PEAK OF FLIGHT NEWSLETTER

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LITTLE JOE 6 SCRATCH BUILT CARDSTOCK ROCKET

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PEAK OF FLIGHT

Little Joe 6 Scratch Built Cardstock Rocket

By Steve Riegel

The plans presented in this article were originally developed by Jeff Lane, Colorado Springs Rocket Society, NAR Section 515, and posted to Rocket Reviews here: https://www.rocketreviews.com/scratch-little-joe-6-by-jeff-lane.html. I modified the design for use in my junior high rocketry class. The original plans called for a scratch-built escape tower made from toothpicks and skewers. While impressive, the tower was quite challenging to build and I was concerned it would prove too complex for young fingers.

FIGURE 1: COMPLETED CARDSTOCK ROCKET WITH ALTERNATE ESCAPE TOWER.

I created a folded cardstock replacement for the tower that looks ok from "launch pad distance" and is much easier to fabricate. While Jeff's original instructions were adequate for an experienced builder, I wanted to add additional details to help the students work through construction. Finally, I modified the motor mount to take 18 mm motors without an adaptor, again to facilitate use by my students and make this a good "small field" flier.

Per Jeff's design, this is a 1:31 scale model of the Little Joe I vehicle. The vehicle was intended to test the Mercury capsule and various systems during development. This model is based on Little Joe 6, actually the second Little Joe, launch on October 4, 1959 from Wallops Island. The Mercury capsule mockup ("boilerplate") was mounted on a short adapter to the booster with a mission objective to test escape tower function. I found few images of the Little Joe 6 vehicle with the one shown here being the most useful for locating markings, fin colors, etc. While I believe I've got things in the right relative position additional photos might give a more accurate alignment.

FIGURE 2: LITTLE JOE 6 FROM WALLOPS ISLAND, 1959

This Little Joe has three-dimensional fins to retain rigidity while still allowing cardstock construction. The length of the fins and their sweep bring the CP sufficiently far back that no nose ballast is required for stability.

Materials required: 4 sheets of 110 lb cardstock, ~ 8.5" x 5.5" of 1/4" foam board, white glue (Elmer's), ~3' elastic shock cord, 2' of 100 lb Kevlar, a 16"-18" parachute, plus white paint and red paint or marker for touch ups.

This model is rated skill level 4 - moderately challenging

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(Apogee Components rating scale) due to the need for rolling and gluing a number of small cardstock parts without getting glue on the surface of the pieces. Elmer's glue has the advantage over Tightbond or other yellow glues as it dries clear should any sneak out of a seam. The parts can be printed from the files listed:

https://www.apogeerockets.com/downloads/PDFs/little_joe_bulkheads.pdf
https://www.apogeerockets.com/downloads/PDFs/little_joe_fins_v2.pdf
https://www.apogeerockets.com/downloads/PDFs/little_joe_paper_shrouds_v2.pdf
https://www.apogeerockets.com/downloads/PDFs/little_joe_non-foil_option_v2.pdf
https://www.apogeerockets.com/downloads/PDFs/18_mm_motor_mount_and alternate_escape_tower.pdf

The first four files above were developed by Jeff Lane and are as presented in his original post with the exception of adjusting the contrast for clearer printing on my printer. The fifth file contains my modified 18 mm motor mount and escape tower. My modification does not use all the parts Jeff designed for the escape tower assembly and reuses other parts in a novel way. On the "bulkheads" sheet, the two centering rings for the motor mount are not used (they have 24mm holes). On the "paper shrouds" sheet, the "shroud adjacent to nose cone" and "Ms. Pac Man" cone are not needed. I elected not to use the nose cone shoulder wrap (see capsule assembly section).
Jeff made the decision to use glue tabs made from scrap cardstock on all the body tubes and shrouds so that all rolled edges are abutting rather than overlapping. The only exception was the fins because integrated tabs did not affect the outer profile. My modified escape tower also has integrated glue tabs. Scrap cardstock (65-110 lb) will work for all glue tabs.

Big gotcha:

While most of the construction is straightforward, Jeff noted a significant warning regarding the fins, quoted here: "Do not force the corners of the [fin] seams together but allow them to fit according to their natural fold. If you try to force the corners to fit perfectly, you will wind up with some warping and hence induce spin during flight. In fact, it would be best to test build a couple of fins to get them right before doing the final fins. It's only paper."

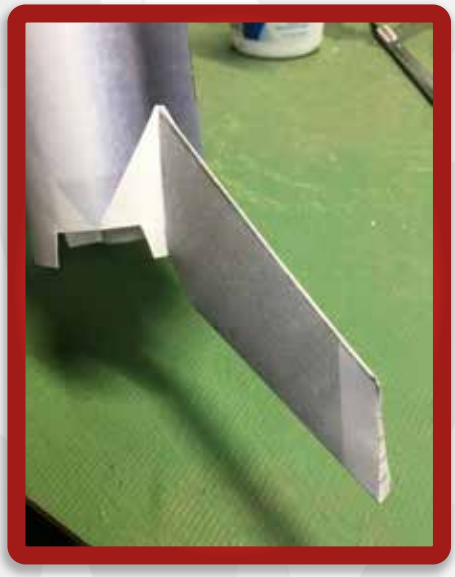

FIGURE 3: ALLOW FINS TO TAKE THEIR NATURAL FOLD, OR YOU'LL GET WARPING.

Construction:

Print the file little_joe_bulkheads.pdf (B/W) onto ordinary printer paper. Print the remaining four files (color) onto 110 lb cardstock.

The motor mount is first to build and is straightforward. Cut out the motor tube and roll it around an 18mm motor casing, gluing the tab where it overlaps. The motor tube wraps a little bit farther around than the glue tab so make sure

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FIGURE 4: ROLLING MOTOR MOUNT AROUND 18MM CASING

to fit the tube around a motor casing. Remove the motor casing and set the tube aside to dry. Take the ¼" by 8" motor block strip and wrap it around your little finger to make a ring approximately ½" in diameter. Glue and wind the remaining length of the strip around that ring until it is just big enough to fit into the front end of the motor tube. Use additional scrap cardstock strips if needed to achieve the correct fit. This ring is the motor block. When the motor block has dried, glue it into, and even with, the front end of the motor tube.

Roughly cut out the two motor centering rings (18 mm hole) and the four rectangular ribs for the motor mount and glue to a piece of foam board. Cut out the rings and ribs from the foam board. Glue the front ring to the motor tube over the lines indicated on the motor tube. Glue the ribs at ¼ intervals around the motor tube so that they touch the motor tube and the front ring. Glue the rear centering ring into place, pushing it up so it touches the four ribs (see Figure 6). Add glue fillets to all joints. Let dry completely.

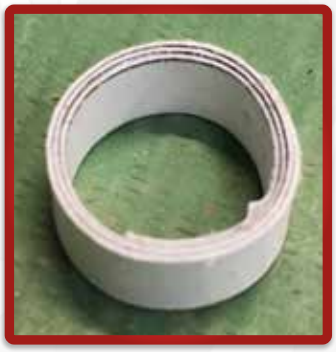

FIGURE 5: ENGINE BLOCK MADE FROM A STRIP OF PAPER

The body tube is cut out and glued together with a scrap of cardstock about ½" wide glued along the inside of the seam. It helps to gently roll the body so it takes on a natural curve before gluing. Glue one side of the glue tab inside the body and let it dry (Figure 7). Then apply glue to the other side of the glue tab and glue the other side of the seam in place. Let dry completely.

FIGURE 6: COMPLETED MOTOR MOUNT

When the body tube seam is dry, test fit the motor mount into the body. Sand the rings if needed to get them to fit into the body. If the fit is too loose, wind strips of scrap cardstock around the rings to build up the diameter (arrow seen in Figure 8). When you are satisfied with the fit, glue the motor mount into the body tube so the rear centering ring is approximately 1/16" recessed into the end of

FIGURE 7: ROLL AND GLUE THE MAIN BODY TUBE

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FIGURE 8: WRAP A STRIP OF PAPER AROUND THE RIND IF THE FIT INTO THE TUBE IS LOOSE

the motor tube. The four tabs at the back of the body tube will stick out past the centering ring. You should have approximately 1/4" – 3/8" of the motor tube exposed (see figure 9). Apply a glue fillet around the rear centering ring and the body tube. Set aside to dry.

Next is the Mercury capsule. Rough cut the two nose cone bulkheads and the capsule/reduction adaptor (slightly smaller than the bulkheads) and glue to foam board. Then cut those parts from the foam board.

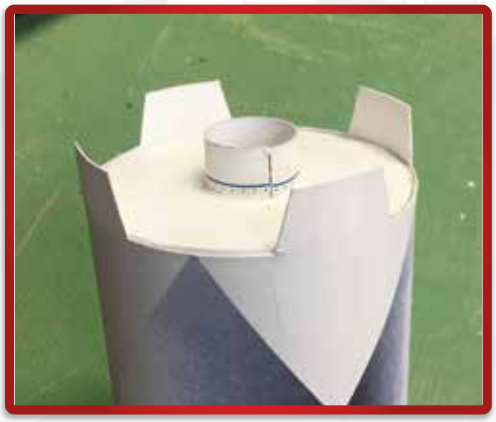

FIGURE 9: INSERTING MOTOR MOUNT IN AFT END OF ROCKET

Cut out, roll and glue the capsule inner body tube using a glue tab cut from scrap cardstock. Test fit but do not glue the two bulkheads and capsule/reduction adaptor onto the inner body tube (see figure 10). Remove the rings and set aside.

Cut out, roll and

FIGURE 10: TEST FIT OF INNER CAPSULE TUBE AND CAPSULE BULKHEADS

glue the capsule shroud using a glue tab of scrap cardstock. Cut out, roll and glue the reduction shroud with a glue tab of scrap cardstock.

Slide the capsule shroud onto the inner body tube and glue it in place so that the shroud just touches the bottom of the printed band on the inner body tube. Slide the capsule/reduction adapter ring onto the inner body tube. Apply a line of glue around the inner body tube and the forward edge of the capsule/reduction adapter ring and press the ring forward until it seats into the lower edge of the capsule. About 1/16" of the ring should be visible all around the edge of

FIGURE 11: THE RING SHOULD PROTRUDE ABOUT 1/16" FROM THE LOWER EDGE OF THE CAPSULE SHROUD.

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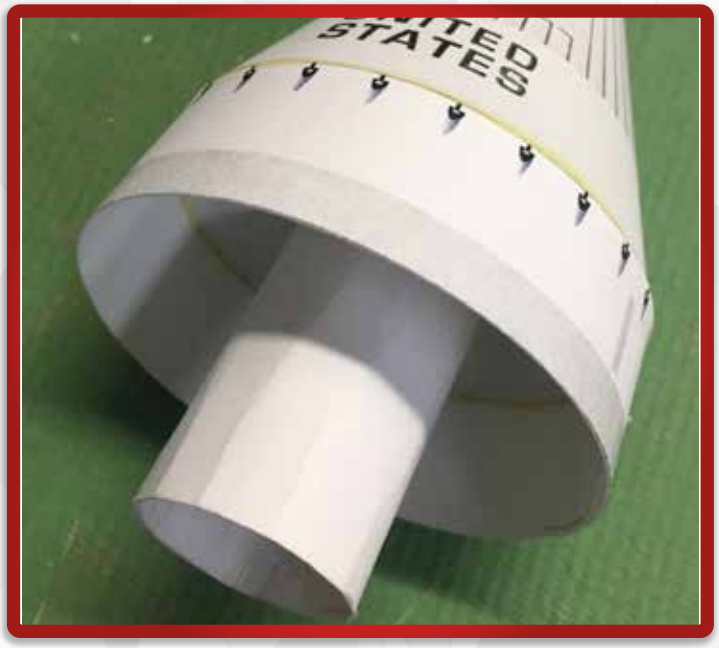

FIGURE 12: ADDING REDUCTION ADAPTOR SHROUD

the capsule (see figure 11).

Test fit the two bulkheads inside the main body tube and check for a good fit. If needed, sand the rings or add strips of scrap cardstock around the perimeter to ensure a snug but not overly tight fit. Apply a bead of glue to the inside of the forward edge of the reduction adapter shroud and slide it onto the exposed rim of the capsule/reduction adapter ring (figure 12).

Apply glue to the inside rear edge of the capsule/reduction adapter shroud and around the inner body tube. Slide one of the bulkheads onto the inner body tube and press it into the rear edge of the reduction adapter shroud. About ½ of the bulkhead should remain visible below the edge of the shroud. Apply a fillet of glue were the inner body tube and bulkhead meet.

FIGURE 13: GLUE THE ADAPTER SHROUD AND FINAL BULKHEAD ONTO THE TUBE

Apply a line of glue around the end of the inner body tube and slide the remaining bulkhead onto it (see figure 13). Apply a fillet of glue around the joint.

The next piece is the platform for the escape tower. Start by cutting out, rolling, and gluing the inner escape tower tube. Then cut out the four tower base wrap strips (each is a different width). Wrap and glue the first (widest) strip flush around one end of the inner escape tower tube. Do the same with the second strip (see figure 14). Before the glue dries on the second strip, check the fit of the band inside the top of the Mercury capsule. Add or remove material to that band as needed to achieve a snug

FIGURE 14: ESCAPE TOWER PLATFORM

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FIGURE 15: INVERT AND TEST-FIT THE ESCAPE TOWER PLATFORM INTO THE TOP OF THE CAPSULE.

fit into the top of the Mercury capsule (see figure 15). If you add additional strips, make sure they are the same width as the one printed with the plans!

Wrap and glue the third strip flush with the end of the escape tower base as with wraps one and two. There will be a noticeable step down between the third and second wraps (see figure 16). At this point, trace the circular platform made by the three wraps onto a piece of scrap cardstock and cut out the circle. Glue that circle to the top of the escape tower platform (again, see figure 16). Add the final (fourth) wrap to the tower platform. This wrap is not flush with the end but centered within the width of the third wrap (see figure 17).

Color the platform top, side and underside (wraps three and four) with a red pen or paint. Glue the platform into position on top of the Mercury capsule (figure 18).

FIGURE 16: BUILD UP THE EDGE OF THE PLATFORM WITH THE THINNER STRIPS OF PAPER AND ADD THE CIRCULAR DISK TO THE TOP.

The escape tower scaffold is a trifold of printed cardstock. Cut out the pattern and score the reverse side of the piece along the indicated lines with a ruler and ballpoint pen. Also score joint for the three tabs top and bottom, again on the back side of the pattern. The scoring allows for crisp folds. Fold the tower and glue with the provided tab (figure 19). Reference the diagram (figure 20) for alignment of the tower, upper tank, capsule, fins and launch lug. Glue the tower to the top of the platform (figure 19).

FIGURE 17: THE ESCAPE TOWER BAND IS ANOTHER THIN STRIP OF PAPER AROUND THE PERIMETER OF THE PLATFORM

The next part of the escape tower is the tank on top of the scaffold. Cut out and glue the tank using a scrap of cardstock for the glue tab. Glue the tank top disk to some scrap foam board, cut it out, and glue it into the top of the tank. Wind and glue the tank base wrap (white) and top wrap (red) around the bottom end of the tank. Trace the bottom of the tank wrap disk onto scrap cardstock and cut out the bottom piece. Glue in place with the red bands oriented as in the alignment diagram. Touch up the red as desired and glue tank onto top of tower so that the two red bands are positioned as in the alignment guide.

FIGURE 18: COLOR THE TOP OF THE CAPSULE PLATFORM RED

The final piece of the tower assembly is adding the nozzles for the escape motors. Cut out the three nozzles, roll and glue with a tab of cardstock. Glue them on each side of the tower with the apex of the cone at the base of the tank (figure

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FIGURE 19: ASSEMBLE THE TOWER

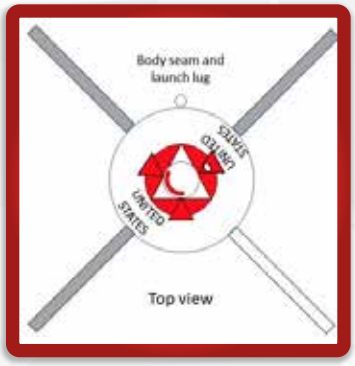

FIGURE 20: ALIGNMENT GUIDE

22). The nozzle with the white circle goes on the tower on the opposite side from the red arcs on the tank.

With that, the capsule is almost finished. The last step is to add the four red wraps around the juncture of the capsule shroud and the reduction adapter shroud. These strips simulate the heat shield on the capsule. Cut out the four strips and wind them in descending order of size (widest to narrowest) to cover the joint between the two shrouds. Each subsequent wrap is centered on the previous one (see figure 23). Touch up any white edges with a red marker or paint.

The fins are easy to build, but here are four tips: 1) Before folding, score with a tool that is small enough to be accurate but doesn't cut. (A jeweler's screwdriver with a slightly rounded tip works great.) 2) Insert a small piece of flat aluminum or a small ruler to provide support inside the fins while gluing on the tabs. 3) Add a wedge of 1/4" foam board at the root edge and make sure it is recessed slightly to allow for the curvature of the body tube for enhanced rigidity (figure 24). 4) And do not force the corners of the seams together but allow them to fit according to their natural fold. Once the fins are complete, glue them to the body at the four tabs. There are faint white triangles on the body tube to show where to glue the fins. Refer to the alignment guide (Figure 20) for placement of the odd white fin. Once the fins are attached, run a thin fillet of white glue along the root edge on each side.

FIGURE 21: ESCAPE TOWER GLUED ONTO TOP OF PLATFORM

Now add the launch lug. Cut out and roll the launch lug around any handy tubular form between 1/8" and 3/16" in diameter. I used a scrap of fiberglass rod here but things like a paint brush handle or small dowel would work just as well. Glue the overlap on the launch lug. When dry, glue the launch lug to the body tube along the body seam, centered roughly in the middle of the body. Make sure the launch

FIGURE 22: COMPLETED TOWER WITH NOZZLES

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FIGURE 23: THE RED HEAT-SHIELD BAND IS ADDED.

lug is parallel to the body tube. Figure 25.

The parachute is attached to an elastic shock cord. 3' of ¼" sewing elastic works well or you can get purpose made latex shock cord from a rocketry supply company (e.g., Apogee part #30330). The shock cord is attached to the rocket body and the capsule assembly. Make the shock cord mounts first. Cut two pieces of scrap cardstock (for shock cord mounts) about 1" x 3" long. Fold them in thirds.

Over time, elastic will degrade and eventually snap. Kevlar is much more durable. Attaching Kevlar to the shock cord mounts allows you to replace the elastic more easily. Take two pieces of Kevlar cord (100 lb is fine, e.g., Apogee part #30325) about 1 foot long and tie loops in each end. Apply glue to the middle third of one of your shock cord mounts and lay one Kevlar loop over the glue. Fold the end of the mount onto the Kevlar loop and press down firmly. Apply glue to the cardstock and fold over again, pressing down firmly. One end of the Kevlar

FIGURE 24: RECESS THE FOAM WEDGE IN THE FIN SO IT WILL EASILY CONFORM TO THE TUBE

FIGURE 25: GLUING ON THE LAUNCH LUG OVER THE BODY SEAM

is now firmly glued inside the shock cord mount and the other end is left free. Do the same for the other mount with the other piece of Kevlar.

FIGURE 26: COMPLETED SHOCK CORD ASSEMBLY

Gently curve one of the shock cord mounts to match the curve of the rocket body, apply glue to one side of the mount and glue it in place about halfway down the inside of the rocket body. Take the other shock cord mount, curve it to match the inside of the inner capsule tube, and z-glue it in place there. Fold a piece of duct tape around the Kevlar where it crosses the front edge of the rocket body (Figure 27). This mitigates the chances

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FIGURE 27: MAKE A SHOCK CORD BUMPER FROM MASKING TAPE

of the Kevlar cutting down through the rocket body ("zippering"). Tie the shock cord between the free loops of each shock cord mount.

To protect the delicate fins, this rocket uses a 16"-18" plastic chute despite the lighter weight. I cut an apex vent in mine to reduce sway during descent and attached the chute with a snap swivel. You can give the model a quick shot of clear coat to protect the paper and improve contrast with the grey areas. With that, your rocket is complete!

Due to the diameter of the rocket body, I use as many as 7 sheets of recovery wadding in my rocket. This model is designed to fly on 18mm Estes black powder motors. For very small fields, I use B6-2. https://www.apogeerockets.com/Rocket_Motors/Estes_Motors/18mm_Motors/Estes_Motors_B6-2. For larger fields, I like C6-3 https://www.apogeerockets.com/Rocket_Motors/Estes_Motors/18mm_Motors/Estes_Motors_C6-3_3-pack. B6-4 has too long a delay and may impact prior to ejection (ask me how I know!). I have not flown this on C6-5 but suspect the lower ballistic coefficient of the rocket would result in ejection well after apogee.

You could also experiment with 18mm composite motors, e.g., C- or D-impulse Q-Jet (https://www.apogeerockets.com/Rocket-Motors/Quest-Motors/Quest-Q-Jet-Composite-Motor-D16-4). The motor will stick out of the motor tube about ¼". Wrap a piece of masking tape around the exposed end of the motor and the motor tube to secure the motor in flight.

I hope you find this a fun and satisfying build. My students have shown that it is well within their capabilities by the end of a semester of building. Given the very modest cost, it's

FIGURE 28: COMPLETED LITTLE JOE ROCKET

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easy to simply re-print a page or two if you want to practice a couple of times on any of the parts.

Option:

Jeff's original plans called for a 24mm motor mount (see unused rings on file little_joe_bulkheads.pdf). The capsule inner tube has a 24mm ID and would serve as a template for the motor tube. This model will fly on Estes D12-5 motors just fine. Jeff Lane suggested it could even be flown on an E9 or E12 motor but this would send it over 1000' and I have not attempted such a flight. Given the light weight, that would likely require a considerable walk to recover it… No nose weight is required if flying on a 24mm D motor but you should check stability (e.g., swing test) if flying an E.

About the Author:

Steve Riegel is a high school chemistry teacher, retired Air Force officer, amateur astronomer, and NAR Level 2 certified rocketeer. When not teaching, he enjoys adding steampunk details to model rockets and turning masses of perfectly fine fabric into tiny snips and shreds on his basement floor. He is a member of the Colorado Springs Rocket Society (COSROCS), NAR Section 515, and the Southern Colorado Rocketeers (SCORE), NAR Section 632. He lives in Colorado Springs with his wife, Jennifer, and dogs Lyra and Loki.

FIGURE 29: THE LITTLE JOE TAKES FLIGHT