PEAK OF FLIGHT

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Rear Ejection Techniques

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APOGEE COMPONENTS

Rear Ejection Techniques

By Tim Van Milligan

Rear ejection, as its name implies, is where the recovery device (parachute or streamer) is ejected out the back of the rocket instead of the front end. In this article, I'll give you some strategies to use when designing rockets to use rear ejection.

In the grand scheme of things, rear ejection is pretty rare in model rocketry. Just looking through any manufacturer's catalog, and you'll see that there are many more kits that use traditional nose cone ejection than there are those that use rear ejection. The main reason for this is that it is more complicated. The rocket has to be designed and prepared differently than one where the parachute is ejected out the front end. But it is possible to use the technique if you want.

Figure 1: The SR-72 Darkbird kit rearward ejects the motor pod to move the CG back to the glide position, and so the elevator flaps can activate upward to pull out of a dive.

The most common use of rear ejection in kit form is for glider rockets. The ejection of the motor is used to reconfigure the glider's surfaces, and to lower the weight of the portion that is gliding back. Some classic kits are the SR-72 DarkBird **Figure 1** (https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/SR-72-Darkbird) and the Estes Scissor Wing Transport (https://www.estesrockets.com/media/instructions/001265_SCISSOR_WING_TRANSPORT.pdf)

Design Strategies

To use rear ejection, it is recommended that you run a stuffer tube up through the rocket so that the hot gasses of the ejection charge push down, but start from the top section of the rocket (**Figure 2**).

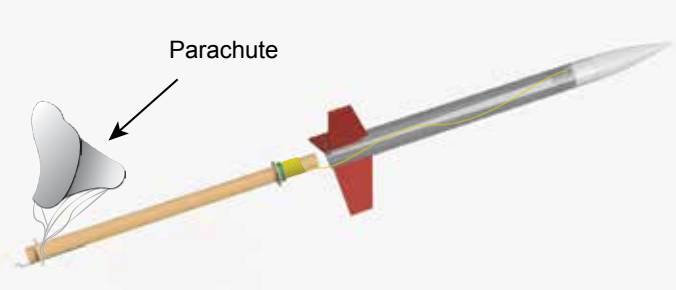

Figure 2: A good design approach for rear ejection uses a long stuffer tube to duct the exhaust gasses to the front of the rocket.

If you just try to use a short engine tube and put the recovery device in front of the motor mount such as shown in **Figure 3**, the ejection charge will push it tightly into the front of the rocket, and probably wad it up into a little plastic ball from all the residual heat in the tube.

You need to duct the ejection gasses and use them to push the parachute out, instead of relying on the motor mount to pull it out.

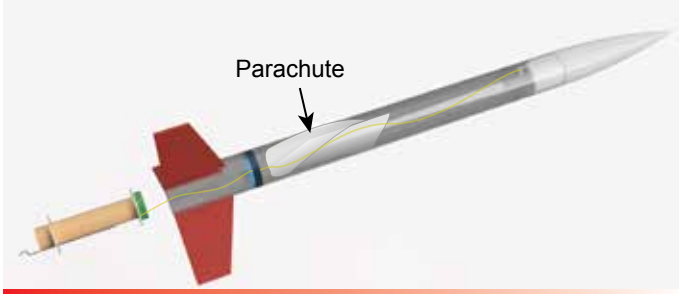

Figure 3: Poor design for rear ejection, because the ejection charge will wedge the recovery device further into the tube and heat it to the point of melting.

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The heart of the rear ejection model is the motor mount. As suggested, it should be a long stuffer tube as shown in **Figure 4**.

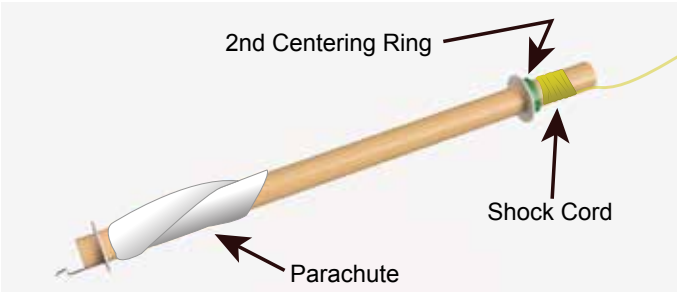

Figure 4: The engine mount of the rear ejection rocket. Wind the shock cord around the front end, and it will slide off easily at motor ejection.

The forward centering ring should not be placed all the way to the front end. A short length of tube should extend forward of the ring as seen in **Figure 4**. The reason is that you want to wind the Kevlar® shock cord around the tube. Don't shove it into the front of the tube, or there is a good chance that it will tangle and then prevent the motor tube from ejecting completely from the rocket.

Wrapping the shock cord around the tube is preferred. The cord will easily slide off the tube. It is sort of like a fishing rod, where the string is wrapped around a dowel and slides easily off when you make a cast into the water. I've never had one fail in all the rear ejection rockets I've built.

Where it can fail is the centering ring. The centering ring is the anchor for the shock cord, and it has to be strong. For some reason, rear ejection rockets put a lot more strain on the anchor point than a traditional nose cone ejection. I'm not sure why this is, but I've found out through trial and error that this anchor point is where you have to add extra reinforcement. As shown in **Figure 4**, I put a second centering ring in front of the large ring to increase the strength of the shock cord anchor.

I also recommend adding a sleeve over the outside of the motor tube to increase its strength too. For the sleeve, I simply wrap and glue a sheet of paper to the tube. It is the same technique I use for rolling custom tubes, which is shown in **Peak-of-Flight Newsletter #330** (https://www.apogeerockets.com/education/downloads/Newsletter330.pdf).

The recovery device (parachute or streamer) should be wrapped around the motor tube. The suspension (shroud) lines should also be wrapped around the tube. It is because the force of ejection is so hard with rear ejection that I prefer to wrap the shroud lines around the tube too. So the whole parachute has to unwind before it inflates. This slows it down quite a bit, but it puts less stress on the suspension lines (**Figure 5**).

Figure 5: Wrap the streamer or parachute neatly around the tube so that it will unfurl slowly at ejection.

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Advantages of Rear Ejection

The biggest advantage of using rear ejection is that it allows you to lower the drag of the rocket by eliminating the gap between the nose cone and the body tube. The joint can be filled with epoxy-clay (https://www.apogeerockets.com/Building_Supplies/Epoxy_Clay/FIXIT_Epoxy_Clay) and smoothed out. This eliminates a trip point that could cause the laminar airflow over the nose from transitioning to turbulent flow. When you have turbulent flow, the drag almost always increases and the rocket doesn't fly as high.

It is for this reason that the tiny models we flew in the altitude event at the World Space Modeling Championships (**Figure 6**) were uni-body and rear-ejection. The nose and the tube were a single piece so that the gap between the nose and the tube was eliminated.

Figure 6: The competition model that we used at the World Space Modeling Championship in 2016 features a uni-body with rear ejection.

It should be noted that these models are small, only 18mm in diameter, so you can see that it is possible to use rear ejection on little rockets too.

The next advantage of rear ejection is that it moves the strongest part of the rocket to the front end. Usually the strongest point is at the rear where the tube is stiffer because of the centering rings. Normally for rockets it may not make a difference where the strongest point of the rocket is. But if you're planning on having the nose land first for some reason, then having the strong part near the front may be advantageous. For the Spot-Landing event in NAR competition, I use rear ejection because I want the nose to hit the ground first (**Figure 7**).

Figure 7: My spot landing rocket uses rear ejection to make sure the nose cone lands first.

The other advantage of rear ejection is that it is an example of a zipperless design. There are no side forces present during ejection that may pull the motor sideways and cause the shock cord to cut into the tube.

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Another advantage of rear ejection is that you can use it for a simplified arrangement for dual deployment. If you let the motor's ejection charge be the apogee deployment charge, the payload bay can be used exclusively for the main parachute. You can mount the electronics in the nose cone of the rocket with the main chute anchored at the base of the nose cone.

The next advantage of the rear ejection technique shown here is that the extra length of stuffer tube inside the rocket moves the CG further forward. This increases the stability of the model because it will be more nose heavy. Those little FAI stages that we flew in international competition were on the hairy edge of stability, so the extra tube did help a little bit. And those glider model kits like the SR-72 Darkbird definitely needs the extra weight up front to allow the rocket to fly straight on its upward trajectory.

Rear ejection can also be used on the booster stages of multi-stage rockets too. I've used this technique on scale models like the Nike Apache rocket where the upper stage is ignited by the booster stage. People have a hard time understanding how the ejection charge can ignite the upper stage and still push the motor mount tube out the back end. But there is plenty of energy to do both successfully. See Peak of Flight Newsletter #416 (https://www.apogeerockets.com/education/downloads/Newsletter416.pdf) for additional details on this.

The final advantage of rear ejection is that it can be wadding-less too. The front centering ring blocks the ejection gasses from allowing heat to get to the parachute that is wrapped around the tube.

Disadvantages of Rear Ejection

The biggest disadvantage of rear ejection is that it is far more complicated than the traditional nose cone ejection. There are a few more components involved in the setup of the rocket, and you have to make sure that you pay attention to your launch preparations to prep the rocket correctly.

The second disadvantage is that because of the stuffer tube inside the rocket, there is less room for the recovery device. This means you can't pack the chute as loosely as you'd like to. Therefore the reliability of chute opening can be reduced. It is more important than ever to pay attention when you are prepping the model for flight to make sure everything will unroll quickly and without tangling. The larger the diameter of the tube, the more room there is for the parachute, which increases opening reliability.

And as mentioned previously, rear ejection models are prone to failure unless you make them stronger. This is going to add a little more weight to your rocket, but typically it is in a good location - the front end which makes the rocket more stable.

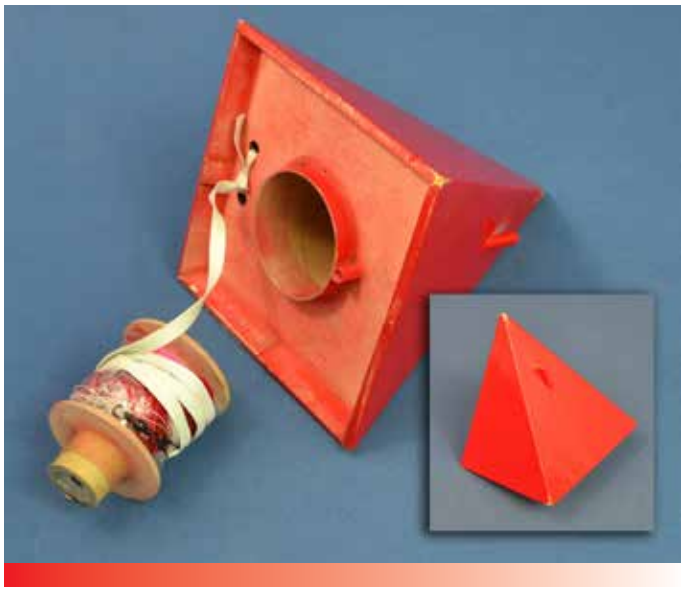

Figure 8: The Khufu's Pyramid rocket uses rear ejection.

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One big disadvantage of rear ejection is that you can't easily use through the wall fins. The inside of the rocket tube has to be free of protrusions so that the centering rings can slide easily as the engine mount tube ejects rearward.

Similarly, designs that have fins attached to a boattail like the V-2 rocket are very difficult to design with rear ejection. The whole aft section of the rocket would have to be detachable in order to eject successfully. At that point, you can't tell if it is rear ejection or traditional nose-cone ejection.

Finally, it is hard to design minimum diameter models that use rear ejection with a safe recovery (we all know the Estes Mosquito ejects the motor without a streamer). If you have ideas on how to accomplish this so that both the motor and the rocket come down with recovery devices, I'd be interested in seeing it. For that matter, if you have other designs that use rear ejection that haven't been covered here, I'd be interested in seeing those too.

Additional Information:

Peak-of-Flight Newsletter #212 (https://www.apogeerockets.com/education/downloads/Newsletter212.pdf)

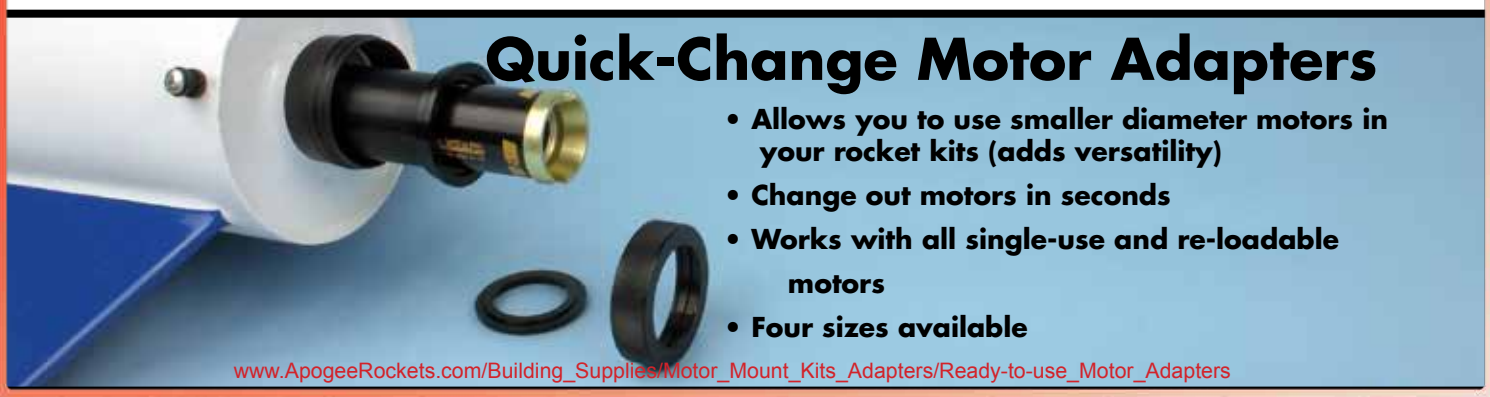
Rocket kits with Rear Ejection

Apogee Components SR-72 Darkbird: https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/SR-72-Darkbird

Sunward Aerospace Khufu's Pyramid: https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/Khufu39-s-Pyramid

Sunward Aerospace King Tut's Pyramid: https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/King-Tut39-s-Pyramid

US Rockets Dual 18mm Rear Eject: https://www.apogeerockets.com/Rocket-Kits/Skill-Level-4-Model-Rocket-Kits/Dual-18mm-Rear-Eject

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 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 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 FREE e-zine newsletter about model rockets. You can email him by using the contact form at: https://www.apogeerockets.com/Contact.