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NEWSLETTER

Tracking Down Lost Rockets

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Tracking Down Lost Rockets

By Tim Van Milligan

A reader, Carter Askren, asks:

"My daughter and I flew a streamer recovery rocket that went up straight, then veered to the right. I was wondering how I can tell how far out (not just altitude) it goes; we couldn't find it after it disappeared behind trees and landed in a field (I scoured the field and the trees and couldn't see anything, so I figured it went farther than I thought and landed in a thicket further down the field.) I was looking through binoculars, so I don't know how far out it went. Here are my questions:

1. How do you judge the distance?

2. Do you recommend the Apogee Altitude Tracking Device (http://www.apogeerockets.com/altitude_tracker.asp), and would it work for a horizontal distance?

3. And why didn't the rocket just come straight back down like most of my streamer rockets?

4. I've seen some web sites that have a pinger for rockets. Where do I find one?"

Carter asks some great questions. In a nutshell, the questions point to a common problem that all rocketeers face. In other words, what can we do to improve the odds of getting our rockets back after the launch?

There are a number of solutions. With the invention of modern electronics and GPS devices, some of them are very accurate. Unfortunately, they aren't cheap yet. A GPS tracking system currently costs about $600 for the electronics. Hopefully prices will come down, but it may be a long while yet before they fit into the general budget of most rocketeers.

If you are interested in the GPS solution, a great reference is an R&D report by Michael Konshak titled "GPS Recovery Technique for Rocketry." This can be found on the Apogee Components web site at: http://www.apogeerockets.com/education/r%26d_projects.asp

A slightly less expensive method is to use radio tracking. This involves a radio transmitter in the rocket, a handheld receiver, and a directional antenna. I've been told that

Photo 1: If the rocket lands beyond that first small ridge, it is going to be tough to find in the trees.

it still involves about $200 to $300 for equipment. If you are interested in going that route, there are some plans on the web site: www.JBGizmo.com.

Cheap Methods for Finding Lost Rockets

Unfortunately, once a rocket is "lost," I don't have any solutions to help you find it.

Your priority should be to make sure your rocket doesn't become lost in the first place. In other words, you have to make some preparations before you actually launch it. And that is the purpose of this article—to give you some ideas and techniques you can use to make sure your rocket doesn't become lost.

Your first preparation technique should be to run your flight simulations using the RockSim software (http://www.Apogeerockets.com/rocksim.asp). You want to know how the rocket is going to behave when you launch it, i.e. what path is the rocket going to take when it leaves the launch pad? From this RockSim can estimate the projected altitude, and drift distance too.

I've been stressing the use of RockSim for a long time, and I'm pleased to say that most people have been taking that advice. And I know that other modelers are also mak-

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ing the recommendation, so I know that they see the value in pre-launch simulations too.

I have seen a large number of people take their laptop computers with them to the launch field to run some final simulations using that day's actual weather conditions. I think these people are very smart. It is really worth the few extra minutes of prep time. If you are working with other modelers on the rocket, such as a school or a club project, you probably have someone that is assigned the responsibility of running these on-the-field launch simulations. GREAT! That is the right thing to do.

The next preparation step that I would recommend is to get a bird's eye view of the launch site. In layman's terms, get a lay of the land.

I find using the free Google Earth software to be indispensable for this. You can download it for your computer at: http://earth.google.com/download-earth.html

I like Google Earth better than a mapping web site like Mapquest because you can zoom in a lot further and it has better distance measuring features.

With it, you can check out the launch site while you're at home the night before a launch. The first thing you want to do is find the actual launch site location. If you are going to be flying the rockets at a club launch site, then I may have some good news for you. We've put together a Google-Earth file that you can download from our web site at: http://www.apogeerockets.com/Launch_sites.asp. This file gives the exact location of the launch sites for many clubs around the world. By the way, if your club's site is not listed, please help us to update this file by giving us your club's location.

The next thing you should do is print out the aerial images of your launch area so that you can take them with you to the launch site. You can make a big map image by tiling several smaller images together, like a big jigsaw puzzle. So now you have a print out, what do you do with it? That is a great question.

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Study the photo and look for those things that could be a hazard for recovery. For example, the image in Photo 2 shows the aerial view of the launch site used by the Denver, Colorado club. The members launch from the western end of a large parking lot. Directly south, about 1000 feet away lies a large

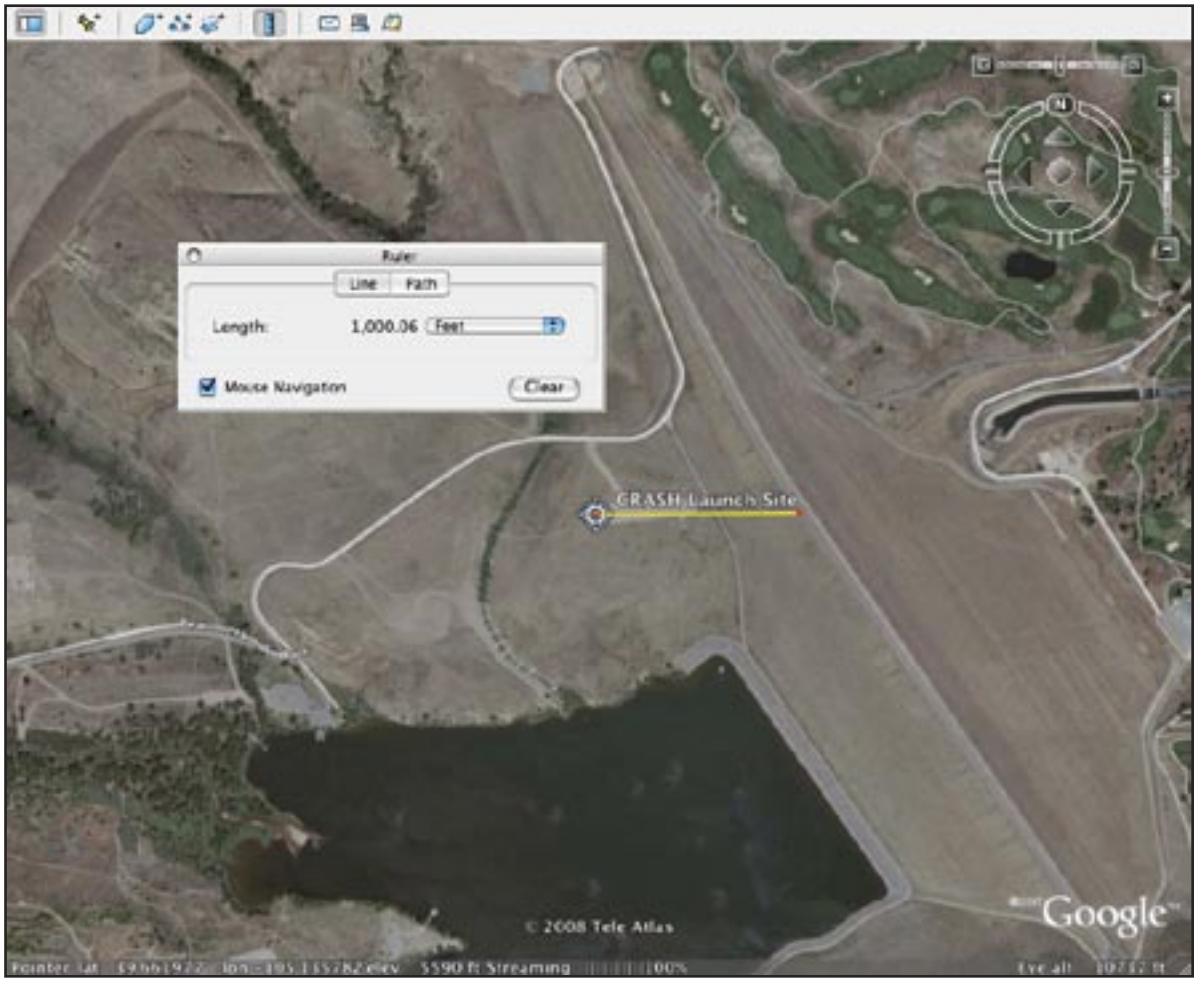
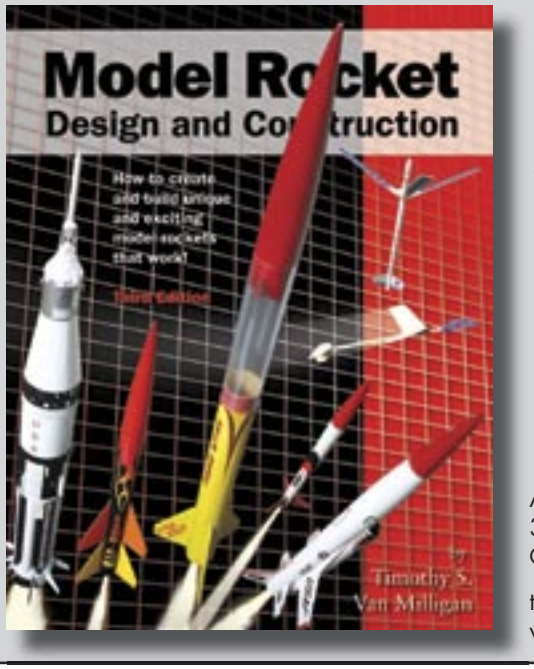


Photo 2: A screen shot taken from the Google-Earth software that shows the general layout of the launch site used by the Denver, Colorado rocketry club (C.R.A.S.H.)



Model Rocket Design and Construction

By Timothy S. Van Milligan

New 3rd Edition Now Shipping!

This new 328 page guidebook for serious rocket designers contains the most up-to-date information on creating unique and exciting models that really work. With 566 illustrations and 175 photos, it is the ultimate resource if you want to make rockets that will push the edge of the performance envelope. Because of the number of pictures, it is also a great gift to give to beginners to start them on their rocketry future.

For more information, and to order this hefty book, visit the Apogee web site at: www.ApogeeRockets.com/design_book.asp

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reservoir. To the east is the dam that holds back the water in the reservoir. On the other side of the dam is a golf course.

I used the ruler in Google Earth to draw a line that was approximately 1000 feet long so I could get a perspective on where most rockets might land. This line helps to give a distance perspective that you might not otherwise have. For example, about 500 feet to the west of the launch point is a curvy green line. This is a small creek bed. Because creeks and rivers lie in the lowest points on the terrain, I know that it is going to be a downhill walk from the launch point to the creek, and then up again if the rocket lands even further to the west.

Now that I know there is a creek there, I can be better prepared for it. I don't know how wet it is in the bottom, but I might want to bring some waterproof boots, just in case there is some water in it.

Some creek beds are very steep and almost impassible. In that case, I can follow the road out. So I want to know which roads to use to get to different areas of the recovery zone. If I have to jump in the car to retrieve the rocket, that information can save me a lot of time.

Do you see how getting a lay of the land by using Google-Earth can help you to prepare for the launch? And it's free, so use it.

Launch Day Preparations

Now we're ready to launch the rocket. I would suggest that you get a buddy to help you spot the rocket in the air. Actually, the more friends you can get for this task, the better. If you're launching as part of a school project, you should have several people assigned to this task. The more eyes searching the sky, the better your chances of getting your rocket back.

People that do not have much experience with launching rockets have to be given some lessons on how to spot (track) a rocket. The informal way of spotting a rocket isn't good enough. If you have ever lost a rocket and there were a lot of people watching it, you know what I'm talking about. Everyone has a general idea where the rocket landed. But no one can give you a specific location where to look. How aggravating is that? It makes you want to pull your hair out.

Give some instructions on how to track a rocket. Your spotters need to look for more than just the obvious landmarks. Here is a typical conversation that happens with spotters:

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Photo 3: Which tree did it land behind?

"The rocket went behind that tree," the spotter says as they are pointing at a tree.

"Which tree?" you ask.

They walk over to you and then they point at the tree on the horizon. "That big one next to that grey building," they say.

Did you get what is wrong with that conversation?

When they walked over to you, they just lost their line on the rocket. Their reference angle that they were using just changed! You'll be walking past the tree, but the rocket will be off to one side of you.

When you are spotting a rocket that landed, you need more than one reference landmark. You need at least two.

You and your spotters need a second landmark. Here is what is important: the second reference landmark has to be "BEHIND" you (in the opposite compass direction where the rocket traveled. Read that again, because it is very important. I NEVER see anyone that is spotting a rocket look behind them for that second reference landmark.

Before you take one step in the direction of your rocket to retrieve it, stop and raise both hands up to shoulder level. Twist your body and point one hand toward the rocket, and the other in the opposite direction. Find a reference landmark on both sides of you along the line made by your outstretched arms.

This makes a big difference when you start after your rocket. If you get out to that tree landmark, you can turn around and line yourself up with that second landmark that is behind you. Then you know you're walking the correct line toward your rocket.

Without this second reference point, you'll quickly get off your line once you start going after your rocket. I can't remember a time when I didn't have to deviate from the walk-line to go around an obstacle, find an easier way

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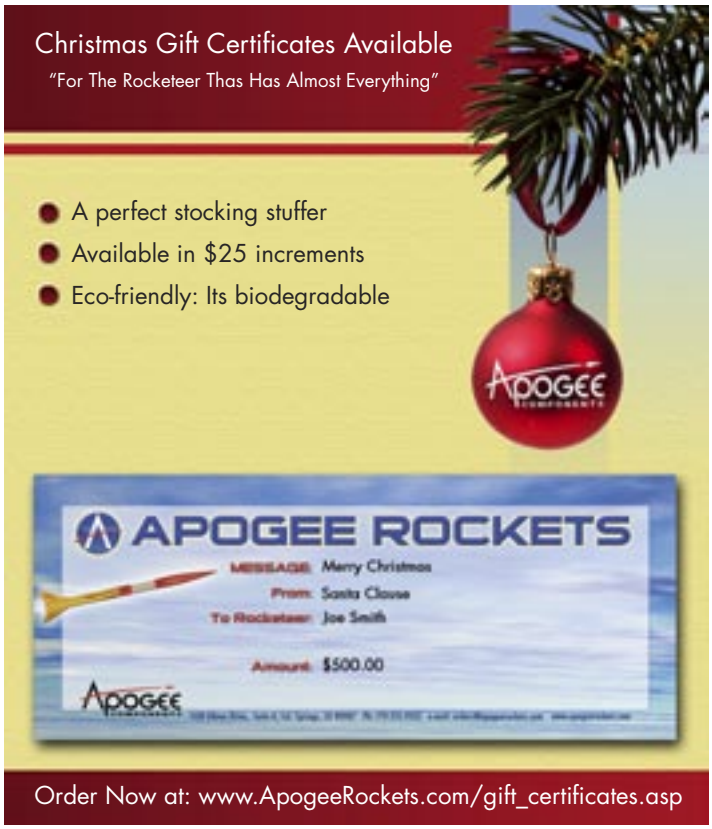

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across a ravine or around a steep hill. But once you get past it, the second reference landmark will allow you to pick up your walking line again.

If you have trackers at the launch site that are dedicated to finding your rocket alone, I suggest you have some walkie-talkies or cell phones that you can use to communicate back to them. They can also help you to get back on your walking line if you deviate too far from it.

How Far Do You Walk?

Judging horizontal distances involving a drifting rocket is always difficult. Most of the time it is a guess.

I was watching a show on cable TV about snipers and archers. They said something that got my attention, because it directly related to rocketry. They said that most of their training is how to judge the distance to the target. Because of this, I suppose that it is possible to learn the skill. Unfortunately, I don't yet possess that skill.

However, it is possible with two trackers and some simple instruments to find out with great precision how far away the rocket has landed.

I got this idea from a report that has been on our web site for a number of years. It is called: *"Triangulation: A Rocketry Recovery Aid"* by David Shenosky. You can download it free at: http://www.apogeerockets.com/education/r%26d_projects.asp

Photo 4: Using a tracking scope like this one, allows you to fix the position of the rocket by triangulation.

Basically, you have two spotters at a known distance apart that are tracking the rocket as it descends. They each have a simple scope (shown in Photo 4) that they point at the rocket where it lands.

By knowing the angles indicated on the scopes, it is fairly simple to determine where the rocket landed by using

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triangulation. Figure 5 below shows the basic layout and how the system works.

The two spotters, we'll call them "Left-spotter" and "Right-Spotter," are a known distance apart. It doesn't matter how far apart they are, but you have to know the exact distance. Also keep in mind that the further apart the scopes are, the more accurate the technique becomes. The limiting factor becomes how easy is it for the spotters to pick up the rocket as it launches into the air. I strongly recommend walkie-talkie radios so that the spotters can be informed when the rocket is going to be launched.

It also doesn't matter where on the range the spotters are relative to the launch pad. Just put them where they have an unobstructed view of the launch pad so they can get a fix on it as it zooms skyward.

Set-up is easy. Once the tracking scopes are placed in the correct positions at the proper distance apart, start by pointing each gun-sight on the scope directly at the other tracker. Then protractor gauge is then rotated to zero. It is important that they are "zeroed out" prior to the rocket launch.

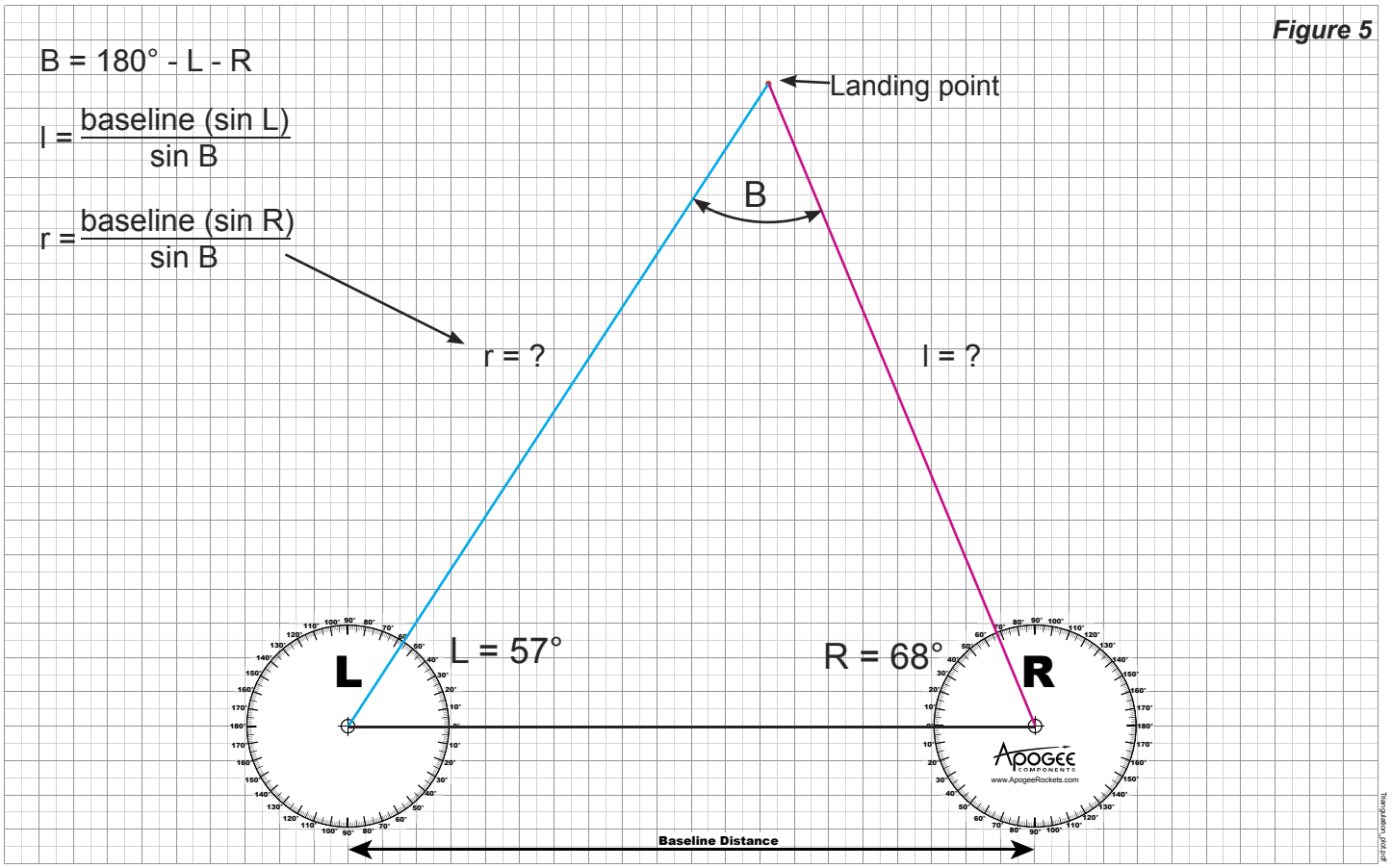
Once the rocket is in the air, both trackers swivel their respective gun-sights and point it in the direction of the rocket. All they have to do is keep the gun-sight on the rocket until it lands on the ground, or they lose sight of it as it drifts behind a tree.

The pointer on the front of the gun-sight points at the angle on the protractor on the flat plate. The trackers should write down the angle, or report it back to the headquarters via the radio.

From these angles, it only takes a couple of minutes to triangulate on the landing point of the rocket. Again, Figure 5 shows the basic formulas for finding the distances of the legs of the triangle.

But don't let the math scare you, especially if you're working with younger children in a educational setting.

You can create a scale plot, where you can just measure the distances. For example, say the background grid in figure 5 was in centimeters. The baseline distance is 200 meters, which on the plotboard would be 20 centimeters. Then you can just take your angle measurements, and draw lines on the plot board. Finally, the students would just measure the lengths of the other two sides of the triangle



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with a ruler, and convert them to actual distance by multiplying by the scale factor. For example, if the red line measures 20.6 cm, then the distance the rocket landed from the right side tracker would be 206 meters. Pretty simple, huh?

To make your job easier, I've created some sample plot sheets for you that can be printed out on 11 X 17 size paper. You'll find at: http://www.ApogeeRockets.com/education/downloads/triangulation.zip. The grid is in centimeters, which makes it easy to scale for students.

I would highly recommend this method if you are working with a school group. Not only are you learning about rocketry, but you're also using mathematics, trigonometry, and map reading too. The educational value is really intense, and besides, it is a lot of fun.

Plot On An Aerial Photograph

If you want make it even easier for students, I've got another suggestion. Why not plot directly on an aerial photograph like shown in Photo 6 below?

This is great, but it will involve more preparation before you go out to the launch site. It will also require a bit of graphic arts capability using drawing programs like Adobe Illustrator.

The first step is to get your Google Earth aerial views as mentioned previously. But instead of printing them, we need to do a screen capture so we can edit the images. If you don't know how to make a screen capture of your computer's screen, see RockSim video tutorial #16, which you can view at: http://www.apogeerockets.com/RockSim_tutorials.asp

Next, you need to know exactly where you are going to set up your tracking scopes on the range. See why this takes some preparation? You can't do this on the day of the launch, because you'll be running out to your launch range to confirm the exact location of your scopes. Why? Some of the images in Google Earth are old, and you don't want to go out to the range and discover a new building that was

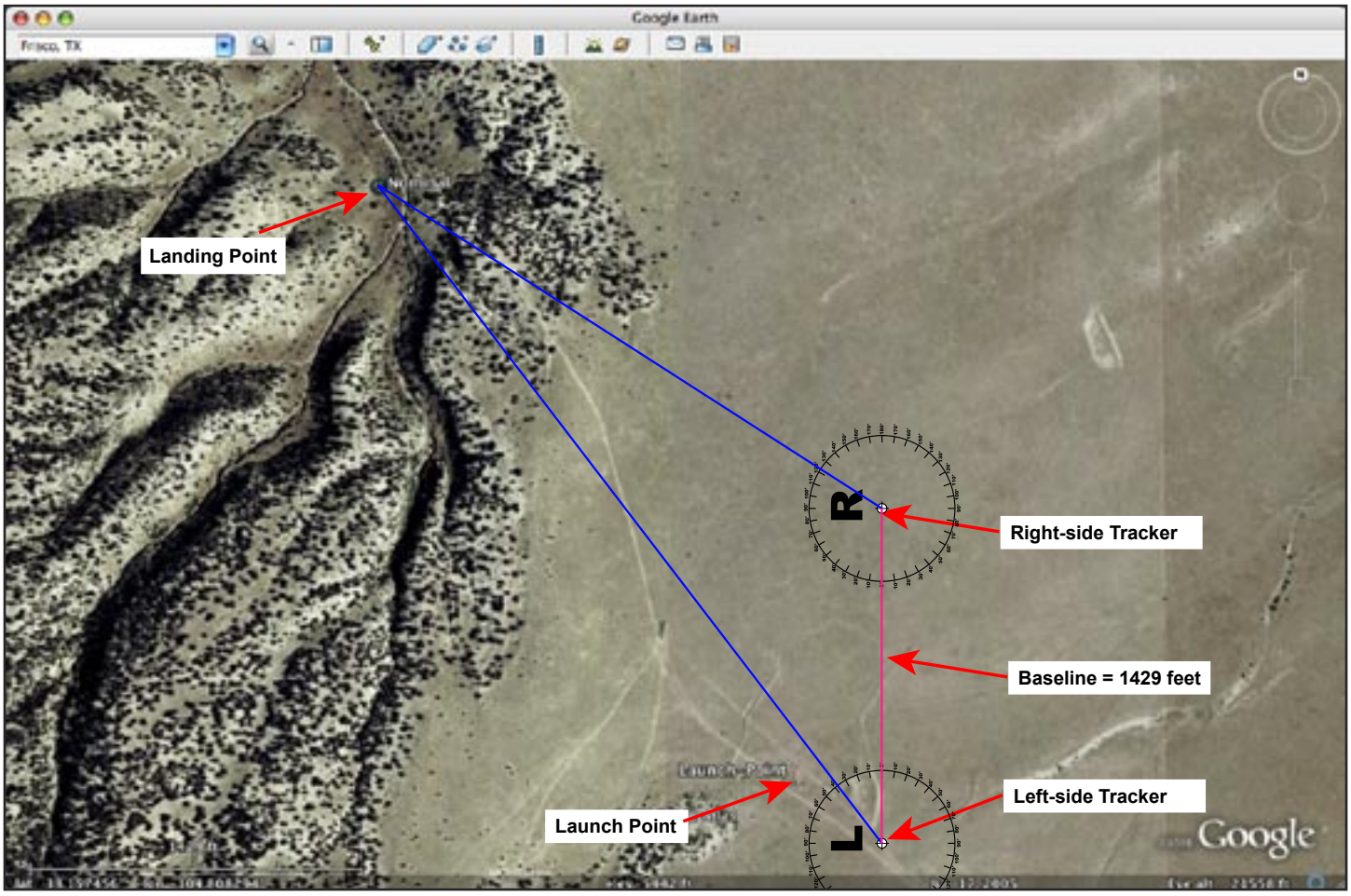

Photo 6: A composite image made from a Google-Earth screen shot combined with protractor rosettes. By knowing the position of the two trackers, and the angles to the rocket, it is easy to find the lost rocket.

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placed where you were going to have a tracking scope.

Then open the aerial image in the drawing program and create a protractor rosette centered over each tracker location on the aerial image.

I've already created the rosettes for you in a vector drawing format. They were in the download that has the plot grid that was mentioned previously.

When everything is ready, you can print out this aerial image and use it on the field. You can draw directly on the image and then give it to the person that is going to hunt down the rocket after it was launched.

This plot is very useful. For example, in Photo 6, you'll see that the rocket landed in a ravine with steep sides. It would be very hard to find in this location (I know, I actually lost a rocket in this very ravine near Pueblo, Colorado). Having the aerial map would give the searcher a much better idea of where to look for the rockets.

On last thing about this tracking method; if you add other spotters, you narrow down the error even more!

You'll find plans for building the scopes in the next newsletter. I was surprised at how cheap it was to build. It is basically a wood disk attached to a camera tripod. I had all the parts in my work area except for a small blind-nut. I bought a pack of four of them for under a $1.

Retrieving The Rocket – The Last 100 feet.

Using the above optical tracking methods, you should be able to get in the general area of the rocket with a reasonable amount of certainty. But it never fails, according to Murphy's law, your rocket will land in some really tall grass and will be hidden good.

There is one last "cheap" device that can help you find your rocket. That is an audible beeper. In Carter's questions at the beginning of this article, he calls it a "pinger."

Basically, the electronic beeper device emits a very loud siren or chirping sound. Once your in the general vicinity of the rocket, the sound coming from the rocket will let you pin-point the exact location so you can retrieve it.

Beepers like this are easy to find on the internet. For bigger rockets, we at Apogee Components sell a device that really puts out the sound—105 decibels worth of noise! It is called the BeepX, and it is manufactured by Transolve. You can find it on the Apogee Components web site at: www. apogeerockets.com/BeepX.asp

Other Answers to the Reader's Questions

So far, I've answered questions number 1 and 4. In question 2, Andrew asks about using the Apogee Tracking Device to find distance.

Unfortunately, it only does vertical distance. If you want to know more about tracking the vertical distance of a rocket, see newsletters #92 and #93. You'll find them at: http://www.apogeerockets.com/education/newsletter_archive.asp

In question 3, Andrew asked why the rocket didn't come down fairly straight like his other streamer rockets. Without being at the actual launch, it is hard to say. But if any wind was blowing, the path to the ground would be more of a diagonal line. The stronger the wind, the more horizontal that line will be.

Additionally, if the rocket was fairly long, it is possible to get body-tube lift as the rocket is descending. Essentially, the rocket is gliding as it is falling and can travel quite a distance horizontally in almost any direction.

Conclusion

In this article I presented a number of things you can do to get your rocket back after a flight. But you'll notice that you have to do them prior to launching the rocket. I just want to point out that preparation for a launch is probably one of the most important flying skills that every modeler should concentrate on. It plays a huge role in the success of the launch, and if you are able to get the rocket back after a high flight.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. Before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit. He has a B.S. in Aeronautical Engineering from Embry-Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward a M.S. in Space Technology from the Florida Institute of Technology in Melbourne, Florida. Currently, he is the owner of Apogee Components (http://www.apogeerockets.com) and the curator of the rocketry education web site: http://www.apogeerockets.com/education/. He is also the author of the books: *"Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics"* and publisher of a FREE e-zine newsletter about model rockets. You can subscribe to the e-zine at the Apogee Components web site or by sending an e-mail to: ezine@apogeerockets.com with "SUB-