PEAK OF FLIGHT NEWSLETTER

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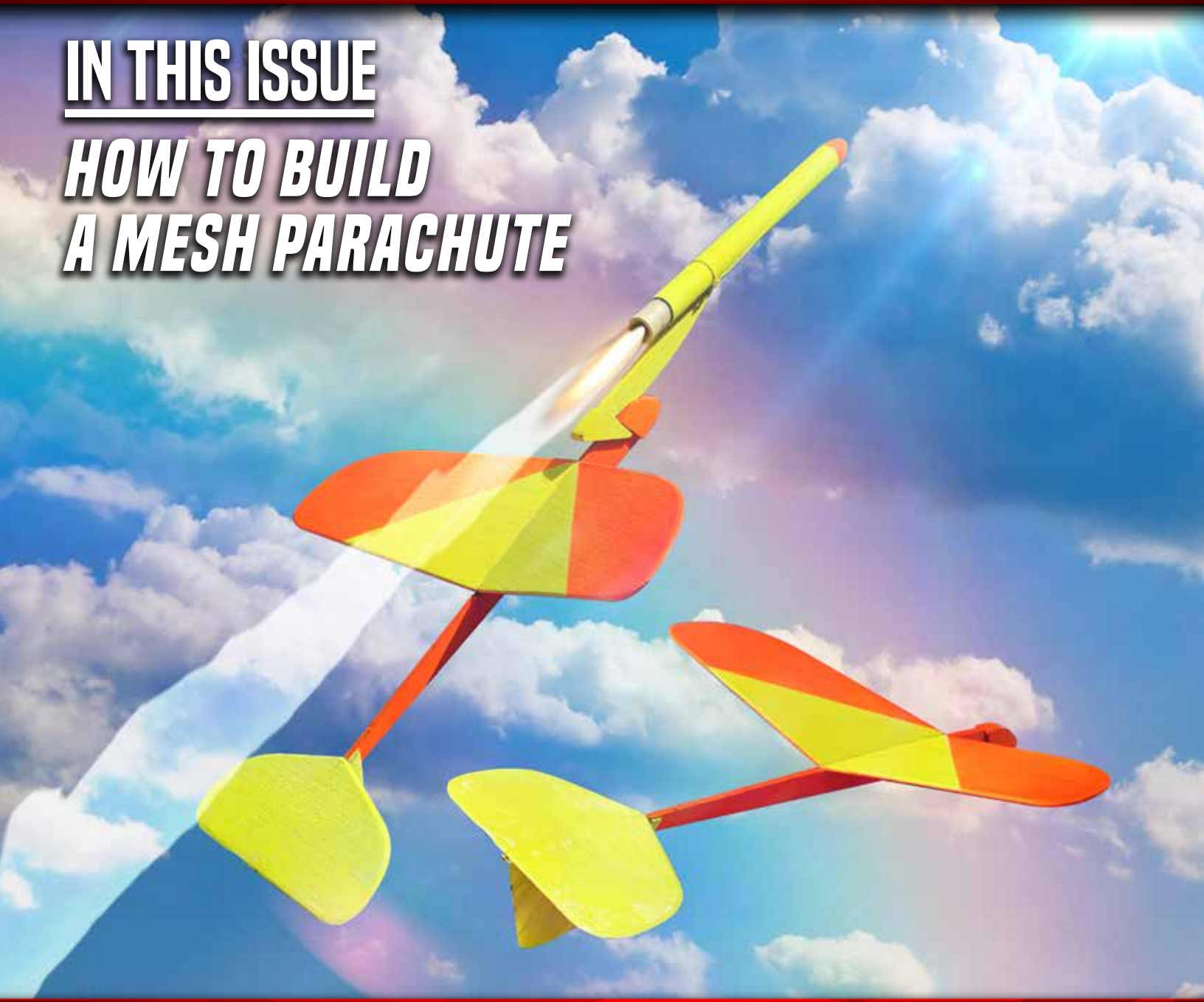
HOW TO BUILD A MESH PARACHUTE



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PEAK OF FLIGHT

How to Build a Mesh Parachute

By Chris Flanigan and John Pacente

Introduction

Some rocketry applications require that the rocket's parachute open extremely reliably and have very repeatable performance. TARC - The American Rocketry Challenge[1] - is an excellent example. Other competition examples include the NAR Precision Payload event and the FAI S2/P "precision fragile payload" event. For these flights, the duration portion of the score could be significantly degraded by a tangled parachute or snagged shroud lines.

One method to improve parachute reliability and repeatability is to use what I will call a "mesh parachute". A mesh parachute replaces the shroud lines with a mesh fabric (see Figure 1). With no shroud lines to tangle, parachute deployment is very reliable.

Mesh parachutes are sometimes used as drogue or pilot parachutes to pull out and deploy larger parachutes. Mesh parachutes are very popular in BASE jumping[2] where parachute reliability is critical[3]. Oddly, mesh parachutes are also popular as children's' toys ("little green army paratroopers")[4]. A variant of the mesh parachute is used as a training resistance aide for runners.[5]

For precision events like TARC and S2/P, the parachute may need to be a special size to provide the correct amount of drag to achieve the target duration. This article describes how to make a mesh parachute. Construction time is approximately one hour to make a mesh parachute by hand. If you have a sewing machine (or know someone who does), construction will be much faster.

Materials

You'll need the following materials to make a mesh parachute.

- Canopy material, such as lightweight (1.1 ounce) rip-stop nylon https://www.seattlefabrics.com/60-11-Ounce-Uncoated-Ripstop-1000-linear-yard_p_34.html
- Polyester mesh (also called tulle fabric). Note: do not use nylon tulle, as it rips very easily. https://www.amazon.com/Fabric-Wedding-Decoration-Bridal-Shower/dp/B0838G2VHG
- Heavy-duty thread such as upholstery thread https://www.hobbylobby.com/Fabric-Sewing/Sewing-Quilting-Notions/Thread/1374-Gray-Extra-Strong-Bonded-Nylon-Upholstery-Thread/p/80757918
- "Lite Ply" poplar plywood for the attachment button https://www.towerhobbies.com/product/poplar-lite-ply-18-x-6-x-12-6/MID5510.html
- Medium-strength Kevlar cord https://www.apogeerockets.com/Building_Supplies/Parachutes_Recovery_Equipment/Shock_Cord/Kevlar_Cord_300
- 1/8" diameter wood dowel or graphite tube

FIGURE 1. A MESH PARACHUTE MAY IMPROVE DESCENT RELIABILITY AND REPEATABILITY. (PHOTO BY MARC MCREYNOLDS)

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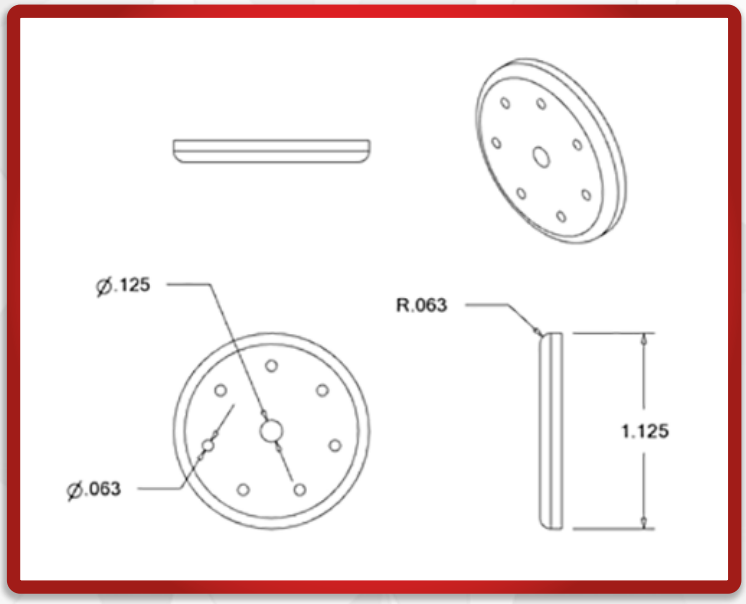

Step 1 – Make the Attachment Button

To connect the mesh parachute to the rocket, an "attachment button" is used. This device spreads the loads from a shock cord into the mesh fabric.

a) Cut out the template for the attachment button (see drawing). The button should be approximately 1-1/8" diameter.

b) Glue the template to lite ply using a glue stick or spray cement.

c) Cut out the attachment button. A razor saw works well.

d) Sand the button round and smooth. Sand a radius along one edge. Note that the edge/face with the radius will be the "down" face that contacts the mesh fabric. The edge/face without the radius will be the "up" side that faces away from the mesh fabric. If you prefer, you can sand a radius on both edges to avoid any up/down installation issues.

e) Drill an 1/8" hole in the center.

f) Drill the seven 1/16" holes (for attaching the button to the tulle fabric).

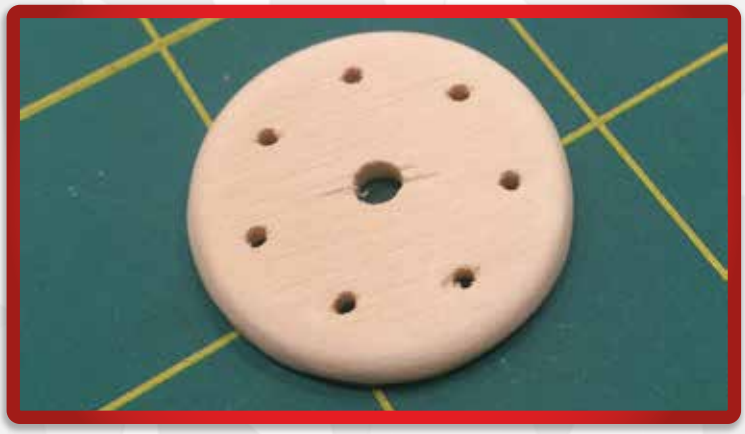

FIGURE 2: THE ATTACHMENT BUTTON DISTRIBUTES THE LOAD FROM THE SHOCK CORD INTO THE MESH FABRIC.

An attachment button is shown in Figure 2. Alternatively, you can make the attachment button by 3D printing. An example STL file is available at https://www.thingiverse.com/thing:4650588.

Step 2 – Mesh Disk

a) Create a circular template of the desired diameter. One method to create the template is to get a large piece of cardboard or foamboard, place a nail or thumbtack in the center, then use a string-and-pencil

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to draw a large circle (https://www.youtube.com/watch?v=_yqmqESN_Oo). Another method is to use a graphics or CAD program to create and print wedges of the desired radius/angle, then tape the wedges together to form the circular template.

b) Lay the mesh fabric on a flat surface (table, kitchen counter, etc).

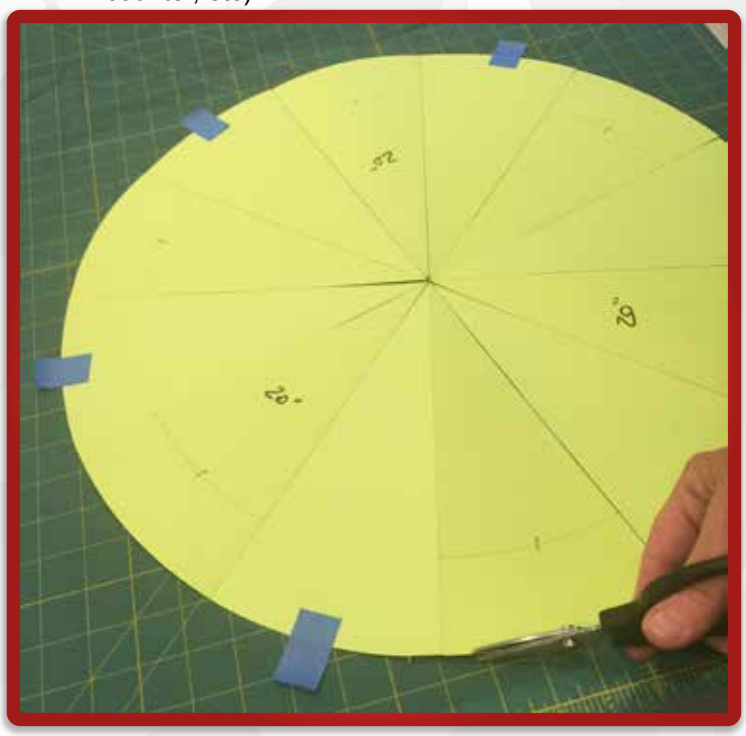

FIGURE 3. CUT OUT A DISK OF THE MESH MATERIAL USING THE CIRCULAR TEMPLATE.

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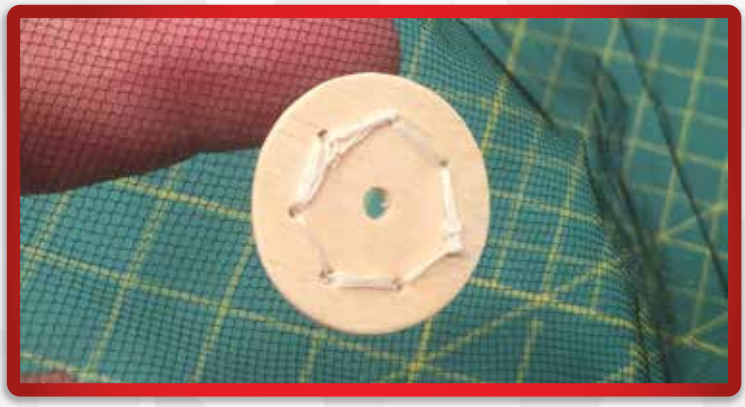

FIGURE 4. SEW THE ATTACHMENT BUTTON TO THE MESH DISK.

c) Tape the circular template to the mesh fabric.

d) Use scissors (or razor blade) to cut out a disk of mesh fabric. See Figure 3.

Step 3 – Sew Attachment Button to Mesh Disk

a) Fold the mesh disk into triangles to locate the center of the mesh.

b) Mark the center of the mesh with a piece of tape.

c) Place the mesh disk on a flat surface, with the center marking piece of tape on the **downwards** side.

d) Place the attachment button on top of the mesh disk. The radiused edge of the attachment button should face **downwards** towards the mesh disk. The center hole of the attachment button should align with the center of the mesh disk.

e) Place strips of masking tape along the edge of the attachment button to temporarily secure the button to the mesh disk.

f) Sew the attachment button to the mesh disk. Use a long length of thread to go around the hole pattern at least twice. See Figure 4.

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Step 4 – Parachute Attachment Cord

a) Cut a ¾" length of wood dowel or carbon rod

b) Cut an 8" length of Kevlar cord

c) Tie one end of the Kevlar cord around the rod. Apply thin CA to secure the knot in the Kevlar cord and to secure the cord to the rod.

d) Use an XActo knife to poke a tiny center hole in the mesh fabric. The hole should be just large enough for the Kevlar cord to pass through.

e) Push the Kevlar cord through the center hole of the attachment button and mesh disk. Depending on the size of the Kevlar cord knot, you might need to enlarge the center hole in the attachment button a little bit to achieve a nice fit (see Figure 5).

f) Create a loop on the other end of the Kevlar cord. Use thin CA to secure the knot.

g) Secure the rod to the attachment button using CA or a little bit of 5-minute epoxy. See Figure 5.

FIGURE 5. MAKE THE PARACHUTE ATTACHMENT USING KEVLAR CORD AND A WOOD DOWEL.

Step 5 – Canopy Disk

a) Lay the canopy fabric on a flat surface.

b) Tape the circular template to the canopy fabric.

c) Use the circular template and a scissors (or razor blade) to cut out a disk of canopy fabric.

FIGURE 6. USE TAPE STRIPS TO TEMPORARILY ATTACH THE CANOPY DISK TO THE MESH DISK.

Step 6 – Parachute Assembly

a) Place the mesh disk on a flat surface. The attachment button should be on the **upper** surface of the mesh disk, with the parachute attachment loop on the **bottom** side.

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FIGURE 7. USE A "CARPET STITCH" TO SEW THE CANOPY DISK TO THE MESH DISK.

b) Place the canopy disk on top of the mesh disk. The attachment button should now be **between** the mesh disk and the canopy disk.

c) Use some masking tape strips to temporary secure the canopy disk to the mesh disk. See Figure 6.

d) Sew the canopy disk to the mesh disk. If hand sewing, a "carpet" stitch[6] is good for connecting two pieces of fabric. Stitches should be made with ~¼" spacing and ¼" offset inboard from the edge of the disk. The stitches should be moderately snug but not excessively tight. A bit of slack/looseness will allow the stitches to "relax" into a nice pattern. See Figure 7.

e) You should stitch in ~45-degree segments. For best results, stitch segments on opposite sides. For example, stitch the edge segment from 0 to 45 degrees, then stitch the segment from 180 to 225 degrees, then 90 to 135 degrees, then 270 to 315 degrees, etc.

A completed mesh parachute is shown in Figure 8. It may look a bit unusual compared to a standard parachute with shroud lines.

FIGURE 8. THE COMPLETED MESH PARACHUTE WILL LOOK A BIT UNUSUAL.

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Drag Coefficient of Mesh Parachutes

Drag performance of mesh parachutes can be calculated from flight test data. Results for six test flights are shown in Figure 9. The flight model resembled a typical TARC or S2/P model, with a mass of 282 grams during descent. The mesh parachute was constructed of 21" diameter canopy and mesh disks. Descent rates are listed in Table 1. The average descent rate was 18.7 feet/sec.

The drag coefficient can be calculated from the equation for steady state descent rate:

$$C_d = \frac{M\,G}{0.5\,\rho\,V^2 A}$$

where

C_d = Drag coefficient
M = Mass
G = Acceleration due to gravity
ρ = Air density
V = Descent velocity
A = Area of the parachute

For the test flight configuration and results (282 grams, 18.7 ft/sec, 21" diameter parachute), the average drag coefficient was 0.69. Not surprisingly, this was a bit lower than typical drag coefficient values for a parasheet (0.8 to

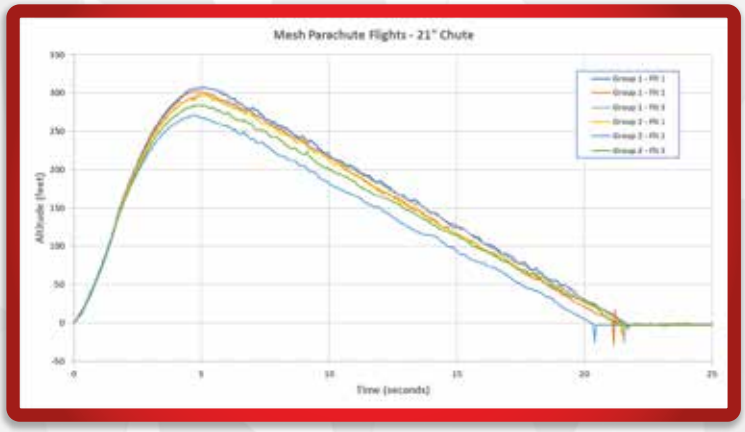

FIGURE 9. ALTITUDES AND DESCENT RATES OF TEST FLIGHTS WERE MEASURED USING AN ONBOARD ALTIMETER.

		Alt (ft)	Rate (ft/sec)	
Group 1	Flight 1	307	19.0	
	Flight 2	301	19.6	
	Flight 3	297	18.6	
Group 2	Flight 1	296	19.2	
	Flight 2	270	17.9	
	Flight 3	284	17.8	
Average			18.7	
Std Dev			0.64	3.4%

TABLE 1. DESCENT RATES FROM THE TEST FLIGHTS.

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1.0) or a hemispherical parachute (1.5). A drag coefficient of ~0.69 should be used in Rocksim, OpenRocket, or other programs to simulate the descent performance when using mesh parachutes.

Advantages and Disadvantages

Mesh parachutes have advantages and disadvantages. *Advantages include:*

- **Deployment Reliability.** The mesh parachute appears to deploy quickly and reliably. There aren't any shroud lines to tangle. I've had 100% perfect deployment so far on test flights.
- **Performance Reliability.** On test flights so far, the drag coefficient of the parachute has been very repeatable. On previous S2/P and TARC flights, I've seen significantly different descent performance on multiple flights using the same model and the same parachute. Was it the deployed shape of the chute? Was it shroud line hang-ups? Was it thermals/downdrafts? It's difficult to be certain, but the mesh parachute flights have been very repeatable so far.
- **Better Stability During Descent.** The mesh parachute seems to be somewhat more stable than a traditional parachute during descent. The rocket model still sways (or cones) during descent but not as much as with a traditional parachute. Also, the parachute doesn't appear to "dump air" the way that regular parachutes do when the rocket is coning during descent. One possible reason is that the mesh parachute canopy is close to being a hemisphere during descent. This is probably due to the mesh essentially acting as very short shroud lines ("shroud" length = 1/2 of parachute diameter instead of the more typical shroud line length of 1D or greater).

Potential disadvantages of a mesh parachute include:

- **Volume.** A mesh parachute doesn't pack very efficiently. You need a lot of internal volume in the rocket to store the mesh as well as the canopy. That shouldn't be a problem for most S2/P or TARC models.
- **Adjustability.** Traditional parachutes have some ability to be tailored by reefing the shroud lines or by cutting a spill hole. I don't know if either of these methods would work for a mesh parachute.
- **Availability.** I've only found one model rocket vendor that sells mesh parachutes (www.modelrocketparachutes.com with their "nylamesh" chutes). They only list two sizes (15" and 36"). So mesh parachutes may have to be custom "build your own" to achieve the desired performance.

Summary and Conclusions

Mesh parachutes may be helpful for certain types of events where parachute reliability is paramount. Using the techniques in this article, you can size and construct the right parachute for your particular application.

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1 https://rocketcontest.org/

2 https://www.basejumper.com/Articles/Gear/Pilot_Chutes_675.html

3 https://squirrel.ws/equipment/base-jumping/snatch

4 https://www.amazon.com/CSYS-Parachute-Throwing-Launcher-Landing/dp/B071G6B3Q1

5 https://www.amazon.com/Kangler-Training-Resistance-Parachute-Acceleration/dp/B07VXQP683

6 https://www.youtube.com/watch?v=1FknfumFPX8&t=235s, 3:50 into the video

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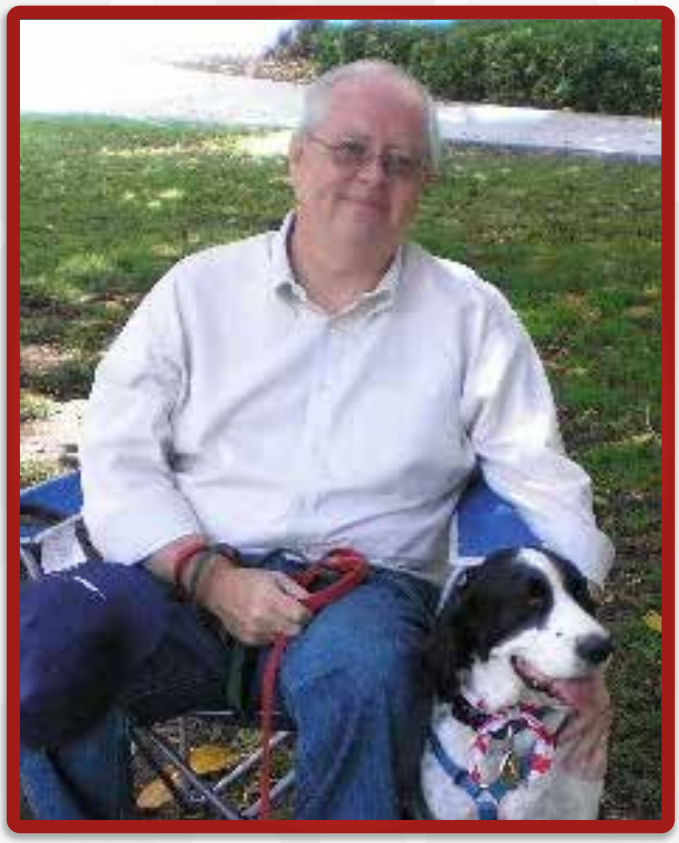

About the Author:

Chris Flanigan has been flying model rockets since the '70's. He is active in competition rocketry, both domestic and international. His day job involves real rockets, satellites, and other high technology systems. He is currently supporting independent review of loads and dynamics for NASA's new Space Launch System (SLS) vehicle.