PEAK OF FLIGHT

NEWSLETTER

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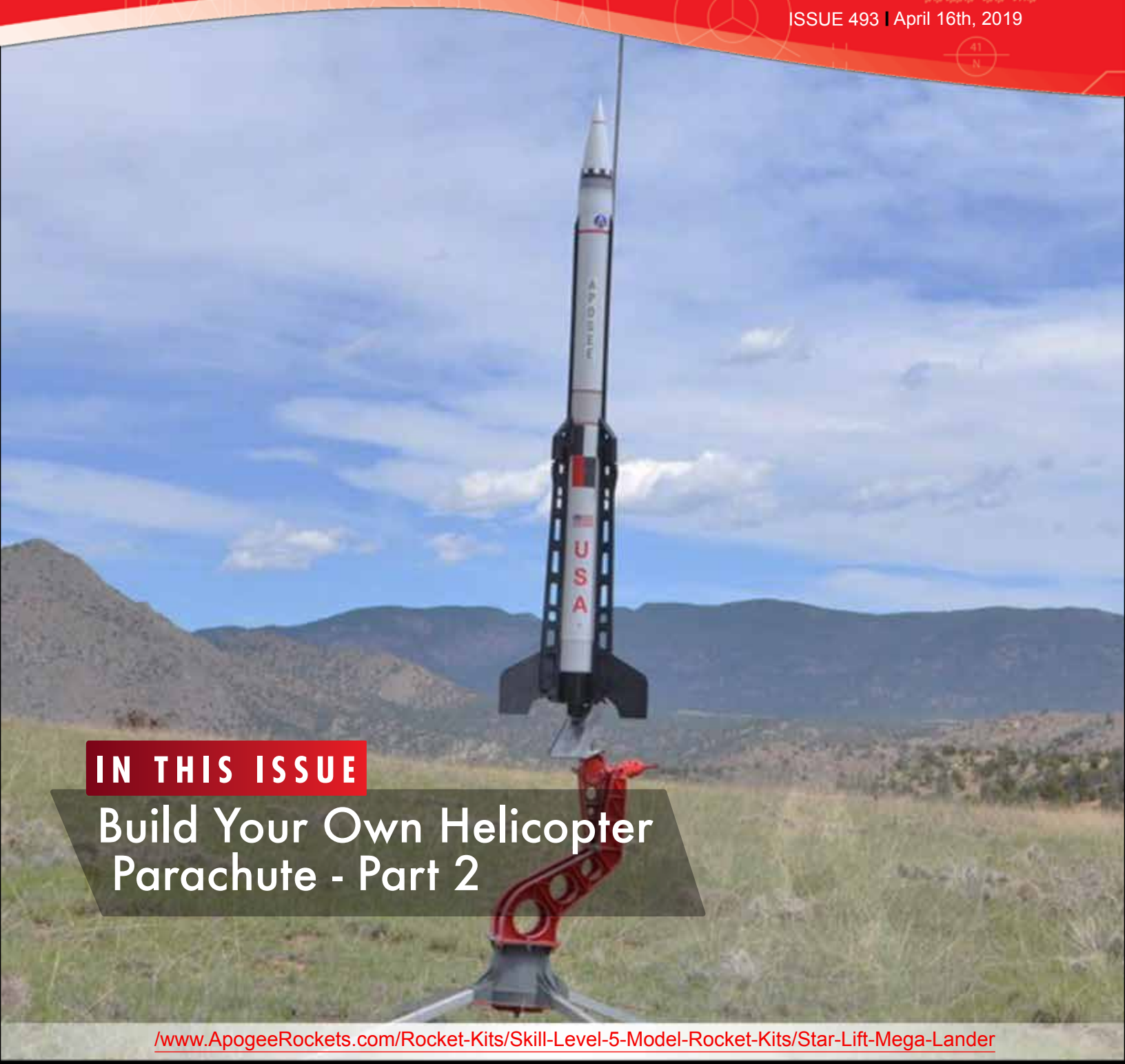

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APOGEE COMPONENTS

Build Your Own Helicopter Parachute - Part 2

By Dave Flanagan

The Symmetric Gore VRD

Some modelers might prefer to make the other version of the VRD – the symmetric gore VRD. There are only two main differences between the asymmetric gore and the symmetric gore VRD.

Building the Symmetric Gore VRD

The steps to make a symmetric gore VRD are exactly those used to make the asymmetric gore VRD with two exceptions.

The Canopy

The gores of the symmetric gore VRD are identical to the gores of the asymmetric gore VRD except the base of the gore does not have the ten degree angle shown in Figure 4 (**Part 1, Page 3**). The base of the gore is perpendicular to the midline of the gore. It is exactly a one eighth "pie slice" of a regular octagon. See **Figure 18**.

Figure 18. The patterns for the gores of the asymmetric gore model (bottom) and the symmetric gore model (top) are shown.

The Suspension Line System

The suspension line system of the symmetric gore VRD is identical to that of the asymmetric gore VRD except that when the SL's are attached to the PBL's they are not attached in the center. They are all slightly offset from the center of the PBL the same amount in the same direction (see **Figures 19** and **20**). How much? It is the modeler's choice. The greater the offset the faster the VRD will spin. The knots attaching the SL's to the PBL's should not be glued until the rate of spin is dialed in. Toss testing is the best way to determine the spin rate. Use a dummy payload that weighs about the same amount as the rocket to be recovered.

The alternate method of creating PBL's discussed above for asymmetric gore VRD's can also be used on symmetric gore VRD's. However, each of the two lines creating the PBL is marked at different distances from the tips of the gores (modeler's choice). This creates the "offset" that the VRD needs to spin. All PBL's created this way must be the same. The spin rate cannot be adjusted once the knots are tied.

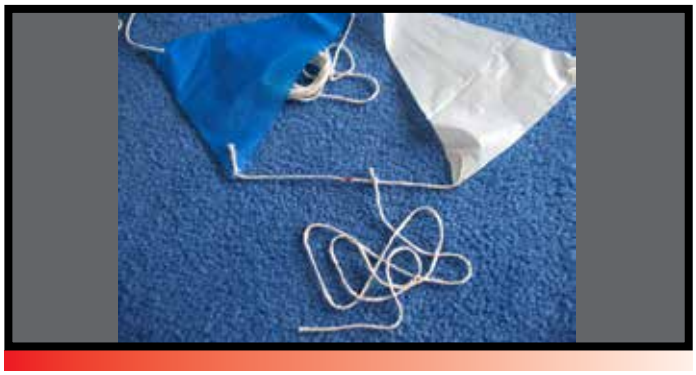

Figure 19. Traditional PBL's have been installed. The offset of a SL from the center of a PBL is shown.

Figure 20. The symmetric gore VRD is complete except for measuring the lines and tying them together. The top of the parachute is shown. Note the AIL tucked under the blue gore. Note each SL is offset the same amount and in the same direction from the center of its PBL.

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Figure 21 (a), (b). Two views of a symmetric gore VRD during toss testing are shown. During flight it is not generally possible to tell the difference between a symmetric gore and an asymmetric gore VRD.

Flying the VRD

There are two methods of preparing either type of VRD for flight. The quick way begins with one hand holding it by the payload attachment point (called the "suspension line confluence" by parachute engineers). The modeler can then drape the rocket over his shoulder onto his back and keep the parachute in front. Make sure all four gores (lobes) are pulled out and away from the suspension lines and each other. Nested and/or inverted gores are a guaranteed malfunction. "Milk" the suspension lines down to the canopy then basically compress the canopy into a cylindrical form suitable for the rocket but also as even as possible. Wrap a bit of the suspension lines (including all PBL material) around the canopy and place the parachute in the rocket.

Figure 22. (a) The modeler is gripping the PBL's and has cleared all four gores (lobes) from the center of the parachute. The red arrows point to the midpoint of the base of each gore. (b) These same points are shown on the inflated parachute during toss testing. These are the parts of the parachute that catch air and start the inflation process. They must be clear of the suspension line system and each other.

The VRD can also be "side packed". Lay the parachute on a flat surface, secure the snap swivel, and collect all the lobes and SL's on one side and the AIL on the other. Carefully stack the gores or lobes on top of each other making sure all material is pulled up and out of the lines and that the gores are not inverted or nested one inside another. Then s-fold the gore material, stacking it on top of itself until the AIL is on top of the SL's. Fold the canopy as needed to fit in the rocket and wrap some of the suspension lines around it. See **Figure 23**.

Note: The reliability of all types of parachutes is improved when the suspension lines are kept taut and even during packing.

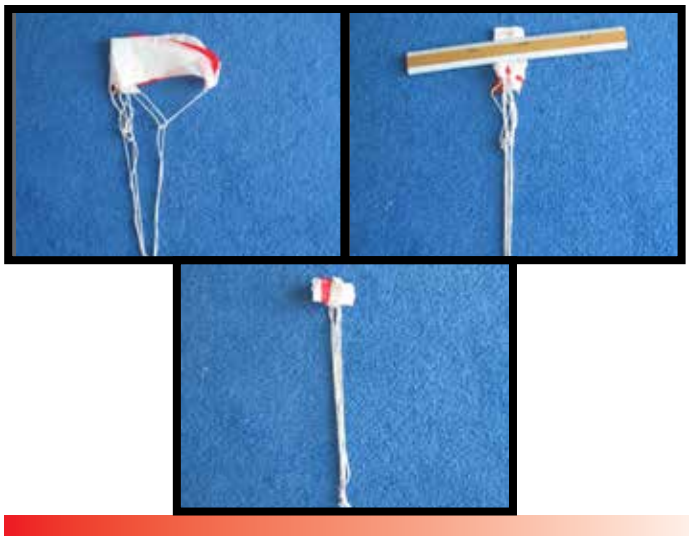

Figure 23. (a) The VRD is on laid on its side and the SL's are separated from the AIL as much as possible. (b) Secure the base of the gores (at the PBL's) and carefully s-fold the canopy onto itself until the AIL is on top of the SL's. (The ruler shown is just to keep the canopy from un-folding while the picture was taken.) (c) Roll the canopy down towards the SL confluence point at least as far as the PBL's.

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Toss testing is required. The only way a modeler can get a feel for how the VRD should be packed is by toss testing it. It will take several dozen toss tests to see how the parachute responds to minor variations in packing technique. The modeler will see malfunctions during toss testing and learn much. However, it is better to see failures during toss testing than in flight.

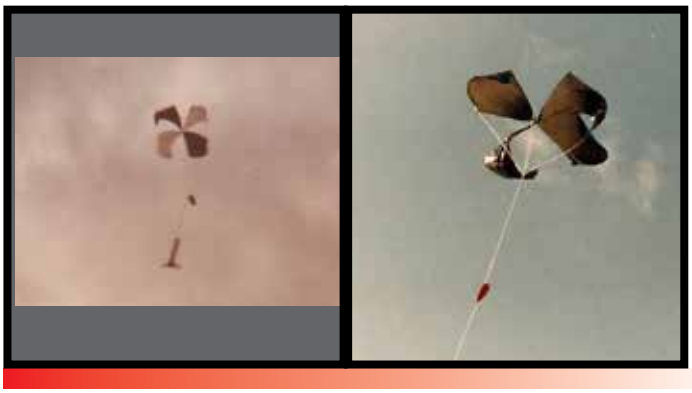

Figure 24. (a) The black and white VRD is open and flying correctly. (b) The all black VRD has malfunctioned. One lobe of this VRD is partially inverted and not fully inflated. This is likely due to a packing error. Though only three lobes were "flying" the rocket was not damaged. These two pictures are scanned photographs of some of the earliest flights of model VRD's during development (1983).

When dealing with a VRD in all phases (packing, toss testing, recovery, etc.) make every effort to avoid tangling the lines and lobes. Gores are easily inverted or nested in one another, passed through the PBL's of other gores, or tangled with the AIL, etc. This is especially problematic during toss testing. Use a dummy payload that cannot bounce or roll up into the canopy or lines. For toss testing over dirt or grass the author uses lead fishing weights shaped like a pyramid. Upon landing the weight just buries itself slightly in the dirt and stays there. Small fabric shot bags work well over harder surfaces. Correcting minor tangling of a VRD requires the patience of a saint. Correcting major tangling of a VRD requires the patience of a saint and a master's degree in topology. Avoid the challenge.

Research Project Opportunities

There is ample opportunity for research involving the VRD. For example, both the asymmetric and symmetric gore VRD's presented here are the author's interpretation of a real parachute. No one knows which model has the higher drag coefficient. Compare the two with simple drop tests.

The VRD may produce lift. As they rotate around the axis the gores or lobes may actually be "gliding" and producing lift as well as drag. The higher drag coefficients claimed (up to 1.6) tend to support this. However it is not clear that either of the adaptations presented here is as effective.

The gore planform of the asymmetric gore VRD Figure 4 **(Part 1, Page 3)** shows an angle of ten degrees. This is called the "beta angle" and is symbolized by 'β'. The author has flown VRD's with β=5°, 10° and 15°. The selection of β=10° was subjective. Given a constant system weight (m), increasing the beta angle will make the VRD rotate more quickly. It is also true that given a constant beta angle, a greater system weight also produces faster rotation. Quantifying these relationships would be interesting. In "math speak" this is $\omega=\omega(m, \beta)$, i.e. the spin rate is a function of two independent variables, the mass and the beta angle. Perhaps video analysis of simple drop tests would be useful.

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Performance may be improved by varying dimensions. The selection for the lengths of the AIL, PBL's, and the SL's are all arbitrary although the modeler will notice that the relationship between them is AIL ≈ SL + PBL/2. This means that when the parachute is hung by its swivel the tips of the gores are at the same level as the apex. When the parachute inflates the two halves of each PBL spread out, pulling the gore tips below the apex. This may not be the best arrangement.

Even when packed correctly deployment issues can occur in VRD's due to uneven inflation of the gores or lobes. Perhaps there are ways to pack the parachute so that all four lobes inflate at the same time. Another possible way to control the VRD's gores during inflation involves additional "bridge lines". PBL's connect the tips of adjacent gores. However additional bridge lines farther up the gores towards the apex might provide additional control. A careful examination of Figure 2 shows something called an "inter-panel line" connecting adjacent gores of the real VRD in some unclear fashion. This suggests that the original inventor of the VRD might have had similar thoughts.

Have fun.

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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 holds an expert skydiver rating and is a former Army paratrooper. 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 model rockets, usually ones recovered by weird parachutes.