APOGEE COMPONENTS

PEAK OF FLIGHT
NEWSLETTER

Trimming a Rocket Boosted Glider
How to get that perfect glide with the least amount of effort (Part 1 of 2)

RockSim Design
The "Streamline" by James Adams

Question & Answer Corner
Sizing the static pressure hole for your altimeter

Kit of The Month
The Apogee 1/70th Scale Saturn 1B

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Trimming A Rocket Boosted Glider

By Tim Van Milligan

Introduction

Building and successfully flying a rocket-launched glider is not easy, or you'd see everyone doing it. The hardest part is trimming the glider so that it transitions into a nice steady flight. What makes it so tough? The glider has to be trimmed for both a very high speed launch, and then a nice slow gliding descent. Often times, these two don't go together and the model ends up becoming confetti all across the sky.

But when a rocket-launched glider is successful, it is really a sight to behold. The gracefulness of the glide is so very hard to describe. And because it is so challenging to accomplish successfully, the sight takes on even more significance.

This article explains the process of trimming the glider so that it does work successfullly. It assumes that you already have a glider design in mind and are in the midst of building it. If you don't have a glider, you might start with a simple one like the Condor Boost Glider kit (www.ApogeeRockets.com/condor_glider.asp). It is a robust glider that I found to be a little easier to trim than a lot of gliders.

If you're a little more daring and want to try to design and build your own, you will find the book Model Rocket Design and Construction (www.ApogeeRockets.com/design_book.asp) to be extremely helpful. It has a whole chapter dedicated to the art of building and flying gliders.

Trimming

The final act prior to launching is to adjust the vehicle's aerodynamic control surface and to properly position the CG to achieve a stable glide. This is called trimming the glider.

Trimming actually begins during the construction process. It cannot be stressed enough to build with high quality components and use assembly fixtures to get all the parts aligned properly. It is a good idea to weigh everything so that the port (left) side of the glider has the same mass as the starboard (right) side. This will make it easier to get a nice level glide.

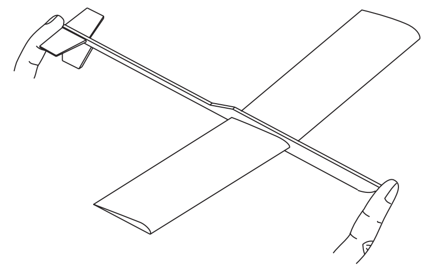

Figure 1: Balance the glider on your fingers to see if one wing is heavier than the other.

After you construct your glider, you should check this by balancing the glider by holding at the very front and back, balancing on your fingers as shown in Figure 1. A slightly heavier wing is ok, as that will help to get the glider to enter into a circlular pattern, so it doesn't fly out of sight. But one wing that is significantly heavier is bad. It is likely to make a quick death-spiral right into the ground. It is better to weigh the wings before you glue them on the fuselage. Adding clay to the underside tip of the "light-weight" wing so the glider is balanced is possible, but it is going to be harder to trim for a nice glide.

It is actually during the design process where you'll need to figure out where the CG should be positioned. By knowing this in advance, you can determine how long to make the front part of the fuselage boom. It is desirable to design the fuselage so that you won't need to add extra mass later to get the CG in the correct spot for maximum duration glides.

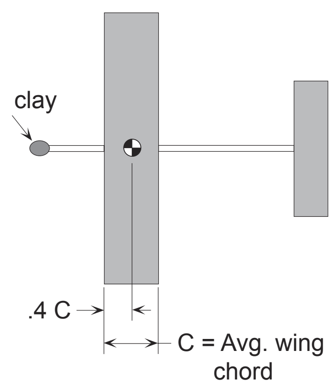

Figure 2: An approximate position to place the CG.

Where should the CG be on your glider? The CG for conventional configuration gliders is listed in the "Size

Continued on page 3

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Continued from page 2

Trimming A Rocket Boosted Glider

Chart for Gliders” in the book *Model Rocket Design and Construction*. If you don’t have the book yet, a very rough starting point is to set the CG at 40% (of the average wing chord) back of the wing leading edge (Figure 2).

But ideally, the CG should be positioned to give your glider a 10% to 15% stability margin. But what does this mean?

Like a model rocket, a glider’s stability is defined by the relationship between the CG and the CP. There are just two small differences though. First, the CP on a glider is called the *Neutral Point*.

The second difference is the reference length used to define how far in front the CG is from the Neutral Point. On a cylindrical rocket, the diameter of the tube is used as the reference length. On a glider, the Mean Aerodynamic Chord (M.A.C.) length is used (called the “average chord” in Fig. 11-25 of the book *Model Rocket Design and Construction*).

For example, if your glider had a M.A.C. length of 7.62 cm (3.0 inches), and you wanted a 10% stability margin for the glider, you would multiply 0.1 times 7.62 cm, for a distance of .762 cm (0.3 inch). You would then balance the

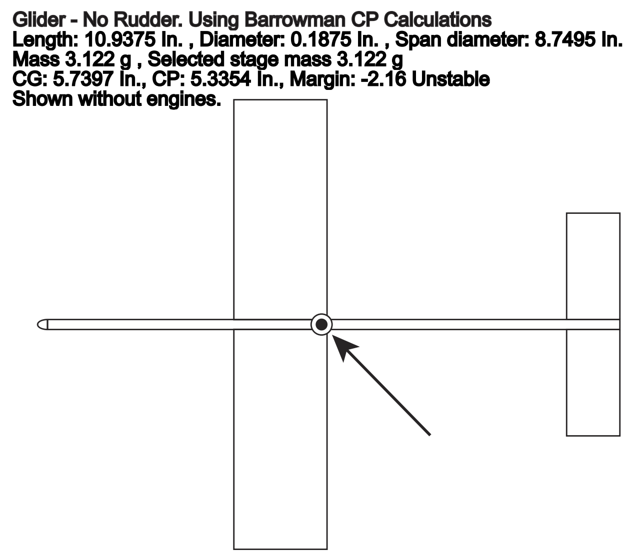


Figure 3: With a little ingenuity, the RockSim software can be used to find the Neutral Point of a glider.

Continued on page 4

Continued from page 3

Trimming A Rocket Boosted Glider

glider so the CG was 0.762 cm (0.3 inch) in FRONT of the Neutral Point position.

Determining the Neutral Point position is complex. Fortunately, there are many online calculators available. Do a search engine query on the search term “neutral point calculator” or “glider CG calculator.”

You can also get a good estimate of the Neutral Point position by using the RockSim software. It does have some advantages, but it is a little more work at the beginning, because you have to enter each component into the software.

One thing that confuses new users to RockSim version 8 is that you can’t have a rectangular fuselage in RockSim; it requires circular cross sections. To get around this limitation, you can estimate the fuselage as a small diameter rod, and attach the wings to that.

The advantage to using RockSim is that once you have the basic components in the software, you can easily change the shape and get instantaneous results on where the Neutral Point (the CP in RockSim) is. Then you can find exactly how much nose weight you’ll need and where to position it to get the CG in the correct position for the desired stability margin. To reduce the amount of nose mass, you can use RockSim to calculate the optimum length of the forward part of the fuselage.

The other advantage of using RockSim is that you can get more creative on wing planforms than you can when using online neutral point calculators.

RockSim isn’t perfect, and when finding the Neutral Point using the software, you have to make these adjustments:

1. Use the Barrowman CP calculation method.
2. Do not install the rudder or try to account for the hook on the front with a small fin. Use just the wings and the horizontal tail.

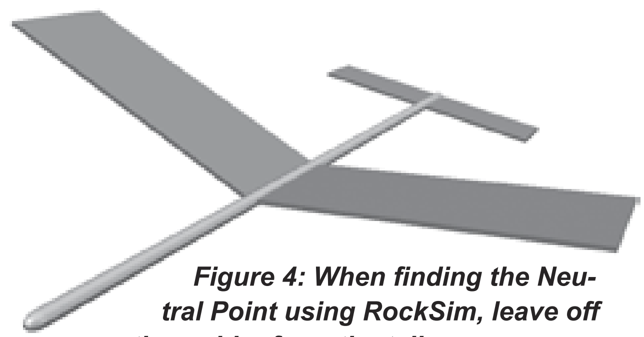


Figure 4: When finding the Neutral Point using RockSim, leave off the rudder from the tail.

3. The CP (neutral point) is going to be too far back initially. The reason is that Rocksim assumes the horizontal tail is 100% effective. But because of downwash of air over the tail, in reality, the tail is only 85% effective (see Figure 4). You’ll need to reduce the area of the tail by 15% to account for this and give a more accurate CP position.

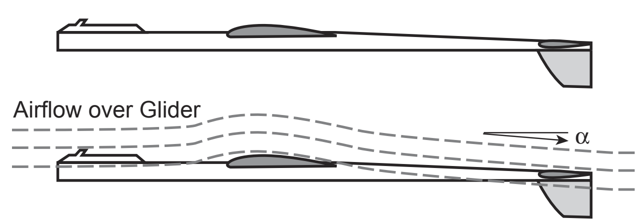


Figure 4: Downwash of air over the horizontal tail reduces its effectiveness because it effectively changes the angle-of-attack of the tail.

Continued on page 5

Continued from page 4

Trimming A Rocket Boosted Glider

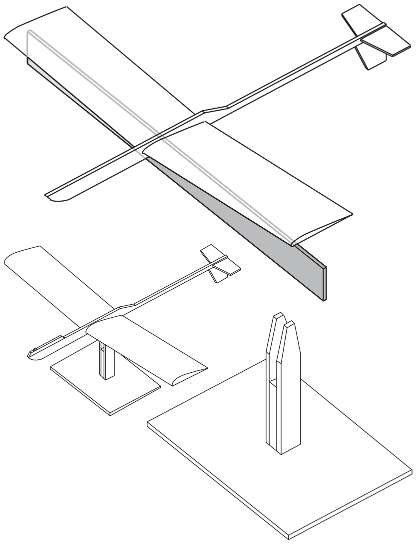


Figure 5: Different ways to balance your glider to find the CG.

Once you determine where the CG "should" be, the next step is to balance the built glider and find out where it currently lies. This is done by simply balancing the glider on a ruler. You can also make a simple balance fixture like shown in Figure 5. The advantage of this is that it is more accurate because the glider will stay in place so you can mark it more easily.

Hopefully, you've designed the glider well enough that it doesn't take a lot of extra mass added to the model. That is the beauty of using RockSim. You don't want to add mass, because it lowers the potential altitude the model can fly to when you launch it. The lighter you build your model, the higher it will boost and the longer it will take to glide back down to the ground.

Important safety note: If you ever need to add mass to the glider, always use modeling clay. Nails and other metal objects should not be used. If they were to fall off during flight, they are hard to see, and they could hurt someone.

Flight Trimming

Once you have the CG in the correct spot, will it automatically be trimmed and ready to launch? No, you'll still need to tweak the glider for a good glide.

There are two different schools of thought on trimming gliders. The first says to keep the Neutral Point-based CG position as an absolute physical criteria. Do not allow it to deviate, as any repositioning of the CG will mean the glider is not optimized for the slowest rate of descent. Trimming the glider for a nice glide then, is acomplished by tweaking (warping or repositioning) the control surfaces like the ailerons, rudder and horizontal stabilizer.

The second school of thought has believers that say control surfaces should NOT be warped at all. The glider should be built so that the horizontal stabilizer (tail) is as close to zero degrees incidence (called *decalage*) as possible (see Figure 6). This will result in the straightest boost and put the glider the highest into the air. To do this though, the CG position would have to be moved back and forth to get a stable glide.

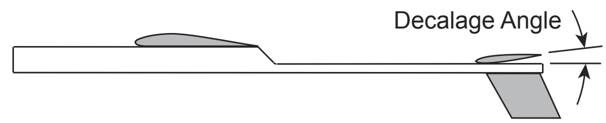


Figure 6: The decalage angle controls how fast the glider will pull out of a dive.

The first school of thought comes from people that have experience with hand launched gliders (HLG). The second comes from competitive rocketeers that desire to get the highest rocket-powered launches before the glider detaches from the pop-pod. We'll call them the ballistics experts.

They both have their merits, and you'll probably want to

Continued on page 6

Continued from page 5

Trimming A Rocket Boosted Glider

study the techniques of each as you begin to trim your own gliders.

The advantage of the HLG techniques is that you'll get a good glide a little more quickly. But the downside is that your rocket may not boost as high because of higher drag, and the trajectory may even be a little more arched (non-vertical).

The ballistic experts say that their gliders are more likely to survive the higher velocities encountered during an actual rocket launch because the surfaces are straighter and hence more streamlined. The lift-off trajectory will also be straighter and as a result the rocket will be a lot higher in the air when the glider is released. They go on to say that while they may have a faster rate of descent, there is a greater likelihood that the glider will stumble upon a thermal and that will cause them to stay in the air for a longer period of time.

The downside of the ballistic technique method is that it is harder to trim the glider by hand tossing. It usually takes the glider a little more vertical distance to transition to a glide. You may not have the arm strength to throw the glider high enough in the air to give it the room it needs to make a successful transition to a flat glide.

Beginners to rocket launched gliders will probably find the HLG techniques helpful initially because it gets them a successful launch and nice glide faster. But as your design and construction skills improve with experience, you'll want to incorporate more of the ballistic techniques to get a higher and straighter boost.

Regardless of which method you prefer, it can be very difficult to trim it if the model doesn't have the proper alignments built in, and the various parts are skewed at odd angles. Take your time building the glider, and make sure the parts are aligned correctly, and that the airfoil on the right wing matches the one on the left. Use construction jigs and fixtures whenever possible. It may take a little extra time to scratch build an angle checking fixture, but it is well worth the effort - as the model will be much easier to trim during the hand tosses.

Next Issue:

In the next issue, I'll describe the actual warping and CG manipulation techniques of the two different trimming methods.

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

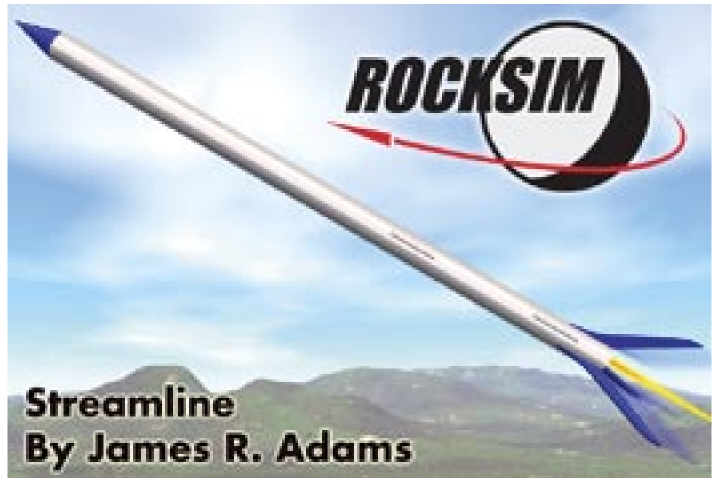
RockSim Design

The “Streamline”: A Reader Submitted RockSim Design File

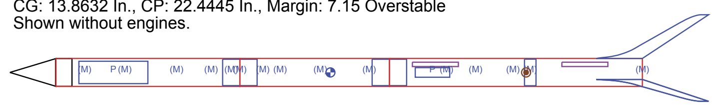
I know a lot of readers are creating some nifty new designs with RockSim. The purpose of this column is to share some of those designs with other users of the software. If you have one to share, please send it to us!

The “Streamline” comes from 16-year old James R. Adams. He writes about it:

“I have always dreamed of having/helping with a satellite so I figured that it had better go high. I started designing it and the design just kind of fell in place. I then started to research some electronics for it since it was going to go so high, so I bought and incorporated the electronics into it which made the design quite different (also an altitude decrease of about 3000 ft). I was kind of disappointed about the altitude decrease but it still seemed pretty good. I thought it was great, but then my little brother had a scout water rocket build and he wanted a good fin design so I designed the fins, put them on this one and the altitude increased. I kept tinkering with it for a couple of months until I decided that it was perfect. It looks awesome but not quite what someone would think of (at least me), as a typical looking model rocket. I tested it with some smaller engines (D-12) for about 8 times until I got everything synchronized with the electronics and real world happenings (so some of the small but important details aren’t actually in the RockSim design file). I am very pleased with it and eager to test it to its limits (the cold winter came on, so I haven’t finished testing yet but I’m very excited and pleased). Rockets are awesome!”



Streamline by James R. Adams
Length: 30.3800 In. , Diameter: 1.2100 In. , Span diameter: 4.9900 In.
Mass 178.836 g , Selected stage mass 178.836 g
CG: 13.8632 In., CP: 22.4445 In., Margin: 7.15 Overstable
Shown without engines.



Download the design file at: www.ApogeeRockets.com/education/downloads/streamline.zip

EMRR Corner

Here’s the summary of a featured tip that will help in ***“Strengthening Paper Model Rockets”***:

(1.) Use internal centering rings and foam board to add strength

(2.) Coat the inside of the rocket with glue

(3.) Coat the rocket using something like Mod Podge (try airbrushing it). Also coat the rocket first with an acrylic clear coat so that the ink does not run when applying the Mod Podge. Try to put on 3 or 4 coats.

(4.) Last, but not least, bulk up your fins by placing additional card stock or balsa in the fins. This only works if the fins have space internally for the added card stock.

For the full tip and all the pictures, visit EMRR!

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KIT OF THE MONTH

Apogee 1/70th Scale Saturn 1B

Apogee 1/70th Scale Saturn 1B
Skill Level: 5 - Extremely Challenging
Recovery type: Two nylon-cloth parachutes 36 inches, and 24 inches.
Length: 38.3 inches (97.3 cm)
Diameter: 3.78 inches (9.6 cm)

The reason the Saturn 1B ranks on top of your list of favorite rockets is because it includes the eight fuel tanks in a big cluster, the unique transition section that conforms to the eight tank tubes, and eight fins — twice as many as any other NASA rocket. Plus it has a lot of corrugations that give the rocket surface texture. Finally, it has an elaborate paint pattern that makes it really eye appealing.

When you tell your friends that you built the awesome Saturn 1B, their jaws will drop in disbelief. Surely something as handsome as the beautiful Saturn 1B you're holding couldn't have been built by you?

Most people wouldn't even dare to undertake such a intricate looking rocket. But you're different.

Photo by Joyce Guzik

You know this kit is less complex because it comes with a special video instruction book. You'll be learning the techniques simply by watching the little assembly movies. When you're done, you'll have a huge sense of accomplishment and a can-do attitude to tackle other complex looking rockets. Once you make this one, nothing will seem to challenge your skills.

This is a museum-quality rocket kit — it actually is on display in several museums! Get your's today.

Kit Features

- 29mm Motor Mount
- Cast-Resin Fins
- Injection Molded Capsule, Escape Tower, Nozzles, RCS motors and Tank Skirt
- Intricate Vacuum-Form Stringer Wraps
- Embossed Transition Wrap
- High Quality Water-Slide Decals
- Premium Quality Body Tubes
- High-Strength Rip-Stop Nylon Parachutes
- 4 hours of Video Instructions
- Lightweight Cardstock Centering Rings
- Removable Display Nozzles

For more detailed information, go to:
http://www.ApogeeRockets.com/saturn_1B.asp

Question & Answer Corner

Why Not Use A Huge Static Pressure Port For Your Altimeter Bay?

By Tim Van Milligan

Robert K. asks: *"Why is the size of the pressure equalization ports drilled into the body tube when the payload is an altimeter important? Intuitively, it would seem the bigger the better."*

Answer: I agree that a big hole seems more logical. After all, the pressure inside the tube would seem to stabilize faster if the air was allowed to go in and out of the rocket faster.

The altimeter measures static pressure. There is also dynamic pressure, which is the pressure difference produced by flowing air. For example, air flowing over the top part of an airfoil will have a lower pressure (the dynamic pressure) than the surrounding air (the static pressure). The difference between the two causes lift on the wing.

I think that if the hole is too big, you run the risk of creating whorls of air inside the rocket. So now you're not measuring static pressure, but dynamic pressure. Dynamic pressure being lower, it would give a false reading of the rocket being too high.

If you need an altimeter, Apogee Components has one for you. Check out our web site at: www.ApogeeRockets.com/altimeter.asp