PEAK OF FLIGHT NEWSLETTER

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IN THIS ISSUE

UPGRADING LOW POWER ROCKET KIT PARACHUTES

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PEAK OF FLIGHT

Upgrading Low Power Rocket Kit Parachutes

By Dave Flanagan

Introduction

Many LPR (Low Power Rocketry) model kits are supplied with very simple plastic parachutes. Let's face it – the parachute is not that important to most modelers. The parachute is needed just so the model can be flown more than once. Modelers can spend hours or days building a beautiful model then spend fifteen minutes attaching shroud lines to a piece of plastic sheet and looping the resulting chute on to a nose cone. Parachutes are a low priority to most modelers.

But since a lot of time, money, and effort are often invested in building a rocket, it may be useful to put a little extra time and effort into the rocket's parachute as well. The model may last longer and fly more. This article describes simple ways to improve the parachute that comes with typical LPR kits. An alternate way of building them that incorporates these ideas is also shown.

Note that although this article concerns LPR kit parachutes, some of the concepts also apply to larger parachutes of this same type used in MPR and HPR models.

LPR Kit Parachutes Issues

The parachute kits supplied with LPR models provide minimal shroud line material. When installed according to the directions the shroud lines (more properly called "suspension lines") are no more than one canopy diameter long (1.0D) and are often shorter. However, longer lines (≥1.5D) are known to increase the drag of this kind of parachute. Duration competitors have been using longer lines since at least the early 1970's [1]. Wind tunnel studies performed by a number of organizations on parachutes both large and small demonstrate that a 6% to 8% increase in parachute drag can result from increasing the suspension line length from 1.0D up to the range of 1.5D to 2.0D [2]. Use longer lines for the extra drag. Your model may land more gently.

Another issue is the way the lines are attached to the canopy. Directions vary, but usually call for a single loop of line to be attached at each end to two corners of the canopy to form two "shroud lines." This likely causes uneven lines since there will be some variation in the way the lines are attached at the six or eight attachment points. This is especially true if the lines are tied to reinforced holes rather than taped. LPR kit chutes are of a design (called "flat circulars") that is inherently unstable. They may oscillate, they may glide, or they may do both. Uneven lines can make this instability even worse. Poorly installed and uneven lines might contribute to the rapid spiraling, helical descents often seen at the range that end with the rocket airframe slamming into the ground. In the full scale parachute world great care is taken to make sure all suspension lines are the same length. For example, the suspension lines of the huge Apollo Program parachutes were 1440" long. The maximum allowable variation between any two adjacent lines was 5", or 0.35% [2]. On an 18" suspension line that same variation would be 0.063", or less than one tenth of an inch. This might be a difficult goal for modelers to achieve but it highlights the importance of keeping suspension lines as even as possible.

Also, kit chutes are generally attached directly to the nose cone of the model. Aerospace engineers are very wary of doing this when designing full scale systems and usually specify that a bridle or riser be added between the vehicle and the parachute. The concern is that the turbulent wake (burble) trailing behind the payload can cause problems with the performance of the parachute. Unpredictable openings and unstable descents are possible in poorly designed full scale systems. These are called "forebody wake effects" [2]. Small parachutes fill very quickly, so it is unlikely that forebody wake effects are a problem during the inflation of a LPR kit parachute. However, it is certainly possible to imagine that the nose cone, airframe, chute protector, chute release, etc., could all create turbulent wakes during descent. If these are suspended too close to the parachute, its performance (stability, drag, etc.) might possibly be affected.

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Continued on page 3

Upgrading Low Power Rocket Kit Parachutes

Continued from page 2

There is a very easy fix for any such adverse forebody wake effects that might exist - simply use a “riser” or “bridle” between the nose cone of the rocket and the parachute as is done with full scale systems. This will allow the parachute to get clear of the rocket components when it is ejected and be in “clean” air for opening. And during descent the rocket components will be well below the parachute so any turbulence they may create can dissipate. In full scale systems the length of the riser or bridle is dictated by the payload, parachute type, flight regime, and other factors but for LPR applications a good rule of thumb is to use at least one parachute diameter (1.0D).

FIGURE 1: SKYDIVERS ARE NOT REALLY “AEROSPACE VEHICLES” BUT THE SAME PRINCIPLES APPLY. THIS JUMPER HAS JUST RELEASED HER WHITE PILOT CHUTE INTO THE SMOOTH AIR FLOW THAT IS OFF TO ONE SIDE OF HER BODY AND AWAY FROM THE TURBULENT FLOW (BURBLE) THAT IS PRESENT OVER HER BACK. THE LONG BLACK BRIDLE WILL ALLOW IT TO INFLATE WELL ABOVE THE BURBLE AND THUS SAFELY DEPLOY HER MAIN PARACHUTE.

Continued on page 4

Upgrading Low Power Rocket Kit Parachutes

Continued from page 3

Building an Upgraded Kit Parachute

When I build a kit parachute I discard everything except the canopy. The canopies are great - they are usually brightly colored and have great (and sometimes useful) geometric patterns. I replace the line material with a lightweight twine, and I attach my lines to the plastic canopy with simple scotch tape. I prefer a fuzzy twine and “transparent” or “invisible” tape. These can be found in almost any “dollar store” and ten bucks will easily buy you enough for fifty chutes. You can also tie the lines in place on the canopy if you choose, but the adhesive paper reinforcing rings included in the kit must be used. The one thing I add to the parachute kit is a snap swivel. The flexibility that a snap swivel offers is well worth the minimal cost in dollars and weight. See Figure 2.

FIGURE 2: THIS IS ALL YOU NEED TO BUILD AN UPGRADED KIT CHUTE. IF YOU CHOOSE TO TIE THE LINES TO THE CANOPY INSTEAD OF TAPING THEM YOU CAN SKIP THE TAPE BUT YOU MUST USE THE ADHESIVE PAPER RING REINFORCEMENTS THAT COME WITH THE KIT.

I first trim the canopy from the stock polyethylene sheet as instructed. I rarely use apex vents (“spill holes”) in kit chutes but if you know you want one this is a good time to create it.

I cut each line individually to about 2.5D (2.5 times the canopy diameter) except for one which I cut to about 4.0D. I tape each line into place on the periphery of the chute and make sure the tape is firmly in place by placing the tape joint on a solid surface and rubbing it with something hard like a coin or the handle of a pair of scissors. See Figure 3. If you prefer to tie your lines to the canopy this is fine, but again tie each one in place individually. Figure 4 shows all the lines installed with tape.

FIGURE 3: CANOPIES USUALLY DON’T TEAR AND LINES USUALLY DON’T BREAK WHEN A SUSPENSION LINE FAILS. IT IS USUALLY THE JOINT ITSELF. MAKE SURE THE TAPE SECURING THE LINE IS FIRMLY SEATED.

Continued on page 5

Upgrading Low Power Rocket Kit Parachutes

Continued from page 4

FIGURE 4: THE LINE AT THE TWO O'CLOCK POSITION IS CLEARLY LONGER THAN THE OTHERS AND WILL BE USED TO CREATE THE BRIDLE.

Once the lines are installed (by either method), I use a fixture consisting of a pin mounted in a scrap of wood to align the line attachment points. I carefully press each one down onto the pin making sure the skirt (periphery) of the parachute is absolutely even at the line attachment points. See Figure 5.

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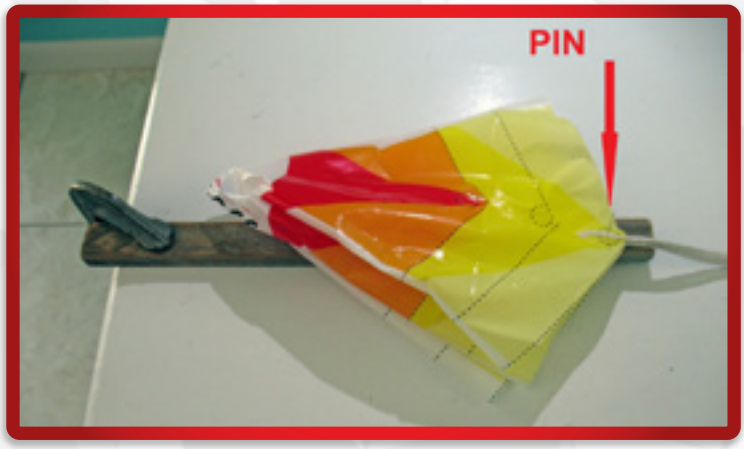

FIGURE 5: ALIGN THE SKIRT (PERIPHERY) OF THE PARACHUTE AT THE LINE ATTACHMENT POINTS.

Once the parachute is secured in the fixture, I carefully smooth all the lines down and away from the canopy making sure they are evenly tensioned. I then mark the group at ~1.5D from the secured line attachment points and carefully tie an overhand knot (tightly!) at the mark to create what aerospace engineers call the "suspension line confluence."

This results in a lot of excess line below the confluence point (knot). One line is longer than the others. This long one becomes the bridle or riser. I trim the excess from all the shorter lines. I tie the snap swivel to the long one about 1.0D (or more) below the suspension line confluence which creates the bridle. Sometimes I secure all the knots with a drop of white glue. Figures 6 and 7 show the finished chute.

Continued on page 6

Upgrading Low Power Rocket Kit Parachutes

Continued from page 5

FIGURE 6: THIS IS THE FINISHED UPGRADED 18" LPR KIT PARACHUTE.

FIGURE 7: UPGRADED KIT PARACHUTE RETURNING THE AUTHOR'S BIG BERTHA FROM ITS FIRST (AND ONLY) FLIGHT. THE DESCENT WAS QUITE STATELY BUT SADLY ENDED AMONG ROCKET EATING TREES.

Summary

The three parts to upgrading your LPR kit parachute are then:

1. Use longer lines.
2. Make certain the lines are as even as possible.
3. Add a bridle or riser between the suspension lines and the nose cone of the rocket.

References

1. Stine, G. Harry. Handbook of Model Rocketry, 4th ed. 1976.
2. Knacke, T. W. Parachute Recovery Systems Design Manual. NWC-TP-6575. March 1991.

Continued on page 7

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Upgrading Low Power Rocket Kit Parachutes

Continued from page 6

About the Author

Dave is a registered professional engineer with over twenty years of aerospace experience at NASA's JSC and MSFC. He holds B.S. and M.S. degrees in engineering and a B.S. degree in science, and while at MSFC supported NASA's University Student Launch Initiative. He earned his airborne wings in the Army and holds an expert skydiver rating from the U.S. Parachute Association. Dave is an FAA master parachute rigger and has completed the AIAA Parachute Systems Technology Short Course. He is also a FAA licensed private pilot and an EAA 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 really weird looking parachutes.

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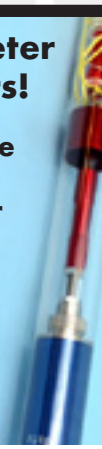

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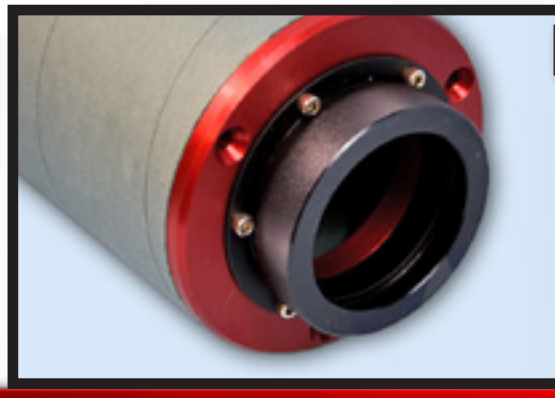

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