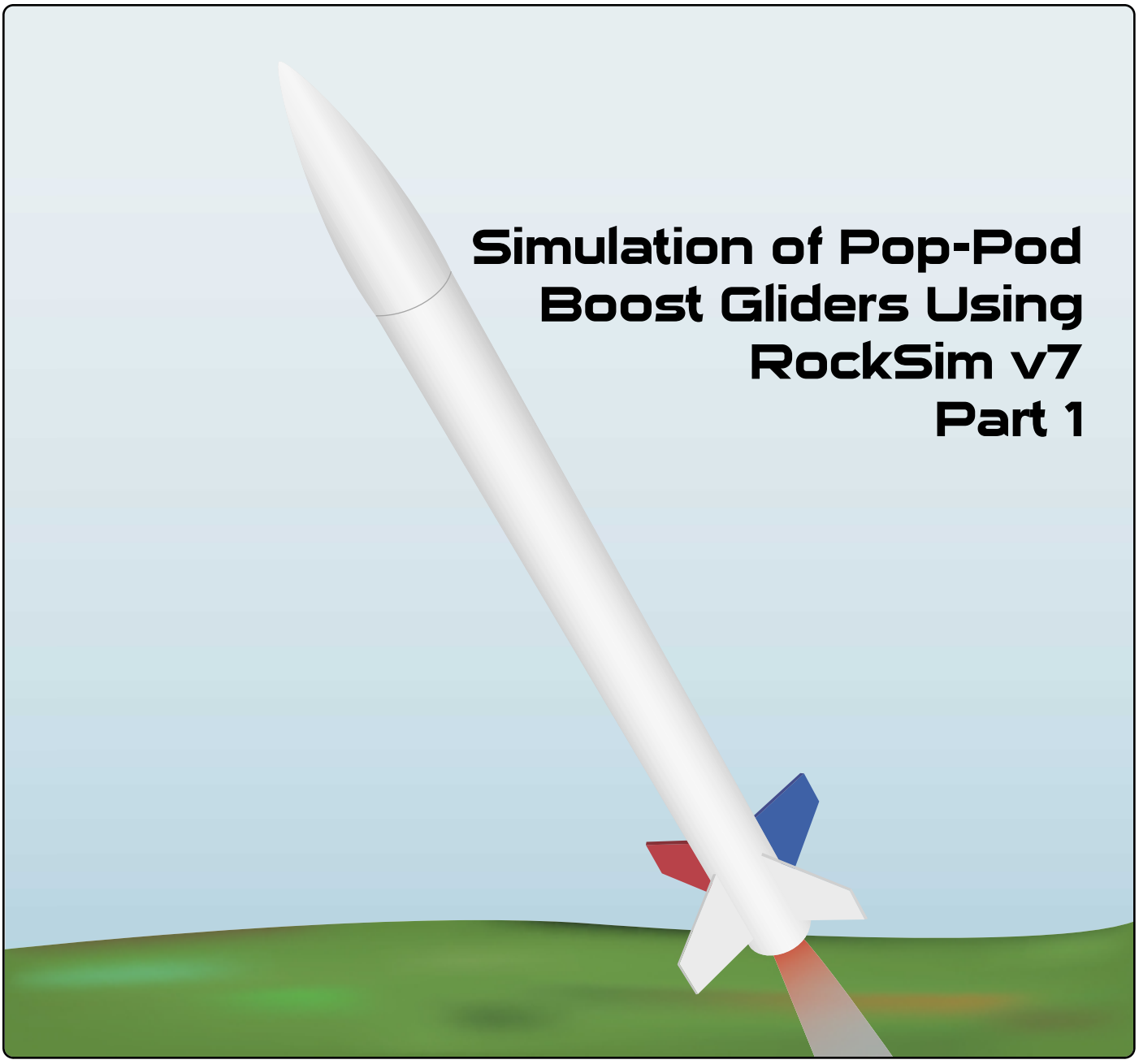
ISSUE 116, DEC. 5, 2003

APOGEE PEAK OF FLIGHT NEWSLETTER



Simulation of Pop-Pod Boost Gliders Using RockSim v7 Part 1

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APOGEE PEAK OF FLIGHT

Simulation of Pop Pod Boost Gliders Using RockSim Version 7. Part 1

Bruce S. Levison

Bruce S. Levison 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 neutral point (CP) will be in the right location on the boost glider. 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 older and demo versions of the RockSim software.

This article describes how to use RockSim version 7 to simulate pop pod boost glider rocket designs where the motor (pop) pod separates from the glider at apogee and the glider glides 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 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.

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.

Part one of this article covers the simulation of the glider from the Quest Flat Cat boost glider see Figure 1. Part two covers the simulation of the pop pod and the glide recovery flight. The Quest Flat Cat was chosen since it is a simple generic pop pod boost glider design that has been simulated using other software programs.

Overall design of the pop pod glider see Figure 2.

Open RockSim version 7 and select File-new. On the rocket design attributes tab select; Use RockSim method for static stability analysis, for simulation method select; Use

Continued on page 3

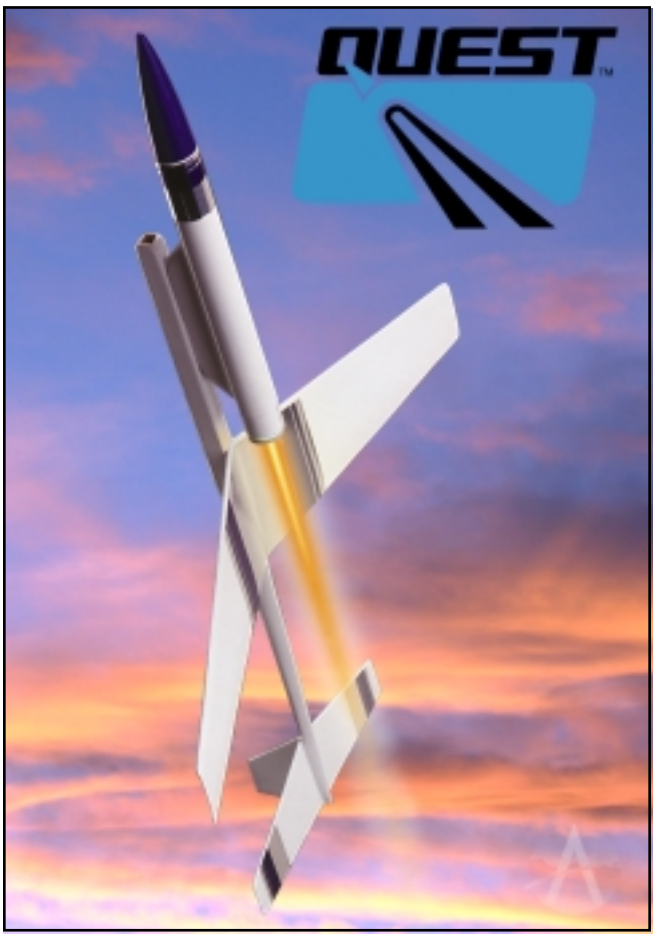


Figure 1. Quest Flat Cat Pop-Pod Boost Glider

Pop-Pod Gliders

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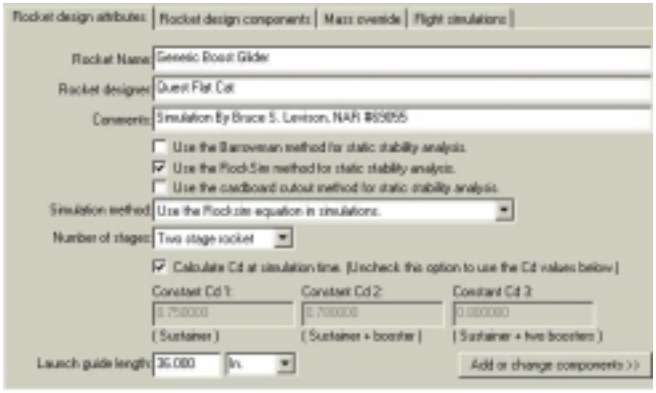


Figure 2. Design Attributes screen for the Quest Flat Cat Pop Pod Boost Glider.

RockSim equations in the simulations and set the number of stages to; Two stage rocket. This is a good time to name the design and set the launch rod length, I used 36 inches.

Next click on the rocket design components tab and for the sustainer, which will be the glider or boosted dart, create a phantom body tube that has an outer diameter (OD) equal to that of the pop pod plus twice the height of the pod mount (for this case BT-20, 0.736" +2* 0.5" = 1.736" pod mount height) that is only 0.001" long. To keep the weight down specify the inner Diameter (ID) to be .0001" less than the OD and specify this as a motor mount tube for any motor diameter. Be sure to remember or write down the motor diameter you used since this value will be used in a later step. Assign the tube to be a lightweight material such as Balsa and for the second part of this article indicate that the tube is a motor mount for 13mm diameter engines.

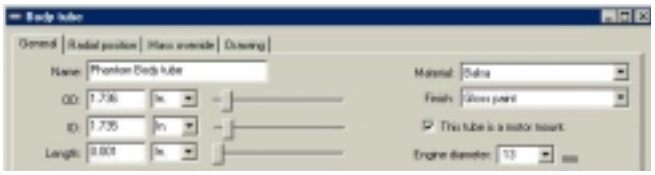


Figure 3: Create a phantom body tube to offset the glider from the Pop pod.

Select a Custom fin set design for the phantom body tube

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Figure 4: Specify the Glider Body.

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Read Newsletter #98

How-To Start A School Rocketry Program
See Newsletter #112

How-To Track A Rocket's Altitude
Jump to Newsletter #93

Pop-Pod Gliders

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and specify the dimensions of the glider body, be sure to set the fin count to 1 on the glider body thickness to 0.25".

The points in the Fin Plan are (counter clockwise from left to right):

0.0, 0.0
0.0, 6.5
0.125, 14.5
0.25, 14.5
0.25, 0.0

Select another simple trapezoidal fin set for the phantom body tube and specify the dimensions of the glider wing for just one side, be sure to set the fin count to 1 and a fin thickness of 0.125" also set the location to zero (see Figure 5).

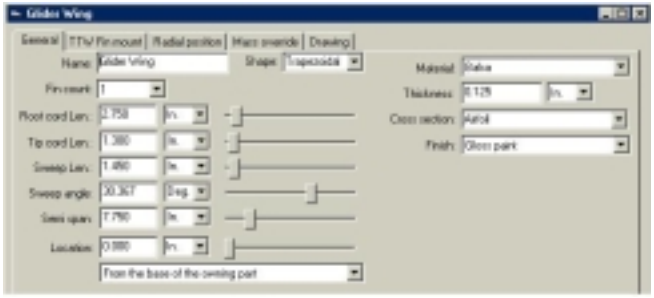


Figure 5: Specify the Glider Wing.

Specifying the Glider Stabilizer

Select another simple trapezoidal fin set for the phantom body tube and specify the dimensions of the glider stabilizer for just one side, be sure to set the fin count to 1 and a fin thickness of 0.0625" again set the location to zero.

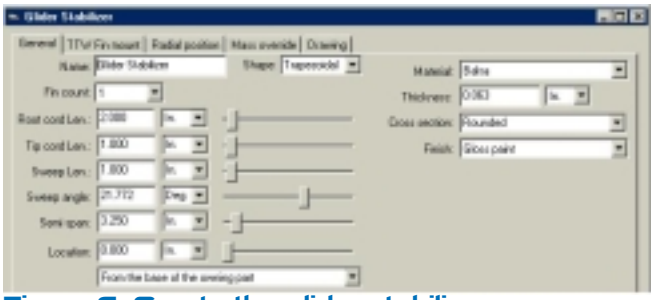


Figure 6: Create the glider stabilizer.

Specifying the Glider Rudder

Select another simple trapezoidal fin set for the phantom body tube and specify the dimensions of the glider rudder for just one side, be sure to set the fin count to 1 and a fin thickness of 0.0625" also set the location to zero (see Figure 7).

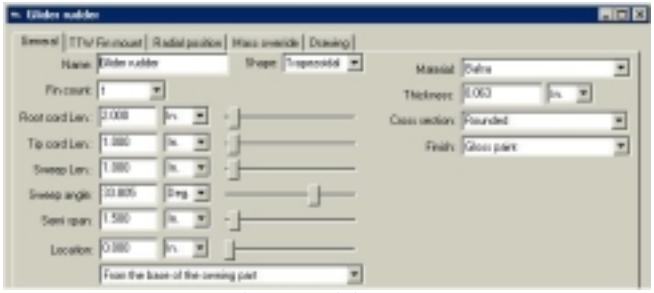


Figure 7: Create the Rudder.

For a more complex wing, stabilizer, rudder, and/or pod mount shapes the "Free Form Custom Fin" set could also be used. For two (or more) out board rudders at the tips of the stabilizer you would have to design two fin mounts and locate them to the tip edge of the stabilizer and assign a rudder fin to each one of them.

Specifying the Glider Body Wing Mount

Assign an inside tube to the Phantom body tube with a minimal diameter and thickness the same length as the root of the wings on the glider body; set the location to zero. See Figure 8 below.

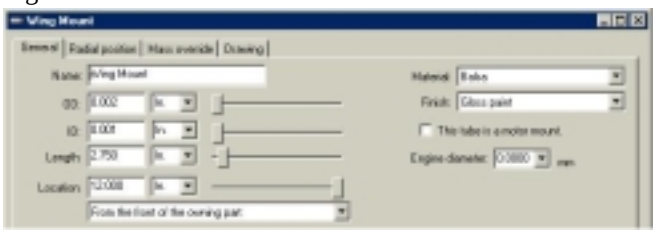


Figure 8: Create a phantom body tube to mount the wings.

Set the radial distance to 0.868, which is half the phantom body tube diameter (or the radius of the pod plus the pod mount height) see figure 10 below.

Repeat this step assigning one more inside mount tube to

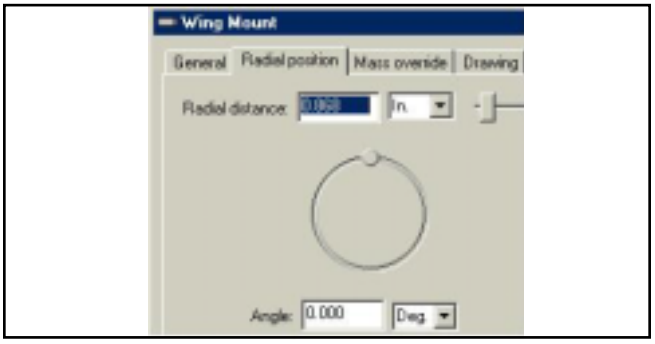


Figure 10: Set the radial position of the phantom tube.

Pop-Pod Gliders

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Figure 11: Create a phantom tube to attach the stabilizers.

the Phantom tube to serve as a common mount (2 inches long) for the rudder and horizontal stabilizers. See Figure 11.

Set the radial distance to 1.118, which is the radius of the pod plus the pod mount height plus the thickness of the glider boom 1/2*0.736" + .5" + 0.25" (see Figure 12 below).

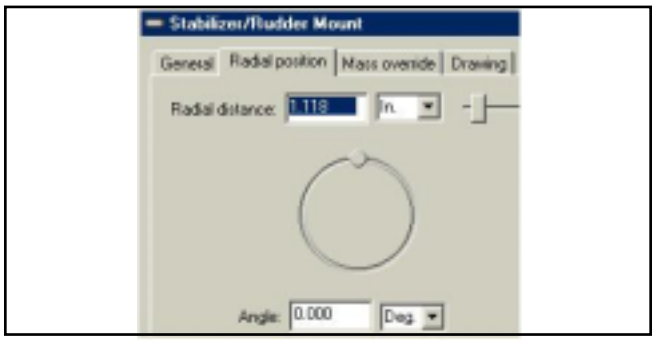


Figure 12: Set the radial position of the tube.

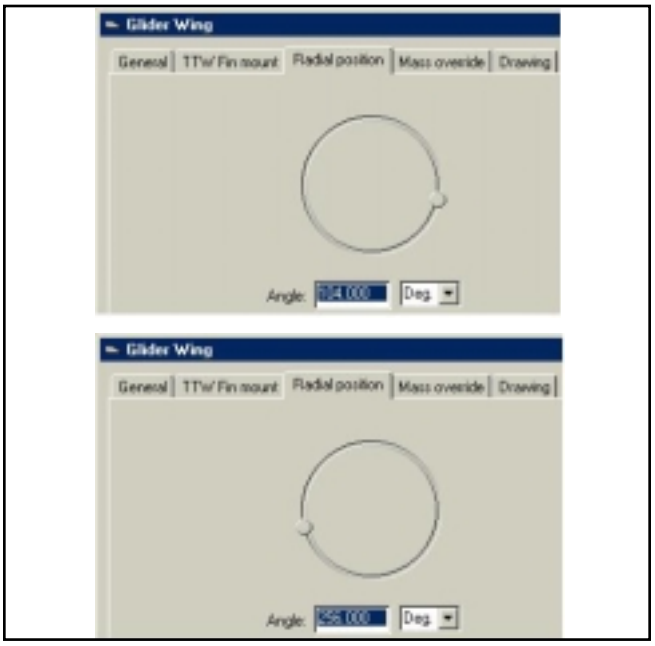
Use a word processing program like Word Pad to change these two inside tube mounts into regular body tubes.

Convert: `<IsInsideTube>1</IsInsideTube>` to `<IsInsideTube>0</IsInsideTube>`

Review my previous work on the simulation of *"Fins on Fins"* http://www.apogeerockets.com/education/downloads/Newsletter113.pdf for details on how to do this. Save the edited file and open it again in RockSim.

Open the wing mount (which used to be an inside tube) and change the location to12 inches from the front of the owning part. Now copy and paste the wing to the wing mount; do this twice, once for each wing. Be sure to delete the wing that was originally assigned to the phantom body tube. Open each wing file and assign one of them a radial position angle of 104 degrees and the other a radial position angle of 256 degrees for the 14-degree dihedral angle of the wings see Figures 13 and 14.

Open the stabilizer/rudder mount and assign the location



Figures 13 (top) and 14 (Bottom): Change the radial position of each wing to set the dihedral.

of 18 inches from the front of the owning part. Copy and paste the stabilizer to the stabilizer/rudder mount do this twice one fin for each side of the stabilizer. Be sure to delete the stabilizer fin that was originally assigned to the phantom body tube. Sequentially, open each stabilizer fin and assign one of them a radial position angle of 90 degrees and the other a radial position angle of 270 degrees as you did for the wings above.

Copy and paste the rudder to the stabilizer/rudder mount. Again be sure to delete the rudder fin that was originally assigned to the phantom body tube. Open the stabilizer fin and be sure it has a radial position angle of 0 degrees.

The parts tree should now look something like Figure 15.

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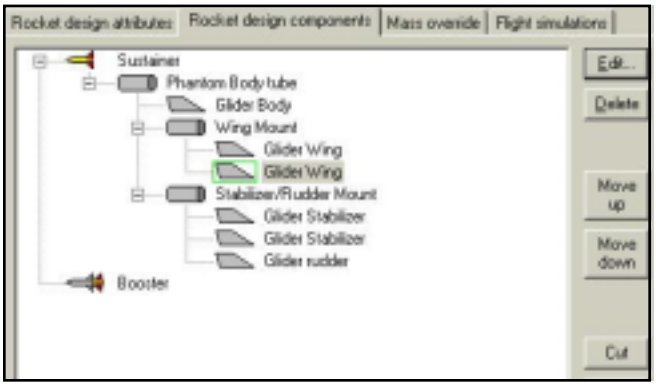


Figure 15: Parts tree after modifying the glider.

Pop-Pod Gliders

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This completes the design of the boost glider it is lacking only one more detail that will make it "glide" in the simulation of the recovery phase of the flight - a parachute! Before we add this last component, and explain how it works, lets take a look at this glider design and its neutral point or CP .

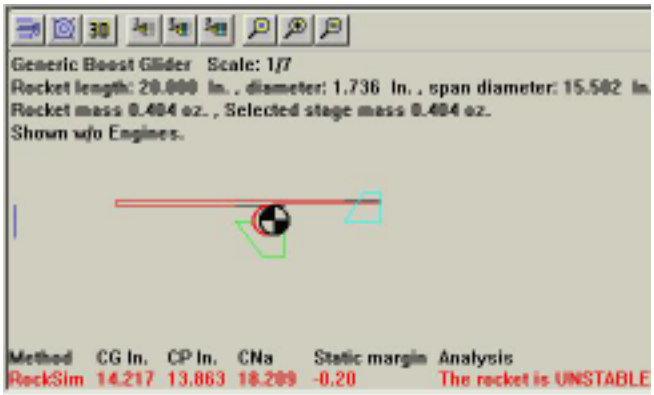


Figure 16: The stability of the glider.

RockSim indicates a CG of 14.217 and a CP of 13.863 giving a static margin of -0.2. Taking a look a Bob Kaplow's work on this very same model (I used the same dimensions and only changed the glider body slightly to reflect its tapered shape) http://www.ninfinger.org/~sven/rockets/rmrfaq.8.html

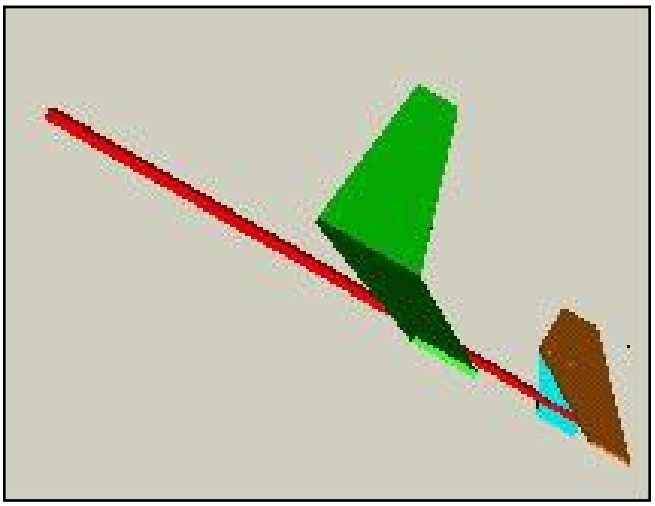


Figure 17: A 3D view of the Flat Cat Glider.

This article indicates: "The Neutral Point is located at 85.38% (2.348 units) from wing L.E., NPg = 1.1540 Stability factor 0.20 Put CG at 70.65% (1.943 units - in this case *"inches."*) from wing L.E., NPb =0.99614"

RockSim gives the CP at 68% (=100%*(13.863-12)/2.75) or 1.86 inches from the wing leading edge (L.E.) and the CG at 81% (=100%*(14.217-12)/2.75) or 2.217 inches from the wing leading edge. Although the two neutral point values are

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Pop-Pod Gliders

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close to one another, RockSim calculates a value that is 15% closer to the wings leading edge than this published value. This difference may be due to the fact that RockSim is taking into account the area of glider body when it determines the CP value. The other method does not take the lift from the body of the glider into its calculations. *(See also* Newsletter #115 *for another explanation.)*

While this simulation indicates a slight negative stability you can always trim the glider by adding nose or tail weight for a better flight. For a level glide the Neutral point or CP of the glider should be the same as the glider's CG or center of gravity. The negative stability case presented here may be the best case for a stable gliding flight; the glider would have a tendency to fly nose up since it is slightly tail heavy! The correct placement of the CG will have to be determined empirically by hand launching the glider and adding or removing nose or tail weight until a stable flight is obtained. Once the amount of this weight is known it can be incorporated into the simulation as a mass object. The actual CG of the glider can also be incorporated on the mass override menu for the sustainer once the glider has been trimmed out for a level (stable) flight.

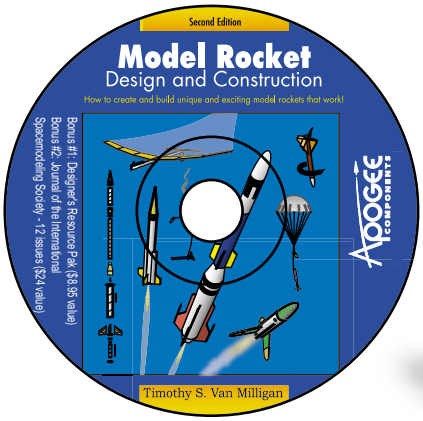
Here is a copy of the RockSim version 7 file for the Glider: (link to Quest_Flat_Cat1.rkt)

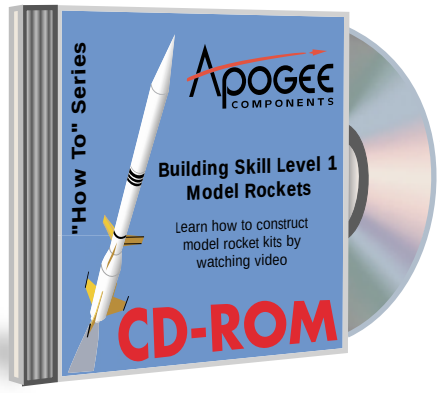
Now that the glider has been simulated and its trim has been accounted for, the next step is to use RockSim to account for the glide phase of the recovery. Part two of this article will cover the techniques to fly this glider with a pop pod and use RockSim to simulate the glide recovery.

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

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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!

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