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# APOGEE PEAK OF FLIGHT NEWSLETTER

# The SPORT Scale PARACHUTE

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# The Sport Scale Parachute

By Mr. David Flanagan

## How To Make A Small Model Rocket Parachute Look More Like Its Big Brother

### The Problem

Most small model rocket parachutes look nothing like their full scale brothers. The main reason is those unsightly lobes that stick out between the lines. Full scale parachutes don't look like this because they have a lots of suspension lines (and very small lobes between them), but this is hard to duplicate with small parachutes. Consider the parachute used to recover NASA's Gemini space capsule. It was about 84 ft. in diameter and had 72 suspension lines [1]. To scale the Gemini parachute accurately (with all 72 lines!), a small 18" rocket parachute would have to have a suspension line about every 3/4" around the edge! This would be hard to do. It would also add to the weight and stiffness of the parachute.

**Figure 1. Gemini Parachute (courtesy NASA-Johnson Space Center)**

Mr. G. Harry Stine published a hint of how to get around this in his book "Handbook of Model Rocketry." Mr. Stine suggested that instead of just taping the lines to the edge of the canopy a modeler could gather a part of the edge of the canopy into a small "pigtail" and tie the line around it. This reduces the circumference of the parachute and makes it look more like a full scale chute. Mr. Stine called this design a "gathered parasheet." [2]

However, Mr. Stine does not provide guidance on how large the pigtail should be at each line attachment point. A pigtail that is too small might not fix the problem, and one that is too large may restrict the canopy from opening all the way!

### The Fix

A long time ago the British figured out that the inflated diameter of a full scale round parachute was about 65% to 70% of the constructed or flat diameter (the diameter of the parachute laid out flat.) [3] And since the perimeter 'P' of a circle is proportional to its diameter 'D' (remember $P = \pi \times D$?), that means the perimeter of the inflated parachute is, apparently, only 65% to 70% of the constructed perimeter.

So the problem then becomes how to get rid of, say, 35% of the constructed perimeter so when the parachute inflates, we see only the 65% of the perimeter and none of the 35% that apparently contributes to those unsightly bulging lobes. We do this by gathering the excess into the pigtails as Mr. Stine suggested. But how much excess is gathered for each pigtail? How long is the pigtail supposed to be?

If a round parachute has a constructed or flat diameter 'D' and has 'n' number of lines then the amount of pigtail sticking out of each line loop is:

$$\text{pigtail} = 0.5498 \times \frac{D}{n}$$

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The situation with small polygonal parachutes like hexagons and octagons that come with small rocket kits is slightly different. Here the number of sides 'n' is usually the same as the number of lines 'n'. There are also two diameters, the inscribed diameter (the diameter of the largest circle that can be drawn inside the polygon, touching each edge at its midpoint) and the circumscribed diameter (the diameter of the largest circle that can be drawn around the polygon which touches the vertices of the edges of the polygon.)

There is a way around this. First, we consider our diameter 'D' to be the inscribed diameter and ignore the circumscribed diameter. The inscribed diameter is the measure of the distance "across the flats" of a polygon that has an even number of sides. And we will assume that a polygon of 'n' sides has 'n' lines, one at each corner (vertex) of the polygon. Then the length of the pigtail sticking out of each line loop will be:

$$\text{pigtail} = 0.175 \times D \times \tan\left(\frac{180}{n}\right)$$

Here "tan" is the tangent function. Most scientific calculators will have a button for this. Make sure the calculator is set on degrees rather than radians. Divide 180 by the number of sides of the polygon, then press the "tan" button. Then finish the calculation.

The table below provides some of the values for selected polygons. The calculation is done for you. To get the pigtail length all you have to do is multiply the coefficient of the selected shape by the inscribed diameter you choose for the parachute.

| Number of Sides or Lines | Coefficient of the Diameter |
|---|---|
| 6 | 0.101 |
| 8 | 0.072 |
| 10 | 0.057 |
| 12 | 0.047 |
| 16 | 0.035 |
| 18 | 0.031 |
| 20 | 0.028 |

## Building A Gathered Parasheet

As an example, let's take a standard 12" polyethylene parachute that often comes as part of a rocket kit, and make a gathered parasheet out of it. Small parachutes with only a few sides are the most challenging, so this will be a very good example.

For the most part constructing a gathered parasheet is the same as constructing a regular chute except for the way the lines are attached.

First we figure the length of the pigtail. The 12" chute has six sides, but it is actually only 11.1" across the flats (inscribed diameter.) Using the table above, 11.1" x 0.101 is 1.12", so the length of the pigtail sticking out of each line loop will be 1.12" Mark this on the canopy at each line location.

**Figure 2. Marking the canopy**

Then tie each line around the pigtail. Pull the pigtail through the line loop until the marks are at the loop. It never hurts to measure the pigtail when you are done, as shown in Figure 3. Tie off the line.

Continued on page 4

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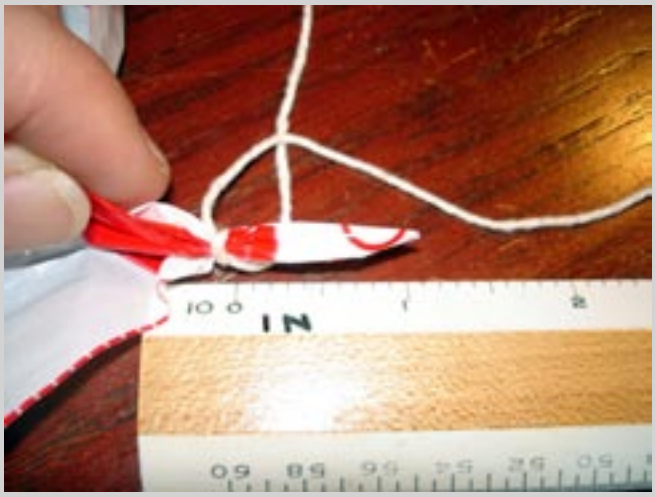

**Figure 3.** Measuring the pigtail

The excess pigtail can be cut off and taped to the underside of the canopy for extra strength and improved appearance. This is shown in Figure 4.

**Figure 4.** Snipping the excess pigtail (and line) and taping it to the inside of the canopy, to improve strength and appearance.

Notice as you finish installing the lines that the parachute already has a bit of a hemispherical shape, as seen in Figure 5.

**Figure 5.** All lines attached

The length of the suspension lines on a gathered parasheet are the same as a regular parachute. Most chutes have a line length equal to the diameter, so this parasheet will have the lines tied off at 11.1".

In flight, the difference is pretty clear: Which looks more like the real Gemini parachute shown in Figure 1, the "regular" kit parachute in Figure 6, or the gathered parasheet in Figure 7?

**Figure 6.** A regular kit parachute built to the manufacturer's directions

Continued on page 5

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**Figure 7.** **The gathered parasheet**

## Performance Notes

The drag coefficient of the gathered parasheet is lower than that of a regular model rocket chute, so they will usually come down faster.

Generally, the gathered parasheet is a bit more stable that the regular model rocket chute.

The gathered parasheet is packed in the rocket the same way that a regular parachute is packed, but it is a little bulkier than a regular chute and will need more room in the rocket.

## Future Work

The gathered parasheet is an attempt to make a small kit parachute look more like a full scale chute. This was done by removing 35% of the perimeter. What would happen if even more of the perimeter was removed? What would the parachute look like? How would it act?

## References

1. Gemini Spacecraft Parachute Landing System, NASA TN D 3496, July 1966

2. Handbook of Model Rocketry, G. Harry Stine, 6th Ed., John Wiley & Sons, New York, NY 1994

3. Parachutes, W. D. Brown, Sir Isaac Pitman & Sons, London, England, ca. 1942

## About The Author

Mr. David 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.

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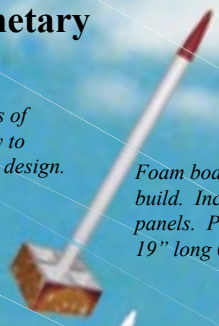
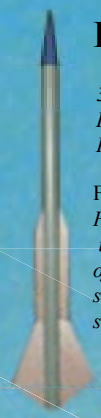


### Box Racer

*Foam board fins for a different build. Includes pre-printed side panels. Plastic nose cone. 19" long 0.976 dia.*

### Space Speedster

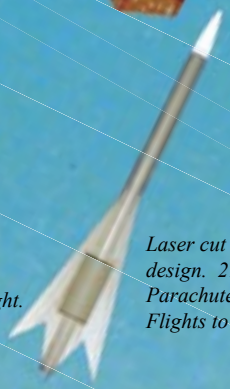
*Printed body with foam board fins. Preprinted fins. Laser cut foam mounting rings.*



### Flechette

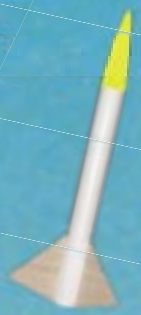
*3 fins 6 piece laser cut balsa. Flights to 1000'/ 300m. Parachute recovery.*

Flechette: *The word flechette is French for "dart." In military use, it is a projectile having the form of a small metal dart: a sharp-pointed tip and a tail with several vanes to stabilize it during flight.*



### Explorer

*Laser cut 4 fin with distinctive design. 21" long 0.976" dia Parachute recovery. Flights to 750'/ 250m*

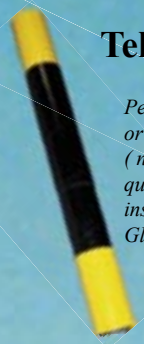


### Bug Me Not!

*Great beginner's rocket. Laser cut fins. Streamer recovery. 0.976" dia 11" long.*

### Lightning Fury

*Simple to build. Laser cut fins. Streamer recovery. 0.796" dia, 21" long*



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**Apogee Components, Inc. is pleased to announce the second annual grant program geared toward model rocketry education organizations!**

Apogee Grant Program

## The rules are simple:

1. Entrants must submit an essay to Apogee. There is no length requirement for the essay.
2. Any club, organization, or school program, is eligible for entry. This would include rocketry clubs or prefectures, 4H, scouts, etc.
3. The content and purpose of the essay is as follows:
   - If we gave you $300.00, How would you use it to impact the rocketry community?
   - How many people do you think it will reach?
   - How many people will be involved in the organizing and running of the event?
   - How big of an effect will it have on the rocketry community?
4. One of the biggest things to keep in mind when composing your essay is **"How is what I am planning unique?"**

There will be only one winner of the grant, which is $300.00 towards any order with Apogee Components.

**The deadline for entry is November 30, 2007.**

Make sure it is post-marked by November 30th!

**The grant winner will be announced on January 1, 2008.**

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# TIP OF THE FIN

One of the more artful aspects of rocket construction has to do with fin alignment – particularly, making sure that your fins are exactly perpendicular to the body tube, and also exactly in line with the tube's axis. Here's a very simple way to help achieve these goals.

Picture 1

Picture 2

Hold the body tube at arm's length (picture 1), with the fin end farthest away from you. Use a background with vertical references, such as the cabinetry in the background of this picture. Adjust the tube in your line of sight so that you can see both across the top of the outside of the tube, as well as and through the inside.

Picture 1 shows that even a slight misalignment of a fin marking line stands out clearly. Picture 2 shows that the alignment line is straight, but the fin needs to be adjusted slightly to the right; note also how the fin's leading edge is darkened to help make it stand out.

# DEFINING MOMENTS

A **Reefed Parachute** is one that uses a device to restrain the parachute so that it does not open immediately upon deployment. You can have both fixed and moving reefing devices. A fixed reefing method could simply be a knot in the shroud lines. A moving reefing device temporarily constrains the 'chute, then moves or releases in some way to allow it to open more.

An easy reefing device that you can employ on just about any parachute is shown in this picture.

Shown is an Apogee 24-inch nylon parachute (http://www.apogeerockets.com/parachutes.asp) with a short section of 1/4-inch launch lug as a reefing device. Place the device at the base of the 'chute when you fold it, and then pack it as usual. When it deploys, the parachute will completely unfurl and extend, and then the combination of gravity and wind forces will cause the device to start sliding down the shroud lines, allowing it to open in a slow and controlled manner.

When would you really want to use a reefing device? Consider the dynamics of a high-speed parachute deployment. If the rocket is still traveling at high velocity and the 'chute snaps open, there will be a huge deceleration force exerted on the entire rocket and recovery system. Not only will you likely tear the parachute, but this situation is also the main cause of zippers – tears in the body tube by the shock cord. A reefing device will allow a high-speed rocket to slow down considerably before the parachute fully opens, thus reducing or eliminating those sharp, damaging forces.

You can experiment with different diameters and lengths of reefing rings and tubes for longer or shorter reefing effects. narrower, longer rings and tubes will create greater restriction, while wider shorter rings and tubes will create lesser restrictions. Give it a try!

# QUESTION & ANSWER

Joe wrote to us and asked, "I would like to build a model of the Thunderbird 3 rocket for an upcoming NAR event. I was wondering if you could point me to information on how to simulate the pods on the ends of the fins. Any help would be greatly appreciated as this is my first complex (and boy is it complex!!!) model in RockSim."

Great question, Joe! Unfortunately, RockSim does not yet support pods on the tips of fins. The way to account for them is to use a mass object to get the model to the right mass. Calculate the combined mass of the components that make up the pods for all fins, and place the mass object in the body at the mid-point of the actual pods. You'll also need to bump up the Cd of the rocket because the pods will add a bit of aerodynamic drag. Once you get these two factors dialed in, you should get pretty good simulation.

We love to hear from those of you who are pushing the limits of RockSim. You can be sure that your ideas are added to the list for consideration in future enhancements. Remember, you can download the free 30-day demo of RockSim at http://www.apogeerockets.com/rocksim_demo.asp.

# Web Site Worth Visiting

This issue's web site is one of the premier BIG high power rocketry organizations – the Maryland Delaware Rocketry Association, Inc. (MDRA). Visit them at: http://www.mdrocketry.org.

Paraphrased from their website, "The MDRA is a non-profit corporation that supports the educational and research endeavors associated with the hobby of rocketry. Our mission is to provide a venue to allow for witnessing and participation in the hobby of rocketry; to inspire thought, action, creativity and challenges for our members. We are dedicated to making these experiences available and accessible to as many members of the community as possible with an emphasis on reaching and nurturing our children through their interest in rocketry. We are working partners with various educational, research and community organizations."

Be sure to reserve a few hours for this website! There are dozens of launch galleries, dating back to before the turn of the century, each loaded with photos and videos of some of the largest and most ambitious high power projects ever undertaken. Also be sure to check out the individual member pages, where you will find information behind the construction of a number of these projects, including evidence of the use of RockSim in the design process.

Their latest launch was Red Glare II, held April 20-22, 2007. The highlight of this event was a drag race of four O-motor powered rockets – absolutely incredible!

Not only do they fly the big stuff, but MDRA also supports "normal" rocketry. They always welcome and encourage model rocketry at their launches, and participate in several community outreach programs every year, including the Team America Rocketry Challenge.