PEAK OF FLIGHT

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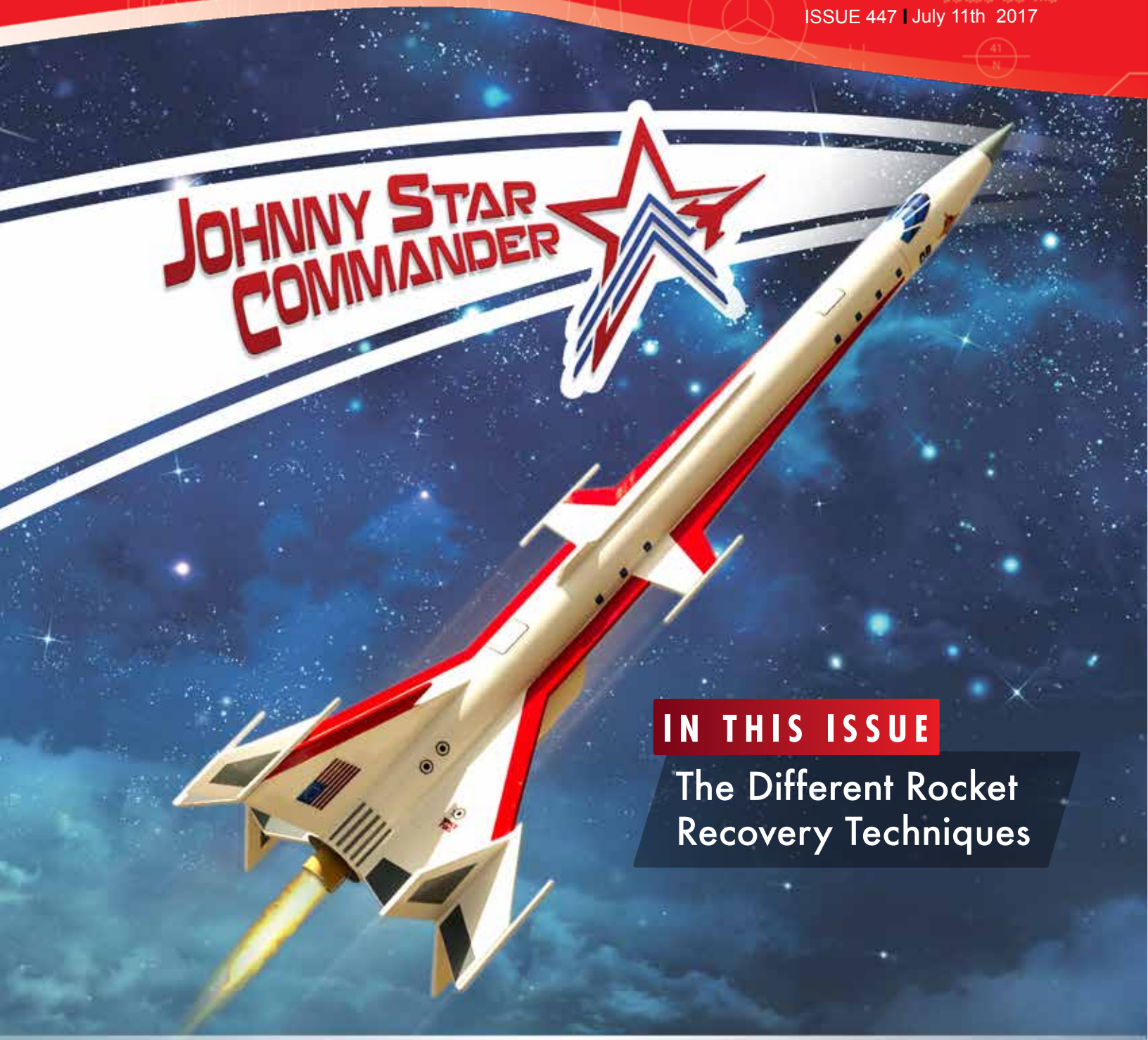

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APOGEE COMPONENTS

The Different Rocket Recovery Techniques

By Tim Van Milligan

Do people marvel at your rockets as it is descending to the ground, or is the show already over? The typical flight of a model rocket lasts about 60 seconds. The amount of time it spends going upward is usually less than 7 seconds, which means that the majority of time the flight is coming down. Do you notice if the spectators are watching your rocket coming down, or is their attention already diverted away? You can easily answer this by asking a simple question about 30 seconds after your rocket touched down: "Did you see where my rocket landed?" If they can't answer that, then they weren't being entertained after the upward portion was over.

In this article I'll review the different types of recovery techniques, and how you can throw some variety into the day and get the attention of the spectators focused back on your rockets.

Figure 1: CHUTERELEASE device

At my local club launch, we are typically working feverishly to get as many rockets into the air as quickly as possible. We draw a lot of fliers, and we want everyone to get as many rockets in the air that they desire. So we don't always wait for the first rocket to touch down before the next one is on its way up. We pause and watch the first rocket all the way to the ground only if something went wrong (no parachute deployment at all) or if it is drifting into an area where it might pose a safety hazard. These are events that we don't celebrate, although unfortunately the modeler will get some unwanted attention afterwards when we ask them what they would do differently next time. The other exception might be when the rocket is using dual-deployment or a Chute Release **Figure 1** (https://www.pogeerockets.com/Electronics-Payloads/Dual-Deployment/Chute-Release), because they have a built in type of anticipation that gets this response every single time: "Wait for it… wait for it… any second now… is it too late?.. Yeah! There it is!"

However, you'll notice that even seasoned Range Safety Officers (RSO) will pause and let the flight play out for a long time if it has a unique type of recovery device. Something about an out of the ordinary recovery technique will even bring out the inner voyeur in the person whose task is to keep the range running quickly. Those flights are celebrated, and everyone will want to know what kit is, or who built it.

Rocket Recovery Systems

A recovery system is any device incorporated into the model for the purpose of returning it safely to the ground. All recovery systems work by developing either lift or additional drag to counteract the force of gravity. Described below are the major methods by which any rocket is returned to the ground in a safe manner. You'll find this information comes from my book: *Model Rocket Design and Construction* (https://www.apogeerockets.com/Rocket_Books_Videos/Books/Model_Rocket_Design_And_Construction).

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About this Newsletter
You can subscribe to receive this e-zine FREE at the Apogee Components website **www.ApogeeComponents.com**, or by clicking the link here Newsletter Sign-Up

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Figure 2: DynaStar ballistic parachute

Parachute Recovery: A parachute is an umbrella-like device used to retard the descent of a falling body by offering resistance to its motion as it moves through the air. If the parachute descends straight down to the ground, it is called a ballistic parachute (**Figure 2**). Ballistic parachutes are the most common recovery method because of the relative ease of constructing a chute and because they make very slow descent speeds possible. Larger and heavier rockets are almost exclusively returned to the ground by parachute. Because they are used so often in rocketry, they are considered "ordinary" by spectators.

If you'd like to learn more about how to pick the size of the parachute for your rocket, see *Peak-of-Flight* Newsletter #361 (https://www.apogeerockets.com/education/downloads/Newsletter361.pdf) or the book *Model Rocket Design and Construction*.

Figure 3: 2" Apogee Mylar Streamers

Streamer Recovery: Streamers are strips of material, generally rectangular in shape, used to slow the rocket down by fluttering in the wind (**Figure 3**). They are used only on smaller models under 56 grams (2 oz), because they do not create as much drag as a parachute. Streamers are very easy to make and to prep for flight. We sell a variety of streamer sizes on the Apogee website at: https://www.apogeerockets.com/Building_Supplies/Parachutes_Recovery_Equipment/Streamers.

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To learn how to pick the right size streamer for your rocket see *Peak-of-Flight* Newsletter #128 and #244 (https://www.apogeerockets.com/education/downloads/Newsletter128.pdf) and (https://www.apogeerockets.com/education/downloads/Newsletter244.pdf).

On very light rockets it may be possible to eliminate the streamer altogether and have the shock cord act as the drag-producing device. When this is done, it is typically called nose-blow recovery. Even high power rockets that use dual-deployment can use this technique of having no streamer. In that situation, it is called drogueless recovery. For a large rocket, you still need a parachute for slowing the rocket when it nears the ground, but drogueless recovery is quite common.

Apogee kits that use streamer recovery are the Blue Streak (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-1-Model-Rocket-Kits/Blue-Streak) and the Aspire (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-1-Model-Rocket-Kits/Aspire).

Tumble or Featherweight Recovery: Small, low-mass rockets often tumble or flutter to the ground. If the speed of the rocket is slow enough during its fall, it may not need any other type of recovery device. This is termed tumble recovery. The tumbling action is achieved by changing the relationship of the center of pressure (CP) and the center-of-gravity (CG) of the model. When the CP is forward of the CG, the rocket becomes unstable and begins to tumble end over end.

Tumbling may be accomplished in two ways: sliding the rocket engine rearward after engine burnout, or by ejecting it entirely from the rocket. If you plan on using this type of rocket, always check its stability before flying it; your rocket may be stable even without the rocket engine installed.

Typically, tumble recovery is applicable only for small and short rockets that are built to withstand the forces of a hard landing on the ground. An important use of tumble recovery is for recovering the lower stages of multi-stage rockets. To see how to design booster stages for tumble recovery, see *Peak-of-Flight* Newsletter Issues #96 and #97 (https://www.apogeerockets.com/education/downloads/Newsletter96.pdf) and (https://www.apogeerockets.com/education/downloads/Newsletter97.pdf).

Figure 4: DynaStar AeroDactyl kit with tumble recovery for the booster stage.

The large booster stage of the AeroDactyl TS rocket kit (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-3-Model-Rocket-Kits/AeroDactyl-TS) was designed this way (**Figure 4**).

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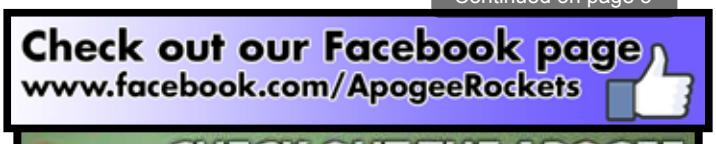

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Sometimes this type of recovery is also called featherweight recovery. In this variation, the engine is ejected entirely from the rocket, and the model still descends in a stable manner.

An example of this is the Odd'l Rockets Sputnik kit (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-1-Model-Rocket-Kits/Oddl-Rockets-Sputnik).

Because the model has such a very low mass in relation to its drag, its terminal velocity is limited, and it falls very slowly. It can be related to the slow, stable flight of a badminton shuttlecock. The Odd'l Rockets Birdie rocket kit (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-2-Model-Rocket-Kits/Birdie) is a perfect example of this recovery technique because it is actually made from badminton shuttlecock.

Another example of the tumble recovery technique is the Odd'L Rockets Break-Away rocket kit (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-2-Model-Rocket-Kits/Break-Away), and the Up-Cup (**Figure 5**) (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-2-Model-Rocket-Kits/Up-Cup).

Figure 5: Up Cup Featherweight kit

Boost-glide Recovery: When the recovery method relies on lift created by wings to act against the force of gravity and the model flies like an airplane, you have glide recovery. Boost-glide recovery has a specific meaning in competition rocketry. It means that the model can separate into multiple pieces, with each piece having its own recovery device. The main portion is the glider, which descends without the motor. This makes it lighter weight, so that it can stay in the air for the longest possible time. These models need to be carefully designed as they are more susceptible to damage during launch than regular models.

Designing and trimming gliders is a worthy challenge, which is why spectators love seeing them fly at launches. For design guidelines, see the book *Model Rocket Design and Construction*. In addition, in the previous issues of the *Peak-of-Flight Newsletter*, we covered a lot of glider info too. See issues: #115, #116, #117, #124, #204, #205, #269, #390, #402.

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If you'd like to try a boost glider, a good one to start with is the Condor Boost Glider (**Figure 6**) (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-2-Model-Rocket-Kits/Condor-Boost-Glider). Another fun one, but a little more challenging is the SR-72 Darkbird (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/SR-72-Darkbird).

All of the glider kits sold by Apogee are listed at: https://www.apogeerockets.com/Rocket-Kits/Glider-Rockets

Figure 6: Condor Boost Glider

Rocket-glide Recovery: While this looks similar to boost-glide recovery, it is much different. In rocket-glide recovery, the model stays together in one piece throughout the gliding descent. Because the glider carries the weight of the motor, they usually descend a little bit faster. They are more complicated too, because they rely on some type of configuration change to transition the model to its gliding state. The wing slides forward to make the configuration change.

Apogee Components sells two rocket-glide recovery kits. They are the Cirrus Breeze (https://www.apogeerockets.com/Rocket_Kits/Skill_Level_5_Kits/Cirrus_Breeze_Rocket_Glider) and the Stratus Gale (**Figure 7**) (https://www.apogeerockets.com/Rocket_Kits/Skill_Level_5_Kits/Stratus_Gale).

Figure 7: Stratus Gale Rocket Glider

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Flexie-glider Recovery: Instead of using a rigid wing to create lift, flexie-gliders use a flexible fabric (usually plastic) wing that folds up for launch (**Figure 8**). This reduces the frontal area of the model, and allows the highest flights of any of the recovery types that utilize lift surfaces. At the peak altitude of the launch, the glider is ejected, the wings deploy and it starts its descent down to the ground. Because the glider is so light, it is also the most efficient and stays in the air the longest.

We don't offer any kits at Apogee, but we do have plans and instructions on how to build one. You'll find it at https://www.apogeerockets.com/Advanced_Construction_Videos/Rocketry_Video_59.

Lifting-body Recovery: These models rely on the fuselage body to create lift to slow the descent of the rocket. They may have short, stubby wings, but these are used only to control the rocket on ascent and for stability during the glide portion of the flight. Of all the recovery types that utilize lift during descent, the lifting body vehicles are the least efficient and descend the fastest. They are however very cool to watch. You'll find a good example of a kit in the Dr. Zooch Lifting Body Space Shuttle kit (https://www.apogeerockets.com/Rocket_Kits/Skill_Level_5_Kits/Lifting_Body_Space_Shuttle).

Figure 8: Flexie-glider wing prototype

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Helicopter Recovery: Like glide recovery, helicopter recovery relies on lift produced to counteract the force of gravity to slow the rocket's descent. However, in this recovery method, the rocket also rotates, resembling a helicopter more than an airplane in its flight characteristics.

Personally, I love helicopter rockets and I've designed numerous designs and written about them here in the *Peak-of-Flight Newsletter*. See issues: #37, #83, #84, #342, #397, #398, 403.

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https://www.apogeerockets.com/education/downloads/Newsletter-403.pdf

Helicopter Recovery kits sold by Apogee:

Heli-Roc - https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/Heli-Roc

Mini-Copter (**Figure 9**) - https://www.apogeerockets.com/Rocket-Kits/Skill-Level-5-Model-Rocket-Kits/Mini-Copter

Rotary Revolution - https://www.apogeerockets.com/Rocket_Kits/Skill_Level_4_Kits/Rotary_Revolution

Gyro Chaser - https://www.apogeerockets.com/Rocket_Kits/Skill_Level_4_Kits/Gyro_Chaser

Texas Twister - https://www.apogeerockets.com/Rocket-Kits/Skill-Level-3-Model-Rocket-Kits/Texas-Twister

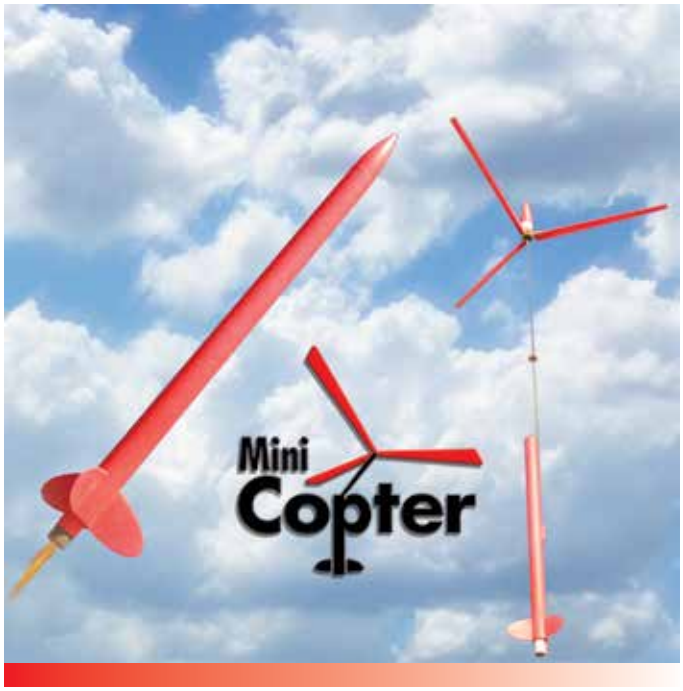

Figure 9: Mini-Copter with helicopter recovery

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Drag Recovery: Drag recovery utilizes the large frontal area of the model to increase the air resistance and thus the drag force of the descending model. This recovery method does not require any other recovery device, as the slow speed of the falling model prevents damage. The drag is also evident on the ascent too; these rockets don't fly very high due to the large frontal area. UFO saucer type model rockets are examples of this type of design. An example kit that we sell on the Apogee website is the Sunward Aerospace Flying Umbrella (**Figure 10**) (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/Flying-Umbrella).

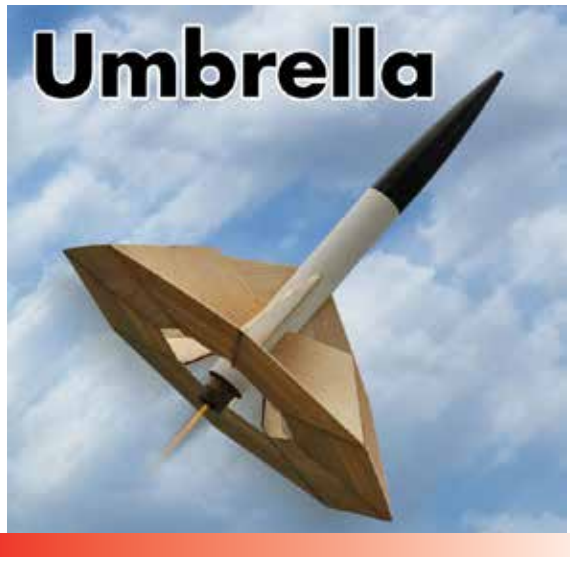

Figure 10: Flying Umbrella

Back-slider Recovery: If the relationship between the Center-of-Pressure (CP) and the Center-of-Gravity (CG) is in the right spot, the long rocket will glide backwards instead of falling horizontally. This is the Back-Slider glider that was developed and patented by brothers Peter and Robert Alway (US Patent #6,926,576 - https://www.google.com/patents/US6926576). They created a cool design and plans for it can be found at: http://www.gorgerocketclub.com/wp-content/uploads/2017/03/Backslider.pdf.

A small hole at the front end forces the ejection charge to create a force that kicks the front end sideways at the apogee point and prevents the rocket from streaming to the ground ballistically (**Figure 11**).

Figure 11: Back-slider recovery design

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Parawing Recovery: If a parachute is reconfigured to utilize lift by gliding instead of drag by falling, it is called a parawing. These gliding chutes are theoretically about four to five times more efficient than ballistic parachutes. The downside is that they can be hard to trim for a nice glide (**Figure 12**).

Plans for making a gliding parachute are found in *Peak-of-Flight Newsletter* #206 and #207.

https://www.apogeerockets.com/education/downloads/Newsletter206.pdf

https://www.apogeerockets.com/education/downloads/Newsletter207.pdf

Figure 12: Parawing parachute design

Rotachute Recovery: Parachutes that have been designed to spin are called rotating parachutes, or rotachutes. There are many different types, including rotafoils, rotasails, and vortex rings. To learn more about rotafoil parachutes, see *Peak-of-Flight* Newsletter #206 (https://www.apogeerockets.com/education/downloads/Newsletter194.pdf).

Other Recovery Concepts

When I wrote the book *Model Rocket Design and Construction*, I envisioned a couple other recovery techniques. So far I haven't had the opportunity to develop them into kits. But how about you? Have you made any designs using these techniques? Let us know so that we can acclaim your design genius.

Horizontal-spin Recovery: This is somewhat related to tumble recovery, but can be applicable to big, higher-powered rockets too. There haven't been any general guidelines published to create the horizontal-spin recovery method, but generally, the models are very long and slender like the back-slider design. But instead of gliding, it spins about the long axis of the rocket. The spinning action of the tube creates lift (due to the Magnus effect), and the model descends at a safe speed.

Figure 13: Horizontal-spin Recovery design

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Aerobrake Recovery: Aerobrake recovery differs from drag recovery in that the speed brakes are deployed at engine ejection. The advantage of this is that the rocket can travel significantly higher (**Figure 14**).

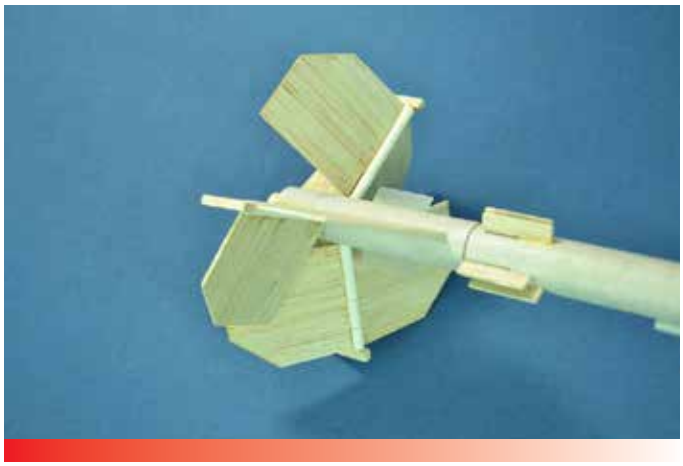

Figure 14: Aerobrake prototype

Magnus-rotor Recovery: The Magnus-rotor recovery method uses a rotating set of blades, each independent of the others, to create lift and drag to slow the rocket to a safe descent speed. Think of the fins being on a pivot and spin perpendicular to the body of the rocket. That is how I envision this type of rocket descending down to the ground (**Figure 14**).

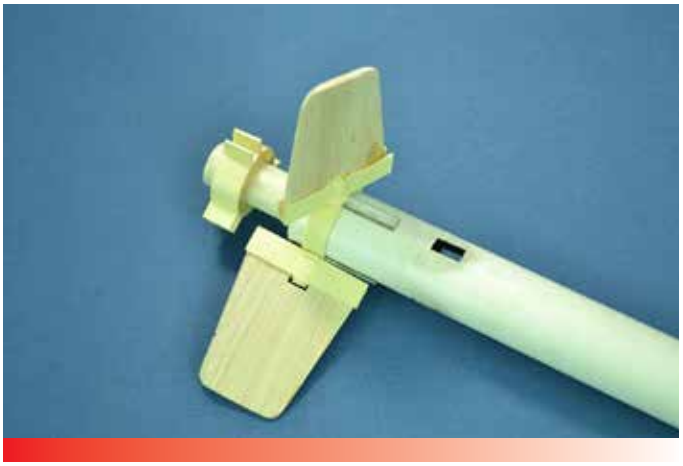

Figure 14: Magnus-rotor prototype

Conclusion

How many of these recovery techniques have you personally been successful at using? What do you think that spectators at your next launch would think if they saw something other than a parachute or streamer? Do you think they'd watch the rocket all the way to the ground? I know I would!

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. He is an avid rocketry competitor, and is Level 3 high power certified. He is often asked what is the biggest rocket he's ever launched. His answer is that 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 an 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 also the author of the books: *Model Rocket Design and Construction*,*69 Simple Science Fair Projects with Model Rockets*: *Aeronautics* and publisher of the *Peak-of-Flight Newsletter*, a FREEz e-zine newsletter about model rockets. You can email him by using the contact form at: https://www.apogeerockets.com/Contact.