PEAK OF FLIGHT

NEWSLETTER

ISSUE 485 | December 25th, 2018

IN THIS ISSUE

The Ringslot Parachutes

www.ApogeeRockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/AMRAAM-AIM-120A

Apogee Components, Inc.
Your Source For Rocket Supplies That Will Take You To The "Peak-of-Flight"
4960 Northpark Drive Colorado Springs, Colorado 80918 USA
www.ApogeeRockets.com e-mail: orders@apogeerockets.com Phone: 719-535-9335 Fax: 719-534-9050

APOGEE COMPONENTS

The Ringslot Parachute

By Dave T. Flanagan

Introduction

The name of the ringslot parachute pretty well describes it – it is nothing more than a collection of material rings and empty slots arranged concentrically. It may sound strange to have so much of the canopy "missing", but the design, at full scale, has a number of uses. Many aircraft and some dragster braking parachutes are ringslots. During military low and medium altitude airdrops of cargo, it is often one or more ringslot parachutes that extract the load from the aircraft. Ringslots have also served as drogues during the initial high-speed portion of military and aerospace high altitude recovery systems.

Figure 1: During Low Altitude Parachute Extraction System (LAPES) operations the ringslot parachute pulls the load from a low flying aircraft. The load drops to the runway and slides to a stop.

At full scale, ringslot parachutes have a number of advantages. One is that compared to a regular parachute (called a "flat circular" by parachute engineers), the opening shock is lower. The "opening force coefficient" for a generic ringslot is about 1.05 compared to a value of about 1.70 for a flat circular. This is partly because the growth in parachute area during inflation of a ringslot parachute is more even (a linear function with time) than that of a flat circular parachute where not much happens at the beginning of the inflation sequence but towards the end…wham…it is open (a power function with time). Ringslots also open much more slowly, as well more evenly, than flat circulars. These characteristics are useful for delicate payloads.

Another advantage is stability. A flat circular parachute will oscillate anywhere from 10 to 40 degrees from vertical whereas ringslots don't oscillate much more than 5 degrees – they descend vertically in the air mass. A ringslot parachute might work very well to land something without tipping it over.

The principal disadvantage of the ring slot is its lower drag coefficient. While a standard flat circular might have a drag coefficient of 0.8, the drag coefficient of a ringslot is perhaps 0.6. So a larger ringslot parachute would be needed to achieve the same rate of descent as a smaller flat circular given a particular payload.

Construction

Smaller ringslots can be made out of polyethylene. It is possible to scale down a ringslot parachute, cut rings from polyethylene canopy material, arrange them appropriately, then install the suspension lines, but this requires incredible patience. The author has come close to doing this by modifying an 12"' commercial parachute kit by cutting the "slots" into the canopy with a hobby knife and leaving the "rings" behind (**Figures: 2 & 3**). But this is just too tedious and time consuming.

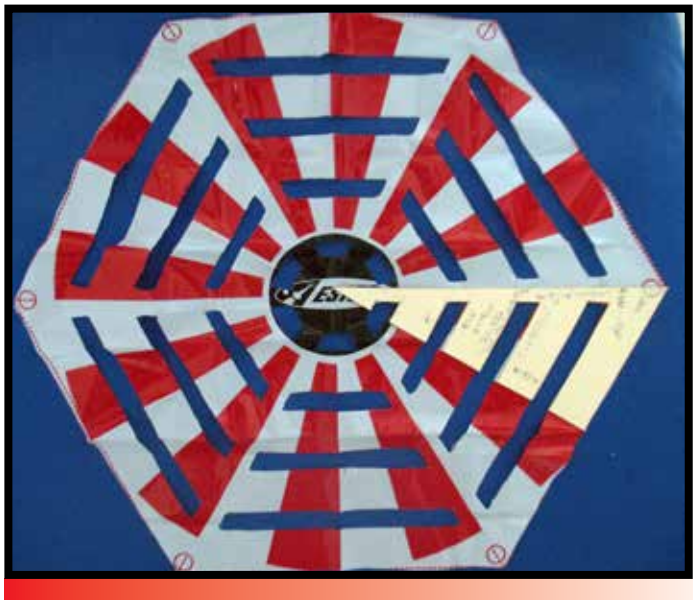

Figure 2: A successful but tedious method of scaling down the ringslot parachute involves actually cutting the "slots" into the canopy in accordance with a predetermined pattern.

Continued on page 3

About this Newsletter

You can subscribe to receive this e-zine FREE at the Apogee Components website **www.ApogeeComponents.com**, or by clicking the link here Newsletter Sign-Up

Newsletter Staff

Writer: Dave T. Flanagan
Layout/Cover Artist: Chris Duran
Proofreader: Michelle Mason

The Ringslot Parachute

Continued from page 2

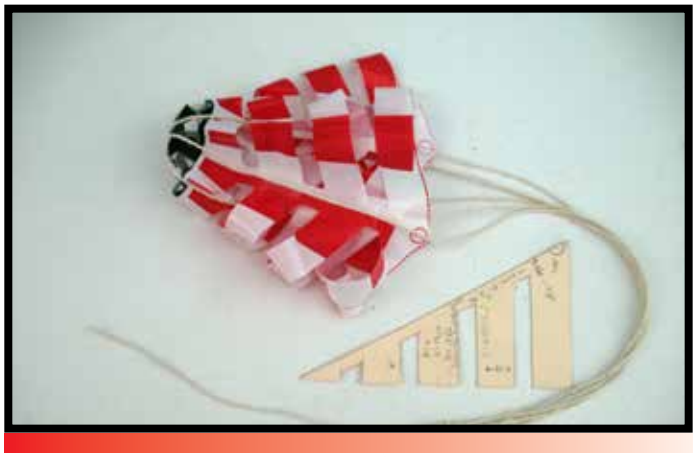

Figure 3: The completed model ringslot parachute made the hard way, with pattern.

An unscientific short cut is in order, which will result in a "sport scale" ringslot parachute. The first step is to build a polygonal kit parachute according to the instructions. However, use continuous (over the top) suspension lines. This is necessary for strength, as canopy material will be removed. Once the parachute is complete, fold the canopy gores all to one side, stacking the gores as shown in **Figure 4**. Depending on the size of the canopy, clothespins, paperclips, or other clamping devices can be used to stabilize the stacked gores. It is important that all the suspension lines are together and that the gores of the canopy lie directly on top of each other. (It is nearly impossible to do this perfectly, so there will be some variation in the finished product.) Then, with scissors or a hobby knife, carefully cut triangular shaped pieces from the stacked gores as shown in **Figure 5**. Triangular pieces should be isosceles triangles with their bases aligned with the gore midline (edge of the folded gore). Again, because of inherent inaccuracy of the gore stacking process, the resulting "rings" and "slots" will not be identical from gore to gore, but they will be close.

There are no specific rules as to how many or how large the removed triangles could or should be, or even the location from which they should be removed. Any member of NASA's Supreme Council of Parachute Experts (SCOPE) would run screaming onto the nearest Interstate upon seeing this design approach. (Yes, SCOPE is a real thing. https://www.nasa.gov/jpl/ldsd/the-supreme-council-of-parachute-experts.) However, there are two guidelines. One is to limit the amount of removed material to 20% of the total canopy area, and the other is to stay away from the very top of the chute. Removing too much total area or taking too much of it from the apex area can cause the parachute not to inflate. The result is a streamer, which while stable, has a very low drag coefficient.

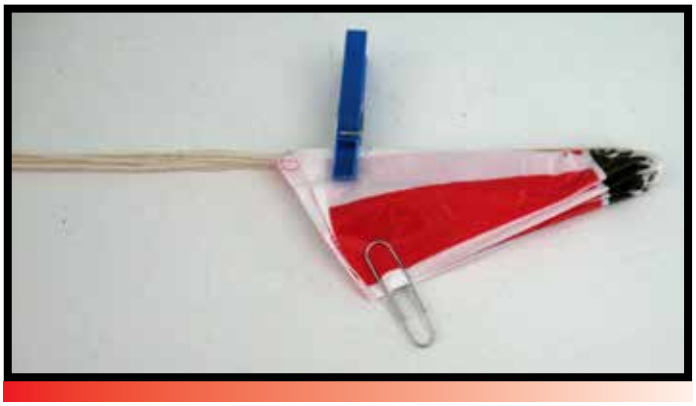

Figure 4: Gores stacked, folded, and secured.

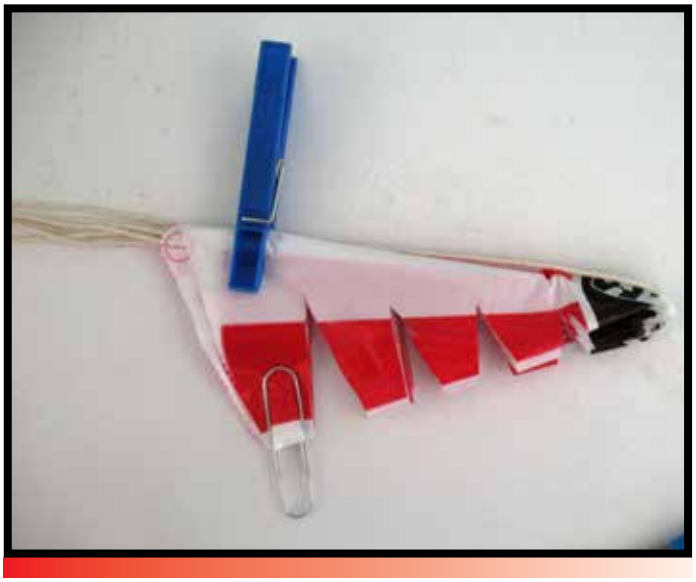

Figure 5: Arbitrary wedge sections (isosceles triangles) removed from the gores to create the sport scale ringslot.

Continued on page 4

Check out our Facebook page
www.facebook.com/ApogeeRockets

New Mid-Power Tube Assortment

You get:
(4) AT 29/13
(4) AT 41/18
(2) AT 56/18
(2) AT 66/18
(1) AC-56
(1) AC-66

www.ApogeeRockets.com/Building_Supplies/Body_Tubes

The Ringslot Parachute

Continued from page 3

Figure 6: Comparing the canopies of the sport scale ringslot model (left) with the ringslot model made the hard way.

Figure 7: The 12" sport scale ringslot model during toss testing.

If you have a sewing machine you can probably make your own larger ring slot parachute from scratch using standard parachute materials. Although the author has not done so there appears to be at least two approaches to such a project. However, ringslots made from fabric are not within the scope of this article.

Testing

Small models like the ones shown can be tested simply by toss testing in the backyard. In fact new ringslots must be tested before use in a rocket. There is no other way (right now) to know if too much material has been removed, or if material has been removed from the wrong places such as the apex area.

Packing the ringslot for toss testing or use in a rocket is a little more difficult because the material of the rings flops around a lot. One way to beat this is to stand on (or otherwise secure) the suspension line confluence point (where the payload attaches). Hold the apex in one hand and use the other hand to sort out the rings and get them to settle on top of each other as much as possible. Then carefully s-fold the canopy and wrap one or two turns of suspension lines around it.

A shortcut that sometimes works is to secure the suspension line confluence then, holding the apex with one hand "milk" the rings upward towards the apex with the other before s-folding. This clears the rings from the suspension line area.

There are many variables here and the only way to get a feel for them is to toss test your ringslot model repeatedly.

To see how the ringslot performs compared to a regular flat circular parachute, build two small (12" to 18") parachutes from identical kits, one as a ringslot and one as a flat circular. Attach identical weights – the author used a 1 oz. fishing weight for the 12" ringslot parachutes shown above. Then, in a safe direction, make like a Major League Baseball pitcher

Continued on page 5

The Ringslot Parachute

Continued from page 4

delivering a fastball. If you chose wisely when you removed the triangular wedges from your canopy, you will see the difference in opening time and opening distance and hear the difference in opening shock.

Extra for Experts

It is possible to approach the design of the sport scale ringslot parachute with more rigor. One constraint is how much material can be removed. Although full-scale ringslots can go as high as 30% due to various supporting tapes and reinforcements, the author recommends that no more than 20% of the total canopy area be removed when building a sport scale ringslot. Parachute engineers call this "geometric porosity". It is the ratio of the area of the material removed to the total area of the parachute before any material is removed. The lower case Greek letter lambda (λ) is often used for geometric porosity. The constraint here is then $\lambda \leq 0.20$.

Symmetry allows the calculation of porosity by looking at just one half of one of the triangular gores of the parachute. For any regular polygon of 'n' sides (an 'n-gon') the area of one half of one gore is

$$S_{half\ gore} = \frac{1}{2} r^2 \sin(180/n) \cos(180/n)$$

where 'r' is the circumscribed (outer) radius.

The area may also be described in terms of the inscribed (inner) radius of the polygon which has a special name – the "apothem" - represented here by 'a'. The inner radius is the gore centerline.

$$S_{half\ gore} = \frac{1}{2} a^2 \tan(180/n)$$

This latter formula might be more useful since it is based on the midline or centerline of the gore from which the wedges of material are removed.

(For some reason parachute engineers have always symbolized parachute area using 'S' instead of 'A'. The reason is unknown.)

Of course the equation for the area of an isosceles triangle is

$$A = \frac{1}{2} bh$$

where 'b' is the base of the triangle (which is aligned with the gore midline) and 'h' is its height.

Geometric porosity is then determined by summing the area of the removed triangular wedges and dividing this sum by the area of one half of one gore.

Making a pattern is essential for better accuracy, and allows for calculating the porosity before taking scissors to the canopy. A properly designed pattern will also preserve the area near the apex of the parachute intact.

Continued on page 6

The Ringslot Parachute

Continued from page 5

Figure 8: A sport scale ringslot model being fabricated from a 32″ kit parachute. Here a pattern of half of a gore was made first and the geometric porosity calculated. This model had a geometric porosity of λ =0.18 which is on the high end of the recommended range. Toss tests showed that, while it did open, opening times were quite long.

Figure 9: The 32″ sport scale ringslot during toss testing.

To cut the wedges more accurately, the triangles can be cut from each gore individually using the pattern. A slightly less accurate method would be to divide the gores in half and process each half of the parachute separately (**Figure 10**).

Future Work

There are many variables in the design and construction of the ring slot parachute, so there are a many opportunities for research projects. One big question is, of course, do these small-scale ringslot parachutes have the same advantages as full-scale ringslot parachutes? Qualitatively this appears true, but quantitatively? No one knows.

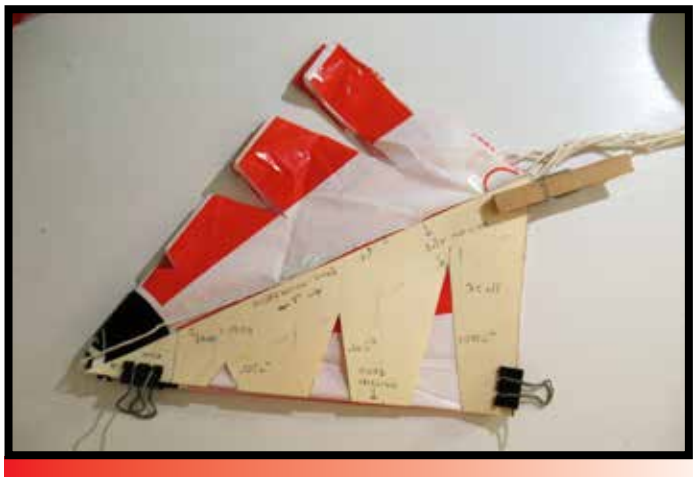

Figure 10: This sport scale ringslot is derived from a commercial 18″ parachute kit. It has an approximate geometric porosity of λ = 0.11. Note that the six gores have been split into two groups and the triangles cut from each group separately using the pattern. This improves accuracy.

Figure 11: A & B. The 18″ sport scale ringslot model during toss testing

Continued on page 7

The Ringslot Parachute

Continued from page 6

The number, size, and distribution of the wedges of material removed are all variables. Perhaps a triangular wedge is not even the best shape! And maybe it is not even necessary to remove material – maybe just slicing the gores in various places will work. The number of gores and the length of the suspension lines will likely also affect performance. Also, can the ringslot be designed so that those annoying continuous (over the top) suspension lines are not necessary?

Can you build a "launcher" that can safely launch your models at the same speed and in the same direction each time so that you can compare models? Or perhaps you can conduct drop tests of models from a building or tower to compare opening times and distances using video. Or perhaps you could obtain descent velocity from an onboard altimeter data that would let you calculate drag coefficients of different models.

You can get as complicated as you want. Have fun.

General Reference

Knacke, T.W., "Parachute Recovery Systems Design Manual", NWC-TP-6575, March 1981.

Figure 1, USAF Photo - https://media.defense.gov

Other Articles By Author

"Oddchutes - Fun with Polygons" https://www.apogeerockets.com/education/downloads/Newsletter191.pdf

"Rotating Parachutes - Two Easy Ways to Make a Spinning Parachute" https://www.apogeerockets.com/education/downloads/Newsletter194.pdf

"Step-by-Step Instructions: Build a Parawing Part 1" https://www.apogeerockets.com/education/downloads/Newsletter206.pdf

"Step-by-Step Instructions: Build a Parawing Part 2" https://www.apogeerockets.com/education/downloads/Newsletter207.pdf

"How To Make A Small Model Rocket Parachute Look More Like Its Big Brother" https://www.apogeerockets.com/education/downloads/Newsletter183.pdf

About The Author:

Dave is a registered professional engineer with well over twenty years of aerospace experience at NASA's JSC and MSFC. He holds bachelors and masters degrees in engineering and a bachelors degree in science, and while at MSFC supported NASA's University Student Launch Initiative. Although no longer actively jumping, he is a former Army paratrooper and holds an expert skydiver rating. Dave is a master parachute rigger and has completed the AIAA Parachute Systems Technology Short Course. He is a licensed private pilot and a certified ultralight pilot. Dave is retired and spends most of his time scuba diving and kayaking but does occasionally fly with the Northeast Florida Association of Rocketry (NEFAR, NAR #563, TRA #35).