

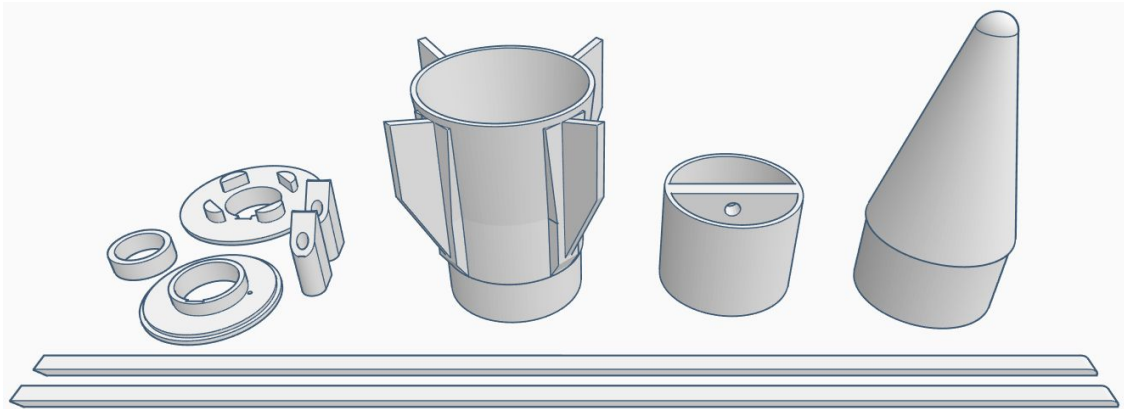
SHAVIT

Builder's Kit Parts List

<u>Quantity</u>	<u>Part</u>
2	Centering Rings (one large, one small)
2	Launch Lugs
1	Fin Unit
1	Motor Block
1	Nose cone
1	Stage Coupler
2	Plastic Conduits
1	Decal Sheet

Parts Needed to Complete

~0.5 ounces	Nose Weight
1	Body Tube, BT-60, 14.125" long (358.8mm)
1	Body Tube, BT-60, 2.7" long (65.6mm)
1	18mm Motor Tube, 3.0" long (76.2mm)
1	Shock Cord, ~36" long (~915mm) elastic
1	Shock Cord, ~28" long (~711mm) Kevlar
1	18" Parachute (457mm)
1	Motor clip (if desired)



BACKGROUND

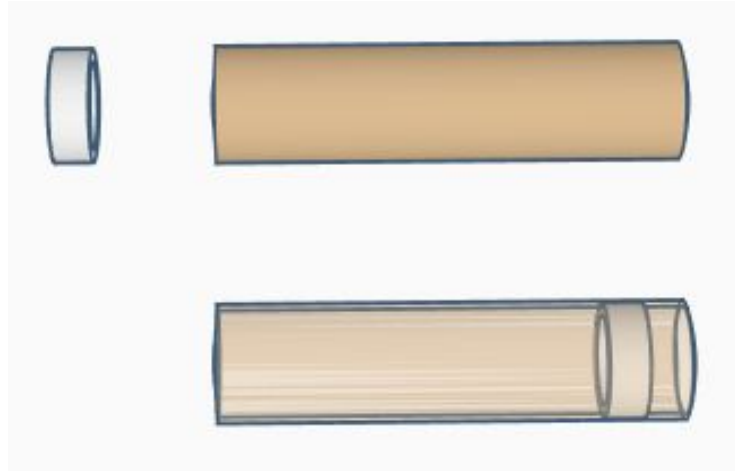
On September 19, 1988, Israel became the 8th country to orbit their own satellite on an indigenous launch vehicle when a Shavit rocket launched the Ofeq-1 satellite from Palmachim Air Base south of Tel Aviv. The Shavit was launched westward over the Mediterranean Sea – a retrograde orbit needed to prevent spent stages from falling on countries potentially hostile to Israel. The Shavit is a three-stage, solid propellant rocket launched from a mobile erector/launcher. According to some reports, the Shavit is based on a two-stage ballistic missile called the Jericho II, though no Jericho II missile has ever been revealed. Shavit is the Hebrew word for Comet, and Ofeq is the Hebrew word for Horizon. Israel has increased the Shavit's performance by adding a stretched first stage (Shavit 1) and then a stretched second stage (Shavit 2). The Shavit 2 is in use today. This kit includes markings for the first Shavit, but provides instructions on how to build the Shavit 1 or Shavit 2.

A unique attribute of every Shavit launcher is the one-piece fairing protecting the satellite during ascent. Most launch vehicles have a payload fairing which splits open in flight. On a Shavit mission, after the second stage burns out and is jettisoned, but before the third stage ignites, the vehicle yaws roughly 20° off course, ejects the fairing forward, then yaws back to the correct course and ignites the third stage motor. This model accurately depicts the one-piece fairing, which is the same length on all Shavit vehicles.

This model was created using photos and drawings of the Shavit available on the internet. Based on reported dimensions (main body diameter of 1.35m), this model is approximately 1:32.5 scale.

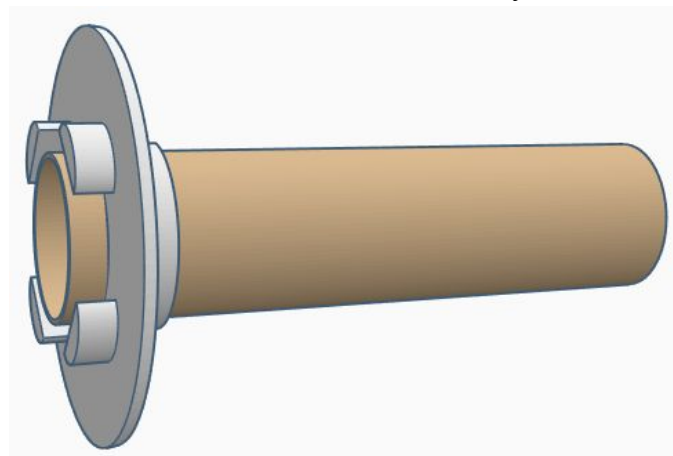
KIT ASSEMBLY

1. Assemble the motor mount/fin can. You'll need an 18mm (BT-20) motor tube 3.0" (76.2mm) long. Note, this motor mount is intended for a "friction fit" of the rocket motor. Mark an expended 18mm motor 1/2" (12.7mm) from one end. Make sure the motor block fits into the tube. Sand as needed to fit. Put a bead of cyanoacrylate (CA) glue ("super glue") roughly 1" (25.4mm) inside one end of the motor tube. Insert the motor block in the other end, then use the expended motor to push the block into the tube, stopping at the 1/2"/12.7mm mark on the motor. Remove the motor quickly.

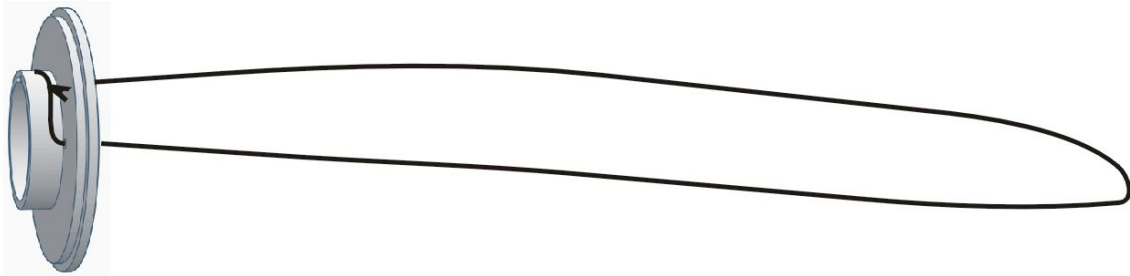


If you want a motor clip (not included), mark the tube 2.25" (57.2mm) from the front end. Cut a narrow slot at this point, and put the forward end of the motor clip in the slot. Secure the clip to the tube in the center of the motor tube with a wrap of 1" (25.4mm) masking tape. Put a bead of glue in the forward end of the tube, just in front of the motor clip. Use an expended motor to push the motor block in until it hits the motor clip. Do NOT install the motor block in the aft end, or no motor will fit!

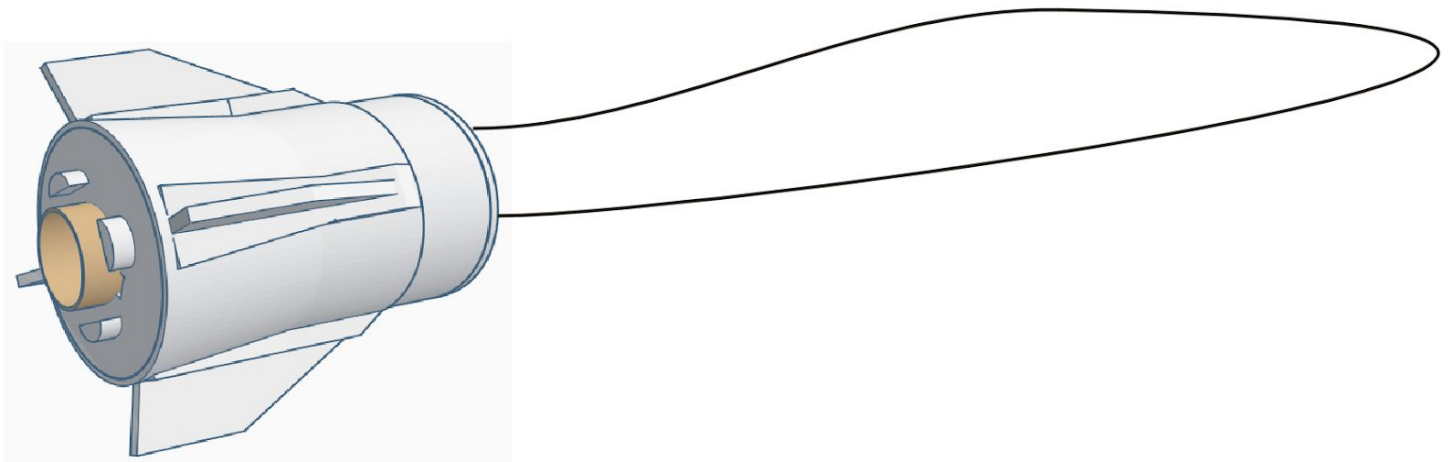
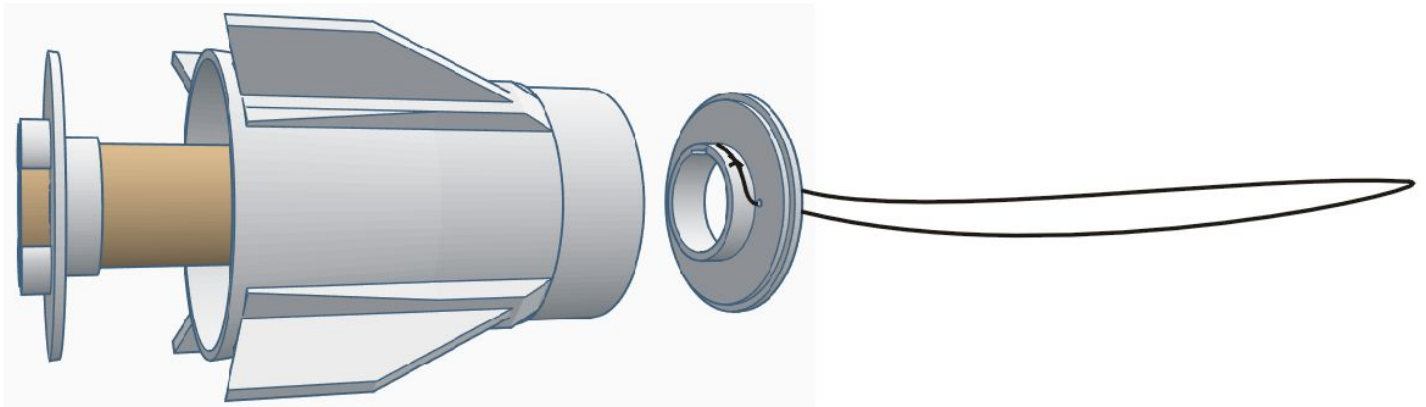
Glue the aft ring to the motor tube, even with the aft end. Allow to dry.



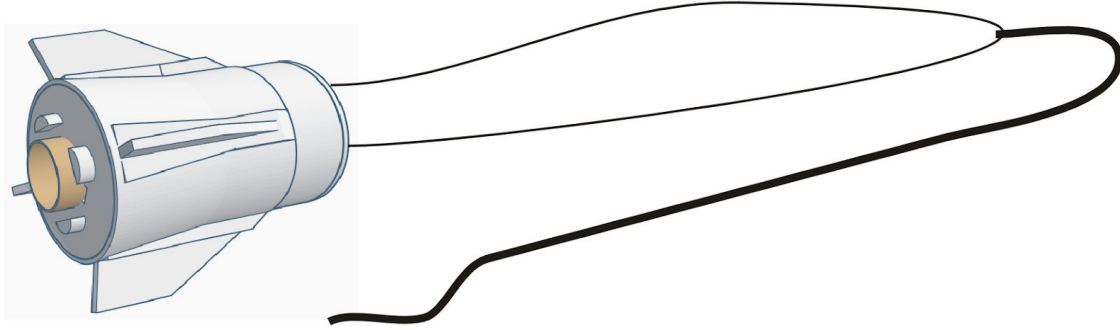
The motor mount is designed to use a Kevlar anchor. 100-pound Kevlar works well. The length should be approximately 28” (711mm). Thread one end of the Kevlar through a hole in the forward centering ring. Tie a double knot or even a triple knot in the Kevlar so it can’t be pulled back through the hole, and use CA to glue it in place. Repeat for the other end of the Kevlar in the other hole on the forward centering ring. Tie a loop in the middle of the Kevlar for attachment of the elastic shock cord in a later step.



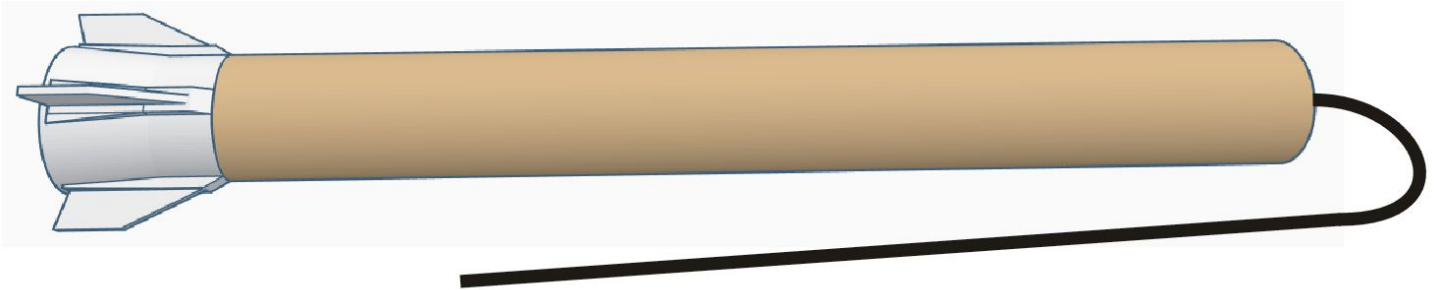
For the next steps, use a SLOW CURE CA glue, to allow time to work with the parts before the glue sets. Put a bead around the aft end of the fin can, then press the motor tube with aft centering ring into the can, stopping when the ring is even with the end of the can. THE FOUR PIECES ON THE AFT END OF THE AFT CENTERING RING (SIMULATED JET VAN BASES) SHOULD BE CENTERED ON THE FOUR FINS. Put a bead of glue into the forward end of the can. Slide the forward centering ring down over the motor tube, and seat the ring into the forward end of the fin can. Allow everything to dry.



Attach an elastic shock cord roughly 36" long (915mm) to the forward loop in the Kevlar shock cord anchor. We prefer 1/4" (6.35mm) braided elastic.

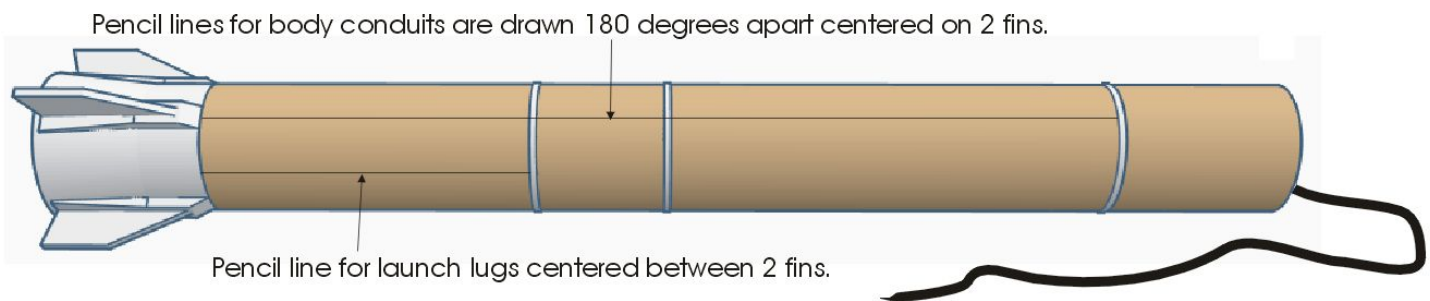


2. Install the fin can. Note, for the Shavit, the body tube length is 14.125" (358.8mm). For the Shavit 1, the tube length is 16 9/16" (420.7mm), and for the Shavit 2 the tube length is 19 7/16" (493.7mm). Test fit the fin can in the body tube. If the fit is too tight, lightly sand until you get the right fit. Apply a generous ring of CA glue inside the main body tube. Drop the shock cord through the tube, then slide the fin can in place. Use putty to hide the can/tube seam. This seam should not be visible.

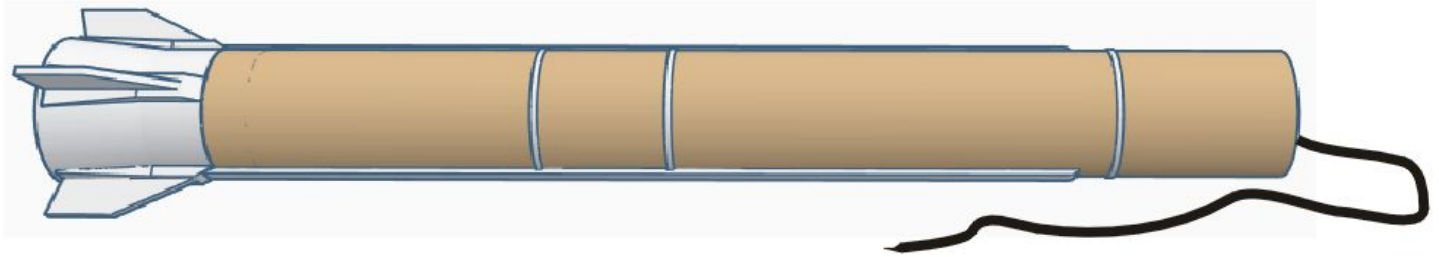


3. Round the fin leading edges. The leading edges of each fin should be rounded. The fin tips and trailing edges remain square.

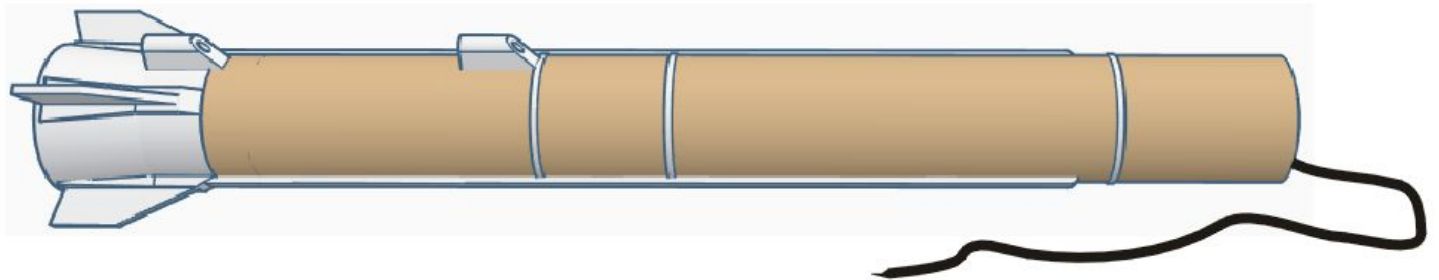
4. Mark the tube and apply tube details. The Shavit has cable raceways/conduits in two locations, 180° apart. Pick two fins on opposite sides, and use a straight edge to draw a line the length of the body tube, in line with the center line of the fin. Also, pick a high point between two fins and draw a line the length of the tube in the location. This line is for the launch lugs which will be attached later. Three bands are applied to the body tube to mark the section of the airframe between the first and second stage motors, and also where the third stage separates from the second stage. You can use 1/16" (1.6mm) striping tape, or cut the bands from cardstock. The first band is applied 4.25" (108.0mm) from the aft end of the body tube (the end where it meets the fin can) if you are building the Shavit. If you are building the Shavit 1 or 2, the band is applied 6 11/16" (168.9mm) from the aft end of the tube. The next band is applied 1.75" (44.5mm) in front of the first band. The final band is applied 2.25" (57.2 mm) from the front end of the tube.



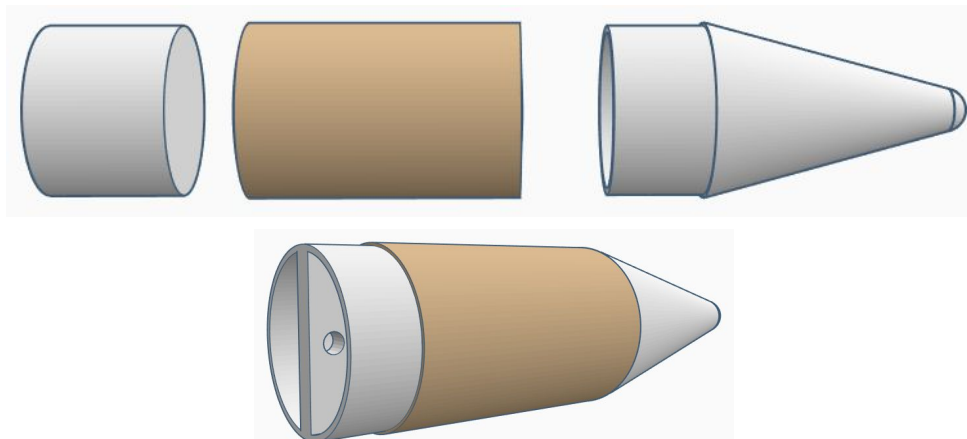
5. Attach the cable conduits. The cable conduits are glued on the lines, aligned with two of the fins, drawn in the last step. One end of each conduit is beveled to match the contour of the fin actuator housing. If you are building the Shavit 1 or 2, you will have to supply your own conduits. Ideally the conduits are 0.2” wide (5.1mm) and 0.08” high (2.0mm). Basswood, balsa, or styrene plastic work well for the conduits. For a Shavit 1 the conduits should be 14” long (355.6mm) and for a Shavit 2 the conduits should be 16 7/8” (428.6mm).



6. Attach the launch lugs. The launch lugs sit towards the aft end of the model so they do not interfere with the decals to be applied later. These instructions apply to all versions of the Shavit. The first launch lug is glued along the line (between two fins) drawn in Step 4, with the aft edge of the launch lug at the point on the fin can where the flared end meets the cylinder. This lug is glued mostly to the plastic can, with just a portion of the lug on the body tube. The second lug is glued to the body tube just behind the first band glued to the body tube in Step 4 (the one furthest aft). Since this band is further forward on the Shavit 1 and Shavit 2, the launch lugs will be further apart on these models, as compared to the Shavit model.

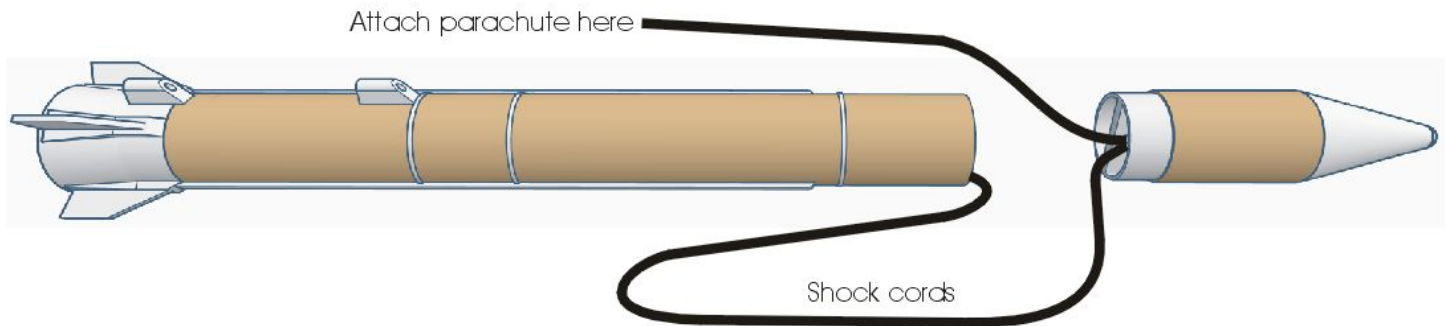


7. Assemble the nose cone. Epoxy weight (approximately ½ ounce) into the tip of the nose cone. Then glue the nose cone into the short length of BT-60, 2.7” (65.6mm) long. The cone and short length of tubing represent the Shavit’s one-piece fairing. Mark the half-way point of the tube coupler length. Apply a generous bead of CA glue into the open end of the short body tube and insert the tube coupler to the mark. **BE SURE TO PUT THE SOLID END INTO THE TUBE.** The open end of the tube coupler has a place to attach the shock cord! Fill the seam between the nose cone and the body tube with putty.



8. Finish the 3D-printed pieces. To finish the 3D-printed pieces, sand all pieces thoroughly, then spray with a sandable, filling primer. Sand the primer, then repeat the process at least once more. After two rounds of primer and sanding, the grooves from the 3D printing should all but disappear. If the grooves are still visible, apply a third coat of filling primer and sand again! Once the finish of the model is satisfactory, paint the entire model gloss white. Allow the paint to dry thoroughly. Next, paint the fins and “jet vane bases” on the aft end of the model black.

9. Final assembly. Use a 18” (457mm) parachute for your model. Run a roughly 6” (152mm) length of Kevlar or elastic through the attach point on the tube coupler, then knot the other ends to form a loop. Attach the parachute and the elastic shock cord attached to the rocket body to the Kevlar loop.



9. Decals. The decals are printed on clear decal film. Cut closely to the marking to minimize the clear film around it. The “IAI” decal is centered on the cylindrical portion of the fairing (short section of BT-60). The first blue stripe is 0.7” (17.8mm) from the front edge of the tube. The second strip is 0.9” (22.9mm) aft of the first stripe. The Star of David markings should be aligned with the fins without conduits, centered between the stripes. The fourth blue stripe is applied ¼” (6.4mm) in front of the upper body tube band marking the Stage 1/Stage 2 interstage. Note, the bands do NOT go over the conduits, they stop at the conduit, so the bands should be carefully cut to length. The second band is 0.9” behind the first (22.9mm), and again the Star of David markings are centered between the stripes, aligned with the fins without conduits. The “ISA” markings, for Israeli Space Agency, are applied forward of the aft set of blue stripes/Star of David markings. The “A” marking should be 7/16” (11.1mm) in front of the stripe. The “S” is 1.25” (31.8mm) forward of the “A” and the “I” is 1.25” (31.8mm) in front of the “S.” Be sure the letters align with the fins and Stars of David.

After the decals are applied, allow them to dry completely. Then apply a coat of clear, semi-gloss paint to seal the decals.

10. Flying. Unless you added a motor clip, the motor must be “friction-fitted” in the model. Wrap tape around the motor and insert into the motor mount. The motor should be snug (so it won’t be ejected) but not so tight you won’t be able to remove it later. A C6-3 or C5-3 are the recommended motors for the first flight. A C12-4 can be used for better performance. We haven’t tested larger (18mm “D”) motors, so try larger motors at your own risk!

