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NEWSLETTER

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Simulating Cluster Parachutes In RockSim

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Simulating Cluster Parachutes In RockSim

By Tim Van Milligan

Figure 1: A rocket with a cluster of chutes just touches down to the ground.

This year's TARC challenge is to use a cluster of parachutes to bring the rocket down to the ground. Because the challenge is different from year's past, people have had a lot of questions on how to simulate this in RockSim.

RockSim can easily simulate this, but you'll want to make a few tweaks to improve the accuracy of your simulations.

In the parachute editor, you'll see a "chute count" field (see Figure 2). This is where you can tell RockSim how many parachutes are in the cluster.

Figure 3: RockSim's 2D flight profile only shows one parachute

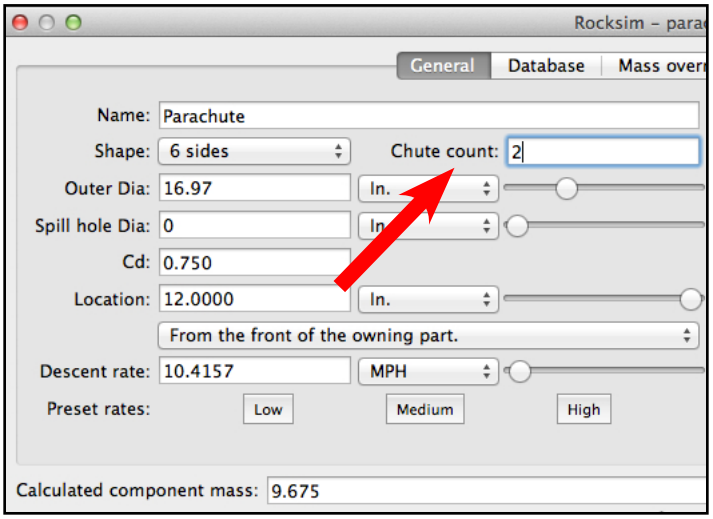

Figure 2: The chute count allows you to change the number of parachutes in the rocket.

The confusing part for many people is that the 2D flight profile still only shows one parachute open. In reality, both parachutes are open in the simulation. It is only that the image is generic with only one chute.

Now if you don't have RockSim, you can still simulate multiple parachutes easily.

To do this, you'd have to use the concept of 'equivalent surface area." Essentially, you'll need to find the dimensions of two smaller parachutes that would equal the surface area of a single larger parachute.

The process of designing a 2-chute cluster would begin by finding a single parachute that would get the rocket down in the correct amount of time.

You really have to look at one number, and that is the descent rate of the rocket. For now, ignore the total time aloft. Why? Because you'll want to assume that you'll be able to zero in on the target altitude, and eject the parachute exactly at that point in the flight.

If you are able to eject at that altitude, then the rocket will need a constant decent rate that is repeatable from one flight to the next.

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But if you look at the descent time without getting the rocket to the right altitude at ejection, then you'll have to come back and re-size your parachute.

Again, the important number is the descent rate. How many feet/sec does the rocket fall with the single parachute?

In RockSim, you can vary the diameter of the parachute until you get the right descent rate.

For example, let's say that your target altitude is 860 feet, and you have to get the rocket back down to the ground in 40 seconds. (NOTE: This is not the TARC targets, I'm just using this as an example. You have to do the math for yourself)

Assume that it will take 7 seconds for the rocket to achieve the target altitude. So you'd subtract this from the total flight duration. That leaves you 33 seconds to get back to the ground.

The descent rate then, is 860 feet divided by 33 seconds. The result is 26 feet/second.

Once you know the descent rate, you'll go back into the parachute editor in RockSim and start changing the outer diameter, as shown in Figure 4.

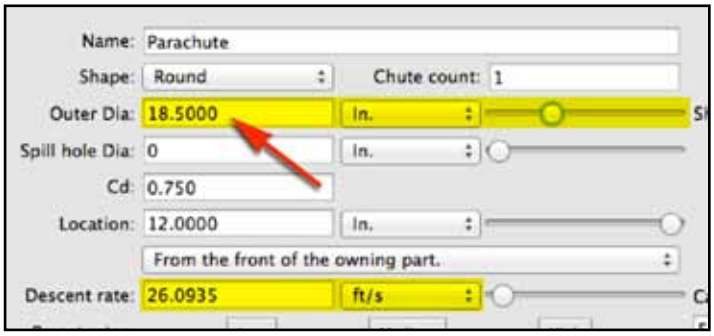

Figure 4: Adjust the parachute's outer diameter until you get the correct descent rate.

At this point, I'd suggest that you err on the side on having the parachute being too big. It is easier to make the parachutes fall faster than it is to make them fall slower. For example, you can add weight to the rocket, or you can cut spill holes in the chutes to make them come down faster. Therefore, if your optimal descent rate is 26.5 feet/sec, you might want to round downward to 26.0 feet/sec, which is a little bit slower.

Once you know the size of the single parachute required to meet the descent requirements, the next thing would be to split the area of the chute into to equal parts.

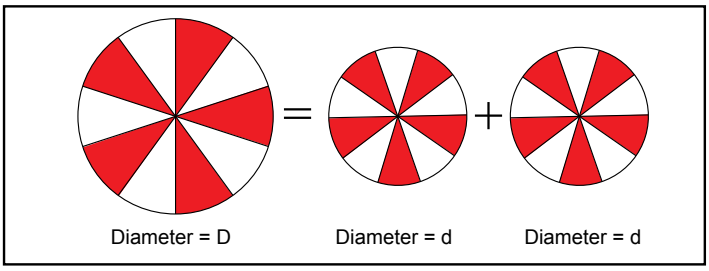

Figure 5: Splitting the big chute into two smaller chutes requires the same surface area.

Equivalent Area

I'll go through the mathematics of finding the equation you'd use to find the diameter of the smaller parachutes.

The area of a circle is given by the equation:

$$A = \pi r^2$$

I prefer to use the diameter to find the area instead of the radius. Making the substitution gives:

$$A = \frac{1}{4} \pi D^2$$

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Where A is the surface area of a the large circular parachute, and D is its diameter

Let's say that small-a is the area of one of the two equivelant chutes. Therefore:

$$2a = A$$

Let's assign a small d to be the diameter of that small chute. Like the big chute, the area would be:

$$a = \frac{1}{4}\pi d^2$$

Now we can begin substituting some variables:

$$2a = \frac{1}{4}\pi D^2$$

$$2\left(\frac{1}{4}\pi d^2\right) = \frac{1}{4}\pi D^2$$

Next, we'll do some simplification of both sides beginning with cancelling terms that appear on both sides of the equation:

$$2\left(\cancel{\frac{1}{4}}\cancel{\pi} d^2\right) = \cancel{\frac{1}{4}}\cancel{\pi} D^2$$

Doing so yields:

$$2d^2 = D^2$$

Divide both sides by 2 gives:

$$d^2 = \frac{1}{2}D^2$$

And finally, to get the small d isolated by itself, we'll take a square root of both sides. This gives us the equation for the diameter of the small parachutes:

$$d = \sqrt{\frac{1}{2}D^2}$$

This is a simple equation that we can use to find the diameter of a circular parachute that has 1/2 the surface area of a large parachute. What you'll do is plug in the diameter of the single chute that you found in RockSim (the big D), and then chug through a little math on your calculator, and find the small d which is what you'll construct your parachute.

Is This Accurate?

The question that everyone asks is, will two small

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chutes have the same drag force as a single large parachute?

The answer is probably "no." From my experience, the two chutes typically produce less drag. The reason is that the chutes tilt outward as they descend, as seen in Figure 6. Effectively, this means air is spilling out the high side of the canopy.

The other thing is that two chutes tend to spin more, particularly if they are unbalanced (such as the suspension lines having slightly different lengths). Again, the air will spill out of the chute as it joustles around, decreasing the efficiency of the parachute.

Because of this, I'll again recommend to start out with a slightly larger diameter chute so that you can account for the faster descent rate.

Drop Tests

To get accurate simulations, you'll need to do parachute drop tests. In these drop tests, you'll need to measure how fast the parachute will fall.

A procedure is found in the R&D report: *"Comparison Of The Number Of Parachutes Versus Descent Rate"* which can be found on the Apogee Components web site at: www.ApogeeRockets.com/downloads/PDFs/Cluster_Parachutes.pdf.

From these tests, you'll adjust the Cd value that is used in RockSim. By default, it is .75, but this can vary with the material used, and the parachute shape. But once you have real descent data, you'll tweak the value in the software to match your real-world descent rate.

I highly recommend drop tests rather than "launch tests." You can get a similar data from doing launch tests, and using the AltimeterTwo www.ApogeeRockets.com/Electronics_Payloads/Electronics/Jolly_Logic_AltimeterTwo) to get the descent rate of the rocket. But it can get very expensive because of the number of rocket motors you'll have to use. And it is much faster to drop the rocket than it is to launch it into the sky, so you'll get data very quickly.

Figure 6: Two parachutes tilt away from each other, decreasing the effectiveness of each canopy.

Chute Design

This is pure speculation, but I suspect that the biggest issue TARC teams will face is how the parachutes behave as they fall. The more they jostle and move around, the less consistent the descent rate will be.

Therefore, I think you may have to consider redesigning the parachute to see if you can get two of them to be more stable as they descent.

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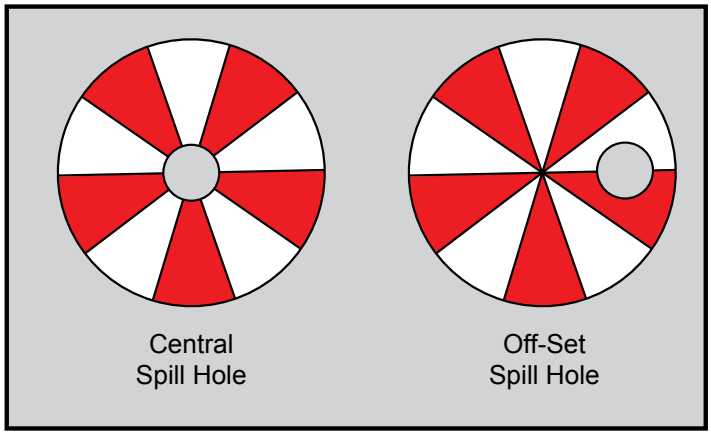

Figure 7: Would an off-set spill hole make a difference in how far the chutes tilted from each other?

There are a lot of things that you could change to try to find a more stable configuration. For example, as shown in Figure 7, what would happen if you moved the spill hole from the center to something that was offset? Would that make the chutes drop more consistently?

What if you made the suspension lines longer on one side of the chute than the other?

Or how about using a train of chutes, where the riser line of one parachute passes through the spill hole of the other? Would that create more consistency?

The amount of variety that you could do would be endless, and it would be a lot of fun too. And please be sure to send me the data, because I'd love to see what you come up with too.

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.

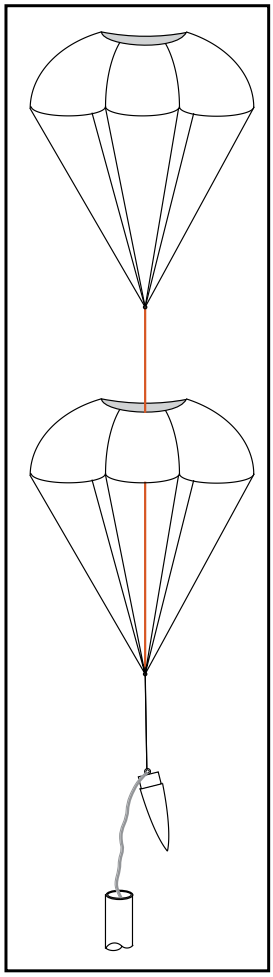
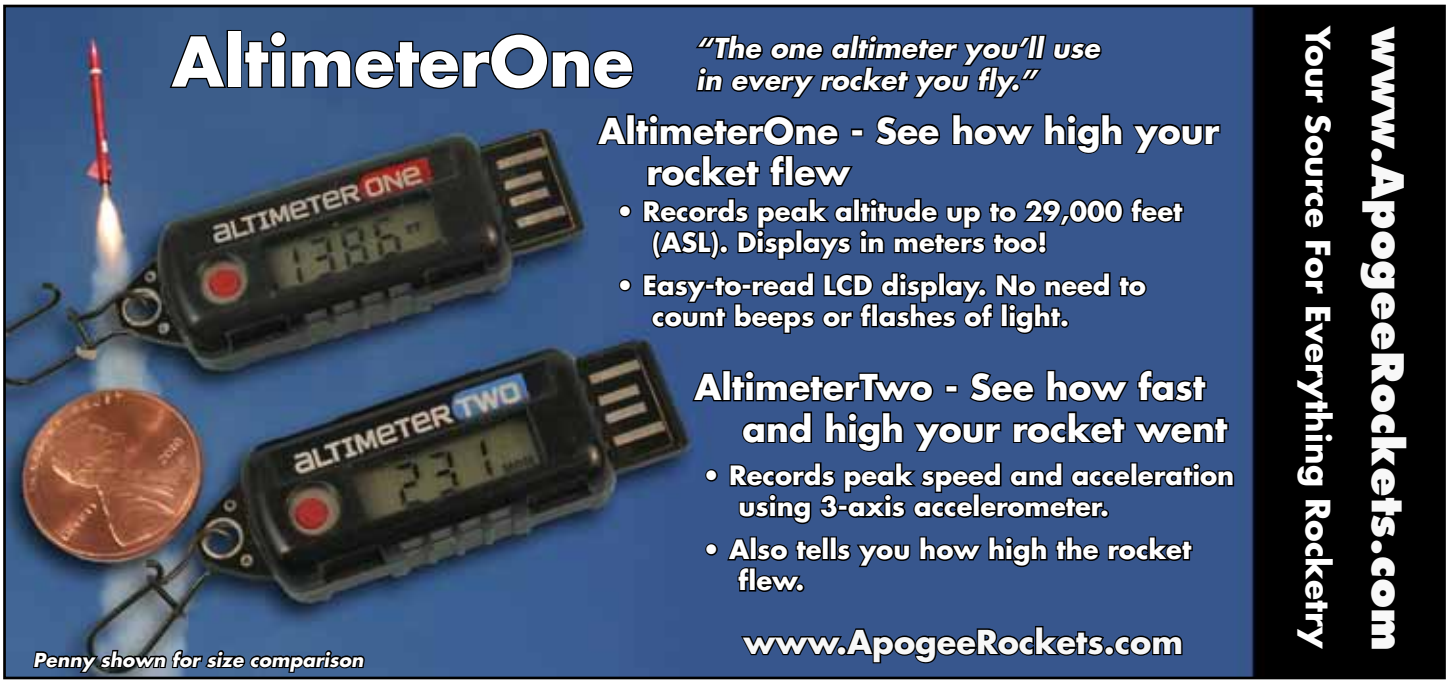
Figure 8: A train of parachutes