Apogee Components

PEAK OF FLIGHT

NEWSLETTER

Trimming a Rocket Boosted Glider

How to get that perfect glide with the least amount of effort (Part 2 of 2)

RockSim Design

The FLASH GORDON Rocket by Ed Schwerkolt and John Coker

Rocket Questions & Answers

EMRR Corner

Kit of The Month

The Apogee Saturn-1B

Photo by: Steve Jurvetson

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ISSUE 205 MARCH 25, 2008

Trimming A Rocket Boosted Glider - Part 2

By Tim Van Milligan

In the last issue of Peak-of-Flight Newsletter, (http://www.ApogeeRockets.com/education/downloads/Newsletter204.pdf) you learned about the importance of a glider's neutral point (where is is optimally balanced), and that there were basically two schools of thought on glider trimming. They are: 1) keep the CG in a fixed location based on the neutral point, and 2) allow the CG to be movable, but don't adjust any control surfaces, which allows a higher boost.

You'll have to decide which approach to use. But once you decide, the next step is to begin trimming the glider for a nice stable flight. The rest of this article explains how to do this.

Flight Trimming Techniques For A Glider With A Neutral-Point Based CG Location.

At this point the glider should be ready for its first hand-toss. Find a grassy area without any trees or other obstructions. Don't throw the glider indoors, as you'll damage both the glider and furniture in the room.

On the first toss, give it a gentle throw. A slight flick-of-the-wrist is all you need to send it on its way. Watch the glider to see if it's about to do something drastic, like pitching upward into a stall, or rolling over on its back and diving straight into the ground. If you built your glider straight-and-true and have it balanced at the correct CG spot in front of the neutral point, it will typically do a slow nosedive.

The ability to pull out of a dive is controlled by the decalage angle. "Decalage" is a negative incidence added to the horizontal tail so that the trailing edge is higher than the leading edge. The larger this angle, the faster it will pull out of a dive. Too much decalage angle, and the glider nose will pull up so high that the wings will stall (lose the ability to generate lift) and the whole glider will drop down. You'll then see it porpoise up and down as it travels away from you.

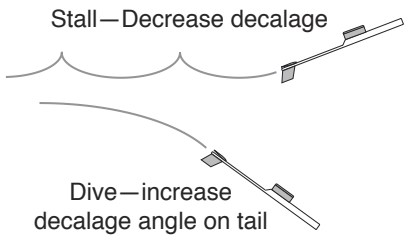

Figure 8

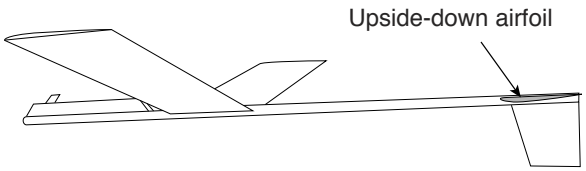

Figure 9: An alternative to decalage is to use a cambered airfoil, but with the curved side downward.

An alternative to the decalage is to use an upside-down airfoil, similar to what you'd sand into the main wing of the glider (see Figure 9). Typically, the decalage angle is so small that you shouldn't have to go to this extreme.

The optimum decalage angle is so that the glider does pull the nose up, but does not stall. This angle will give you the lowest descent rate.

Once the horizontal stabilizer is glued to the model, changing the decalage is then done by warping upward the trailing edge of the horizontal stabilizer. Since you're adjusting the trailing edge, during assembly you should only glue down the front 2/3rd's of the horizontal stabilizer to the fuselage boom.

To warp the wood, begin by adding a drop or two of water to the underside of the horizontal stabilizer. Work that water into the wood along the trailing edge of the part. The water will soften the fibers in the wood making them pliable. After doing this, gently bend the trailing edge of the horizontal stabilizer upward slightly to add decalage to an already constructed glider (see Figure 10). Typically incidence angles will be very small, about 1°-2°. Angles greater

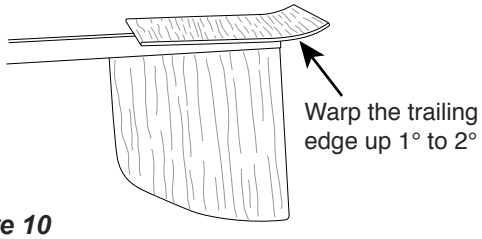

Figure 10

Continued on page 3

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Continued from page 2

Trimming A Rocket Boosted Glider - Part 2

than this may cause the model to loop during the boost phase of the flight. To hold the edge at this angle while the wood dries out, wedge some paper between the underside surface of the horizontal stab and the fuselage boom. Some modelers will use discs of paper made with a paper-hole punch. You can even leave the disks there during the flight to insure that the decalage angle holds.

If the glider pitches up on the first light toss, and it is balanced at the correct CG location, then you have too much decalage built into the horizontal stabilizer. You may need to pry it loose from the fuselage boom and reattach it at the slightly upward angle. In the hand-launched-glider trimming technique, it is not desirable to add nose weight, as that will mean the glider is not balanced at the neutral point position. It is preferred to reduce the incidence angle on the tail surface.

Once the glider is flying fairly level, it is time to throw it harder to see how it will fly at speeds it will typically glide at.

If the glider wants to bank to one side, the problem is that one wing is producing more lift than the other one. For example, if the glider rolls to the right, then the right wing isn't producing as much lift as the left. Another cause may be that one wing is heavier the other. Either way, you'll have to change the airfoil shape by sanding the wing that is dipping. It needs more curvature in it, so sand the top-side of the trailing edge portion of the wing so it is thinner. The added benefit is that this also removes excess mass from the wing so that the little bit extra lift will have a more pronounced effect.

If sanding the wing doesn't fix the roll problem, you'll need to proceed to the next step and warp the wing a little bit. Warp the trailing edge downward, to give it more curvature. This will increase the lift of the wing that is dipping. You can also give some curvature to the other wing too, but instead of warping the trailing edge down, warp it up so that the lift of the wing is reduced (see Figure 11).

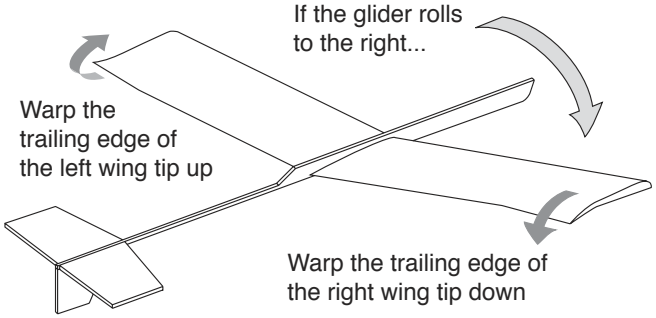

Figure 11: How to correct a glider that rolls to one side. If it banks to the left, reverse the instructions shown here.

Continued on page 4

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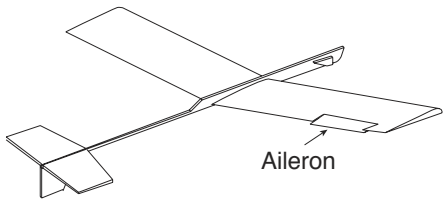

Figure 12: Ailerons increase lift on a wing, and cause the glider to turn.

When warping the wing, only work on the outer third of the wing. It will have the greatest effect. Avoid warping the inner wing panel trailing edges up at all, as this can lead to spiral dives.

If reshaping the wings does not fix the problem, try adding a small amount of clay to the bottom-side-tip of the other wing. This is a last-resort method to fixing a problem rolling tendency.

On actual launched models, it is nice to have the model fly in a gentle circle. This allows the model to stay in a thermal, thereby keeping the model in the air longer, and it also keeps it from flying downwind too far. There are many ways to cause the model to turn. These include deflecting the rudder, adding ailerons (Figure 12) or warping the main wing (Figure 11) to cause one wing to dip, tilting the horizontal stabilizer at a small angle so one tip is higher than the other, or by making one wing slightly heavier. These last two methods — tilting the horizontal stabilizer or adding a tiny amount of weight to one wing — are preferred, because neither of these methods will affect the boost of the model.

If you add weight to a wing tip, you will probably need to remove a touch of mass from the nose of the glider. This should prevent the turn from becoming a spiraling death dive. A tightly turning glider is actually in a dive, so reducing nose mass or giving it a tiny bit more of tail decalage is the correct cure.

Tilting the stabilizer is always a good idea, since it doesn't affect the model's rocket boost, and the mass of the glider is kept lower, allowing higher flights.

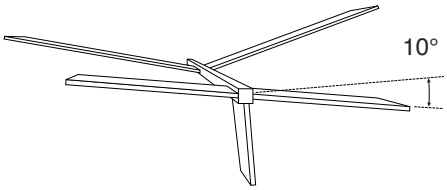

Figure 13: Rear view of a simple glider. Stab tilt will cause the glider to make a turn to the left.

The other two methods — changing the rudder or adding ailerons to the wing (or warping the wing) — will affect the boost of the model. Aileron deflection and warping a wing will cause the model to perform barrel rolls as it climbs skyward. This has the benefit of making boosts more vertical, but it also reduces the maximum altitude of the model because of higher induced drag. However, doing barrel rolls on the way up is better than pitching up and looping while under thrust.

Deflecting the rudder is common in hand-launched gliders to induce a turn in the model's flight. But in rocketry the deflected rudder will cause the model to turn during boosts too; and the turn gets worse as the speed of the model increases. This could be dangerous and should be avoided, as it is certain destruction for the model.

If the model's natural turning ability begins to deteriorate into a spiral, it indicates

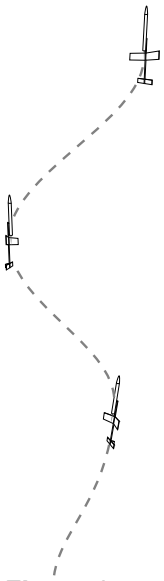

Figure 14: A barrel roll on boost is a sign that one wing is producing more lift.

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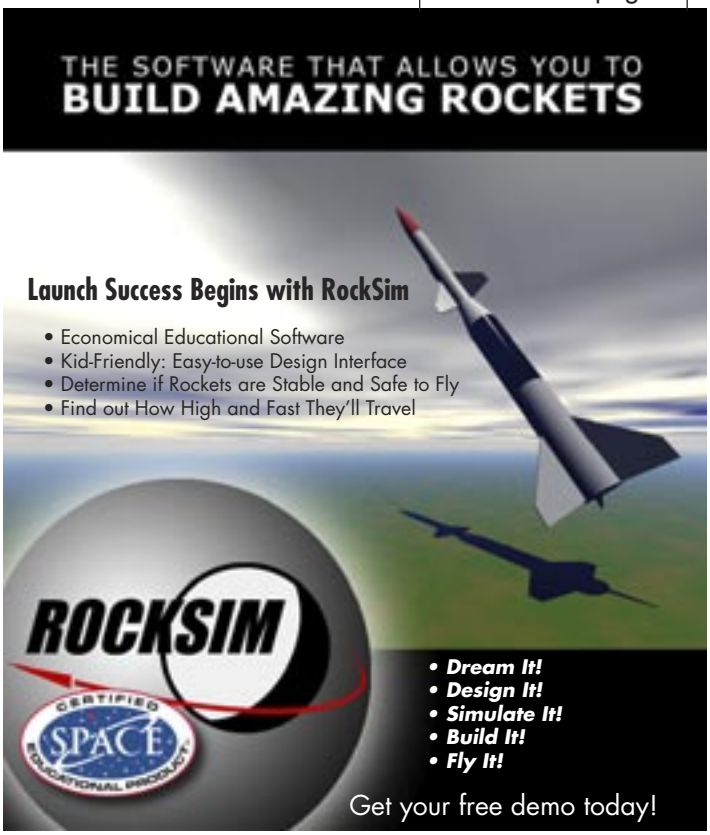


Continued from page 4

Trimming A Rocket Boosted Glider - Part 2

Figure 15: A mis-aligned rudder will cause a turn during boost.

insufficient roll stability in the glider. This is corrected by giving the wings greater dihedral. This should have been done during the construction phase of flight, by mounting the wing so the tips are elevated at an angle of 10°-13°. Adding dihedral to an already constructed model is very tricky, as just the tips of the wing would be cut off (equally) and reattached to the rest of the wing at a greater angle. This is known as tip dihedral.

Before you're ready to launch the rocket, give it one last hard throw at a 45 degree angle up and to your right, and with the wing banked at the same 45 degree angle. The model should slowly roll to the left, changing from a right turn to a left turn. If all is well, the model will gently circle 30 or more feet overhead. If not, you need to do some more flight trimming.

Trimming Method for Optimum Ballistic Flight.

As stated in Part 1 of this article, the key difference of *optimum ballistic trimming* is that everything about the glider needs to be built "flat." No warping of control surfaces is permitted, as that will cause a non-vertical boost and a loss of altitude of the rocket.

This key difference makes it critically important that the glider is very well constructed and balanced. You can't have one wing that is heavier than the other, or the model will start to turn and could end up in a death spiral.

The only surface that is allowed to be warped is the trailing edge of the horizontal stabilizer. It can be bent upward to give the correct amount of decalage for the model to pull out of a dive (Figure 10). But it has to be so slight that it doesn't cause a lot of drag on launch.

The other characteristic that is shared with the hand-launched-glider technique is that the horizontal stabilizer is tilted to induce a left-hand turn (Figure 13).

The good news is that the CG point is not fixed. Here you can add or remove nose weight to the glider to get a good steady glide. But remember that the more nose weight you add, the heavier the model will be and therefore it won't boost as high into the sky and it will take longer to pull out of a dive.

More Information On Glider Trimming

The 3rd Edition to the book Model Rocket Design and Construction (http://www.ApogeeRockets.com/design_book.asp) will have more information on how to trim gliders for awesome flights. You can reserve your copy today.

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 File

The "FLASH GORDON" Rocket - Submitted by Ed Schwerkolt

Ed writes: *"Funny how things add up; last week I was looking for some paint schemes for a V2 and I ran across John Coker's site. Then you published an article about his work.*

On his site I found a neat rocket I had forgotten about — the rocket from the Flash Gordon Series. I use to go to the movies on Sat mornings to watch the old serials.

So I have decided to build a Flash Gordon rocket.

Attached is a RockSim file I worked up to build a 40" model (probably out of turned foam). I saw somewhere you were interested in unusual plans, so here is one.

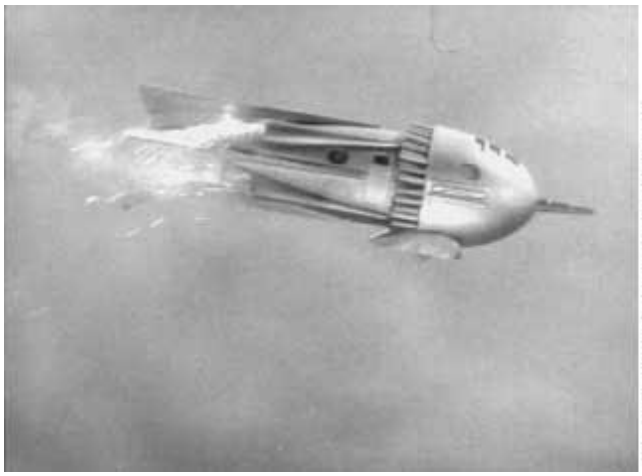
Since the rocket is more then a NCF, it took a bit of work to get it into RS. I have also included the decals you see in the still pics.

Note in the remarks that John is credited with the original grunt work and his website is noted. I wrote to him to ask if ok to send to you and he agreed."

You can download this RockSim design file, which includes the decal artwork at: http://www.ApogeeRockets.com/education/downloads/Flash_Gordon.zip

Ed is modifying a RockSim design by John Coker, who is in the midst of building a high-power version of this rocket. Check out John's project at: http://www.jcrocket.com/flashgordon.shtml

If you have a unique RockSim design file you'd like to share, please send it to us. We'd love to print it here!



Flash Gordon Conquers the Universe
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MAKE STORIES HAPPEN – FLY ROCKETS!

A group of friends and I were out on the windswept plains of Wyoming launching some rockets. All launches were great and each one was captured on film and video. We got down to the last rocket, my Delta-29 which was loaded with a NCR F62-4* Darkstar Motor (my first time with that beast!). Well, according to the manufacturer limits, my heavy rocket was at the maximum weight to lift. We had never launched anything this powerful, so we kind of crept closer to the pad (still around 15 feet away). I had the camera going and I still laugh when I hear myself replayed, "Okay, this one is heavy, so it'll probably sit for a second and lift-off slow." Hah! The next thing on the video is a gush of thick black smoke and a bunch of guys (scared out of their pants) hollering 'words of awe'! We had never seen anything like it. The rocket ripped off out of site atop a column of smoke so vivid it looked like a SAM launch! The Delta-29 recovered nicely about a hundred feet downrange, and we still comment on the first time we used that motor. It's now one of our favorites, and we like to use it as a finale. The look on peoples' faces is priceless!

- J.J. (Wyoming)
*The Darkstar motor is no longer available from Estes/NCR

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Question & Answer Corner

How Do You Find The Drag Coefficient With A Wind Tunnel?

By Tim Van Milligan

Bernie Herman asks: *"Almost every time I see something talking about the coeffecient-of-drag, it states that it is a valueless number, and that the only truly accurate way to determine it is with a wind tunnel. If you have the wind tunnel (or plan on making one soon), how do you determine the CD?"*

Answer: The first thing you have to do is measure the drag force on the rocket in the wind tunnel. At that point, finding the Cd is pretty easy. You look at the equation for Drag, and you solve for the Cd term.

From the Drag formula:

$$\text{Drag Force} = \frac{1}{2}\rho V^2 C_d A$$

Where:
D = Drag
ρ = rho = Density of the air
C_d = drag coefficient
V = velocity of the air flowing through the tunnel
A = reference area—usually it is the area of the base of the nose cone (or largest diameter of the rocket).

Just turn the equation around and solve for Cd after measuring the force on the rocket in the wind tunnel.

$$C_d = \frac{2\ \text{Drag Force}}{\rho V^2 A}$$

The hardest part is actually measuring the drag force on a model rocket. Since the model is small, the forces acting on the rocket in the wind tunnel are very tiny. You need highly accurate measuring devices and very smooth airflow in the wind tunnel. If the airflow becomes turbulent at all, it will change the forces acting on the rocket and screw up the results.

If you have a question that you'd like answered here in this newsletter, please let us know.

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KIT OF THE MONTH

Apogee 1/70th Scale Saturn 1B

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.

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)

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