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PEAK OF FLIGHT

NEWSLETTER

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Cover Photo: The Atlas Agena at Kennedy Space Center. Get a Dr. Zooch version of the rocket at: www.ApogeeRockets.com/Rocket_Kits/Skill_Level_4_Kits/Atlas_Agena

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Selecting the Proper Size Drogue Parachute

By Tim Van Milligan

One question that we're often asked is: "What size drogue parachute should I pick for my dual-deploy rocket?" So today I'll go over some of the issues that you'll have to consider.

First, what is dual-deployment, and when would you use it? This is an easier question to answer. In simple terms, dual-deployment really means: two recovery devices in the rocket that are ejected at different times during the flight. The reason for it is simple: to reduce the drift distance of the rocket, so you don't have so far to chase it. Who likes hiking for miles and miles to retrieve a rocket? Right? And this is especially handy for rockets that go really high, because the higher they go, the farther away they drift with the wind.

Dual-deployment reduces the walk to retrieve the rocket, because the rocket descends faster to the ground. So the wind doesn't have as long to blow the rocket downrange.

If you've never done dual-deployment before, you might be thinking: "If the rocket is descending faster, wouldn't it land really hard and break something?" That is why two recovery devices are used in dual-deployment. The first one is small, and is ejected from the rocket at the apogee point in the flight. You want this recovery device to be small, so that drops like a rocket.

But when the rocket nears the ground (say about 600 feet above ground), the second parachute is ejected from the rocket. This is a big parachute, and slows the rocket down to a safe landing speed. The closer to the ground that it is deployed, the shorter the walk that you'll have to make to retrieve the rocket. But big parachutes take time to fully inflate and to stabilize, so you don't want it to eject too close to the ground. That is why the altitude of 600 feet is chosen for the deployment of the main chute. And if it is a really big rocket that is heavy, you might want that ejection altitude to be even higher, to give the chute more time to unfurl and inflate fully. For Level 3 type rockets a good starting point is around 1000 feet for main chute deployment. Higher altitudes gives more safety margin, but it also

Figure 1: The small drogue parachute slows down the rocket enough to prevent damage of the main chute. But it still allows a fast fall so the rocket doesn't drift too far with the wind.

means a longer walk to get the rocket.

Now we're back to the first recovery device that is ejected at apogee. Notice that I said "recovery device" and not the word "parachute." The reason is that it doesn't necessarily have to be a parachute. You could also use a streamer for this task.

What is the "task" of the first recovery device?

There are a couple of tasks for the first recovery device.

First, it is for visibility of the rocket. Imagine you launched a small rocket to a very high altitude, maybe

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10,000 feet, or maybe even higher. When the rocket goes that high, it gets really hard to see because the apparent size diminishes. At 10,000 feet altitude, you're almost two miles away from the rocket. So imagine how hard it is to see a person standing two miles away from you; now imagine that you're looking for something even smaller in diameter, and you're looking at the silhouette of the back end of it. I'm sure you can see the problem we have... the rocket is hard to see.

Therefore, we want something that will give us a better view of the rocket so we can spot it in the sky. Something brightly colored would help, right?

Why eject this at apogee? The reason for that is simple. At the apogee point, the rocket has no vertical speed. It is going to be traveling at its slowest rate during the trajectory phase of the flight. The slowest speed is always the best time to deploy a recovery device, because the forces trying to rip the recovery device to shreds are lowest at apogee.

Dual-deployment is always controlled with some sort of electronic payload. The first ones were simple timers that fired ejection charges at predetermined points during the flight. But it was soon discovered that if the rocket took an errant path at lift-off, the ejection of the parachutes was always too late and the rocket would already be on the ground.

Because of this reason, dual-deployment electronics are now almost exclusively based on altitude instead of time. This gives a margin of safety that assures that if something goes wrong at lift-off, the rocket will still have a safe recovery. I've witnessed plenty of flights where the electronics saved the day and kept everything safe and in one piece.

But we're all still leery of electronic devices malfunctioning during flight. The forces of launch can dislodge things inside the rocket, and maybe even disconnect the battery that supplies electrical power to the altimeter and the ejection charge igniter (been there, done that...). Therefore, unless you are using an electronic payload that transmits a radio signal to the ground (like the TeleMetrum or TeleMega), you are somewhat unsure if the electronics are functioning properly during the launch and upward coast of the rocket. Incidentally, you can get the TeleMega at: www.ApogeeRockets.com/Electronics_Payloads/Dual-Deployment/TeleMega and the TeleMetrum at: www.ApogeeRockets.com/Electronics_Payloads/Altimeters/TeleMetrum.

It is only the when the first ejection of the recovery device occurs at apogee that we get a clue to the health and status of the electronics. We all hold our breath until we see "laundry" strung out from the rocket.

And then we hold our breath again until we see the main chute come out when the rocket nears the ground. Why? Because we're unsure if it was the electronics that kicked out the first recovery device, or the ejection charge

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Figure 2: Dual deployment is used on high power rockets, or those traveling extremely high.

built into the front of the rocket motor. We use the motor's ejection charge as a back-up, in case something did go wrong with the altimeter in the rocket.

It is for this reason that I personally set the ejection delay on the motor a second longer than it should take for the rocket to reach apogee. That way, it should fire off after the electronics have already deployed the first recovery device. Essentially, if everything is working right, the motor's ejection charge doesn't do anything except to make a pop noise as it vents out through the empty tube. It is that pop noise that confirms to me that the altimeter is working properly, because it had already kicked out the apogee recovery device.

On the other hand, if the altimeter was not working properly, the rocket would arc over and be heading downward when the first recovery device is deployed by the rocket engine's ejection charge. And even though the rocket is destined at this point for a hard landing (since the main chute will never be deployed), it is still preferable and safer than a ballistic impact. With this situation, with the first recovery device out, we have more time to shout and scream for people to look up and get out of the way before the rocket hits the ground.

This happened to me the first time I flew the Level 2 rocket kit from Mad Cow Rocketry (www.ApogeeRockets.com/Rocket_Kits/Skill_Level_4_Kits/Level-2). Fortunately, the rocket survived with only minor damage to the nose cone. I talked about what happened in the last assembly video for the rocket, which you can see at: www.ApogeeRockets.com/Advanced_Construction_videos/Rocketry_Video_122.

The Second Criteria for the First Recovery Device

As we talked about above, the first criteria for the recovery device was visibility. The second criteria, which gets to the size of the device, is the descent rate you want. The bigger the recovery device, like the diameter of the chute, the slower the rocket will descend. Again, this has a direct influence on how far you're going to walk to retrieve the rocket.

If you want a short walk, then obviously you want to use a small diameter parachute, or switch to a streamer. Some flyers will even forgo any recovery device attached to the rocket and go with what is called *"drogueless recovery."* The rocket still ejects, such as the nose section separates from the fin portion, and these parts are still connected together by a long shock cord, but there is no recovery device attached to slow the rocket down. In this configuration, the parts tumble down to the ground, and the shock cord acts like a tiny streamer.

Can you use drogueless recovery? Sure. Go for it! The advantages, other than it allowing your rocket to fall quickly from high altitudes, are that you save space inside the rocket and you don't have to buy a separate drogue chute. So you save money too.

But on the other hand, remember that the drogueless

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rocket is going to be less visible in the sky as it descends. So it if is going really high or you're flying in hazy conditions, then you might want to go with some type of small recovery device to give the rocket some extra visibility.

Is there a maximum descent rate for the rocket while coming down with the drogue or streamer? Yes. The maximum decent rate will be determined by the main chute of the rocket. Specifically, it is the strength of the main chute that will determine how small of a drogue chute you can use.

I try to keep the velocity of the descending rocket under 50 mph to prevent the main chute from being shredded from high opening forces. But there is some leeway in this speed. If you have a strong chute, or if you slow the opening of the chute so all the forces don't occur at the instant of deployment, you can get away with a faster descent rate. Deployment bags and slider rings on the suspension lines are often used for this reason because it slows down the deployment sequence (www.ApogeeRockets.com/Building_Supplies/Parachutes_Recovery_Equipment/Parachute_Deployment_Bags). If you use a deployment bag, remember to set your altimeter to eject at a higher altitude.

The big question you're probably thinking of, is this: *"how much speed can a parachute take without shredding?"*

Figure 3: Deployment bags are used to keep the parachute from opening too fast, and to keep canopy inflation orderly.

To be honest, I don't know. The answer will depend on a combination of the chute size, how well it is constructed, how long it takes to inflate, and the mass of the rocket hanging below the chute. It gets really technical quickly, and I'm not sure anyone can be 100% accurate. The only way to know for sure is to do tests. If there are any parachute experts reading this that would like to take a crack at coming up with an answer or would have a good way to test a parachute system, I'd love to hear about it.

That gets us back to the drogue chute. The descent rate of the rocket is probably going to be a little slower than initial calculations from software like RockSim. The reason

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is the rocket body itself contributes to the drag too. Usually in the descent rate calculations, the surface area of the rocket is smaller than the diameter of the chute, so it is ignored. In this case, the body could be larger than the chute or streamer, so it will have a reduced descent speed in actual life. Think of this as a little bit of a safety margin, and also the reason you've been getting more exercise when retrieving your rockets.

But if you want a higher margin of safety on top of this, and if you have the room in your rocket and can tolerate a longer drift distance of your rocket, I'd say to use a slightly larger drogue parachute on the first launch of the rocket. Get some experience with the flight characteristics of the rocket, so you have some data to compare against. If everything goes well, you can always reduce this size of the drogue chute on subsequent flights.

Procedure for Picking the Drogue Chute Size

1. Run your computer simulations. If it is a brand new design that you haven't flown before and especially if it is a different weight or altitude class than you've flown before, you'll need some baseline information. RockSim (www.apogeerockets.com/RockSim/RockSim_Information) works great for this. You'll start by finding out how much of a delay you'll need for your engine's ejection charge. Personally, and this is only my preference, I set the delay on the motor to be longer by 1 second than what the software indicates.

2. When you're also running your simulations, look at the descent rate of the drogue chute. If it is 50 mph or less, you're probably fine with the size. If you think it is too slow, you can decrease the diameter of the drogue chute. On the other hand, if it is falling too fast in the simulations, then increase the diameter of the drogue chute.

3. If you want to go drogueless set-up, you'll still need

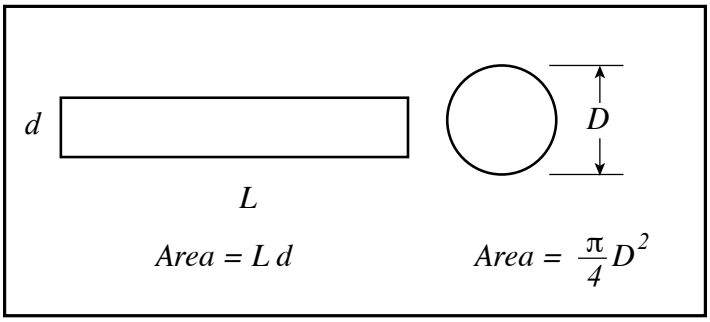

Figure 4: What size parachute would have the same side area as a tube (the rectangle)?

to create a phantom parachute for the computer simulation. Picking the size of this imaginary parachute is the hard part. Why? How accurately can you predict the speed of a tumbling rocket? That is a question I really have no answer to, so like any good engineer, I'll guess. So please don't get angry at me if this doesn't work out accurately for you.

What I'd do is start by finding the equivalent surface area as the lateral area of the largest section of the rocket. For example, if the fin section (the part where the fins attached to the tube) of the rocket measured 4 inches in diameter by 36 inches long, what would be the diameter of a circle that has the equivalent area?

The equation pretty easy to derive from the information in Figure 4. You start by setting the areas to be equal:

$$\frac{\pi}{4} D^2 = L\,d$$

The goal is to isolate the diameter D to one side of the equation. Rearranging the equation gives:

$$D^2 = \frac{4\,L\,d}{\pi}$$

Now you'll take the square root to get the diameter by

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itself:

$$D = \sqrt{\frac{4\,L\,d}{\pi}}$$

Now just plug in the known dimensions and solve:

$$D = \sqrt{\frac{4\,(36)\,(4)}{\pi}}$$

$$D = 13.5 \text{ inches}$$

If we ignore the surface area of the fins and just used the tube, the equivalent area of a circle would have a diameter of 13.5 inches. I'd make this the diameter of the phantom drogue chute in RockSim.

In RockSim, you still need a Cd for this imaginary chute. I'd still go with the default value of .75 that RockSim uses for parachutes. This number I'd say is good for our cylindrical parachute too. I dug out my old copy of *Fluid Dynamic Drag* (See Figure 5), and it estimates that a short cylinder has a drag coefficient of around 0.75.

As shown in RockSim in Figure 6 on the next page, the calculated descent rate for my rocket design is 74.2 mph. It would probably be a little slower than this, because the rocket is in two pieces and they both contribute to the drag.

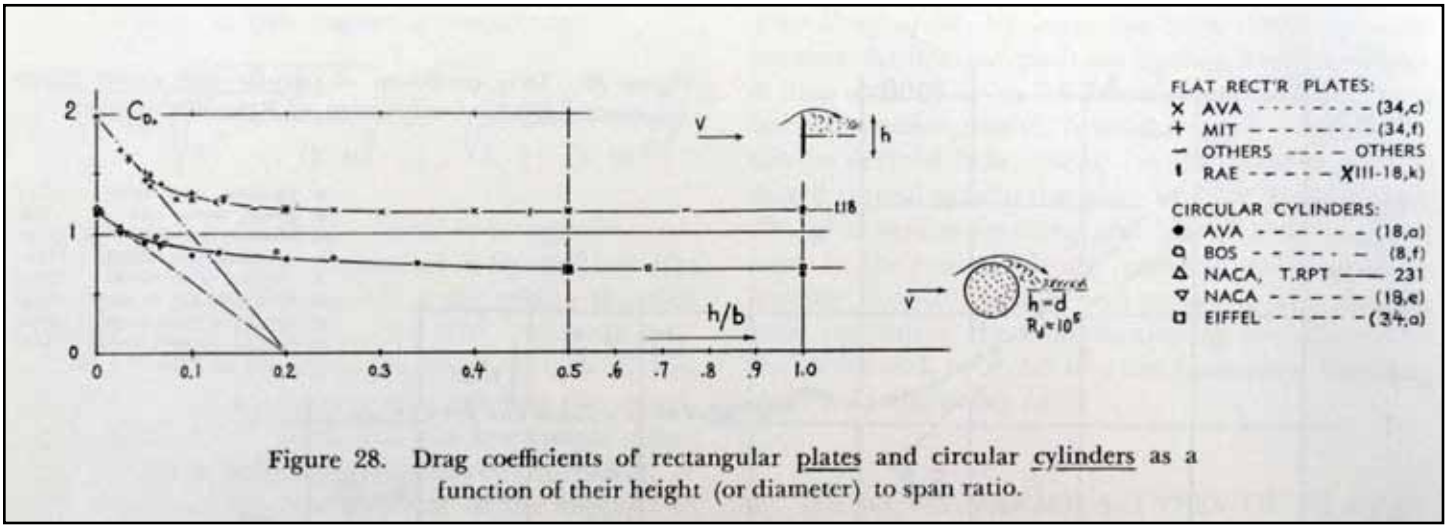

Figure 28. Drag coefficients of rectangular plates and circular cylinders as a function of their height (or diameter) to span ratio.

Figure 5: The drag coefficient of the falling tube is estimated at 0.75. This comes from "Fluid Dynamic Drag" by Dr. -Ing. Sighard. F. Hoerner (1965).

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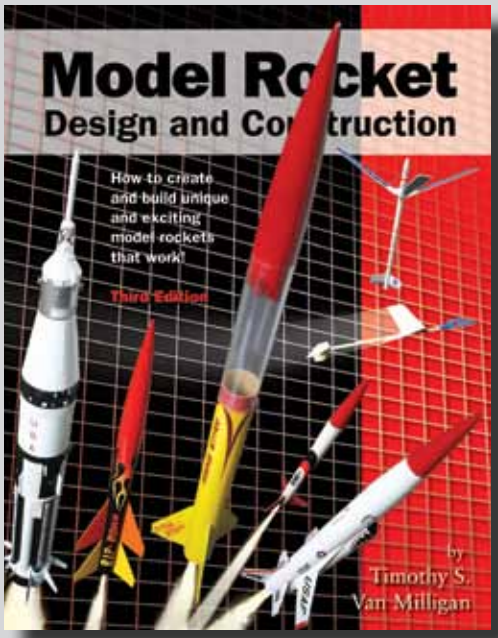

Model Rocket Design and Construction

By Timothy S. Van Milligan

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Figure 6: For my rocket that weighs 4773.9g, RockSim predicts a descent rate of 74.279mph. This is too fast for a drogueless set-up, so a small chute is required.

But I err on the side of caution, and I'd rather put a bigger drogue chute to just to be safe. When I put an 18 inch drogue chute into the same design, it gave me a descent speed of 57 mph. It is a little too fast for my tastes, but when you consider that the contribution of the body parts are ignored, then it probably is safe to fly this design.

Drogue Chute Construction

The question people of ask next, is can a regular small parachute be used as a drogue chute. Technically, it is possible. But since they are designed to open at higher speeds, you really want a chute that is more durable. And that is the difference.

The only real difference between a regular parachute and a drogue chute (www.ApogeeRockets.com/Building_Supplies/Parachutes_Recovery_Equipment/Parachutes/High_Power) is the quality of construction. Chutes specifically intended for drogues are built quite a bit stronger. For example, where a regular parachute might have round suspension lines, a drogue would use flat ribbon-like lines. The reason is that it is easier to sew a flat ribbon to the canopy material, so attachment is stronger.

Because of the extra quality of construction, you'll find drogue chutes to be heavier and take up more room in your rocket. So be aware of that when you are selecting a parachute.

Figure 7: The point where the suspension line is attached to the drogue chute canopy material has been reinforced to prevent the line from pulling out.

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.