Things to know before assembling the model

This is a 1:16 scale paper model of the real Magnetospheric Multiscale Spacecraft (MMS). It's an octagonal shaped model that has 2 decks and a cylinder in the middle with several instruments on both decks. Looks very complicated but the assembly is straightforward. This manual is based on photos that will show all the important steps to assemble the model.
Items needed:

- X-Acto knife (to cut small parts)
- Cutting Mat
- Tweezer
- Metallic ruler
- Scissors
- Cardstock 110 lbs
- Cardstock 90 lbs (for Instruments parts)
- Photo paper or Glossy cardstock (for top skin, bottom skin and solar panels)
- Elmer's glue
- Elmer's glue stick (when indicated)
- Magnifying glass (if needed)

You need to know basic tips and techniques to assemble paper models. This manual will not cover the basic techniques, though. It is assumed that you should have some basic knowledge and techniques for cardmodeling.

Important things to consider:

- Use the X-Acto knife to cut all the small pieces. Be very careful when using the craft knife.
- Score every part of the model that needs to be folded by using a metallic ruler and a dull knife blade. You can also make use of an old pen that has no ink as a scoring tool. Scoring all the parts is important in order to have a great looking model.
- You should know how to roll or curve the paper to make a cylinder or a tube.
- Do not use excess glue on small parts. Use a toothpick to paste the glue on the smaller parts such as putting glue on the corners of a cubical part.
- Make use of a tweezer to press on smaller areas when gluing.
- Let the parts dry out before moving to the next step.

Check this internet link for Card Modeling tips and techniques:

www.cardfaq.org/faq/tips.html

And be very patient.

Printing out the paper model:

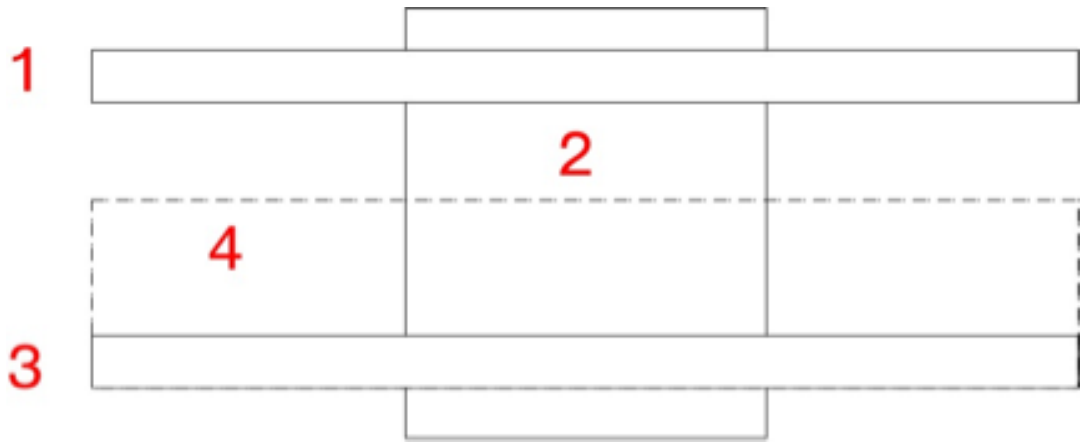
This papermodel will be available in pdf format for download. You will need the updated version of your Adobe Reader in order to view the file on your computer.
You will need a printer and cardstock to print out the whole pdf file.
Select "NO SCALING" in the printer preferences.
For the whole 1:16 scale model, use 110 lbs cardstock. Only for the small parts such as the MMS instruments, you can use a thinner 90 lb cardstock.

The model used for this manual is a prototype, thus you will notice minor differences in the details when compared to the final model.

MMS paper model overview

The MMS (Magnetospheric Multiscale Spacecraft) elements:

1. Upper Deck (Instrument deck)
2. Thrust tube (has the bulkhead, propulsion tanks and orbital debris panels)
3. Lower Deck (Spacecraft deck)
4. Solar panels



There are 4 MMS spacecrafts that will stack on top of each other and will be launched aboard an Atlas V 421 configuration planned for March 2015.
The spacecrafts are called Observatories 1 through 4 and are color coded:

1. Observatory 1 (Gold)
2. Observatory 2 (Blue)
3. Observatory 3 (Green)
4. Observatory 4 (Purple)

The ribs of the thrust tube on each Observatory will have these colors.

Contents

1. **MMS Upper and Lower Decks**

2. **Thrust tube:**

- Thrust tube (3 layers)
- Bulkhead
- Thrust tube upper and lower rings (to connect decks with thrust tube)
- Propulsion Tanks
- Orbital Debris Panels, thrust tube covers and Extensible Boom Antennas

3. **Struts on Spacecraft Deck**

4. **Spacecraft Deck Instruments (Lower Deck):**

- Battery (Bay 2)
- Navigator and USO (Bay 1)
- PSEES (Bay 8)
- C&DH (Bay 5)
- Star Sensors (Bays 4 and 6)
- Propulsion lines (Bays 3 and 7)
- 8 Thrusters and Propulsion Connecting lines
- 1 FEEPS (exterior)
- Fill/Drain Valve and Fairing Access Connectors

5. **Solar Panels**

6. **Instrument Deck elements (Upper Deck):**

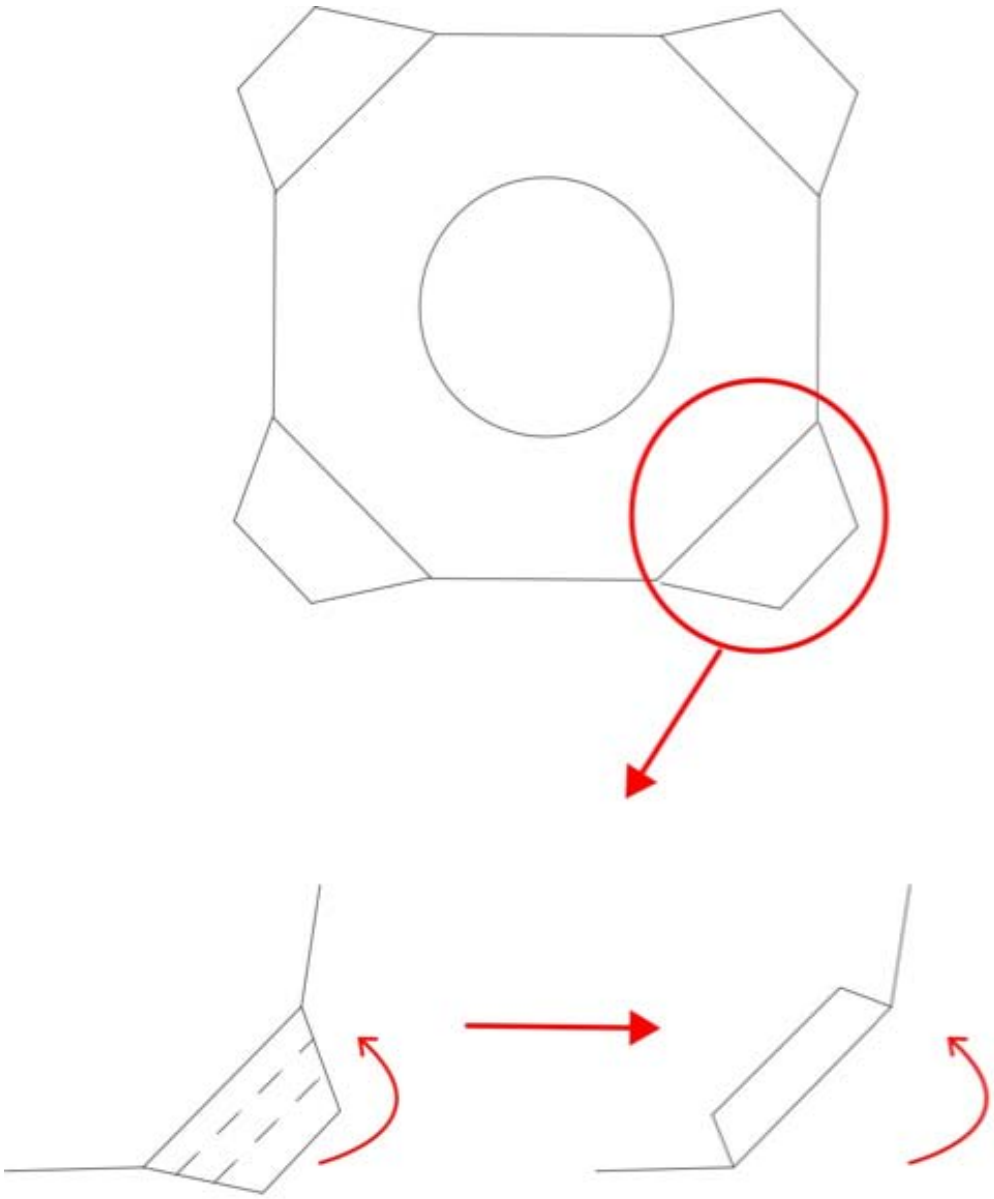
- 8 DIS and DES and Mounting Platforms
- CEB, AEB, IDPU, CDIP
- 4 SDP
- 2 ASPOC
- 1HPCA
- 2 EDI
- 1 FEEPS (exterior)

7. **Finishing MMS exterior**

- GPS Antennas, Mag Booms (stowed), S-Band Antennas

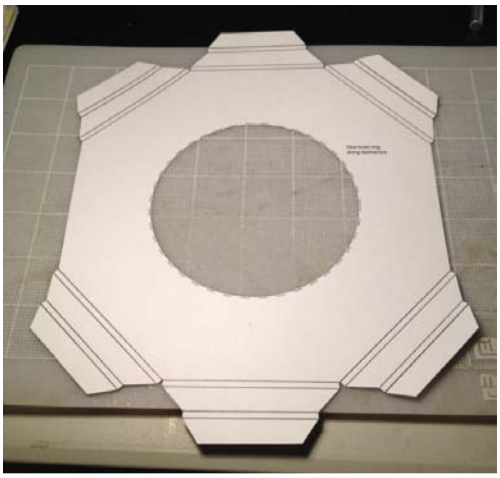
8. **MMS Stand, displaying model**

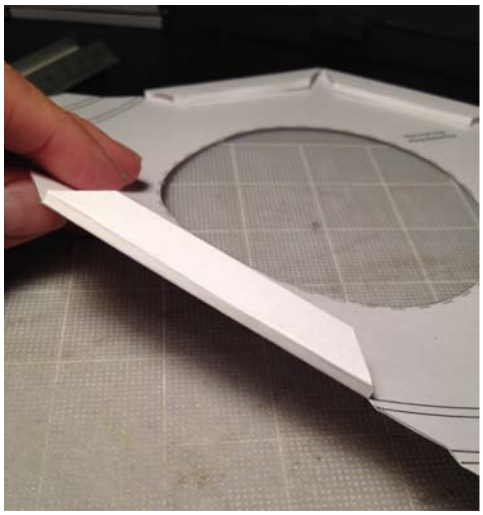
1. Upper and Lower Decks Assembly steps

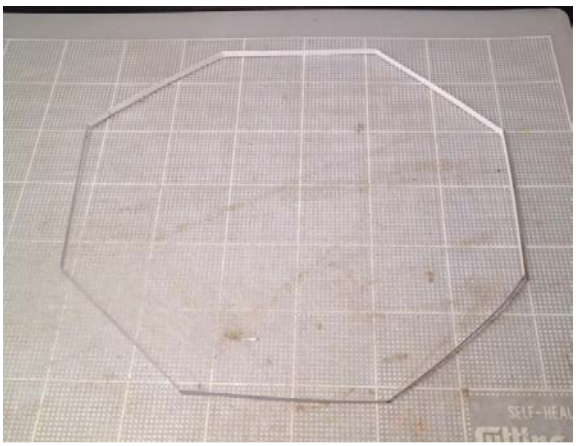


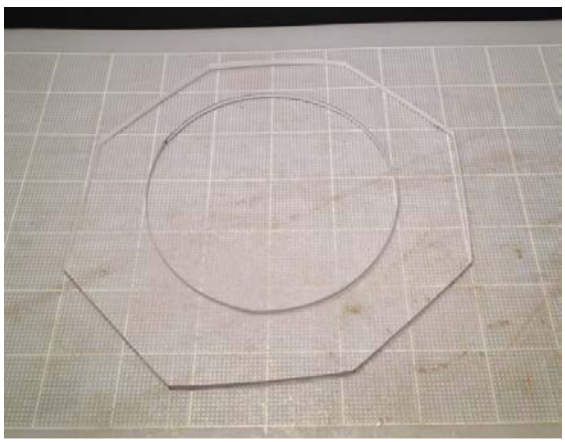
Folding out each corner
(same procedure on both decks)

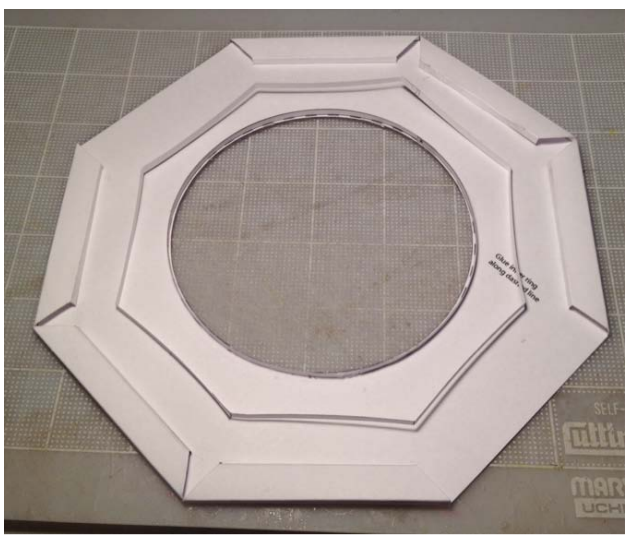
The following steps apply to both decks.



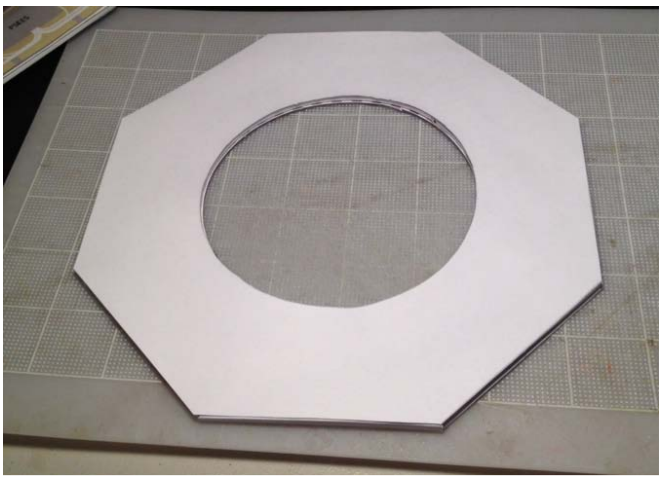


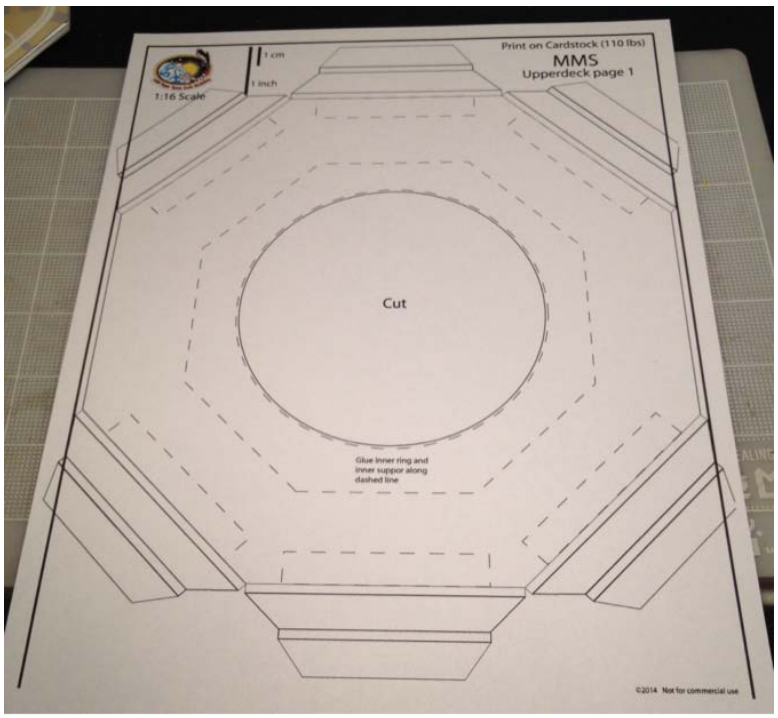






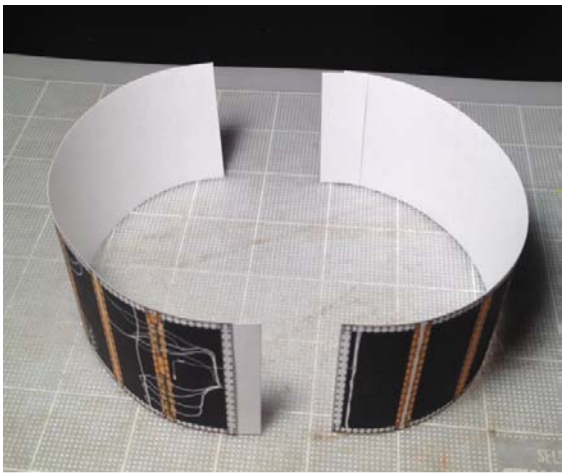
This is a complete deck with the top cover already in place. The inner support structures need to dry out before adding the top cover.
This applies to both Upper and Lower decks of the model.

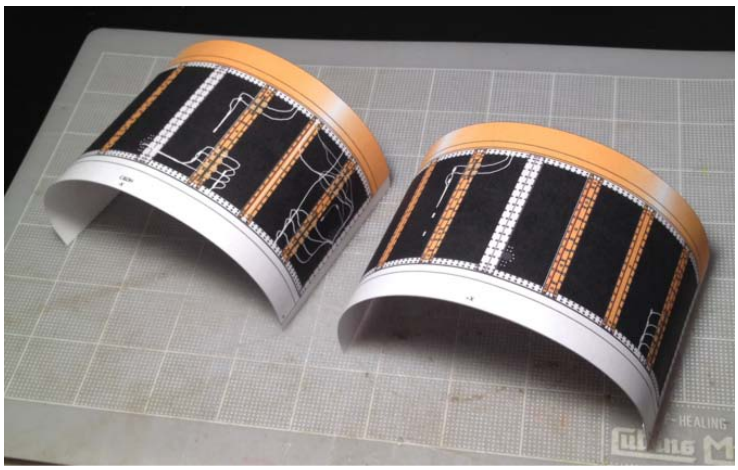


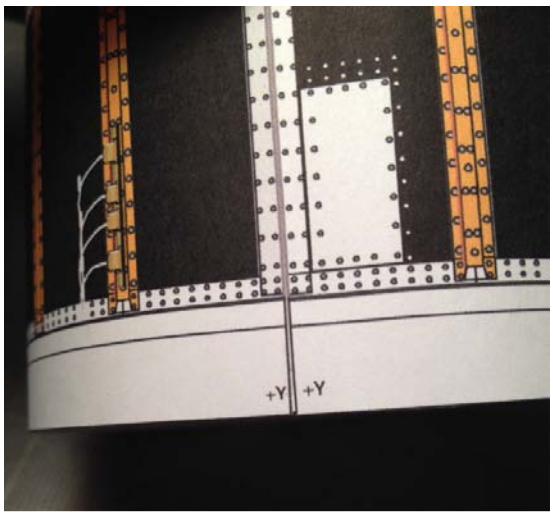


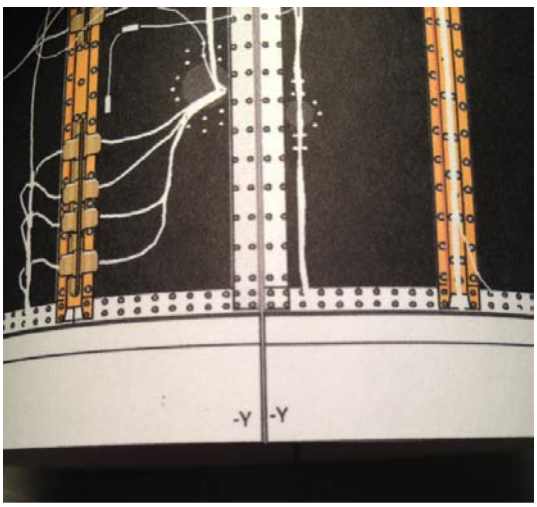
This is the template for the Upper deck. Notice that the tabs on the drawing are outside the border of the pdf. This is done intentionally because the template is in scale, but it will print out fine, and the tabs are important for the assembly of the deck

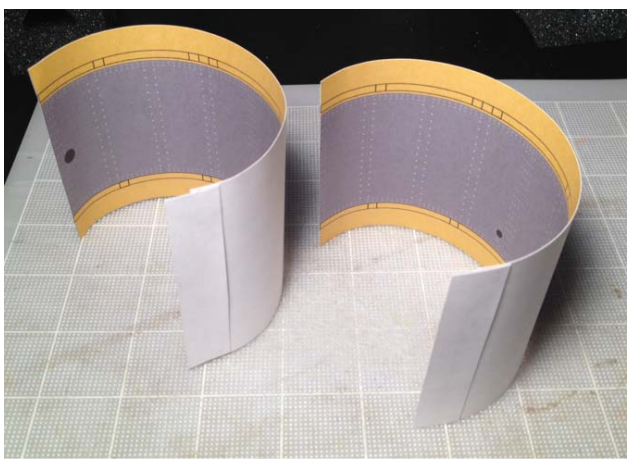
2. Assembly of the Thrust Tube section (3 layers)

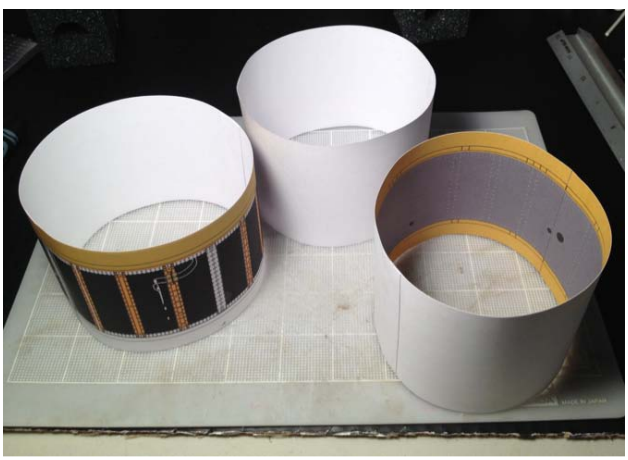


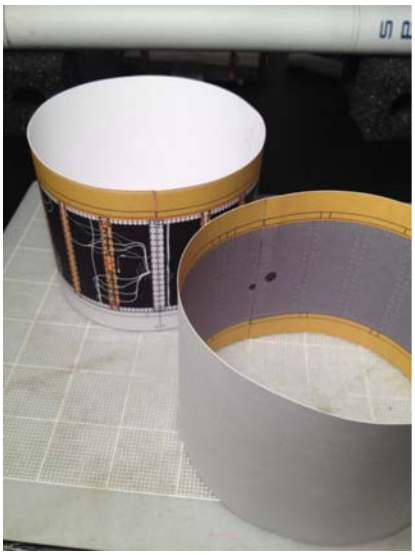


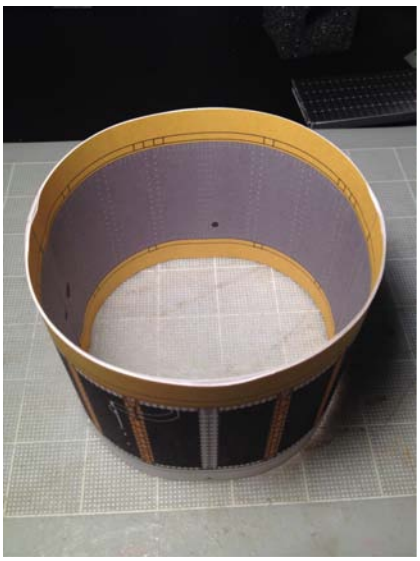






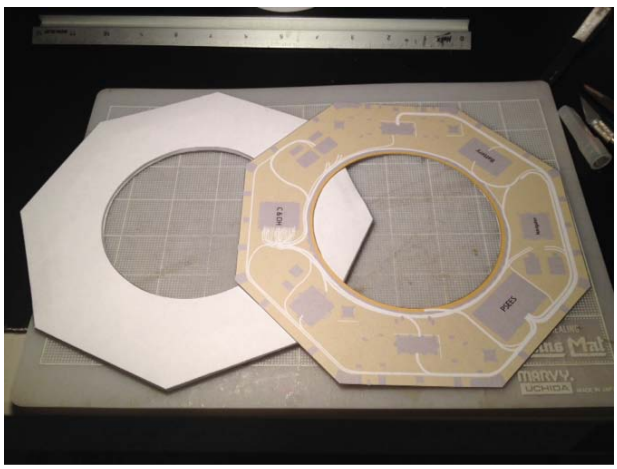


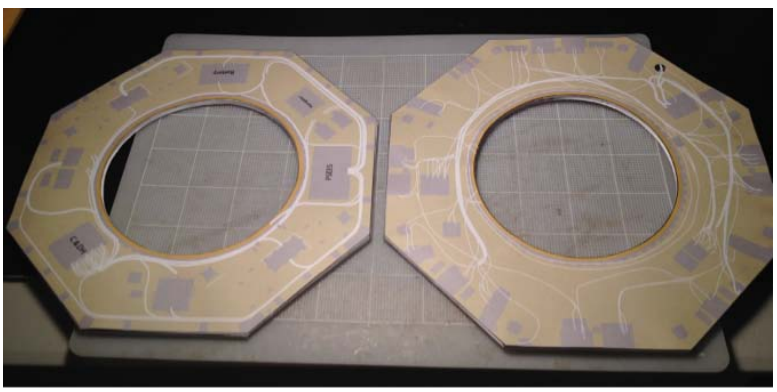


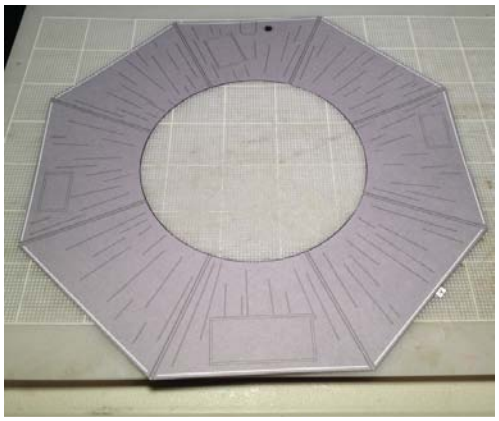


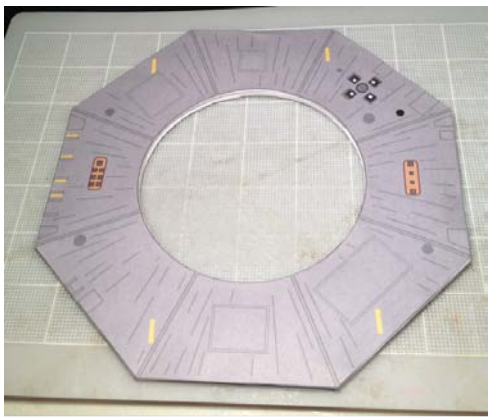
Carefully match the X and Y markers between external and inner skins before gluing them together. The inner tube has black dots that match similar ones on the external tube.

Preparing the decks

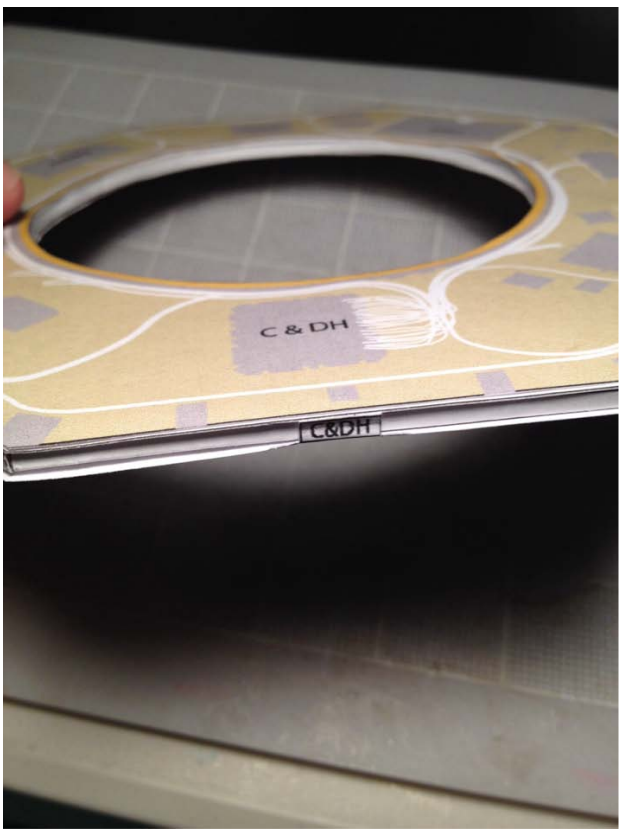








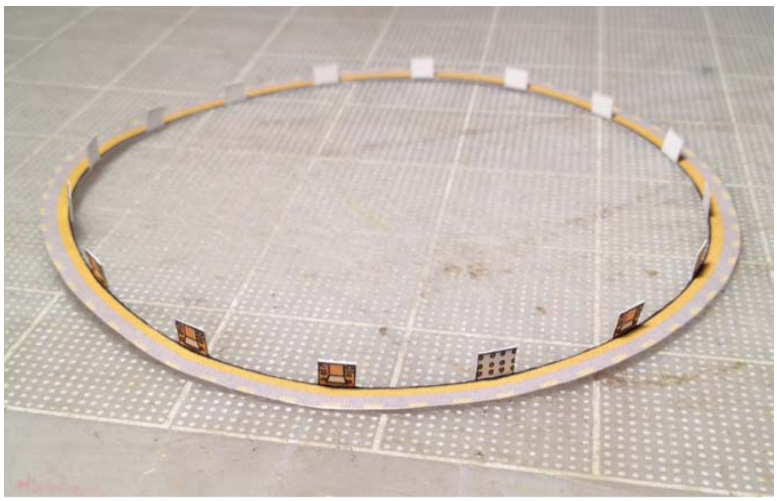
These are the skins from the prototype model.

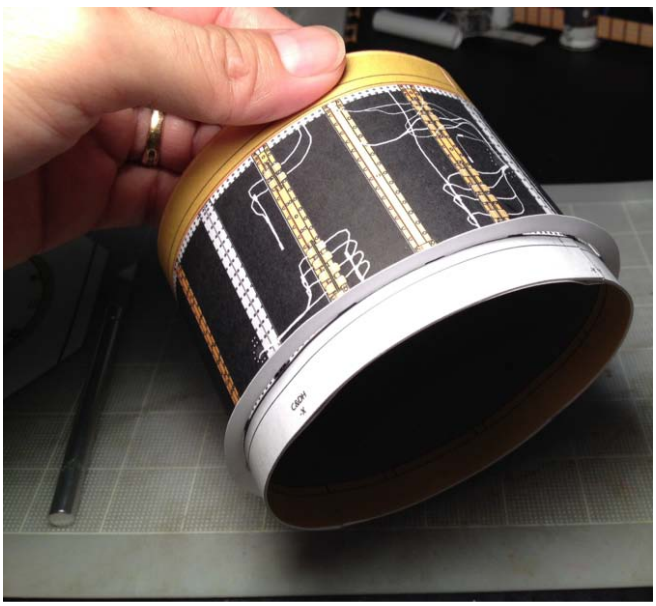


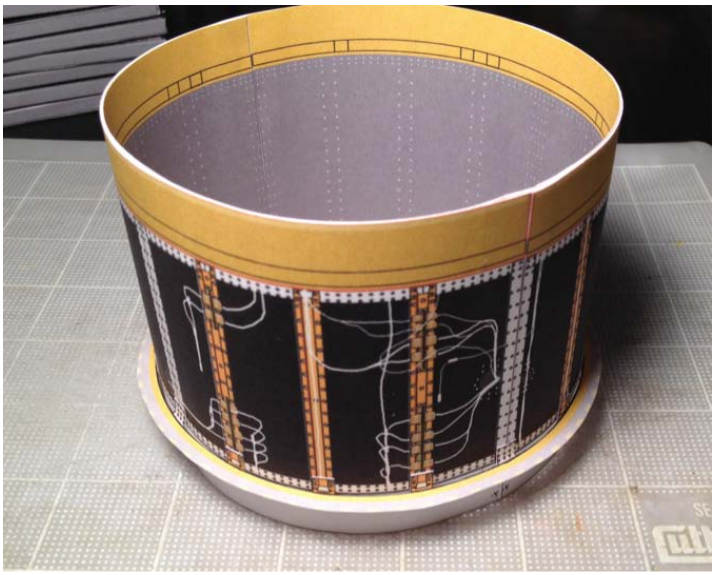
Each Deck skin has a marker that needs to match with the other. This is very important for both sides of each deck to be appropriately oriented for proper placement of instruments and for proper orientation of all the elements on the MMS model.

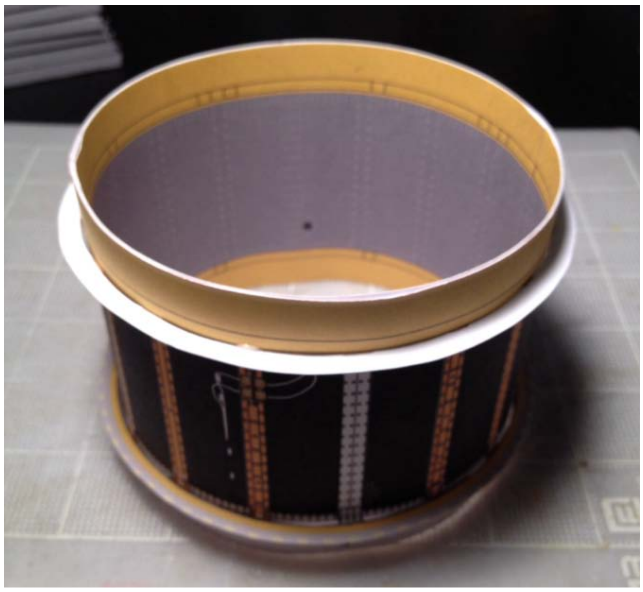
Eventually, the Lower Deck markers will be covered with the solar panels, and the ones on the Upper Deck will be covered with the grey colored strip along the edge.

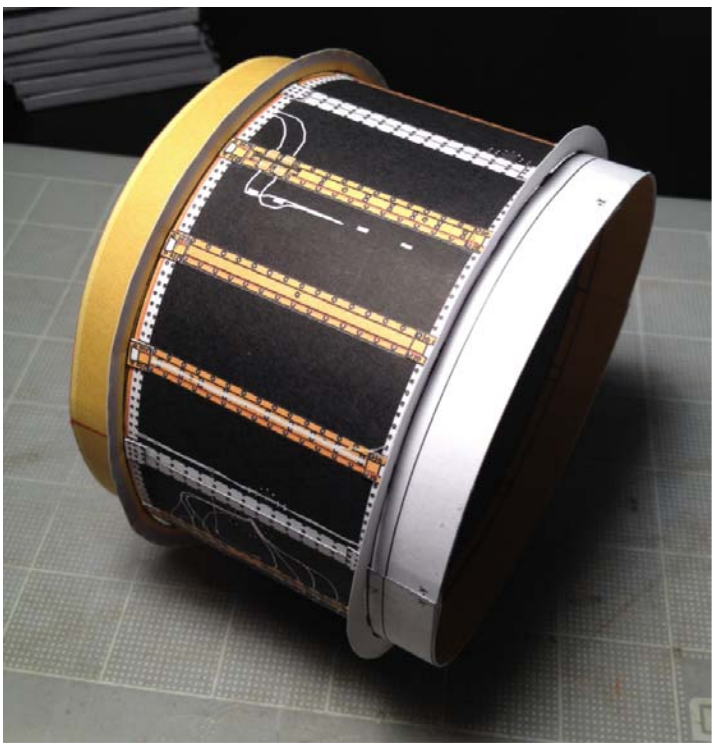
Connecting both decks with the thrust tube



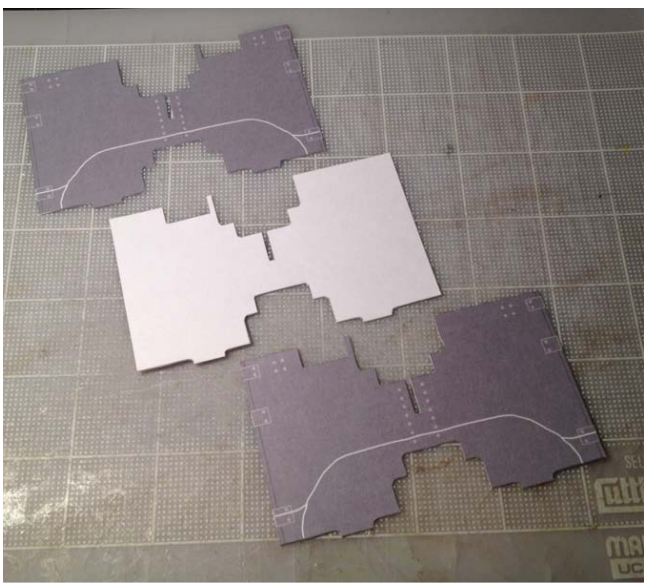


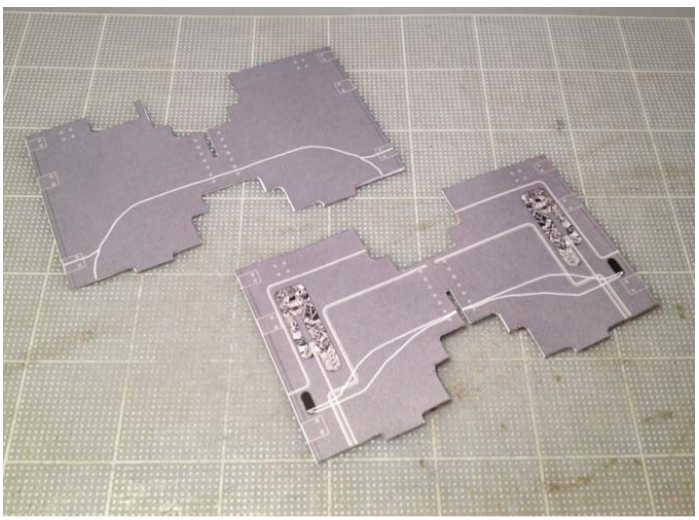


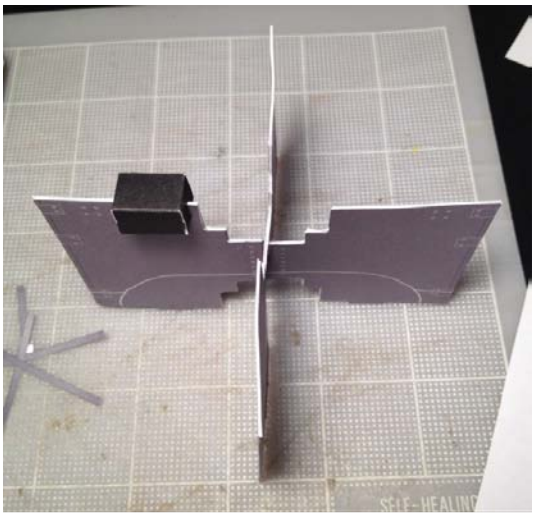


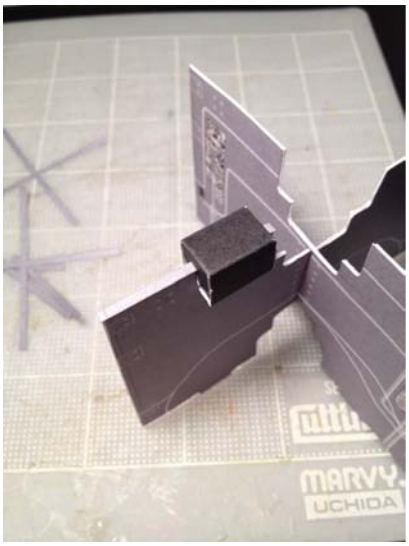


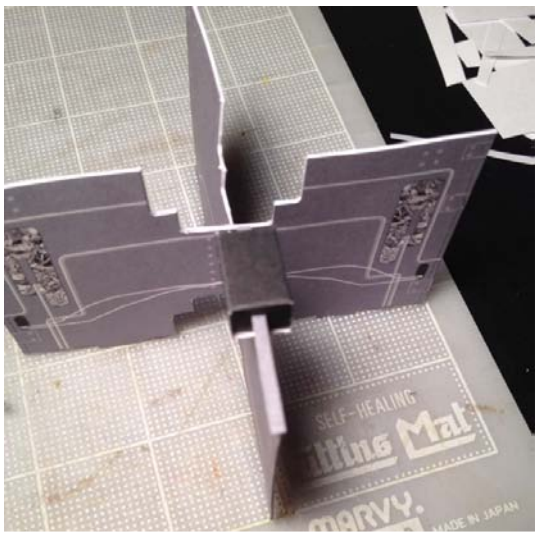
Bulkhead

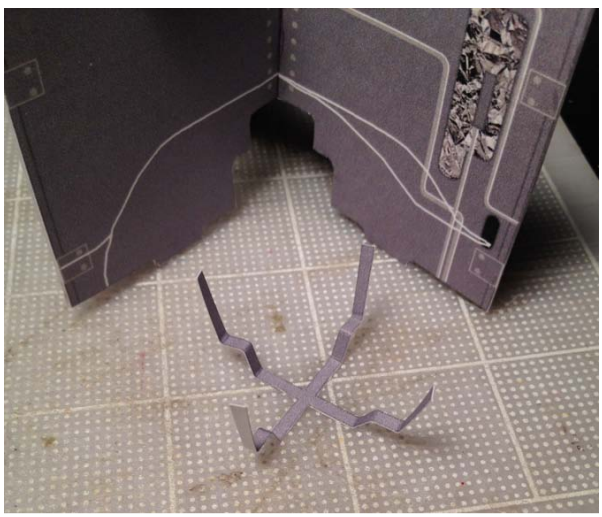


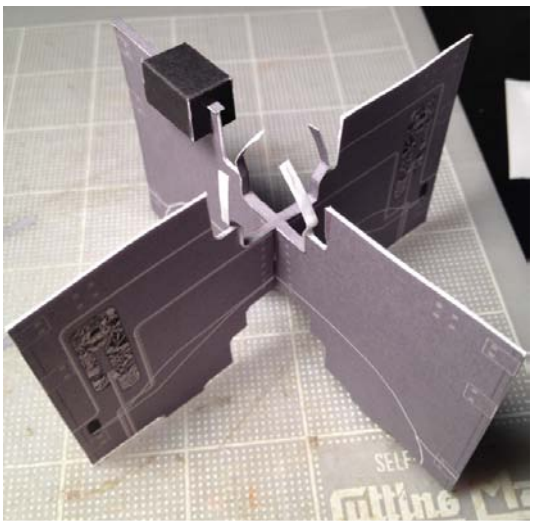


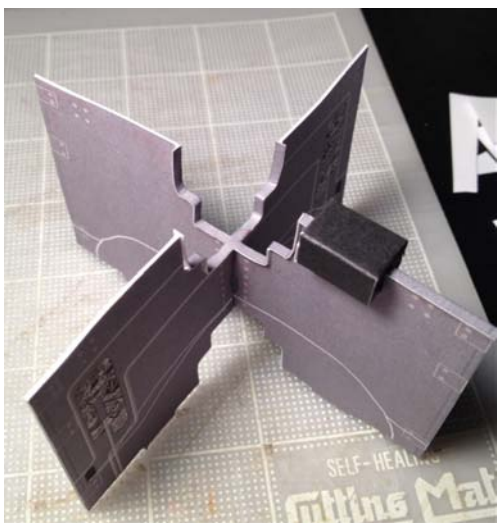


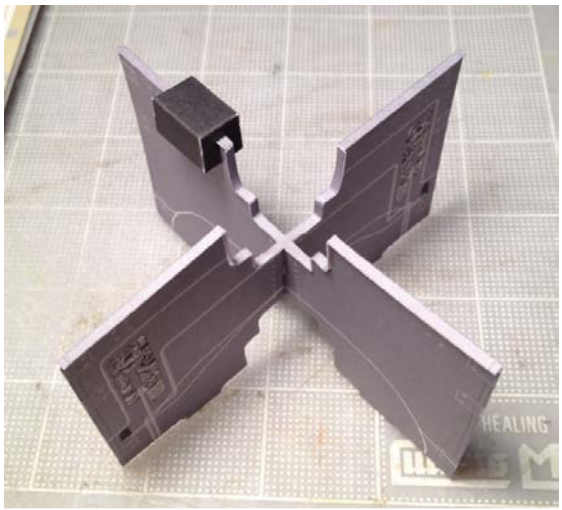

MARVY
UCHIDA

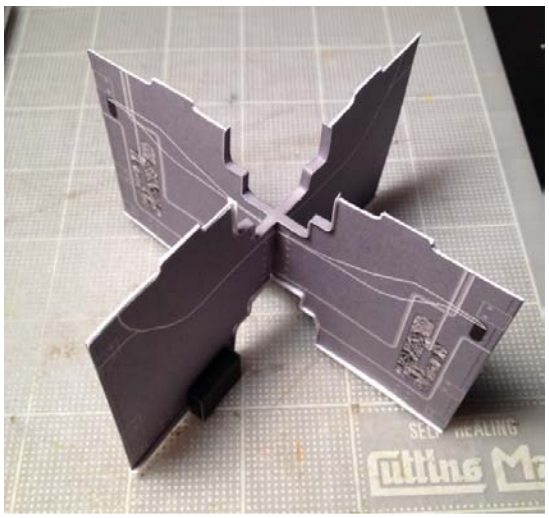

SELF-HEALING
MADE IN JAPAN

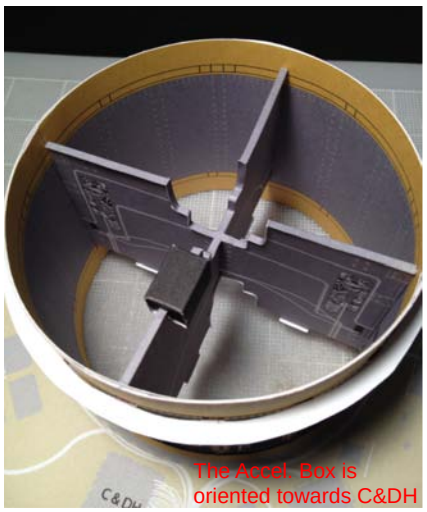


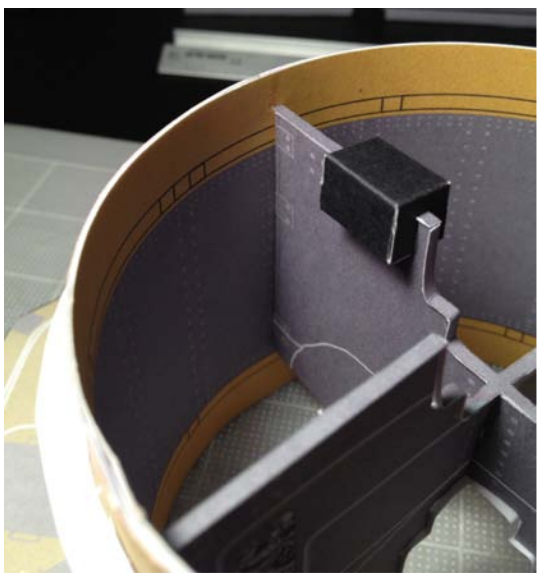


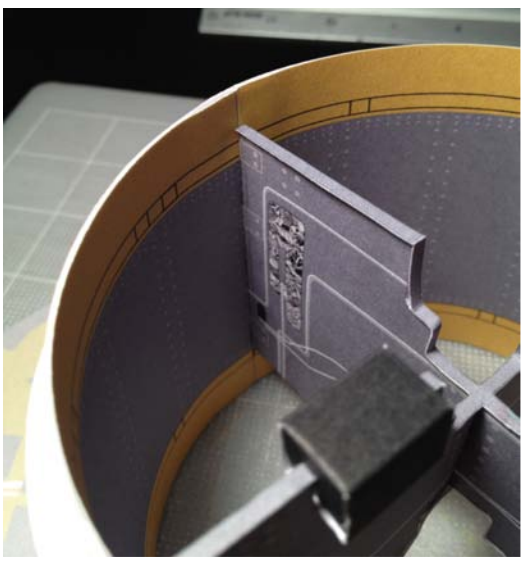


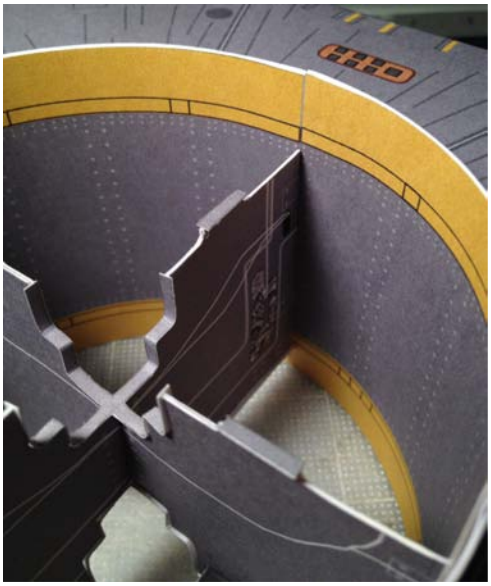


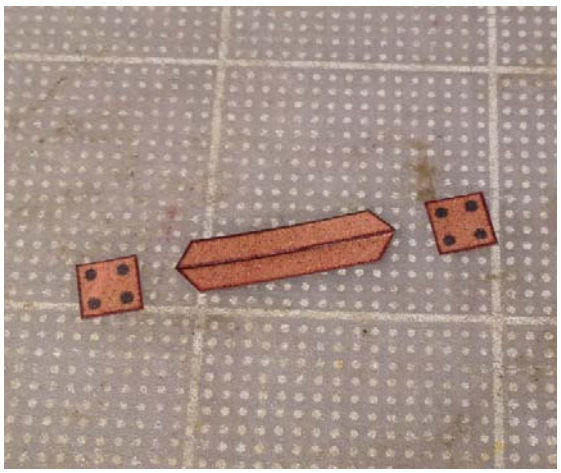


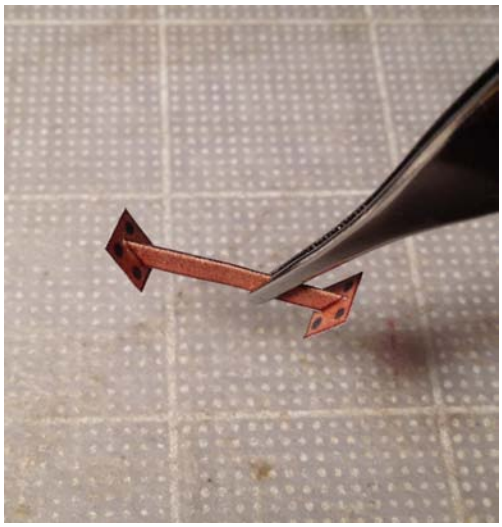

The Accel. Box is
oriented towards C&DH

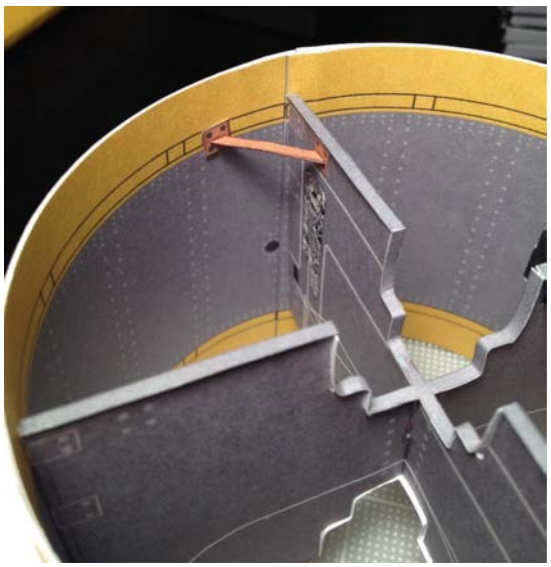


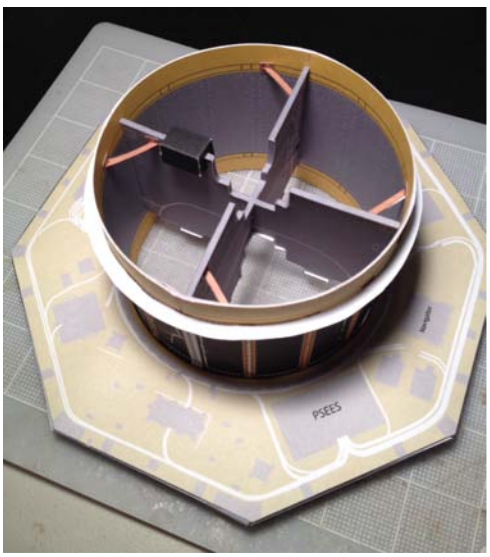




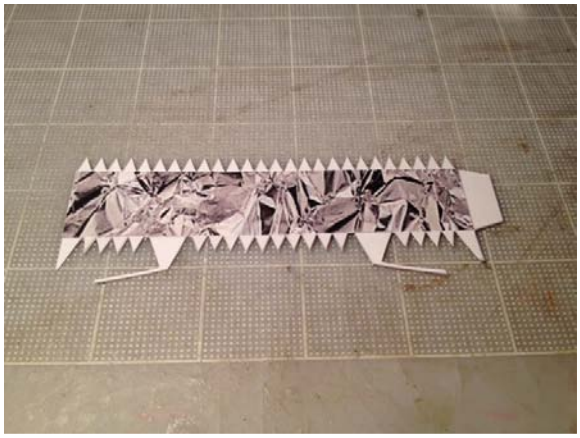


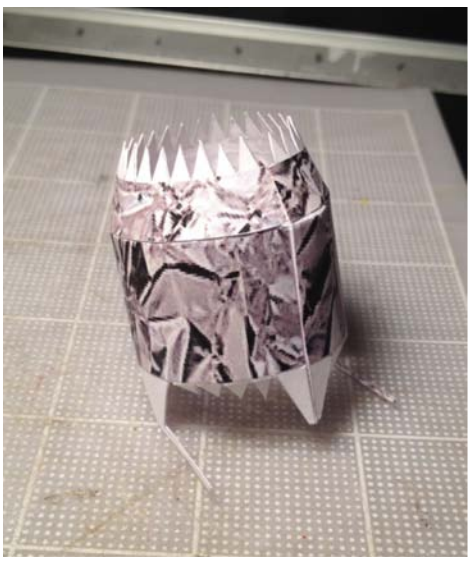


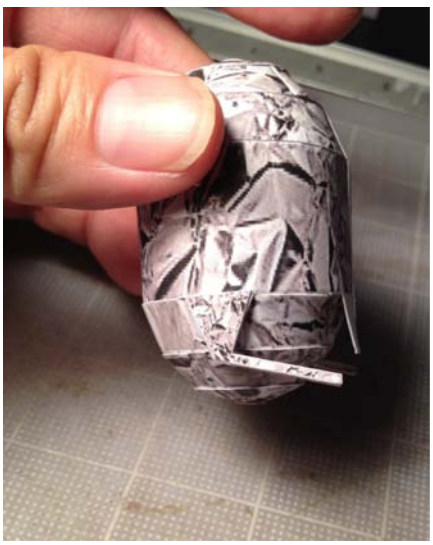


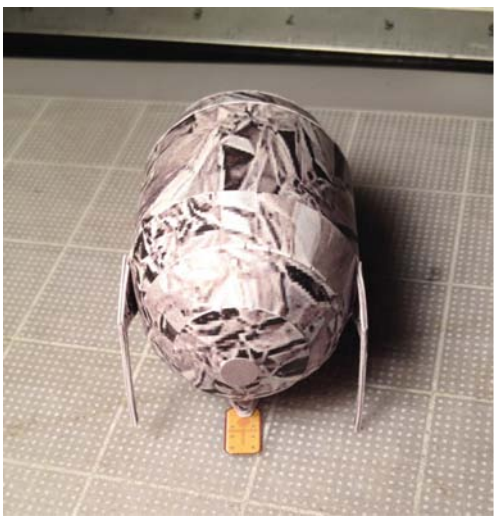


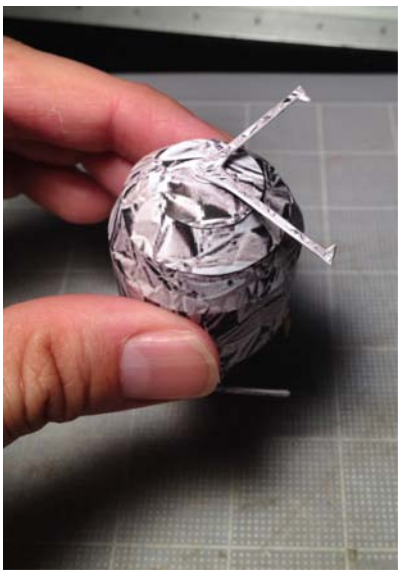
Propulsion Tanks

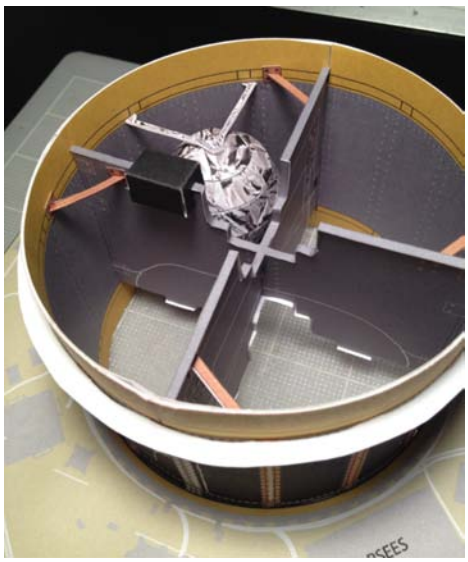


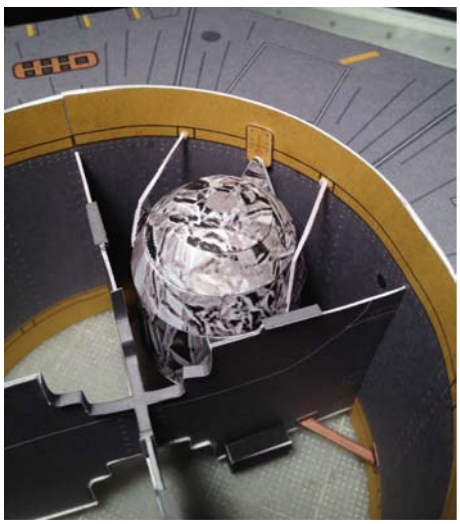


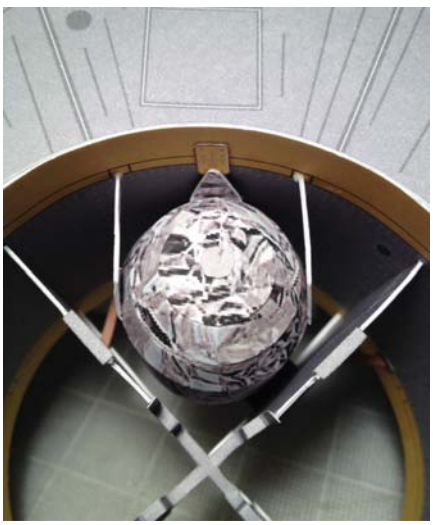


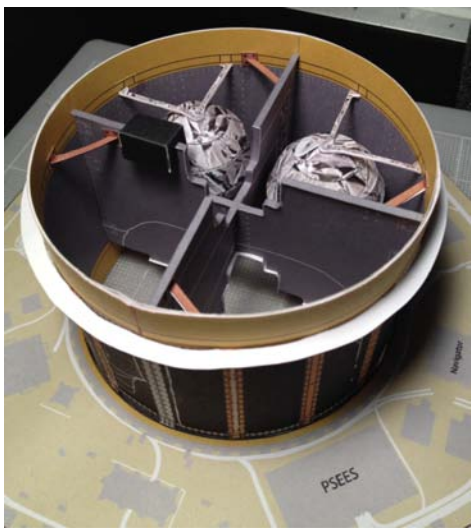


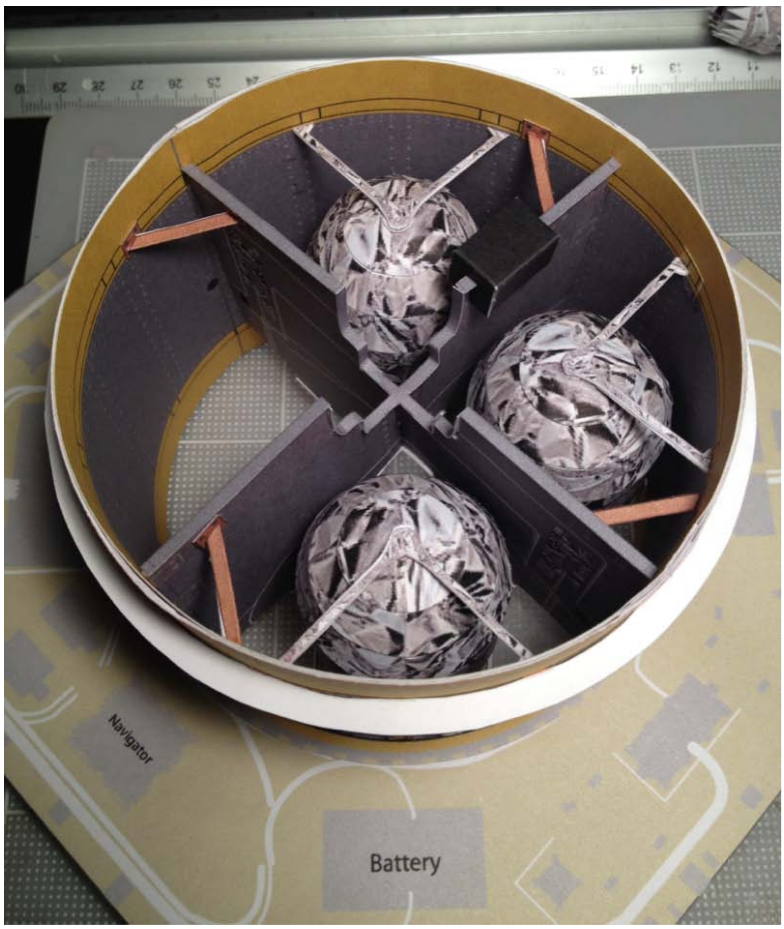


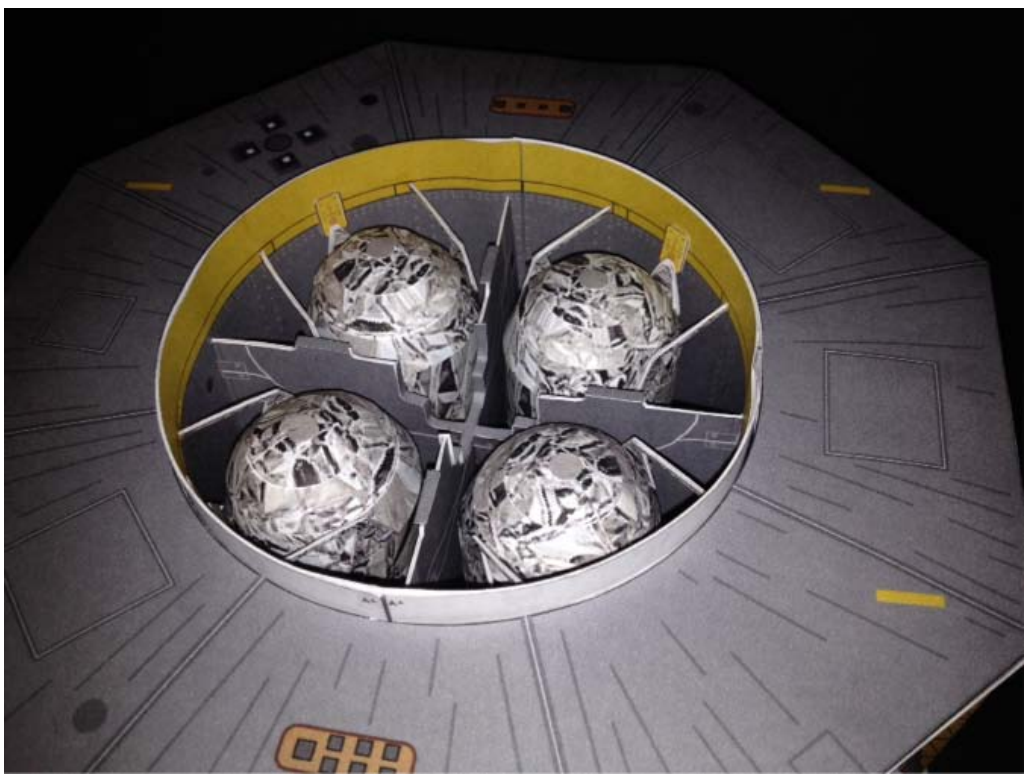




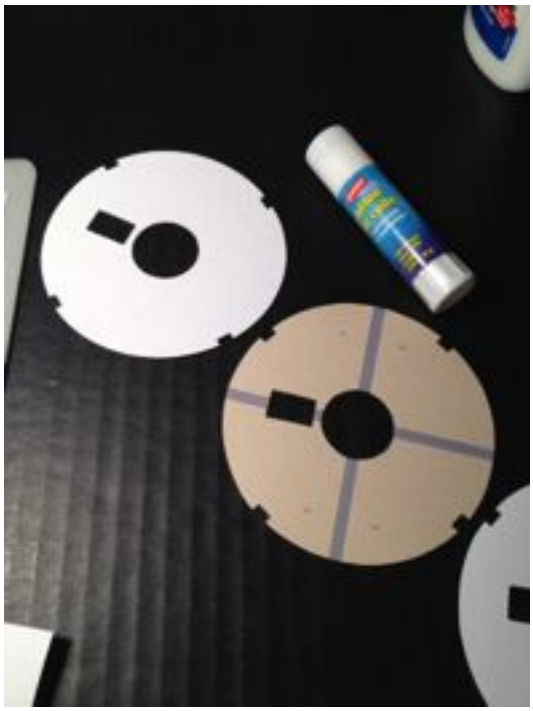




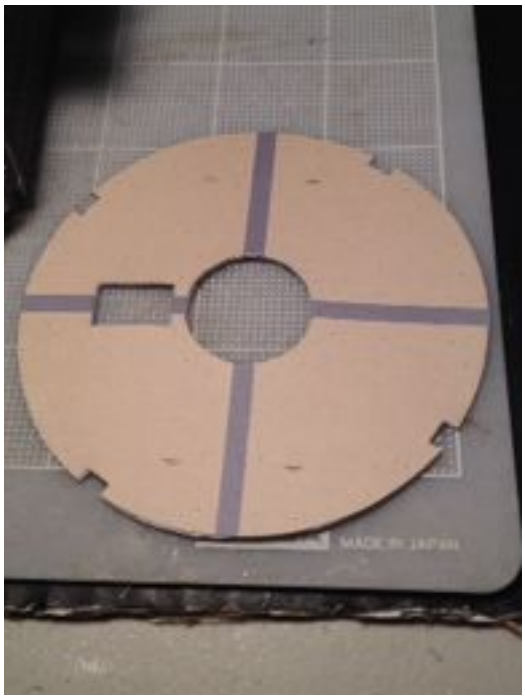

Navigator
Battery



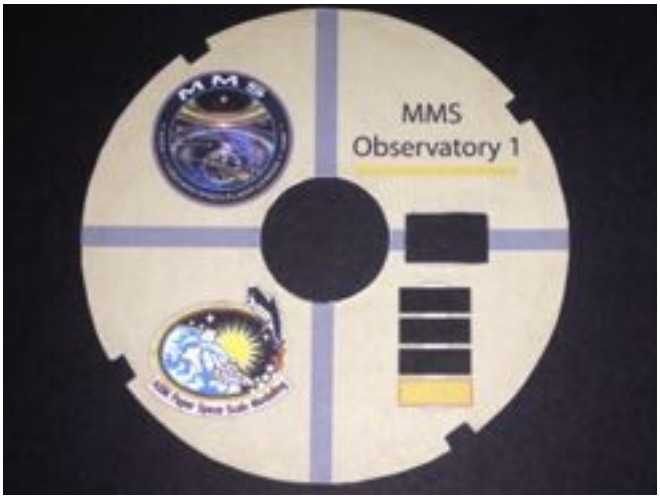
Orbital Debris Panels and Thrust tube covers



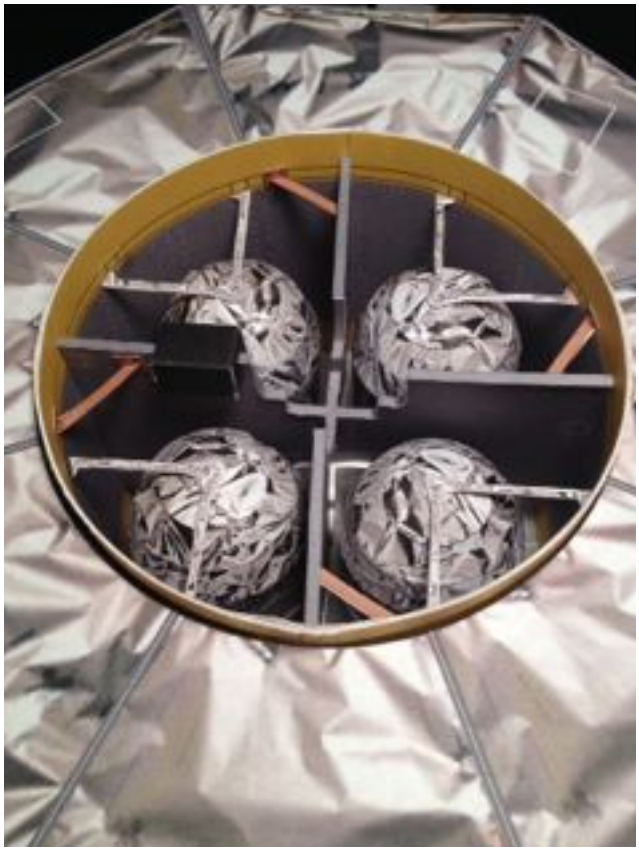
Use glue stick for the debris panels



Top Orbital Debris Panel

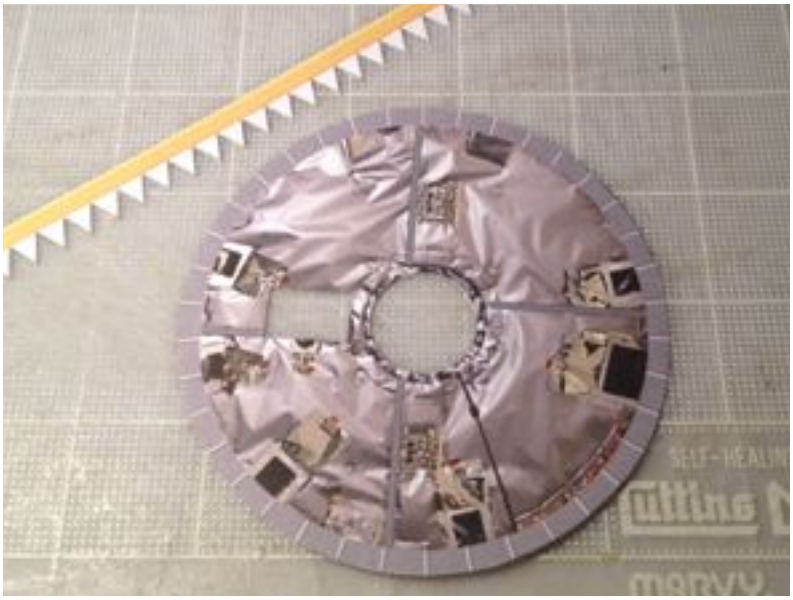


Back side of Top Debris Panel.
Each MMS Observatory will have a unique Orbital Debris Panel with its corresponding color (Gold, Blue, Green or Purple)

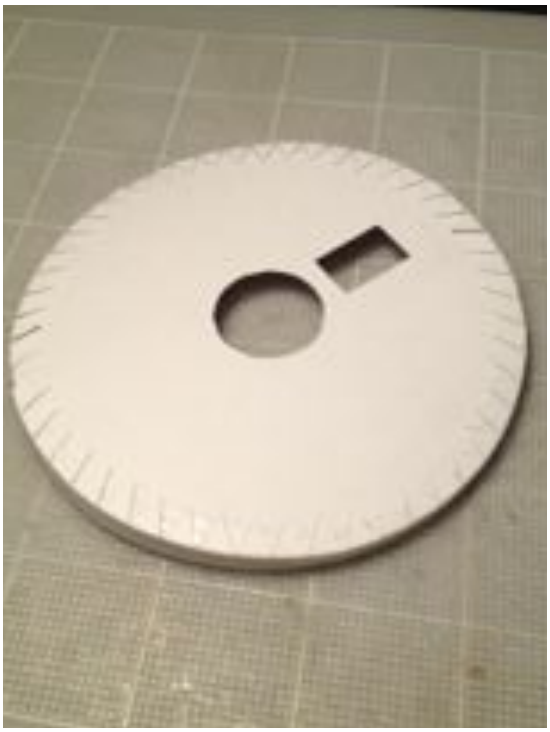


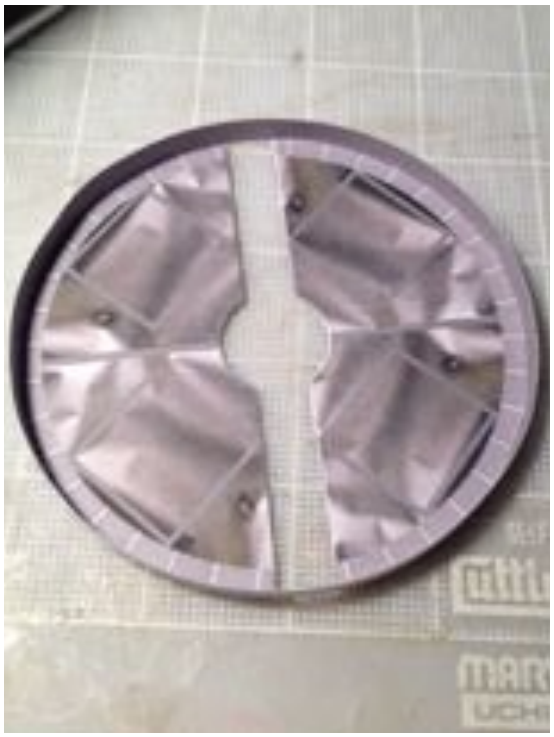
When placing the Orbital Debri Panel, align the black box and snap it with the rectangular cut out of the panel. It should fit perfectly.
DO NOT GLUE the debris panel with the black box.

Adding the Thrust tube covers

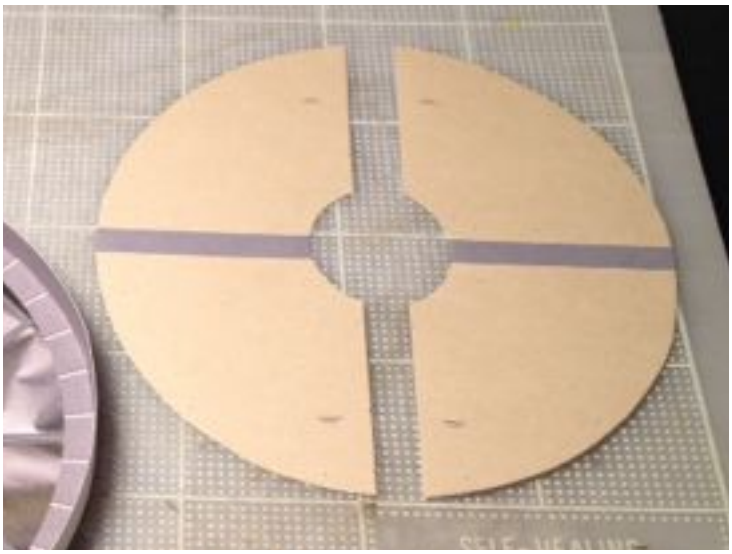


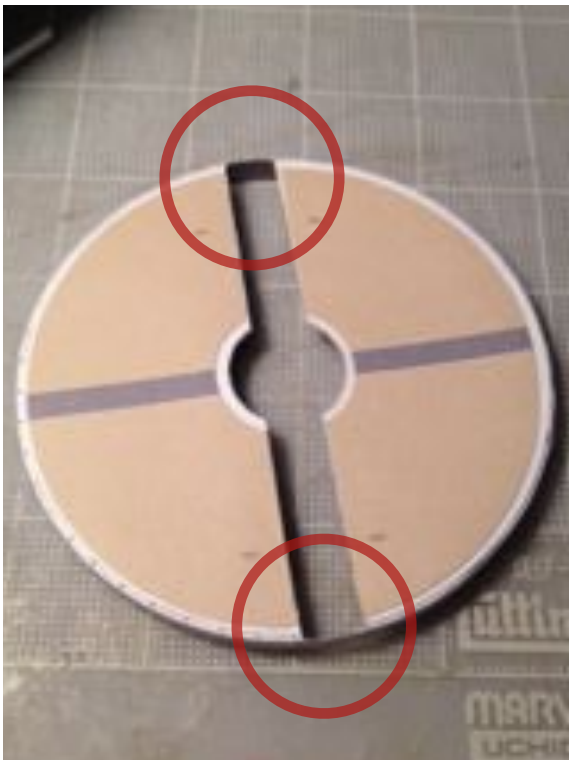
Top Thrust tube cover





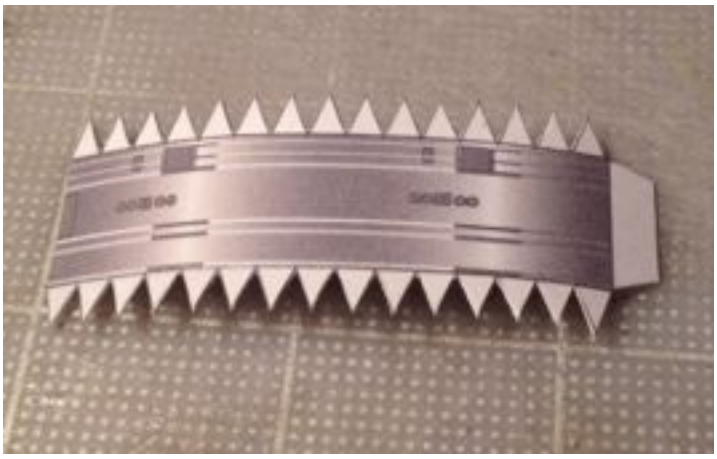
Bottom Thrust tube cover

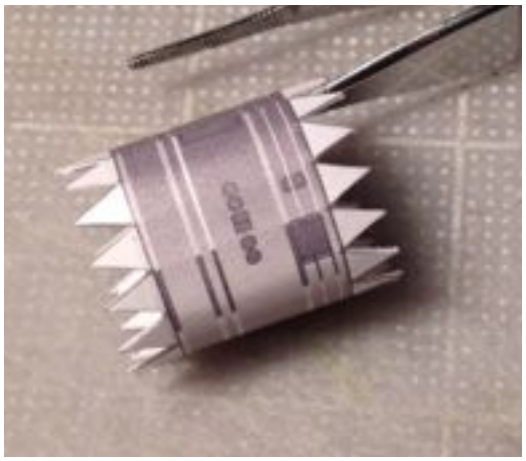


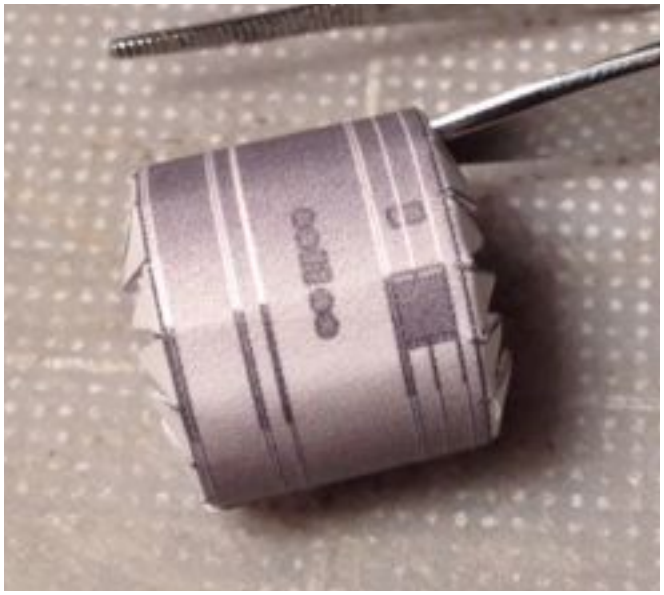


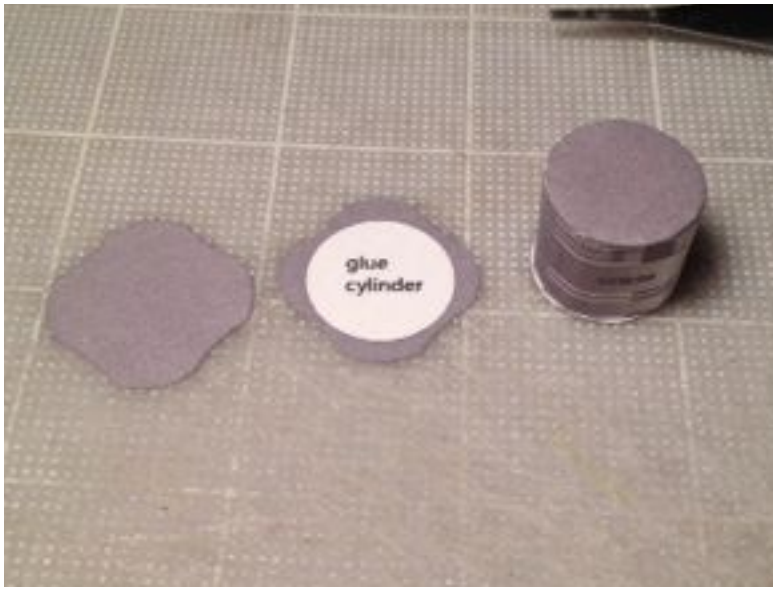
The bottom debris panel is different because it has 2 halves, therefore, when glued to the ring, one must cut out the extra triangular tabs around the areas circled on the above photo.

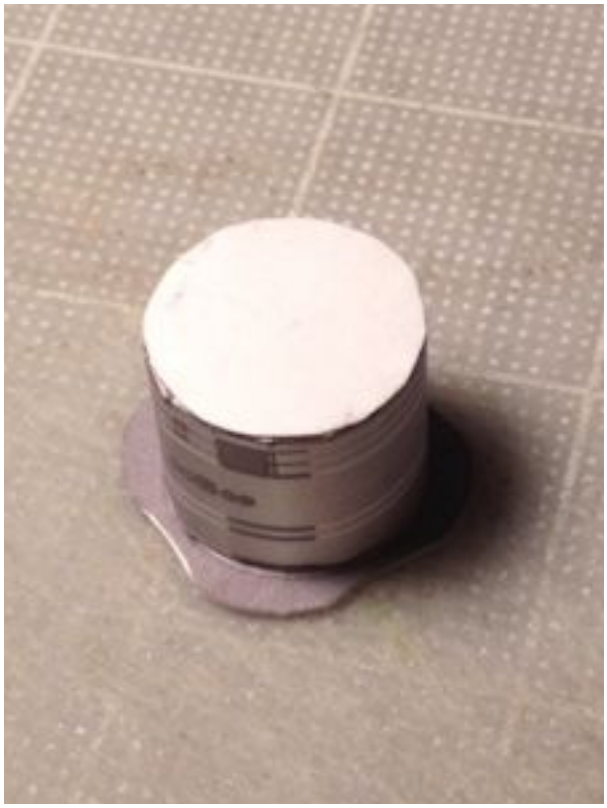
Adding the Axial Double Probe (ADP) canisters

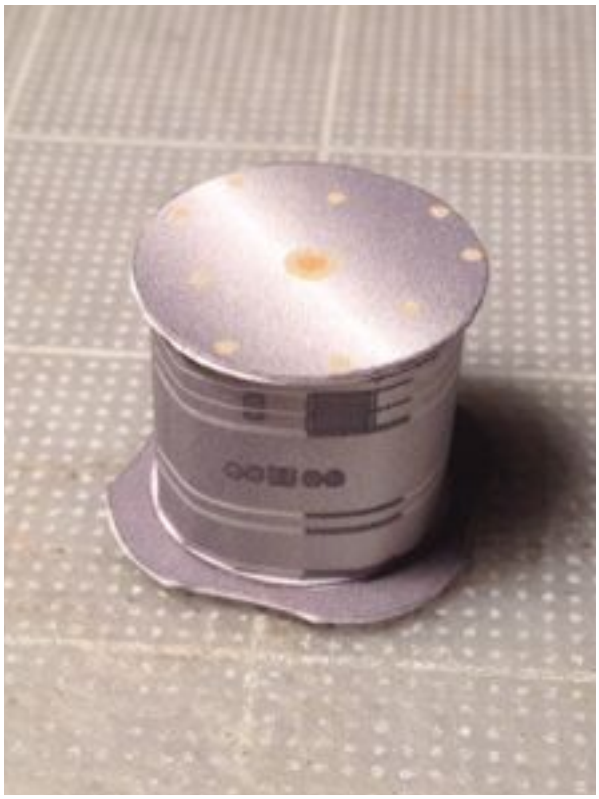




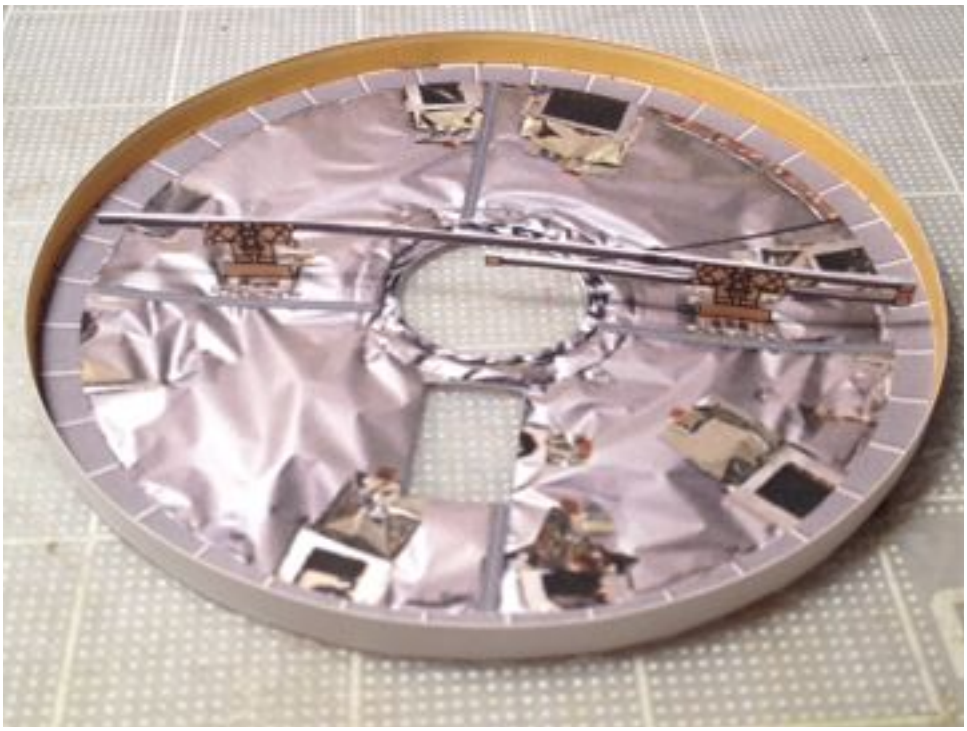



glue
cylinder

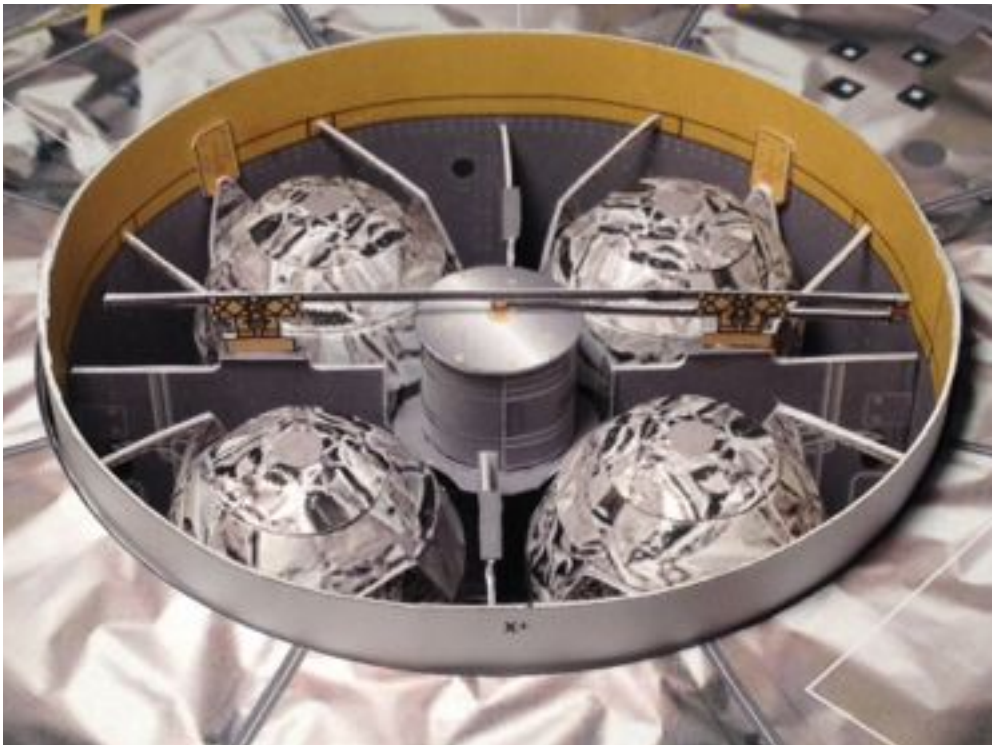




Adding the Extensible Boom Antennas



IMPORTANT: Notice the orientation of the top antenna in relation with the cut out for the box. Glue the antenna on the 2 yellow markings on top of the panel cover.



The bottom antenna is glued on the small gray flat areas of the bulkhead and its orientation needs to match the top antenna as well, pointing towards +Y (see bulkhead markers)

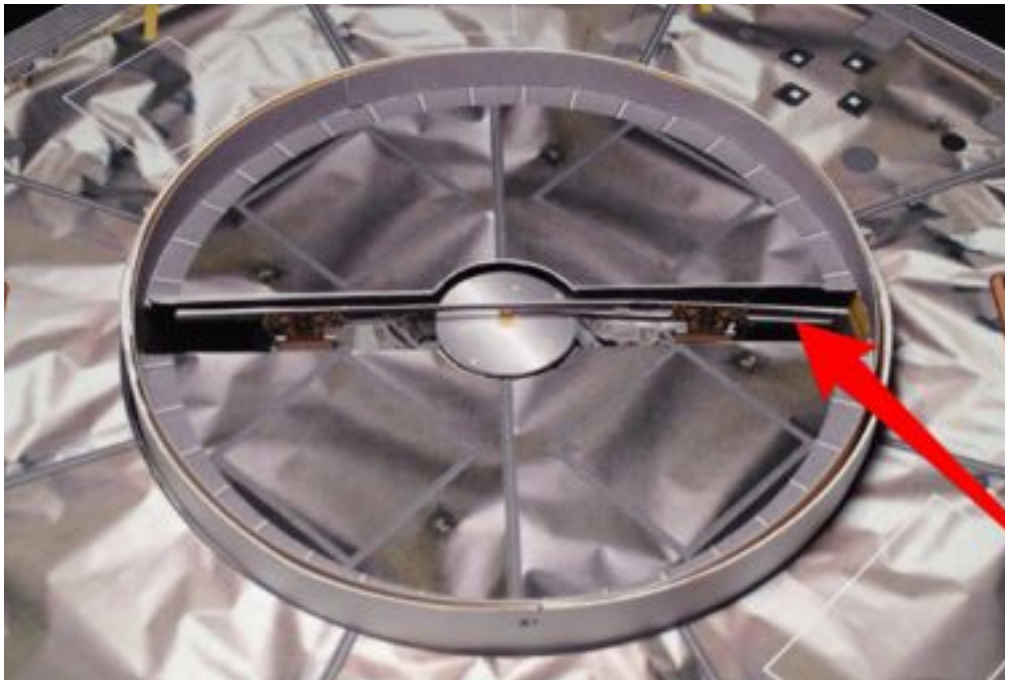
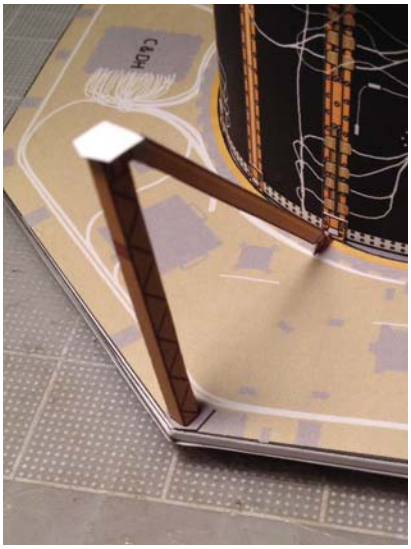
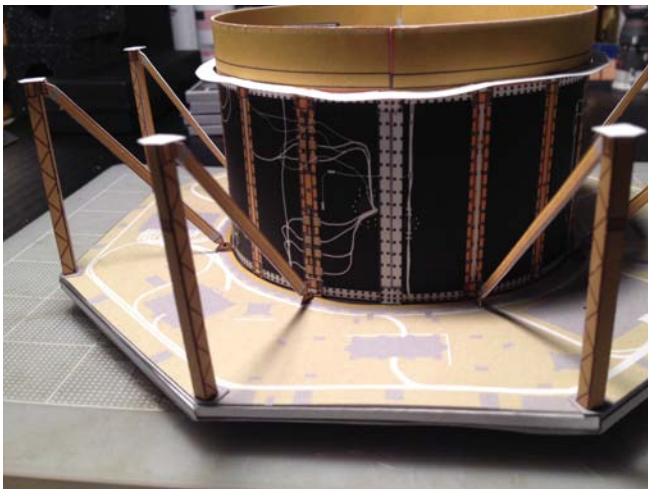
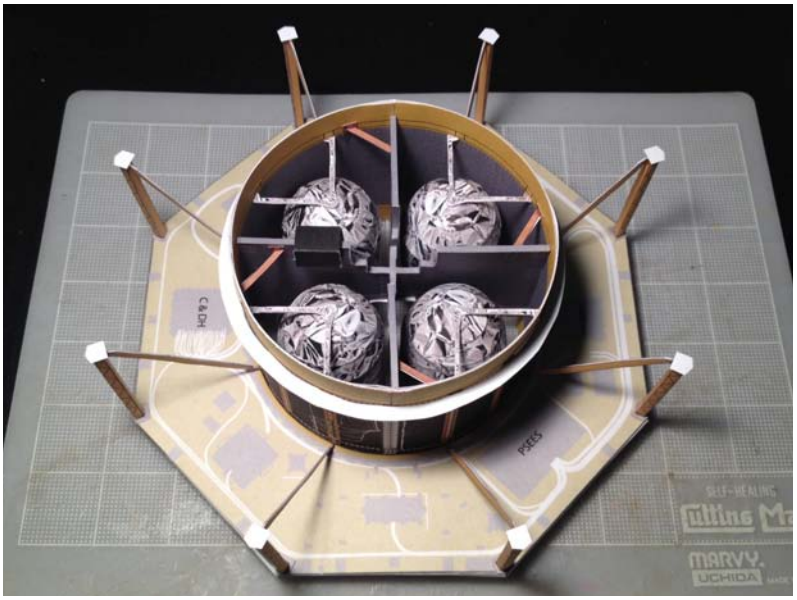


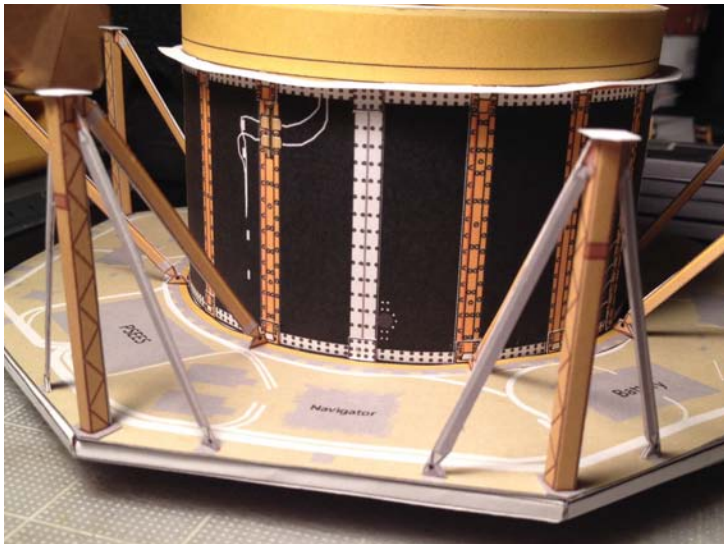
Photo shows the bottom extensible boom antenna with the thrust tube cover on top.
DO NOT GLUE both thrust tube covers on the model. These are detachable.

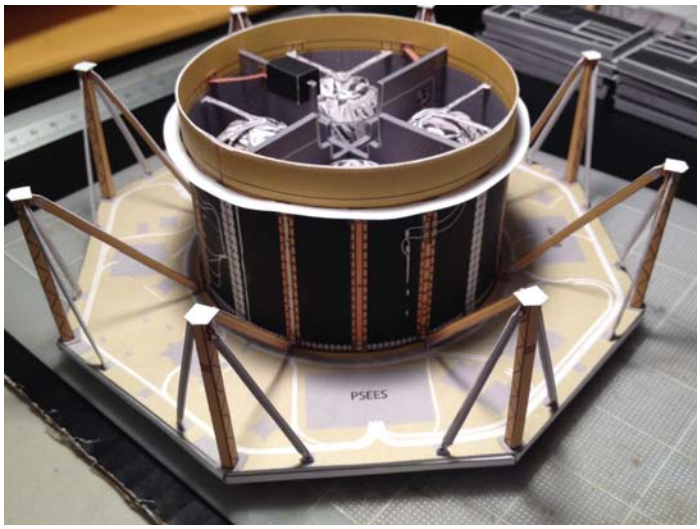
3. Struts Assembly on the Lower Deck

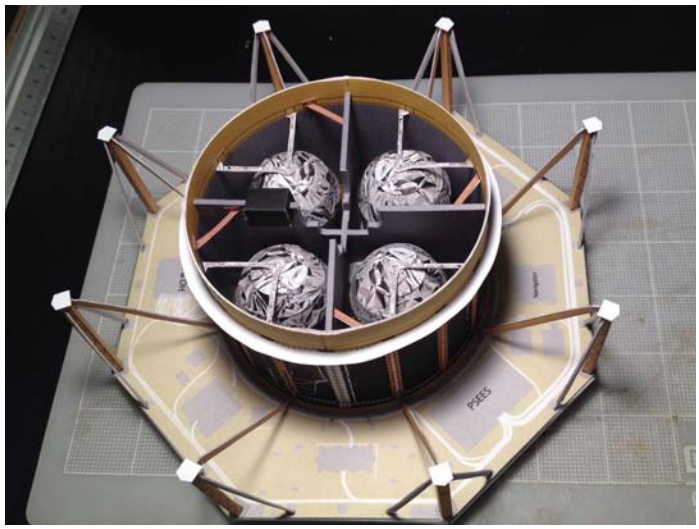


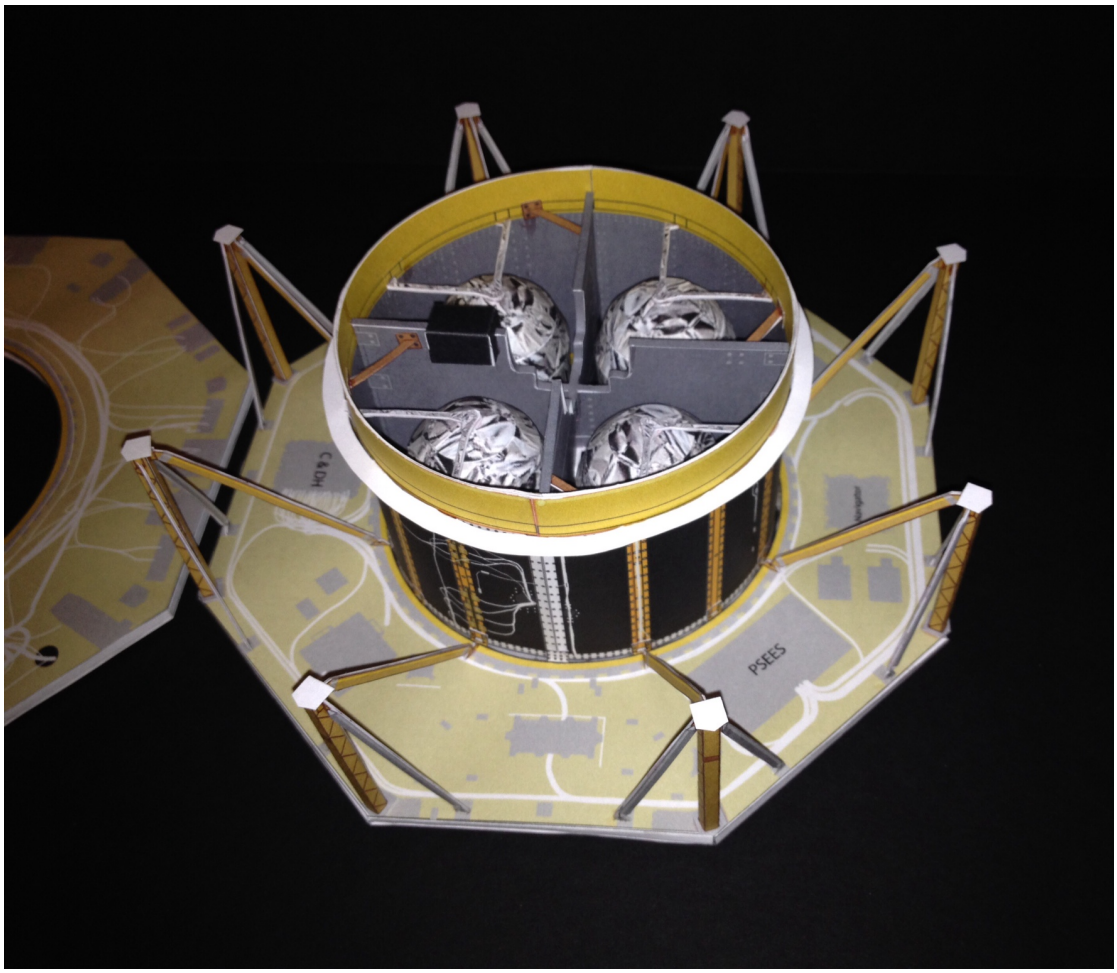


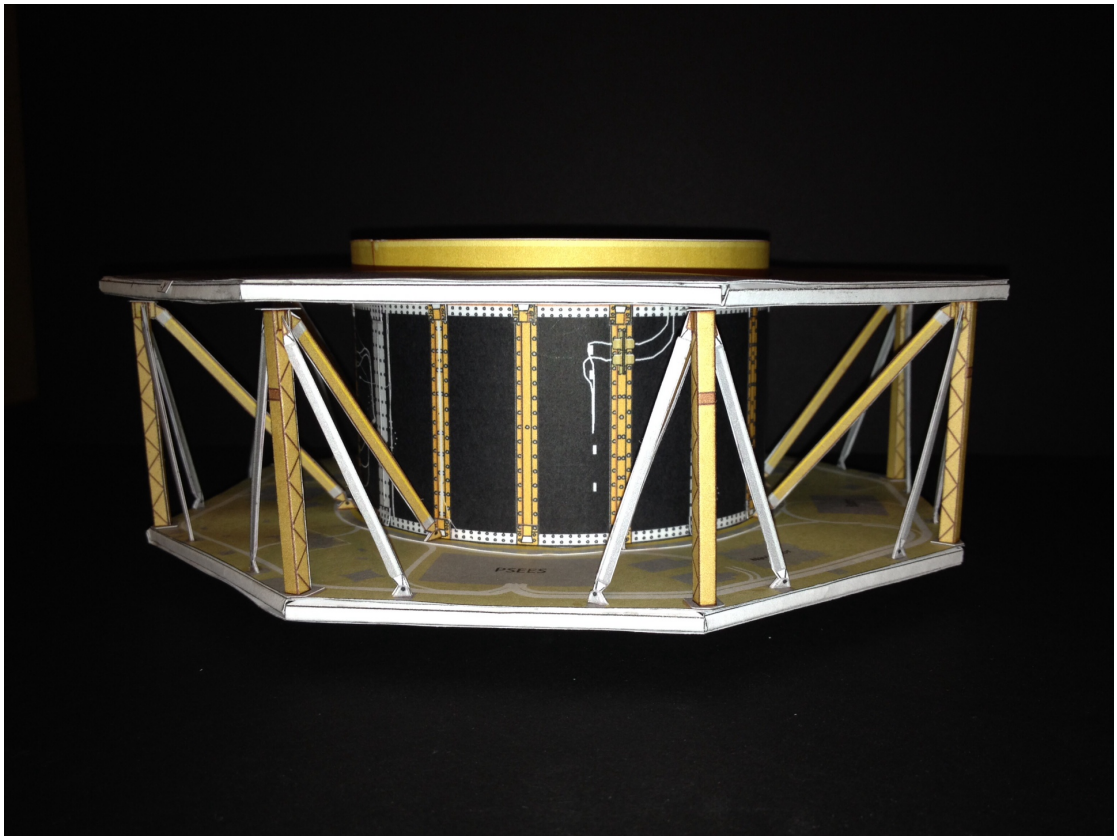

PSEES
MARVY
UCHIDA


Navigator

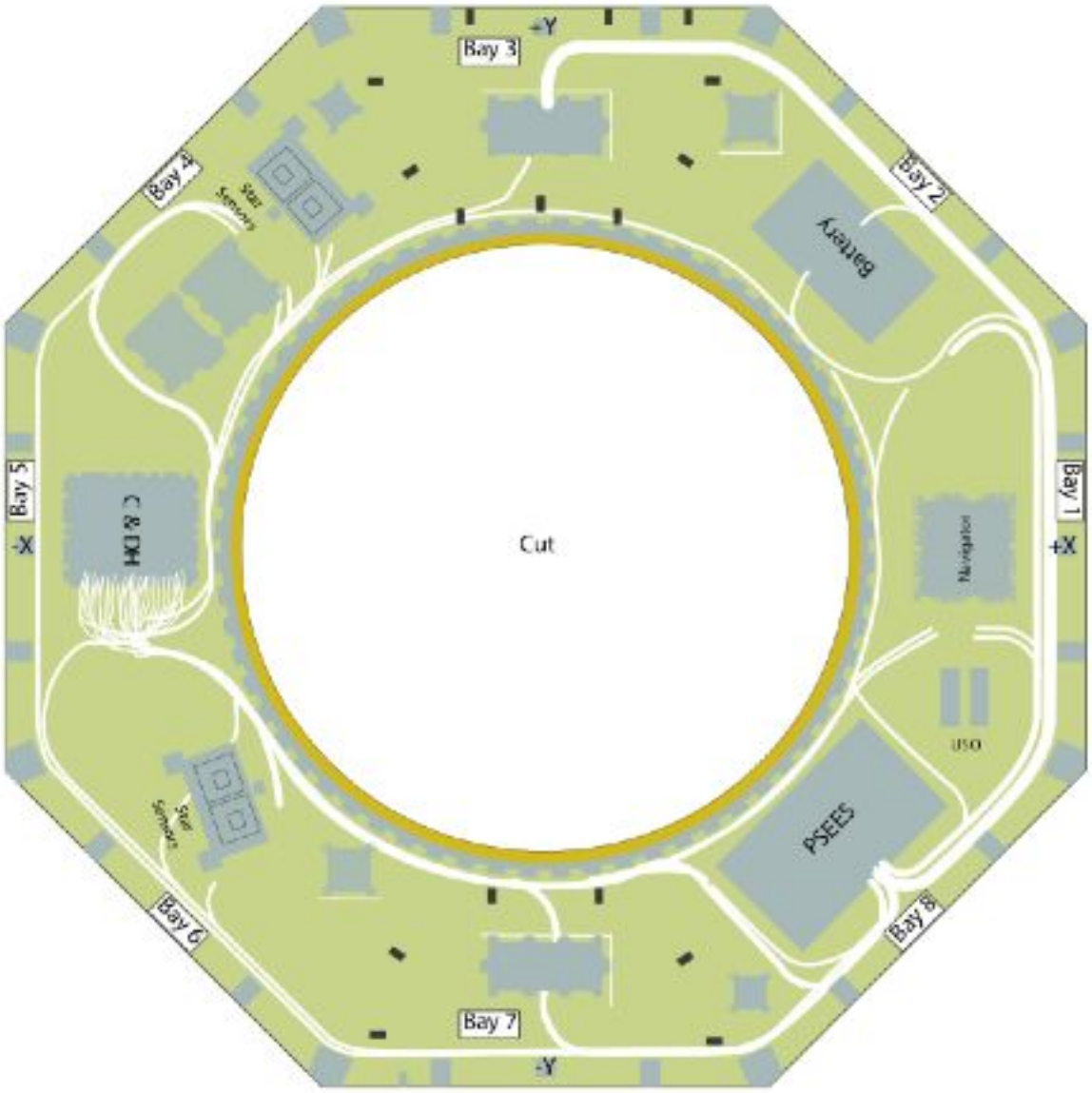

PSEES


PSEES


C&DH
PSEES


PSEES

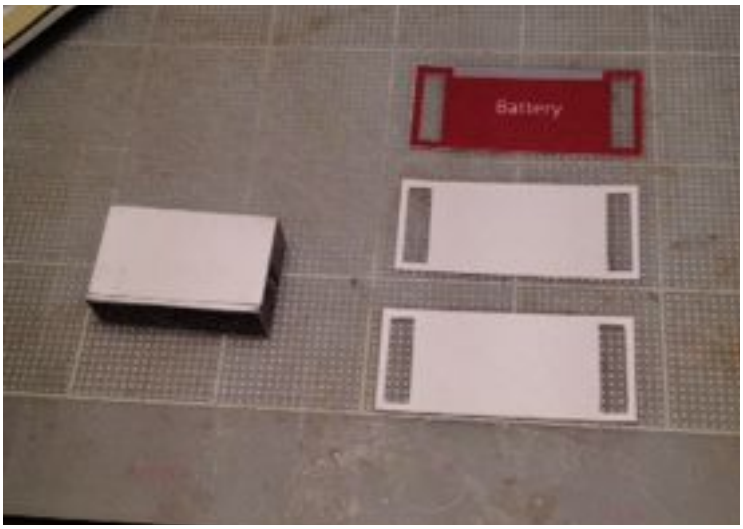
4. Spacecraft Deck Instruments (Lower Deck)

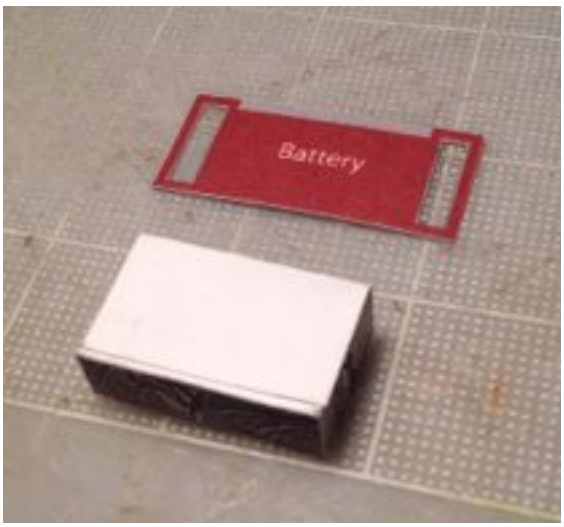


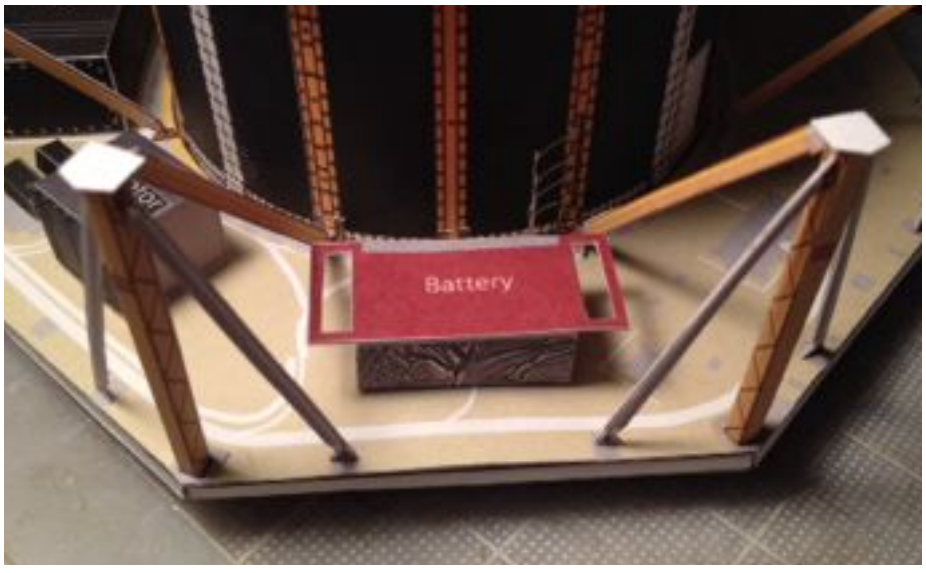
The Spacecraft Deck (Lower Deck) of the MMS has indicators where all the instruments are glued to. The instruments are glued based on the orientation of the text on the boxes.

The X and Y coordinates will assist to orient the model and its elements during the assembly process. At the same time, this model serves as an educational tool to teach the general public about the MMS spacecraft.

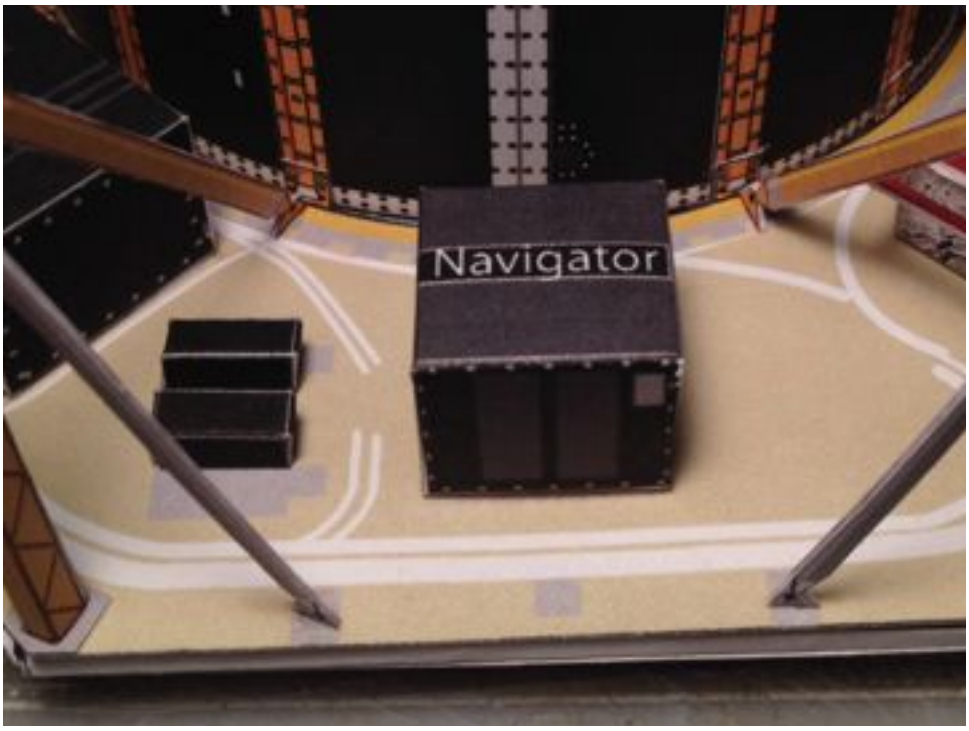
Battery (Bay 2)





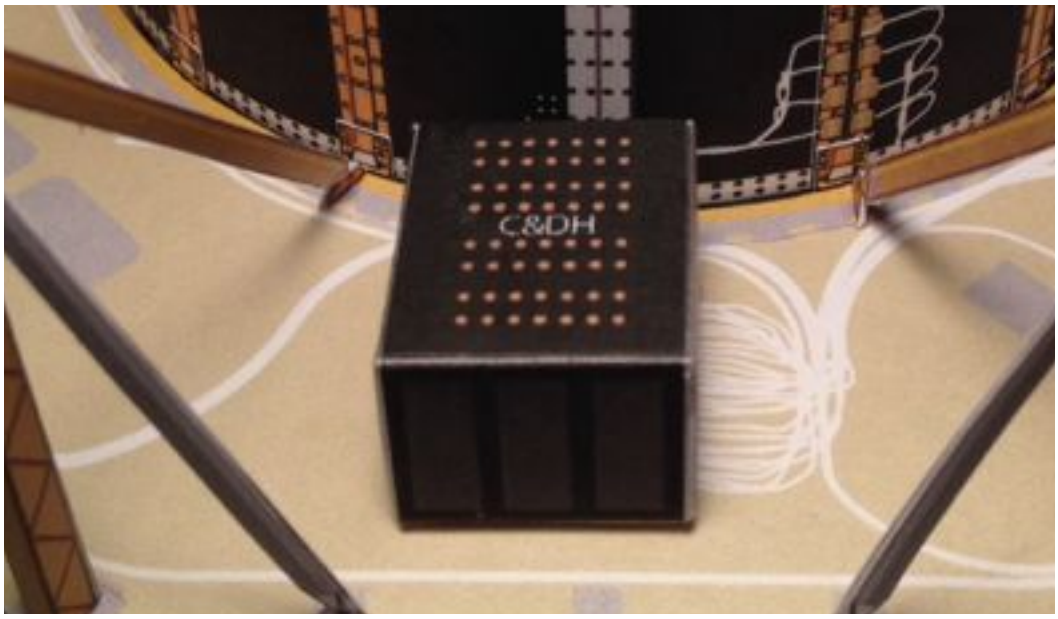


Navigator and USO (Ultra Stable Oscillators) (Bay 1)

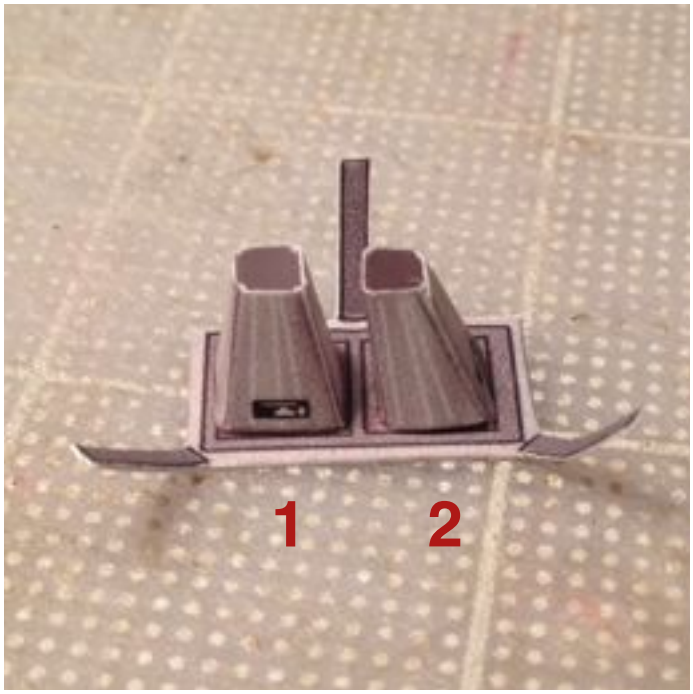


PSEES (Power System and Engine Valve Drive Electronics System) (Bay 8)

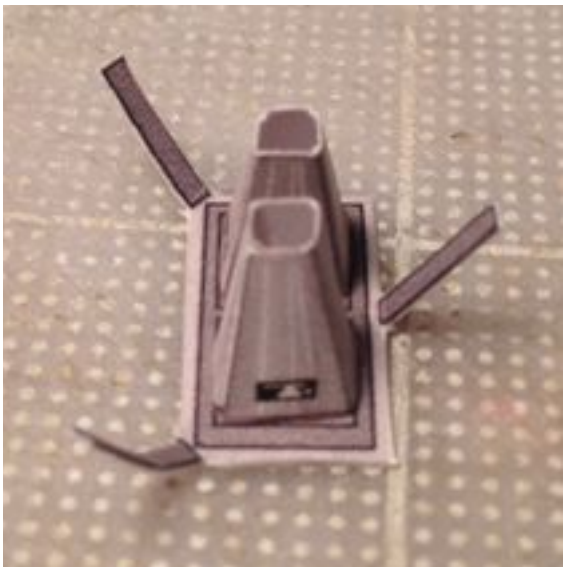
C&DH (Command & Data Handling) (Bay 5)

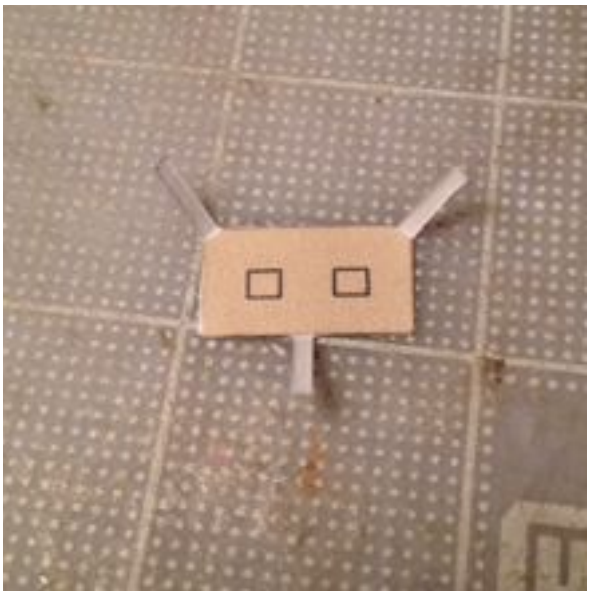


Star Sensors (Bays 4 and 6)

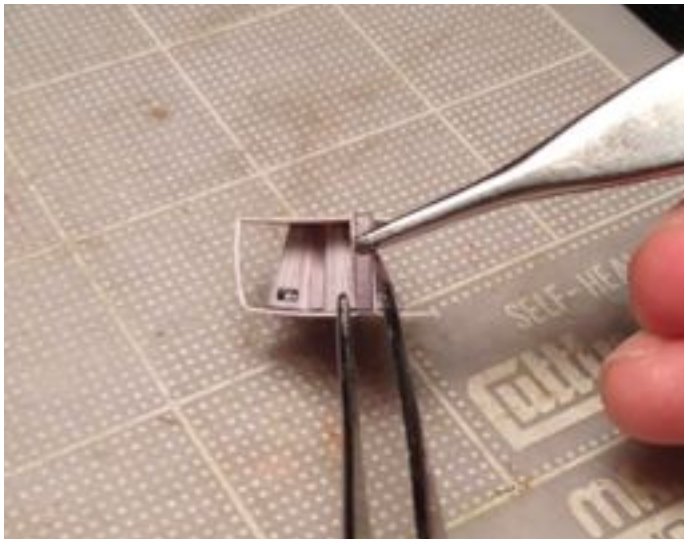


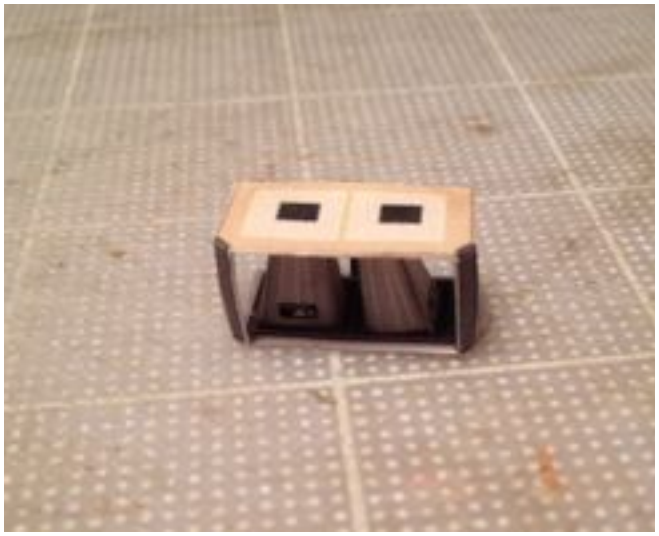
Notice that the pyramidal cone #2 is more slanted in an angle as compared to #1.



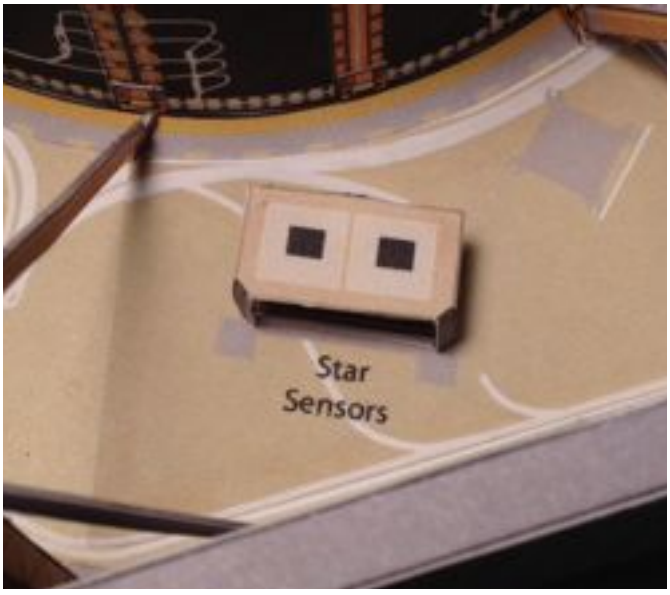


SELF-

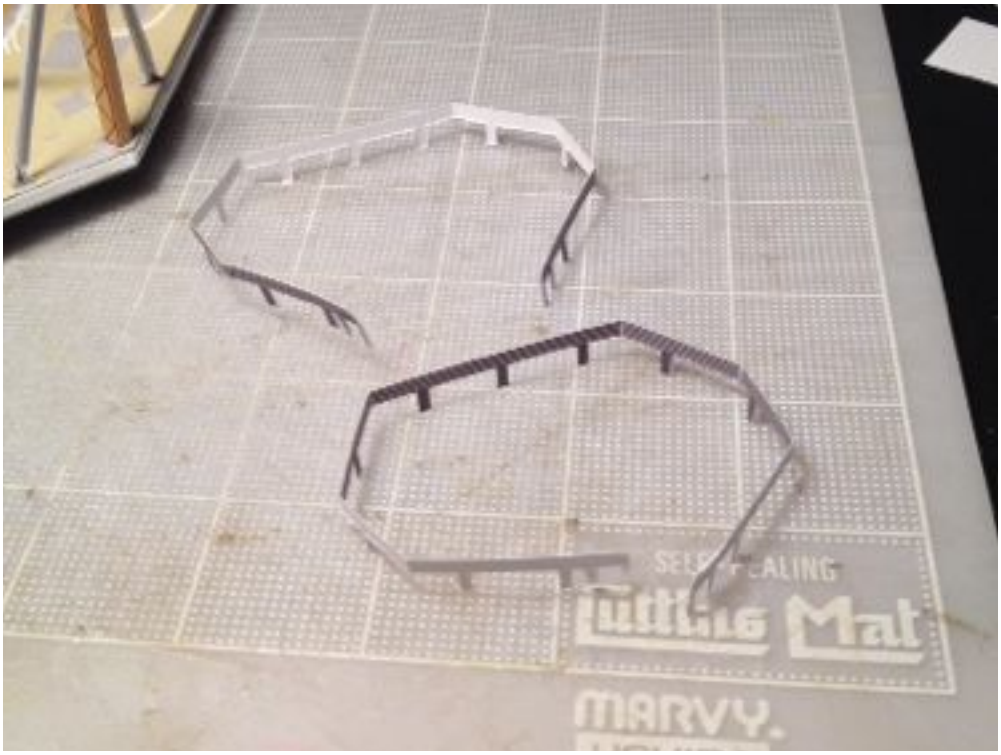


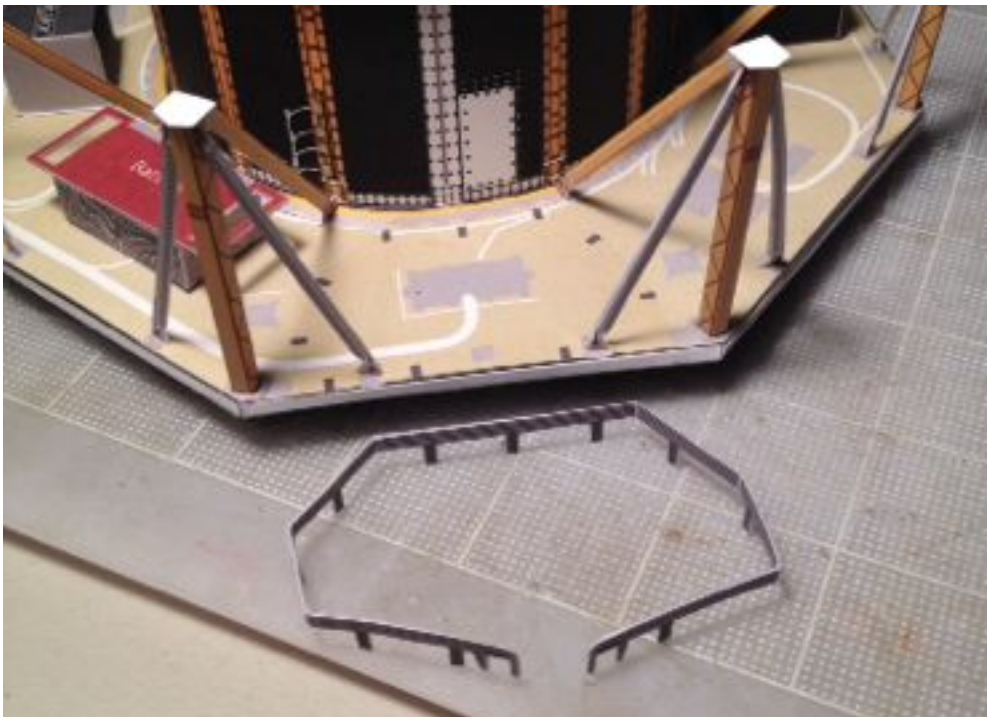


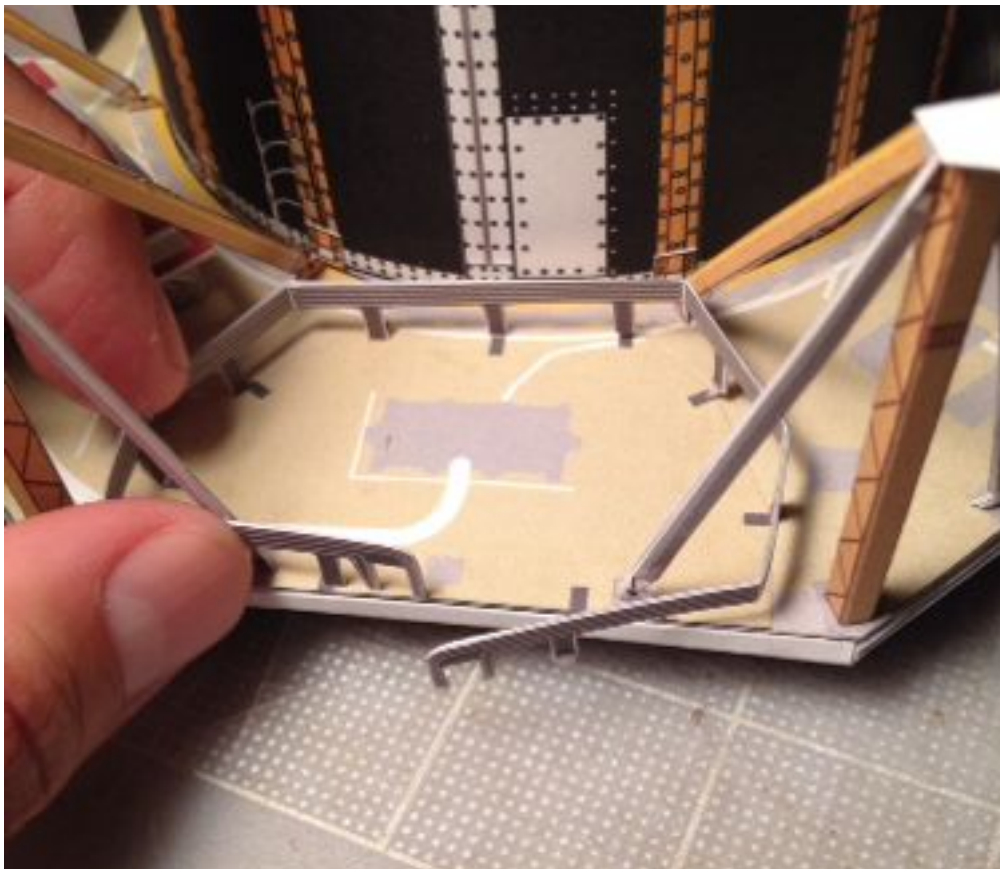
Star
Sensors

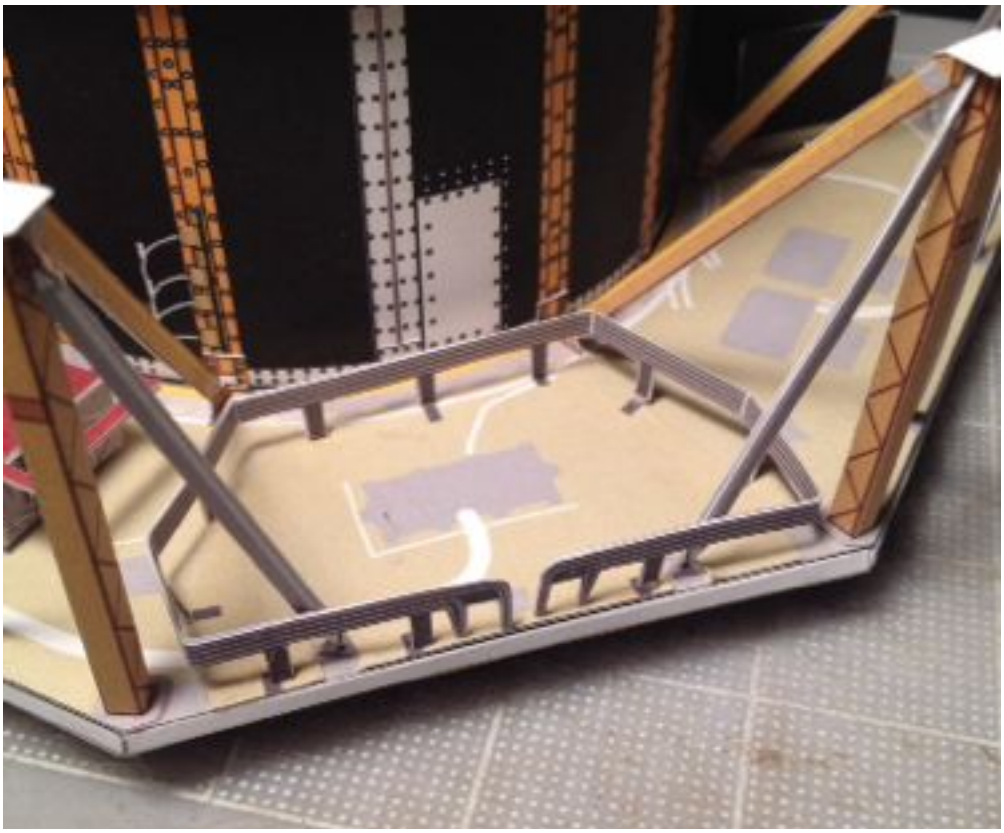

Star
Sensors

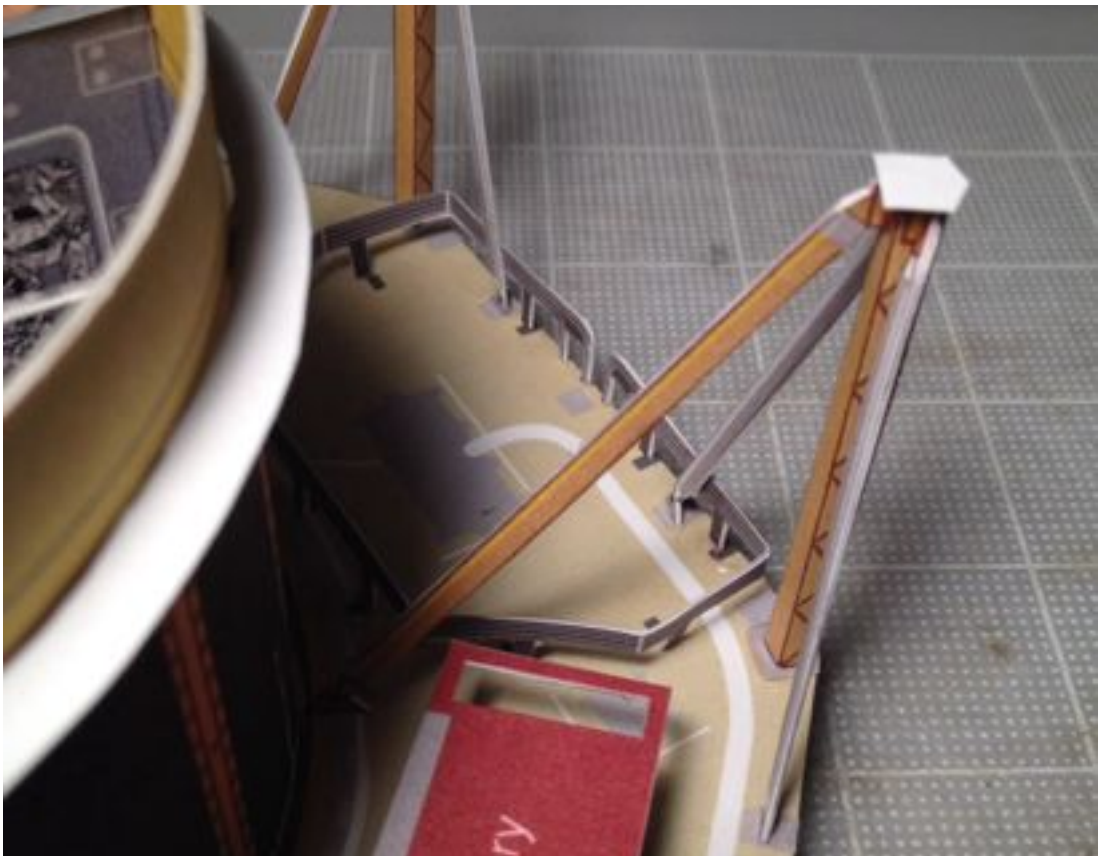
Propulsion Lines (Bay 3)

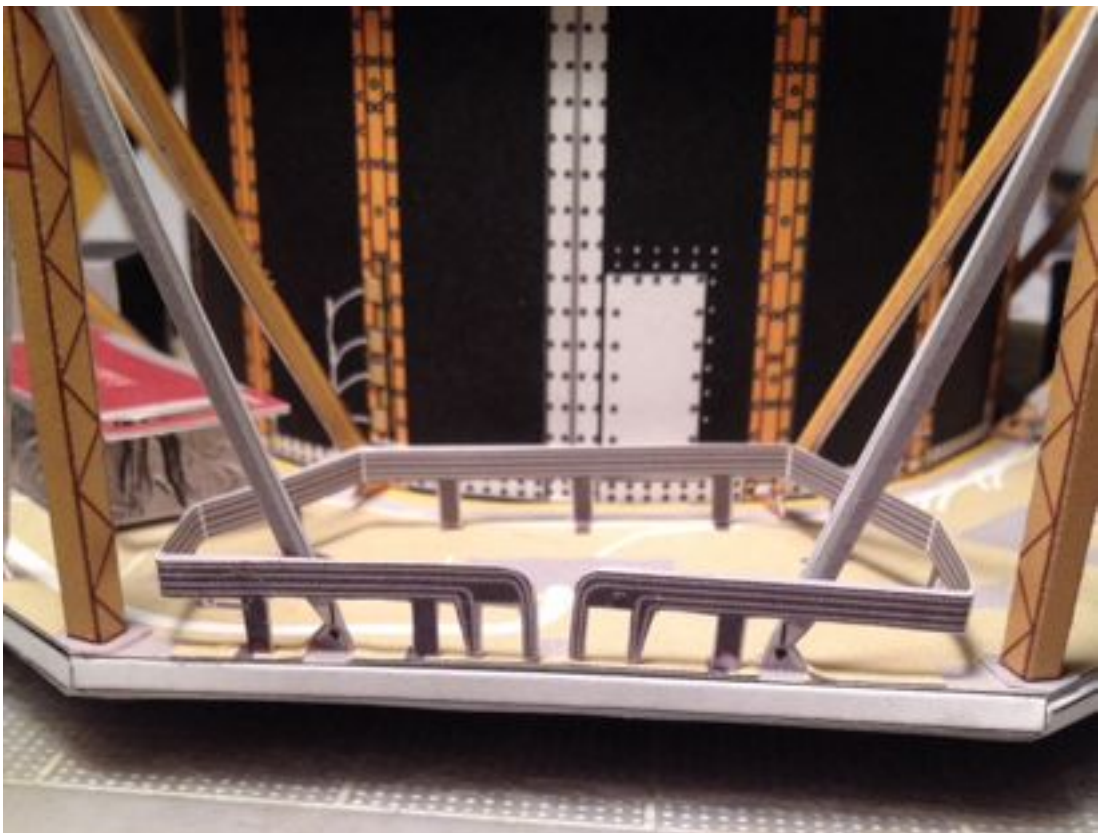




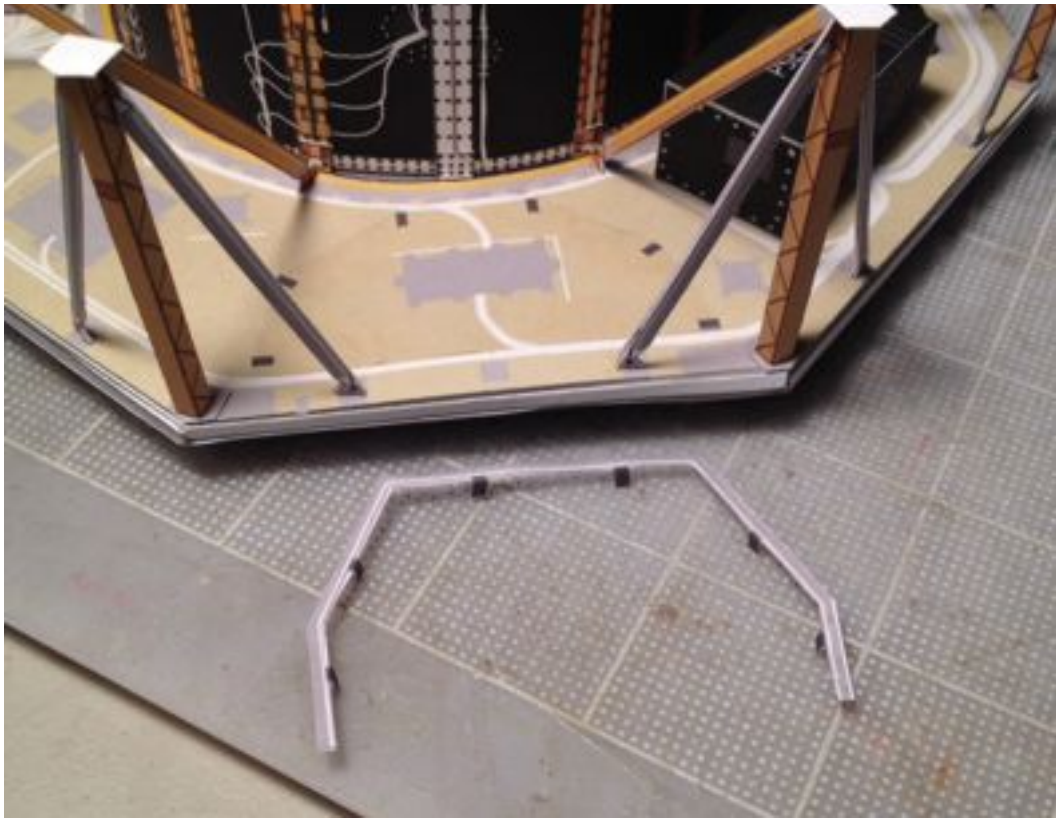


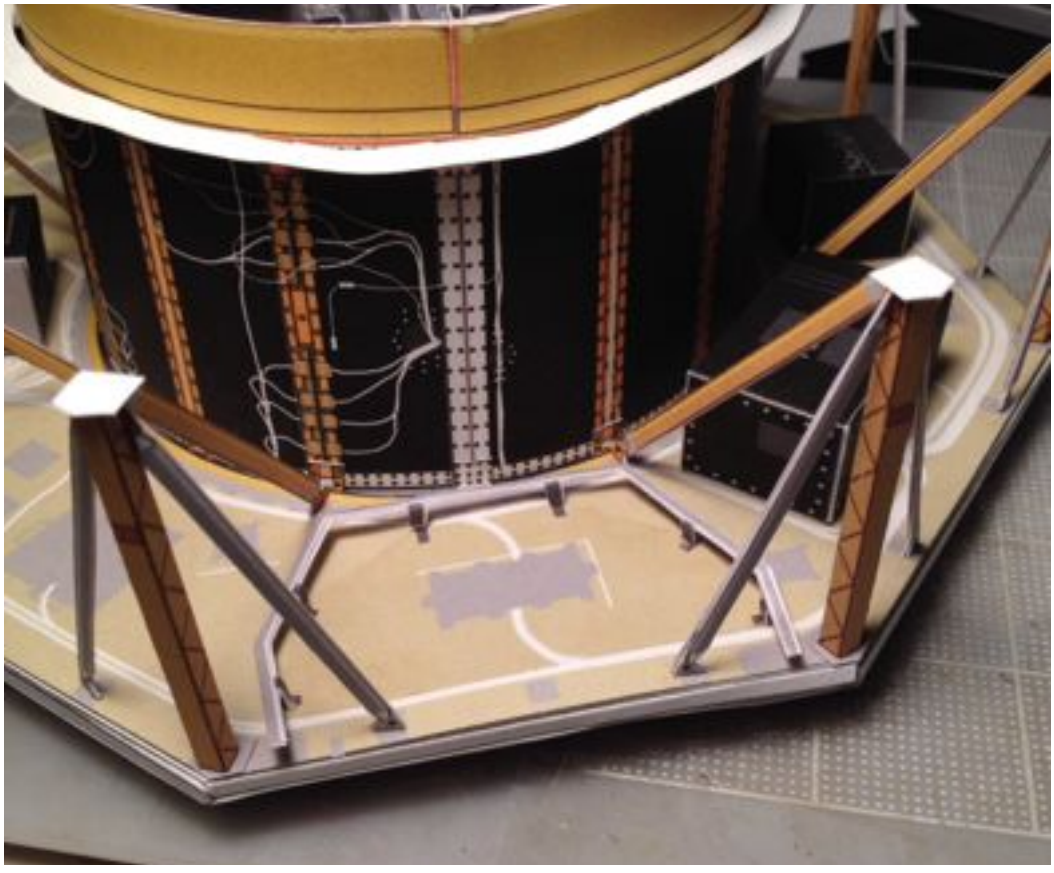


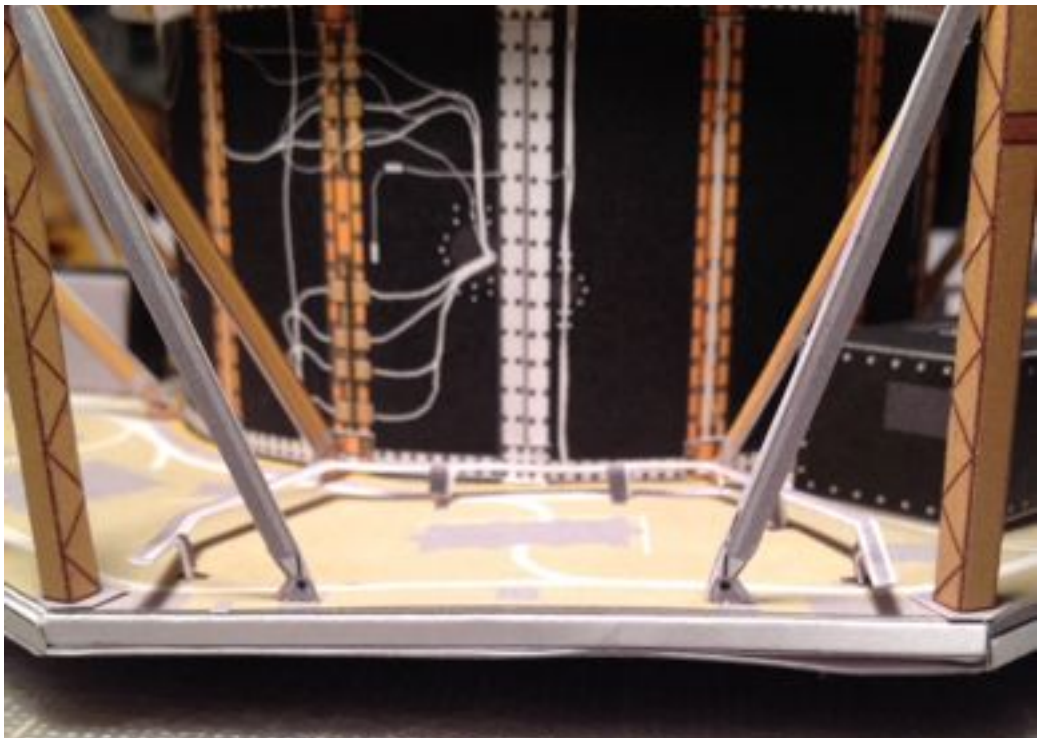




Propulsion lines (Bay 7)





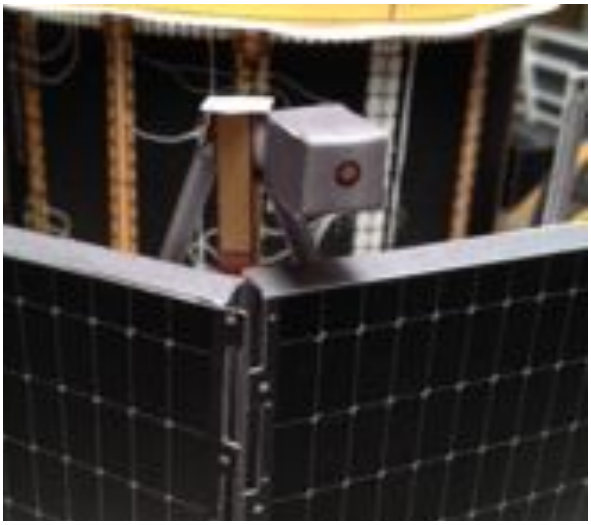


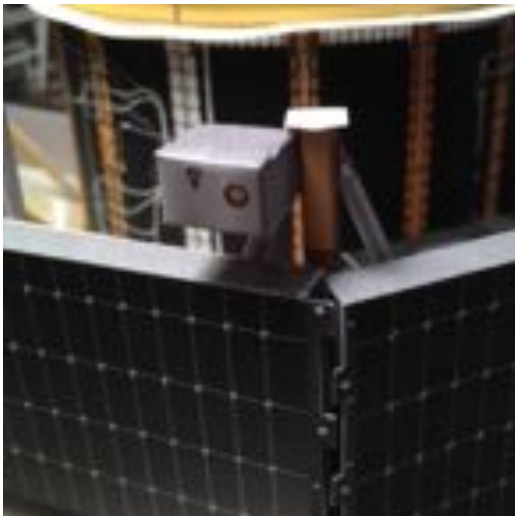
Connecting lines to Thrusters

These connecting lines differ from the final product because they lack the small connectors to the thruster boxes.

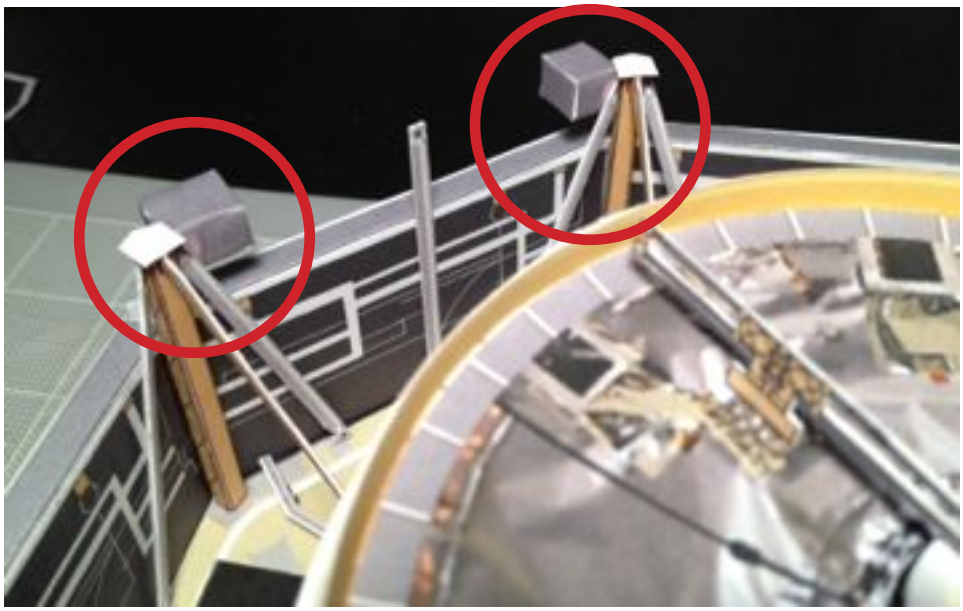
The following photos from the prototype model show the solar panels already in place. **The solar panels have to be glued once all the instruments from the Lower Deck are installed, including the propulsion lines on bays 3 and 7**.
The thruster boxes and connecting lines can be added before or after the installation of the solar panels.

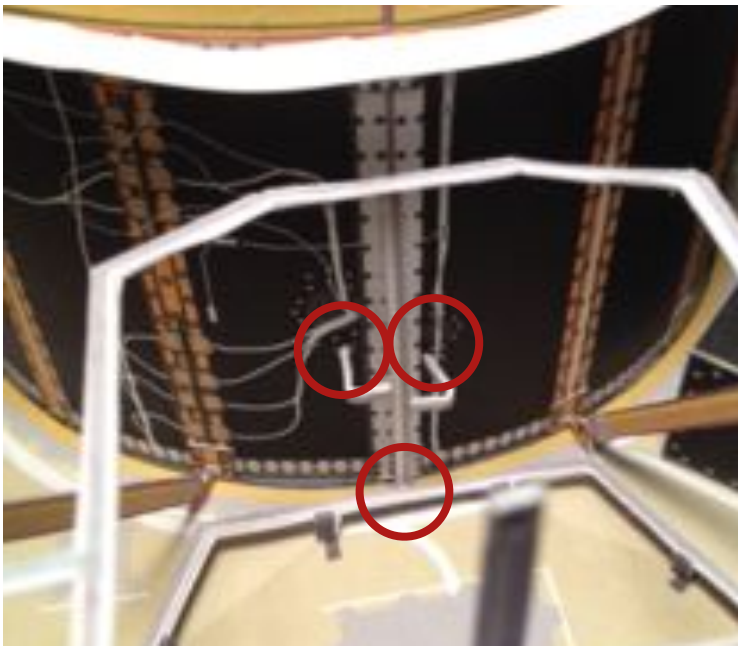
Installing the Upper Thruster boxes



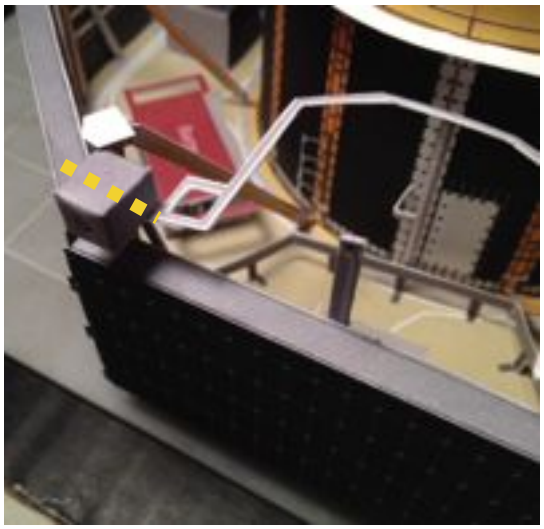


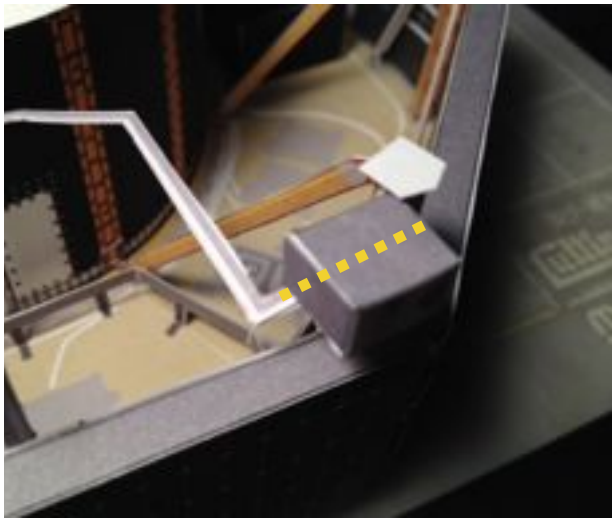
IMPORTANT: Notice the difference on the Thruster boxes. One is a single thruster box and the other a dual thruster box (wider). The single thruster goes on the left side of Bay 7 and left side of Bay 3, and the Dual thruster goes on the right side of Bay 7 and right side of Bay 3. The Lower Thruster boxes are positioned the same way, but the nozzle on the dual thruster boxes point down.
Each box is glued in the angle that is formed between the Main vertical strut and a diagonal strut on each corner of Bays 3 and 7.



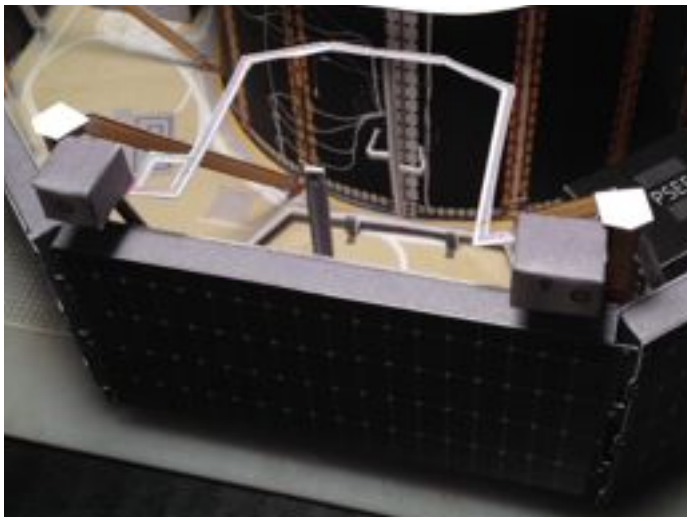


The Connecting lines are glued to the floor of the Lower Deck and to the Thrust tube. (Red circles)
Let them dry completely before connecting them to the thruster boxes.



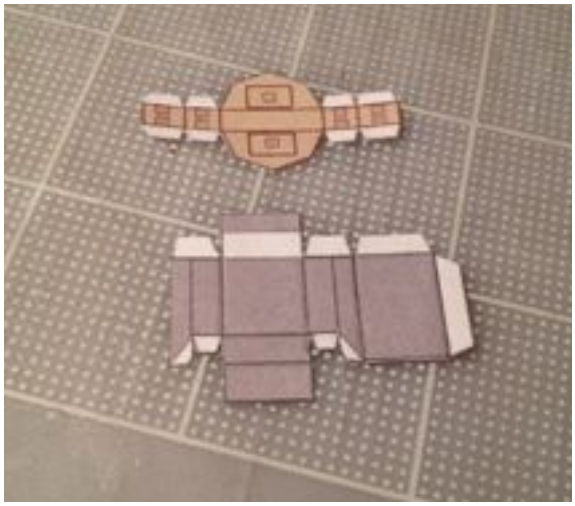


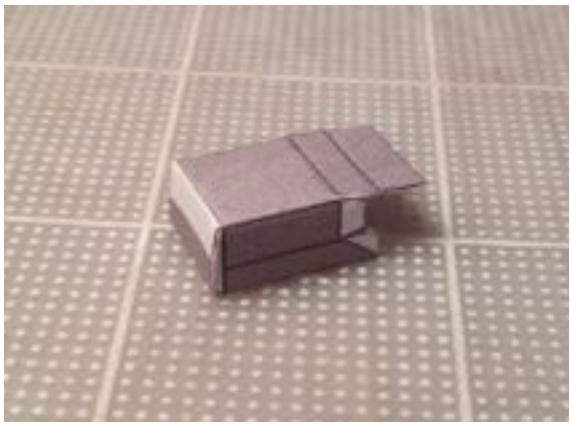
The yellow lines indicate where the propulsion lines connect to the thruster boxes, under each box.

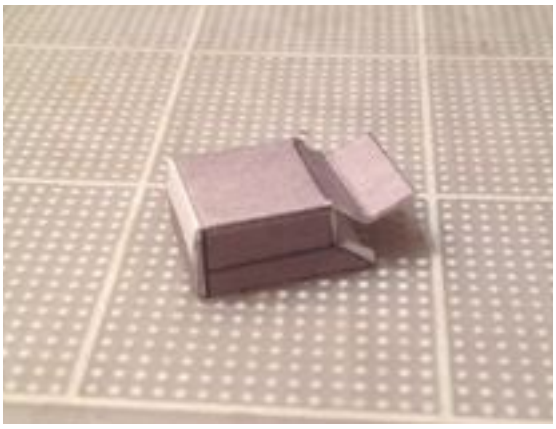


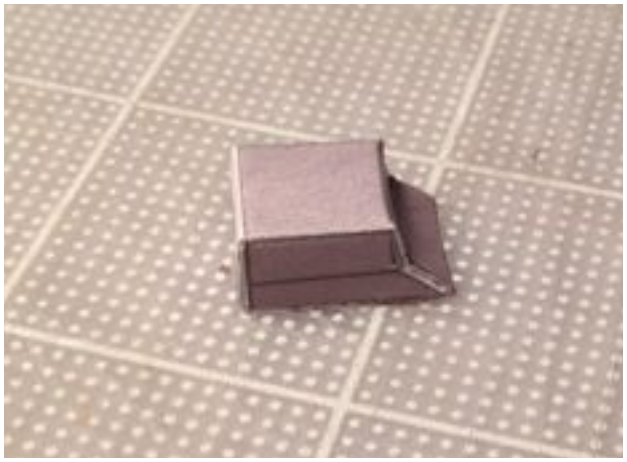
FEEPS (Fly's Eye Energetic Particle Sensors)

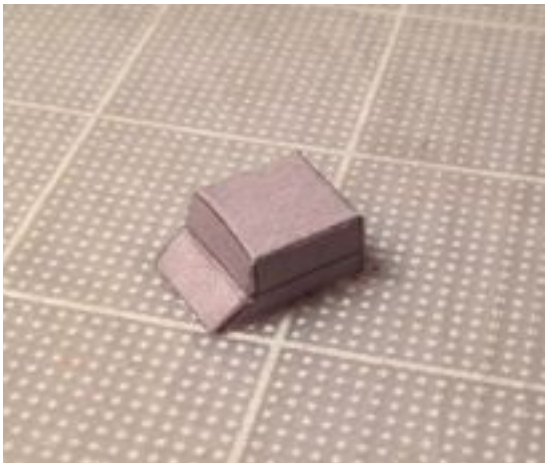
There are 2 FEEPS: one on the Lower Deck underneath Bay 6 and the other on top of the Upper Deck above Bay 2.

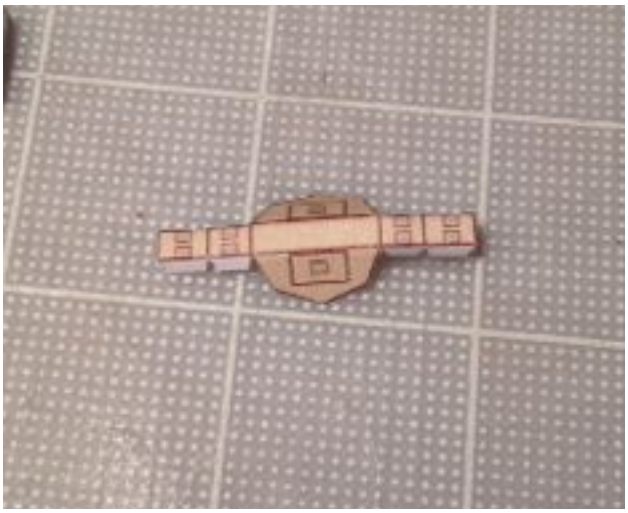


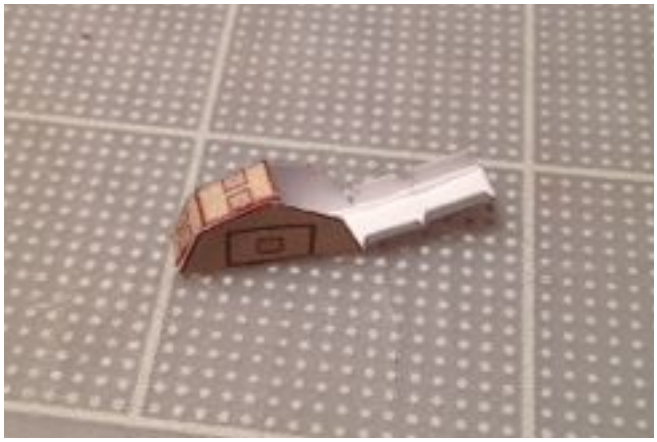


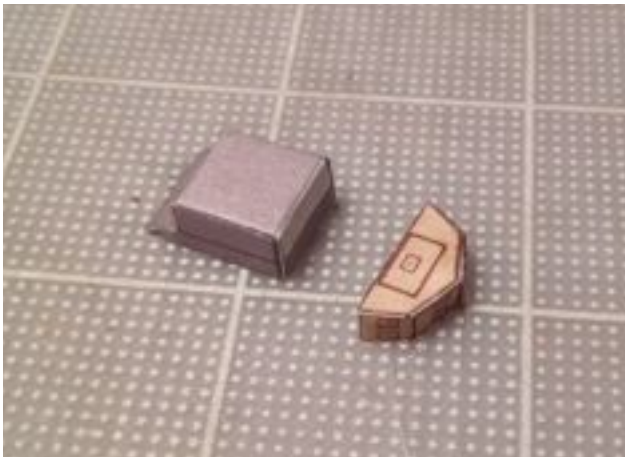


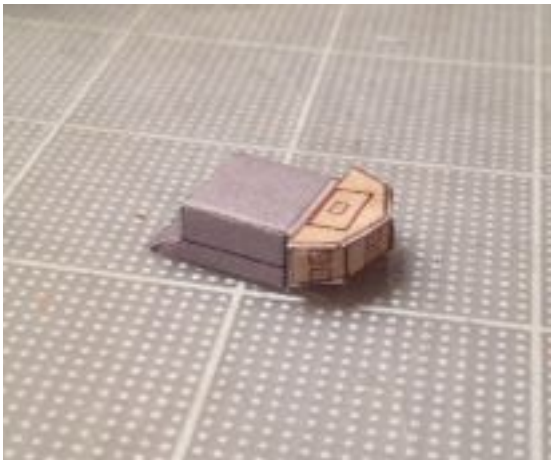


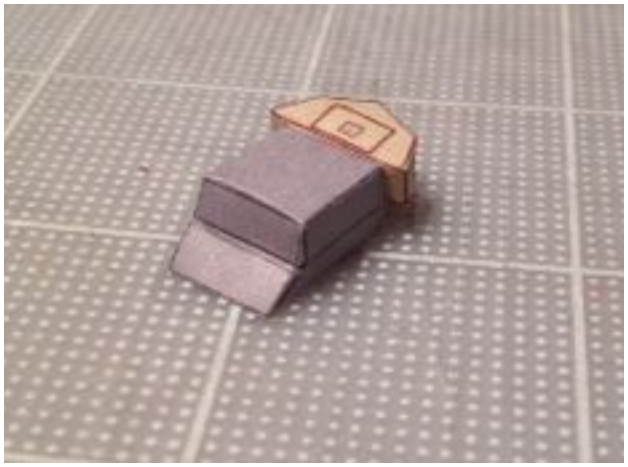


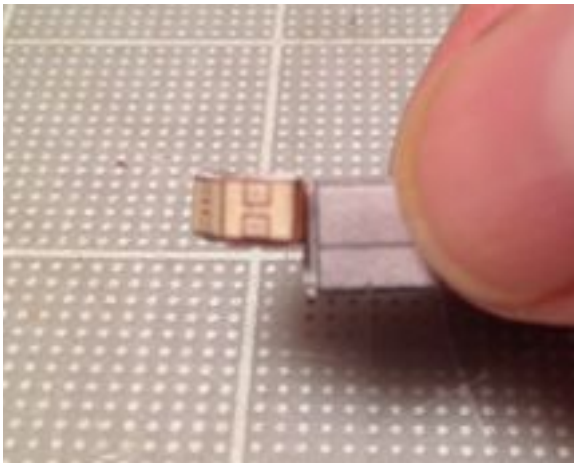


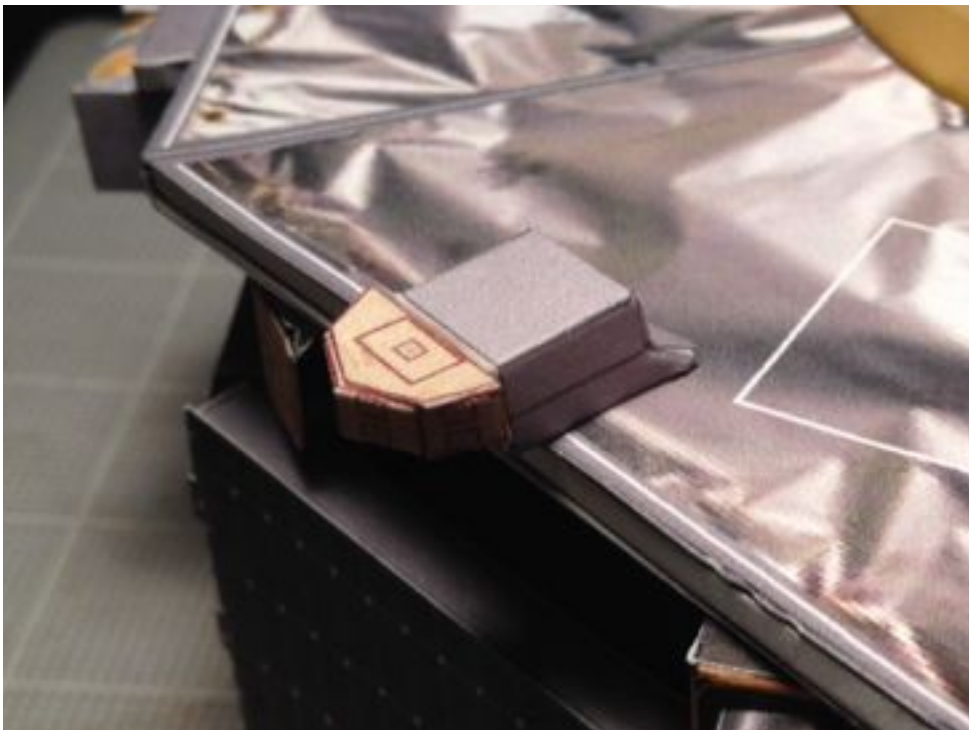




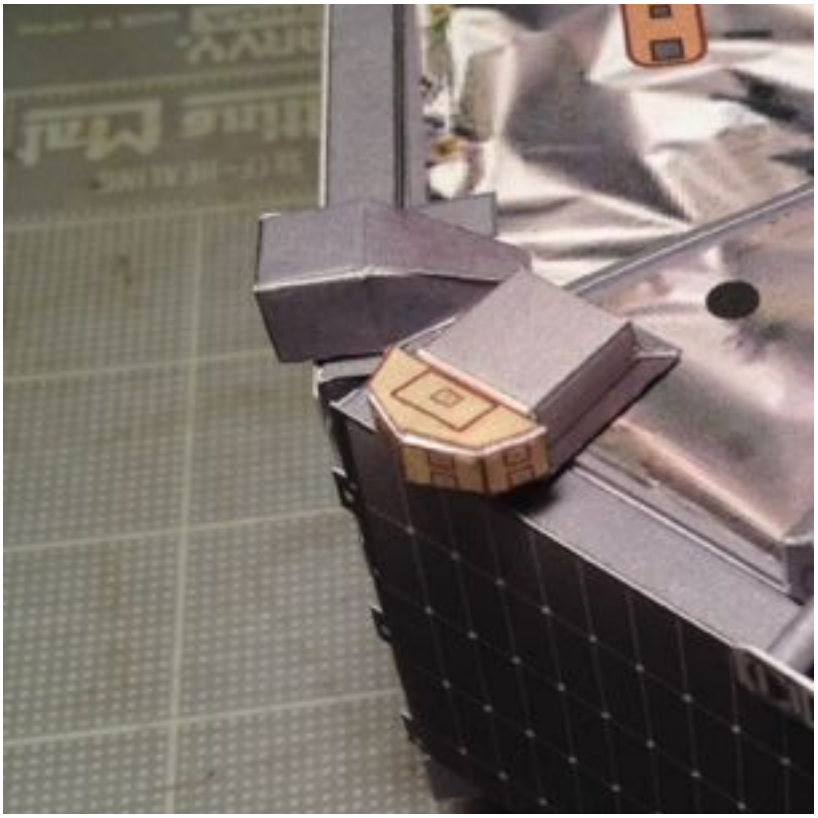




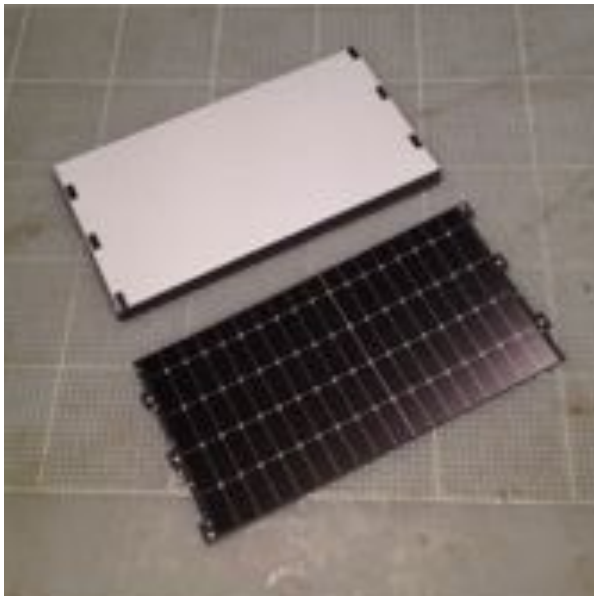




The above photo shows the FEEPS from the **Upper Deck** in its location.
The second FEEPS that goes under the **Lower Deck** will be glued once the solar panels are in place.

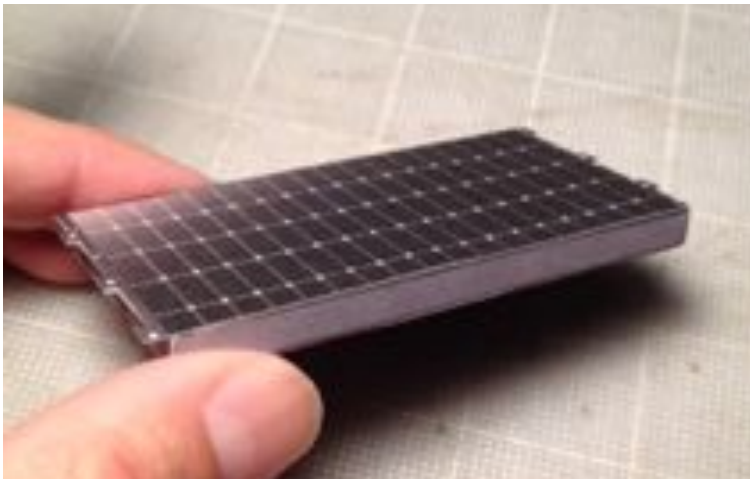


5. Solar Panels installation

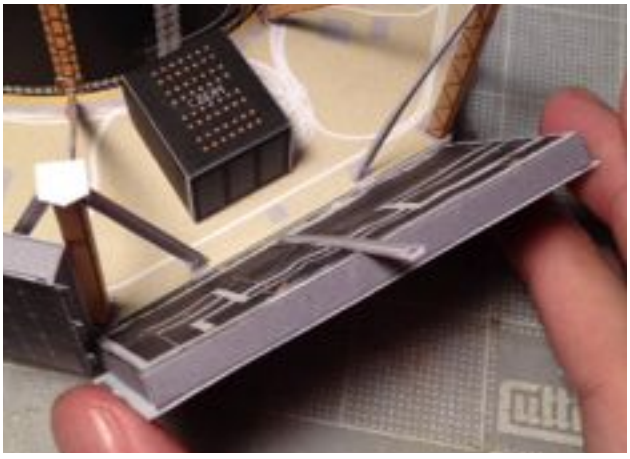


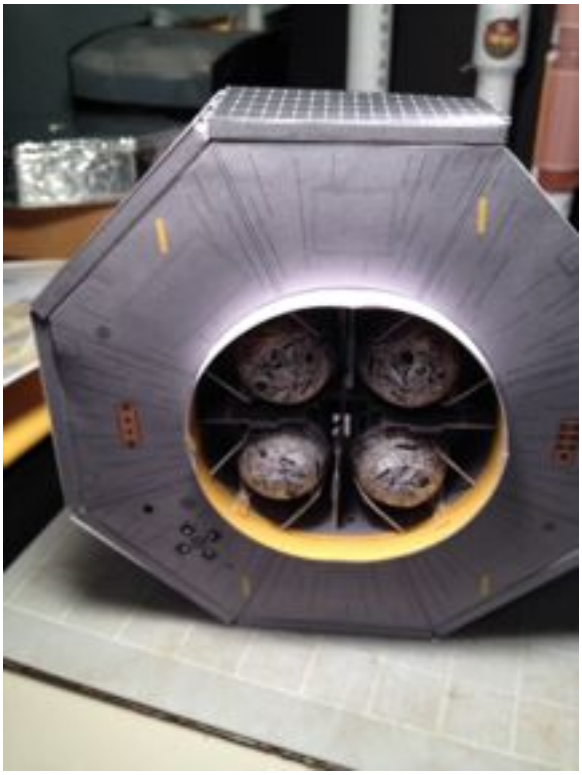
Notice the markers on the solar panel box. The 3 vertical markers on each side need to match the ones on the solar panels. The markers on the left side are much lower than the right side. This is the way how the solar panels are glued to the model.

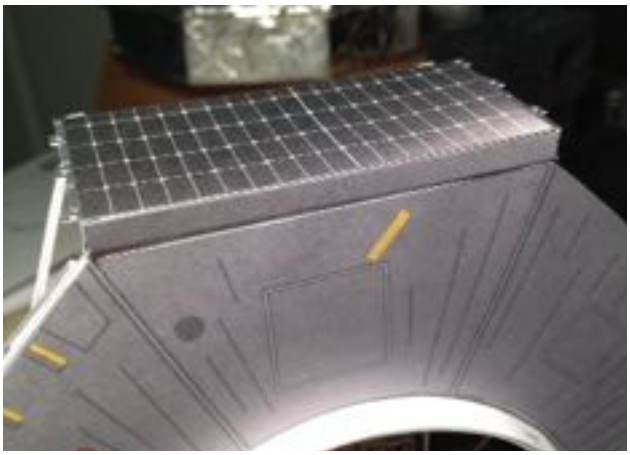
Smear the glue in a thin film along the sides of the solar panel box. Glue stick can be used here but it may dry fast and the panels would not stick firmly.

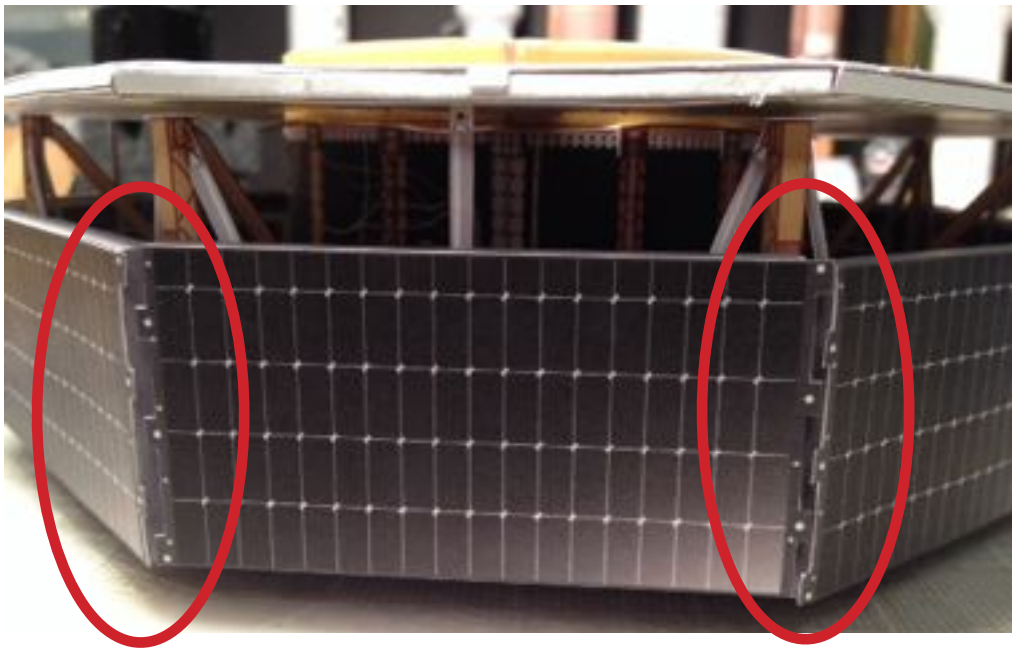


The back portion of the solar panel has a white rectangular area at the bottom that will be glued to the edge of the Lower Deck. Only 4 solar panels have a thin white vertical line in the middle, where the **thinner vertical strut** is glued to. The tweezer in the photo shows that the vertical strut is glued to the black area and not on the white rectangular area.
These 4 solar panels will be glued on the Lower Deck bays that have the X and Y coordinates markers. The rest of the solar panels are glued on the other bays.

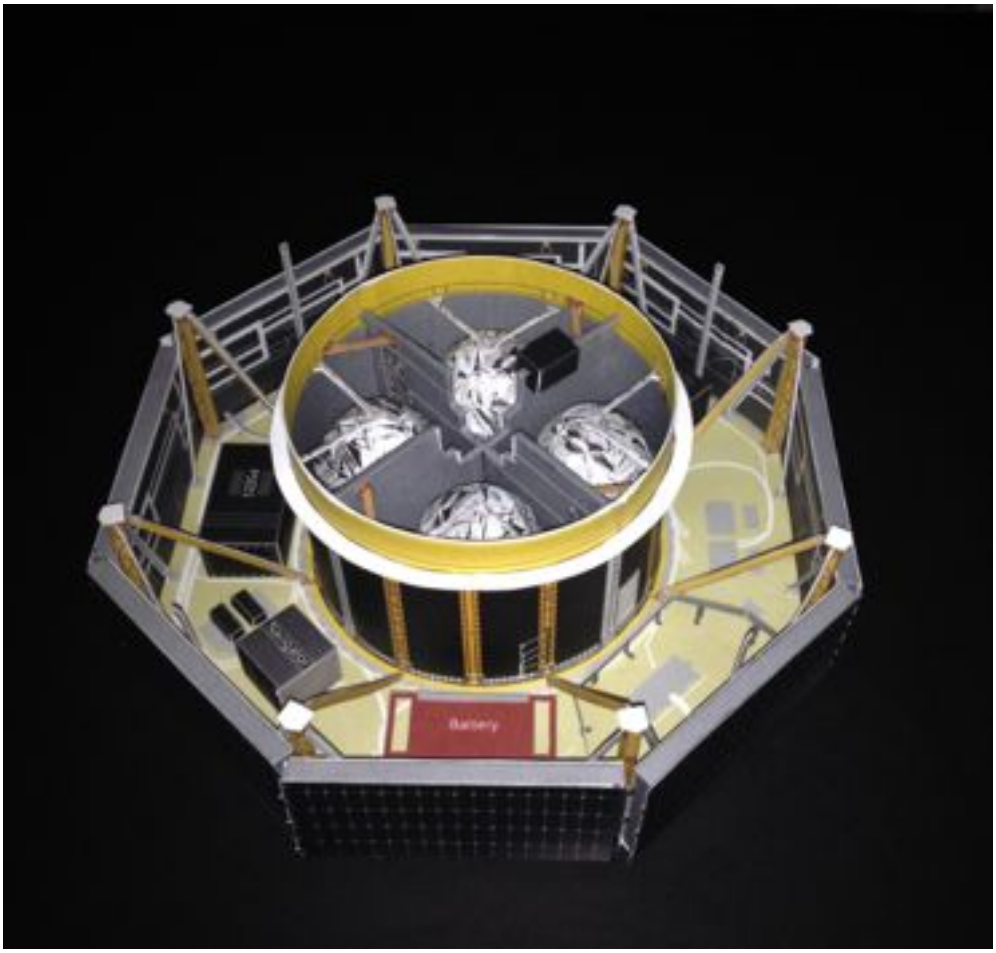


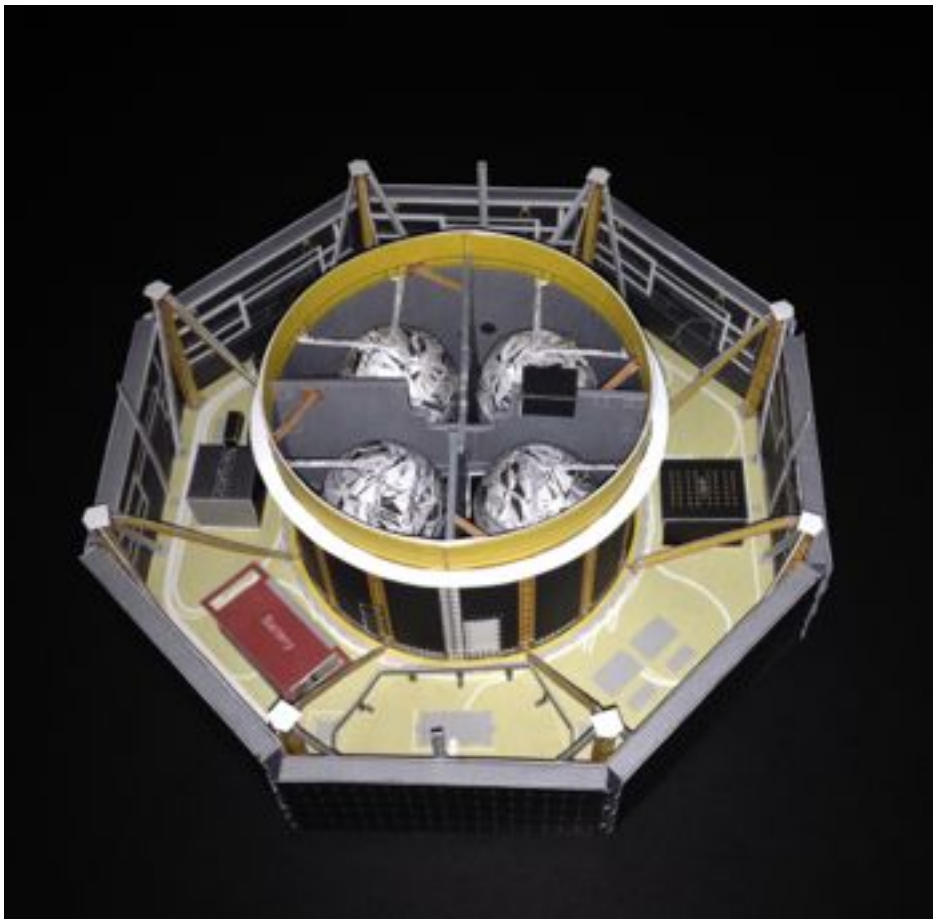


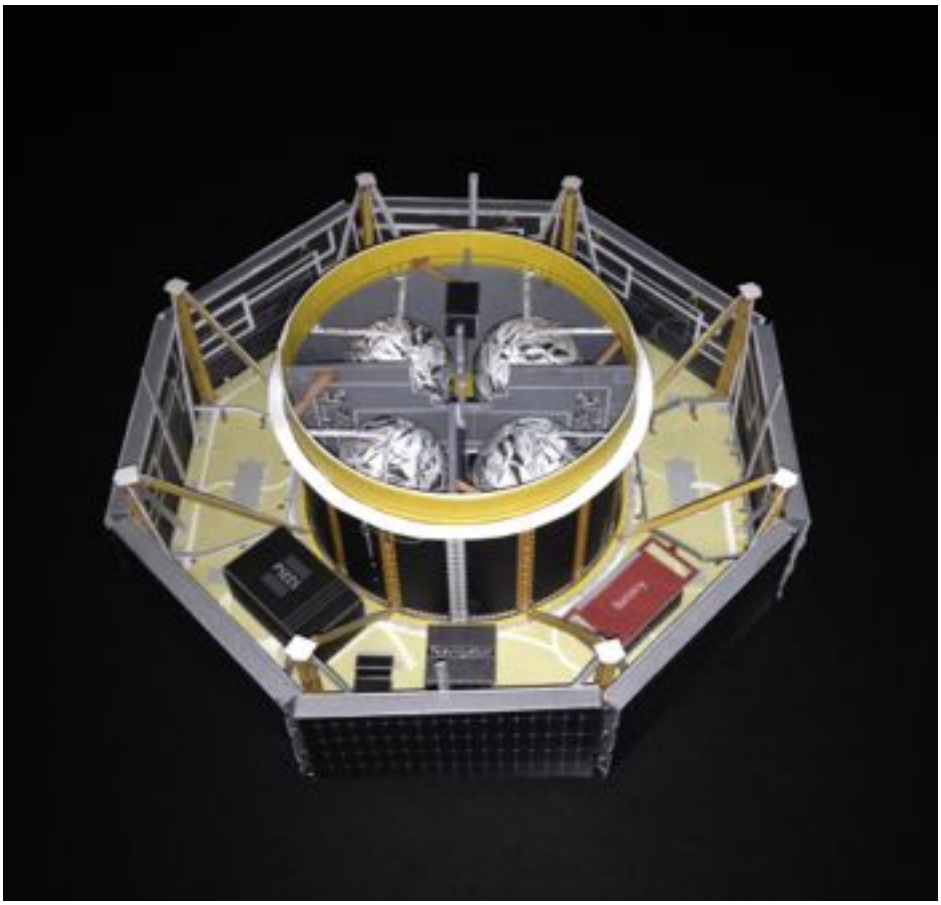


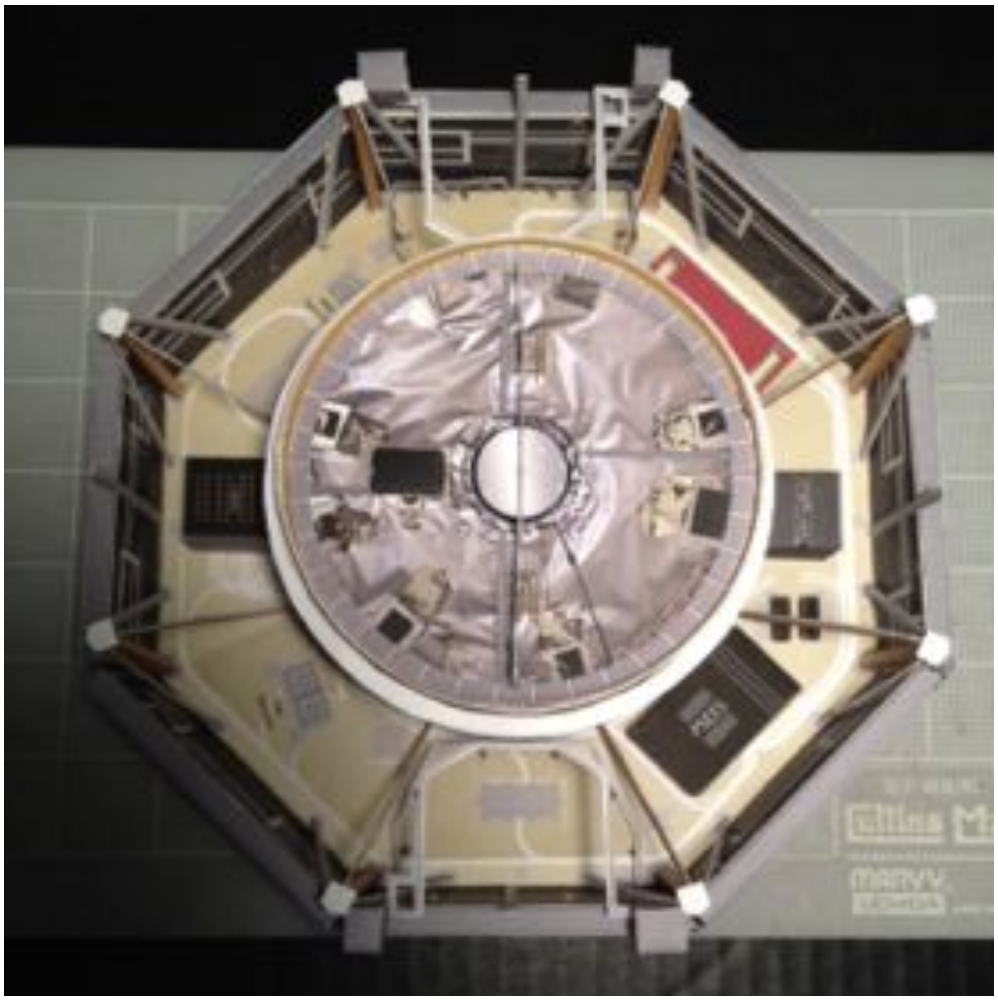


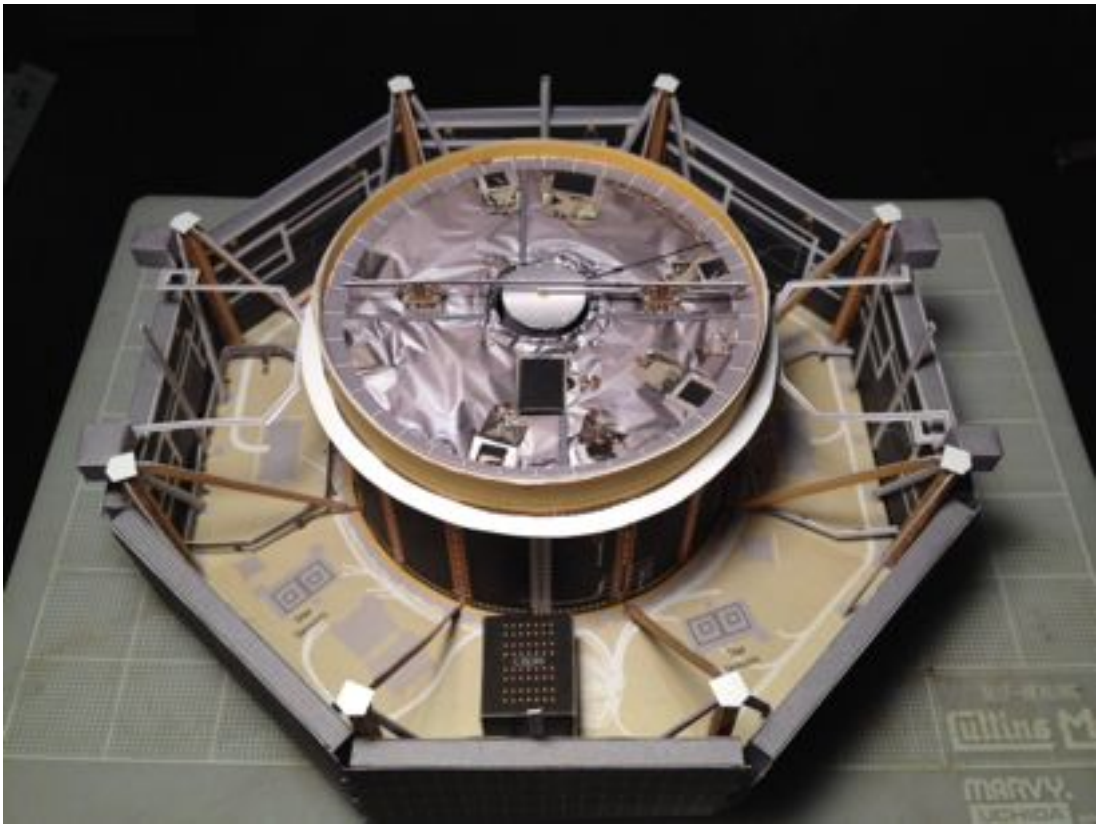
The above photo is from the prototype with the Upper Deck in place. The Upper Deck is detachable and is not glued to the model. The red ovals show the detail of the solar panel corners and how they should look.



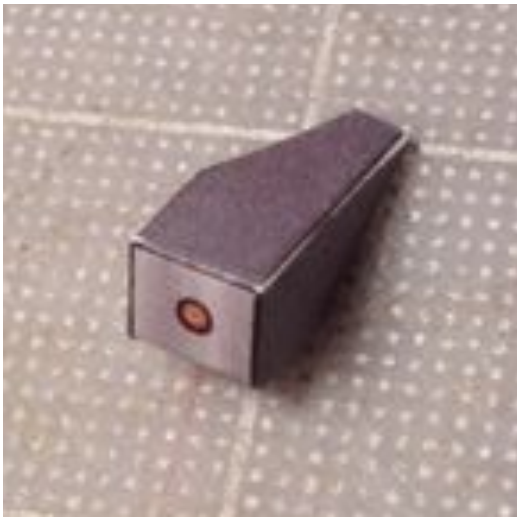




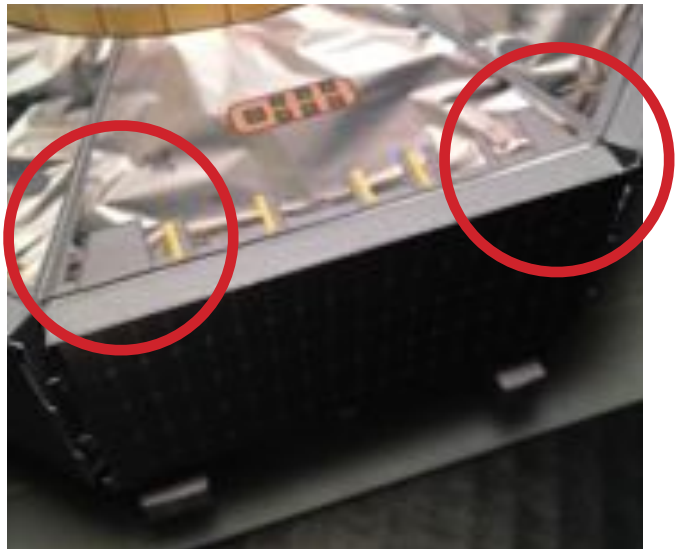


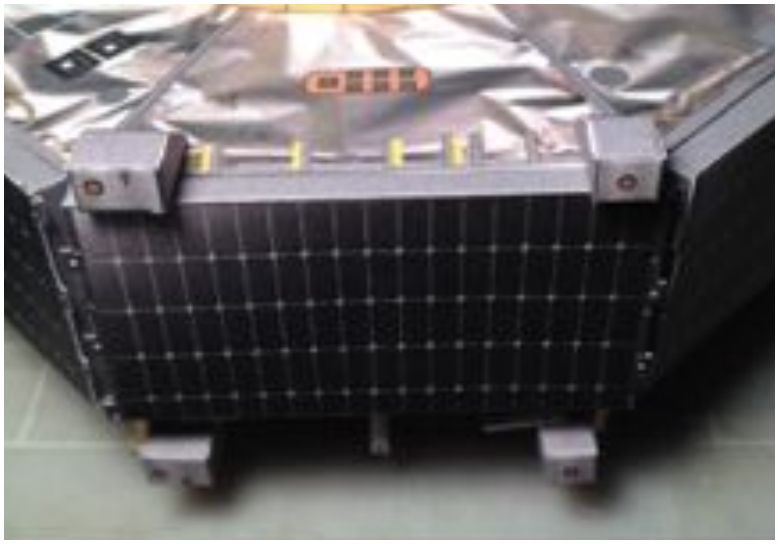


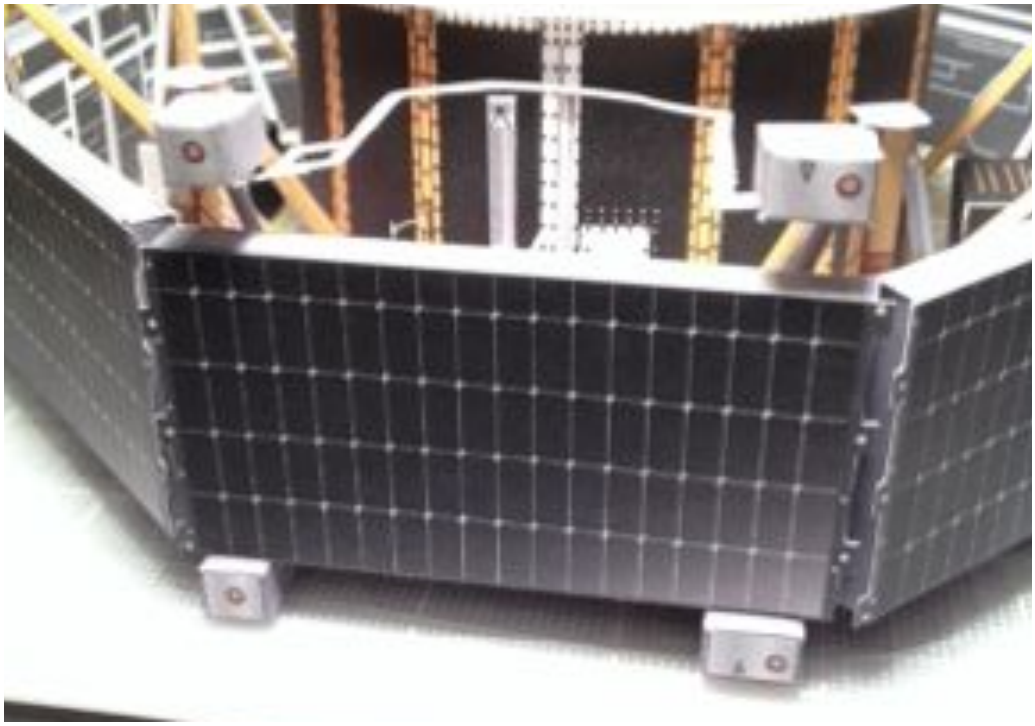
Installing the Lower Thrusters

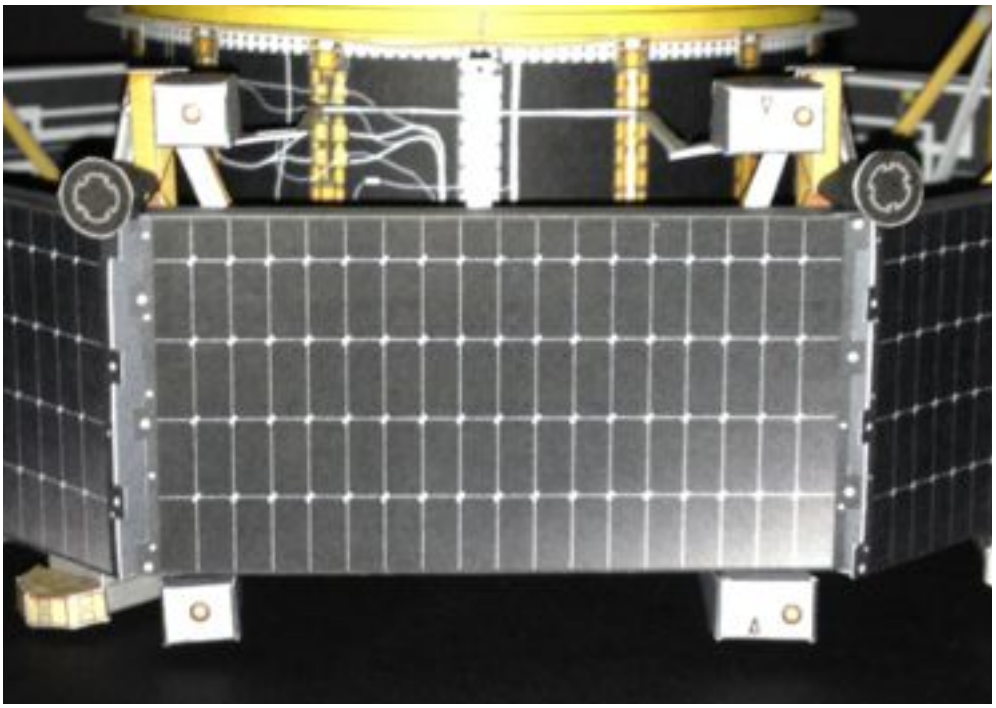


As with the Upper Thrusters, the Lower Thrusters also have Single and Dual boxes.

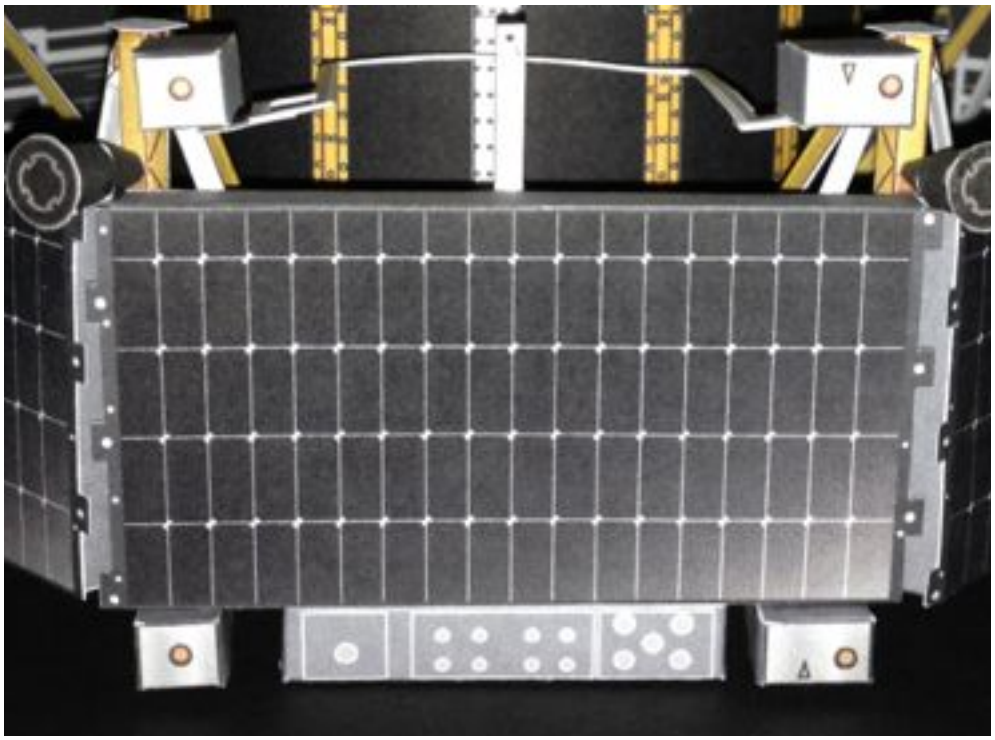








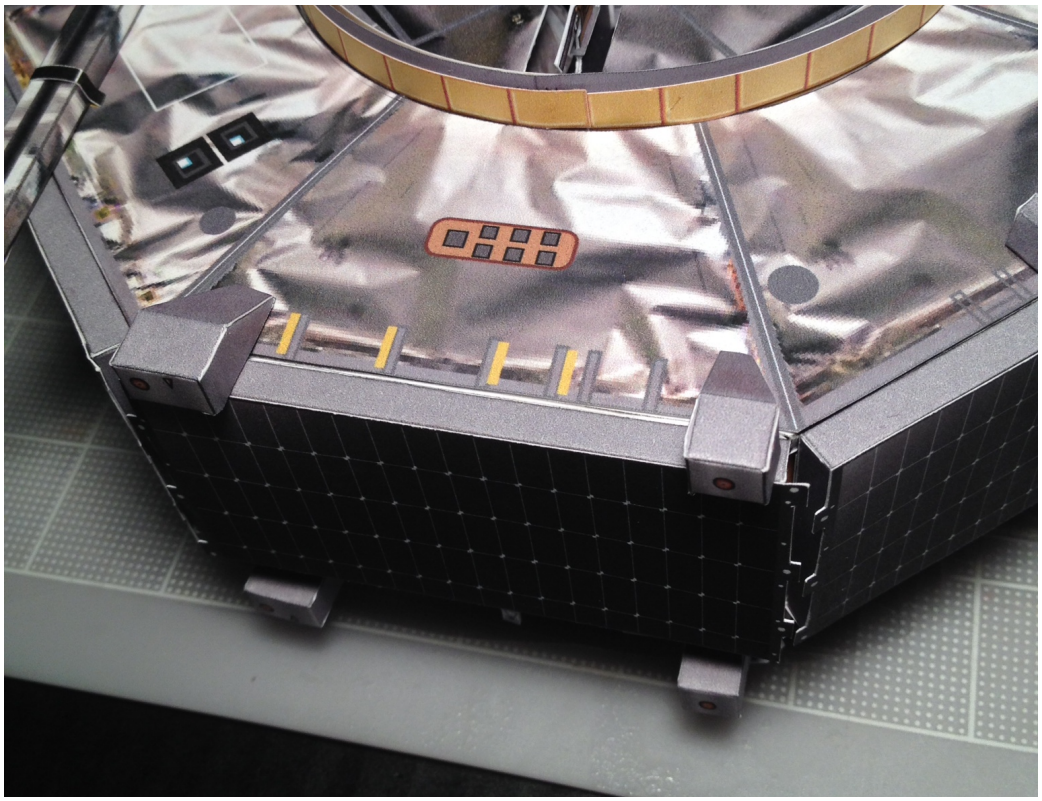
Thrusters on Bay 7

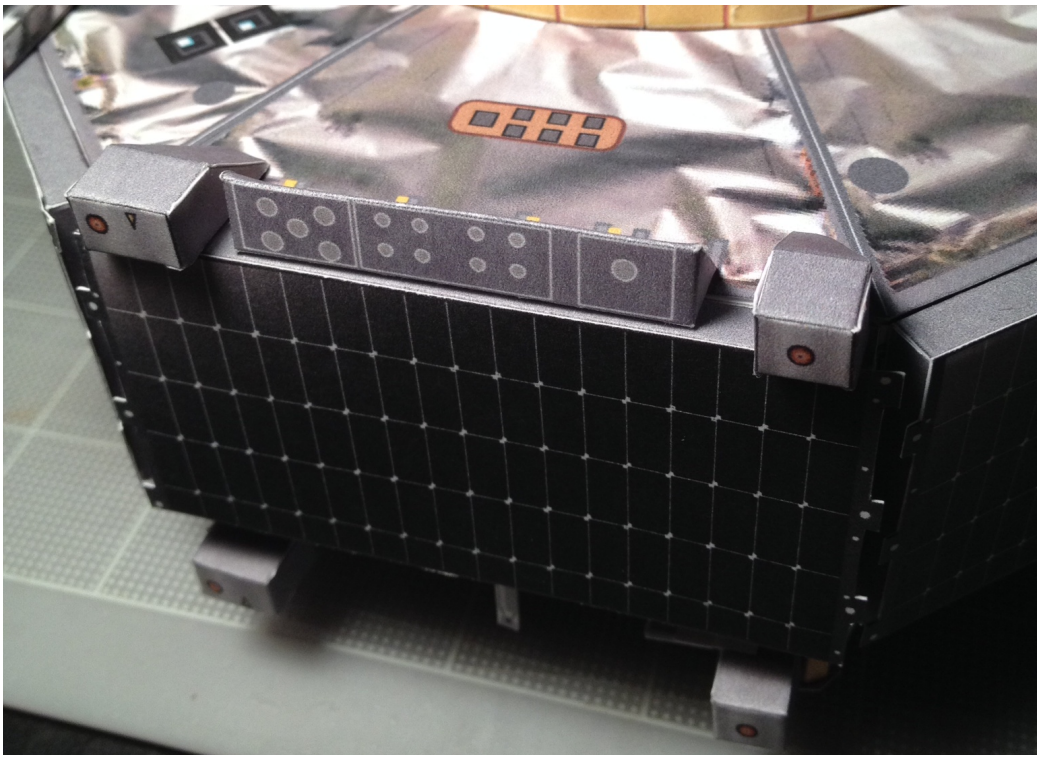


Thrusters on Bay 3

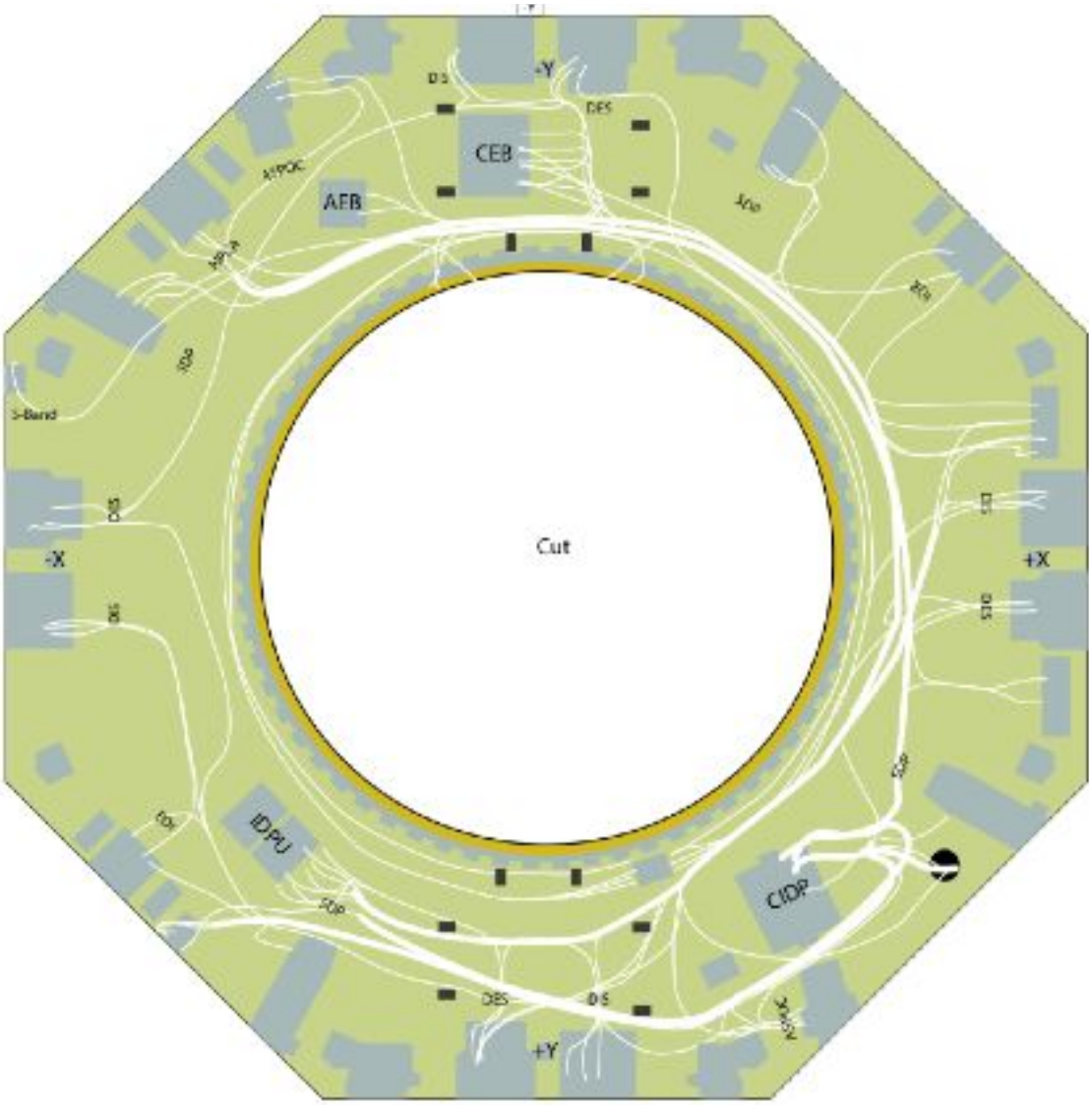
Installing the Fill Drain/Valve and Fairing Access Connectors (Bottom of Lower Deck)

The Fill Drain/Valve is glued once the solar panels are installed.





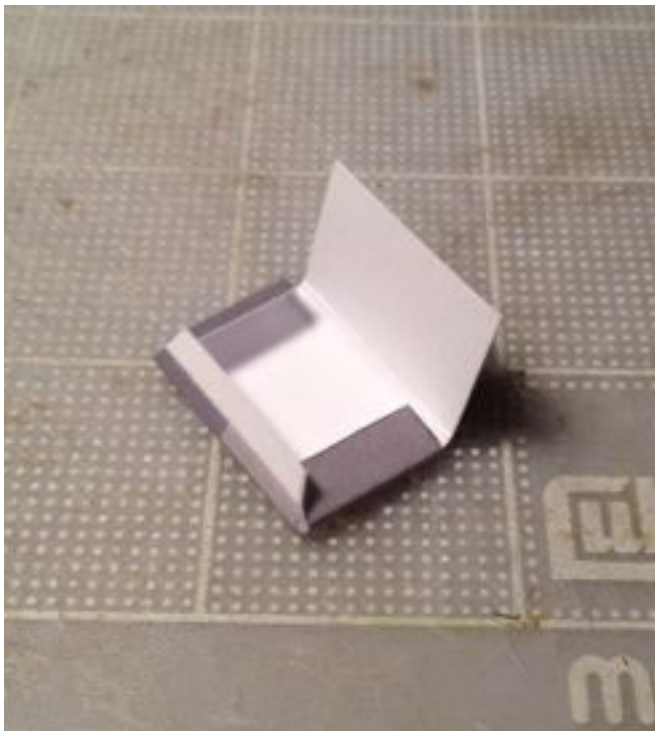
6. Instrument Deck (Upper Deck)

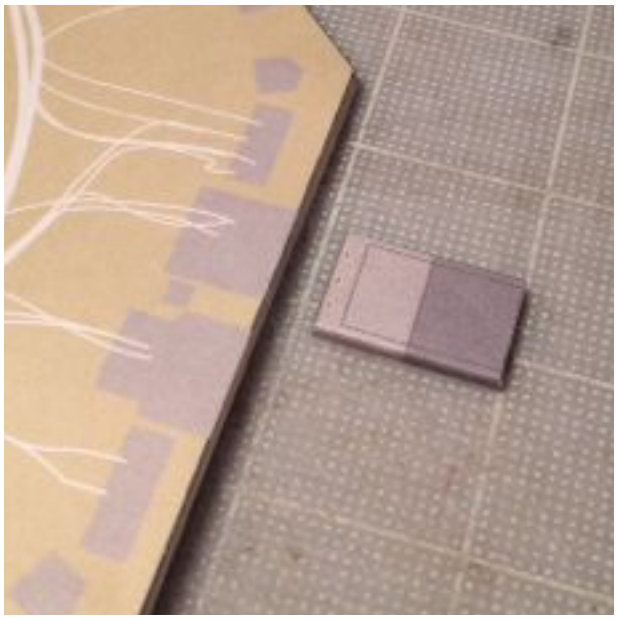


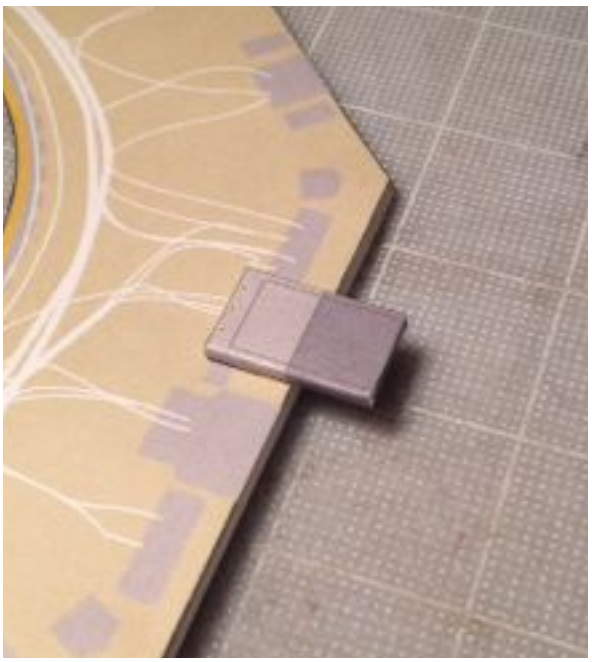
This is the template of the Upper Deck of the MMS model. The shaded areas where the instruments will be glued are labeled with the Instruments names.
Follow the X and Y coordinate markers when placing the Upper Deck on top of the model and match them with the ones on the Lower Deck.
The Upper Deck was not designed to be glued onto the Thrust tube. It is designed to be attached only. It can be removed to see the interior of the MMS model.

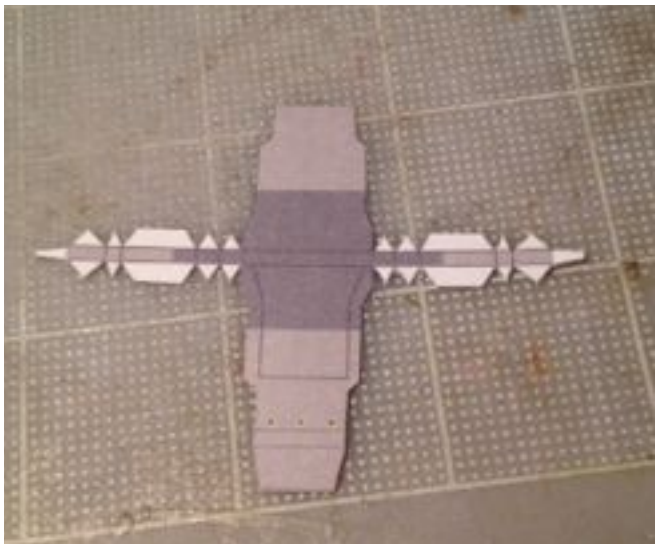
DIS/DES (Dual Ion Spectrometer/Dual Electron Spectrometer)

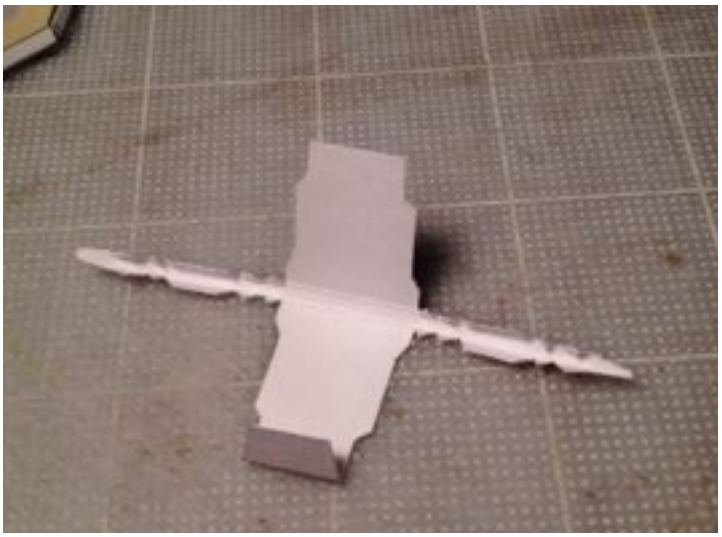
The Mounting "Platforms" have to be assembled for each DIS and DES instruments. There is a total of 4 pairs of DIS and DES. When glued, the dark gray areas are exposed outside the model.

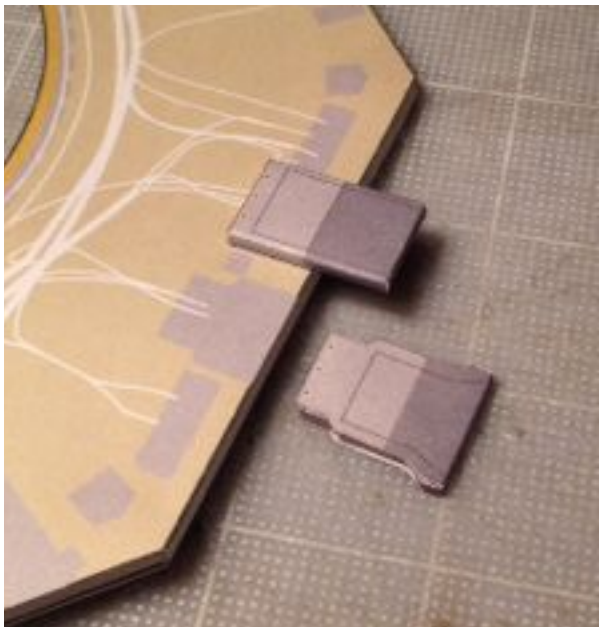


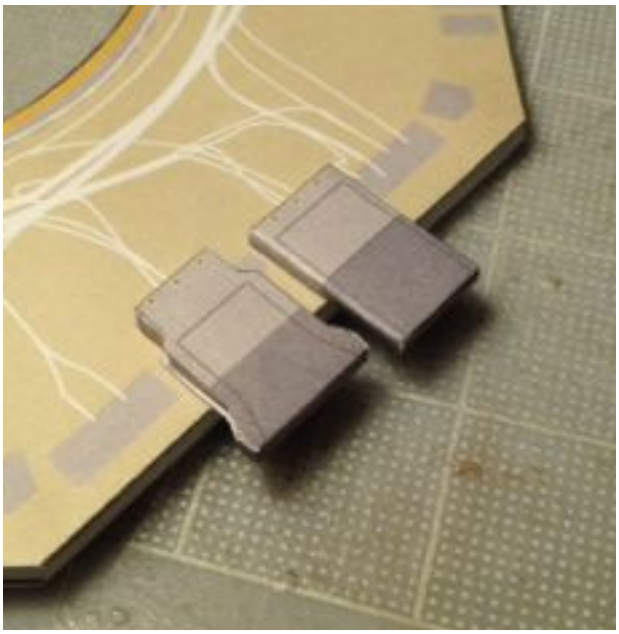




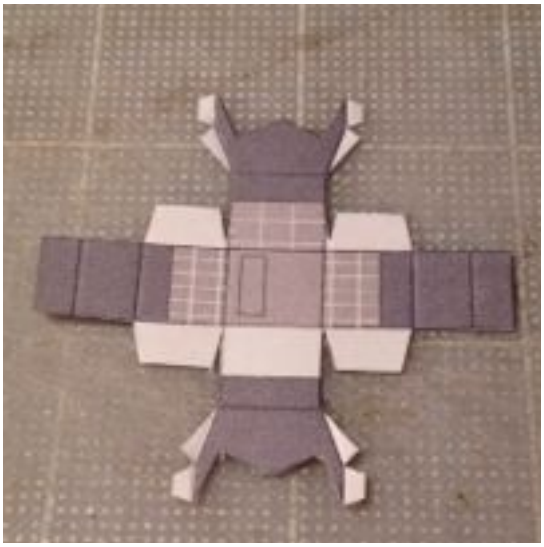


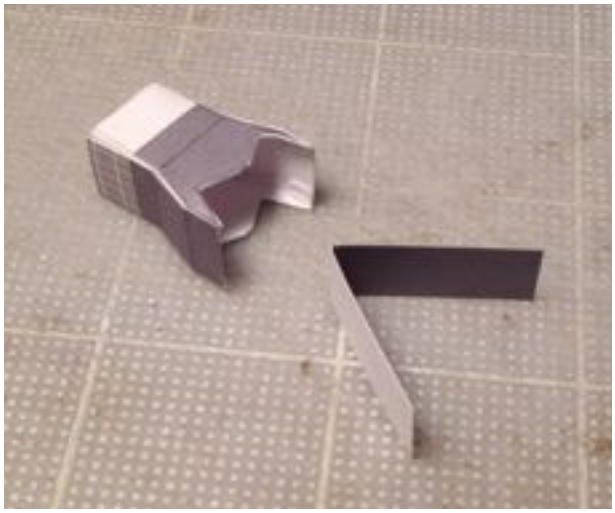


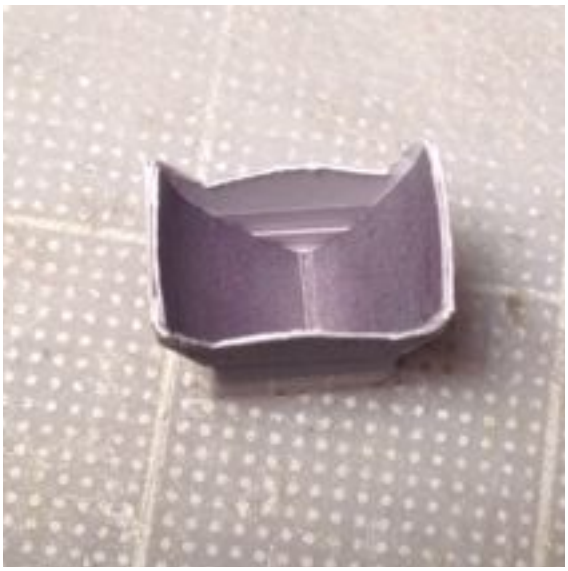


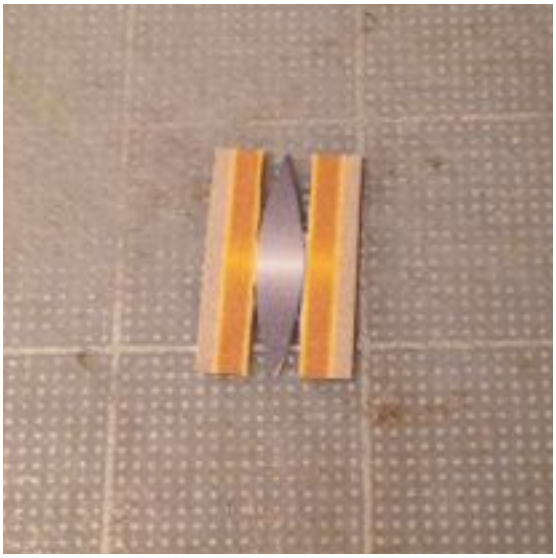


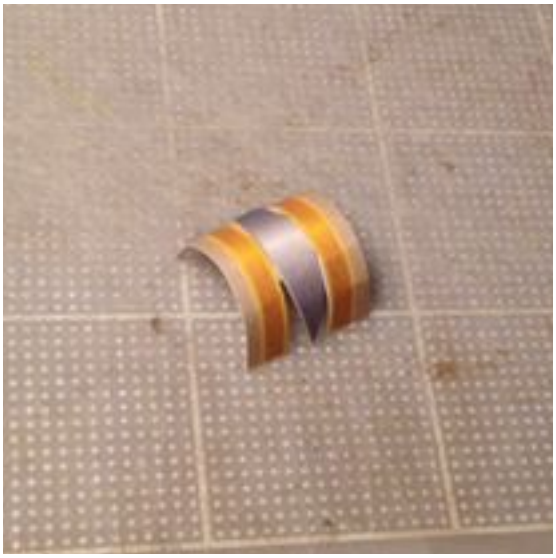
Building the DES

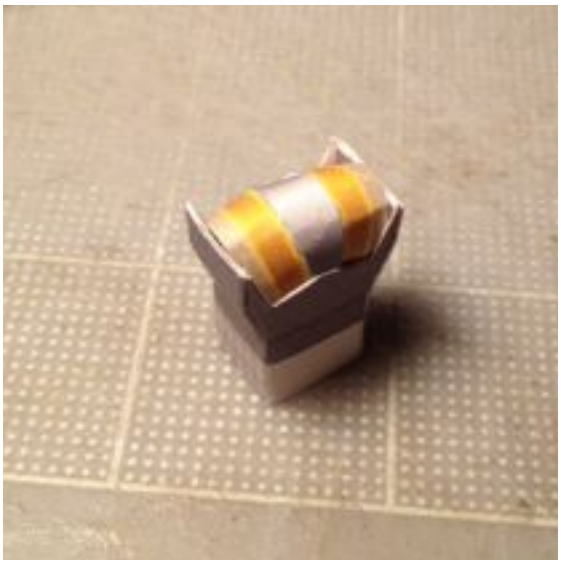


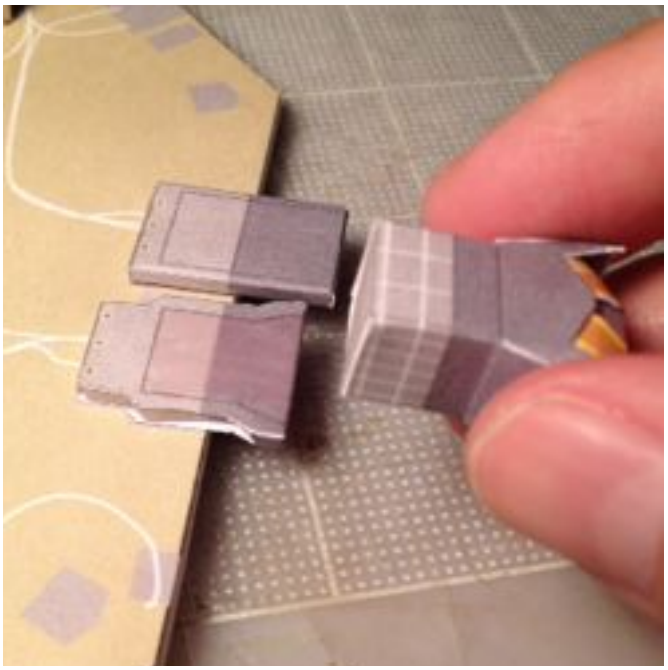


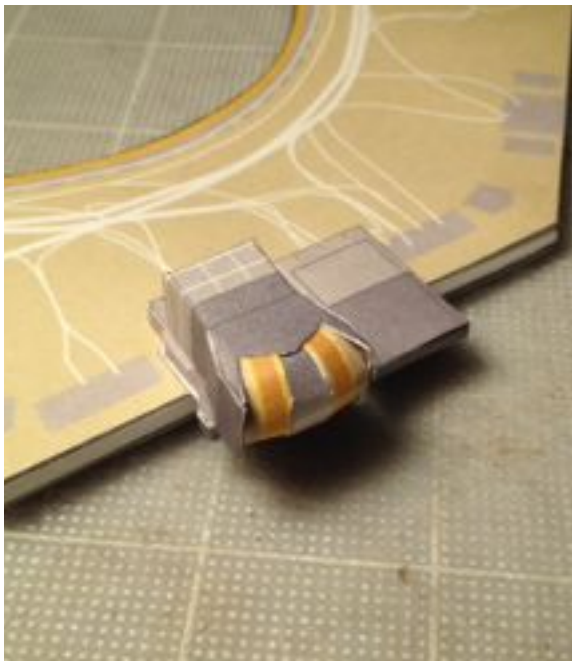




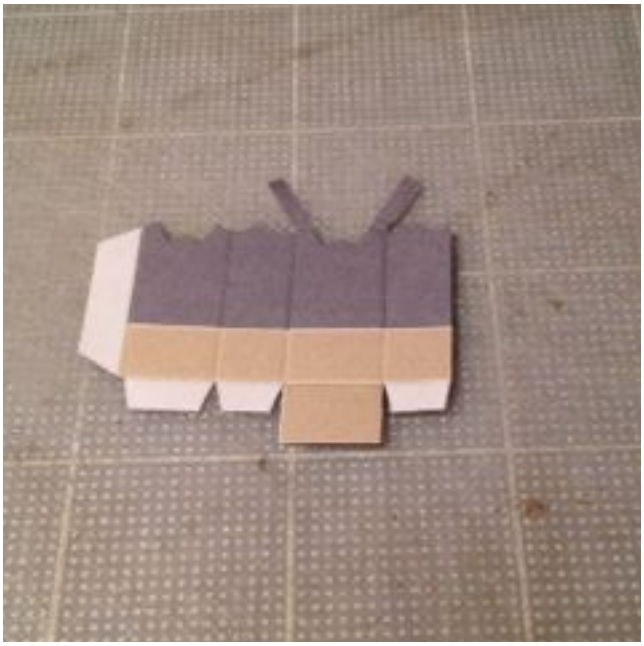


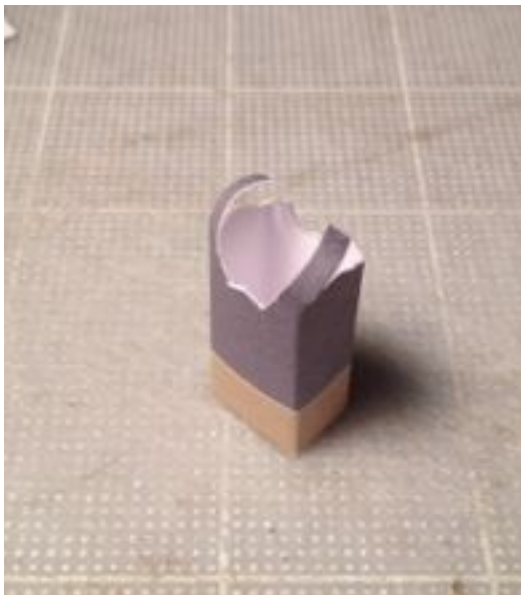


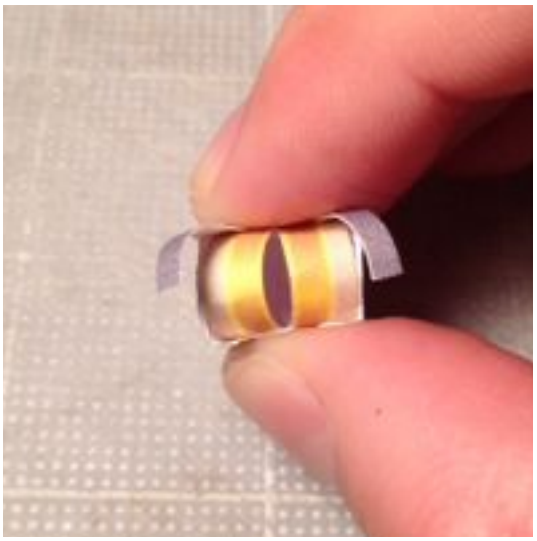


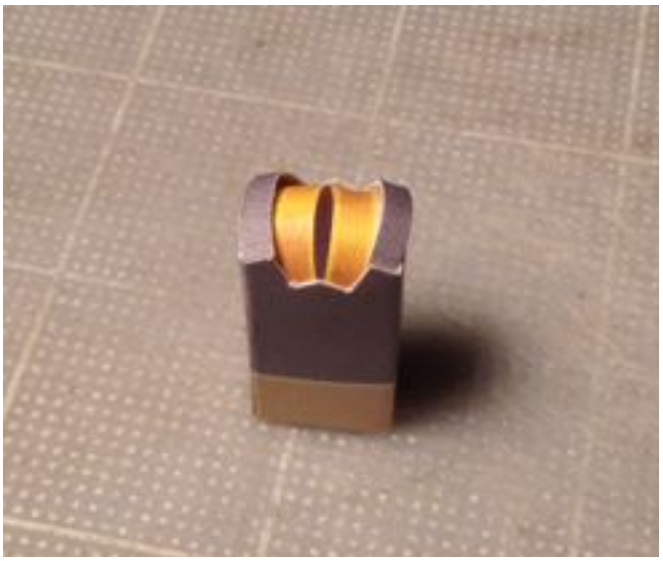


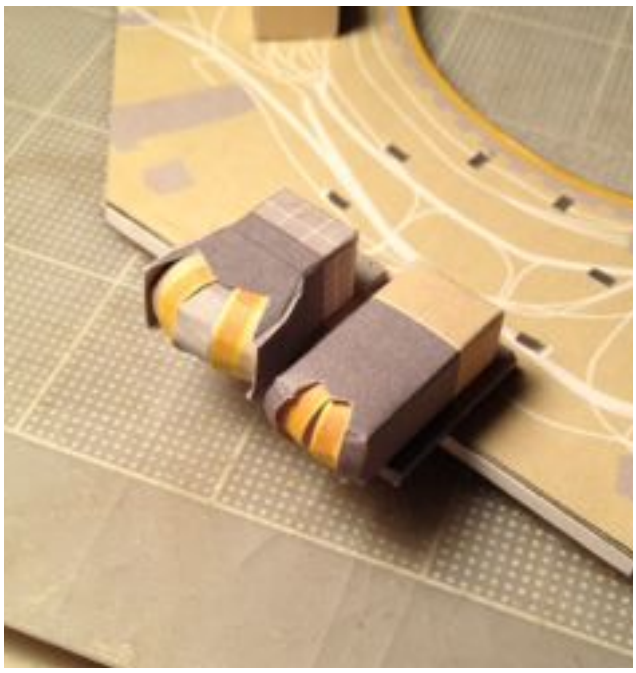
Building the DIS





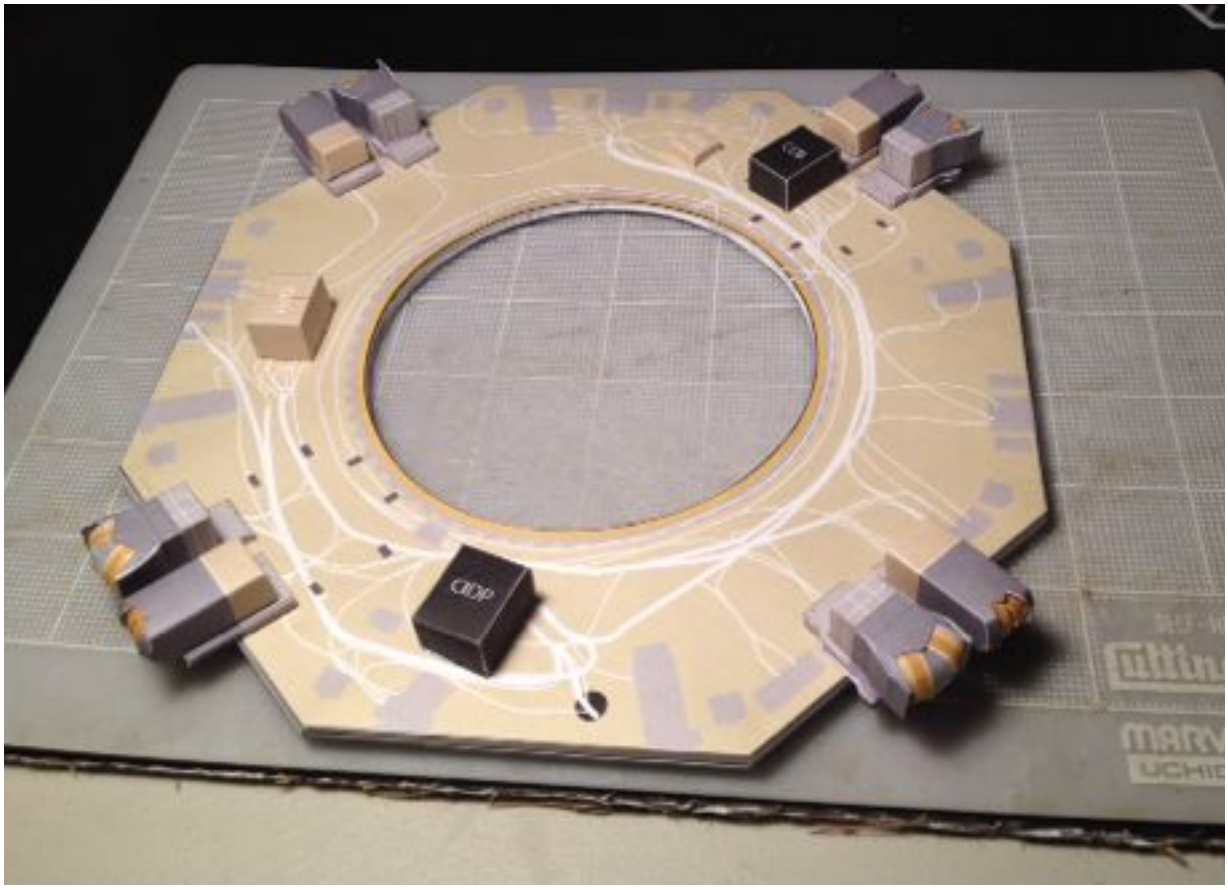






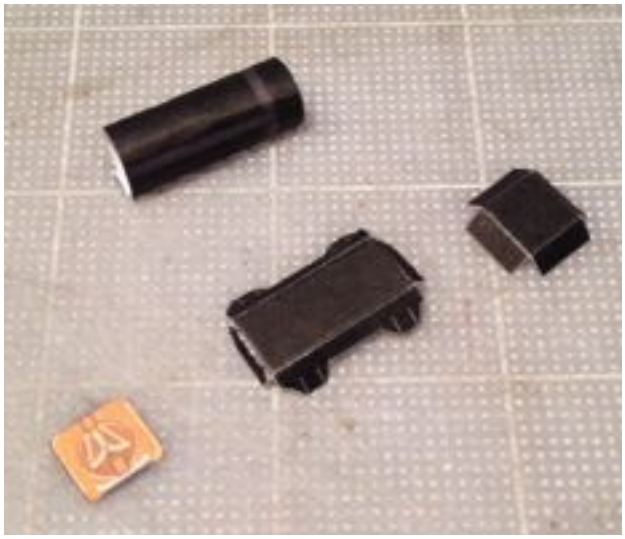
Adding:

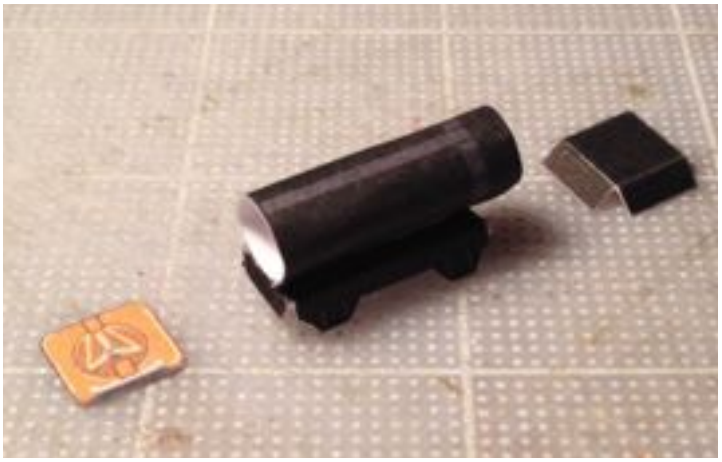
- **CEB -Central Electronics Box (Fields)**
- **AEB -Axial Electronics Box**
- **IDPU -Instrument Data Processing Unit**
- **CDIP -Central Instrument Data Processor**

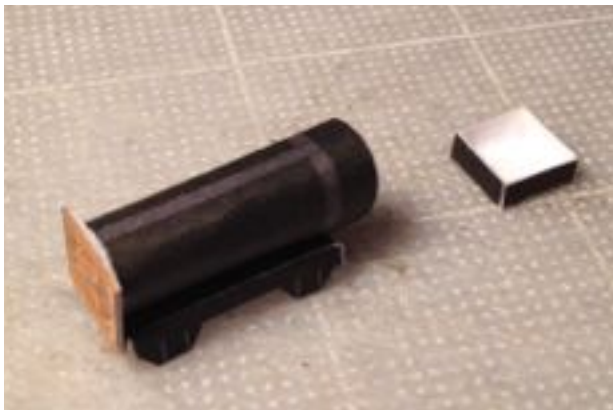


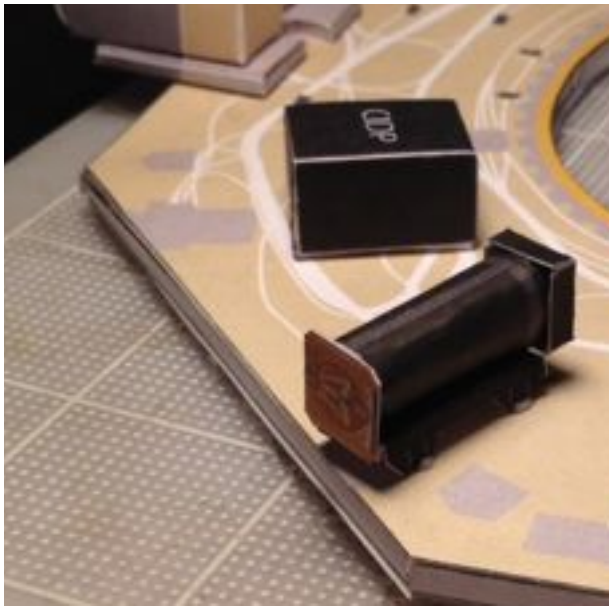
SDP (Spin-Plane Double Probe)

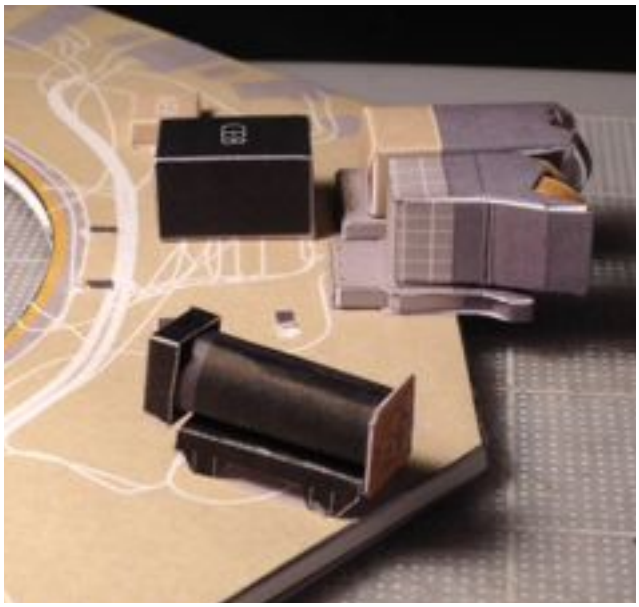
There are 4 SDP instruments.

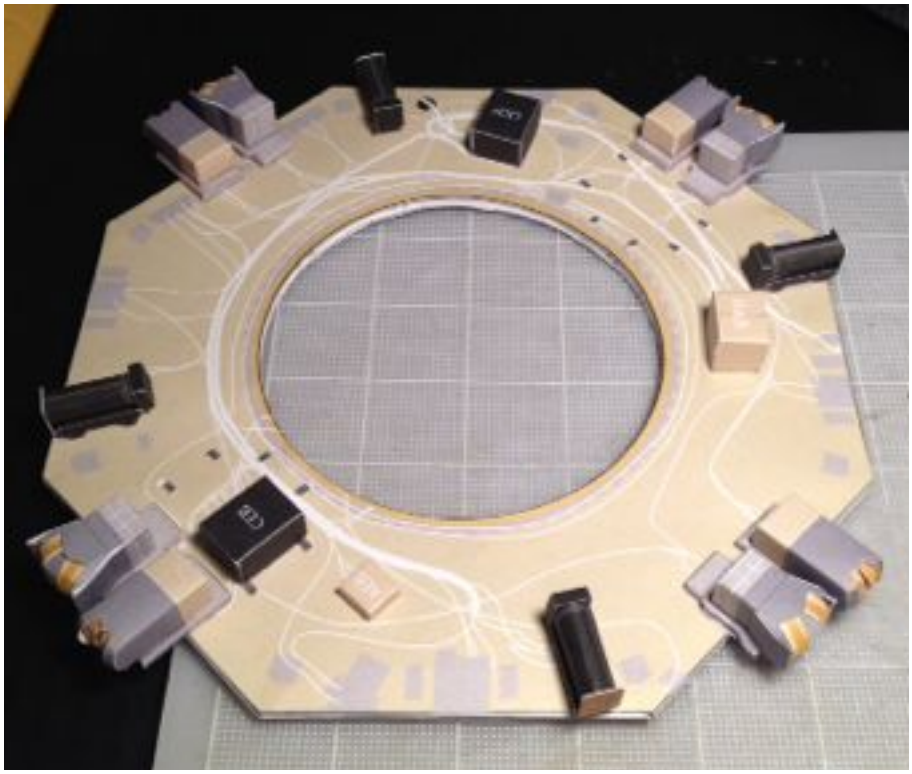






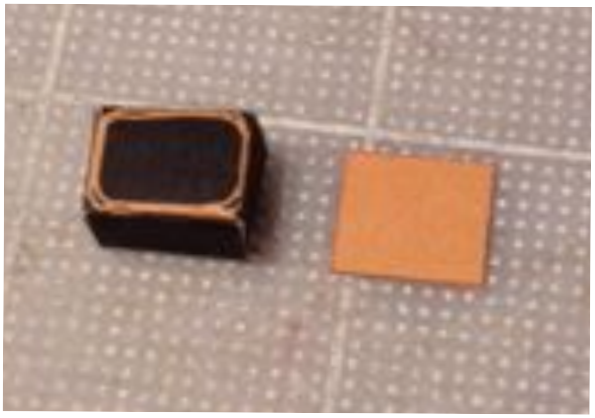


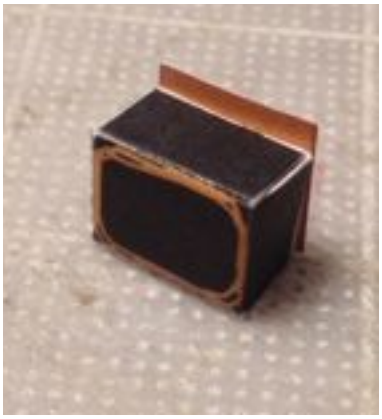


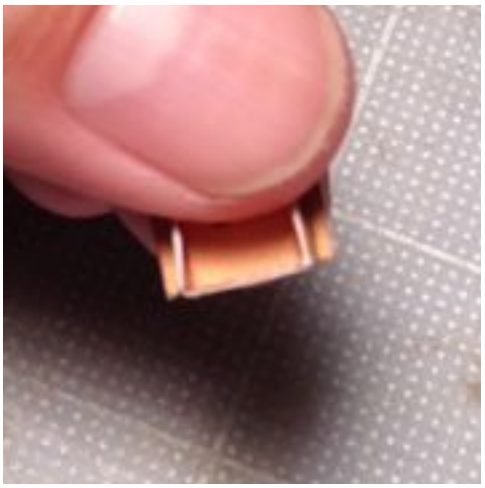


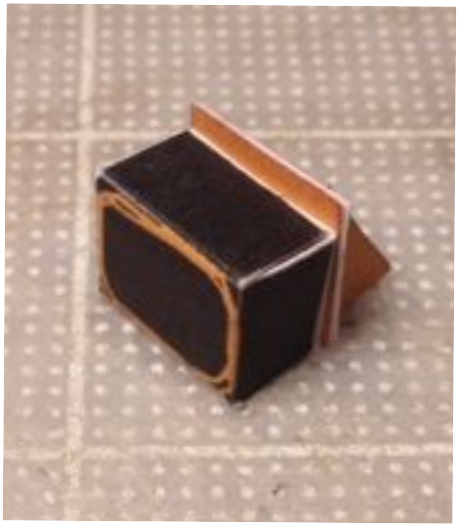
ASPOC (Active Spacecraft Potential Control)

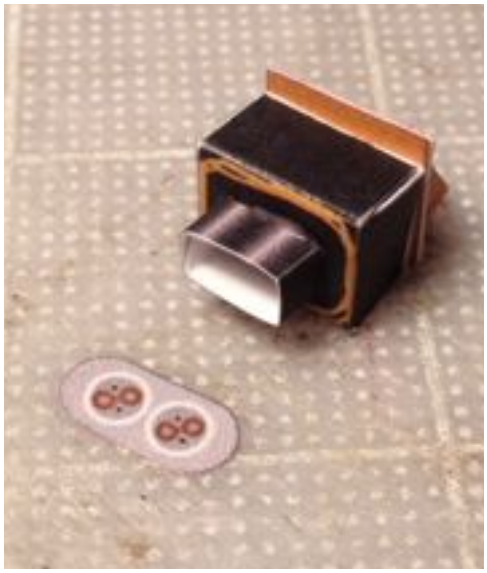
There are 2 ASPOC instruments.











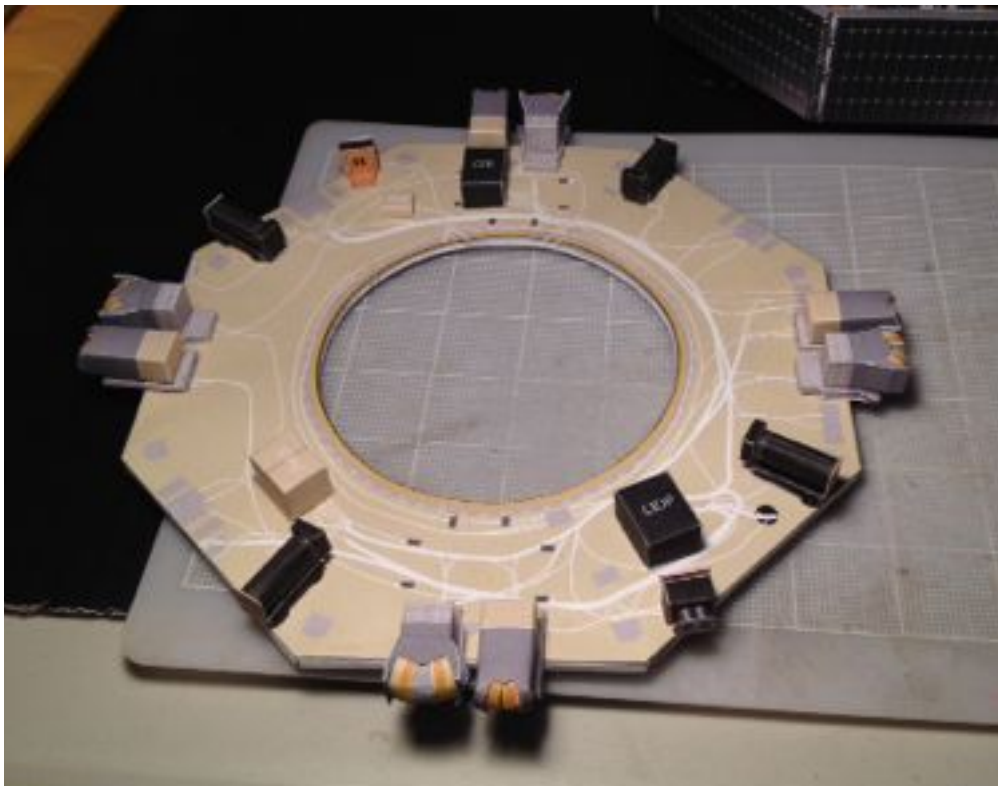
CIDP

CIDP

CIDP

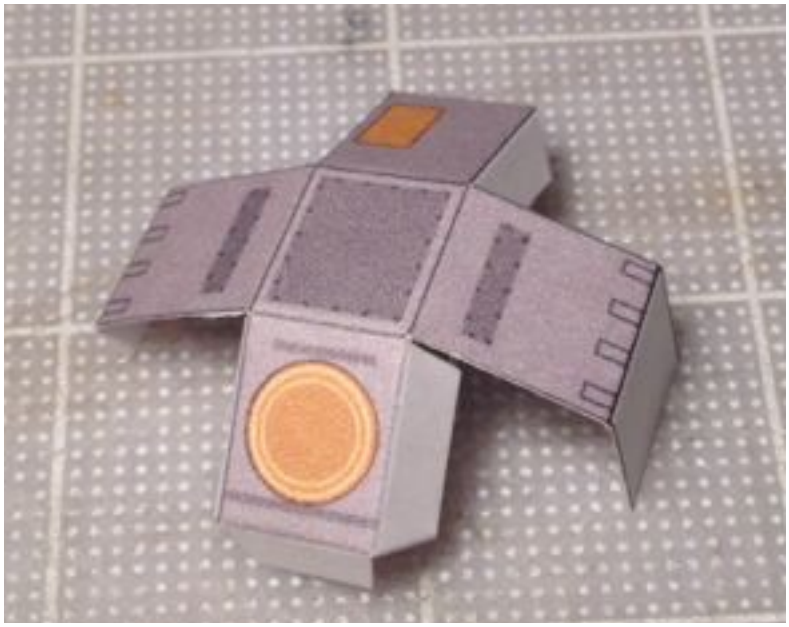
CIDP

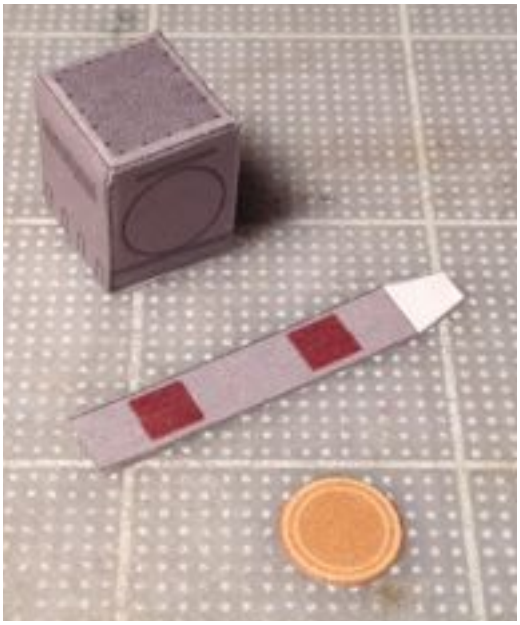
CIDP

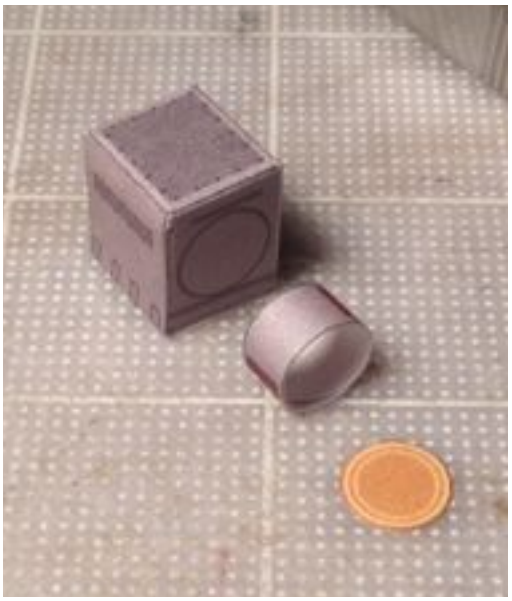


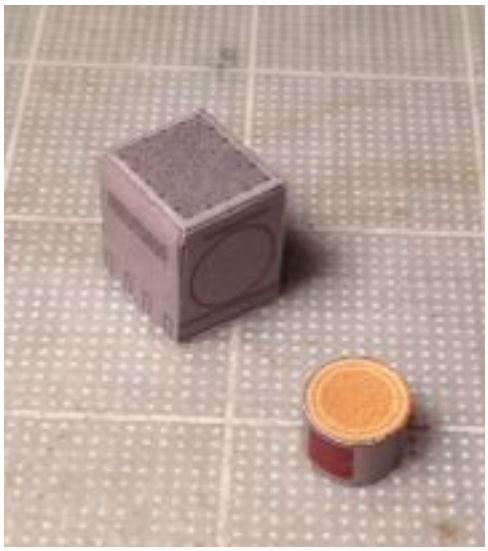
HPCA (Hot Plasma Composition Analyzer)

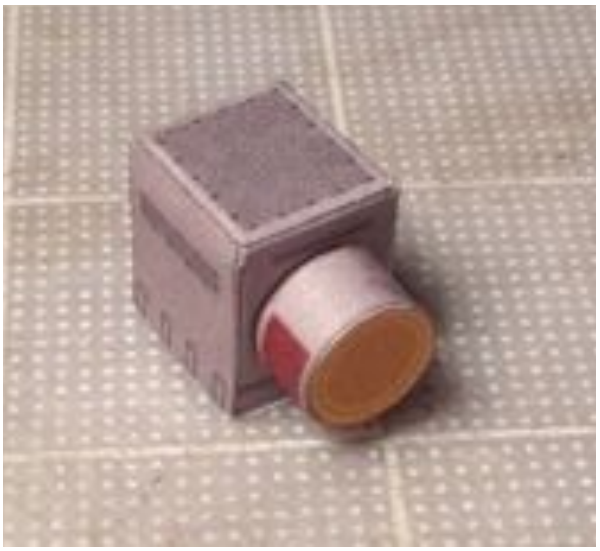
Only 1 instrument.

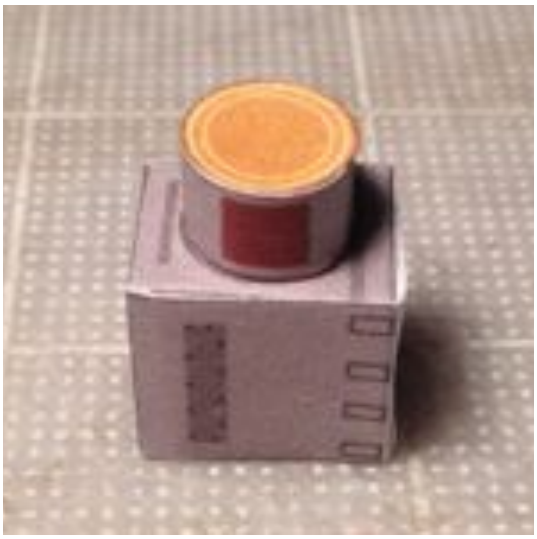


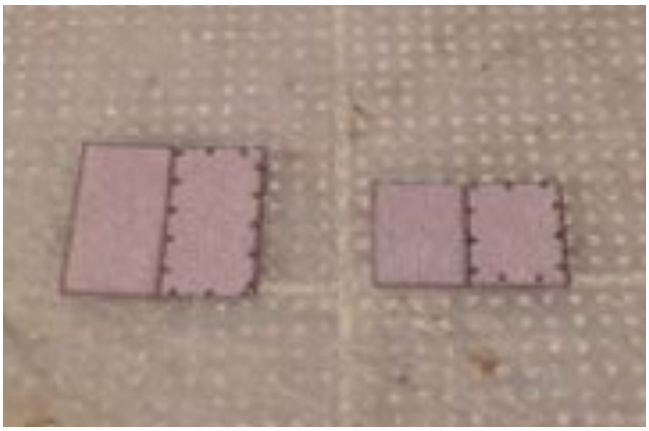


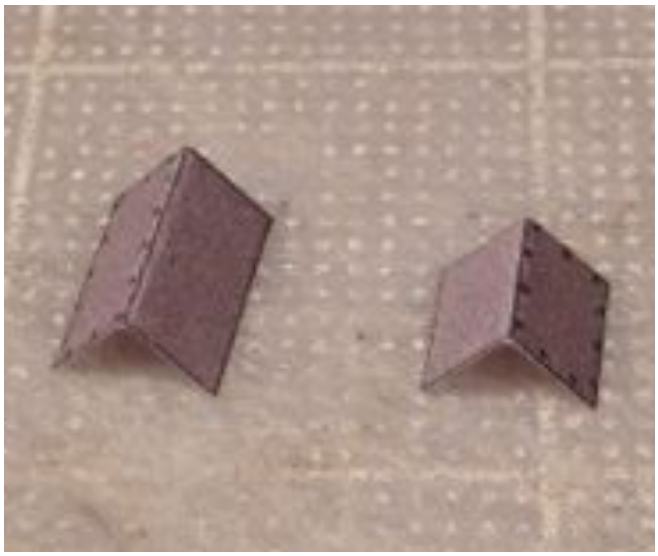


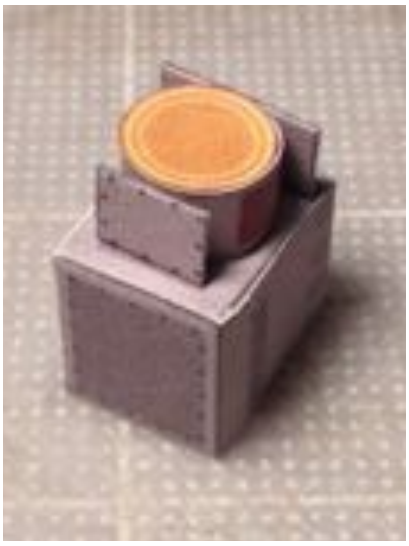


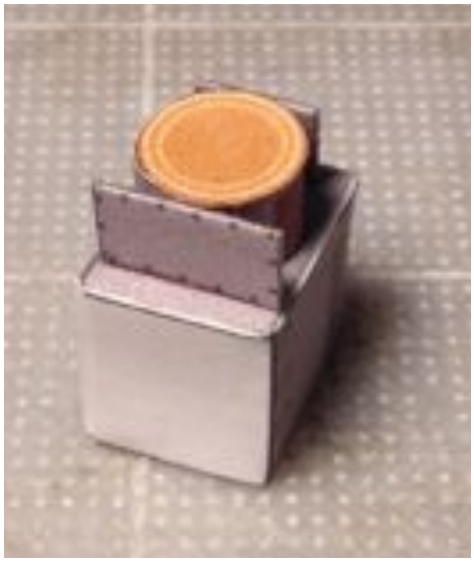


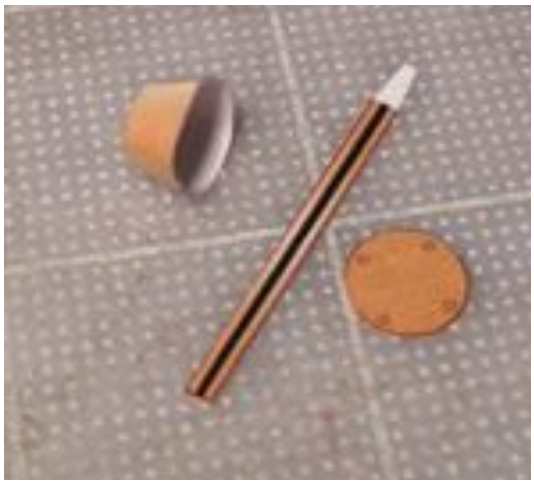


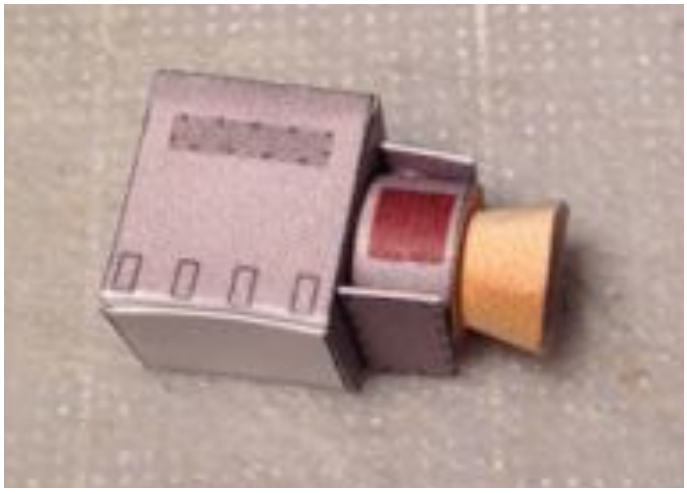


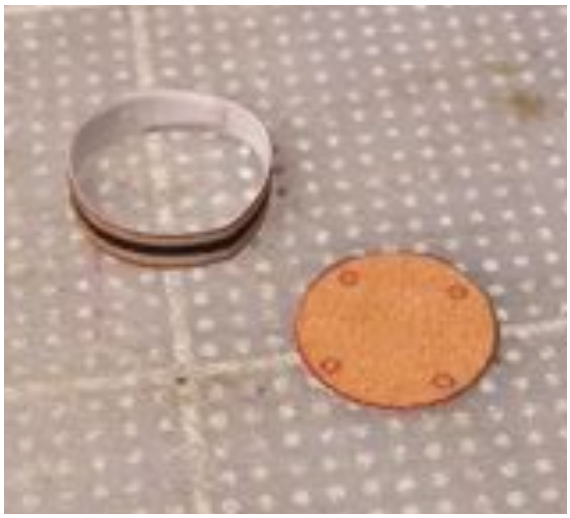


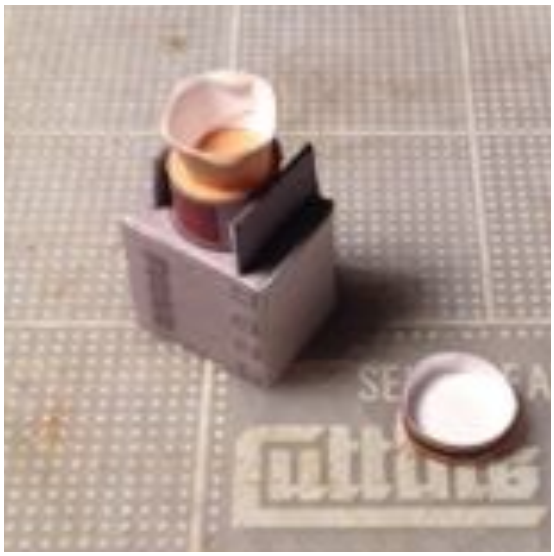


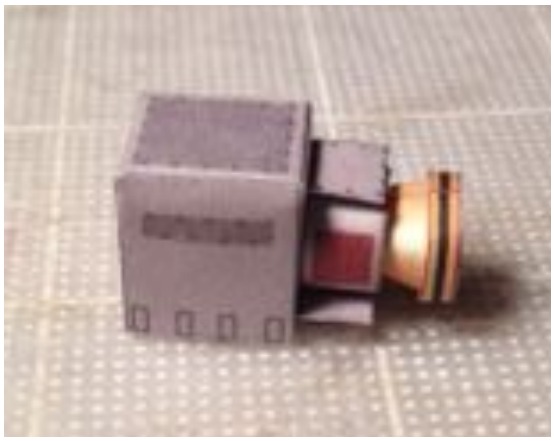


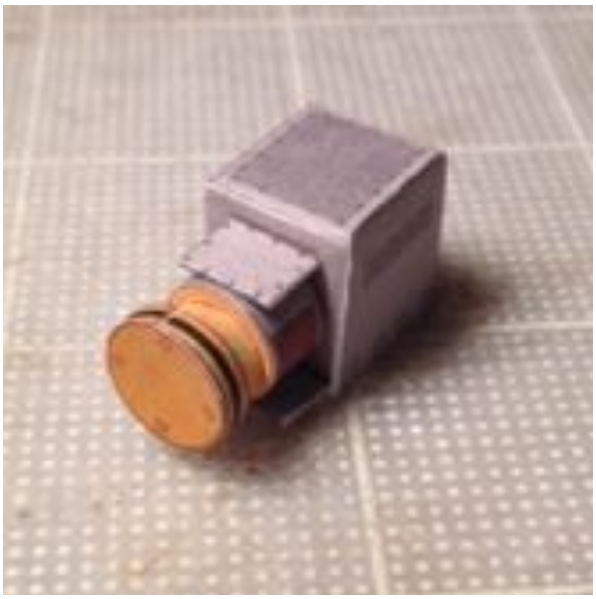


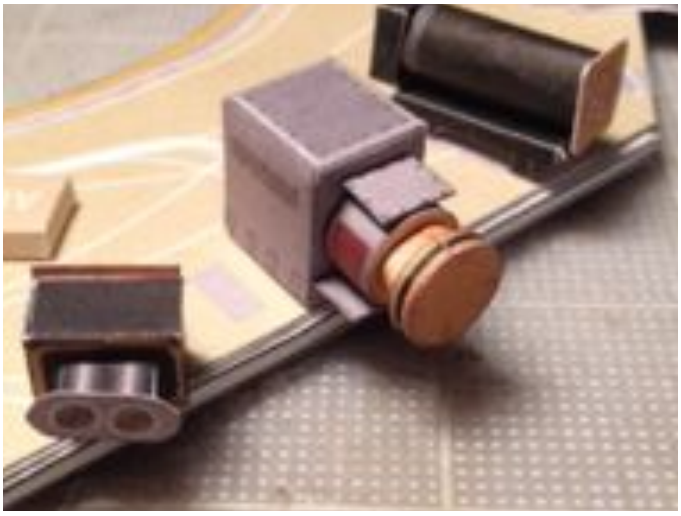


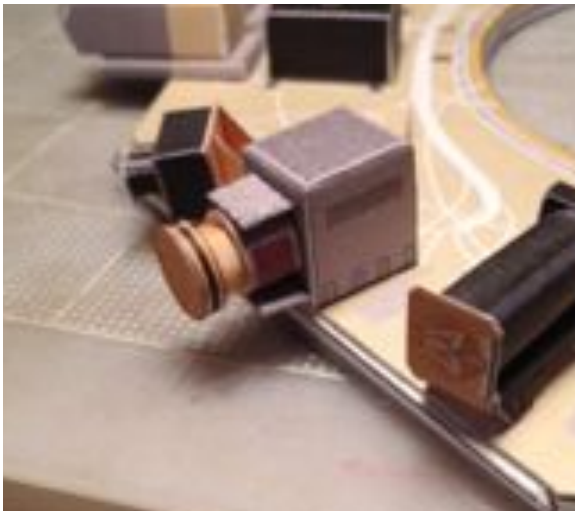






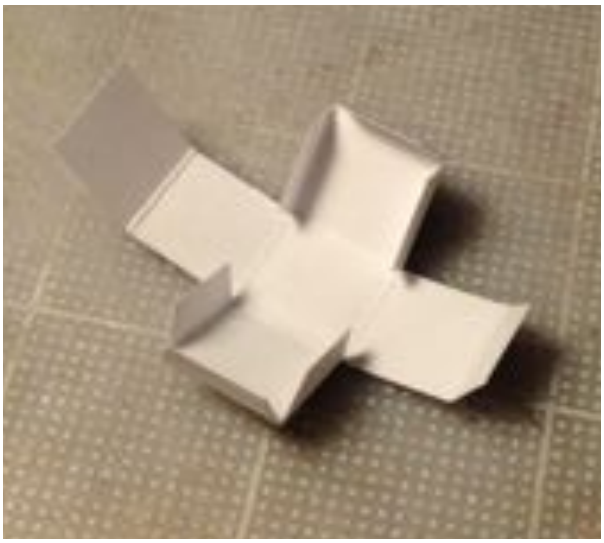


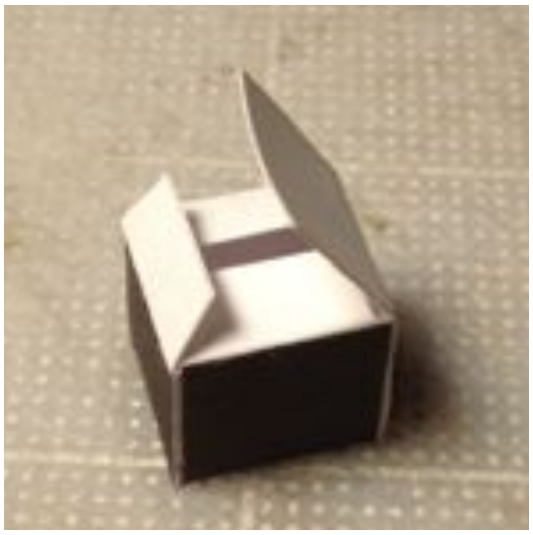


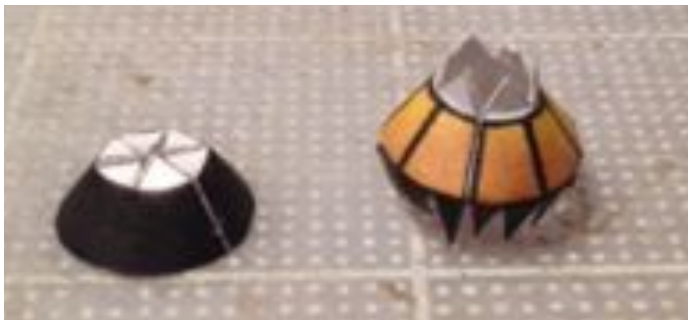


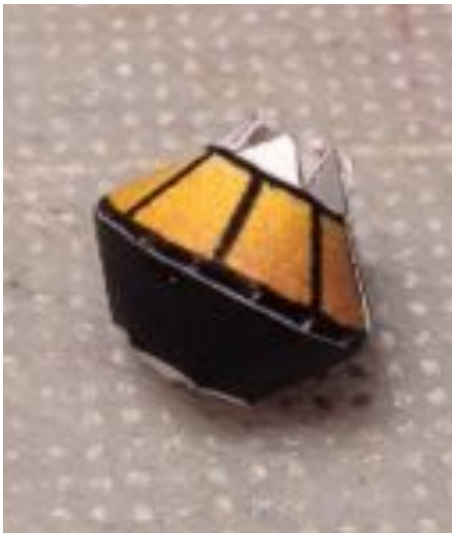
EDI (Electron Drift Instrument)

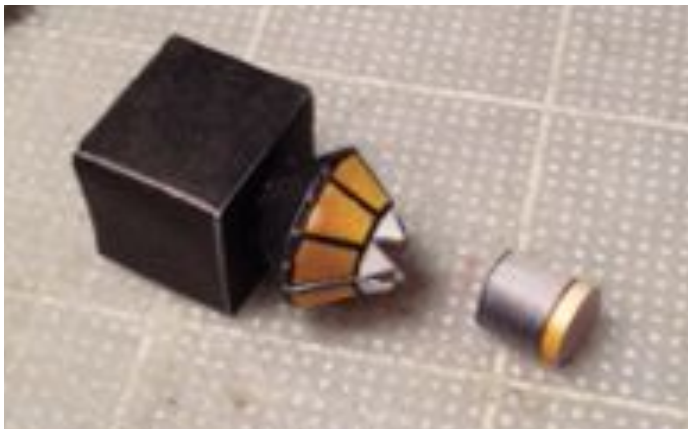
There are 2 EDI instruments.

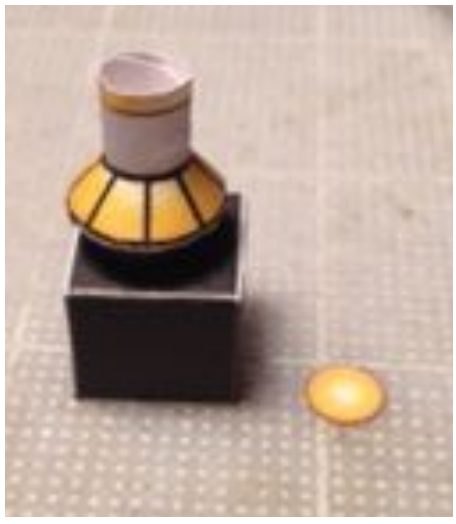


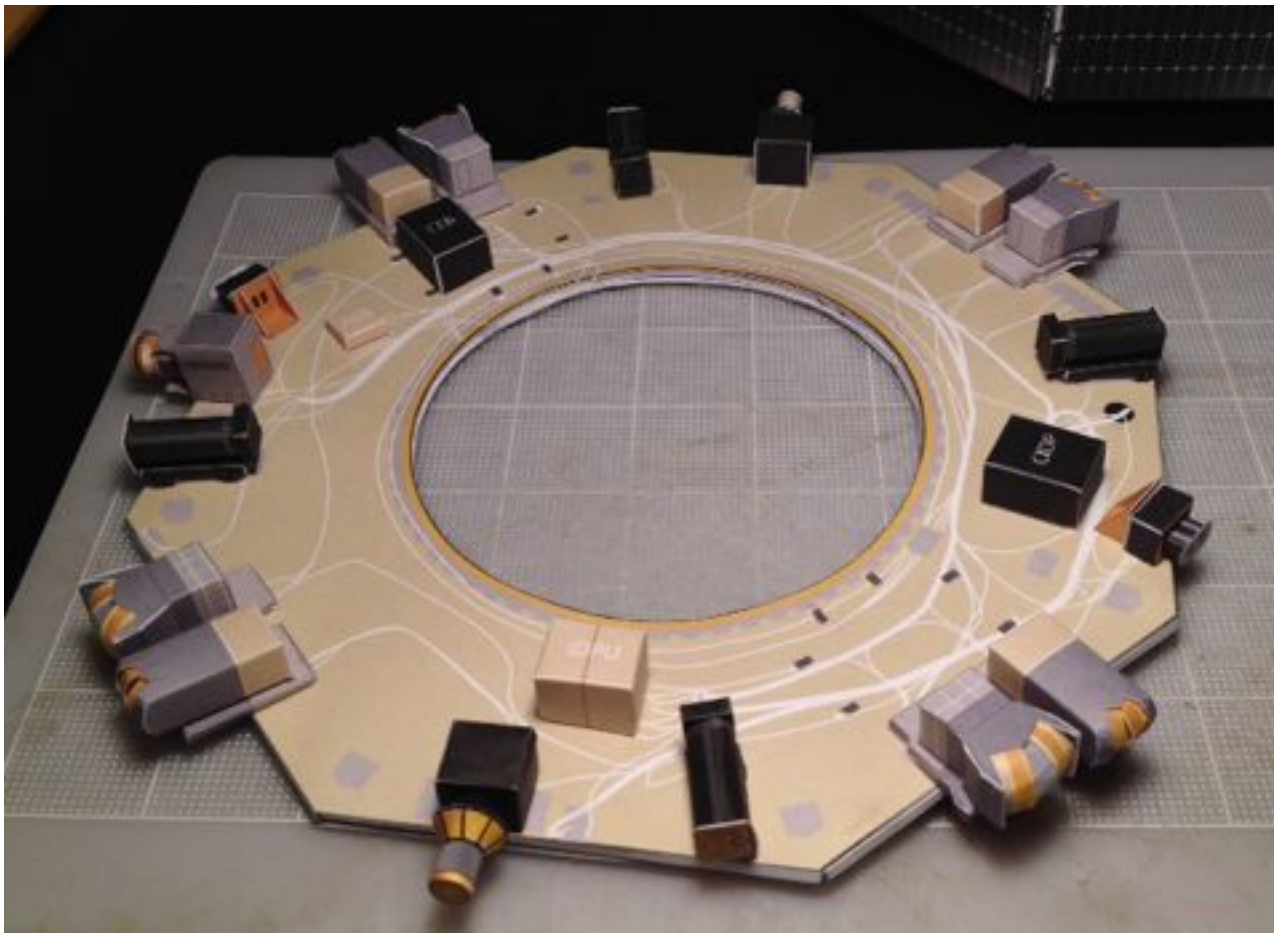








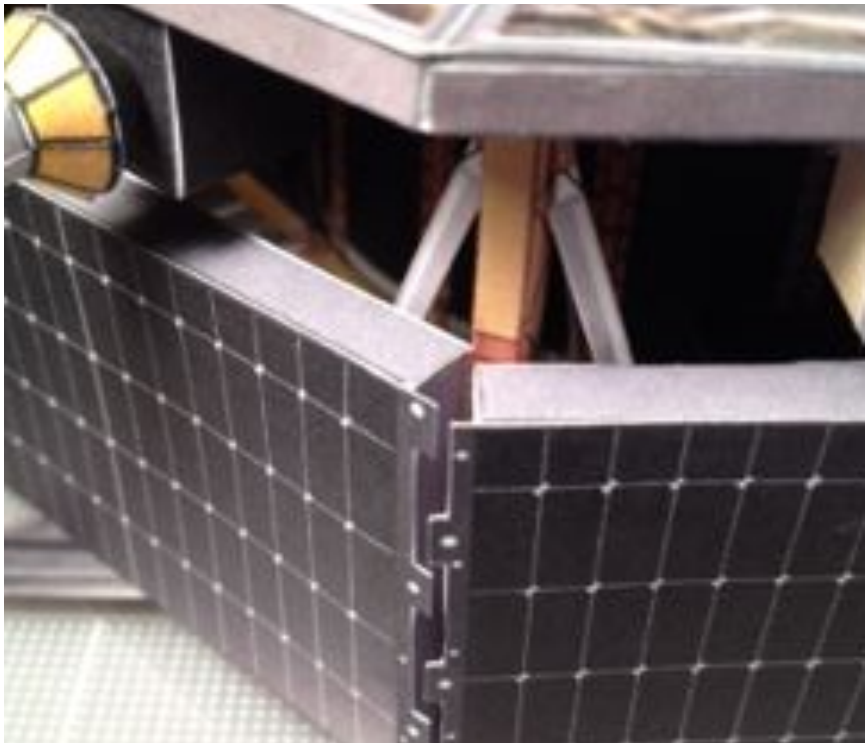


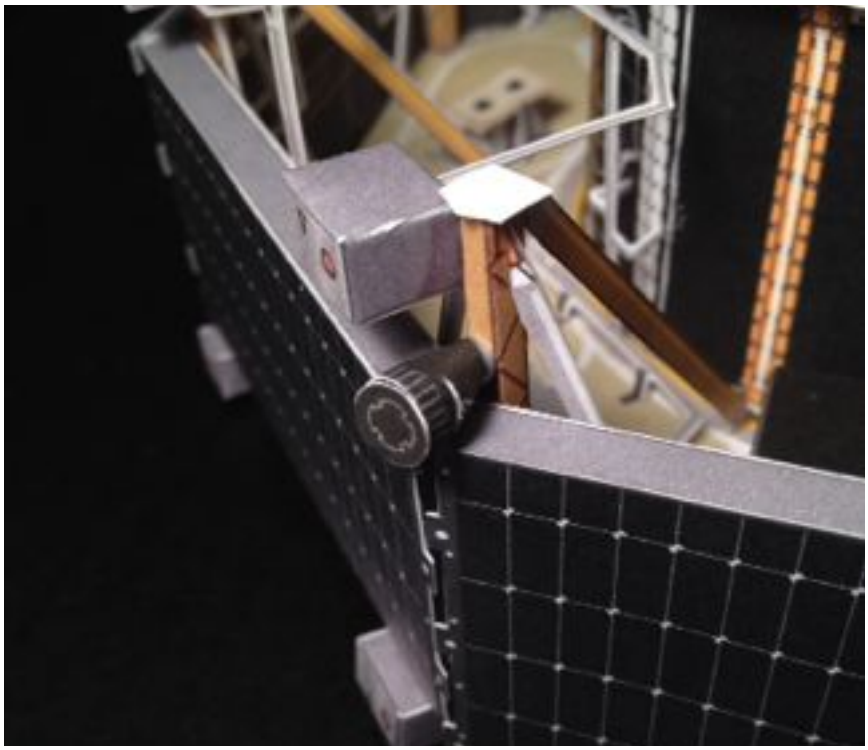


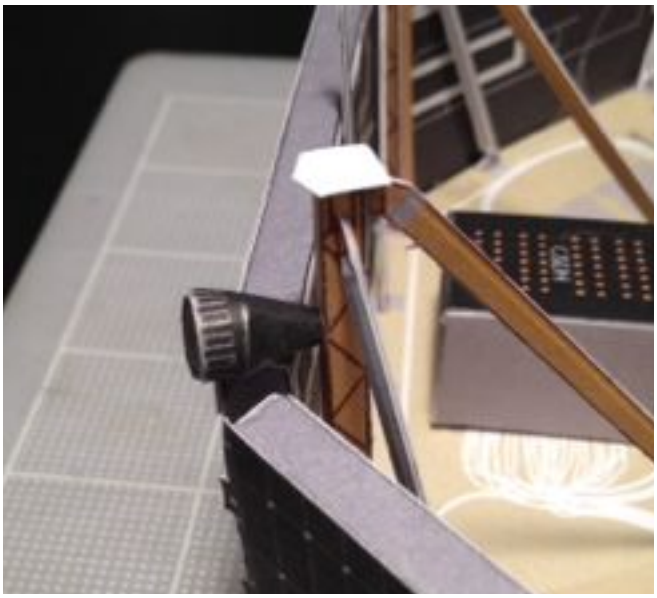
7. Finishing the MMS exterior

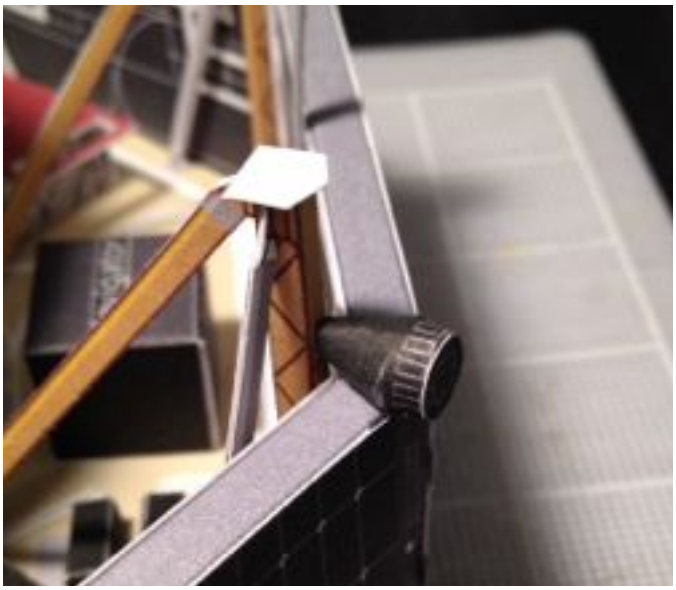
GPS Antennas

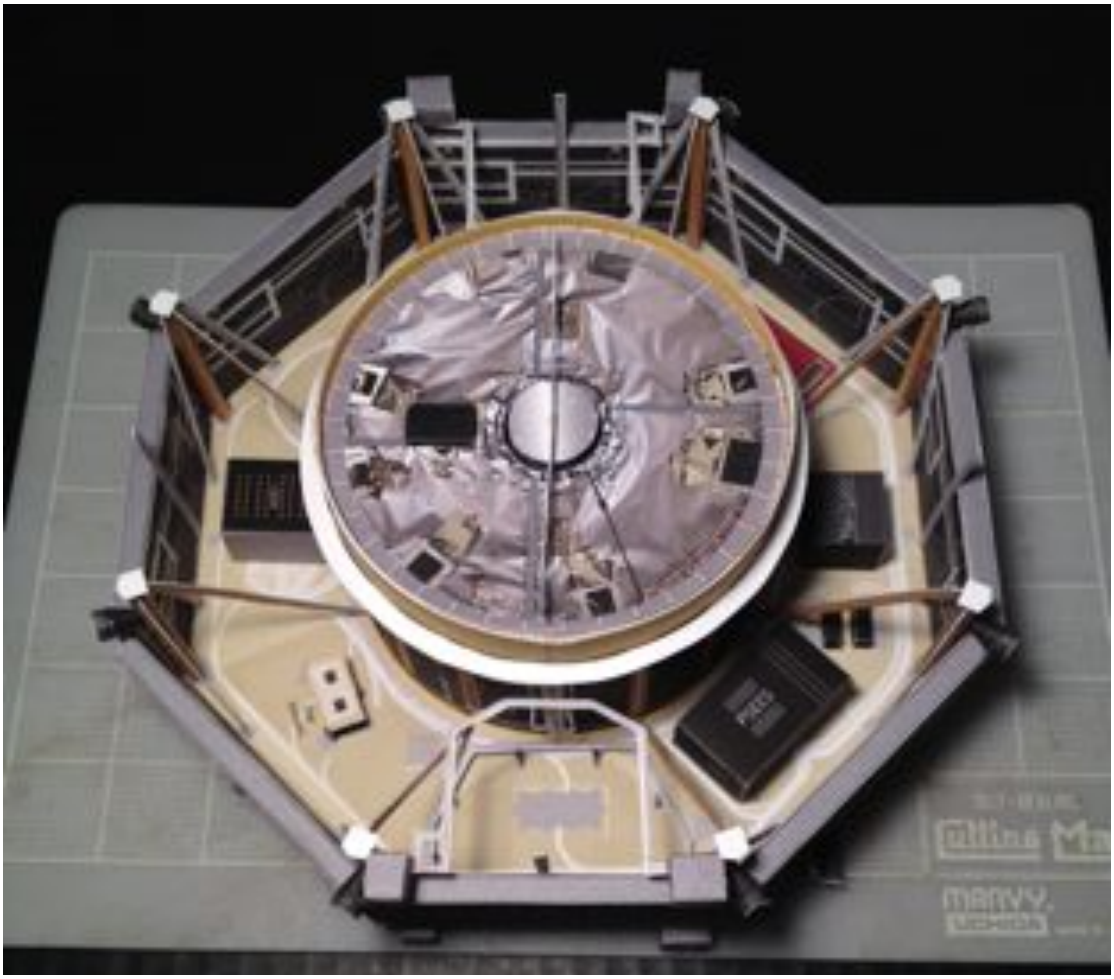
There are 8 antennas.



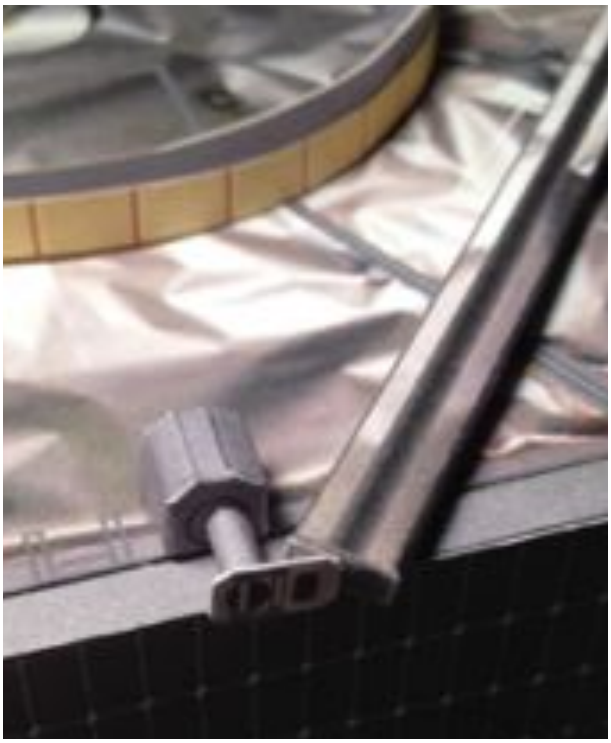


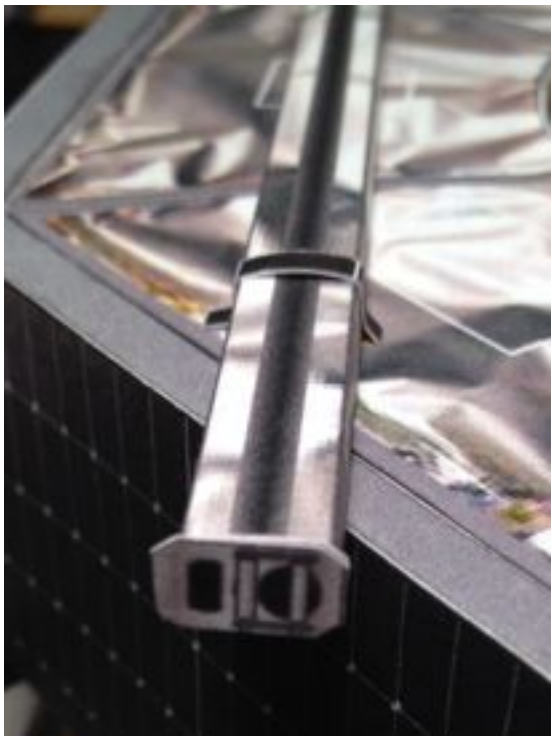


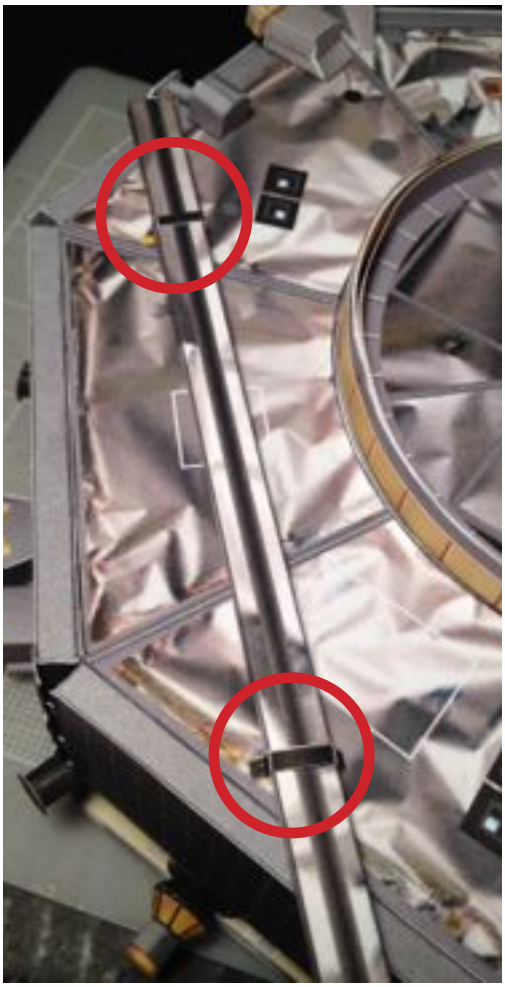




Magnetometer Booms (stowed)

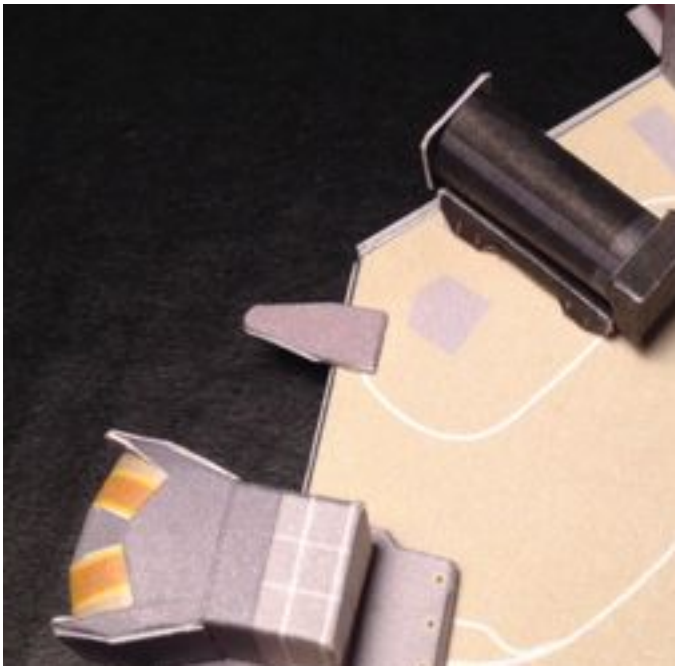




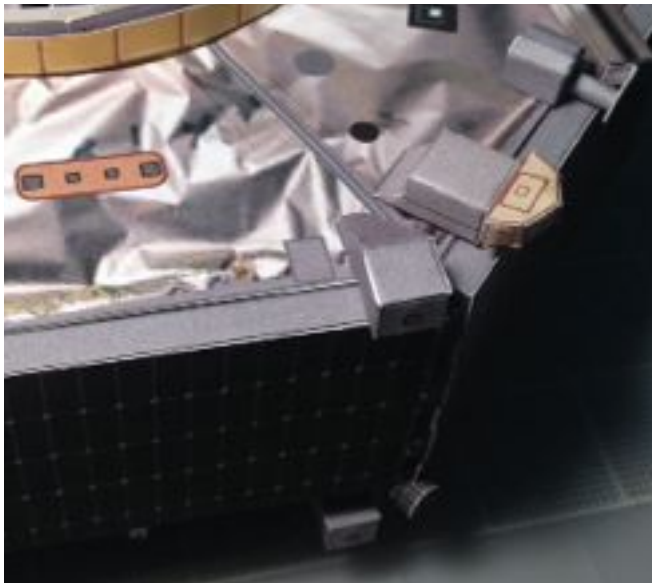


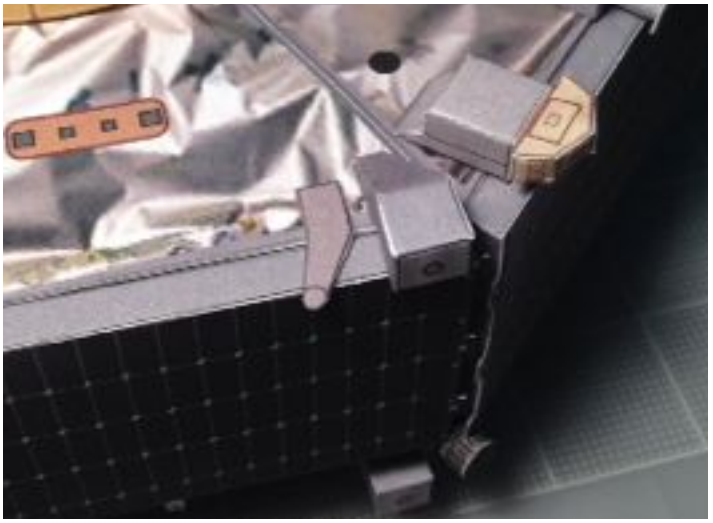
MARVY
UCHIDA

S-Band Antennas

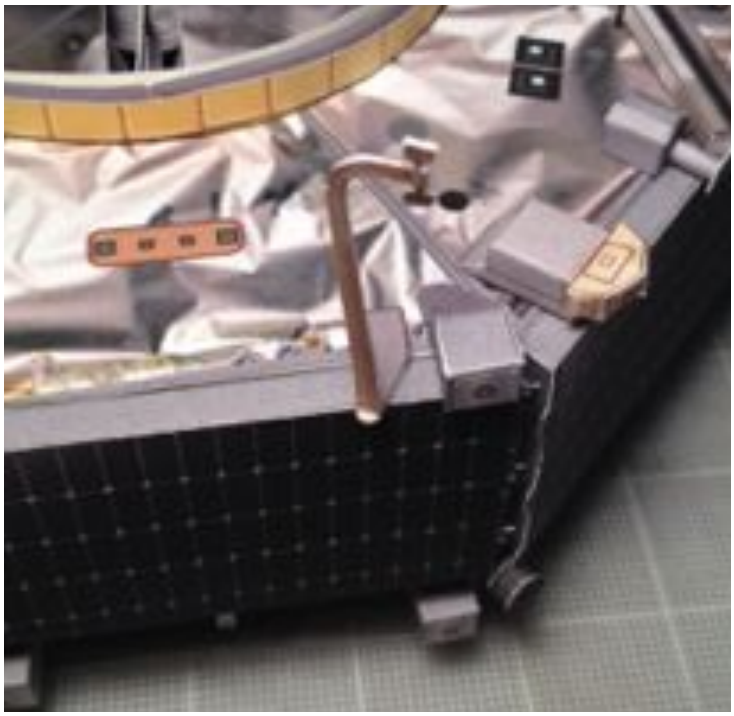


Top and bottom views of the S-Band location on the Upper Deck.

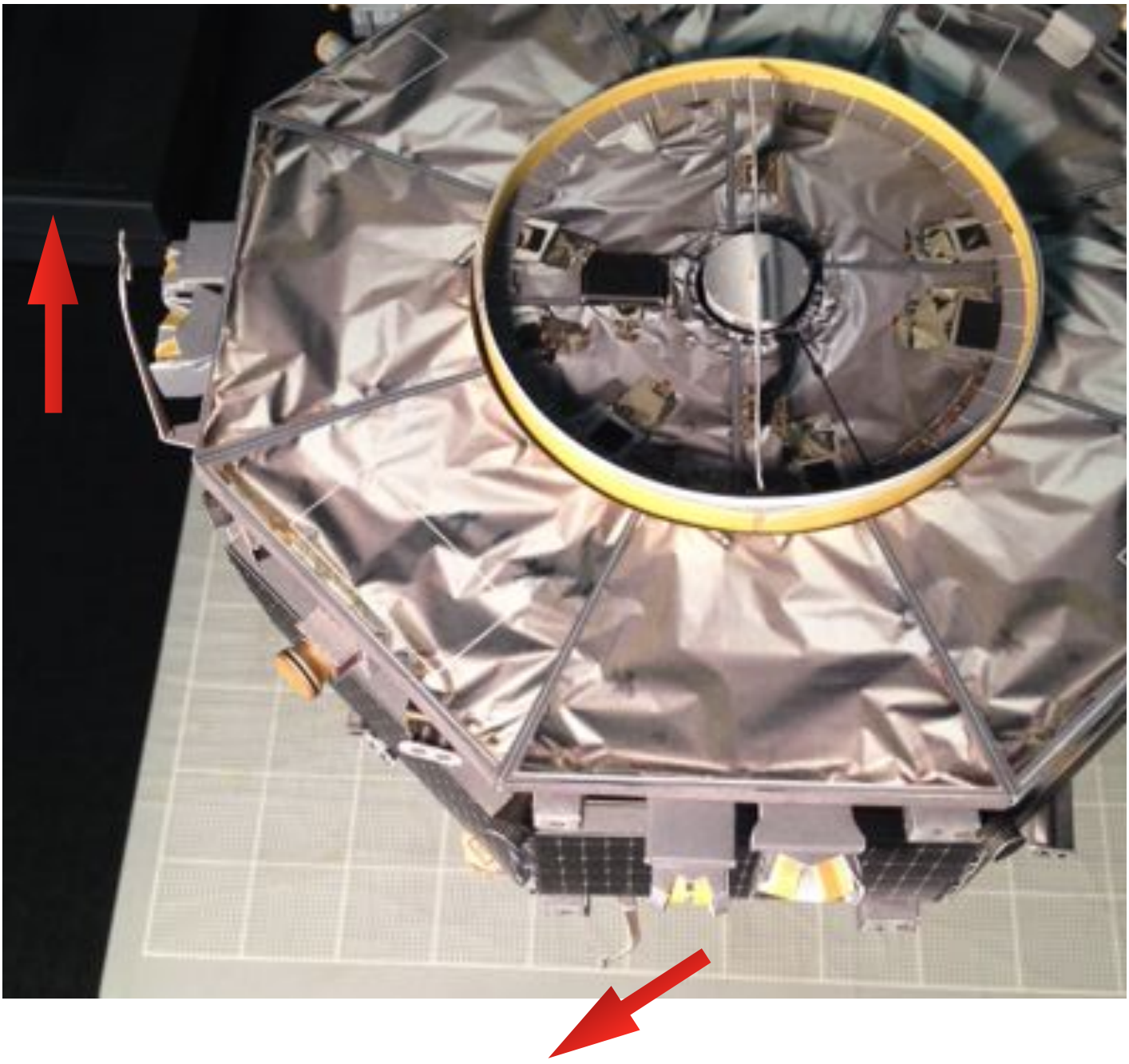




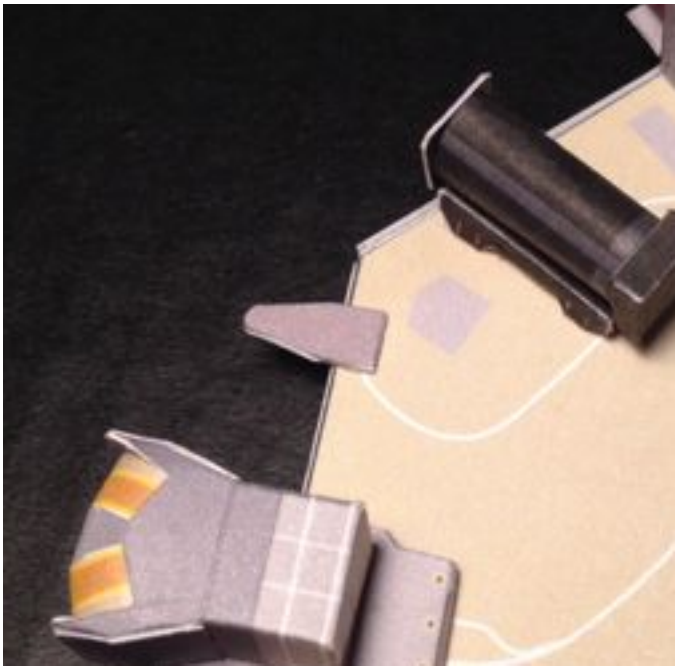
Lower Deck showing the S-Band location



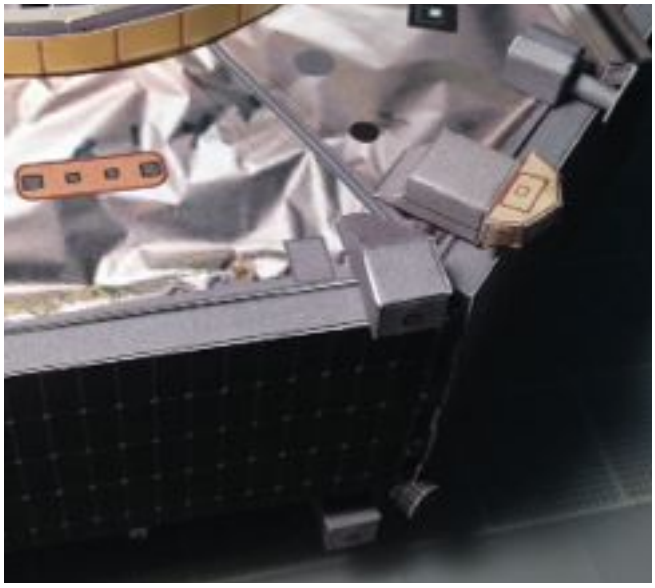
S-Band orientation

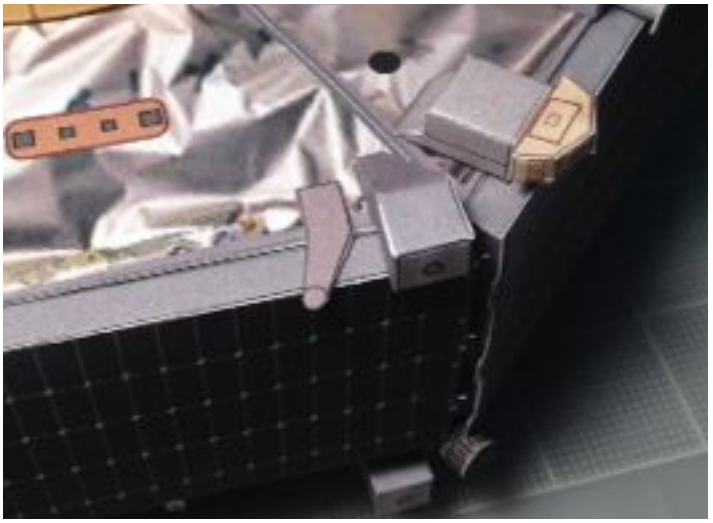


S-Band Antennas

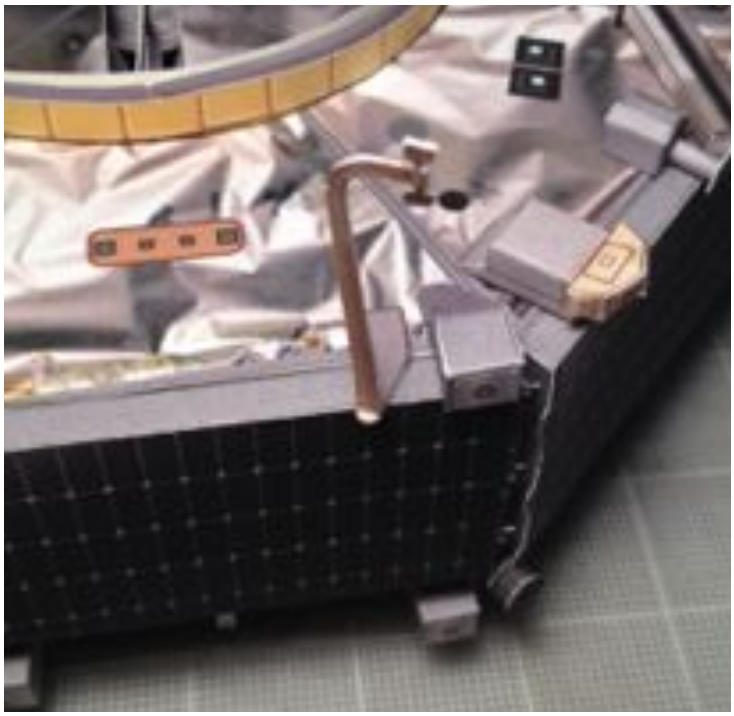


Top and bottom views of the S-Band location on the Upper Deck.

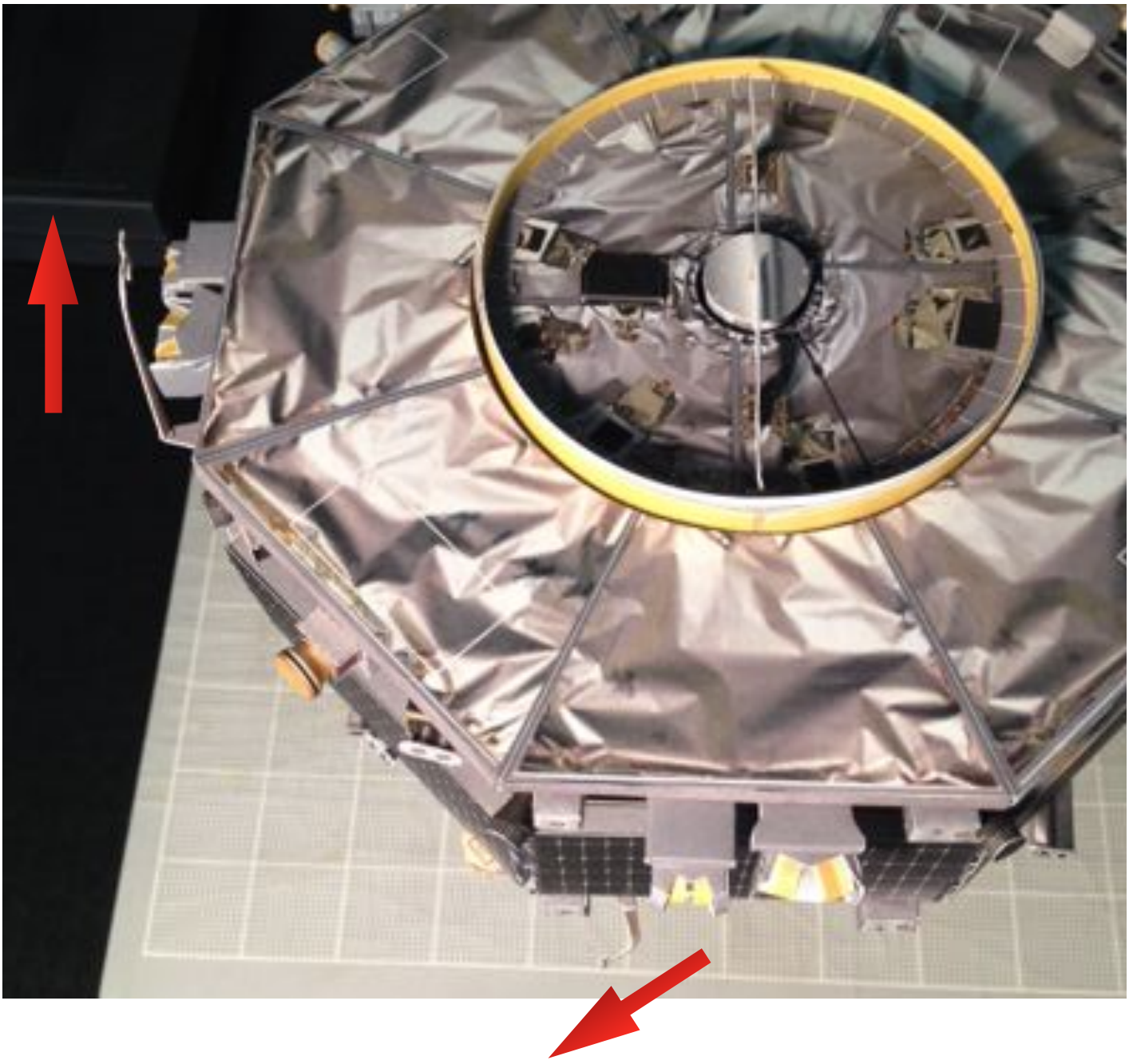




Lower Deck showing the S-Band location

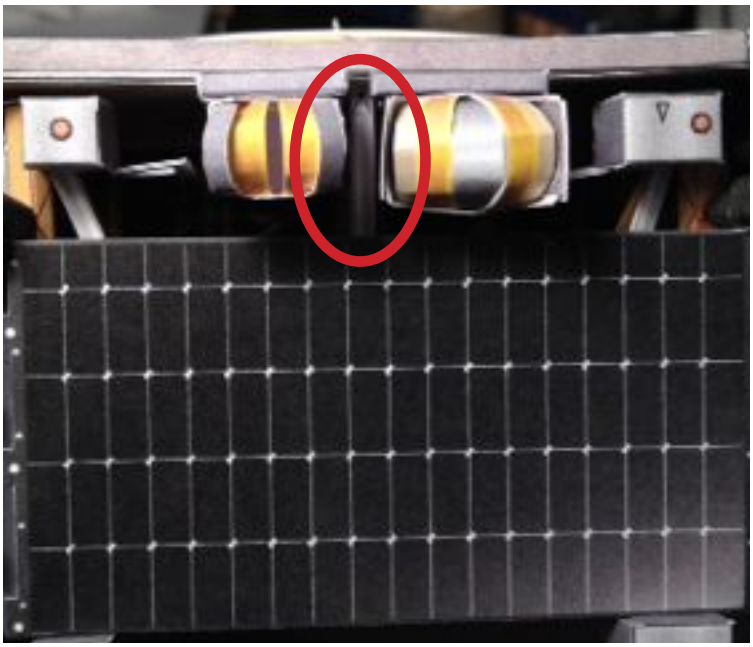


S-Band orientation

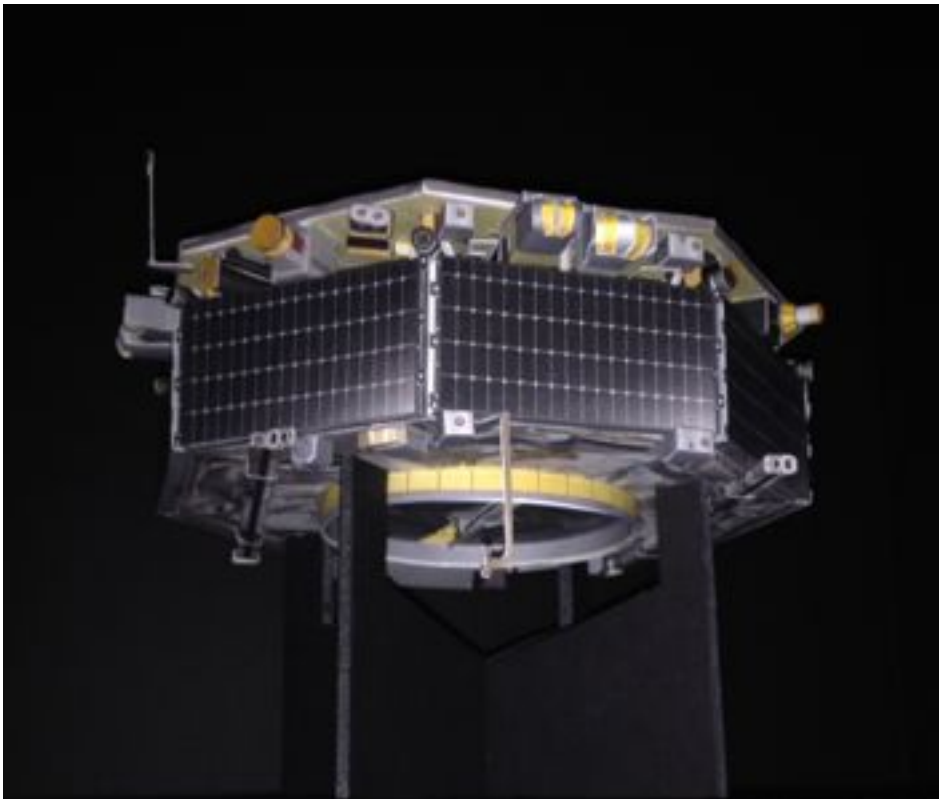


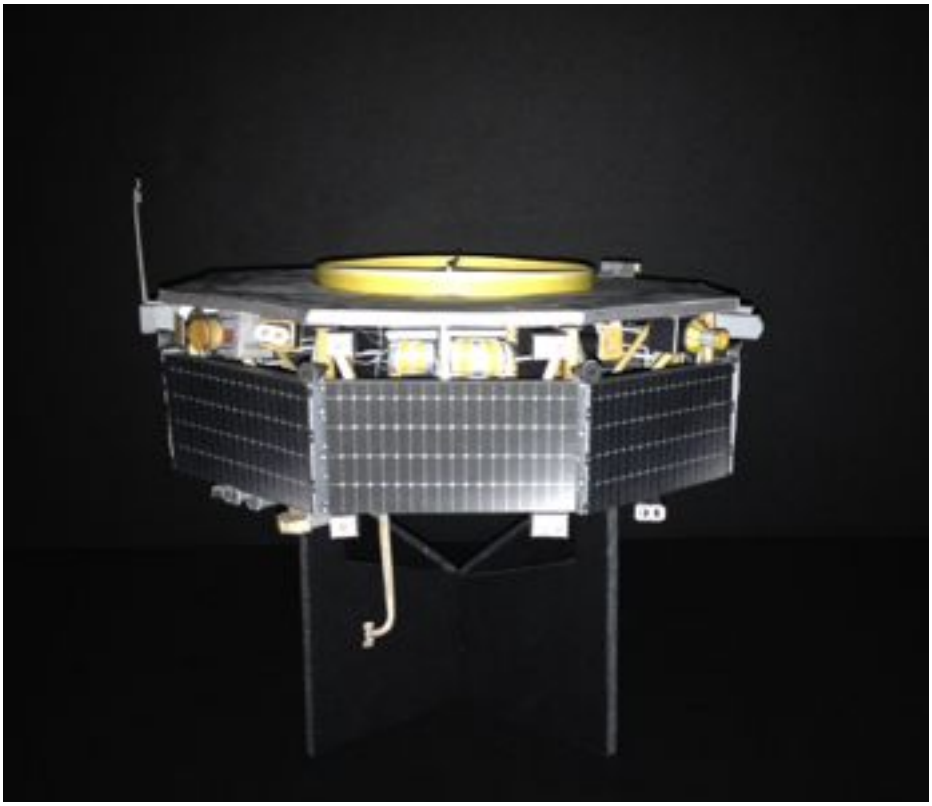
Placing the Upper Deck onto the model

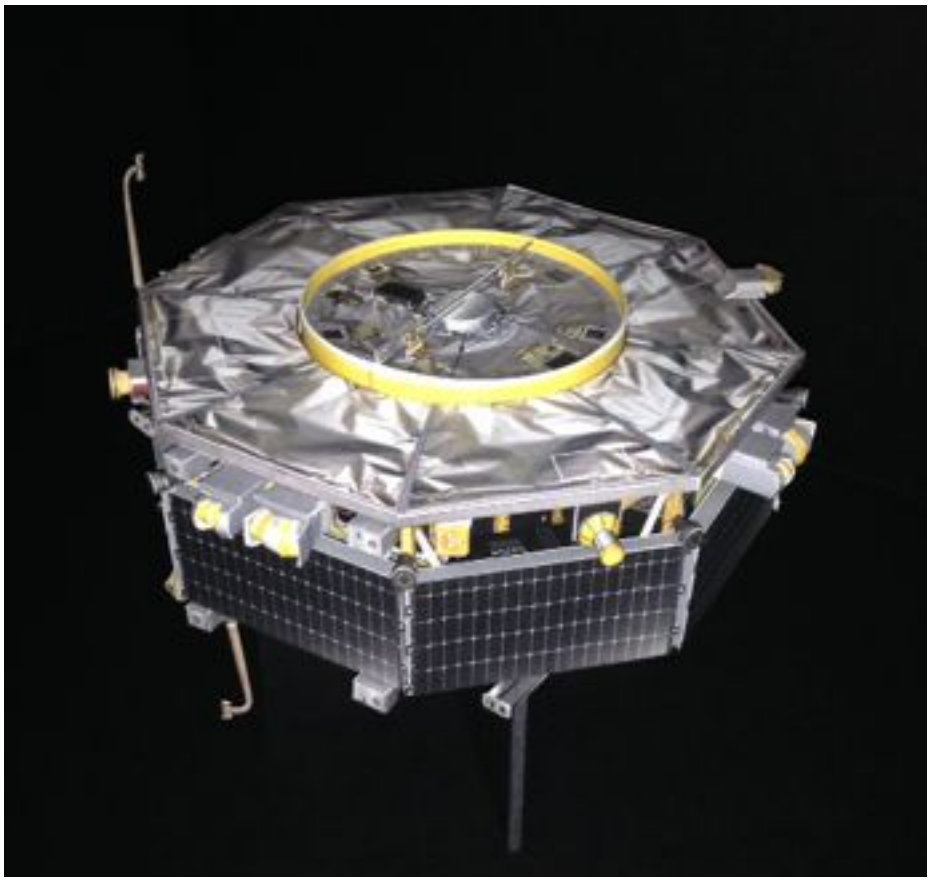
Carefully insert the thrust tube into the Upper Deck hole and match the vertical struts in between the DIS/DES instruments.

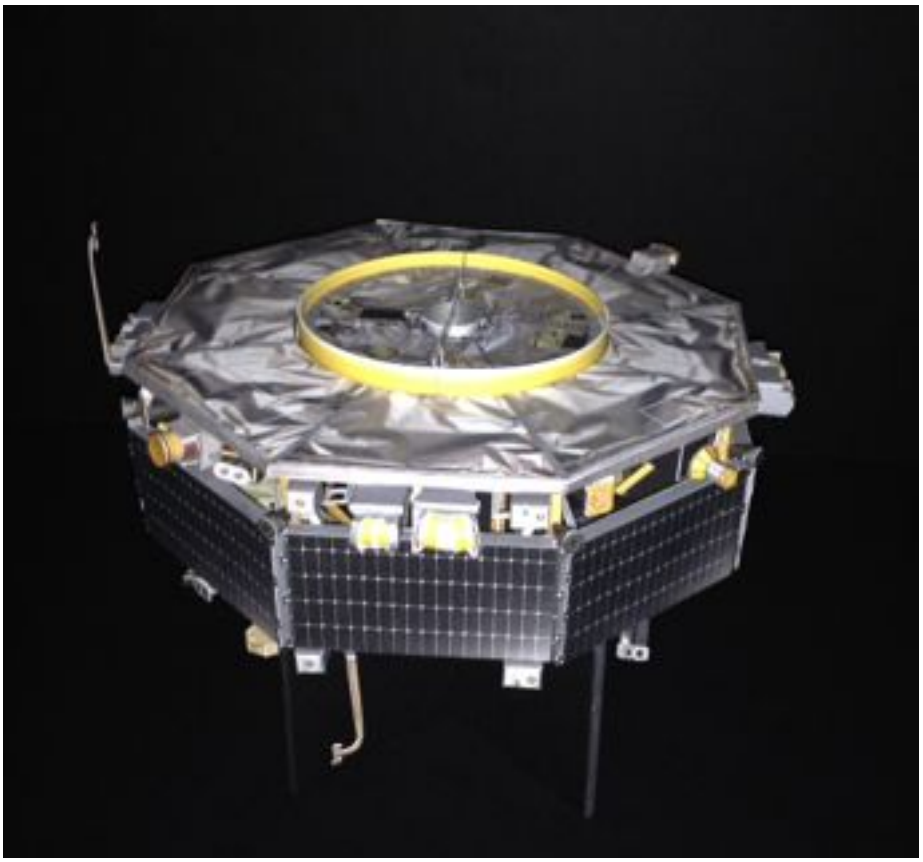


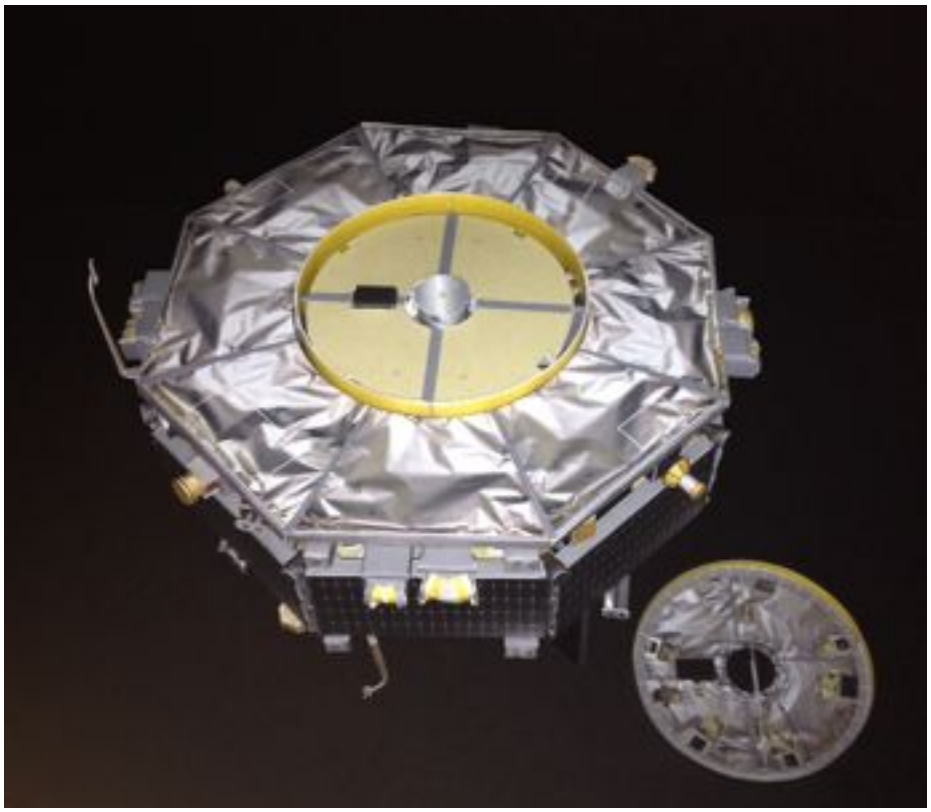
Finished MMS model

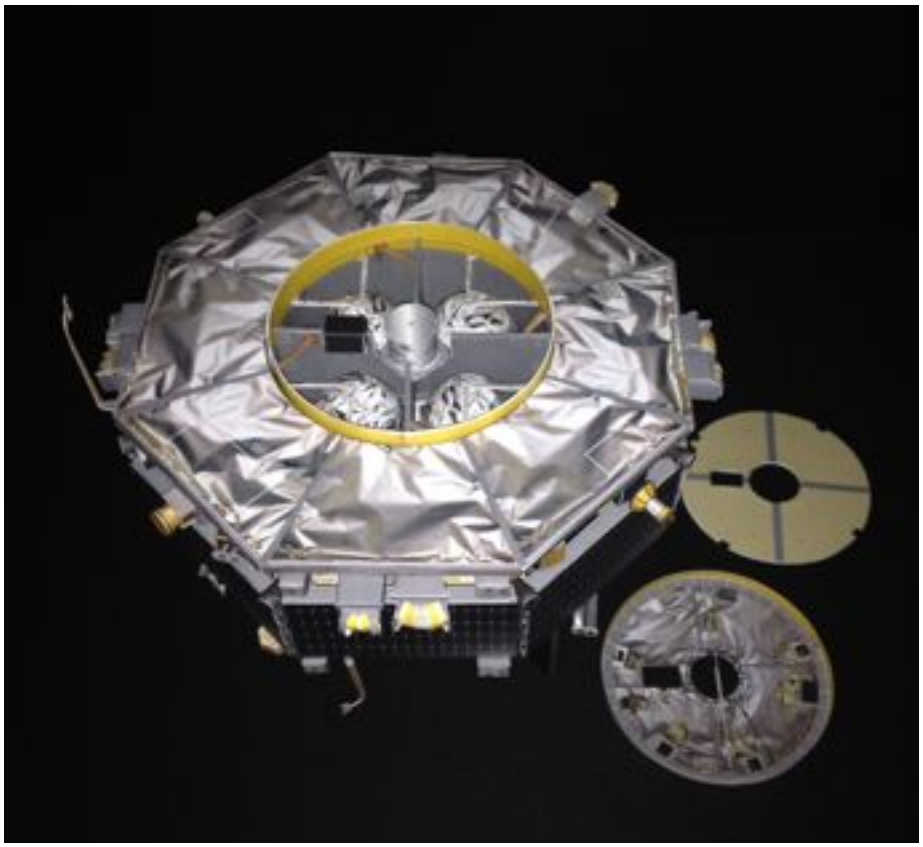


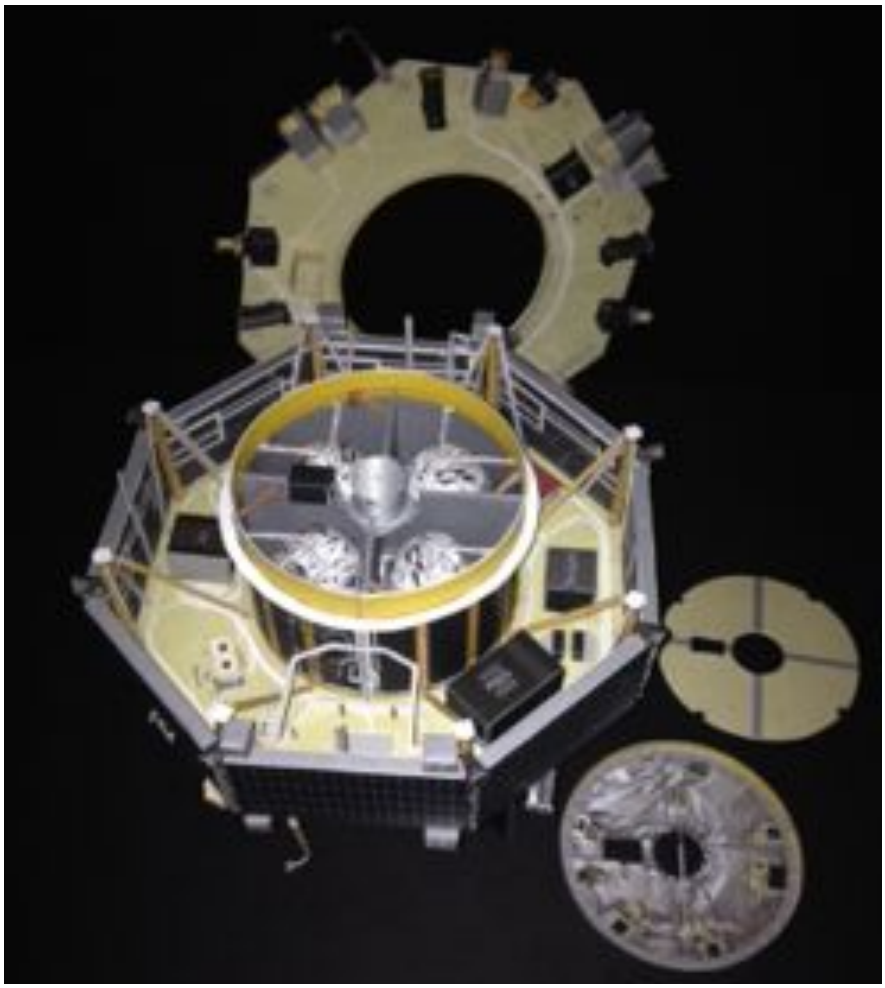


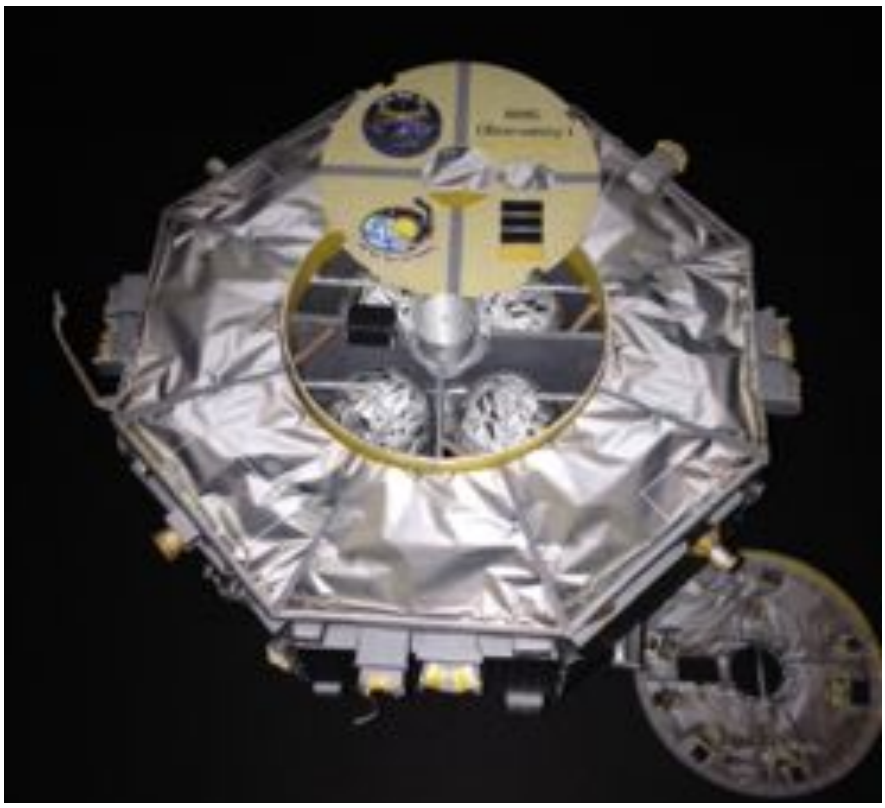


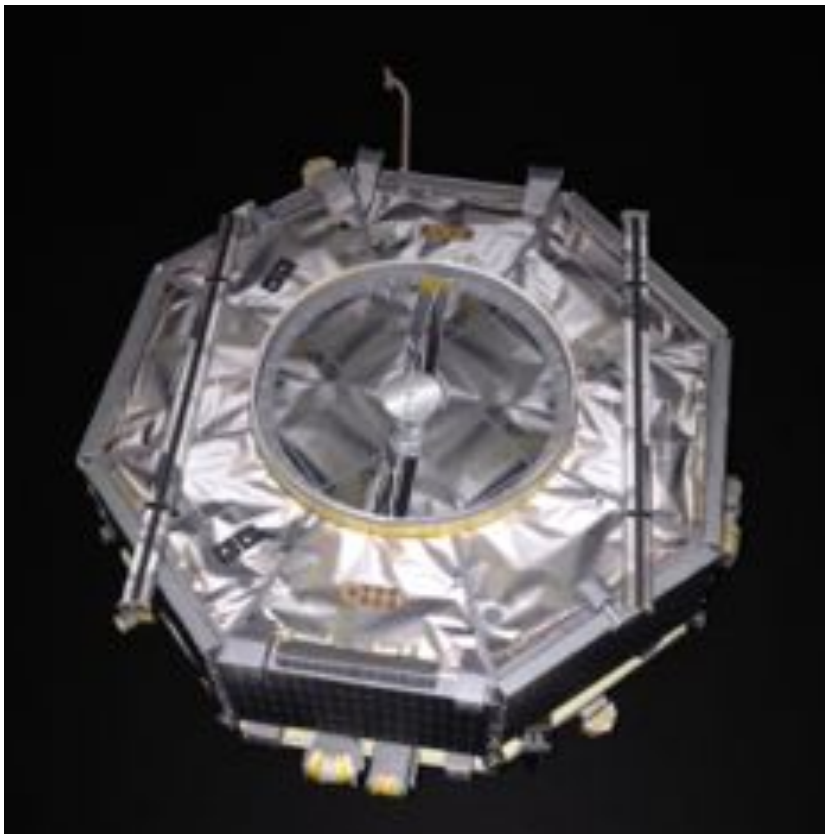


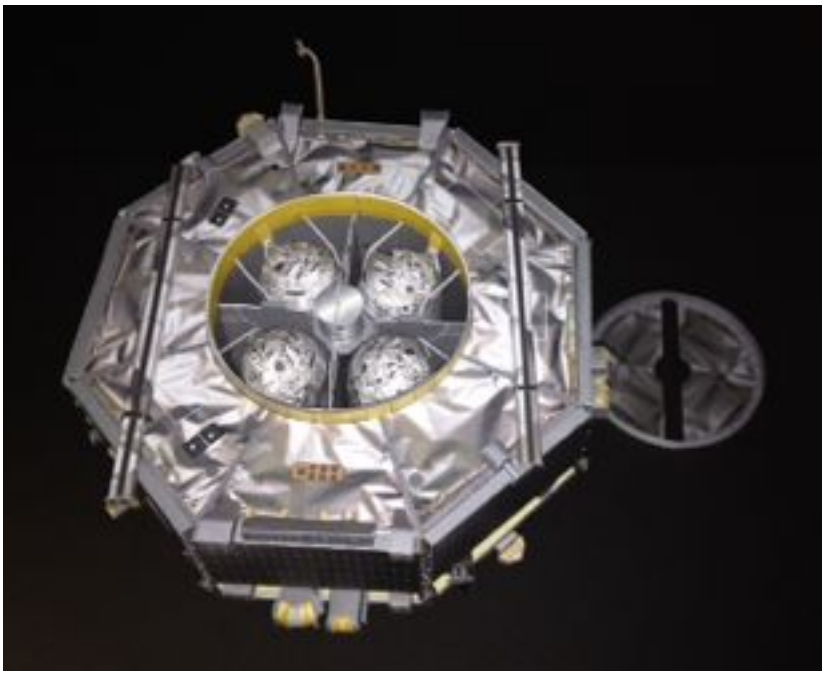












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