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NEWSLETTER

Step-by-Step Instructions: Build a Parawing

Make A Highly Efficient Gliding Parachute For Your Model Rockets

Apogee News

Racing Toward the Finish Line on *Model Rocket Design and Construction*

EMRR Corner

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ISSUE 206 APRIL 8, 2008

Build A Gliding Parachute - Part 1

By David T. Flanagan

Introduction

Most of the parachutes used to recover model rockets are simple devices that generally produce only drag, such as round or cruciform parachutes. They are called "ballistic" parachutes and descend vertically. However, there is another class of parachutes out there called lift-drag parachutes which glide instead of coming straight down. These gliding, lift producing parachutes are far more efficient in retarding the descent of a rocket than parachutes that produce only drag. The drag coefficient of a ballistic parachute is around 1.0, although very lightly loaded competition chutes (which are actually gliding) have demonstrated effective drag coefficients of up to 2.25 [1]. In contrast, considering only vertical velocity (rate of descent), one gliding single keel parawing demonstrated an effective drag coefficient over 6.0, and a twin keel parawing an effective drag coefficient over 8.0 during NASA wind tunnel testing [2,3].

In general modelers do not use these gliding, lift-producing parachutes. Why not? Well, information about full scale gliding chutes is not easy to find, the information that is available is not easy to adapt to a size useful for model rocketry, they are more difficult to build, and are more complex to rig in the rocket.

There are some things to think about before deciding to work with gliding parachutes of any sort

Since there are no reports of research done on very small parawing models, no one knows if the efficiencies of gliding parachutes will fully translate to very small models. NASA generally focused on parawings with keel lengths of about 5 ft. Most rocketeers won't need such large parachutes. Also, to "downscale" these parawings, some modifications need to be made in the design which may also affect efficiency in unknown ways. However, the relative efficiency of gliding parachutes is so great that even if only half of the full scale effectiveness is captured it is still a drastic improvement over the basic ballistic parachutes.

It is very important to be an excellent modeler and to have a great deal of patience. Gliding parachutes require a great deal of both. If you have been building model rockets for long you have probably tried using glide recovery before (rocket glider, boost-glide, etc.) You remember the frustration of building and trimming and flying your first glide recovery models. Gliding parachutes are even worse. They have all the disadvantages of rigid gliders, and a few more as a result of being made of flexible materials. But the payoff of having a highly efficient descent may make it worth the effort.

General Construction Considerations:

Here are three things to consider.

1. Parawings should be made of light flexible material. This of course includes ripstop parachute nylon for larger parawings, but small parawings are easily built from garbage bag plastic or the parts of larger kit chutes. The material should also be impermeable – if you can breathe through it don't use it. You can still make a parawing out of it and it will probably fly, but it won't be as efficient as one made of impermeable material.

2. On larger parawings the material used for suspension lines should be strong and not easily stretched. This is because, unlike regular parachutes, the loads differ on each line of a parawing, so they will not all stretch to the same extent. For smaller parawings this is not a problem – loads are pretty insignificant given the choices of available suspension line material.

3. There are no significant upward size limits for rocketeers – parawings with keel lengths over 25 ft have been flown, and for a time skydivers routinely used both single and twin keel parawings with keel lengths of about 15 to 20 ft, although such large wings required special deployment systems (e.g., sliders, deployment bags). On the small end of the size spectrum fabric stiffness and scaling consider-

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Proofreader: Michelle Mason

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ations are the limiting factors. A parawing with keel length of 25 cm (12 in) has been made from parachute nylon. It actually did open properly and start to fly, but the fabric so easily took a "set" during packing that trim was affected, and flights invariably developed into a "death spiral." A garbage bag plastic parawing with a 40 cm keel length was almost as bad, especially in cold weather where plastic tends to take a set anyway. On the other hand, a nylon parawing of 70 cm keel length flew just fine. A good rule of thumb is 50 cm or greater for carefully built polyethylene parawings, and 70 cm or greater for carefully built nylon parawings. Your first parawing should probably be a larger one.

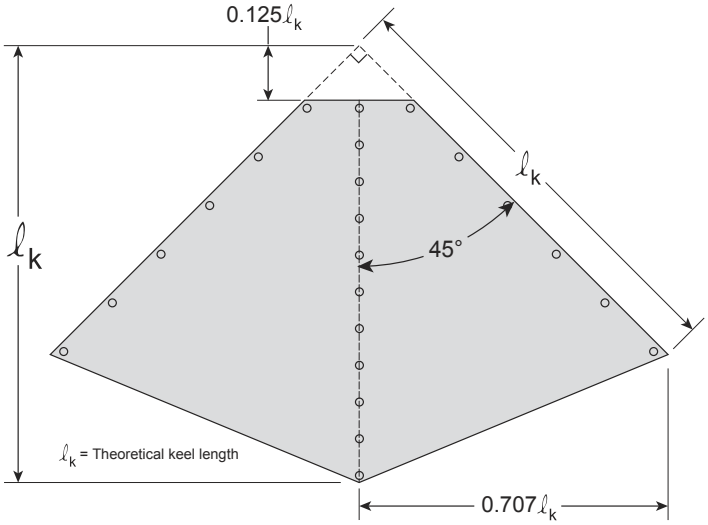

Figure 1a: Single-Keel Parawing pattern. Line locations and lengths are given in Table 1.

By way of example the following sections show how to make a small polyethylene single keel parawing. The material and the manufacturing method can change for other sizes and applications but the basics of parawings as described below will not.

Sizing The Parawing

The size is chosen by selecting the keel length. This is also the reference dimension from which all other dimensions are calculated. The dimensions on the planform sketch and in the table of line lengths and locations are given as coefficients of the reference dimension (keel length) – each of these must be multiplied by the selected keel length to get the actual dimension. Using the metric system is highly recommended. It is much easier to mark a line to a length of 38.9 cm than it is to mark one at 1 ft 3 5/16 in. See Figure 1 for the general planform of a single keel parawing.

In Table 1 eleven keel lines and six leading edge lines are shown. This table is adapted from a wind tunnel study

Continued on page 4

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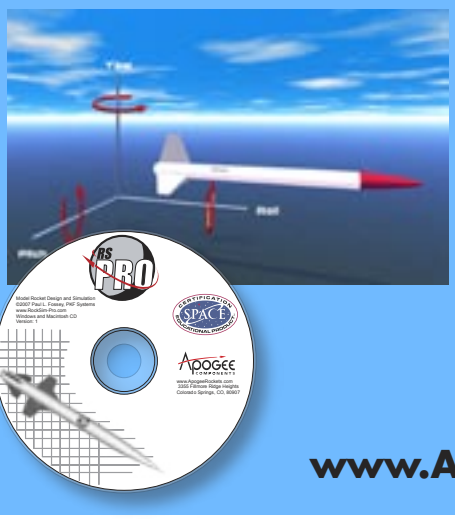

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Build A Gliding Parachute - Part 1

Theoretical Keel Length=	1.000				
Area (standard=	0.692				
Area (very small)=	0.678				
Suspension Line Data					
Keel			Leading Edge		
Line	Location	Length	Line	Location	Length
1	0.125	1.354	1	0.177	1.363
2	0.208	1.350	2	0.333	1.298
3	0.292	1.342	3	0.500	1.254
4	0.375	1.335	4	0.667	1.198
5	0.459	1.317	5	0.833	1.146
6	0.542	1.298	6	1.000	1.255
7	0.645	1.281			
8	0.750	1.263			
9	0.833	1.238			
10	0.917	1.200			
11	1.000	1.403			
Keel line #11 and edge line #6 (bolded) are extra long trim lines (adjusted later)					
For large parawings use all keel and leading edge lines					
For medium parawings skip keel lines 2, 4, 6, 8, and 10					
For very small parawings skip keel lines 2, 4, 6, 8, 10, and leading edge line 1					

Table 1. Single-Keel Parawing. Line locations and lengths given as coefficients of the keel length (reference dimension). Source: NASA TN D 3940 Page 26 Figure 13 Rig A

of parawings with keel lengths of five feet. For large parawings (keel lengths 1.0 m or more) use all the keel lines and all the leading edge lines. For smaller parawings use every other keel line and all the leading edge lines. For the smallest parawings (see Figure 1b) use every other keel line and all leading edge lines EXCEPT the first one at the nose.

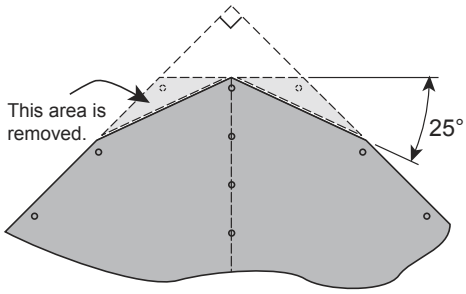

Figure 1b. Nose detail modification for smaller parawings.

Make The Parawing Pattern

Once you have chosen the size make a cardboard pattern of at least half of your parawing (Figure 2). Mark the line locations on the edges. Also write down the lengths of the lines on the pattern. Another way of noting this information on the pattern is to make an Excel™ spreadsheet (or equivalent) that does all the calculations for you – all you have to do is input the keel length. Table 1 is generated from such a spreadsheet with the keel length input as 1.000.

In Figure 2, note the cutout pasted on the planform. It is a printout of an Excel™ spreadsheet that contains all the design data in one place. This is a good idea when designing or building any complicated parachute.

Figure 2. A "half planform" of a parawing having a 60 cm keel length.

Lay out the stock material from which you will make the canopy and tape the corners to keep it from sliding around. Lay the pattern on the material and trace it. Mark the line locations as shown in Figure 3.

Notice in Figure 3 that the printed side of the chute is on the bottom. When the parawing is complete the printed side will be visible from beneath the chute. At this point the outline of the canopy has been traced, and the positions of the line attachment points have been noted.

The keel lines are installed first. In Figure 4, the top

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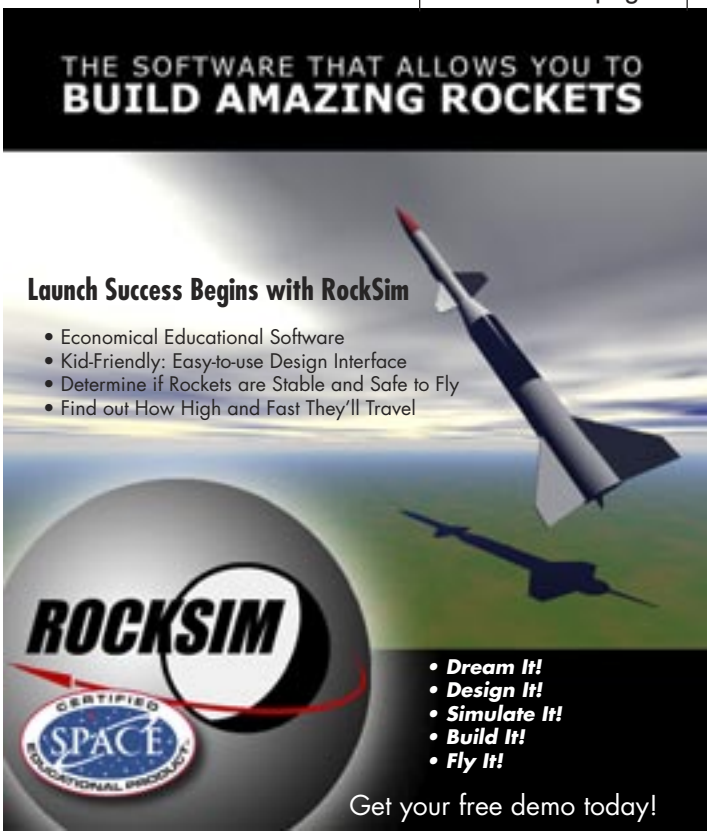

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surface of the canopy is shown with the tail in the foreground (it is flying away from you.)

Figure 3. A 32" Dynastar kit chute is used for raw material for this small parawing.

Attaching The Keel Lines

The keel lines are installed first. Cut all lines to excess length – they will be cut to length after they are attached to the canopy. The first and last (nose and tail) keel lines are installed in the normal fashion, except leave some excess line above the tape securing the aft-most line at the tail. This is used later for flight trimming. All other keel lines are installed from the bottom surface. Punch a hole in the canopy at each keel line location. Thread the line through the hole from the bottom. Lay the end of the line on to the top surface of the canopy pointing towards the tail, and secure it with the sticky dot or tape.

Figure 4. The canopy is ready for the installation of the lines.

Coming In Part 2

In the next issue, we'll finish up the assembly of the parawing, and show how to trim it for an optimum glide.

About the Author:

Mr. Flanagan holds degrees in life sciences and mechanical engineering and is a registered professional engineer in several states. He has held both research and engineering positions with contractors at NASA -JSC, and is currently with Jacobs Engineering at NASA - MSFC supporting the Experimental Fluids and Environmental Test Branch. He is a licensed airplane pilot, ultralight pilot, an expert scuba diver and a former Army paratrooper. He has had a life long interest in parachutes and made his first sky dive at the age of 17. He has made several hundred parachute jumps, holds a master parachute rigger certificate from the FAA, and has completed the University of Minnesota Parachute Technology Short Course. He continues to monitor developments in the field of "aerodynamic decelerators", has made models of most types of parachutes, and has flown most of them in model rockets. He lives in Madison, Alabama, with his wife and two cats.

Figure 5. The nose line (bottom of the picture) and the next two keel lines are installed. Lines are threaded thru the canopy material from the bottom. The end is laid over onto the canopy pointing towards the tail and secured in place.

Home Stretch Reached On 3rd Edition of Model Rocket Design & Construction

By Tim Van Milligan

It is hard to believe it has been 13 years since I wrote the first edition of *Model Rocket Design and Construction.* Was it really that long ago? Sure enough, I just checked my book, and it says copyright 1995. Five years later, I completed the second edition. I was really happy with the 2nd edition, as I added 40 pages worth of information. That book was 160 pages long, and I thought that there wasn't much more I could put into it.

Why hasn't there been an update for eight years? As soon as I completed that book, I started writing the first of these newsletters. My excuse is that I've been putting all my energy into giving you free information in these newsletter. But I feel the time is right for a new edition.

Last November I started putting together an outline of all the good stuff that I wanted in the third edition. In January of this year, I dedicated about four hours per day for the revision process. My goal was to add 20% more to it—about 30 to 40 more pages of new information.

But as I got heavily into it, I realized that I couldn't just plug in the old newsletter articles. For one thing, the writing style was completely different. Then I found that there were a number of holes in the book where I knew people would have questions. I get customer questions all the time, so I knew the areas where the lack of info was.

It turned out to be a bigger challenge that I had originally thought. A lot bigger. Four hours wasn't enough time.

I'm on the home stretch now with the revision. Last Wednesday, I finished the last major piece of writing that I had to do. There is still a lot of work to do, but it is mostly just clean-up work of editing, proof reading, and page layout.

The new book will be at least 288 pages long. That's 128 pages more than the 2nd edition! No wonder I feel that a huge load has been lifted from my shoulders. Looking back on what was added to this book, I can better comprehend the accomplishment.

What's new in it, you ask? I did use a lot of the how-to construction articles that have appeared in this newsletter. For example, you'll find this issue's feature article on gliding parachutes. Having all the information in one book is a lot easier than having to download the articles from the internet. And it will be in formatted in the correct sequence with the basic information that the book already contained.

But there is a lot of new stuff that has never been printed before. I wanted to make sure to do this, so you will have a good excuse to get a copy when the book comes out in a few months. For example, the chapter on rocket construction techniques has a lot more information now; it went from 20 pages to 49 pages long.

One area that I put a lot of work on was classifying the different types of recovery systems used in model rocketry.

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What Are You Trying to Say to Me?

(Just some of the 861 terms defined in the EMRR Rocket Glossary)

Asymmetric Fins - set of fins that are not identical in size, shape and relative position on an airframe.

Butt Joint - A joint made by gluing an edge to a surface, such as a fin to a body tube.

Goonybird - A rocket design series sold by Estes from 1973 -1975. They were described as the "Zaniest flying freaks in the universe".

Launch Happy - Euphoria from being overly addicted to burnt fuel fumes on a particular day. Symptoms include repeatedly launching a model on increasingly more powerful motors until there are no motors left or the rocket shreds.

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New Design Book Coming Soon

In past editions, this part of the book has become one of the most quoted/reviewed sections. I suppose it is because everyone that teaches rocketry to students has to cover the topic of recovery systems. The obvious place to look for that information is in this book.

In the first edition, I had the basic categories that most everyone knows about. You know... parachute recovery, streamer recovery, nose blow recovery, tumble recovery, glide recovery, drag recovery, and helicopter recovery. I think Estes' educational information didn't have nose-blow and drag recovery, so in 1995 I felt personally proud that my little book had something that they didn't have.

The second edition of the book added two more methods that weren't previously classified, bringing the total to nine different recovery types. I was beaming with pride in 2000, because those two little types gave the book some serious sales appeal. But I was a bit crushed when some of the first reviewers gave away the secrets. Some even printed the pictures of them in their own educational publications. Those people won't be reviewing the book this time around.

The third edition will have sixteen different categories! There are two new ones that I had to make up brand new words for, because they had never been classified. I can't take credit for inventing the new recovery types, as I've seen other people fly them in the past. But I do take credit/blame for the new recovery-type names.

I will give you a glimpse of one of the new categories. I cheated... I broke glide recovery into two types: boost-glider and rocket-glider. I figure if the N.A.R. has a good reason for the distinction, that is good enough for my book.

The number of new line-art illustrations is something that I know you'll cherish. It takes an incredible amount of time to make the line-art drawings compared to dropping in a photograph. But they are so much cleaner looking, and it is easier to emphasize the important stuff that rocket designers need to know. That is why I do them. I want you to design *successful* rockets. In fact, I redrew a large number of the old drawings because I felt that they weren't good enough at explaining things.

I added a bit more on building high powered rockets. But Mark Canepa's book *Modern High Power Rocketry* is so well done, that I decided to concentrate on other aspects of rocket design. If you don't have *Modern High Power Rocketry*, you can order it at: http://www.ApogeeRockets.com/Modern_hpr.asp.

Another new section I added in this book is how to accomplish successful parallel staging. You know... strap-on

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New Design Book Coming Soon

boosters! Everyone asks me about them, and I don't think any other book covers this topic. So look for that too.

There is one completely new chapter in this book. It is about using your computer as a rocket design tool. You've probably read in the past that RockSim is a direct descendant of this book. Paul Fossey, the programmer of RockSim, read the first edition of this book, and was so inspired that he contacted me about writing a program to assist rocket designers. And from that, RockSim was born. Because of that, your PC has become probably the most important design tool in your arsenal besides your own brain. That makes it worthy to write about. So the new chapter describes all the neat things you can do to make better models with the help of your computer.

As I said, the majority of my work on the book is done. And it couldn't come soon enough. You see, we're just about out of copies of the 2nd edition. At this point, if you have the 2nd edition, you've got a nice collector's item. I'm not going to reprint more copies.

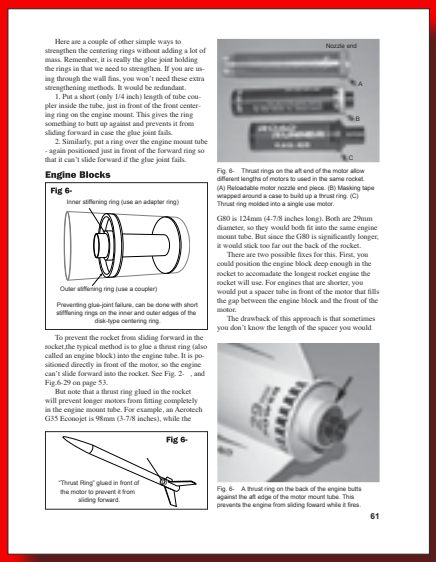
I will be taking pre-orders for the 3rd edition as soon as it gets proofread. It is far enough along that I don't want to make you wait. In other words, you'll be able to order it, and we'll ship it when we get the printed versions (hopefully less than 3 or 4 months). While you're waiting for that, I'll send you a pdf version of the book on a CD-ROM right away. I know a CD-ROM isn't as nice as a printed book, but I don't like taking your money without sending you something in return. You know me by now... my integrity demands that of me, or it won't let me sleep at night.

If you would like to place a pre-order now, I'm also going to give you a special price. The regular price will be $36.00, but I'm going to offer you the pre-order price of $27.66 -- which is what we're currently selling the 2nd edition for. This pre-order price will not last very long, and after the web site is updated in a few weeks, we will not extend it to fence-sitters. The reason for the pre-order price is so I can get a little extra cash to pay the printing company. They want their money up-front before they print the books. Once they get paid, the pre-order deal will be over.

If you want to place a pre-order for the new 288 page, 3rd edition of *Model Rocket Design and Construction*, you can do so at: http://www.ApogeeRockets.com/design_book.asp. Scroll down to the bottom of the page where the pre-order deal is listed.

You might as well get two or three... I'm sure you'll want to donate one to your kid's school and the local library.

Model Rocket Design And Construction


Here are a couple of other simple ways to strengthen the centering rings without adding a lot of mass. Remember, it is really the glue joint holding the rings in that we need to strengthen. If you are using through the wall fins, you won't need these extra strengthening methods. It would be redundant.

1. Put a short (only 1/4 inch) length of tube coupler inside the tube, just in front of the front centering ring on the engine mount. This gives the ring something to butt up against and prevents it from sliding forward in case the glue joint fails.

2. Similarly, put a ring over the engine mount tube – again positioned just in front of the forward ring so that it can't slide forward if the glue joint fails.

Engine Blocks

Fig 6-
Inner stiffening ring (use an adapter ring)
Outer stiffening ring (use a coupler)
Preventing glue-joint failure, can be done with short stiffening rings on the inner and outer edges of the disk-type centering ring.

To prevent the rocket from sliding forward in the rocket,the typical method is to glue a thrust ring (also called an engine block) into the engine tube. It is positioned directly in front of the motor, so the engine can't slide forward into the rocket. See Fig. 2- , and Fig.6-29 on page 53.

But note that a thrust ring glued in the rocket will prevent longer motors from fitting completely in the engine mount tube. For example, an Aerotech G15 Econojet is 98mm (3-7/8 inches), while the

Fig 6-
"Thrust Ring" glued in front of the motor to prevent it from sliding forward.

Nozzle end
A
B
C
Fig. 6- Thrust rings on the aft end of the motor allow different lengths of motors to used in the same rocket. (A) Reloadable motor nozzle and piece. (B) Masking tape wrapped around a case to build up a thrust ring. (C) Thrust ring molded into a single use motor.

G80 is 124mm (4-7/8 inches long). Both are 29mm diameter, so they would both fit into the same engine mount tube. But since the G80 is significantly longer, it would stick too far out the back of the rocket.

There are two possible fixes for this. First, you could position the engine block deep enough in the rocket to accomodate the longest rocket engine the rocket will use. For engines that are shorter, you would put a spacer tube in front of the motor that fills the gap between the engine block and the front of the motor.

The drawback of this approach is that sometimes you don't know the length of the spacer you would

Fig. 6- A thrust ring on the back of the engine butts against the aft edge of the motor mount tube. This prevents the engine from sliding toward while it fires.

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KIT OF THE MONTH

DynaStar Snarky

The Snarky rocket is a very distinctive rocket kit. It was designed by Shrox, which explains why it has a unique shape. It looks more like an airplane than a missile. But don't let that fool you. It is fully rocket-powered, and it is big! This unique combination is definitely something that will get you noticed at your next rocket launch.

The Snarky is designed to look like an Air Force target drone. That means its purpose is to mimic the flight of enemy airplanes, so that the Air Force can practice intercepting it. But this isn't a scale model. We designed it just for kicks, and to show you how much fun you really can have with model rocketry.

The air-scoop on the bottom of the model is just one thing that makes this rocket kit unusual. No other rocket kit has one like this. And it actually helps stabilize the rocket; you'll find that it flies straight as an arrow on every single launch.

Besides the air scoop, the fins are assymetric. That means they aren't equally spaced around the rocket like they are on other kits. The combination of the scoop and the assymetric fins, plus the large size of this kit is what makes it stand out among all the other rockets at the flying range.

Besides the cool design, the model is accented by a lot of colorful pressure-sensitive decals. It's as mean as it looks.

Snarky Kit Specifications:

Skill Level 4: Slightly Challenging
Length: 28.5" (72.4 cm)
Diameter: 2.217" (56.3 mm)
Weight (without motor): 6.3 oz (180 gm)
Recovery: 32" plastic parachute

Kit Features

- Plastic Nose cone
- Die-cut Balsa Fins
- Colorful pressure-sensitive decals
- Detailed Instructions
- Kevlar® Shock Cord
- 32" Diameter Plastic Parachute
- Premium Quality Body Tubes
- Flies Estes D12 or Aerotech 24mm motors

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