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PEAK OF FLIGHT

NEWSLETTER

Step-by-Step Instructions: Build a Parawing

Make A Highly Efficient Gliding Parachute For Your Model Rockets (Part 2 of 2)

Reloadable Rocket Motors

Answers To Your Frequently Asked Questions

EMRR Corner

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Build A Gliding Parachute - Part 2

By David T. Flanagan

This is the second part of the how-to article of building, trimming, and flying a single-keel parawing for model rocket use. Part one, which was in Apogee's Peak-of-Flight Newsletter #206 (http://www.ApogeeRockets.com/education/Downloads/Newsletter206.pdf) gave some general considerations on how to size a parawing, as well as material selection. This portion finishes the construction and gets into the trimming and packing of the parachute for launch.

Attaching the Keel Lines: Continued

Once the keel lines are installed they are marked to length, tied off, and trimmed prior to proceeding. Fold the wings back so the top surfaces are touching and the keel is fully exposed. Hold the canopy in place with weights. Measure each line and mark it. Try to keep the same amount of tension on each line as you measure and mark it. Pick up all the lines and adjust them so the marks you made are next to each other. Tie an overhand knot, then trim the excess line from the knot except for one (usually the longest one). See Figure 6. Many arrangements for line groups are possible but the parawing as shown here will have three line groups – one keel group and two leading edge groups.

From Figure 6, you can see that the wings are folded back so the leading edges are touching and the keel is straight. The parawing is secured with weights, and the lines have been measured, marked, tied and trimmed.

Figure 6. The keel line group is complete.

Figure 7. Marking the leading edge lines to length: this is done in pairs to promote symmetry. Separate the lines into the left and right groups only after marking all the lines. Note the keel lines (left side of the picture) have been routed out of the way.

Attaching The Leading Edge Lines

The leading edge lines are installed after the keel lines. Again, cut all lines to excess length. Lines are installed in the normal fashion on the leading edges except for the two wing tip lines. These must be rigged the same way as the keel line at the tail – they must have some excess line sticking out above the tape or sticky dot.

Figure 8. The tip-line attachements are just folded over and taped to the canopy. These lines are used to trim the parawing during toss testing.

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Proofreader: Michelle Mason

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They will be used to trim the parawing for flight.

Lay out the parawing so that the leading edges are matched together and the keel lines are out of the way. Secure the canopy in place with weights. Mark the leading edge lines to length in pairs (this helps symmetry, which is very important). See Figure 7.

Once the lines are marked in pairs, separate the left and right leading edge groups from each other. Line up and tie the lines of each group off the same way the keel lines were tied off, and trim the excess except for the one line in each group.

Confluence

The three line groups (left leading edge, keel, and right leading edge) are joined together by tying an overhand knot using the surviving string from each group. Line up the three knots. Tie a single overhand knot in the three lines a comfortable distance away from the individual knots. This forms the confluence.

Trimming

Now comes the hard part. Lay the parawing flat on the floor upside down, pointing away from you. Hold the

Figure 9. The parawing is ready for a pull test. It is pointed away from the modeler who is about to pull straight up on the confluence. Note the excess trim line at each wing tip and the aft-most (tail) keel line. Many tests are required to establish the correct trim.

line confluence in your hand. Pull straight up. The canopy should surge slightly away from you in an attempt to fly overhead. Any turns will be immediately obvious. Shorten the opposite wingtip line or lengthen line on the side of the

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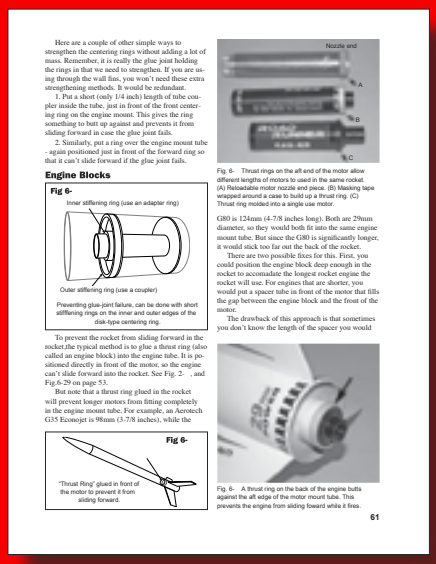
Model Rocket Design And Construction



Here are a couple of other simple ways to strengthen the centering rings without adding a lot of mass. Remember, it is really the glue joint holding the rings in that we need to strengthen. If you are using through the wall fins, you won't need these extra strengthening methods. It would be redundant.

1. Put a short (only 1/4 inch) length of tube coupler inside the tube, just in front of the front centering ring on the engine mount. This gives the ring something to butt up against and prevents it from sliding forward in case the glue joint fails.

2. Similarly, put a ring over the engine mount tube - again positioned just in front of the forward ring so that it can't slide forward if the glue joint fails.

Engine Blocks

Fig 6-

Inner stiffening ring (use an adapter ring)

Outer stiffening ring (use a coupler)

Preventing glue-joint failure, can be done with short stiffening rings on the inner and outer edges of the disk-type centering ring.

To prevent the rocket from sliding forward in the rocket,the typical method is to glue a thrust ring (also called an engine block) into the engine tube. It is positioned directly in front of the motor, so the engine can't slide forward into the rocket. See Fig. 2- , and Fig.6-29 on page 53.

But note that a thrust ring glued in the rocket will prevent longer motors from fitting completely in the engine mount tube. For example, an Aerotech G35 Ecosojet is 98mm (3-7/8 inches), while the

Fig 6-

"Thrust Ring" glued in front of the motor to prevent it from sliding forward.

Nozzle end

A

B

C

Fig. 6- Thrust rings on the aft end of the motor allow different lengths of motors to used in the same rocket. (A) Reloadable motor nozzle end piece. (B) Masking tape wrapped around a case to build up a thrust ring. (C) Thrust ring molded into a single use motor.

G80 is 124mm (4-7/8 inches long). Both are 29mm diameter, so they would both fit into the same engine mount tube. But since the G80 is significantly longer, it would stick too far out the back of the rocket.

There are two possible fixes for this. First, you could position the engine block deep enough in the rocket to accomadate the longest rocket engine the rocket will use. For engines that are shorter, you would put a spacer tube in front of the motor that fills the gap between the engine block and the front of the motor.

The drawback of this approach is that sometimes you don't know the length of the spacer you would

Fig. 6- A thrust ring on the back of the engine butts against the aft edge of the motor mount tube. This prevents the engine from sliding foward while it fires.

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Figure 10. The trimmed parawing. Note the three line groups. The confluence is slightly out of sight below the picture.

turn. The glide angle will also be evident. If the parawing shudders and backs up and bounces off your knees it is too close to a stall. Lengthen the aft-most lines on the keel or leading edges. Likewise if it surges way too fast it is not close enough to the stall configuration. Flying as near as possible to a stall is best – it is efficient and any turns are less likely to turn into a death spiral. Many pull tests are required to get the trim right. Figure 9 shows the parawing prepped for a pull test.

Once the trim is right, the wing tip and aft keel lines are secured with a "locking tab." Fold the excess line down over the tape that attaches the line to the canopy and secure it with another piece of tape. Masking tape or other removable tape is best in case it is necessary to re-trim the parawing (see Figure 8).

Toss testing the parawing in the back yard is a good way to verify the trim

Rigging

Preparing the parawing for flight is a bit more complicated than preparing a regular chute. Make sure the lines are not tangled, then lay the parawing on its side and secure the payload (see Figure 10).

Carefully S-fold the canopy on to its tail as shown in Figure 11. Keep all lines taut (keeping the lines taut is VERY important)

The canopy is then folded or rolled from the top down towards the payload. Size the package for your rocket body. Keep all lines taut. This takes practice.

You might want to do a few toss tests with a dummy payload just to make sure you have packed the wing correctly. You can also check the trim with a toss test. You may have to re-trim the parawing a couple of times.

Figure 10. Packing the parawing. The lines are cleared, the payload is secured, and the canopy is placed on its side. Here the left leading edge is on top. The canopy can also be packed with the right leading edge on top.

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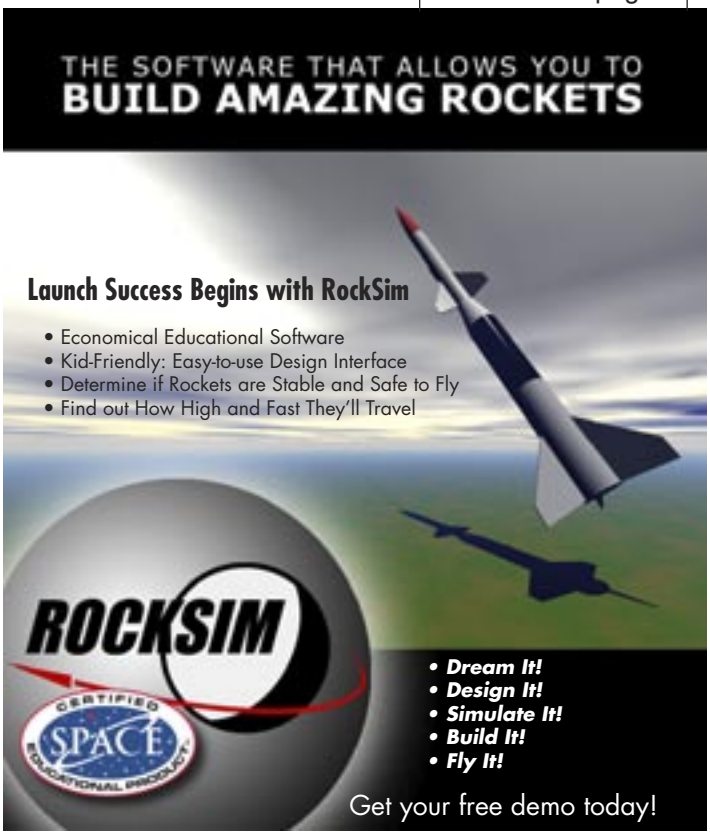

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Figure 11. The canopy is S-folded onto its tail while keeping the lines taut.

References:

The MS Excel™ file for the sizing table from "part 1" can be downloaded from the Apogee Components web site. http://www.ApogeeRockets.com/Education/downloads/PW_DES.xls

[1] *Handbook of Model Rocketry*, G. Harry Stine, 6th Ed., John Wiley & Sons, NY NY

[2] *Low Speed Wind Tunnel Investigation of Tension-Structure Parawings,* Naeseth, R. L. and Fournier, P.G., NASA TN-D-3940 June 1967

[3] *Low Speed Wind Tunnel Investigation of All-Flexible Twin Keel Tension Structure Parawings,* Fournier, P.G., NASA TN-D-5965, October 1970

http://2e5.com/kite/nasa/reports/ This web site has a listing of all the NASA technical notes dealing with parawings. They were considered for the descent of the Apollo capsule in the 1960's.

Twin-Keel Parawing Plans. Apogee Technical Publication #7. http://www.apogeerockets.com/technical_publications.asp

More information about parawings will be available in the third edition of *Model Rocket Design and Construction*. http://www.ApogeeRockets.com/design_book.asp

About the Author:

Mr. Flanagan holds degrees in life sciences and mechanical engineering and is a registered professional engineer in several states. He has held both research and engineering positions with contractors at NASA -JSC, and is currently with Jacobs Engineering at NASA - MSFC supporting the Experimental Fluids and Environmental Test Branch. He is a licensed airplane pilot, ultralight pilot, an expert scuba diver and a former Army paratrooper. He has had a life long interest in parachutes and made his first sky dive at the age of 17. He has made several hundred parachute jumps, holds a master parachute rigger certificate from the FAA, and has completed the University of Minnesota Parachute Technology Short Course. He continues to monitor developments in the field of "aerodynamic decelerators", has made models of most types of parachutes, and has flown most of them in model rockets. He lives in Madison, Alabama, with his wife and two cats.

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A Beginner's Guide To Reloadable Rocket Engines

By Tim Van Milligan

We get quite a few questions from modelers about reloadable rocket engines. So I'll use this space to answer some of the most frequently asked questions. If you have any questions that are not answered here, please let me know, as I have a feeling this will be a two-part article.

Q #1: What is the difference between reloadable motors and other rocket engines?

A #1: There are several differences. First, as the name suggests, reloadable motor casings can be used more than once. The advantage of this is that they can save you money if you launch rockets often. I did a simple break-even analysis for a small 24mm reloadable motor in Peak-of-Flight Newsletter #189 (http://www.ApogeeRockets.com/education/downloads/newsletter189.pdf). You can do the same to figure out if it makes sense for your fleet.

The other difference is that all reloadable motors use composite propellant. Many small motors use black-powder propellant. Black powder is OK for small motors, but it is not suitable for bigger engines because it is brittle and can cause major problems in bigger sizes.

Q #2: Can I use reload engines in my current fleet of rocket kits? What about the length? Won't it stick out the back? And what about the engine hook?

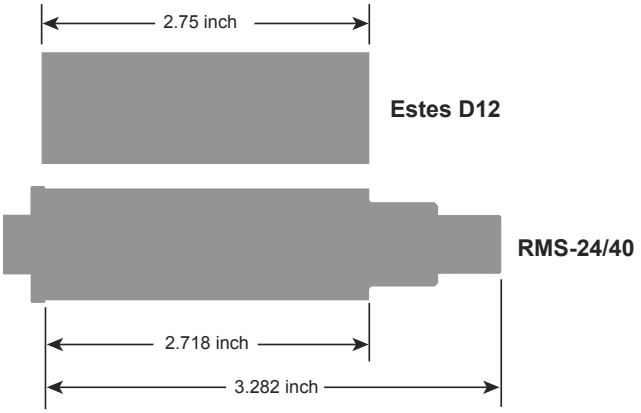

Fig. 1: Silhouette of engine sizes. While the RMS-24/40 case is longer, it will still fit in your "built" rockets.

A #2: These are good questions because if you compare the length of the Estes D12 motor to the RMS-24/40 case, it appears that the reloadable one will not fit.

Notice in Fig. 1 that the RMS-24/40 motor steps down toward the right side (the forward end). That reduced diameter section is designed to slip through the engine block that you have in your rocket. In this way, you can insert the

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FAQ About Reloadable Rocket Engines

motor into rocket kits that you have already built. The large section in the middle is pretty close to the length of an Estes D12 rocket motor, so the length is not really an issue.

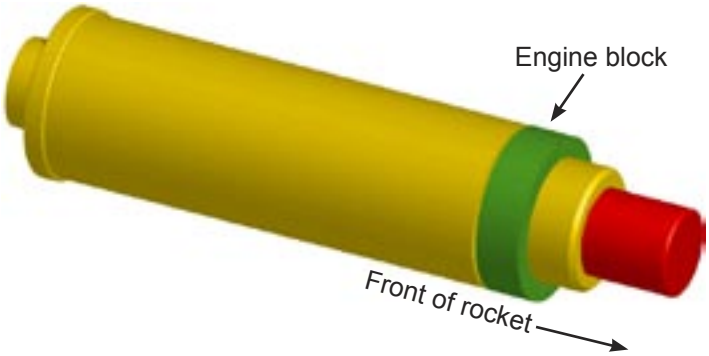

Fig. 2: The front end of the RMS-24/40 case will fit through the engine block in your "built" rockets.

You may find that the fit is tight as it goes through the engine block. There is a little lip/burr on the inside edge of the paper engine block ring that causes the friction. What you can do is glue sandpaper around a long wooden dowel, then sand out the inside of the ring to loosen the fit.

If you have an engine hook in your rocket, you'll find that it simply snaps over the back edge of the casing in one of the two gaps provided in the black ring on the back of the motor casing (see the Fig. 3 photo).

If you have not built the rocket kit yet, I'd leave out the installation of the engine block altogether. Then you don't

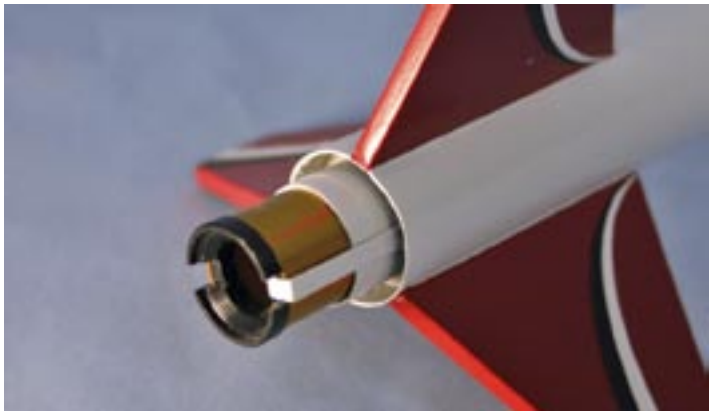

Fig. 3: The engine hook fits in the cut-out notch on the aft closure ring. (For clarity, nozzle not shown)

have to worry about the engine block getting in the way.

Q #3: If you don't have an engine block in the engine mount, then what prevents the motor from sliding through?

A #3: See that lip on the back end of the reload casing? That is the engine block! It prevents the motor from going in too far. In Fig. 4 on the next page, you'll see that the lip butts up against the engine mount tube. The advantage of this is that you can use any length motor and not have to worry about installing spacers or having an engine block ring get in the way of a longer motor. To hold the motor in, simply wrap a couple of layers of masking tape around it and the tube as shown.

An alternate method of engine retention is to use the

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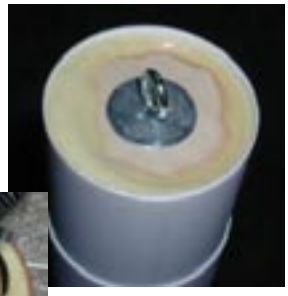
Elmer's ProBond/Gorilla Polyurethane Glue

Elmer's ProBond Polyurethane Glue. It is called "The Ultimate Adhesive", "Bonds Virtually Everything", "Super Strong", "Sand Easily", "Water Proof", and "Stainable/Paintable". The outside cover said that it is the strength of epoxy without the mixing.



In general, the glue easy to work with exception for one primary issue. It expands somewhat in volume after being applied. This has not been a problem for attaching centering rings to the motor tube and to the inside of the body. It has been fine for attaching nylon straps to the motor tube and to pistons (if used).

Once dry it appears porous, but it does sand easier than epoxy and I had no primer interactions.

(Comments made by Nick of EMRR)

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FAQ About Reloadable Rocket Engines

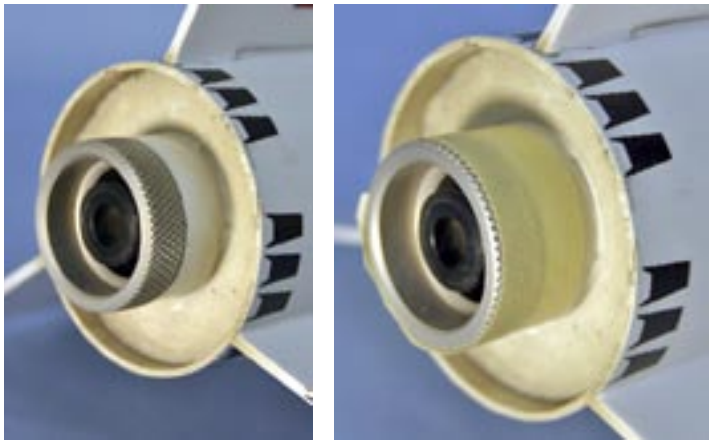

Fig. 4: The aft metal ring acts as an engine block. To hold the motor in, just wrap masking tape around it.

Aero Pack motor retainers as shown in the advertisement on this page. It gives the rocket a more polished look. For more information on engine retention, see the book Model Rocket Design and Construction (http://www.ApogeeRockets.com/design_book.asp) or the information page on the Apogee web site: http://www.apogeerockets.com/education/motor_retention.asp.

Q #4: What is the difference between the RMS-29/120 (P/N 60005) and the RMS-29/40-120 (P/N 60006)?

A #4: One is slighly shorter than the other. Because of this, the reload propellant kits are NOT interchangable. You have to be really careful not to buy the wrong reloads. I really wish that Aerotech made only one of them, since it is so easy to get them mixed up.

One case is not better than the other. They just have different reloads. Which one you should own will be determined by which motor (based on thrust curve and flame color) you want for your particular flight.

For more information or to order reloads, please visit: http://www.apogeerockets.com/Rouse-Tech_Motors.asp and http://www.apogeerockets.com/Aerotech_Reload_Motors.asp

Fig. 5: Two different "G-engine" size reload casings.

KIT OF THE MONTH

DynaStar Snarky

The Snarky rocket is a very distinctive rocket kit. It was designed by Shrox, which explains why it has a unique shape. It looks more like an airplane than a missile. But don't let that fool you. It is fully rocket-powered, and it is big! This unique combination is definitely something that will get you noticed at your next rocket launch.

The Snarky is designed to look like an Air Force target drone. That means its purpose is to mimic the flight of enemy airplanes, so that the Air Force can practice intercepting it. But this isn't a scale model. We designed it just for kicks, and to show you how much fun you really can have with model rocketry.

The air-scoop on the bottom of the model is just one thing that makes this rocket kit unusual. No other rocket kit has one like this. And it actually helps stabilize the rocket; you'll find that it flies straight as an arrow on every single launch.

Besides the air scoop, the fins are assymetric. That means they aren't equally spaced around the rocket like they are on other kits. The combination of the scoop and the assymetric fins, plus the large size of this kit is what makes it stand out among all the other rockets at the flying range.

Besides the cool design, the model is accented by a lot of colorful pressure-sensitive decals. It's as mean as it looks.

Snarky Kit Specifications:

Skill Level 4: Slightly Challenging
Length: 28.5" (72.4 cm)
Diameter: 2.217" (56.3 mm)
Weight (without motor): 6.3 oz (180 gm)
Recovery: 32" plastic parachute

Kit Features

- Plastic Nose cone
- Die-cut Balsa Fins
- Colorful pressure-sensitive decals
- Detailed Instructions
- Kevlar® Shock Cord
- 32" Diameter Plastic Parachute
- Premium Quality Body Tubes
- Flies Estes D12 or Aerotech 24mm motors

For more detailed information, go to:
http://www.ApogeeRockets.com/snarky.asp