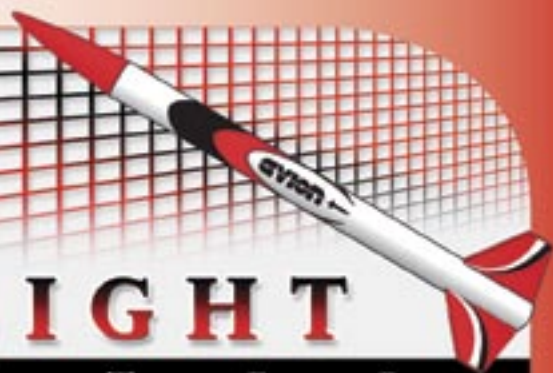




# PEAK OF FLIGHT

N E W S L E T T E R



## In This Issue

### *Sport Parachute Technology Applied to Rocketry*



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# PEAK OF FLIGHT

## Sport Parachuting Technology Applied to Rocketry

By Annette Sostarich

One of the best parts of having a multitude of interests is that sometimes techniques from one field can be applied to another field. This is particularly true, of course, when it comes to fields that are somewhat related to one another. An example is the use of ripstop nylon, commonly used in parachutes, as a kite making material. The link is even stronger between sport parachuting and sport rocketry, because they both use parachutes.

Sport parachutes are some of the most reliable devices ever designed by man. They need to be. Unlike rocketry, the consequences of a failure are sometimes the worst imaginable. We would like the recovery systems on our rockets to be that reliable, because even though there are no lives at stake, we do have a great deal of time, effort, and money invested in our aerial vehicles. There are a number of things we can do to improve on our rocket recovery systems using some of the technology developed in the sport parachuting world over the past several decades.

### Large Parachute Packing Techniques

When I was a skydiving student in the early 80s, parachute technology for students was still in the Army Surplus stage. This meant round parachutes, hard landings, and parachute harnesses of the "one size fits none" variety. It also meant that I learned a great deal about packing round parachutes of the 35 foot diameter range. On small rocket parachutes up to about 3 or 4 feet, you can get away with the traditional rocket parachute packing technique of simply "spiking" the parachute and then rolling it up and winding the lines around the outside of the bundle. Small parachutes are too stiff and have too little fabric to be able to do much else. On a larger parachute you can do better.

The first thing that can be done differently on a larger parachute is to neatly fold each panel of the parachute in half while keeping all the lines in the center. This is called "flaking" the parachute and helps ensure a full deployment as each panel catches the air. To do this properly you must maintain some tension on the parachute and lines. It may be necessary to recruit a helper to hold the apex of the parachute to keep tension as you fold panels. In the early days of skydiving, we would go find a student with nothing better to do and have them lean back in the harness while

the apex of the parachute was tied down. If your parachute is really large you may have to consider the idea of putting a loop on the apex that can be tied to a solid object while someone holds the lines to give you tension. Photo 1 shows the panels split with half on each side. Photo 2 shows the parachute folded in half with all the lines on one side.



**Photo 1:** Folding starts by having all the lines are gathered together centered in the middle of the parachute.



**Photo 2:** Next, each panel is folded down, one at a time.

Now that the parachute is properly folded you can decide what to do with your lines. On medium sized parachutes of 3 feet to 6 feet, you can still wrap the lines around the parachute as you do with the little tiny rockets. There is a better way to do this, though. Instead of holding the parachute in one hand and winding the lines around the bundle, lay the lines out on a flat surface and roll the parachute onto the lines. This keeps the lines from becoming twisted

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#### Newsletter Staff

**Writer:** Tim Van Milligan  
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## Applications of Sport Parachute Technology

as you wrap them around the parachute. Other options are to daisy chain the lines, which keeps them neat and slows down the deployment slightly, or to use a deployment bag or diaper with line stowage.

### Issues with Kevlar® lines

Kevlar ([www.ApogeeRockets.com/shock\\_cord.asp](http://www.ApogeeRockets.com/shock_cord.asp)) is almost a miracle material. It's stronger than steel yet more flexible, extremely heat resistant, and can be woven or braided into fabric, webbing, or line. It does have its weaknesses, however. It's not very abrasion resistant. It also weakens with repeated flexing over a period of time. Knots and joints in Kevlar line are particularly vulnerable. Kevlar also has little to no stretch, unlike nylon. In the mid-1980s, Kevlar hit the scene in skydiving as a wonder material for parachute lines. Kevlar lines could be made about half the diameter of nylon lines, and have the same strength. After Kevlar lines had been in service for a few months, however, they began to break. It only took a couple of hundred jumps to stress the Kevlar to the point of failure, and Kevlar lines quietly disappeared from parachutes.

In the world of high performance kite flying, Kevlar or similar material is often used as line on stunt kites, but it's never tied directly to the stunt kite handles. Instead it is sleeved with a hollow braided line made of some other material such as nylon, and then the sleeved line is tied.

This is what I have done on my largest rocket. I use Kevlar as a shock cord, but I sleeve it with tubular nylon. (Photo 3) Notice that the Kevlar is longer than the tubular nylon and it is also tied to the quick link just to make sure that it doesn't change position. I consider the tubular nylon to be a sacrificial layer that can always be replaced since it's not as heat resistant as the Kevlar is. The tubular nylon also helps reduce the possibility of zippering, since it is



**Photo 3: Tubular nylon strap covers the Kevlar®**

wider than the Kevlar. A shock cord protector, like the one sold at Apogee Components basically does the same thing ([www.ApogeeRockets.com/shock\\_cord\\_protectors.asp](http://www.ApogeeRockets.com/shock_cord_protectors.asp))

This seems to go against the current conventional wisdom of sleeving the nylon with the Kevlar, instead of the Kevlar with the nylon, but it has worked well for me so far.

### Reefing Systems – Sliders

Reefing is a sailing term meaning to take in sail. In the context of parachuting it means approximately the same thing – to “take in” a parachute and hold it in a partially deployed condition for a small amount of time to reduce opening shock. This can be done in a number of ways, depending on how slowly you need the parachute to open. Hundred-foot cargo chutes are held partially closed by lines going through rings in the canopy skirt, which are then cut by a pyrotechnic cutter at the appropriate time. Sport parachuting rigs use a device called a “slider” which consists merely of a piece of fabric that has grommets in all four corners for the line groups to go through. (Photo 4)

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**Photo 4: A parachute reefing panel.**

The slider is pulled up to the skirt of the canopy during packing, and catches some air of its own during deployment, holding the canopy skirt closed for a moment before it slides down the lines. The slider size determines opening speed. Sliders of this type can be purchased for rocketry purposes from a number of rocketry dealers.

A slider for a rocket parachute could also be nothing more than a small metal ring, a rubber "O" ring, or a small tube (see Peak-of-Flight Newsletter #183 at: [www.ApogeeRockets.com/education/downloads/Newsletter183.pdf](http://www.ApogeeRockets.com/education/downloads/Newsletter183.pdf)) that fits loosely over the lines and is pushed up to the canopy skirt during packing. The only criteria is that it be a welded ring that has no openings that can snag a line, and that it not be so large that it goes up the parachute skirt and chokes it off. Sport parachutes have small plastic discs sewn into the canopy skirt called "slider stops" to prevent the slider climbing up the parachute during deployment.

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## Reefing Systems – Daisy Chaining

Daisy Chaining is another simple way of reefing a parachute, and it has the added advantage of keeping your lines neat for an orderly deployment. Early parachuting experimenters would sometimes leave the aircraft with a parachute packed into a paper bag held in their arms and the lines of the parachute daisy chained. (DON'T try this at home!) The most important thing to remember if you daisy chain parachute lines is always begin daisy chaining from the bottom of the lines and work your way toward the skirt of the parachute!

This way the opening parachute can easily pull out the daisy chain. If you start from the skirt of the parachute and work your way down, the parachute will never open.

To begin, make a loop in the lines close to the nose cone end by picking up a bight of the lines and putting a half twist in it. Next, pick up another loop above the loop that you're holding and put that loop through the first loop. Continue doing this until you reach the skirt of the parachute. There's no need to pull the loops tight, they will probably work better if you leave them loose. Photos 5 through 8 illustrate this. Daisy chaining can also be done on non-elastic shock cords to keep them neat. Apogee Components has done an instructional video showing how



**Photo 5-8: Sequence of Daisy Chaining the Shroud Lines.**



## Applications of Sport Parachute Technology

to do this using a crochet hook ([www.ApogeeRockets.com/Rocketry\\_Videos/Rocketry\\_Video\\_31.asp](http://www.ApogeeRockets.com/Rocketry_Videos/Rocketry_Video_31.asp)). On all but the smallest shock cords, it can be done without a crochet hook.

### Deployment bags and Diapers

The function of a deployment bag is to “stage” the deployment of a parachute so that everything doesn’t happen all at once, increasing reliability. The parachute is folded inside the bag, and the bag has some means of line stowage so that the lines will always stretch out to their full length before the parachute is allowed to open. On a sport parachuting deployment bag, (Photo 9) The lines are stowed in rubber bands, and the two line stows closest to the skirt of the canopy hold the bag closed by going through grommets in the bag flap. (Photo 10)

The deployment sequence of the bagged parachute goes something like this: a small parachute (known as a



**Photo 9: Rubber bands holding the lines allows for them to stretch out in an orderly manner.**



**Photo 10: Line stows hold the deployment bag closed.**

pilot chute) is deployed first. In skydiving, the pilot chute is either ejected from the pack by a spring, or it is deployed by hand by simply extracting it from a pouch and throwing it into the air stream. The pilot chute is affixed to the top of the deployment bag and extracts the deployment bag from the pack. As the pilot chute continues to separate from the jumper, the lines are extracted from their stows in order until the last two stows open the bag and allow the parachute to open. Photo 11 on the next page shows the pilot chute (white) attachment to the bag.

A rocketry deployment bag has only a couple of differences. The line stows do not hold the flap closed, and of course it’s a different shape in order to fit into an airframe. Apogee Components carries this kind of bag at: [www.ApogeeRockets.com/Deployment\\_Bags.asp](http://www.ApogeeRockets.com/Deployment_Bags.asp). Another major difference is these bags are designed to be what is known as “free bags”, which means that they do not remain attached to the apex of the parachute. This is a system used

Continued on page 6



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## Applications of Sport Parachute Technology



**Photo 11: Pilot chute attached to the deployment bag that holds the main parachute.**

on sport parachuting reserves, because it cuts down the risk of entanglement. The downside of this system is that your nose cone and airframe are going to be coming down separately instead of connected. An alternate method, used on skydiving main parachutes, is to have a bridle several feet long connecting the apex of the parachute to the inside of the deployment bag. This can only be done if you have a

parachute with a reinforced apex, such as large parachutes that have the lines running all the way across the top of the canopy instead of just stitched to the canopy skirt as in the "Cert 3" chutes from SkyAngle ([www.ApogeeRockets.com/parachutes.asp#High-Power\\_chutes](http://www.ApogeeRockets.com/parachutes.asp#High-Power_chutes)). Just before the parachute is put in the deployment bag, the bridle is "S" folded and secured with a light-duty rubber band. This is very nearly as reliable as the free bag system, and it keeps all your parts together.

Deployment bags do slow down the opening sequence somewhat, so be sure to allow for an additional 1 to 2 second delay before you have an open parachute. You might want to set your main parachute opening altitude a little bit higher if you're using dual deployment.

You will also need a pilot chute in this system, which can be any 12 to 18 inch ordinary nylon parachute. The ejected nosecone will pull this out of the rocket, and it will then pull the bag out of the rocket.

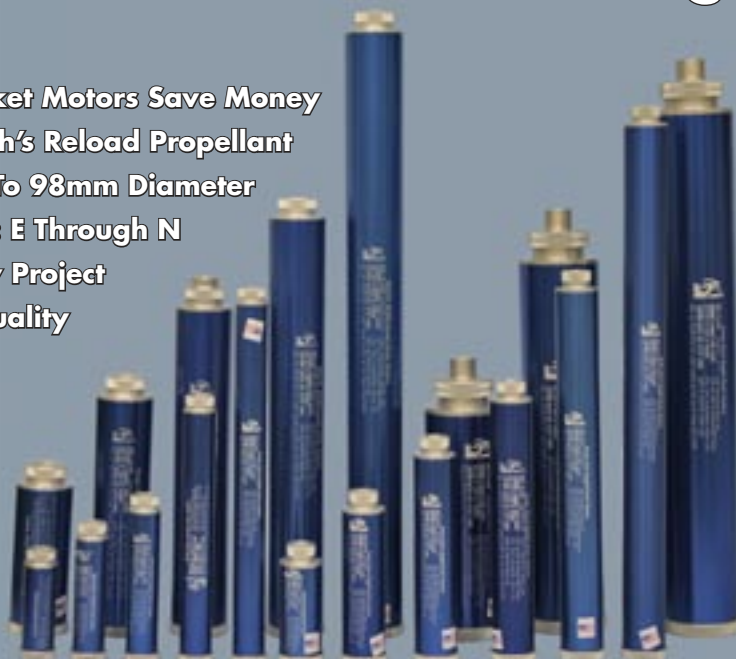
## Diaper System

A slightly simpler alternative to the bag, used on some reserve parachutes, is known as the "diaper". This is simply a strip of cloth or webbing wrapped around the skirt of the parachute, and held closed by one to three bights of

Continued on page 7

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## Applications of Sport Parachute Technology



**Photo 12:** The Diaper system has a faster deployment than a deployment bag.

line (Photo 12 – The diaper is black and the parachute is orange). You still need a pilot chute, but the diaper is less bulky, weighs less, and makes for a slightly faster deployment.

As you can see, parachute packing is not Rocket Science. It just requires a moderate but not obsessive amount of neatness, and some attention to detail.

### The Tangle-Proof Chute

Sometimes, rather than go to the lengths described in the previous section to prevent tangles, it can be useful to have a parachute that is impossible to tangle. This is especially true of pilot chutes, since they are the first thing thrown into the airstream and everything else depends on them. If you need a parachute that absolutely, positively, cannot tangle, building one with nylon netting instead of lines is the best way I know. Photo 13 illustrates a typical



**Photo 13:** A tangle-free pilot chute.

skydiving mesh pilot chute of about 30 inch diameter, the design of which can be easily scaled down for use in rocketry. This is probably something you would have to make yourself, but it's not hard to do with basic sewing skills. After the parachute canopy is made, you need four or six triangular pieces of nylon netting that when sewed together to make a conical shape similar to the shape that parachute lines would take on. Note the white reinforcing tapes at the mesh joints. Since the mesh is not very strong, the joints between the mesh panels need to be reinforced with nylon tape. The top of the mesh cone is then simply stitched to the skirt of the canopy, and a bridle of nylon webbing is

Continued on page 8

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stitched to the point of the cone.

The best way to pack this type is to lay flat with the canopy forming a circle and the mesh up, fold in half putting the mesh inside (since it's more fragile and snag prone), and then fold again and roll up.

The only downside of the mesh chute is that it is very bulky compared to a traditional chute of the same size, so its uses will probably be limited to pilot chutes and other specialized applications.

## Snag-Proofing

Another thing that skydivers are meticulous about is having as few things to snag a parachute or a line on as possible, to the extent of forbidding shoes or boots with lacing hooks on them. Lines have caught on such things before, and that can make for a very bad day. It's worthwhile being just as meticulous with the inside of your airframe. Shock cord mounting systems, rail button or launch lug mounts that protrude through the airframe, all this needs to be smoothed out or faired over in some fashion to present no resistance to an ejecting parachute. Duct tape (in the field), fiberglass tape, or epoxy can all be used to round sharp projections and make for a smooth ejection.

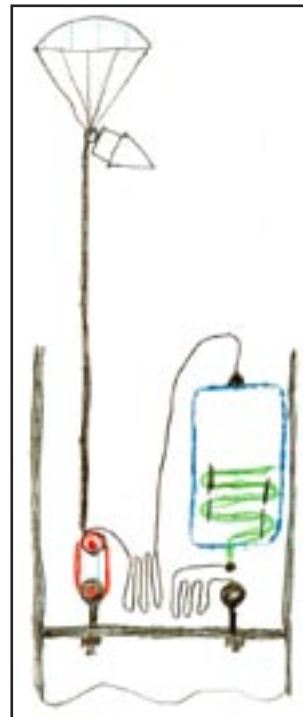
## Drogue as pilot chute

Why do you need a drogue AND a pilot chute? Well, the short answer is you don't. Tandem parachuting, which involves two people under one parachute, would not work as well unless the freefall rate of the pair could be slowed down. The pair has the air resistance of one person but the weight of two, so a drogue chute is used to slow them to normal solo freefall speed. The drogue is anchored to the harness by a quick release mechanism, and when released becomes the main pilot chute. We can do the same thing in rocketry using either the reefing cutter described below,

or a new product from Apogee Components known as the "Tender Descender" ([www.apogeerockets.com/Tender\\_Descender.asp](http://www.apogeerockets.com/Tender_Descender.asp)). Both of these devices use a small pyrotechnic charge to cut or release the pilot chute bridle from the main airframe.

Drawing 1 shows how it's done (not to scale). When the drogue charge fires at apogee, the nose cone and drogue chute are ejected. The drogue bridle (Shock Cord) has a loop or "D" ring that at this time is connected to the airframe by a separable device such as the Tender Descender (shown in red). When the main deployment charge fires, it releases the "D" ring, allowing the rest of the shock cord to pull the main parachute deployment bag (Shown in blue) out of the airframe, deploying the main parachute. The deployment bag can either be a free bag, or an attached bag as described above in the section on deployment bags. If used as a free bag, the pilot chute/drogue should be of appropriate size to lower the nose cone safely to the ground. This is usually not a problem unless your nose cone is very large or has a lot of ballast added to it.

The main advantage of this system is simplicity. You only need one compartment for both drogue and main parachute, and you don't need a separate pilot chute for your bagged main parachute.



**Drawing 1: Parachute tether release device.**

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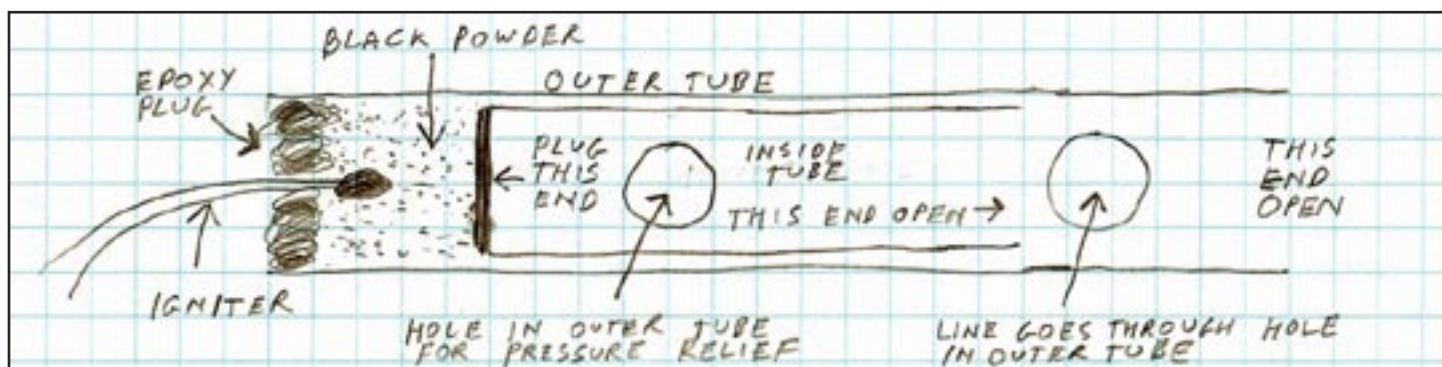
## Applications of Sport Parachute Technology

### A Homemade Reefing Cutter

The larger a parachute gets, more elaborate its reefing system might be. Very large parachutes (think Apollo Spacecraft) are often reefed in several stages. One way this is done is through a pyrotechnic device designed to cut a line at a particular time. Here is a design that will allow you to easily build something similar. Start with a couple of lengths of brass tubing. The outer tube should be between 1/4 inch and 3/8 inch in diameter, and the inner tube should be the next size down, so that it can easily telescope into the outer tube. The tubes can be between 2 and 3 inches long. The only hard part will be drilling two holes, approxi-

mately half the diameter of the tube, all the way through both sides of the outer tube. One set will be close to one end of the outer tube; this will be where the string or line that you want cut will go. The other set should be approximately 1/3 of the way from the opposite end of the tube. (See Drawing 2 for details.) This is a relief hole for the combustion gases after the line has been cut. These holes will need to be carefully deburred on the inside so that the inner tube can slide freely. This can be done with a drill bit of the same diameter as the inner diameter of the tube. The inner tube is prepared by capping one end with an epoxy plug.

The inside tube will be about  $\frac{1}{2}$  the length of the outside tube, to allow room on one end for the igniter and powder charge, and room on the other end for the open hole that



Drawing 2: Reefing Cutter

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## Applications of Sport Parachute Technology

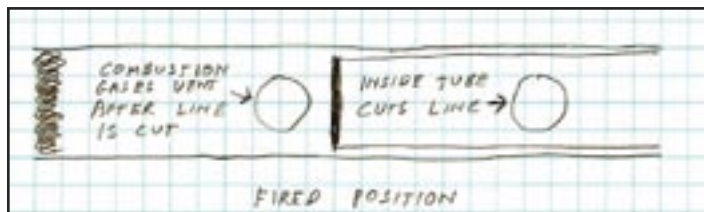
the line goes through. Insert the inside tube into the outer tube with the open end of the inside tube towards the end of the outer tube that has the hole. The open end of the inside tube should be just above the hole. I will refer to this as the bottom end. Put a small amount of black powder in the top end, insert an igniter, and seal the cavity with epoxy. When the igniter fires, it will push the inside tube down until its sharp edge cuts the line as it passes the bottom hole. After the edge of the inside tube passes the bottom hole, the top hole opens up so that the pressure from the powder charge is vented safely. (Drawing 3)

Why do this instead of just using an igniter to burn through a line? This system keeps the fire somewhat contained, so there's less chance of burning something you don't want burned. It can also be anchored to the airframe, reducing stress on igniter wires that can cause a failure. This device, like the homemade explosive bolts in a previous newsletter, will require considerable experimentation to come up with a reliable configuration. The good news is the parts can probably be reused several times with a little bit of cleaning up.

This reefing cutter should look familiar. There was a similar design that was featured in Newsletter 277 ([www.ApogeeRockets.com/education/downloads/Newsletter.pdf](http://www.ApogeeRockets.com/education/downloads/Newsletter.pdf))

### About the Author

Ever since she can remember, Annette Sostarich has been fascinated with two subjects - electronics and avia-

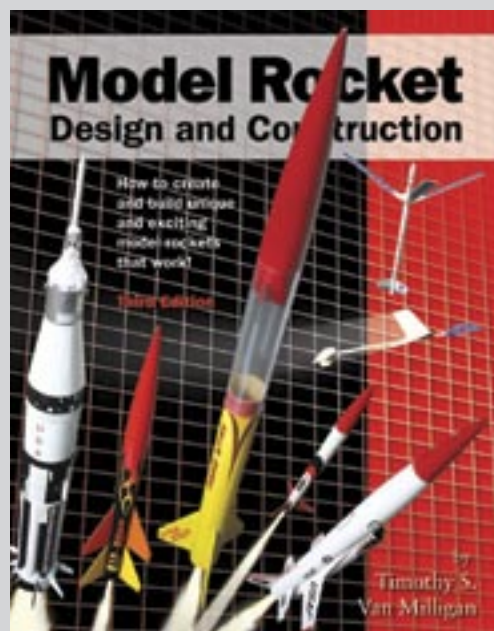


**Drawing 3: Line cutter after firing the powder.**

tion. From watching planes take off as a kid on Saturday mornings to over 450 parachute jumps, designing and building numerous kites, volunteer work at Tucson, Arizona's Pima Air & Space Museum in their restoration hangar, and now designing unusual rockets, there have been a lot of adventures.

Her electronics background began with picking up a soldering iron by the wrong end at the age of 12, and has since been parlayed into a part-time computer repair business. She is just beginning to apply electronics to rocketry with subcompact video cameras as payloads. She met her husband of 28 years while skydiving, and they jumped into their own wedding. Her husband is an aircraft mechanic who is currently building an airplane in their garage. Her next major rocketry project will be a level 2 Certification bird that will be equipped with some of the ideas in this article in addition to radio tracking so she can get it back!

Annette is also the author of the article in *Peak-of-Flight Newsletter* #260 ([www.ApogeeRockets.com/education/downloads/Newsletter260.pdf](http://www.ApogeeRockets.com/education/downloads/Newsletter260.pdf)) that covers how to make functional strap-on booster rockets.



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