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NEWSLETTER

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ISSUE 245 OCTOBER 6, 2009

Rocket Plan: The "Kink" Superroc Rocket

Written By Tim Van Milligan

In Peak-of-Flight Newsletter 243 (www.ApogeeRockets.com/education/downloads/Newsletter243.pdf), I showed the development of the Fly-Apart Rail Guides. As I began writing that article, I thought there would be room enough in the issue to present plans for the 13 foot tall Superroc-style rocket. Unfortunately, there wasn't. So in this issue, I will give you the plans for the model.

I actually flew this rocket, and unfortunately, it bent in three places. The reason it crimped is that the top five feet of the rocket were unsupported and bending in the wind while the rocket sat on the launch pad. Because the tip of the rocket was going in one direction and the rear in a different direction, it didn't stand a chance. It kinked about 20 feet after it cleared the launch rail.

Hence the name: "Kink." I decided to have a little fun with the name. If you can't poke fun at yourself when things go wrong, you might be in the wrong hobby.

Will it kink for you? That is a good question. There is always a chance that these supperroc models might kink. I think that if you fully support the entire length of the rocket prior to launch, there is a much better chance that it will fly fine. That was the whole purpose of using the rail launcher in the first place.

There are a few other things you have to watch out for when building with these long superroc models that have a bearing on if it will kink. First of all, you have to make sure that the tube joints are absolutely straight, and second, you want the tubes as stiff as possible. A layer of fiberglass cloth over the tubes isn't a bad idea, although it will add weight to the rocket.

Figure 1: The 13 foot tall Kink superroc.

Design Philosophy

When I created this design, I wanted the rocket to be pretty light weight, since it was for a rocket contest, and yet use off the shelf components. It was designed for F-engine motors, which meant I had to make the engine mount section at least 29mm in diameter. But to keep the weight low, I decided to transition the diameter down to something smaller near the top of the rocket. If you take a look at Figure 2, you'll notice that the diameter steps down three times from the largest diameter of 29mm at the base of the rocket.

The trade-off of doing this is that the rocket will be less rigid than a rocket with a constant diameter for its entire length. That is a common trade-off in rocketry; strength versus weight. I decided to go for reduced weight.

What is Different in This Design?

In reality, this is a fairly simple rocket, other than a requirement for having three transition sections in the rocket. Basically, it is just a longer model rocket—really long!

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About the only thing that is unique is that I designed the rocket to come apart in four sections. The reason for this is so that it is easier to transport to and from the launch site. Obviously, it would be difficult to strap a 13-foot tall rocket to your car and drive it to the range. But it is reasonable to have four sections that are each a little over 3 feet long stowed in the truck of your car. In fact, it should easily fit inside your trunk, and can be assembled on the field in about five minutes.

Transition Assembly

As I mentioned, the only modestly challenging part of this rocket is making the transition sections and the shoulders where the parts of the rocket are assembled on the field.

I like to use a technique that I have in the book Model Rocket Design and Construction (www.ApogeeRockets.com/design_book.asp) for making a removable transition. When it is done, it will look like Figure 3.

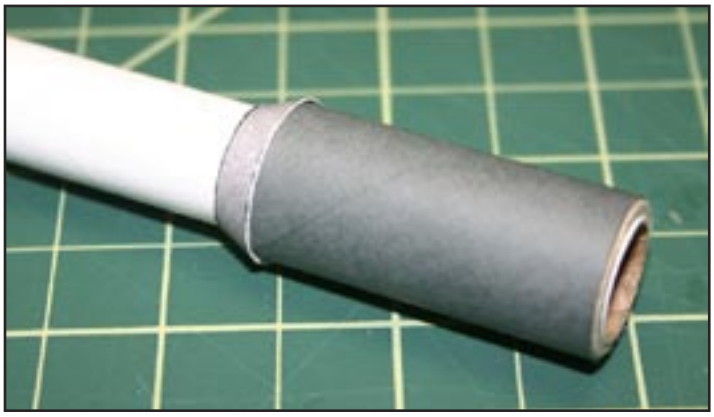

Figure 3: The rocket separates at each transition section. This plugs in to the larger tube below it and is friction-fitted so there is no wobble in the joint.

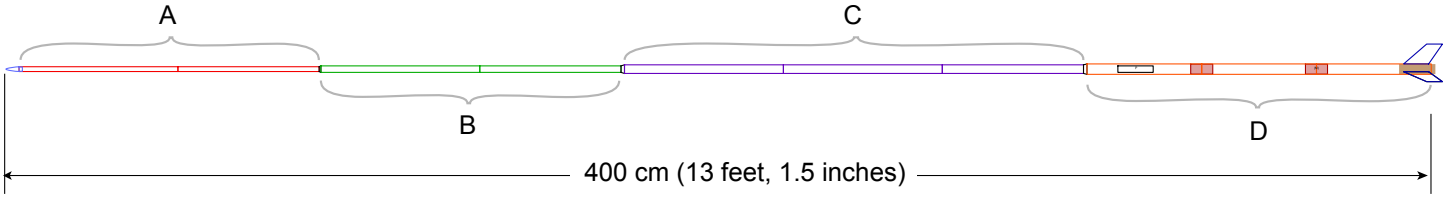

Figure 2: The Kink superroc is built in four sections that are designed to separate for easier transport to and from the launch site.

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What this technique reminds me of is making a custom nose cone. We need a nose part, which will be our paper transition, and then a shoulder that will fit into the tube. The shoulder will be made from a tube coupler, since it is already sized perfectly to fit into the lower tube.

To make sure the upper tube is perfectly straight and concentric with the tube coupler, we'll actually extend the smaller forward tube all the way through the coupler. We'll use a couple of centering rings to align the tubes perfectly. But the standard centering rings are the same outer diameter as the coupler (see Figure 4). To make them fit inside the coupler, you'll need to peel off a few layers of paper. For this, I usually use a hobby knife, as shown in Figure 5.

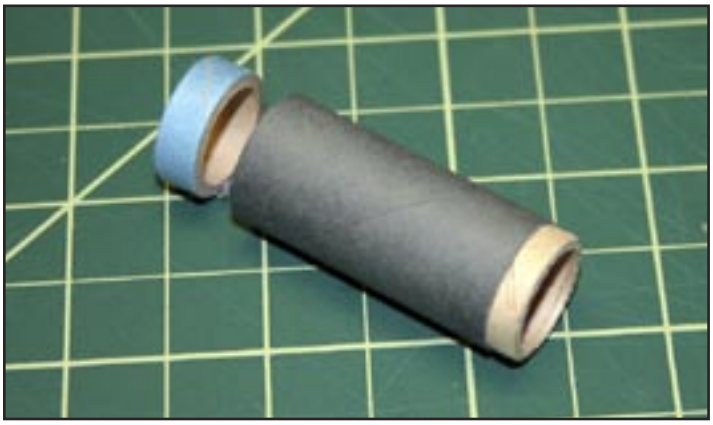

Figure 4: The standard centering rings are the same diameter as the coupler, so they need modification.

Once the rings fit into the coupler, go ahead and dry assemble the coupler on the end of the small tube. Don't glue anything up yet, until you have the paper transition created.

Assembly of the paper transition is the tricky part, es-

Figure 5: To make the centering ring fit, you'll need to peel off a few layers of paper with a hobby knife.

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The "Kink" Superroc Rocket Plan

pecially if you are looking for a nice smooth surface where the edges come together. I've found that it is more "technique" than anything else, which is the secret of getting a good edge joint. If you want to see my personal techniques, you can find it on rocketry construction video #12, which is found on the Apogee web site (www.ApogeeRockets.com/Rocketry_Videos/Rocketry_Video_12.asp).

Once the transition is made, you'll slide it onto the small tube and over the edge of the tube coupler. I like to have the forward centering ring hang out of the coupler by about 1/20th of an inch, so that it gives more surface area for the glue to attach to. That is why I told you not to glue anything up yet. You want the rings to slide around a little bit so you can get everything in a proper position before you apply any glue.

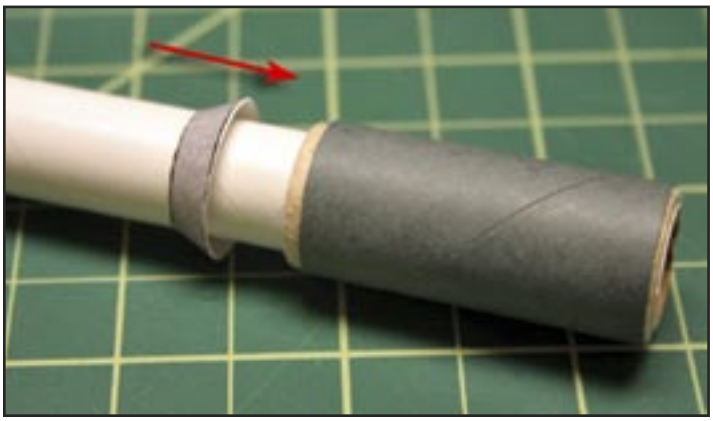

Figure 6: The forward centering ring hangs out of the coupler a tiny amount to give more surface area for the transition to attach to.

You'll notice that on the upper two transitions, the inner tube is open, and not capped off. This means that the ejection charge gases could pass through the entire length of the tube if we wanted. In this design, that is OK. But we're actually not going to let that happen.

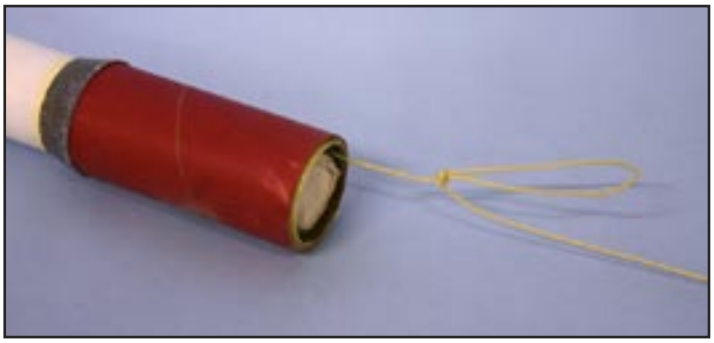

Figure 7: The bottom transition is the only one to be capped off. We'll also need to attach a shock chord to this section to keep the rocket together.

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The parachute is going to be placed in the lowest body tube. Because of this, we only need to cap off the bottom of the lowest transition. We'll also need to attach a shock cord to this transition so that the entire rocket stays together during descent.

Capping it off is easy. One way is to use a balsa block and a metal screw eye, onto which you can attach the shock cord to the upper section. Unfortunately, balsa blocks are expensive, so I capped if off with a disk made from cardstock. I also choose to use 100lb-Kevlar® shock cord (part number 30325 from www.apogeerockets.com/shock_cord.asp). What I did is to tie the cord around the tube, and pass it out the bottom of the coupler through a little notch cut in the aft centering ring. Again, a little notch is cut along the edge to allow the shock cord to pass through (see Figure 8).

In the lower body tube, the shock cord is anchored using the classic Estes-style paper shock cord mount. That is sufficient for this size rocket.

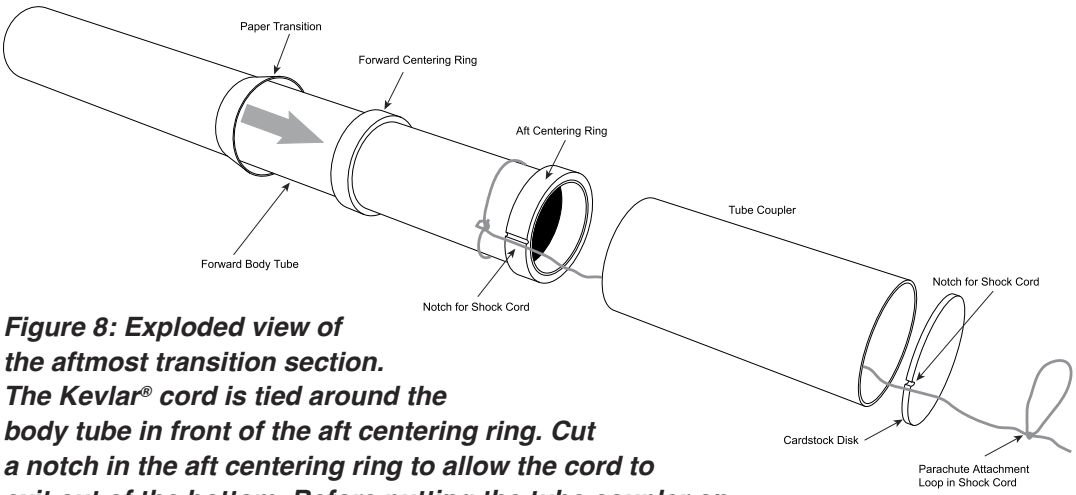

Figure 8: Exploded view of the aftmost transition section. The Kevlar® cord is tied around the body tube in front of the aft centering ring. Cut a notch in the aft centering ring to allow the cord to exit out of the bottom. Before putting the tube coupler on, work some wood-glue into the knot on the shock cord, and where it touches the body tube. This will make it a secure anchor point to keep the rocket together.

Cutting the Tubes to Length

If you use full-length tubes for all the components in this rocket, the overall length of the rocket will actually be too long. Why?

One rule of superroc competition events says that the rocket has to be a certain length. For example, the F-Engine class of events says the maximum length (as measured from the base of the motor to the tip of the nose) is 400 cm. Actually, the rocket can be longer than this. But since you don't get any extra points for the extra length, you might as well

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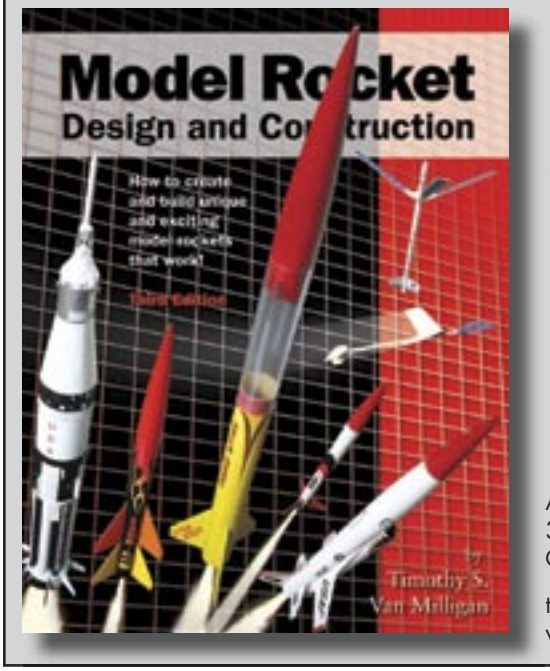

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The "Kink" Superroc Rocket Plan

cut it back to 400 cm. This will make it lighter weight, and should help a little bit with the overall stiffness of the rocket.

Since the rocket breaks down into four sections, you can wait until you have everything together to make the final length cut. I'd cut off from the forward body tube. Therefore, don't glue on the nose cone until after you've measured the overall length of your rocket and have cut that forward section to the correct length. You'll be cutting it down to approximately 13 inches, but the exact length will depend on your construction skills when assembling the transition sections.

The only other unusual thing about the rocket is that it requires the Fly-Apart Rail Guides. The construction of these was covered in Newsletter 243.

As I said at the beginning of this article, make sure all your tubes are perfectly straight when you glue them together. You might consider applying a layer of fiberglass over the tubes to stiffen them up, but that is a topic for a future article.

In conclusion, I think that you'll find that this is actually an easy model to build. And when you fly it, let me know how it does. I'm interested in knowing if your's kinks too.

Parts List

(1) 13mm nose cone (Apogee P/N 19700)
(2) 13mm X 18" long tubes (Apogee P/N 10063)
(2) 18mm X 18" long tubes (Apogee P/N 10086)

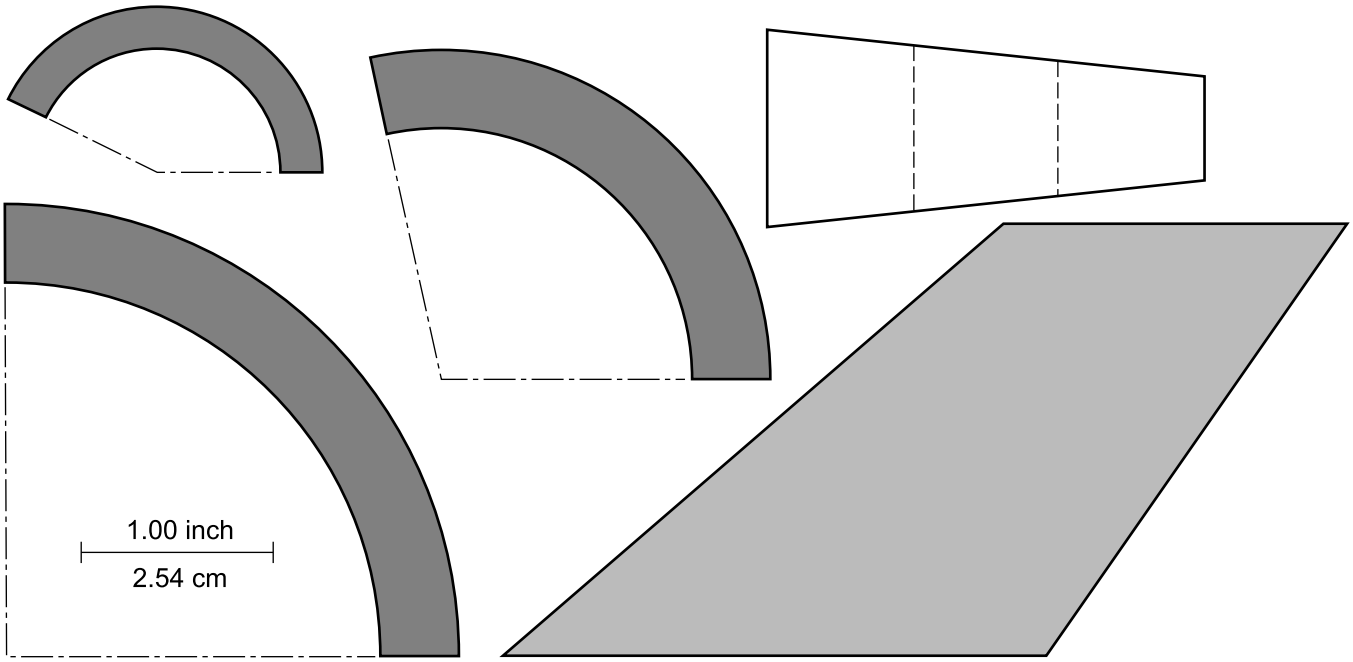

Figure 9: Full-size pattern sheets for the transitions, fins, and shock cord anchor.

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(3) 24mm X 18" long tubes (Apogee P/N 10100)
(3) 29mm X 13" long tubes (Apogee P/N 10111)
(1) Airframe Coupler AC-13B (Apogee P/N 13014)
(3) Airframe Coupler AC-18B (Apogee P/N 13015)
(4) Airframe Coupler AC-24B (Apogee P/N 13009)
(3) Airframe Coupler AC-29A (Apogee P/N 13010)
(2) Centering Ring 13-18 (Apogee P/N 13028)
(2) Centering Ring 18-24 (Apogee P/N 13032)
(2) Centering Ring 24-29 (Apogee P/N 13037)
(1) 24" diameter plastic parachute (Apogee P/N 29116)
(1) Centering cardstock for bulkhead (Apogee P/N 44002)
Balsa Sheet for fins - 1/8" thick

RockSim File

The RockSim design file for this rocket can be downloaded at: www.ApogeeRockets.com/education/downloads/kink-superroc.rkt.zip

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.

Reader Questions and Answers

Responses By Tim Van Milligan

Josh Barnett asks: *"I am in the process of designing my own rocket and I was wondering if long rod-like fins could provide some stability. I have the latest copy of your book; and while it is not listed inside, you would probably know something about it. I was thinking that they would cause less drag and while not providing the amount of lift of the other fins the rocket could be configured so that the small amount of extra stability the fins provided would be all that is needed. Is that possible?"*

The dowels could provide stability. But they are far less effective than the lift created by fins.

To understand this, you'll need to review how stability is defined and how it works. In Figure 1, you see the classic definition of rocket stability. It is when the CG (center-of-gravity) is forward of the CP (center-of-gravity). The CG is where the rocket balances, and is the point on the rocket about which the rocket will rotate.

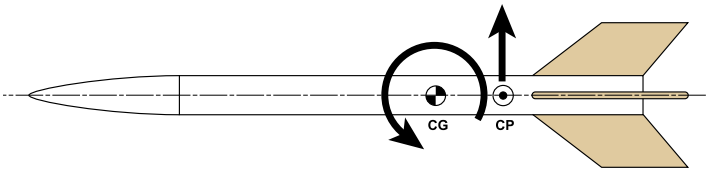

Figure 1: A force at the CP will cause the rocket to rotate around the CG location.

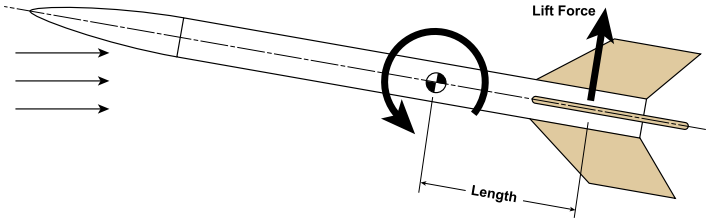

Figure 1: A lift force is created when the rocket travels at an angle-of-attack.

The CP is an imaginary point on the rocket where *all* the aerodynamic forces are said to be concentrated. In real life, there are forces (lift & drag) that are created by all the different parts of the rocket. But to make things simple, we find the balance point on the rocket where the forces in front of this balance point equal the forces behind the point. We call this imaginary point the CP.

The CP point is actually dynamic. That means it shifts positions on the rocket as the forces acting on the rocket fluctuate. For example, if the rocket begins flying at an angle-of-attack, such as shown in Figure 2, the CP will move a little bit further aft. Why is this? The big reason is that the fins create a large lift force.

In response to this lift force, the rocket will rotate around the CG point until the model points its nose back to

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Reader Questions and Answers

zero-degrees angle-of-attack. This is good, and is what we expect.

What I want to point out is that the distance between the new lift force and the CG is quite large. The result of this is that it doesn't take a very big lift force to start the rocket turning back into the direction of travel.

In Figure 3, we see that an increased drag force also arises as the rocket travels at an angle-of-attack. But the distance away (the pivot arm length) from the CG is a lot smaller.

What this means is that it will take a larger drag force to get the same result for the rocket to turn back into the direction of travel. Because of this, we can say that the lift force is much more efficient than the drag force in getting the rocket to behave like we want it to.

But if you are going to use a drag force, it is possible. You just have to make the drag force big, and you have to move it further away from the centerline of the rocket. That is why when you see a rocket that uses dowels for fins,

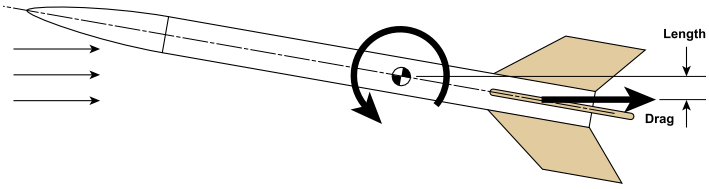

Figure 3: A drag force will also cause the rocket to rotate and try to get it back to 0° angle-of-attack.

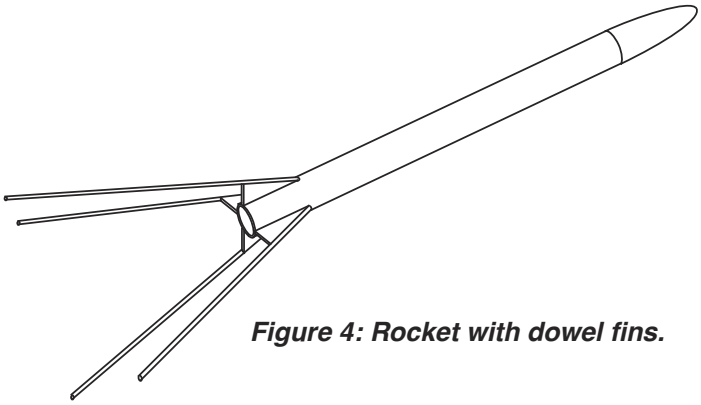

Figure 4: Rocket with dowel fins.

the dowels have to be made quite long so they stick out a distance from the centerline of the rocket (such as shown in Figure 4).

The disadvantage of dowel fins is that the drag is constant throughout the entire flight. You can't turn if off if the rocket is flying straight and true. Lift, on the other hand, does turn on and off during the flight. If the rocket is flying perfectly straight, there isn't any lift force created. So you're not robbing from the speed of the rocket to create a force to stabilize the rocket.

The badminton shuttlecock (birdie) rocket is very similar to a stick-fin rocket. They do work in keeping the rocket really stable, but you pay for that stability in lower altitude (because of all the excess drag).

In conclusion, if you want your rocket to go high, use fins instead of dowels. The lower drag is the reason it will fly higher.

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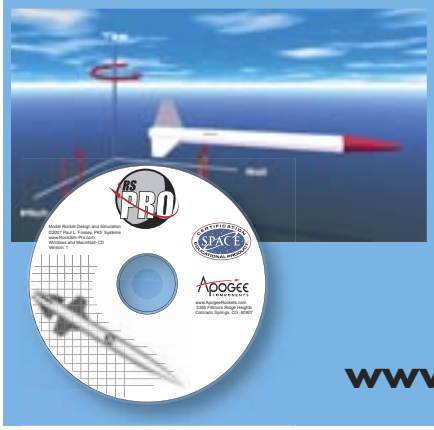

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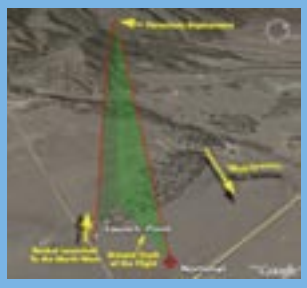

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