# *Backslider: The Super Roc Rocket Glider*

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For decades, rocketeers have noticed that some rockets, particularly long, skinny ones, will glide backwards if they fail to deploy their parachutes. Modelers usually dismiss such recoveries as "dumb luck," but I knew better. Back in the 1970's, I had built a kit by the long-dead manufacturer, AVI, called the Lineaus Gigantus. This rocket carried no recovery system, but rather popped its nose and glided backwards in what the instructions called "Float Recovery." In the 1990's I had used this recovery system in a long scale model of the Hyperion sounding rocket to get qualified flights in NAR Rocket Glide competitions. In the late 1990's, ideas about stability and angle of attack were in the air in the modeling community. In the internet newsgroup rec.models.rockets, hobbyists were discussing how otherwise stable rockets could be unstable at boost and how the swing stability test gave false negatives. At about the same time, I saw a NARCON R&D competitor detail how center of pressure varies with angle of attack. Surrounded by the idea that a rocket could be both stable and unstable, depending on angle of attack, it dawned on me that this could explain the mystery of the gliding super roc.

After NARAM in 1999, my brother Bob and I formed the "Bumbling Brothers Flying Circus," an NAR contest team. We needed an R&D project for NARAM 2000, and settled on a systematic examination of backwards-gliding super rocs, testing my pet theory and optimizing the design of these rockets.

We begin with the basic idea of model rocket stability—the center of gravity (CG) must be ahead of the center of pressure CP) if a model is to fly straight. The center of gravity is easy to understand—it's the balance point of the model on the ground, and most importantly, the rocket's natural pivot point in flight. The center of pressure is more subtle—it is the average point where sideways aerodynamic forces act on a model if the rocket isn't pointed straight ahead. If the air pushes sideways on average behind the CG, the pressure acts to restore the model to straight flight. If, on average, the air pushes sideways ahead of the CG, the pressure will push the rockets nose aside, turning the rocket around.

You can find the CG of a model by balancing it on one finger. The CP is trickier. The first model rocketeers used the cardboard cutout method. They would cut out a profile of the model from cardboard and balance the cardboard cutout on a pencil. Technically the cardboard cutout's balance point is the center of lateral area (CLA). This venerable method turns out to be accurate only for a model traveling directly sideways—a 90-degree angle of attack. Fortunately, the method is very conservative; a conventional rocket that passes the test will be stable. Unfortunately many stable rockets failed the cardboard cutout test.

Then Jim Barrowman showed us the way to calculate the CP for models at low angles of attack - models that were already traveling forward. Unlike the cardboard cutout's CLA, Barrowman's center of pressure (BCP) is not affected by the models body tube—only the fins, nosecone, and transitions come into play. The result is that the BCP can be very far from the CLA, especially in long models with long tubes. Usually the BCP is behind the CLA. Since stability requires the center of pressure to be to the rear of the CG, many models that test unstable with the cardboard cutout method are indeed stable according to Barrowman. Flight experience has proven Barrowman right.

We are interested in models that pass the Barrowman test—the CG is in front if the Barrowman CP (BCP), but fail the cardboard cutout test—the CG is behind the CLA. This can be bad if you launch from a short rod in high winds; an otherwise stable model goes unstable. But our hypothesis is that this condition, a CG ahead of the Barrowman CP, but behind the center of lateral area, leads to a miracle.

Such a model is stable under boost, going forward as long as the angle of attack is low, but it can experience a high angle of attack if it is pointing straight up at apogee. When it experiences a high angle of attack for a moment, and loses its stability. When the air hits the model moving sideways, the model wants to point so that its CG is ahead of the CP. But at high angles of attack, the CP is the center of lateral area, which is ahead of the CG. The model wants to point backwards. But if the model goes straight backwards, the angle of attack goes low again, and now the CP is ahead of the CG. The model wants to turn around again. The model wants to crash, but backwards or forwards? It settles into a compromise angle of attack moving backwards. It glides.

I have seen this phenomenon many times while string-testing models without recognizing what was in front of my eyes. Often a stable model will fail the string test, its tail pointing vaguely forward. You can feel the drag on the model as you try to get it to swing around you. Yet you can start that same model with a good throw as you start the test, and it will point dead straight ahead, whirling easily around you. Those two tests of the same model show the backwards glide mode and boost mode of a backslider.

This recovery system requires the rare circumstance of a perfectly vertical apogee. However there are other ways to reach the state of a high angle of attack. It's not rare to see a model settle into a glide backwards glide when it blows off its nosecone. Bob and I schemed up a project to study a "Nose Blower" rocket for our NARAM R&D project. But it left us wondering how to calculate the CP of a model with a nose cone hanging out on a flexible shock cord. We decided to try a fixed-geometry model, letting the ejection charge vent out a couple forward-facing holes and kicking the model backwards. Then somehow an idea emerged—why not just one hole in the side of the tube? We really wanted a high angle of attack, and didn't care how the rocket got into that state. A simple hole punched in the body tube near one end of the tube would act as a little control thruster when it directed ejection gasses out the side of the model, rotating it into a high angle of attack. And so the Backslider was born.

Bob got things moving by building modular backsliders. The minimum diameter BT-20 models consisted of a 4:1 contest balsa nosecone from Balsa Machining Service, a 34" section of Totally Tubular T-20 with a hole punched near the front end, and a fin unit made of 2.75" of BT-20, a tube coupler that doubled as an engine block, and three square fins of varying sizes (if you don't paint or weight the model, fins between 1" x 1" and 1.5" x 1.5" work). We used electrical tape to hold the three components together. The models had absolutely no moving parts—the engine was fixed, the nose was fixed, and the fins were fixed. The only thing that moved was the gas from the engine during boost and at ejection. For the R&D project we explored the space of CG-CLA-BCP relationships with these models to test our hypothesis and maybe optimize the design.

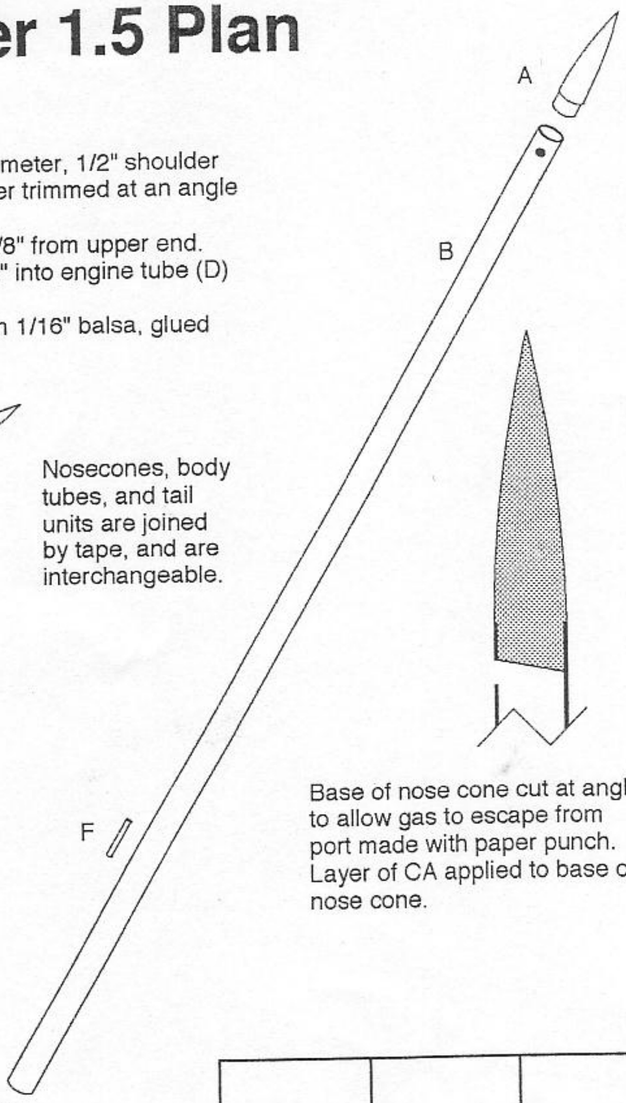
It was gratifying to see the model tumble end-over-end at ejection and then settle into a glide. Our little ejection port pitch maneuver always works. We found that we didn't see a glide over the entire range of CG-CLA-BCP relationships we had predicted, but the phenomenon is reliable if the CG falls in the rear half of the space between the CLA and BCP. We also found that if the model spins on descent it will fall sideways over a wider range of CG-CLA-BCP relationships. Our complete R&D report is available on the internet at http://members.aol.com/petealway/srrg.htm.

Since NARAM 2000, I've been flying a mini backslider—a minimum diameter BT-5 model—frequently at club launches with 1/4A's and 1/2A's. The model failed to glide only once, when I forgot to tape the engine in place. Bob has been experimenting with asymmetrical fin arrangements. Together we have applied for a patent on the Backslider. As far as we can tell, the no-moving-parts super roc rocket glider with the pitch maneuver is original.

# Backslider 1.5 Plan

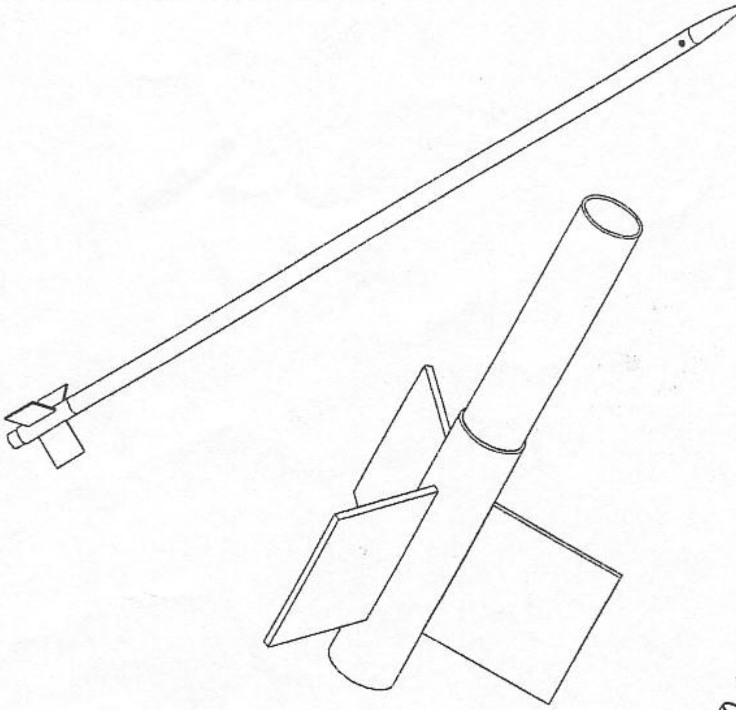
Parts

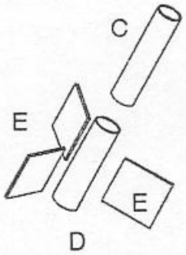
- A Nose Cone, Balsa Machining service, 3" long ogive 0.736" in diameter, 1/2" shoulder 0.710 in diameter, made from lightweight contest balsa. Shoulder trimmed at an angle to allow ejection gas to reach port in tube
- B Body tube, Totally Tubular T-20, 34" long, 1/4" punched about 3/8" from upper end.
- C Tube coupler, Totally Tubular 3" long coupler for T-20, glued 1/2" into engine tube (D)
- D Engine tube, 2.75" long BT-20 (Totally Tubular T-20)
- E Fins, three 1.5" x 1.5" squares (or fins of the same area) cut from 1/16" balsa, glued 180° apart, centerd along length of enging tube (D)
- F Launch Lug, at center of gravity.



Nosecones, body tubes, and tail units are joined by tape, and are interchangeable.

Base of nose cone cut at angle to allow gas to escape from port made with paper punch. Layer of CA applied to base of nose cone.





Center of Gravity:
Our successful test model balanced 28" from the nose tip with the engine in place. A models with a CG 2" more forward crashed. I suggest a balance point 28"-30" from the nose tip, or if you substitute a nose cone of a different length, 7"-9" from the rear of the main tube, B.