



Hexagon (KH-9) Scale Model

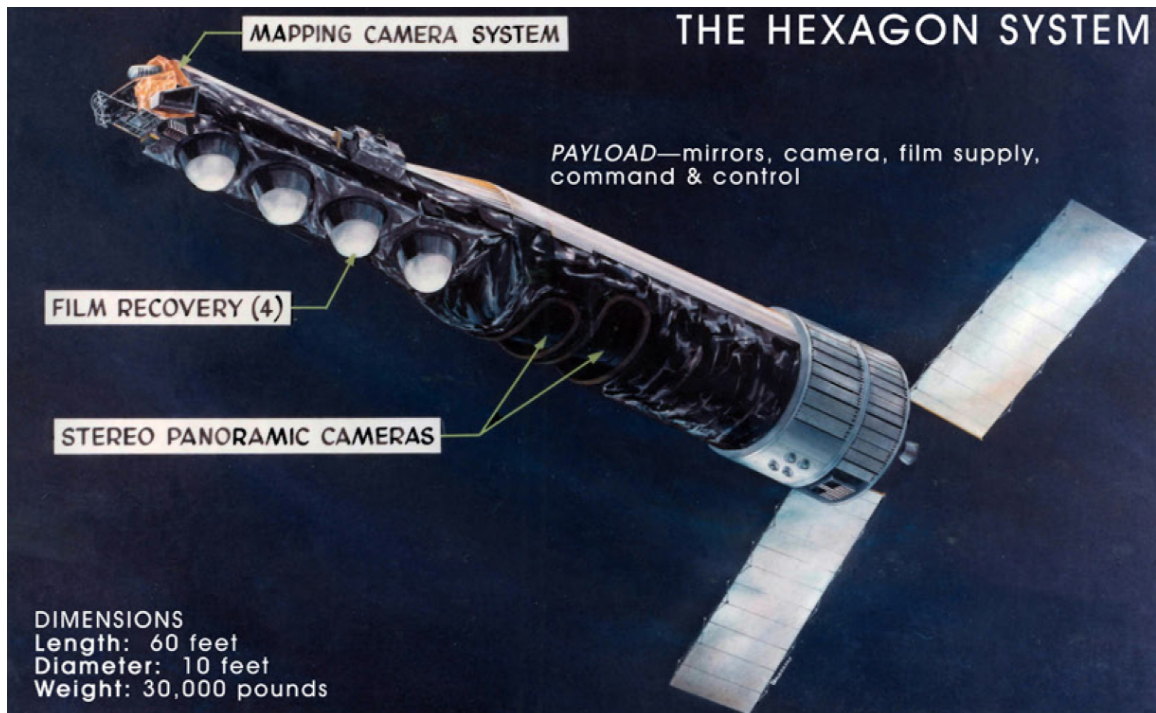


Image Credit: National Reconnaissance Office

This 1/48th scale paper model represents the general arrangement of the National Reconnaissance Office's "Hexagon" or KH-9 satellite. Twenty of these were launched between 1971 and 1986 to provide reconnaissance photos of global hot spots. The prime contractor for the spacecraft was Lockheed while Perkin-Elmer provided the camera system. The mid-section contains a pair of stereo panoramic cameras while the nose has a wide area mapping camera system. The aft section is the satellite bus that provides services like power and pointing. Four capsules were used to return film from the main cameras while a single smaller capsule brought back results from the mapping camera.

This model is a simplified generic version, as actual on-orbit colors are still somewhat speculative. My assumptions are that the upper surfaces were painted or polished metal, with black thermal blankets on the undersides, orange kapton blankets around the nose, and mostly metallic shades on the aft section. I wish to give credit to Giuseppe De Chiara, whose three-view drawing was very helpful in developing this paper model.

For more information, see the project website: <https://www.nro.gov/History-and-Studies/Center-for-the-Study-of-National-Reconnaissance/The-GAMBIT-and-HEXAGON-Programs/>. There is also a nice article on the Space Review website: <https://www.thespacereview.com/article/1774/1>.

General Instructions

Tools and materials needed:

- Scissors
- Hobby knife
- White glue (optional: glue stick, Alene's Tacky Glue)
- Coffee stirring stick or straw, plastic
- Optional: removable low-tack tape

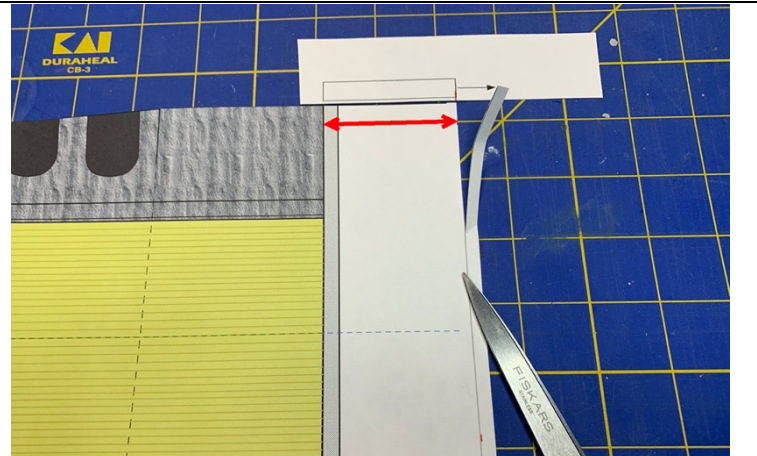
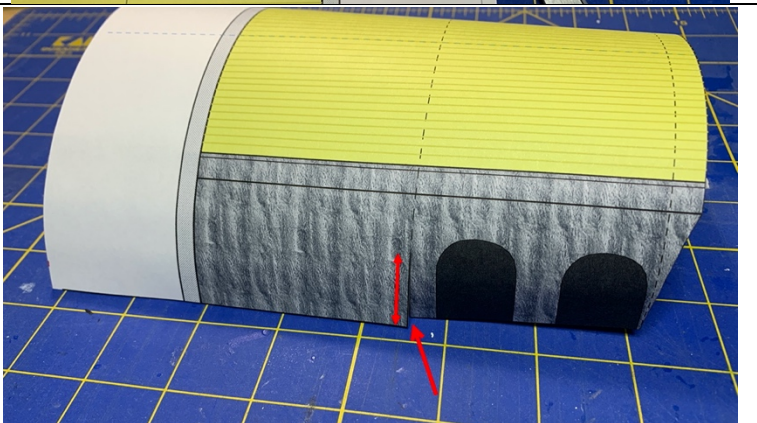
The model should be printed on heavy cardstock and can be cut out using scissors or a hobby knife (e.g., X-Acto). The dashed lines on the drawings indicate folds. To get a sharp fold, lightly score the paper (before or after cutting) with a dull pointed object like an orange stick (cuticle stick for cosmetics) or a dried ballpoint pen. Alternatively, a dull hobby knife can be used with care and a very light touch, being careful not to cut all the way thru. All of these scores are on the front (printed) side unless noted otherwise. Note that not all scores/folds are shown, as the obvious ones (main bus structure panels for example) are indicated by features of the drawing itself.

Areas on the drawings that are filled with a dot pattern are usually gluing surfaces. White glue (e.g., Elmers) is recommended, while a glue stick is recommended for the solar panels. You may need to hold the pieces together for a few minutes to allow the glue to set. This can be done by hand, small clamps, rubber bands or low tack tape. Remember to use only a little bit of glue, as the more you use, the longer it takes to dry.

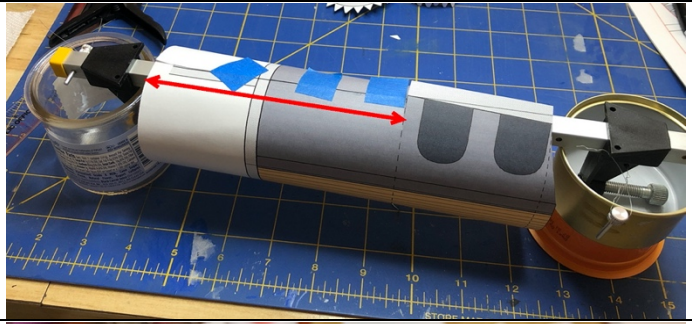
Some Preliminary Information

While this model is in a small scale for paper models (1/48), the result is a large model. The length is longer than a standard 8.5 x 11 inch paper so it will be built in sections and joined together. This makes alignments critical and it means assembly will be challenging in some places. It also has some complex shapes, involving partial conical sections and tricky joints. Because of this, the kit is not recommended for children.

Building Your Model

<p>1. We'll start with the mid-section. Note that the aft section, or Satellite Control Section (SCS) has a slightly larger diameter. We will achieve that by building up the diameter of an extension of the mid section. This also made the mid-section longer than could be printed to scale, so when you cut it out, use the 2.12" rectangle to measure the extension (arrow).</p>	
<p>2. The forward part of this section tapers to an oval shape at the bottom (with the black camera portals). The top half remains a half-cylinder. To achieve this transition, cut a slot along the solid black line as shown. You may need to make this a very narrow triangular cut. Do some dry fits to determine if this is needed.</p>	

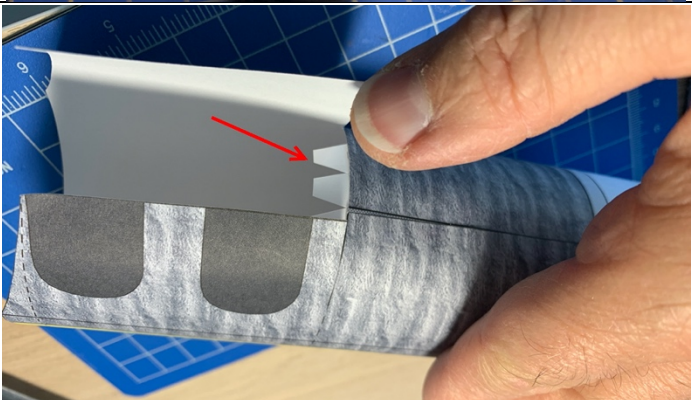
3. Make the mid-section into a tube but only glue the rear portion of the joint (arrow) for now. Note I used a bar from a clamp to serve as an internal support to apply pressure for the glue to set.



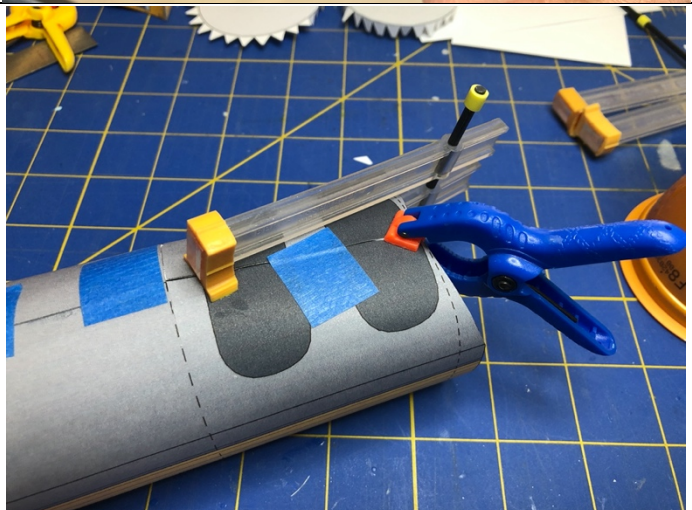
4. Cut out the camera internal bulkhead and glue to the inside at the aft end. This will stiffen it and maintain a round shape. Make sure it is set back at least an inch or so, as another bulkhead will go in here.



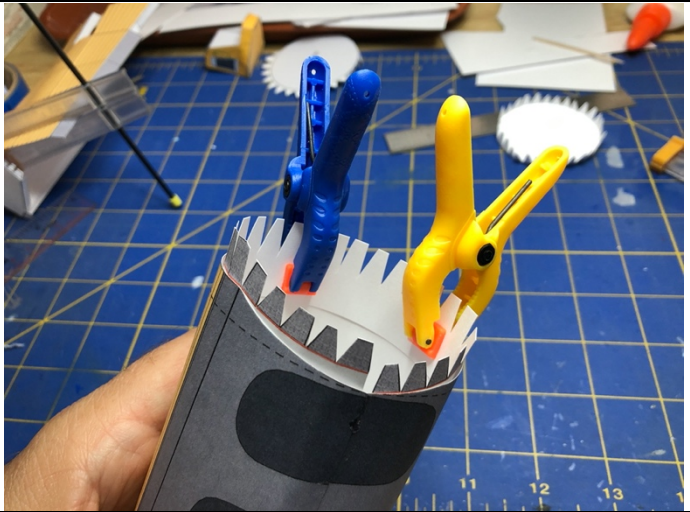
4. After the previous glue joints are set, install the small connector (arrow) inside at the bottom. This will be used to provide some backing to those side slots that were cut to start the taper shape.



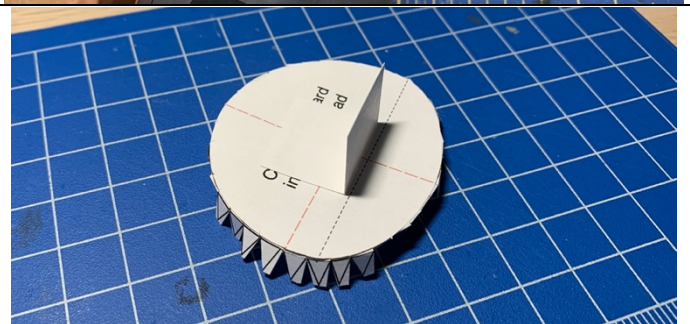
5. When the connector is set, use tape and clamps to glue the tapered joint of the camera section.



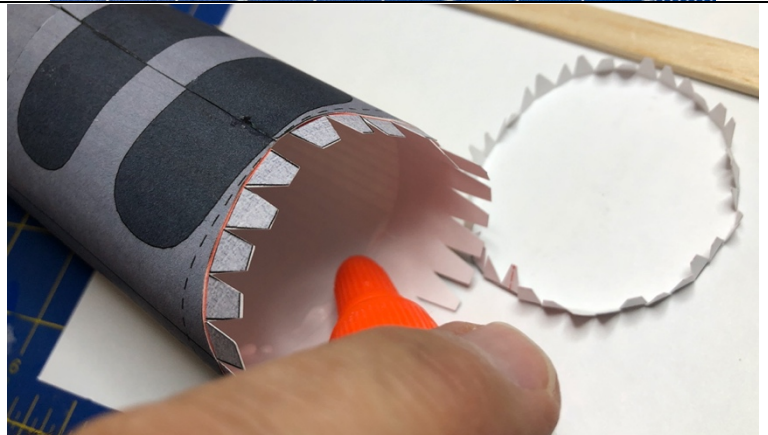
6. Cut out the connector piece and glue it to the inside of the front end of the camera section. Note that the ends meet at the bottom of the section at the black camera openings.



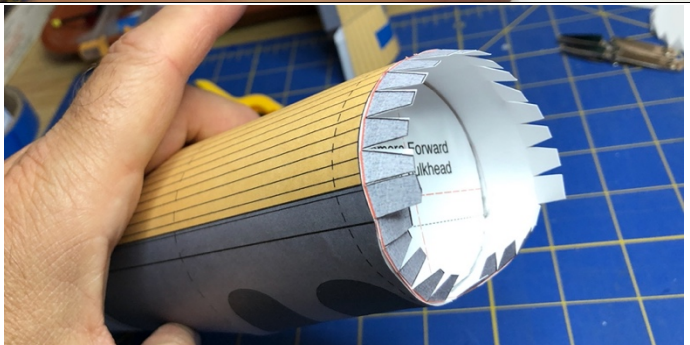
7. Cut out the Camera Forward Bulkhead and glue on a "handle" to the front using a scrap of cardstock. Fold the tabs backwards.



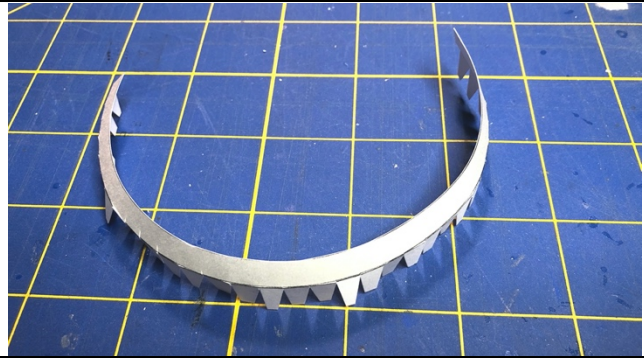
8. Apply glue to the inside of the tube just behind the connector. Now install the bulkhead so the oval shape is at the bottom and semi-circle is at the top and glue it in the camera mid-section.



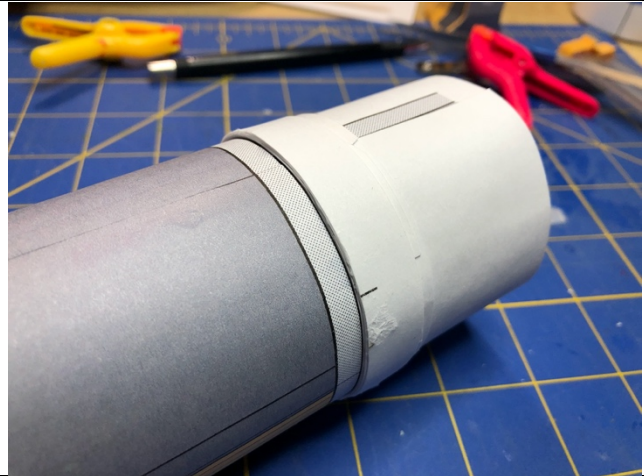
9. The bulkhead should butt up against the connector you just installed. Make sure the bottom is lined up correctly. Note the tab/handle was not installed in this photo.



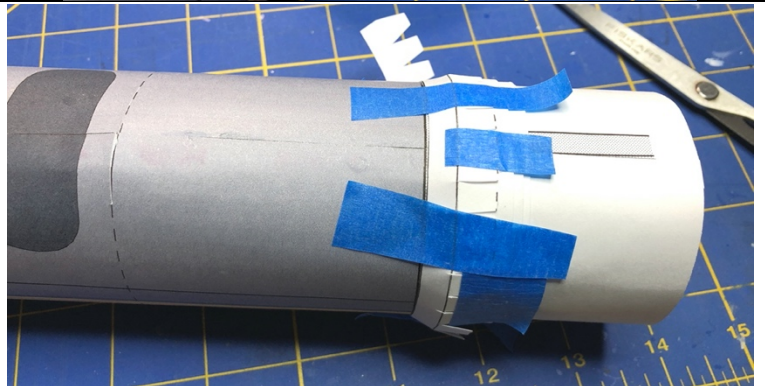
10. Cut out the SCS conical adaptor or ramp strip.



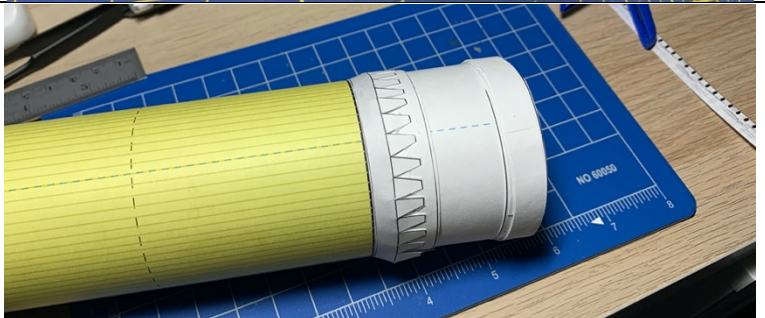
11. Cut out four of the SCS forward build-up strips and glue them to the tube (on the white area) just aft of the gray section. Glue another four at the very end as well (not shown). This will build up the diameter from the camera section to the slightly larger SCS.



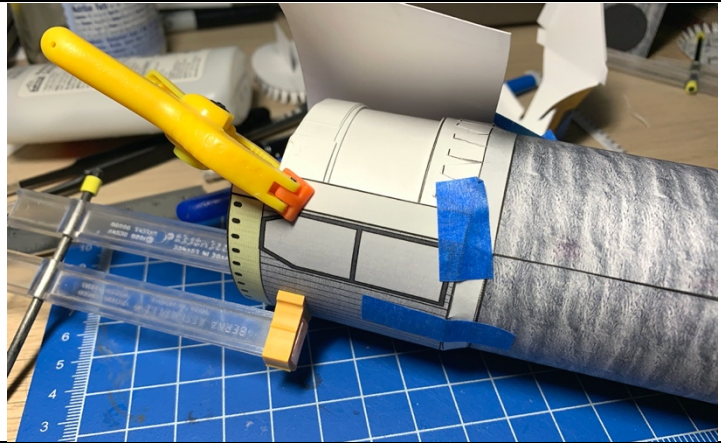
12. Next glue on the conical adaptor section. Use low tack tape to hold it down. It is best to fix the alignment, hold it down with a few small bits of tape, and then glue a little at a time. This piece provides a ramped adaptor between the camera section and the aft SCS.



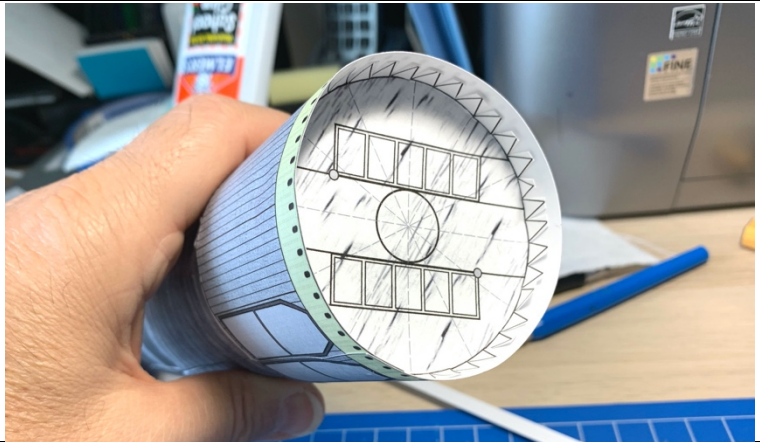
13. This photo shows the conical adaptor installed, as well as the aft build-up layers.



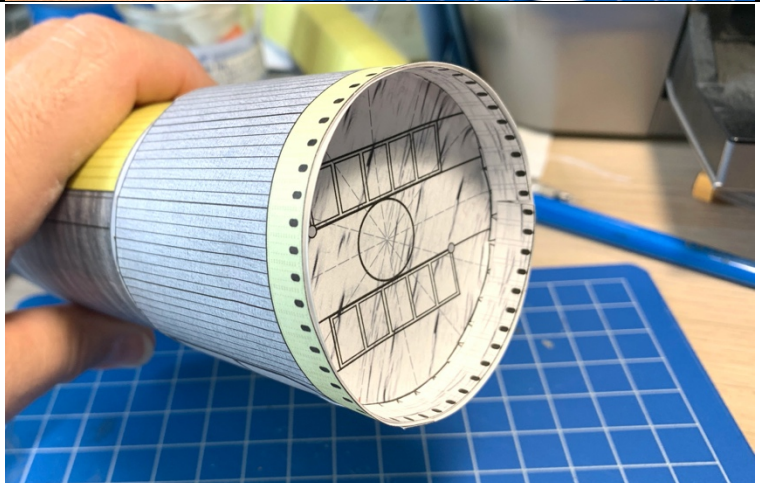
14. Cut out the SCS wrap and glue it on the aft section over everything. Note the little dark ovals go towards the back. Align the dark pointed rectangles to be at the bottom. Again, it is best to line up the entire wrap, tack it down with tape, then glue the bottom edge first. When that is set, glue the remainder of the wrap.



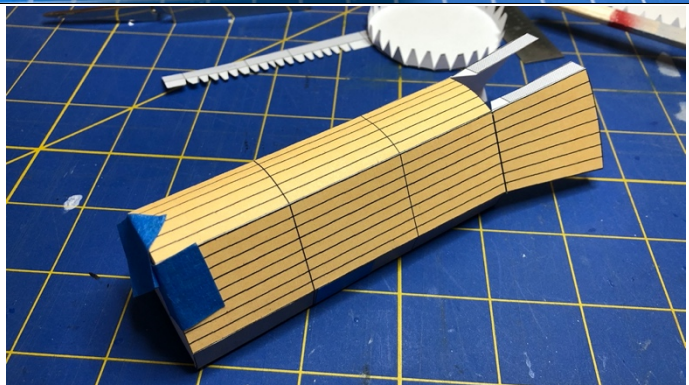
12. Cut out the aft SCS bulkhead, score lightly on the back side and fold the triangle tabs forward. (With the tabs forward you have some control as to where the part sits inside the tube, as you can use tweezers to adjust the position.) Cut out the inside aft liner (with the ovals). Use this as a depth guide while you glue the bulkhead to the inside of the back of the SCS. Dry fit everything before gluing and make sure you have the top-bottom alignment correct. When you have the alignment checked, glue the aft SCS bulkhead into the cavity at the rear of the Mid-Section. It should almost butt up against the end of the main tube.



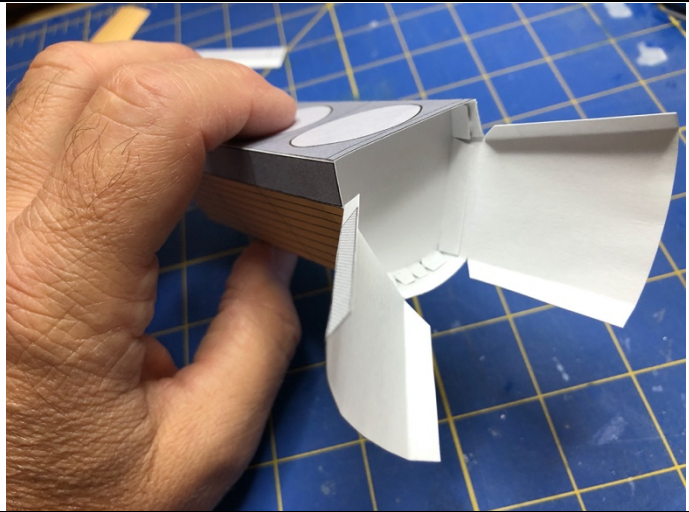
Now take the inside aft liner and check the fit. It goes on the inside, over the triangular tabs. It is probably longer than it needs to be which allows some margin for errors. Glue this in a bit at a time. Make sure the little ovals are towards the rear edge.



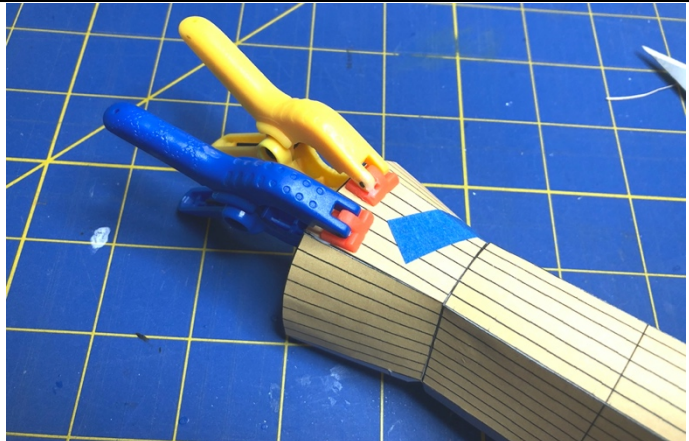
Next we'll start on the forward section. Cut it out and score the main folds (two at the top, and the bottom corners). Note the aft side panels fold outward, so score those on the backside. Fold the tabs back on the front bulkhead, and wrap the side panels around, gluing to the front bulkhead. It is recommended to glue the sides to the front bulkhead in stages, allowing each edge to dry rather than gluing the whole thing at once. This will result in better shape.



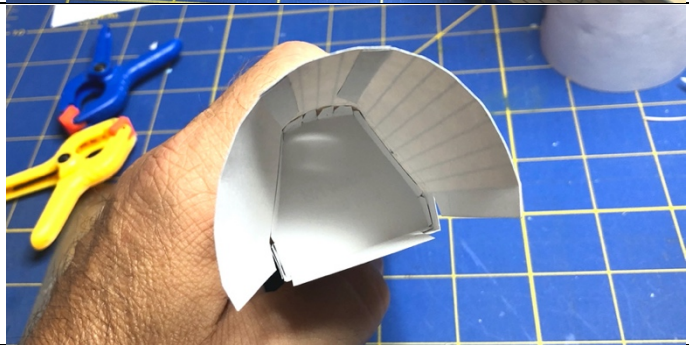
Cut out the internal bulkhead for the forward section and glue it inside the aft end of this assembly.



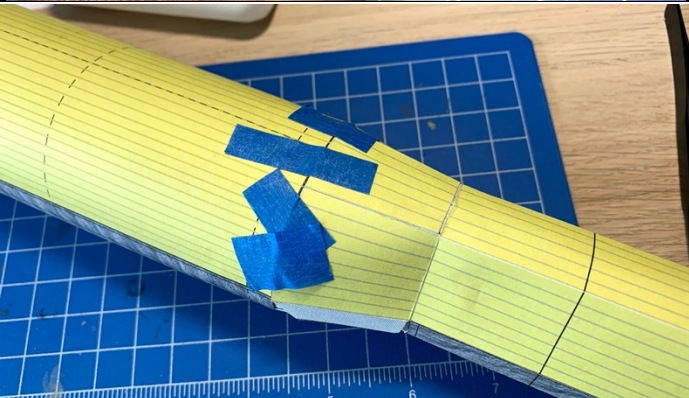
Cut out the top rear panel, curl it a bit, and glue it to the top.



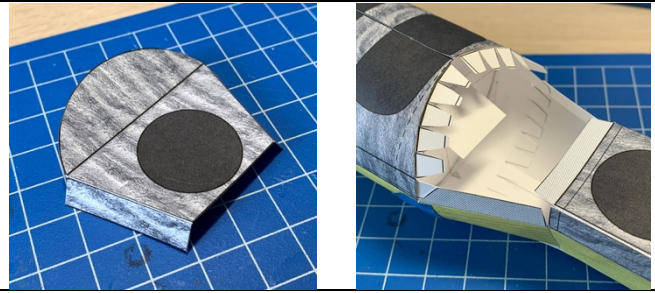
When this dries, shape the aft edge into a circular curve. This will mate with the camera mid-section in the next step.



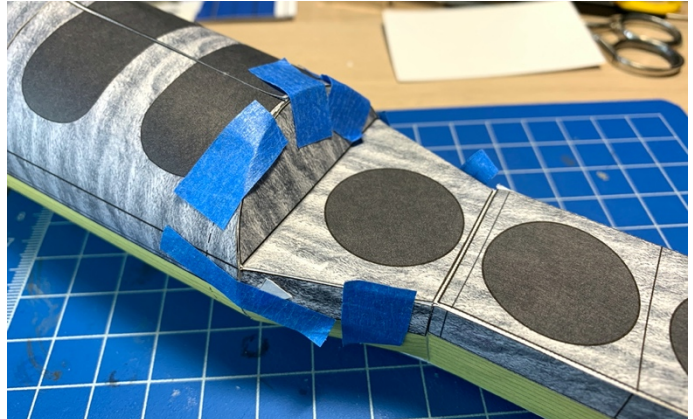
Carefully glue the two sections together using the tabs from the connecting strip. Check the curve shapes carefully, using tape to hold the alignment before gluing. Allow to thoroughly dry.



Cut out the bottom transition panel, which includes one RV location and a curved section that connects the mid and forward sections.



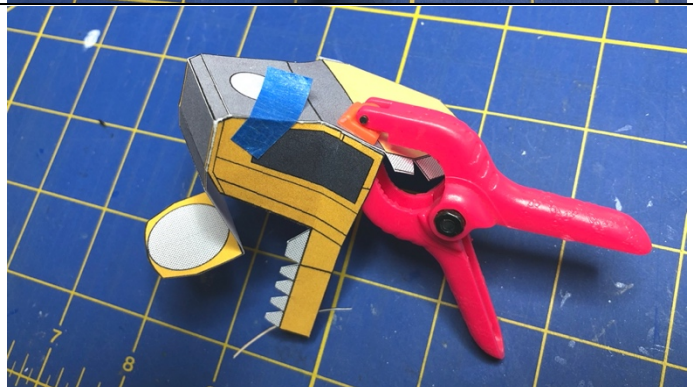
Glue this to the tabs on the connector strip that was installed on the mid-section.



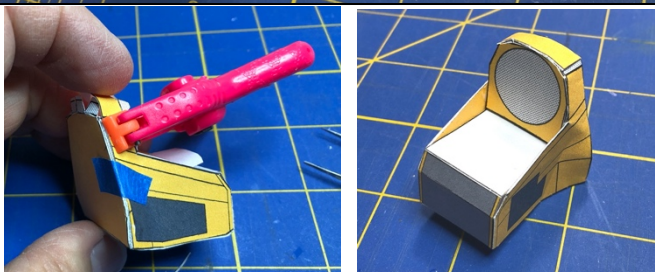
Next we'll moved to the mapping camera at the very front of the spacecraft. Cut it out and fold the tabs per this photo. Note how some panels fold back, and that some gluing tabs fold back while others fold forward. The first items glued should be the two triangular panels folded over and glued. Note they have glue tabs that stick out.



Next, start gluing at the (black) bottom panel, making a trapezoidal box. Do several dry fits before using glue, and check the assembly with low tack tape. Note the side walls will curve outward to match the forward section of the vehicle.



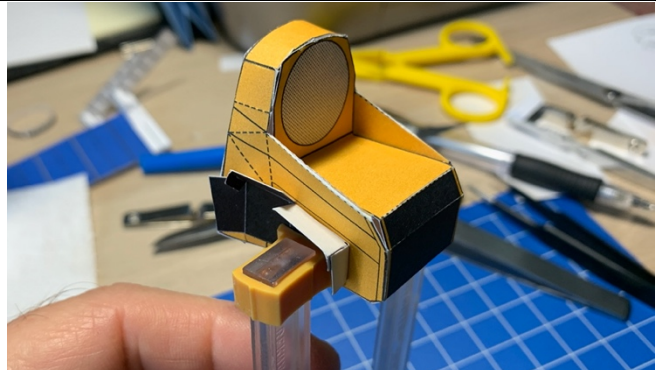
Continue by gluing the side walls as they wrap around the tabs, working from the bottom to the front and eventually the top. There are some folds that need to be scored on the back to result in sort of a shelf. The vertical back wall is where the mapping camera film return vehicle will be mounted later.



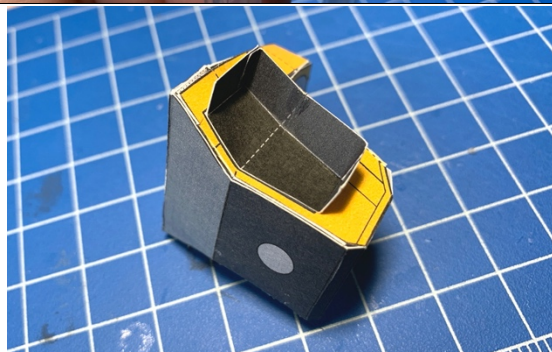
Now make the star camera baffles. (As there is poor documentation on these features, the shapes are approximate.) All the scores are on the back, and fold the small flaps to the inside of the box. This leaves a cleaner outside surface. The port (left) side is a simple box.



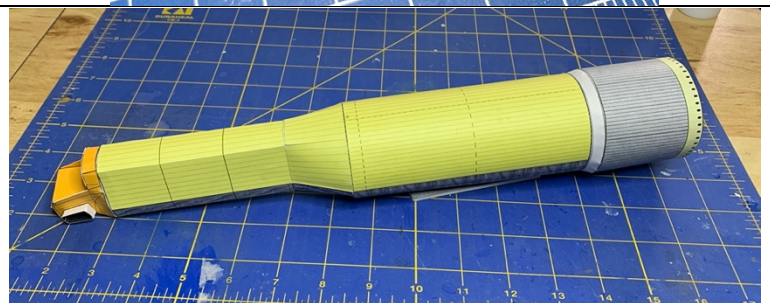
The starboard (right) side baffle is a bit fussier even though it has no bottom. It attaches to a panel that is not flat, so you should score the middle of the back surface. I glued together one corner, then glued it to the camera module before gluing the second corner. Note the slit cut in the top.



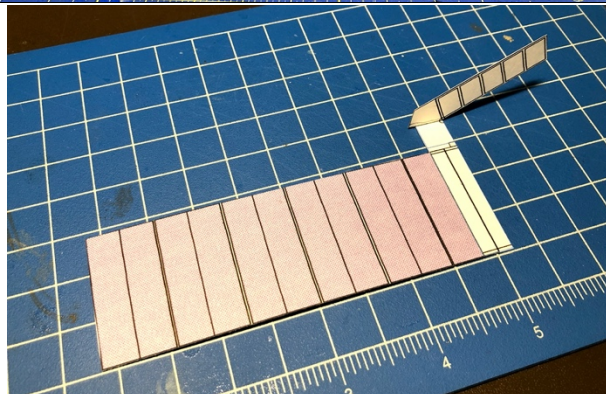
This photo shows the result after gluing the other corner and dabbing some glue on the slit on the top panel.



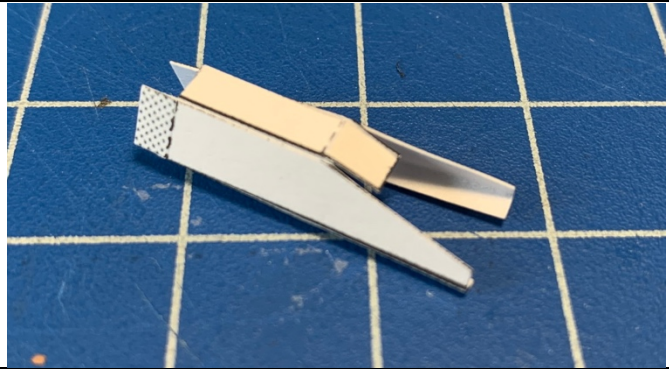
Glue the mapping camera section to the front bulkhead of the forward section. Your model should now look something like the photo at right.



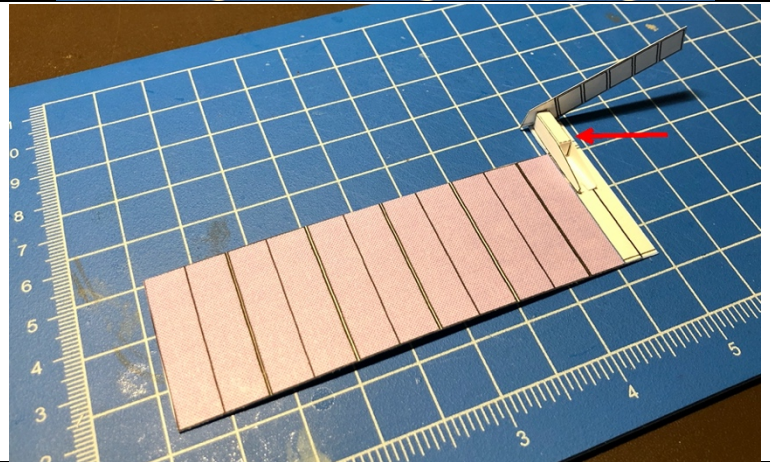
Two solar panels attach to the aft bulkhead. Note there are left and right hand solar panels. Score along the center and fold the back over the front. A glue stick is recommended as it will not warp as much as white glue (Elmers). The left hand wing is shown here with the attach panel folded up. There is a zig-zag pattern provided, and you can score on alternate sides to achieve that effect. I did not do that on my model.



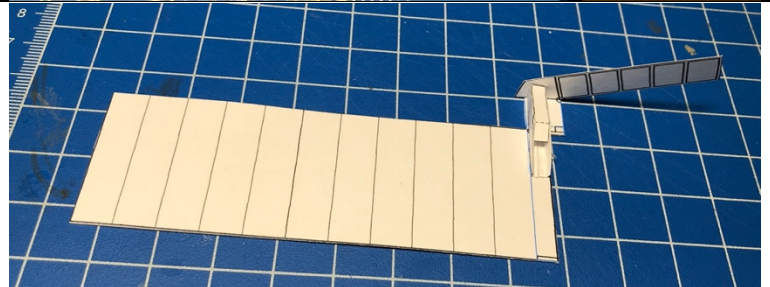
Cut out and fold a reinforcing bracket for each panel. All the scores are on the front.



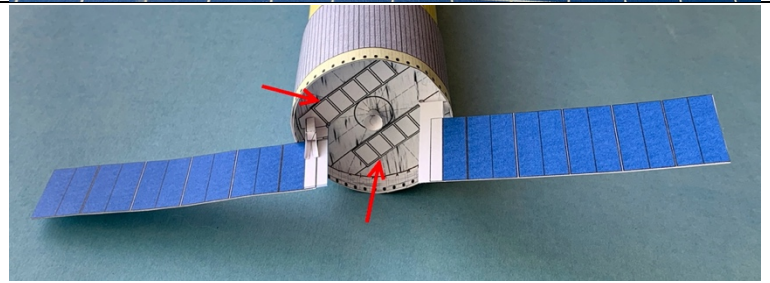
Glue this into the fold at the base of the solar panel attach strip. You need to glue it to the wing strut and the back panel so the solar panel makes an "L" shape.



Note that the right hand solar panel has the reinforcing bracket on the bottom.



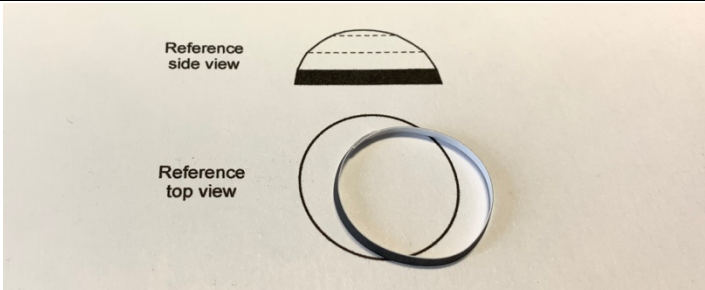
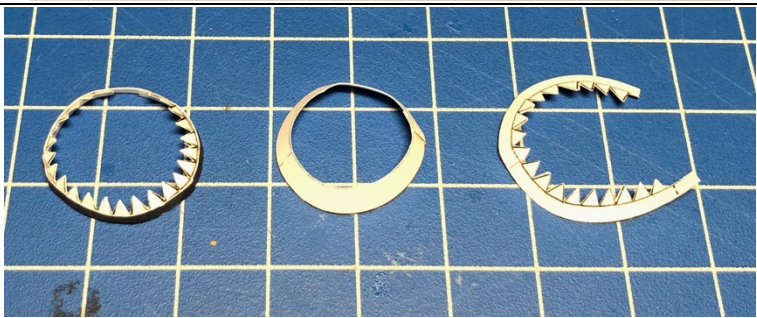
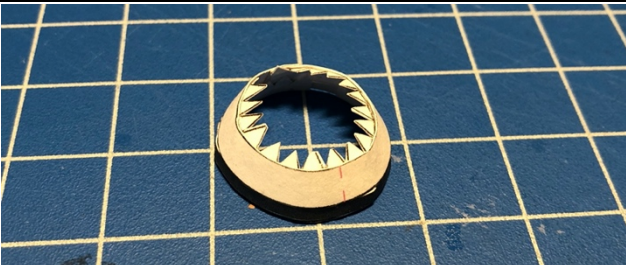
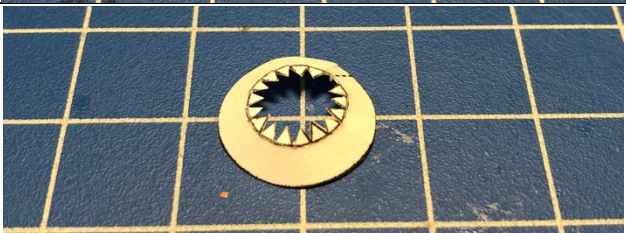
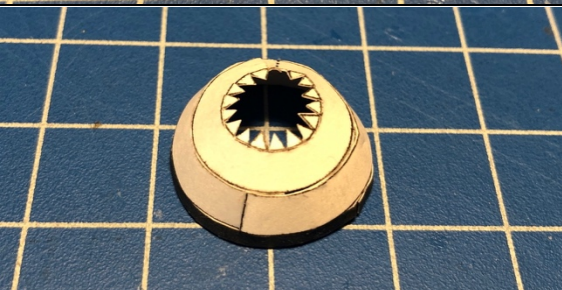

Glue the solar panels to the rear bulkhead. Match the attach strips (arrows) to the pattern on the bulkhead. If the aft bulkhead is recessed too far, stack some cardstock under the attach strips, matching the existing pattern.



Cut out the rocket nozzle and shape it into a conic section. Then glue it to the center of the aft bulkhead.

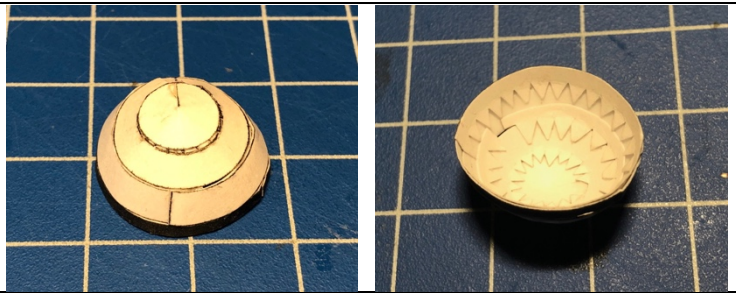
That completes the main spacecraft assembly. Next you can build some film reentry vehicles (RVs). There is a small one that goes on the front of the mapping camera section. There are also four larger RV locations on the underside of the spacecraft. Because part of the RV is recessed, the model only provides the portion of the RV that extends out from the bottom of the main spacecraft body. All four RVs are provided with this kit.

The RVs are complex and fussy to build, as they are small and involve tiny triangle gluing tabs. It is tough to create paper models of curved objects so this is a compromise. The idea is to start at the bottom of the shape with the largest diameter, then build up a layer at a time. To keep the joints relatively smooth, a separate internal connecting strip with small triangular tabs are used in most places. These are installed inside the lower ring with the triangular tabs facing up. Then the next layer can be glued on the lower layer with the connecting tabs inside, resulting in a flush surface (compared to having the tabs part of the lower ring). We'll start with a large RV, as the other version is built the same way.

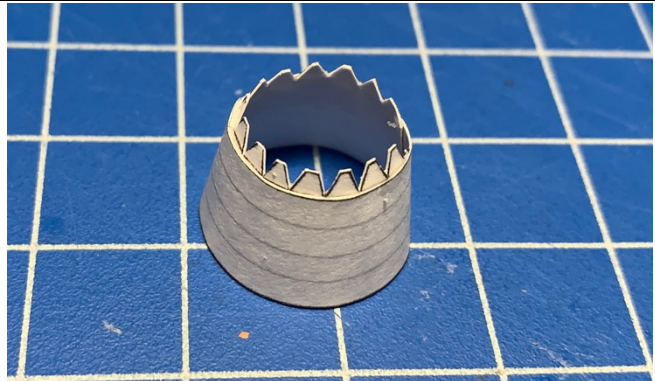
<p>Cut out the lower black ring (1) and the adjacent saw-tooth connector (2). First glue the black ring together, using the "Reference Top View" as a template for the diameters. Then glue the saw tooth connector inside it. All of these rings have markings that shows approximately how far to overlap them to get the right diameter. Always tape this first to check the fit before gluing.</p>	
<p>In the photo, the left-most item is the first ring with the saw-tooth connector installed. Note how the connector is INSIDE the lower ring.</p> <p>Cut out the next ring (3) and glue it into a conic section. Before it sets, check against the first ring to verify the diameters match. In the photo at right, the next ring (3) is in the middle with its saw-tooth(4) at right. When these are stacked up (next step), it should result in a smooth joint.</p>	
<p>Now glue the second saw-tooth connector ring inside the second ring. Then glue it to the first (lowest black) ring layer.</p>	
<p>The next layer (5) does not have an internal connector, so cut it out, glue it into a conical shape while making sure the diameter matches the layer below it. Use tape or a small clamp to set that diameter before gluing.</p>	
<p>Glue that ring to the lower assembly. You are starting to build up the round shape of the RV nose.</p>	
<p>The very last piece is the nose (6), which is a shallow cone. Cut the slice out, form a cone and glue it into that shape. I like to use small clamps (found in electronics supply shops) for these assemblies. Note there is a piece "6a" provided which is slightly larger. This could be handy as it is tough to get precise results.</p>	

Finally glue the nose cap on the assembly as shown in the left photo. The right photo shows how the inside of the assembly looks, with each layer and connectors stacked up.

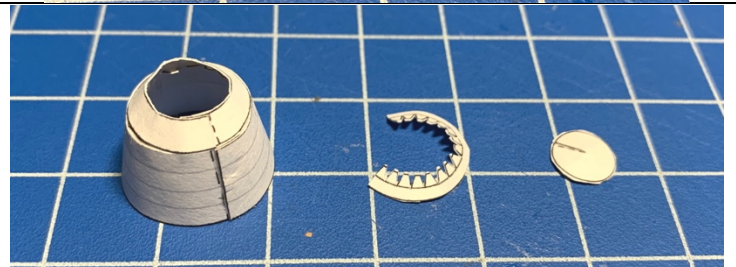
Make up to four of these and glue to the bottom of the forward section of the spacecraft.



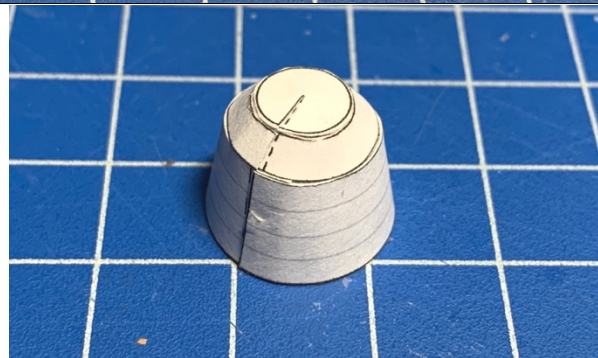
The smaller mapping camera film pod goes together in a similar fashion. It has more of the main RV body so the round cap is simpler with fewer parts. Start by gluing the base section into a conical shape (left). There is an internal connection ring with a saw-tooth shown already installed.



Glue the next ring into a conic section after verifying the diameter and fit to the first piece you made in the previous step. Then glue it to the previous assembly (left). I find it easier to install the interior saw-tooth connector (center) after this step, but you could do it either way.

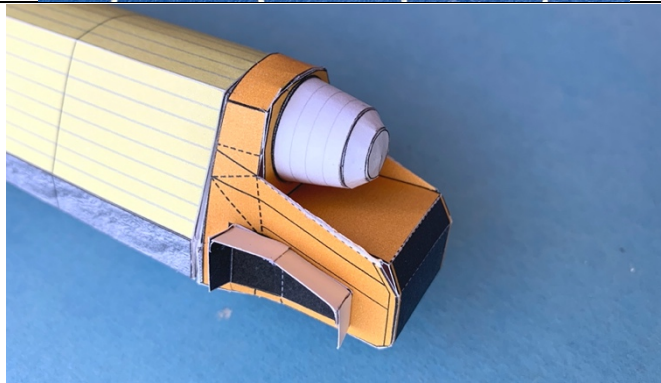


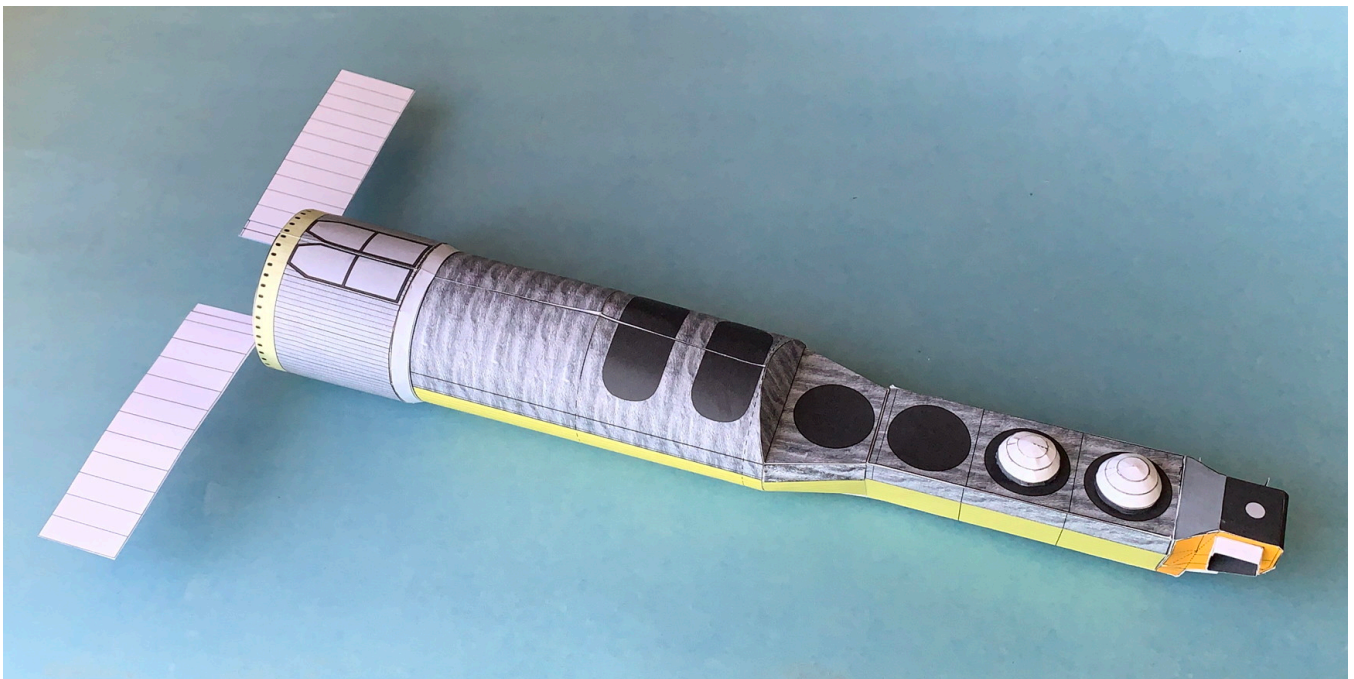
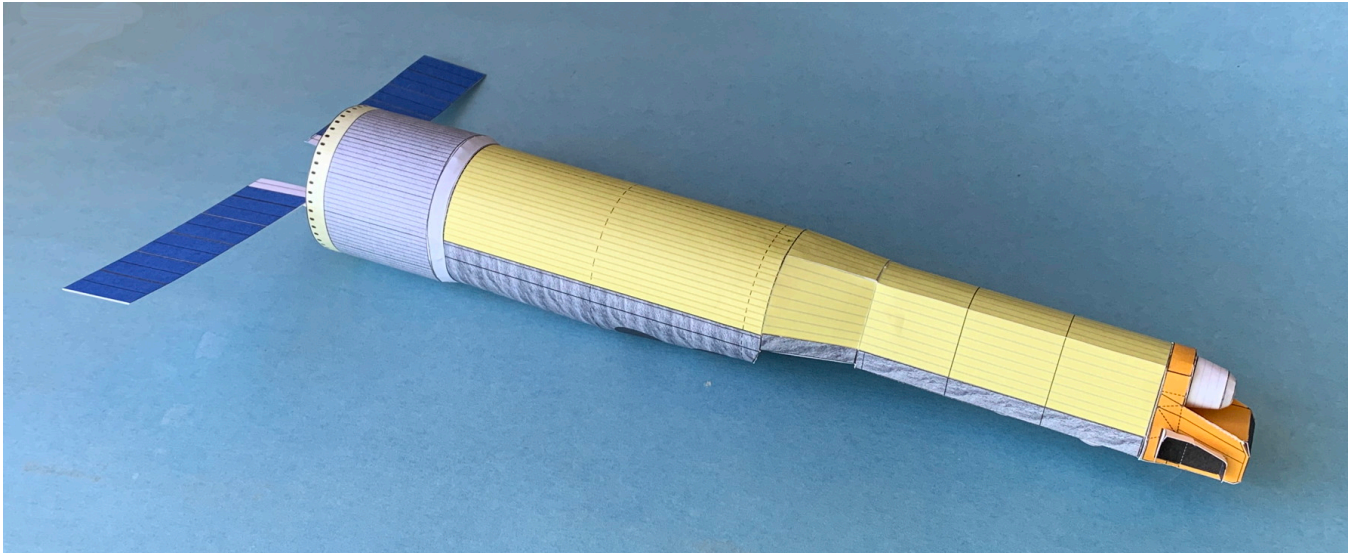
Cut out the nose cap and glue it over itself to form a shallow cone (previous photo, right). While the glue is still setting you can press some "roundness" into the tip. Then attach to the lower assembly.



Glue this RV to the locating circle on the front of the mapping camera section.

That's it, you are done and now have a 1/48th scale model of one of the most complex machines ever launched into space.





Final Comments

Note that there are some details that are not provided on this model. These include:

- Mapping camera forward doppler beacon spiral antenna
- Forward section auxiliary payloads (varied per mission)

I may provide these with a future update, or you may create your own detail parts.

Note the mapping camera and its film RV only flew on missions 5 thru 16.

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For more information on building models of real spacecraft, see www.spaceinminiature.com.