

# **PEAK<sub>OF</sub> FLIGHT**

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**NEWSLETTER**

ISSUE 524 / JUNE 23RD 2020

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***THE DSP FLYING MODEL  
ROCKET***



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## The DSP Flying Model Rocket

By Steve Riegel

### Introduction

In 1995, I was assigned as a newly minted second lieutenant to the Space Based Infrared System Program Office at Los Angeles AFB, CA. That office managed the contracts to procure missile warning satellites for the United States Air Force. At the time, the current system was called the Defense Support Program (DSP) (Figure 1). The rotating satellite had a cylindrical body, four large solar arrays splayed out behind it, and a long, conical sunshade for the primary infrared sensor. The spin of the satellite swept the sensor around the disk of the Earth continuously to scan for the heat of a missile launch. The last DSP launched in 2007.



**FIGURE 1: DEFENSE SUPPORT PROGRAM (DSP) SATELLITE. ARTIST RENDITION ON ON-ORBIT CONFIGURATION. IMAGE**

**SOURCE:** [https://en.wikipedia.org/wiki/Defense\\_Support\\_Program#/media/File:DSP\\_Phase3.jpg](https://en.wikipedia.org/wiki/Defense_Support_Program#/media/File:DSP_Phase3.jpg)

Fast forward to 2014. I had just retired from the Air Force, moved to Colorado Springs, and rediscovered my childhood hobby of model rocketry. Very soon after, I began to dream of someday building a DSP model to fly and recover shuttlecock style. However, it took another six years before I got around to building a working prototype... I always envisioned the model recovering by spinning down

gently on the four solar arrays. To achieve that, I knew it would have to be light. Having built a cardstock version of the Little Joe I (<https://www.apogeerockets.com/education/downloads/Newsletter511.pdf>), I felt I finally had the construction skills to tackle the project.

The finer details are my best interpretation of available photos of the satellite and models. These did not always agree so I used artistic license where needed. One significant deviation from the real satellite is the lack of tilt on the telescope sunshade. The telescope is canted off axis so that the spin of the spacecraft sweeps a linear sensor that extends from the nadir (center of Earth's disk) to the edge of the Earth's disk. On my model, this would have introduced some odd beveled cuts and, more importantly, compromised the durability for the angled cone hitting the ground. For these reasons, I simplified the design with a straight-through telescope assembly. While I did my best to keep dimensions approximately to scale, this is very much a sport scale model.

Lacking a CAD software package, but having accrued decades of Microsoft Office use, I designed the entire model (except the conical sunshade at the top) using geometrical objects in Microsoft Word. I made the sunshade using the transition generator at <http://www.delorie.com/rockets/transitions.html>. Most of the effort was rotating and aligning the various pieces, first individually and later as groups of objects. Piece by piece, the design came together. I did a lot of "rapid prototyping" (i.e., print, cut, try again) to test various designs, refine them, and move to the next element.

The finished model is based around a core BT-20 18mm motor tube. This provides a structure to align the various pieces and has enough rigidity to withstand the nose-first impact upon landing. Most of the model is made from 110 lb cardstock with a few bits of foamcore board and some bamboos skewers for the solar array struts. To help keep the weight down, I opted to let the motor kick out the back with a streamer. Other materials include a razor knife with a fine tip, metal straight edge to cut against, scoring tool (dead ball point pen works well), white glue, various thicknesses of CA glue, a foot or so of Kevlar thread, and a 1" wide streamer about a foot long.

### Assembly

Assembly can be broken down into four major subcomponents: main body, solar panels, sensor stack, and detail

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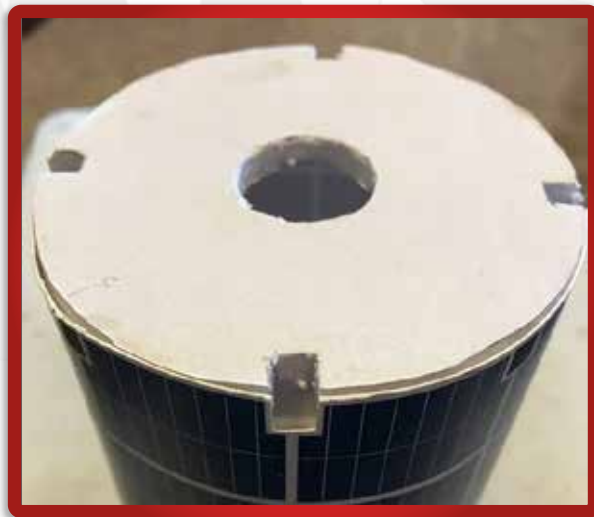
## The DSP Flying Model Rocket

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bits. To start construction, print out the four pages of the plan on 110 lb cardstock (you could also use Bristol board which is a little heavier), printing the solar panel page twice.

Start by cutting a 9 3/4" long piece of BT-20. This is a smidge longer than needed but allows for some margin of error in cutting and folding the various pieces. Next, cut out the main body wrap. Cut out the four crosshatched squares on the bottom edge of the body. These will allow the solar panel support struts to protrude out of the rocket. Cut out the body glue tab, apply glue to one half of the strip, and glue it to the short edge of the body wrap. When the glue is dry, gently curl the body wrap to preform it and reduce stress on the joint. Apply glue to the other half of the glue strip and carefully glue the ends of the wrap together to form a cylinder 3" across and about 4 1/4" high.

Cut out the two 3" circles, including the central holes, and glue them to foamcore. When dry, cut out the disks from the foamcore. These are the centering rings to support the central tube and give form to the body wrap. Test fit the centering rings in the body wrap. If needed, sand to fit or wind and glue strips of scrap cardstock around the ring. It should fit inside the body wrap without gapping but should not require force to slide the ring into the body. The black ring is the forward one (on the body edge with the four yellow rectangles). The grey ring is the aft ring (on the edge with the four notches cut out).



**FIGURE 2: AFT CENTERING RING SHOWING LOCATION OF NOTCHES FOR FIN SPARS.**

Slide the aft ring into position (don't glue it yet!!) and mark the positions of the four notches in the body wrap on the centering ring. I also mark the position of the body wrap seam so I can align the notches correctly. Remove the ring and cut square notches in the edge of the ring as deep as they are wide (about 3/16") (Figure 2). Wrap a strip of paper around the BT-20 and mark the overlap point. Divide its length into quarters and mark the motor tube. Extend the four marks along the length of the tube. Apply glue to one end of the motor tube and insert it into the aft centering ring so that the four lines are centered on the four notches you cut earlier. Square up the centering ring flush on the end of the motor tube and let dry. Apply a glue fillet around the motor tube where it meets the ring.

Before we glue the body wrap in place, we need to build and install the four solar arrays. Cut out the four panels around the perimeter. Score along the tab fold lines and on either side of the thin yellow strips at the tabs and in the

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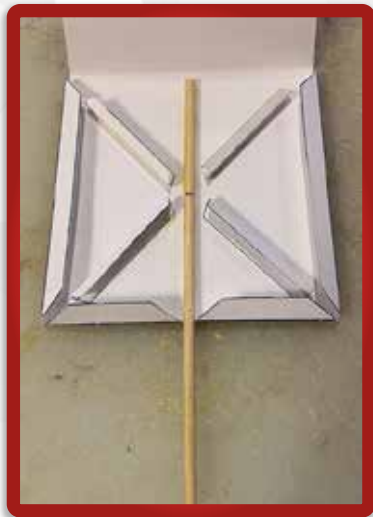


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## The DSP Flying Model Rocket

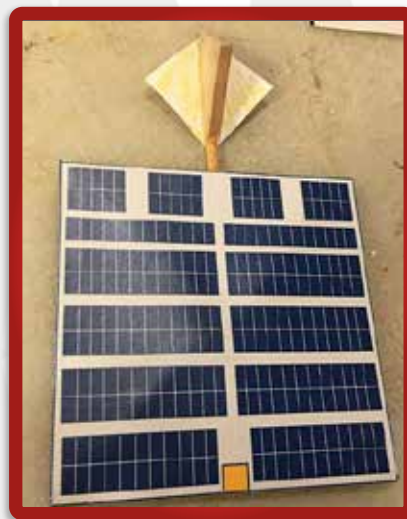
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center. The two fin halves fold together like a pizza box with the yellow strips on the perimeter. Cut four lengths of bamboo skewers (approximately 1/8" diameter) 4-11/16" long. You may wish to paint the exposed portions of the strut black (between about 3" and 3 1/2" from one end) although I left mine natural. Glue the spar inside the fin box so that one end is flush with the fold and the other end protrudes through the gap in the glue tabs opposite the hinge. Mark the strut approximately 1 1/2" from the inner end (roughly the center of the panel). Cut out the four spacers for each solar panel, score on the lines and fold to make a channel. Apply glue to one tab on the spacer and glue it on the line from the corner of the panel to the center point. The support will not fully span the distance. Do this for all four supports (Figure 3).



**FIGURE 3: INTERIOR OF FOUR SOLAR PANEL ASSEMBLIES.**

Apply glue to the tops of all tabs and along the top of the central spar and secure the top flap into position, taking care to press it gently along the spar and the four supports. Repeat for the other three solar panels.



**FIGURE 4: GLUING THE FIN SUPPORT.**

Cut out the triangular internal fin brace template and cut four pieces of 1/8" balsa, noting the grain direction on the template. Cut out the four fin root reinforcement tabs and gently preform around a skewer to give a curved hinge line and two flat triangular flaps.

Cut out the 3 degree fin angle guide. This will be used to give the fin roots slight cant that will cause the finished model to spin in flight. Apply glue along the inside of the hinge line and inside the two side flaps of one of the fin root reinforcement tabs. Lay the exposed panel spar into the hinge line so that it is flush with one end of the hinge. Apply glue to the long edge of the balsa fin brace and lay that on top of the spar, flush with the end (Figure 4). Smooth the two side flaps to secure the fin brace and spar. Before the glue has set, use the fin angle guide to gently tip the fin brace assembly to one side (Figure 5). If the flat-lying panel is toward you and the fin brace is pointing away from you, the fin brace should lay over to the right. Allow the fin root to dry. Repeat assembly for the remaining solar panels.

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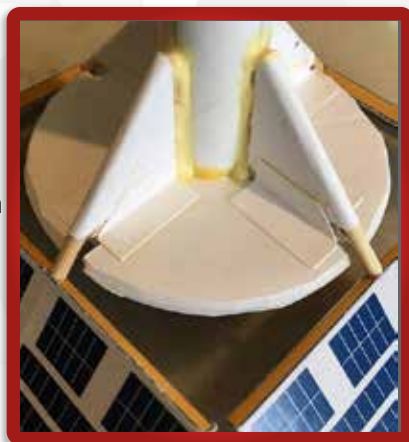
## The DSP Flying Model Rocket

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**FIGURE 5: TILTING THE FIN SUPPORT TO 3 DEGREES. NOTE THE DIRECTION OF THE TILT.**

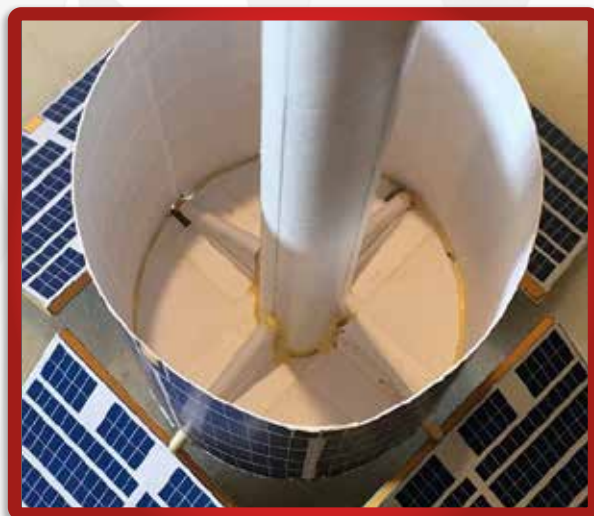
When viewed from the rear edge, the panel should be tilted slightly to the left relative to the body. Glue in the remaining panels. When dry, cut small internal fillets of scrap cardstock and reinforce the joints along the centering ring (Figure 6).



**FIGURE 6: GLUING THE FINS TO THE MOTOR TUBE AND AFT CENTERING RING.**

When the fin brace assemblies are dry, it's time to glue the fins into the body. Apply glue along the two shorter edges of the fin brace and glue it to the rear centering ring and body tube using the vertical lines to help position the fin brace. Check that you have a slight tilt in the solar panel.

Test fit the body wrap to ensure it slides into position on the rear centering ring. The four solar panels struts should extend through the notches in the body wrap and the rear edge of the wrap should be flush with the centering ring. Apply glue inside the body wrap and glue into position (Figure 7). Let dry. When the rear joint is dry, test fit the forward centering ring and then glue it into position (Figure 8). This completes the main body and solar panel assembly.



**FIGURE 7: GLUING THE BODY WRAP TO THE AFT CENTERING RING.**

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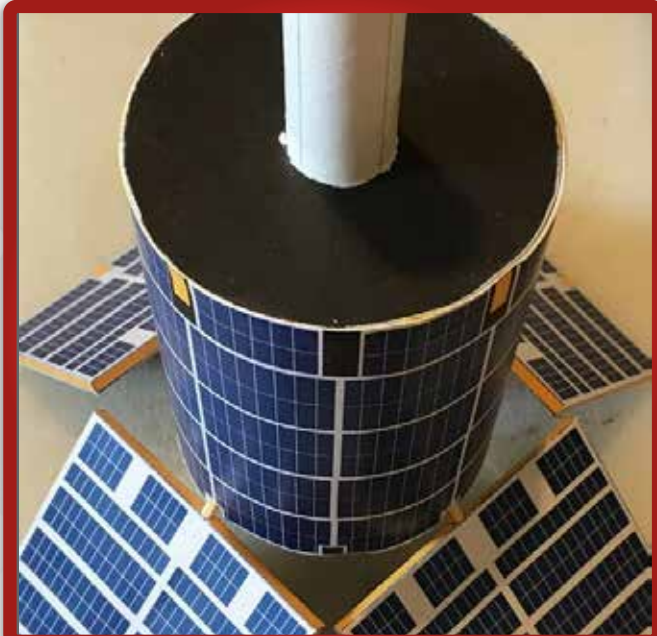




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**FIGURE 8: FORWARD CENTERING RING.**

The sensor stack consists of six major pieces. Start with the gold and silver lower platform. Cut it out around the perimeter, taking care not to cut off the glue tabs. Cut the short inner edge of the glue tab free from the neighboring panel section. Score the fold lines for all glue tabs and at the joint between the gold side panels and the silver top. Cut out the two small rectangles on the indicated side panels. These are where you will install the two “dish antenna” support arms. Glue the side panels together to form an octagon (Figure 9).



**FIGURE 9: BASE OF THE SENSOR STACK.**



**FIGURE 10: SCORE LINE LOCATIONS ON REVERSE OF DISH ANTENNA SUPPORT ARMS.**

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**FIGURE 11: DISH ANTENNA SUPPORTS GLUED TO GOLD PLATFORM.**

(top of arm) flanked by two wedges (sides). One wedge has the bottom flap attached; the other wedge has the glue tab for the bottom. Glue the bottom flap and narrow end flaps in place to form a tube. Poke the glue tabs of the wider end through the two rectangular holes on the side of the lower platform. Apply glue and fold the tabs along the inside of the platform structure (Figure 11). Take scrap cardstock and apply a patch on the inside of the platform over the hole and glue tabs to reinforce that area (Figure 12). Apply glue to the bottom tabs of the platform and slide it onto the BT-20 tube. Align the large vertical yellow bar on the platform side with one of the yellow rectangles at the top of the body wrap (Figure 13).

Cut out the two gold "support arms" for the dish antennas. Score on a line between the notches of the glue tabs and where the glue tabs bend over (Figure 10). You'll have a skinny rectangle

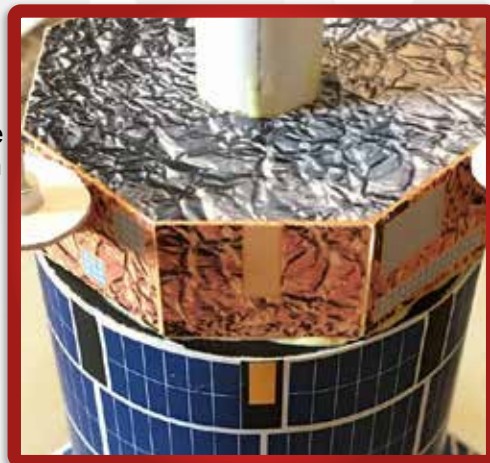


**FIGURE 12: REINFORCEMENTS OVER DISH ANTENNA SUPPORT ARMS.**

body wrap seam (Figure 13. See also Figure 22).

Next cut out, score between the segments and join the sides of the middle platform. When the glue is dry, paint the sides with chrome silver for a mirror appearance. Slide it down the motor tube and glue to

Looking down from the top, I started at the body seam and chose the second yellow rectangle moving counter-clockwise around the wrap. This puts the side of the gold platform with two vertical orange rectangles over the



**FIGURE 13: ALIGN THE YELLOW RECTANGLE ON THE GOLD PLATFORM SIDE WITH ONE OF THE YELLOW RECTANGLES ON THE BODY WRAP.**

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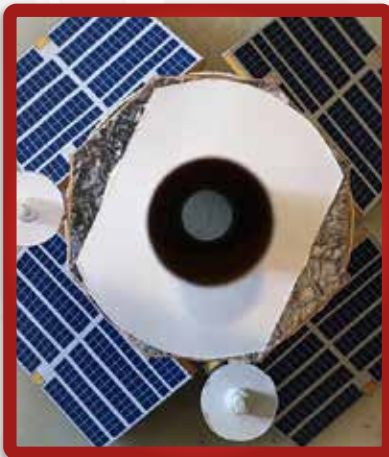
the top of the lower platform so that a vertical seam aligns with the corner seams of the lower platform (Figure 14).

Cut out the three ovals for the forward radiator, including the central holes, and laminate them together. Glue the radiator to the top of the middle platform. As you sight down the motor tube from the front, the long axis of the oval will be aimed left of the yellow rectangle on the lower platform (Figure 15).



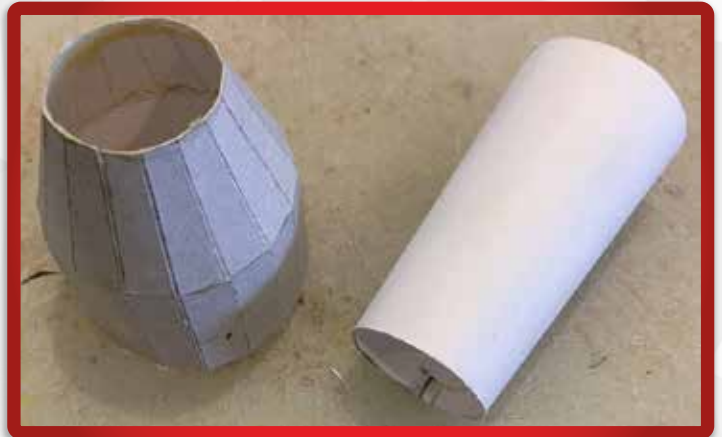
**FIGURE 14: INSTALLING THE SILVER MIDDLE PLATFORM.**

The segmented lower portion of the telescope is built in two pieces. Cut out both and score along the segment lines. Glue the ends with a tab made from scrap cardstock. Gently fold the tabs inward on one side of the lower ring and glue the conical top in place, aligning the segments. Cut out and glue the sunshade



**FIGURE 15: ALIGNING THE FORWARD RADIATOR.**

with a tab of scrap cardstock (Figure 16). I recommend cutting the sunshade a smidge wide and trimming to fit the narrow end to the BT-20 tube. You need to allow for the thickness of the glue tab inside the shade so the shroud needs to be a bit wider than true BT-20 size.



**FIGURE 16: TELESCOPE SHADE ASSEMBLIES**

You need to support the top edge of the conical sunshade to protect it from impact forces on landing. Cut three or four strips of cardstock 1/8" wide. Using the BT-20 as a mandrel (don't glue it to the BT-20!), start winding and gluing a centering ring that will slide over the BT-20 and fit snugly into the top of the conical shade. When the ring is ready, glue it flush to the end of the shade.

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**FIGURE 17: ASSEMBLED TELESCOPE SHADE. CUT OFF THE EXCESS BT-20 AT THE TOP.**

out the end of the telescope shade (Figure 17). I aligned the seam in the telescope shade with the seam in the body wrap since that is the side on which I placed the launch lugs. Using a razor knife, cut off the excess BT-20. Apply thin CA to the centering ring/BT-20 joint.

To provide enough back pressure to eject the motor casing, you need to add a plug to the BT-20 tube. Cut a 1" segment of an 18 mm casing and glue a disk of 1/8" balsa to one end (Figure 18). The balsa end is inserted first. Smear the balsa with wood glue to give some flame resistance and glue the plug flush with the end of the telescope

Paint the telescope assembly chrome silver. Apply some glue to the BT-20 about 2.5" above the forward radiator and to the bottom tabs on the segmented lower part of the telescope assembly. Slide the segmented assembly down the BT-20 so that the segments of the telescope assembly align with the segments of the middle support platform. Follow this with the sunshade. The BT-20 will protrude



**FIGURE 18: PLUG FOR BODY TUBE.**

Cut out the six white disks for the dish antennas and make two stacks of three layers. Cut two pieces of bamboo skewer or dowel 3/8" long. Wind three inches of 1/8" cardstock around one end of each piece to make a roughly 3/16" diameter base. Glue these, card ring down, in the center of the dish antenna. Paint the dowels white. Glue the antennas to the support arms on the gold lower section so that the disk is about 1/16" from the edge of the gold platform. Glue the small gold and white rectangles as fillets between the underside of the dish and the gold support arm (Figure 19).



**FIGURE 19: INSTALLING THE ADDITIONAL BRACES ON THE DISH ANTENNAS.**

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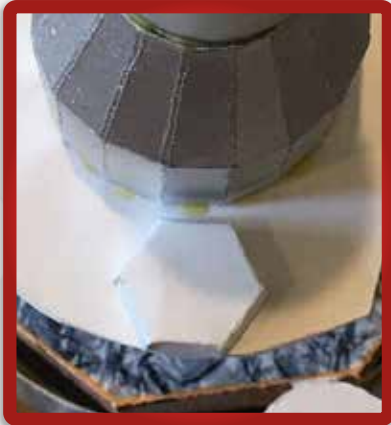


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**FIGURE 20: HEXAGONAL SENSOR PLATFORM ON FORWARD RADIATOR. IT IS FLUSH TO THE OUTER EDGE OF THE RADIATOR.**

cone is placed on the table so that the edge of the cone just touches the segmented silver telescope. Apply a drop of CA glue to the contact point; white glue works for the base of the cone. The other three cones form a triangle. I arranged the three cones wide end down and used a drop of glue to attach the wide ends together in a triangle. When dry, glue to the forward radiator where indicated. One cone just touches the silver telescope assembly. Apply a drop of CA glue to the contact point and use white glue at the base of each cone (Figure 21).

The final detail is the hexagonal star sensor (Figure 22). Cut it out and score the fold lines. Glue it into a hexagonal cone with an internal tab. Paint the inside of the sensor flat black. The opening of the sensor should be over the black square on the side of the gold lower platform with the edge of the sensor flush with the top edge of the platform.

Cut out the four white cones for the auxiliary sensors. Roll and glue with an internal tab of scrap paper (easier to form than cardstock on this scale). Cut out and glue the hexagonal "table" for one of the white cones. Glue it where indicated in Figure 20. Paint the inner surface of each cone flat black. One

The base of the sensor attaches one panel offset to the left of going straight back. You'll need to eyeball and cut the end of the cone at an angle so that it is the right length and mates up to the side of the silver middle platform. Glue the cone in place.



**FIGURE 21: INSTALLING THE AUXILIARY SENSOR CONES. THE EDGE OF THE CONE(S) JUST TOUCHES THE SILVER TELESCOPE ASSEMBLY.**

Attach two short pieces of black 1/8" launch lug to the top and bottom edges of the body wrap, centering them between the fins on the black rectangles on the body edges (Figure 23).



**FIGURE 22: STAR SHADE. CUT THE POINT OFF THE CONE TO FIT AGAINST THE INDICATED SILVER PANEL.**

The final construction piece is to build the motor collar to attach a streamer to the ejected motor (Figure 24). Cut the three pieces (same shape as the forward radiator) and laminate

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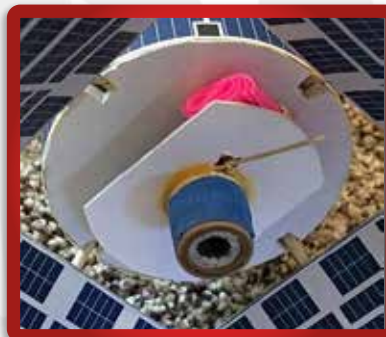
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**FIGURE 23: INSTALLING THE LAUNCH LUGS.**

together. Cut a small notch on the edge of the hole. Cut a 5/8" piece of BT-20 and glue it into the collar so that 1/8" sticks through the collar, adding a good glue fillet around the joint. Tie a piece of Kevlar thread about a foot long to the longer side of the BT-20 ring and pass it through the notch. Apply a dab of glue to secure the Kevlar in place. Tape a 1" streamer about a foot long to the end of the Kevlar thread

To prepare the model for flight, insert the motor into the streamer collar so that the nozzle end sticks out of the BT-20 about 1/4". Tape the motor in place with masking tape. Fold and roll the streamer, wrapping the excess Kevlar thread around the streamer until the streamer is just touch-



**FIGURE 24: MOTOR COLLAR AND STREAMER IN LAUNCH CONFIGURATION. THE MOTOR APPLIES PRESSURE TO HOLD THE STREAMER IN PLACE UNTIL MOTOR EJECTION.**

25), pinning the folded streamer between the collar and the rear bulkhead of the rocket. By rolling the streamer in the excess Kevlar, you will prevent the streamer from being flung outward as the rocket spins on ascent.

I tested this model on both B6 and C6 motors. The B6 flight went less than 100' (estimated) while the C6 was under 200'. Suffice it to say, you're not going to overfly your field! Due to the high drag of this model, booster motors (-0) are appropriate. The motor burn-through will produce enough back pressure to eject the motor even without



**FIGURE 25: MOTOR COLLAR RESTING ON A CLOTHES PIN FOR LAUNCH.**

ing the motor casing. You do not need to friction fit the motor casing as you want it to eject (it should be loose!). To keep the motor in the rocket on the launch pad, rest the motor collar on a clothes pin attached to the launch rod (Figure



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an ejection charge. If you did use a non-booster motor, I would not fly longer than a B6-2 or C6-3 due to the amount of drag (Figure 26, 27).



**FIGURE 26 & 27: LAUNCH AND RECOVERY. THE ROCKET NATURALLY GOES NOSE DOWNWARD AND SPINS DOWN TO A SAFE LANDING.**

The finished model makes a great static display in addition to being a fun small field flier (Figure 28, 29). I hope you enjoy building and flying this cool piece of our Air Force history.

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**FIGURE 28 & 29: THE FINISHED MODEL ROCKET**



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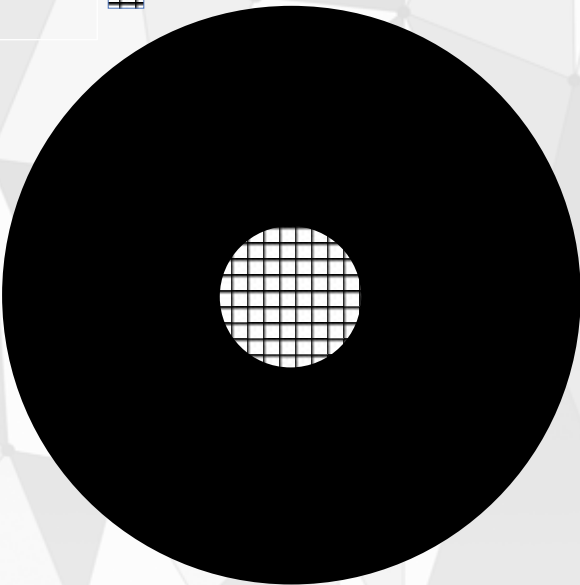
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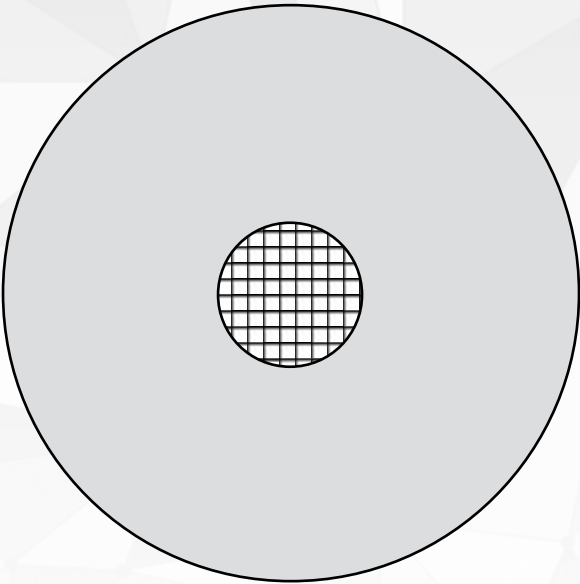




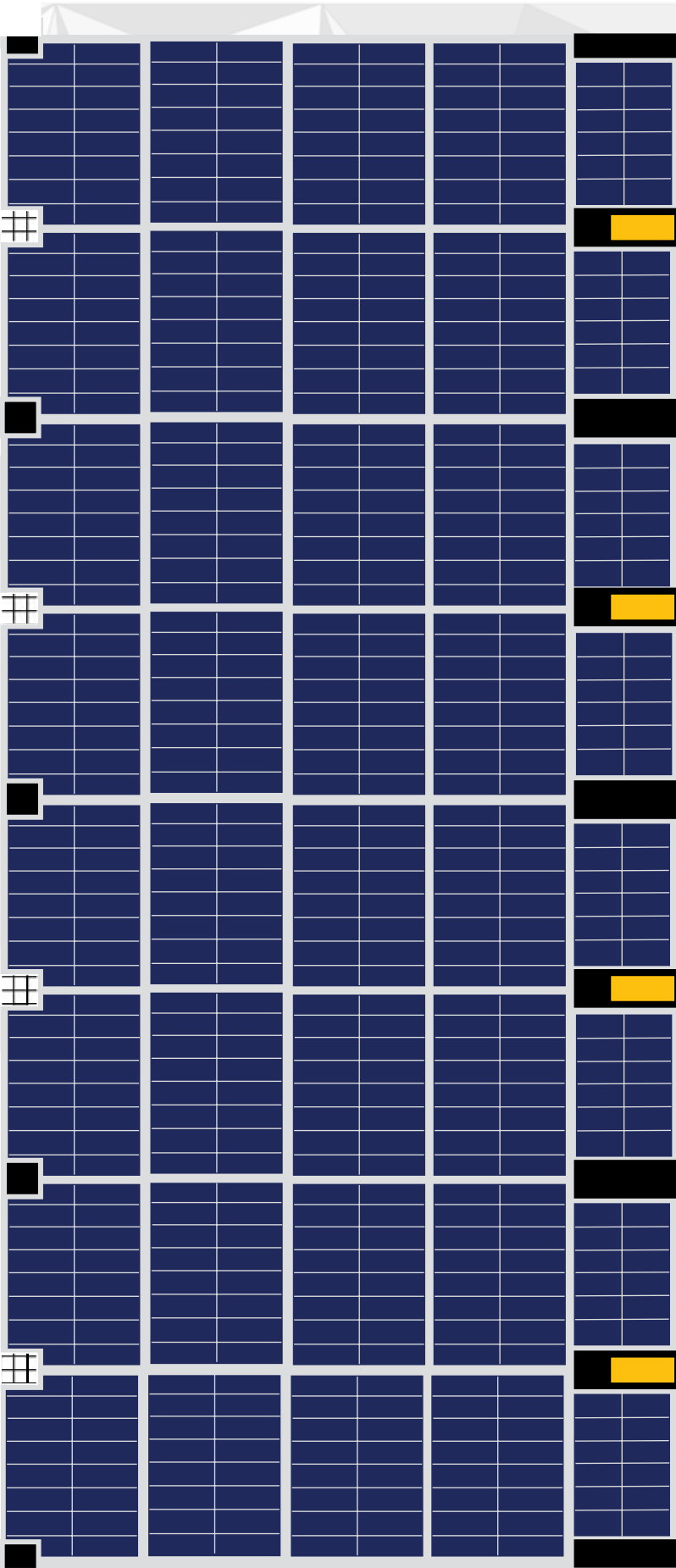
Cut out



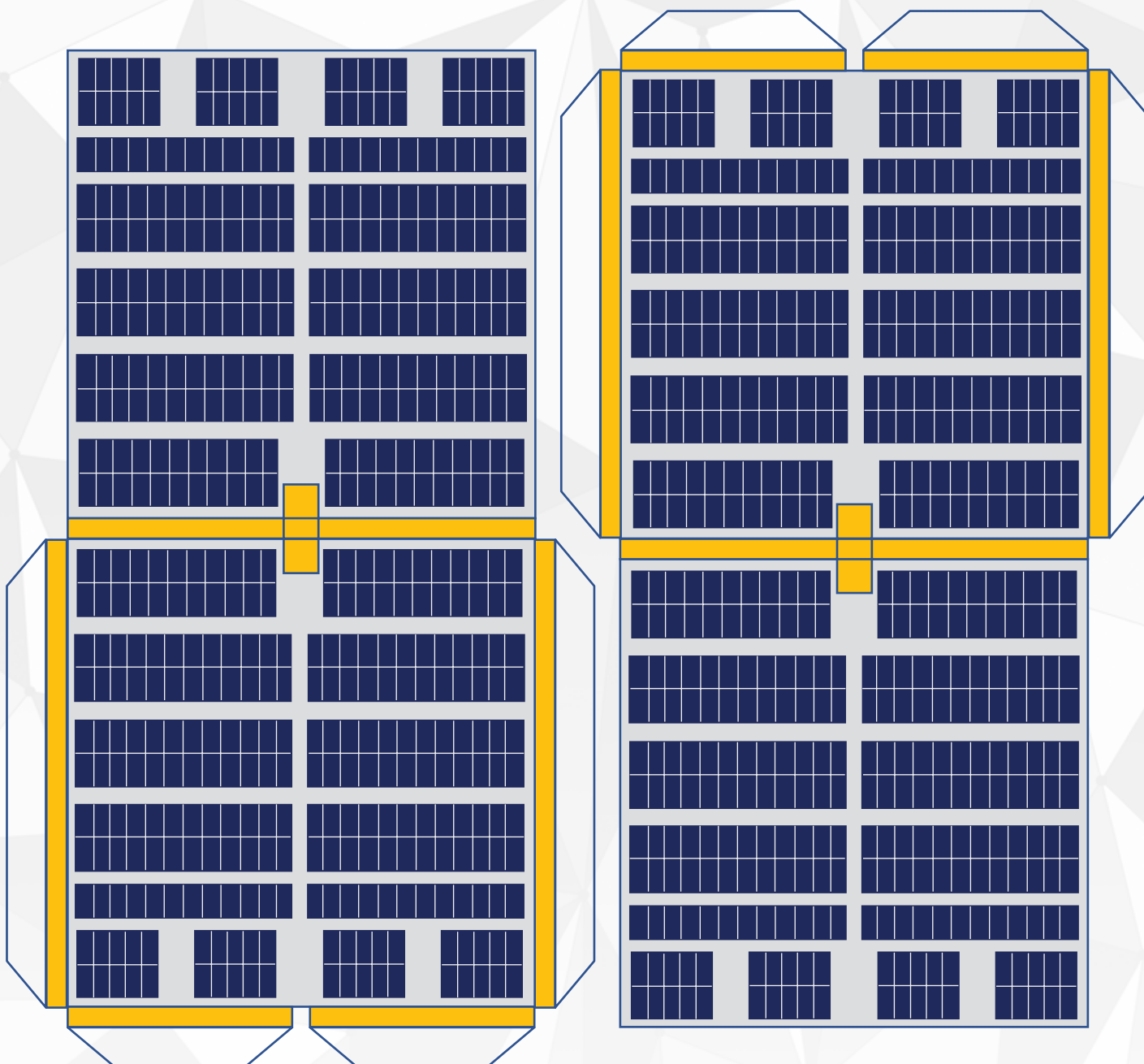
Main body top



Main body bottom



Body seam tab.



Fin root reinforcement



Fin internal rib



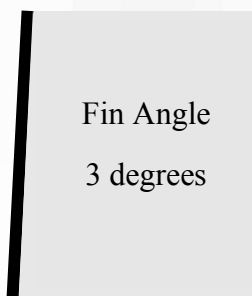
Fin internal rib



Fin internal rib



Fin internal rib



Fin Angle  
3 degrees



Fin internal rib



Fin internal rib



Fin internal rib

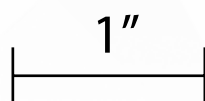


Fin internal rib



Fin root reinforcement

Print this page 2x.



Internal fin brace. Cut 1 per fin from 1/8" balsa. Note grain direction.



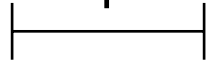
Cut out



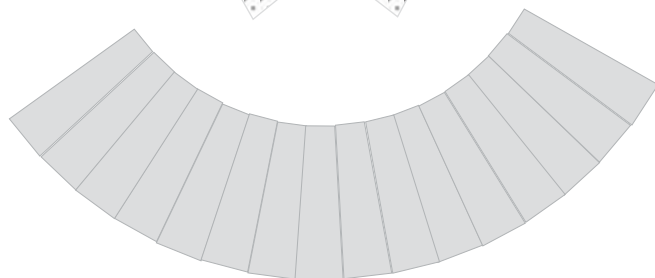
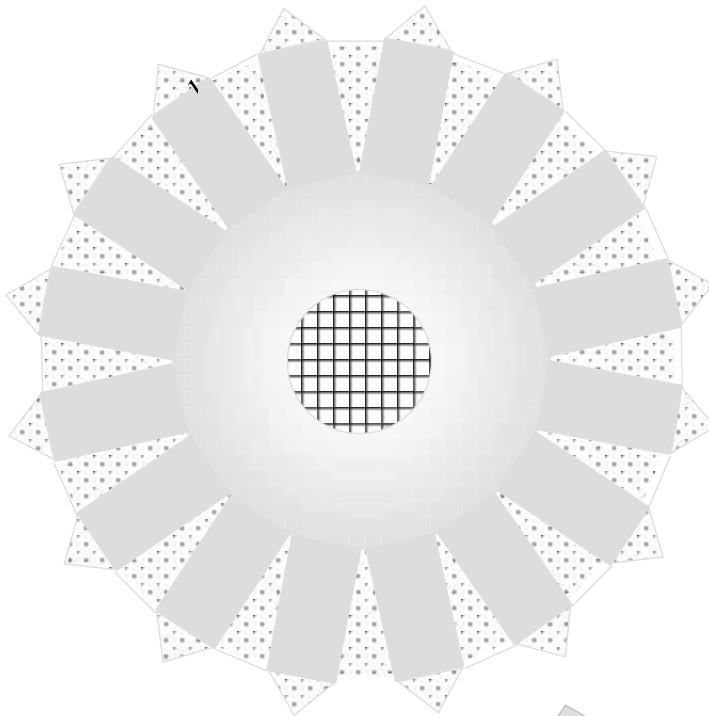
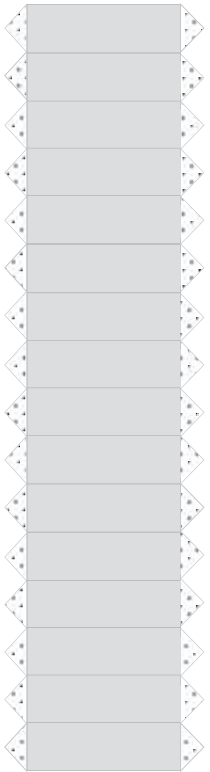
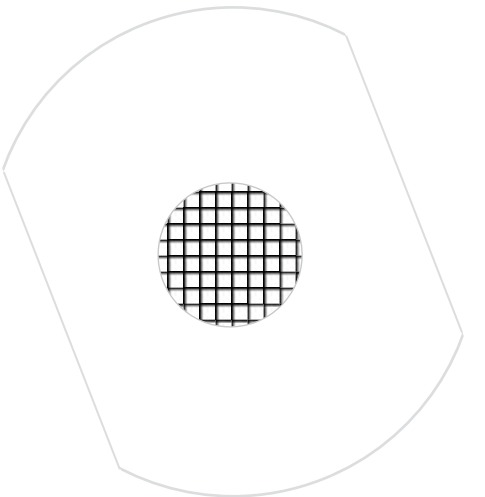
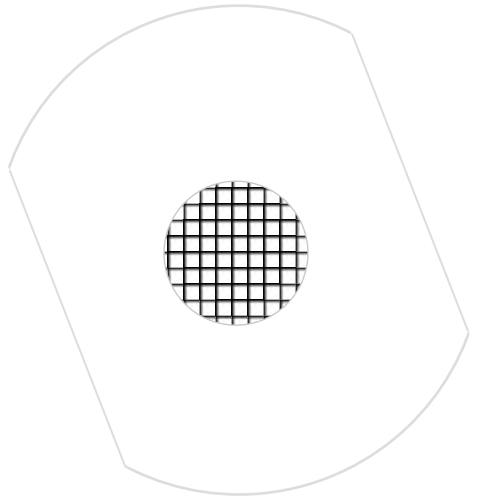
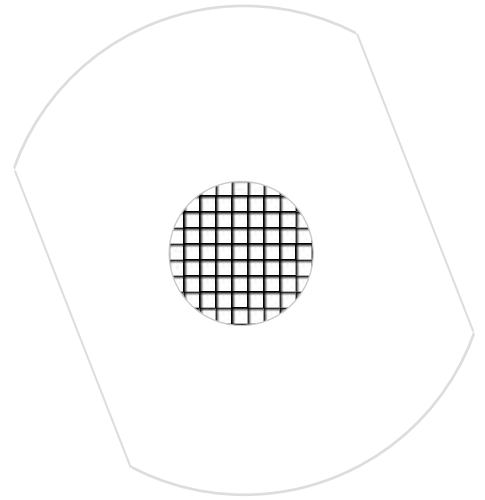
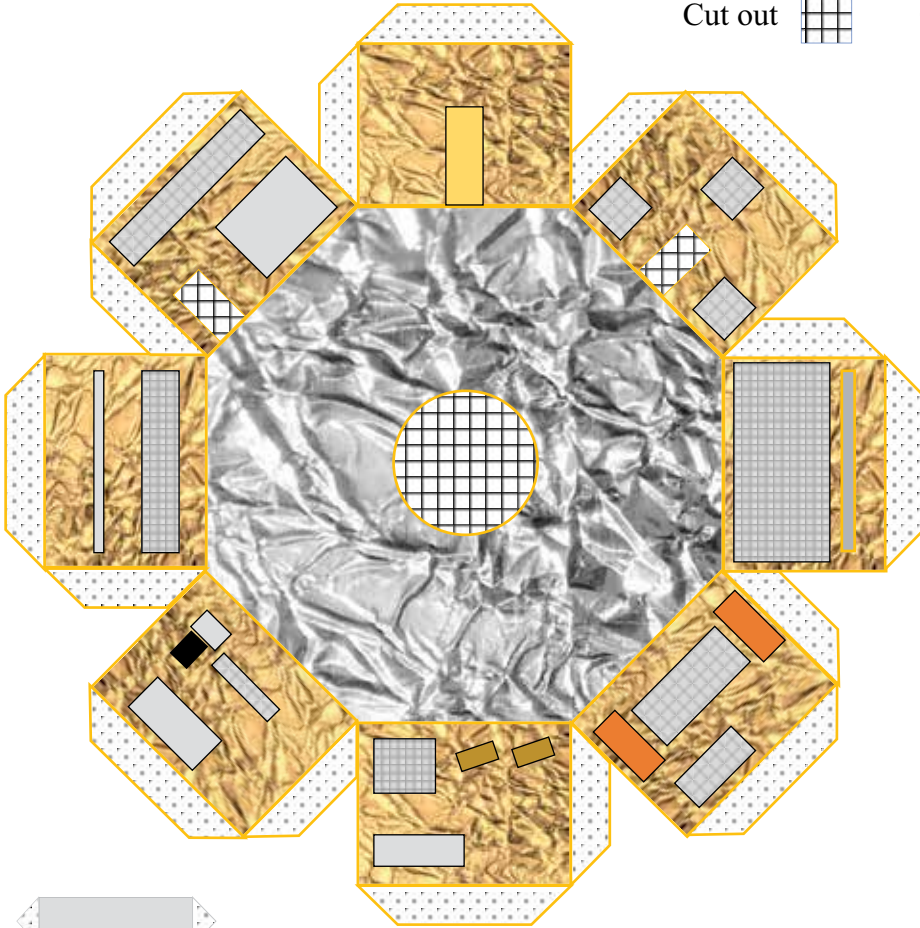
Glue tabs

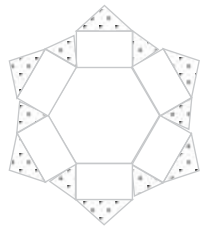



1"



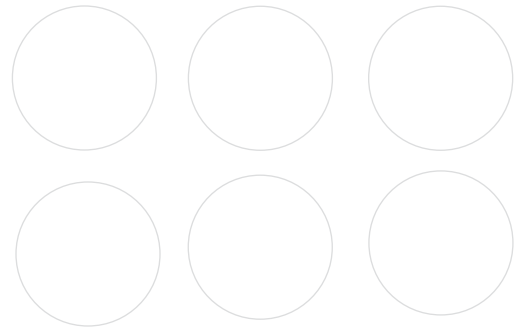
Forward Radiator





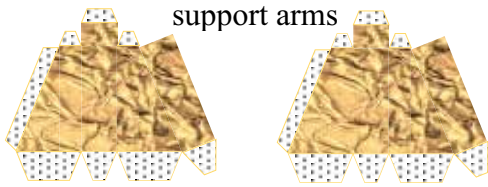
Glue tabs 

1"

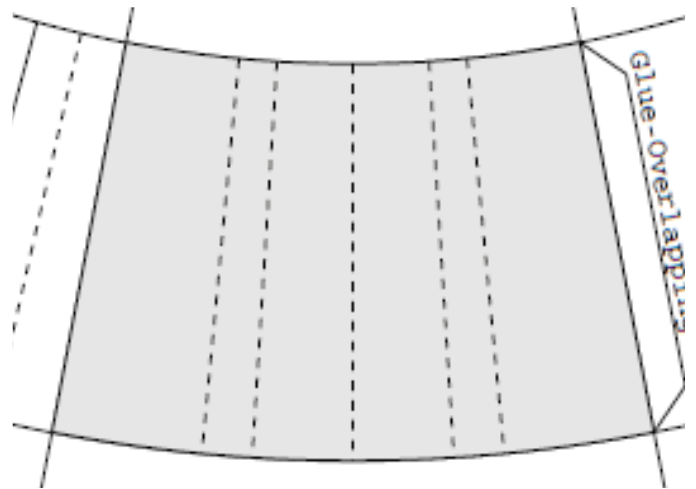


Dish antenna support arms

Dish antenna discs



Dish antenna external reinforcements



Telescope sunshade

Motor collar

