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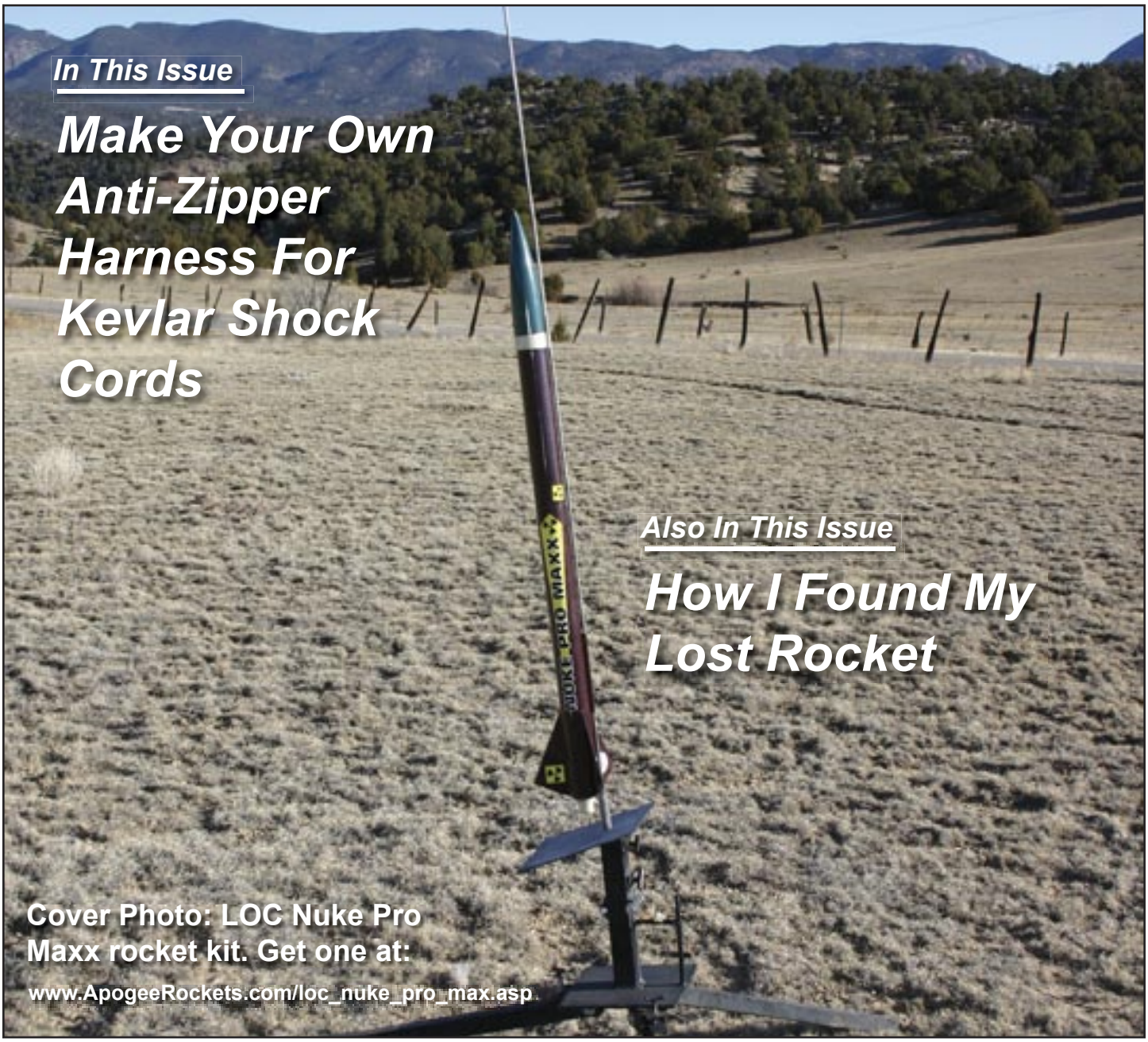
PEAK OF FLIGHT

NEWSLETTER



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Cover Photo: LOC Nuke Pro Maxx rocket kit. Get one at:

www.ApogeeRockets.com/loc_nuke_pro_max.asp

Apogee Components, Inc. — Your Source For Rocket Supplies That Will Take You To The “Peak-of-Flight”
3355 Fillmore Ridge Heights
Colorado Springs, Colorado 80907-9024 USA
www.ApogeeRockets.com e-mail: orders@apogeerockets.com

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Make Your Own Anti-Zipper Harness For Kevlar® Shock Cords

By David Hooten

Kevlar® (www.ApogeeRockets.com/shock_cord.asp) makes a great shock cord. It is six times stronger than steel. It begins to decompose, not melt, at 800 °F (about 500 °C). It is flame resistant and self-extinguishing, so it's ideally suited for the hostile environment inside model rockets. The problem is that it has no stretch and is fairly abrasive, so when the recovery system deploys in less than optimal conditions it can cut through a paper body tube like a hot knife through butter. This type of rocket damage is referred to as a zipper. I've seen several different ideas to help prevent the dreaded zipper. Here is mine.

Photo 1: Kevlar shock cord.

On rockets that use centering rings, I build a Kevlar shock cord harness. It consists of 4 suspension lines, or risers, that extend beyond the end of the body tube and then connect by way of a barrel swivel to the single long shock cord as shown in Photo 2. As the recovery system deploys, the extra risers relieve tension on the line that contacts the edge of the body tube. This ensures that there is not a single line that directs all of the force of the recovery system against the tube. The harness also causes the rocket body to rotate so that when the full force of deployment occurs the body is in-line with the shock cord, preventing damage.

Photo 2: The four-strand harness attached to the body tube at the centering rings of the engine mount tube.

How does it work?

Under optimal conditions the parachute and shock cord pull straight out of the body tube. (Figure 1,A) The force of deployment is divided equally through the harness (red arrows) and the shock cord never contacts the body tube. However, if things always worked out optimally you wouldn't be reading this. In the real world the shock cord and parachute deploy at some angle other than straight out.

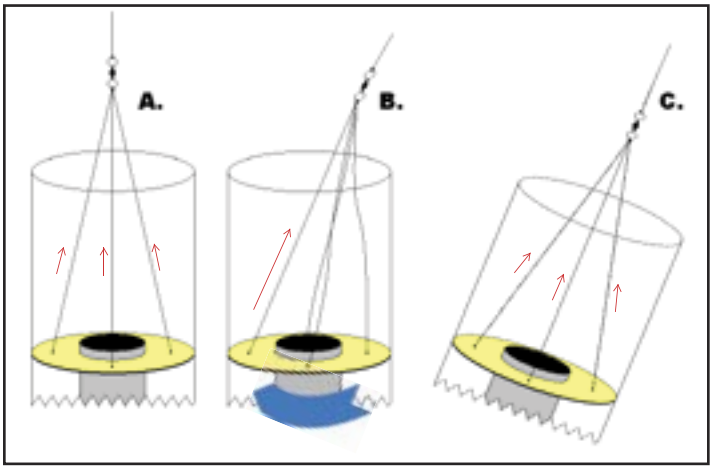

Figure 1: Tension on one strand causes the tube to rotate, relieving the strain on the tube.

When the shock cord is pulled at an angle, the riser that is opposite the direction of pull tightens first, relieving tension on the line that is endangering the body tube. This taut riser transfers the entire force to the upper centering ring. (Figure 1,B) This force applied to the centering ring is off-center for the rocket body. Assuming your rocket's CG is close to the centerline of the body tube, the centering ring becomes the moment arm of a torque force (blue arrow) that rotates the body tube to align it with the shock

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About this Newsletter

You can subscribe to receive this e-zine FREE at the Apogee Components web site (www.ApogeeRockets.com), or by sending an e-mail to: ezine@apogeeRockets.com with "SUBSCRIBE" as the subject line of the message.

Newsletter Staff

Writer: Tim Van Milligan
Layout / Cover Artist: Tim Van Milligan
Proofreader: Michelle Mason

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cord. Physicists define torque (t) as force (F) times the distance from the pivot point (r), t = F * r. Therefore, the further you place the attachment points of the risers from the center of the rocket, the greater this rotating effect will be.

When the body tube is in-line with the main shock cord, the force is then distributed evenly among the four risers and the rotating force is eliminated. (Figure 1,C) This rotation of the rocket body keeps the forces of deployment on the centering ring and away from your body tube. After the parachute fully deploys, gravity causes the rocket to hang straight down from the parachute.

Building it into your next design:

Before building the rocket, start by checking your RockSim (www.ApogeeRockets.com/rocksim.asp) design for the distance from the upper centering ring to the end of the body tube. Then add about 1.5 body diameters. Multiply that by four for the length of Kevlar cord needed for the harness. I'll use my latest rocket as an example. My rocket design called for 12" from the upper centering ring to the end of the body tube. The tube was a 2.6" diameter BT80, so I added 12" + (2.6*1.5=3.9) to that to get to 16". Then I multiplied by 4, so I needed a total of 64" of Kevlar cordage.

Although you are essentially dividing the shock cord into 4 lines, the risers need to be at least as strong as your primary shock cord. When all of the ejection force is directed through a single riser, you want to be sure it is not the weak link in your recovery system.

Next you'll modify the upper centering ring to receive the harness. Start by using a fin marking guide to mark the centering ring with four equally spaced lines that extend from the inside to the outside. Then measure and put a cross mark at the midpoint of those lines so that the risers will be in the "meat" of the ring as shown in Photo 3. On smaller diameter or long bodied rockets you may want to attach the risers closer to the outside of the centering ring. Next, drill 4 holes in the centering ring that correspond to the marks. You want the holes to be just large enough for the Kevlar cord to pass through. On lightweight paper centering rings like the one used in the example, you can use the pointy tip of your hobby knife to make the holes. On plywood rings, use a small drill bit to make clean holes.

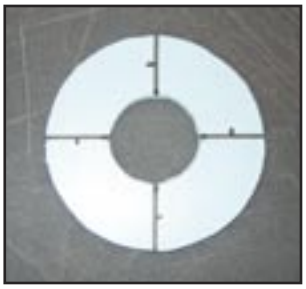

Photo 3: The location of the harness attachment points on the forward centering.

Threading the Harness

With the centering ring ready to go, you'll need to attach the Kevlar cords. Start threading the harness from the inside of the ring, go to the exterior, back inside the next hole and so on until you get to the beginning. When complete there should be two loops on the upper side of the

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centering ring and one loop and the two loose ends on the bottom. (Photo 6) Tie the two ends together with a square knot and trim the ends. Dab a little white glue on the knot to make sure it won't come undone as shown in Photo 5.

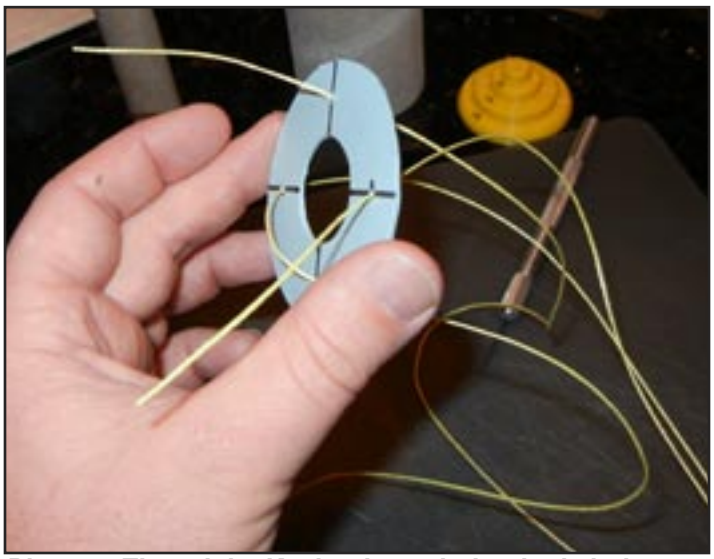

Photo 4: Thread the Kevlar through the ring's holes.

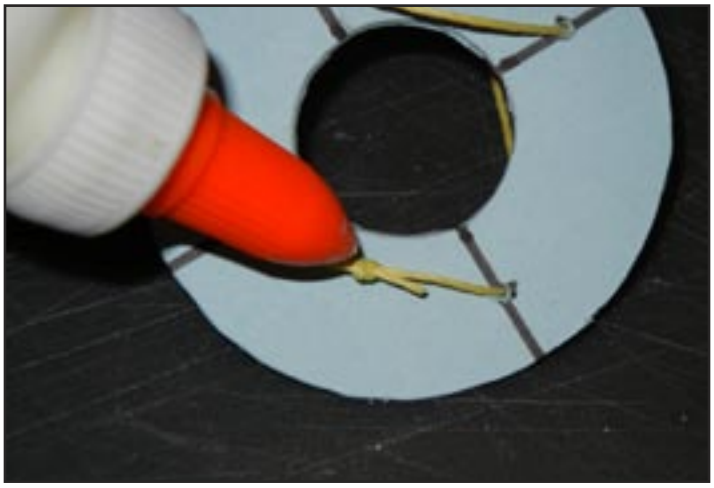

Photo 5: Glue the knots so they can't come undone.

Now space out the lines so that the two loops outside the ring are the same length, and the lines are tight against the underside of the centering ring. (Photo 8)

Pull the two loops tight in order to find and mark the midpoints of the loops. This is where you will attach the

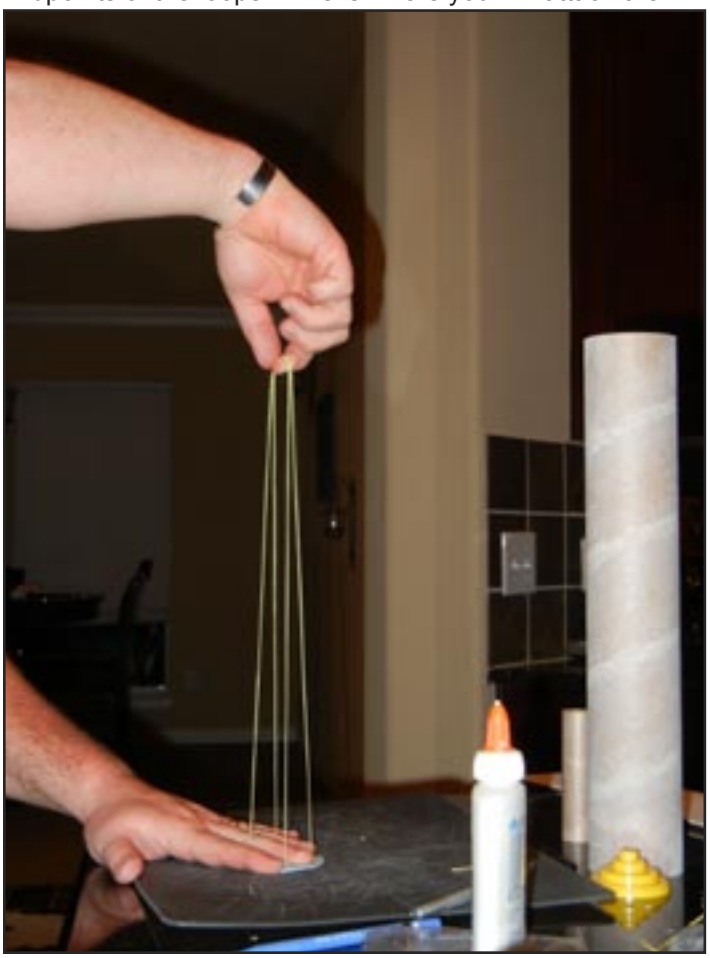

Photo 6: Make sure all the lines are exactly even.

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Photo 7: Attach the lines to a barrel swivel at the exact midpoint of the lines.

barrel swivel (www.ApogeeRockets.com/swivels.asp). It is very important that all 4 suspension lines be equal in length or the rocket will not hang straight down from the harness. Attach the lines to the swivel in the same way you would attach a parachute to the lug on a nose cone. Do not glue this knot until the rocket is complete.

Bringing it all Together:

The harness is now ready to be incorporated into your rocket. Build your motor mount as usual ensuring that the harness extends out of the body tube during construction. (Photos 8 & 9) On the 2.6" model in the example, the 64" of Kevlar produced 4 risers of about 15". That extended the harness 3" beyond the end of the body tube. After

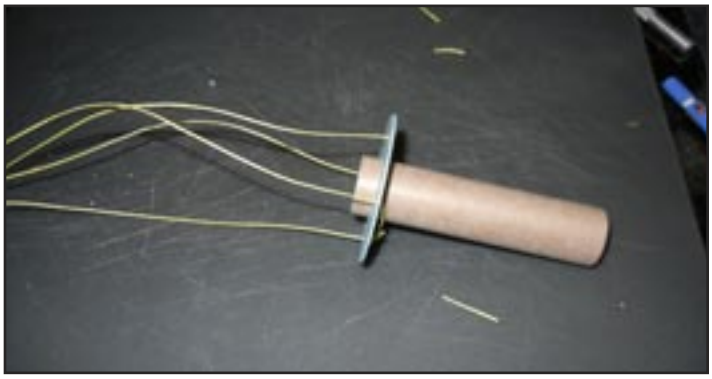

Photo 8: Forward centering ring attached to the engine mount tube.

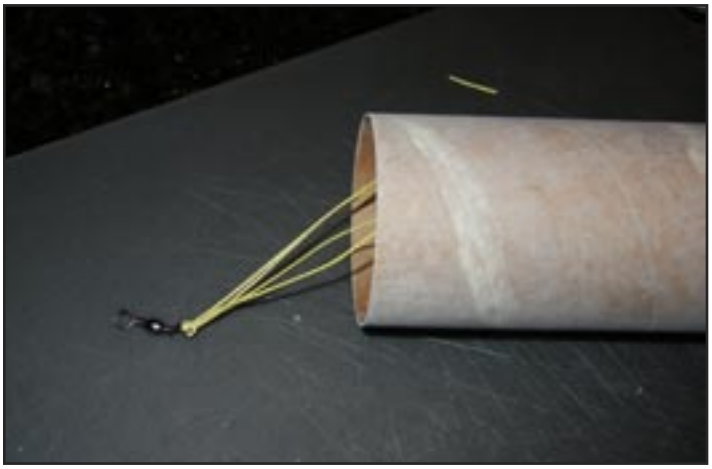

Photo 9: The harness must extend out the forward end of the body tube.

rocket assembly your single shock cord (2-3x the rocket length) is tied to the other end of the swivel to complete the harness. Now you can hold the rocket in the air by the shock cord and see if your suspension lines are all even. Adjust them as necessary to make the rocket hang level then set the knot at the swivel with some white glue.

The Harness in Action

Photo 10 on the next page shows an interior view of a rocket with several successful recoveries using this harness design. This particular rocket weighs a little over 10 oz without the motor and uses fiber centering rings. If you look closely you can see that even though there is no reinforcement to the centering ring, the holes for the risers are still true with no signs of damage or deformation.

This harness adds some weight to the rocket as compared to a single shock cord, but is much lighter than the typical anti-zipper design with its bulkhead and U-bolt assembly. During descent it also causes the rocket to hang

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Photo 10: Interior view of the rocket after several flights. It is sooty, but still strong and functional.

straight down from the parachute so that when it strikes the ground it is much more likely to land on the sturdy base of the rocket rather than the fins. This may allow you to use lighter balsa fins and negate the weight gain while improving the CG/CP relationship.

About the Author

Dave Wooten is a graduate of Texas A&M University where he was also a member of the Corps of Cadets. As an Air Force officer, Dave attended Strike Navigator/NFO training at Pensacola Naval Air Station. He spent a short time teaching field trips and guiding tours at the Naval Aviation Museum. Dave also worked in Air Force Acquisitions, on programs to design and procure air crew life support equipment such as ACES II/III ejection seats, aircrew laser eye protection, flight clothing, and active noise reduction headsets/helmets. He also worked with the USAF Materials Test and Acceptance Lab and the Life Science Equipment Lab/POW MIA accounting program. After leaving the Air Force Dave spent 3 years in construction program management. He is currently a civilian Program Manager working on DoD programs.

In this photo, Dave is holding his scratch-built 1/3 scale AIM120A. It flies on 29mm RMS motors and uses the anti-zipper design in the article. It also employs a 1/4" drop-away launch lug to reduce in-flight drag.

How I Got My Rocket Back

By Tim Van Milligan

A few weeks ago, I launched a LOC Nuke Pro Maxx rocket, which you can see on the cover page of this issue. Inside the rocket were two prototype units of the new AltimeterTwo altimeters. I was flying them to get data back to make sure that they were working properly before we release them in April.

To get comparison data, I also flew a TeleMetrum GPS payload (www.ApogeeRockets.com/Altus_Metrum_GPS.asp). What I needed was the data from the accelerometer onboard the TeleMetrum unit. This was going to be used to compare with the speed and acceleration that was captured by the two AltimeterTwo devices. If all three devices came back with the same max speeds, then everything would be good.

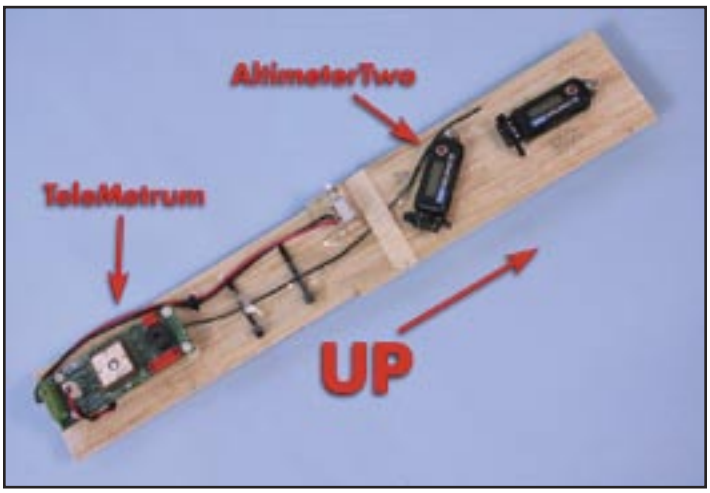

Photo 1: This rocket contained some very expensive electronics, including two very expensive prototypes of the AltimeterTwo altimeters.

The weather on the launch day was nice, but a little bit breezy. The first launch of the LOC Nuke-Pro Maxx (www.ApogeeRockets.com/loc_nuke_pro_max.asp) with all the devices onboard went off without a hitch on an F52 motor from Aerotech (www.ApogeeRockets.com/Aerotech_Reload_Motors.asp#29mm_Reloads), and the data came back great. The readings from both AltimeterTwo were a bit over 155-mph, and the Telemetrm was showing around 165 mph. That is well within the margin of error that I was expecting.

So I loaded the rocket up again, but this time with a 38mm-diameter G46 motor from Cesaroni (www.ApogeeRockets.com/Cesaroni_38mm_Reload_Kits.asp). The first flight went about 840 feet, so I was expecting around double that for the G-motor flight.

The rocket ripped off the pad, and everything was going fine until the deployment. What happened was the elastic shock cord in the Nuke-Pro Maxx kit let go, and the bottom section tumbled away from the payload bay.

The upper payload bay then started really drifting rather quickly and wasn't descending very fast because it had less weight suspended under the chute.

I started chasing, but it was drifting beyond a 200 foot

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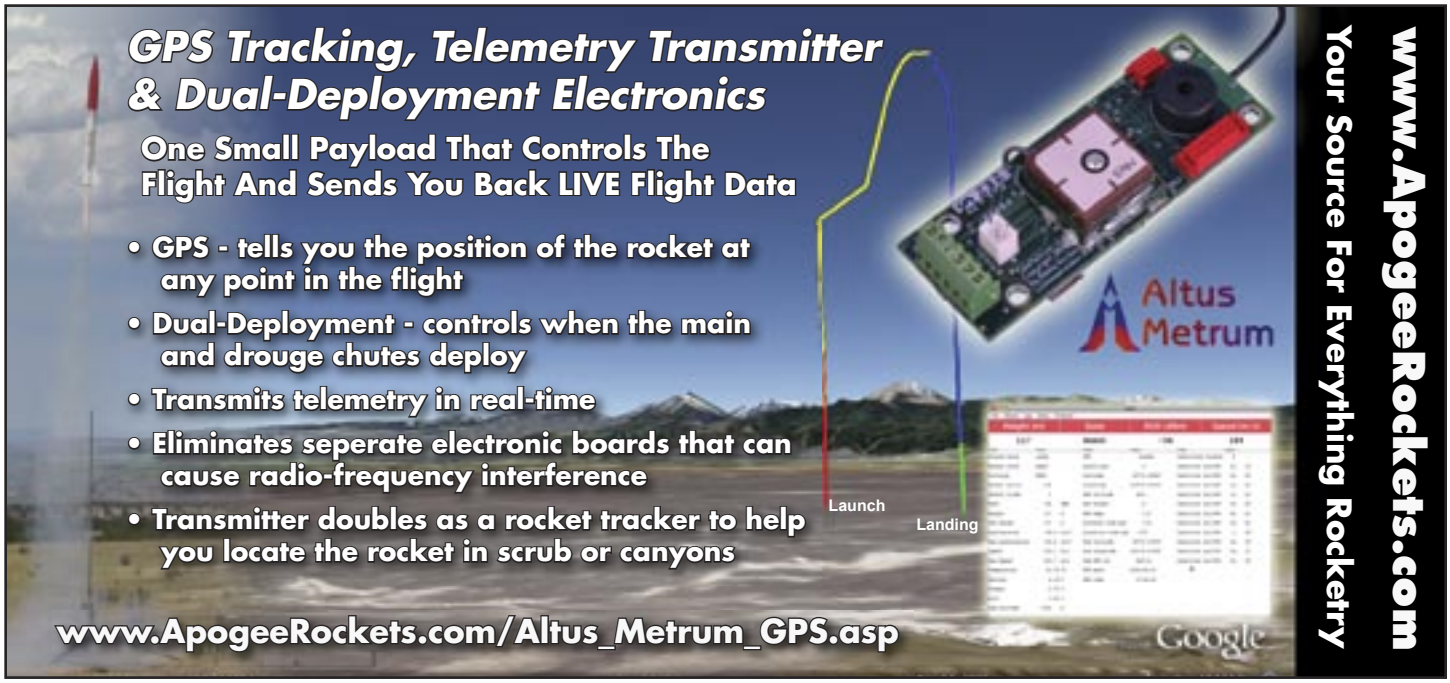

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tall mountain. My legs could not keep up with it, and I lost sight of it beyond the top of the tree-covered mountain.

To say the least, I was a bit dejected. I really didn't want to lose the expensive prototypes of the AltimeterTwos. After walking back to my car, I took a look at the telemetry data from the TeleMetrum. It had transmitted the GPS position data just fine, but the signal cut off when the rocket drifted behind the mountain (I wasn't using a real antenna on the device, because I really wasn't interested in the GPS coordinates).

But I did have something to work with. I knew the last known position of the rocket, and the direction it was travelling. And the TeleMetrum software has the option of exporting out a trajectory file that could be read by Google-Earth. But unfortunately, I didn't have an internet connection on the launch field, and I wasn't able to bring up Google-Earth to look at it.

I packed up all my equipment, and spent the next two hours searching for the rocket, to no avail. I wasn't able to find it.

When I got back home, I immediately opened up Google-Earth and took a look at the trajectory plot (see Photo 2). The red line was when the rocket was accelerating (under thrust). The yellow line is the estimated GPS position during coast. The reason it is not curved like a normal trajectory is that the rocket is moving so fast that the GPS signal is lost. When the rocket slows down (after parachute deployment), the GPS signal gets reacquired, and the blue line shows the drifting of the rocket.

Since the signal was lost, the blue line on the Google-Earth plot abruptly ends mid-flight.

Google-Earth is a fantastic program, because it allows you to look at things from any position or view-angle. With

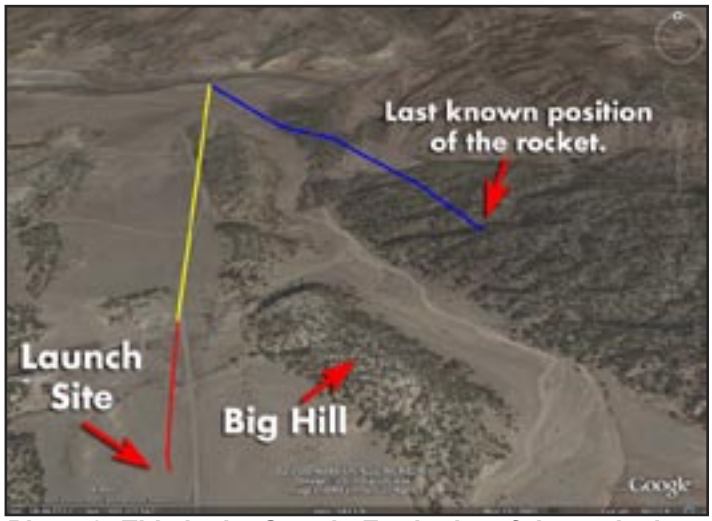

Photo 2: This is the Google-Earth plot of the rocket's trajectory. The path stops because the rocket drifted behind a mountain and the radio signal was lost.

that feature, I just repositioned the view in Google-Earth so that I was looking right along the blue trajectory line. My goal was to make it into a "dot" instead of a line. But because the wind was not consistent that day, I could only estimate the line. But I could then project the line forward by finding a point on the ground where the line should end.

Now that I had a projected landing point, I simply read the lattitude and longitude points right off of Google-Earth. See Photo 3. This whole process took less than ten minutes.

But I had to wait a couple of days to go back out and try to find the rocket. That happens when you run a business, and you can't always get away when you want.

With a borrowed hand-held GPS unit (see Photo 4), and a little help from Robby (the guy that ships your packages when you order from Apogee), we headed right to the

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Photo 3: By looking down along the flight path (the blue line), I was able to get an estimate of where the rocket landed (white dot).

coordinates that I had estimated where the rocket should have landed. It took us about a half-hour just to get to the location, because the terrain was pretty rugged and rocky. The rocket was not exactly where I had predicted it would be. But expanding outward our perimeter from that point, we soon spotted the parachute dangling from the top of a large Juniper tree. It only landed about a hundred yards from the predicted spot.

Photo 4: The hand-held GPS receiver that we used to find the rocket.

The reason it wasn't where I predicted was because the wind was not blowing at a constant speed or direction. But it was pretty close. I was very impressed at this whole process, that I wanted to share it with you.

Next time, I'll have the right electronic equipment with me, so I can find the rocket a lot quicker. But this worked and I got my expensive electronics back.

Photo 5: The yellow parachute dangles from the top of a tree, telling us where the rocket had landed.

I have to say that the TeleMetrum saved the day. I got it back, and I can't say how pleased I am with its performance. It just works!

Getting the TeleMetrum back home and recharging the battery, it was no worse for the experience. I was able to download all the actual flight information and make the comparison with the AltimeterTwos. Here it is:

TeleMetrum: Altitude: 1948 feet, Speed: 214 mph
AltimeterTwo #1 Altitude: 1968 feet, Speed: 240 mph
AltimeterTwo #2 Altitude: 1956 feet, Speed: 243 mph

Pretty good, if I say so myself!

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