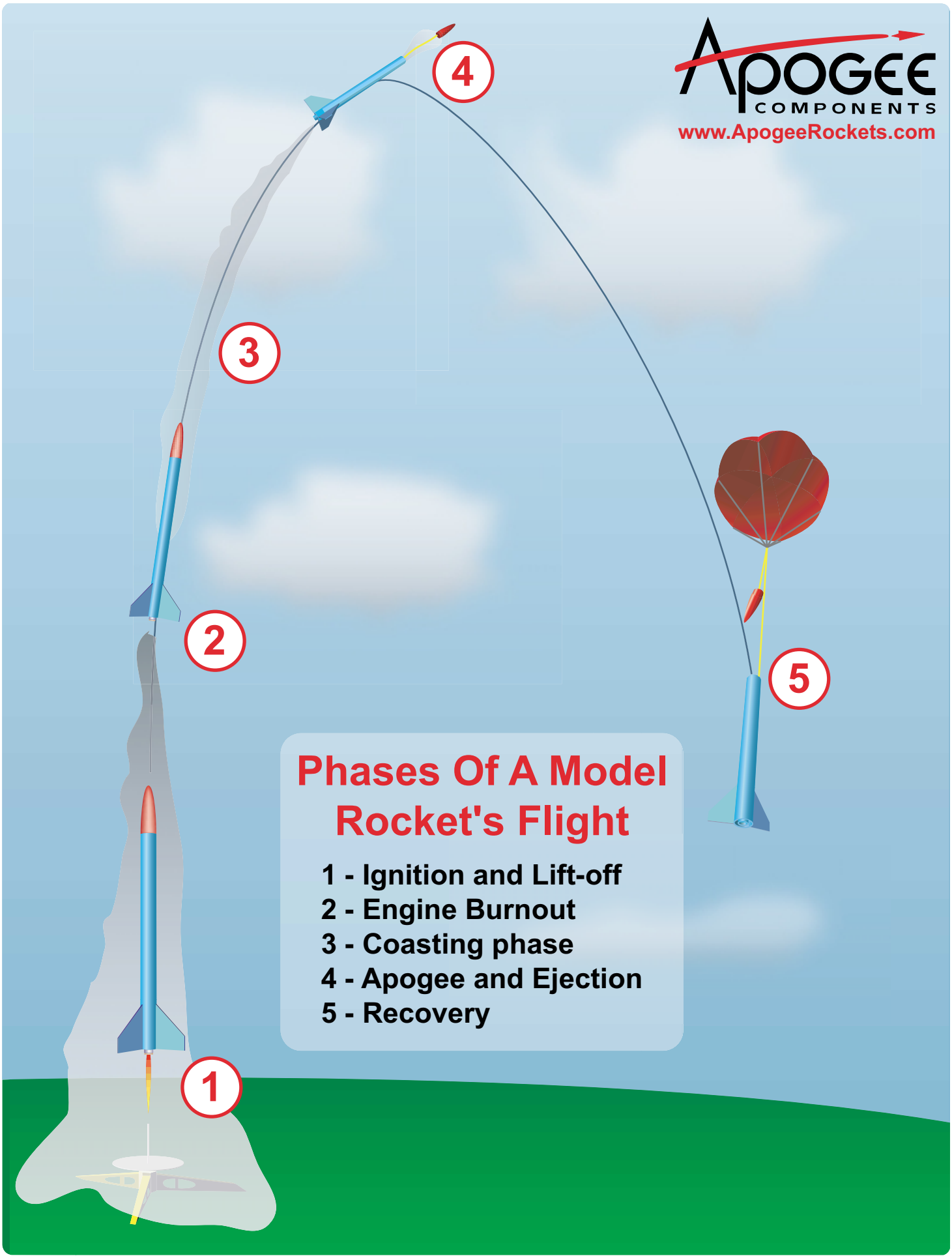
The propellant inside the motor burns quickly. In most motors, the propellant is consumed in less than three seconds, at which point "burnout" occurs. This means the motor is no longer producing a thrust force.

By the time the motor burns out, the rocket has already reached its top speed. It cannot go any faster from this point on.

Most people are surprised that burnout occurs at a very low altitude. While the rocket may reach hundreds or thousands of feet in the air, the burnout location on most rockets is about 50-80 feet in the air.

Phase 3 - Coasting

When the motor burns out, the rocket may be travelling hundreds of miles per hour. We don't want the parachute to come out of the model while it is going this fast. Otherwise, it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Phases Of A Model Rocket's Flight
1 - Ignition and Lift-off
2 - Engine Burnout
3 - Coasting phase
4 - Apogee and Ejection
5 - Recovery

Phases Of Flight

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will be ripped to shreds.

We want the model to coast upward and bleed off some speed. The period of time that starts at engine burnout, and ends when the parachute is ejected out of the rocket is called the *"Coast Phase."*

Even though the rocket motor isn't making thrust, there is something happening inside of it. The special composition called the *delay element* (or *delay grain*) is burning at a slow rate.

It is obvious that something is going on, becuase there is still smoke coming out of the rocket motor. Maybe this is what causes confusion among new modelers that they think the motor keeps burning all the way until it reaches *apogee* (the highest point in the flight).

The smoke serves a purpose though. It allows us to track the rocket -- in other words, to follow its progress into the air. Sometimes the rocket moves so fast, that it is hard to follow with our eyes. So the smoke gives us a visual indication where the model is.

There is something worth mentioning. The smoke produced by the delay grain is not as dark or as thick as the smoke produced by the motor while it is producting thrust. The delay smoke is whiter, and wispy.

Phase 4 - Apogee and Ejection

When the delay composition is done burning, it starts the "ejection charge" that is also built into the motor. This ejection charge burns quickly, and is directed inside the rocket. It's goal is to push off the nose cone, and eject the parachute out of the rocket.

Typically, we desire the ejection to occur right at *apogee* (the highest point in the trajectory of the rocket). It is at this point the rocket has slowed down to its minimum velocity. So when the chute comes out, it isn't hit by a huge gust of air.

The modeler controls when the ejection charge pushes out the parachute by proper motor selection. If you use a motor that has too long of a coast phase delay, the rocket will arc over, and will eject the chute while the rocket has built up some speed when it is coming back down to the ground. Likewise, too short of a delay will mean the rocket hasn't coasted to its highest point.

Phase 5 - Recovery

After the parachute has ejected, it fully inflates, and the rocket has begun its recovery phase.

Nothing much happens during the recovery phase. The model just drifts slowly to the ground under the canopy of the parachute. But it is at the mercy of any wind that is blowing. The stronger the wind, the further the model will drift away from the launch pad.

Because of this, modelers have searched for ways to keep the model from drifting out of sight. The most common thing they do is to switch from a parachute to a streamer. A streamer does the same thing as a parachute, but it falls faster, so it doesn't drift as far. There are other things a modeler can also do to prevent the rocket from drifting too far. You could cut a hole in the canopy of the chute, to make it fall faster. Similarly, you can tie the suspension lines together to *reef* the chute (to prevent it from opening fully). Again, this makes the rocket fall faster, so it doesn't drift as far during the recovery phase.

Summary

With the exception of the recovery phase, the flight of the rocket is controlled by the rocket motor. For a new modeler just starting out, *proper motor selection* is a very important part of the launch process.

Fortunately, most new modelers choose kits to fly. The manufacturer of the kit will make a recommendation on which motor to choose for the flight. As long as you follow this recommendation, your flight should be a success.

Where To Go For More Information?

Now that you know what to expect when you go to launch your rocket, you probably have more questions about the various aspects of the flight. For example, you might want to know more about how rocket motors work, or how much weight any given rocket motor can loft into the air?

So I'll give you some links to previous issues of the Apogee Peak of Flight Newsletter that you can explore at your own pace. For your convenience, I've broken it down into the five different phase of flight.

Phase 1 - Ignition and Lift-off

Issue #1 - How are your flying skills?

Attention Rocketry Manufacturers and Vendors

Apogee Components is accepting proposals for joint ventures; including helping you market and selling your rocketry items. If you are interested in reaching a larger audience with your products (at no up-front costs to you), please feel free to give us a call. I can be reached at: (719) 535-9335, or by email at http://www.ApogeeRockets.com/Contact_us.html

Phases Of Flight

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Issue #38 - Selecting Rocket Motors (part 1)

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All these articles can be found on the Apogee Components web site at: http://www.ApogeeRockets.com/education/newsletter_archive.asp

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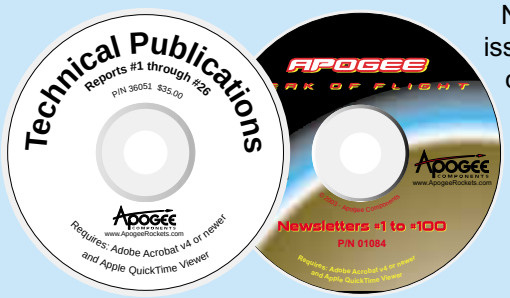

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