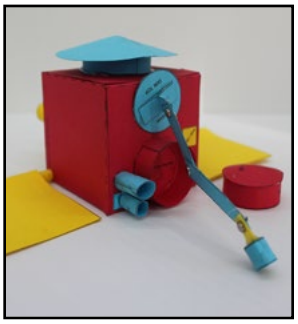
ART PROJECT INSTRUCTABLE



You have had an introduction MISSIONMakers and OSIRIS-REx—it's time to do the Guided Engineering Project! Below is an implementation overview. Instructables—detailed step-by step instructions with photos—aid the making portion of the project (pp. 7 - 36). Each team—all team, spacecraft, science and flight—has its own set of instructables.

- Mission Manager has both her own instructable and places where she supports other teams, delineated by a green band in the instructables.
- Leaders may show sections of the instructable with a projector to guide learners through tricky sections.
- Leaders may decide to have all learners build some portions for the simple machine/maker experience, (the Touch and Go Sample Acquisition Mechanism (TAGSAM) for example).
- As with any lab or maker-project, leaders should make a sample OSIRIS-REx model in preparation to become familiar with the making process and learn strategies to support students.

SUPPLIES

Supplies for Students:

- **OSIRIS-REx Templates *(Copy onto colored card stock or white card stock as indicated on templates. Do not use regular copy paper because it is too flimsy.)***
- **Teams/Color Key Handout *(page 5)***
- **Tiny brads *(4 per team, available at hobby shops. You can also order 1/8 Round Brads in bulk at: www.eyeletoutlet.com.)***
- **Plastic flexible straws *(2 per team)***
- **Scissors**
- **Hot glue**
- **Zip-lock bags**
- **Rulers**
- **Pencils**
- **Markers *(if using white templates)***

Teacher Tools:

- **Hole punch with adjustable settings *(can be obtained from craft and construction stores. You can get an inexpensive rotary leather punch online at www.harborfreight.com)***
- **A Push Pin or Thumb Tack can also be used to poke the small holes**
- **Regular hole punch is needed for solar arrays**

Preparation Time: 60 min
Implementation Time: 60 - 90 min

MAKER OVERVIEW:

1) Team
• Collaboration for the construction of the OSIRIS-REx spacecraft mirrors the teamwork involved in real mission planning and management.
• Your leader or teacher will help you break into teams of four.

2) Collect
• Student Supplies as listed to the left
• One set of Instructables: All Team, Spacecraft, Flight, Science, Mission Manager
• One set of cardstock, spacecraft templates

3) Plan
• Review the "All Team" instructable as a team
• Each team member will have a different, color-coded instructable
• You will be working side-by-side, but not necessarily doing the same thing
• The Mission Manager both helps the other team members and leads the construction of the final model

4) Make!
• Follow your step-by-step instructables
• Remember, your Mission Manager both helps everyone as needed and leads the construction of the final model (Glue Master)
• As you build, consider how this is similar and different compared to a real NASA mission teams!

All Teams - Black (pages 7-8)
Spaceflight Engineers - Red (pages 9-13)
Flight Teams - Yellow (pages 14-22)
Science Teams - Blue (pages 23-33)
Mission Managers - Green (pages 34-36 and Check Point steps as indicated.)

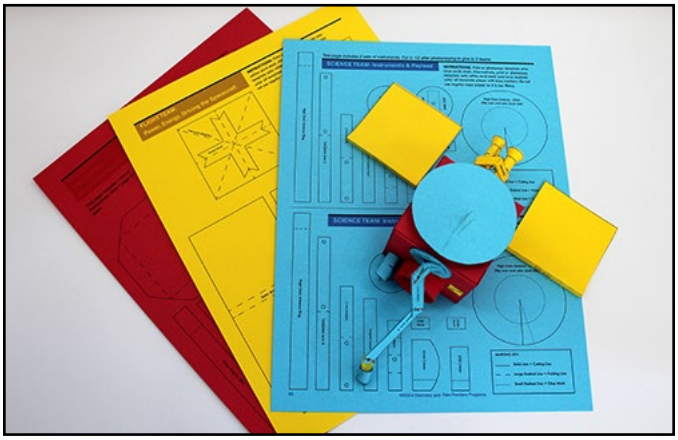
ALL TEAMS: Prepare OSIRIS-REx Model Parts

STEP 1: Collect All Supplies

- Collect all supplies as outlined on page 6.
- Each team gets a Zip-lock bag, scissors, 4 brads, 2 yellow straws and a pencil.
- Markers, glue guns, blue straws and hole punches can be shared.

STEP 2: Teams & Handouts

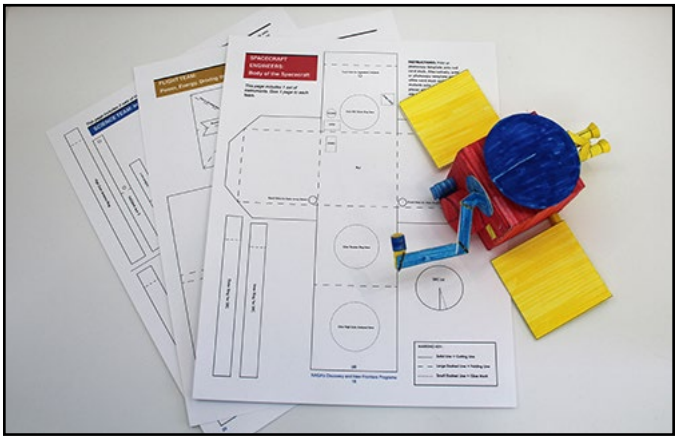
- Student break into teams of 4.
- Teams get a copy of OSIRIS-REx Model Teams Handouts and each student picks a job - 1) Spacecraft Engineer, 2) Flight Team, 3) Science Team and 4) Mission Manager.
- Review your job's color and roles on handout. Mission team steps are color coded below.



STEP 3: Get Templates

(Colored Paper Option)

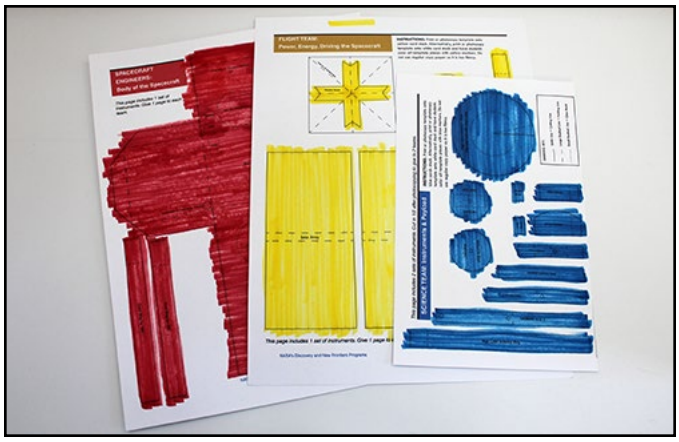
- Each team gets a set of model templates.
- If using colored paper, you'll need 1 red page (Spacecraft Engineer), 1 yellow page (Flight Team), and a 1/2 blue page (Science Team)
- ***Skip to Step 8.***



STEP 4: Get Templates

(White Paper Option)

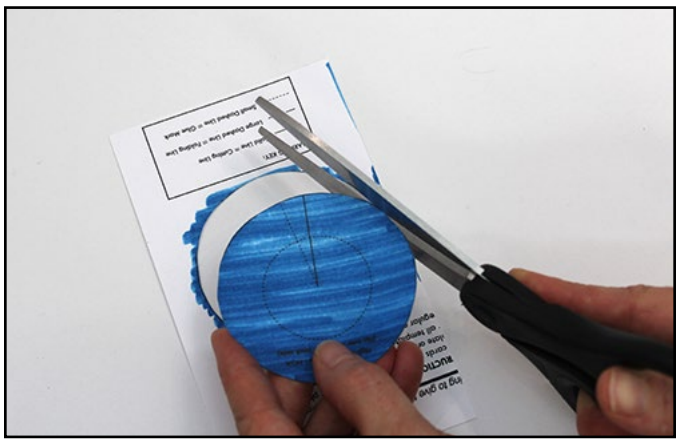
- If you are working with white templates, you'll need 1 Spacecraft Engineer page (color red), 1 Flight Team page (color yellow), and a Science team 1/2 page (color blue).
- Complete steps 5-7.
- *Note: 2 sets of instruments are on the Science Team page templates.*



STEP 5: WHITE PAGES ONLY

Color All Parts with Markers

- If you have white card stock, color all your parts with markers according to your color key.
- **Spacecraft Engineers - red**
- **Flight Team - yellow**
- **Science Team - blue**
- **Mission Manager - green** *Will supervise trouble shooting an final assembly as shown in green. You support other teams so look for green bands!)*



STEP 6: WHITE PAGES ONLY

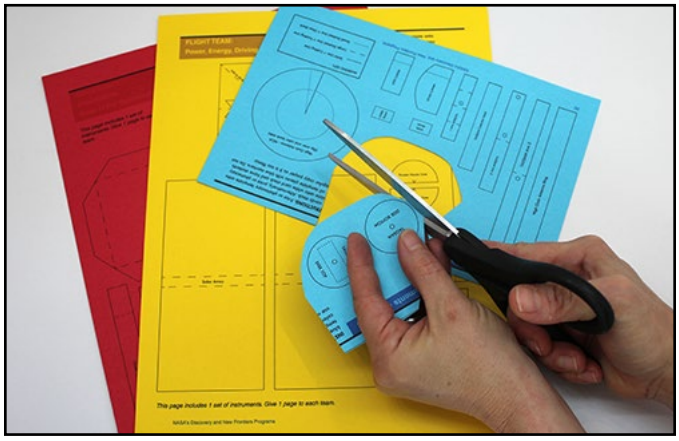
Cut Colored Parts

- Cut out all your parts and put them in your Zip-lock bag.
- These parts are small so the Zip-lock back should be used so that teams don't loose their small parts.

STEP 7: WHITE PAGES ONLY

Color Back of HGA

- If you have white card stock, turn your High Gain Antenna over and color the back side blue as well as the front so that your marks are on the correct side.



STEP 8: COLORED PAGES ONLY

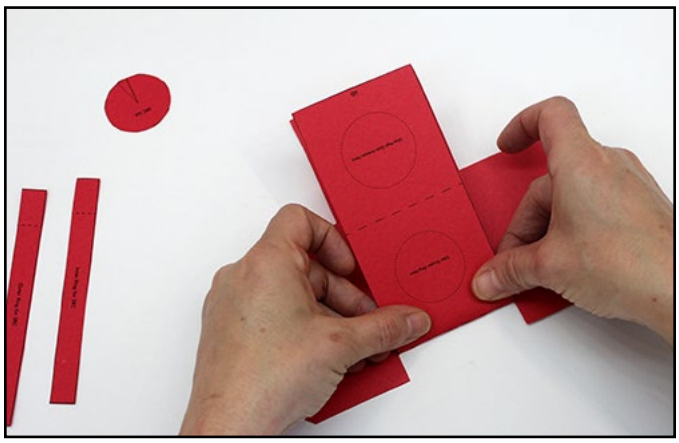
Cut Out Colored Paper Shapes

- If you have colored card stock, cut all pieces on the solid black lines.
- Store all cut parts in your Zip-lock bag.
- *Note: Younger kids can use pieces of cut straws to make their small cylinders.*
  - *Cut 2 yellow straws at 1" length for Thrusters*
  - *Cut 2 1" blue straws for cameras (OCAM & OTES)*

SPACECRAFT ENGINEERING TEAMS: Bus & Sample Return Capsule (SRC)

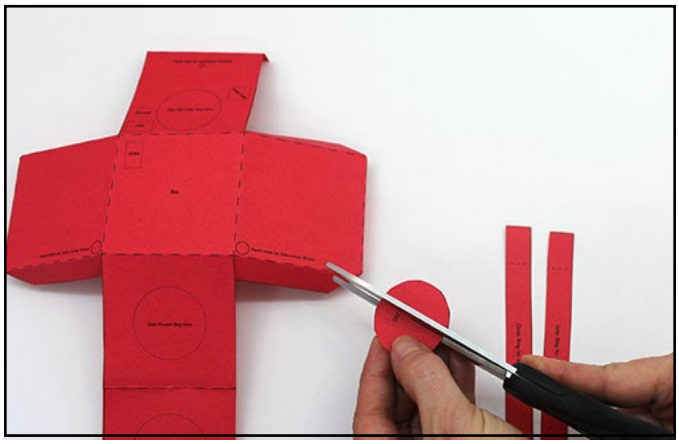
STEP 1: Get Spacecraft Engineer Parts

- The team member representing the Spacecraft Engineer should get out all red parts from Zip-lock.
- You will need the Bus, SRC Lid (Sample Return Capsule), Inner Ring for SRC, and Outer Ring for SRC.



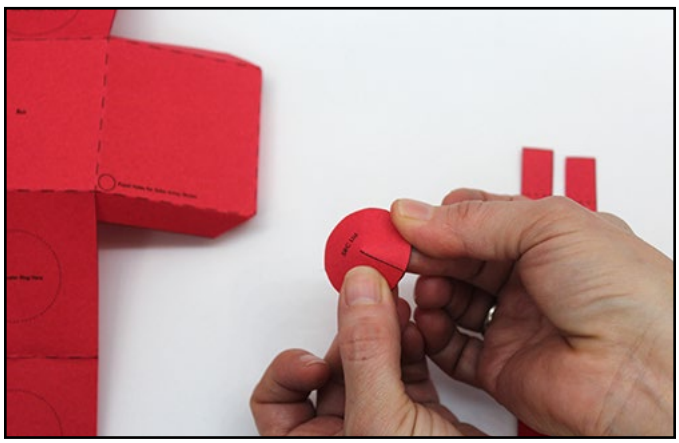
STEP 2: Pre-Fold Bus

- You will start by pre-folding and curling your parts.
- This will make assembly easier and your building more precise.
- Fold the Bus on all large dotted lines.
- Make sure you have cut the solid black line tabs to be able to fold the shape.



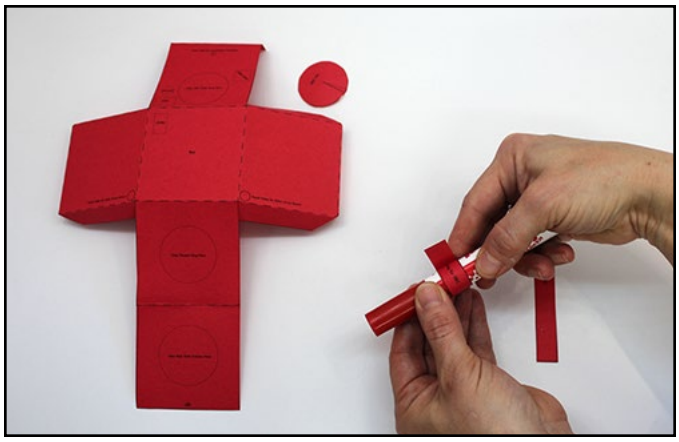
STEP 3: Cut SRC Capsule Radius

- Cut the radius of the SRC Lid on the solid black line.



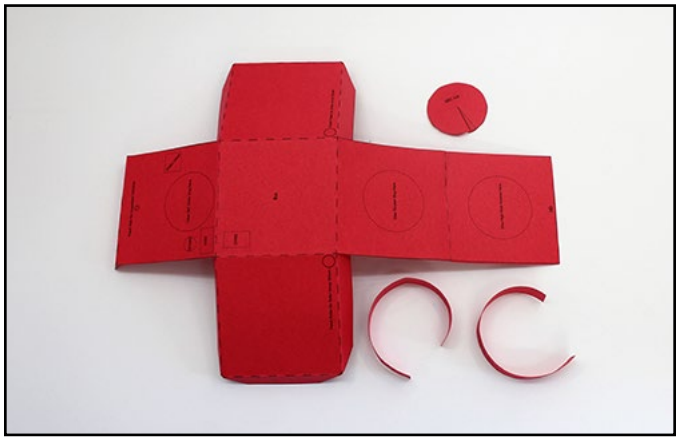
STEP 4: Glue SRC Capsule Cone

- Fold cut edge of SRC Lid circle to dashed line to make a shallow cone.
- Place hot glue on the wedge between the cut edge and dashed line.
- Press together to secure your shallow cone.



STEP 5: Pre-Curl Rings

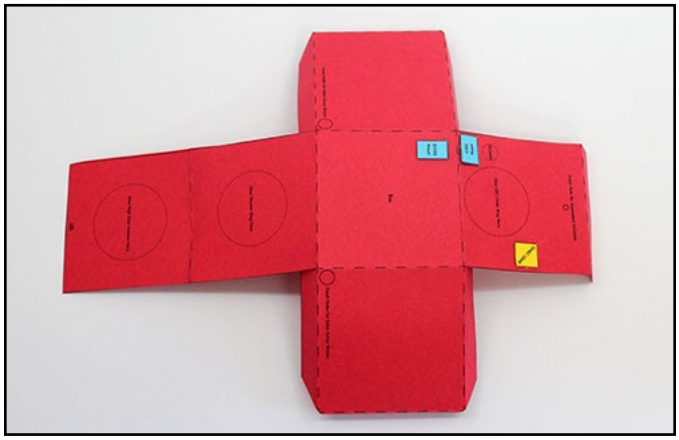
- Pre-curl Inner Ring SRC and Outer Ring SRC by wrapping around a large marker.



MISSION MANAGER

STEP 6: Check Point

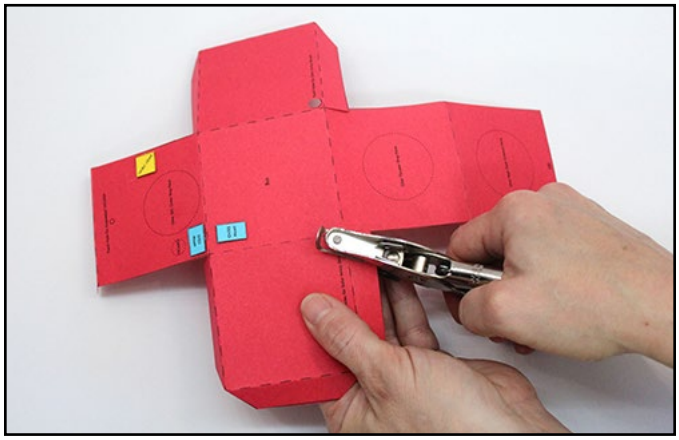
- The Mission Manager should check that the team has a pre-folded bus and pre-curled Outer Ring SRC and Inner Ring SRC.
- Check that you also have a glued SRC cone.



MISSION MANAGER

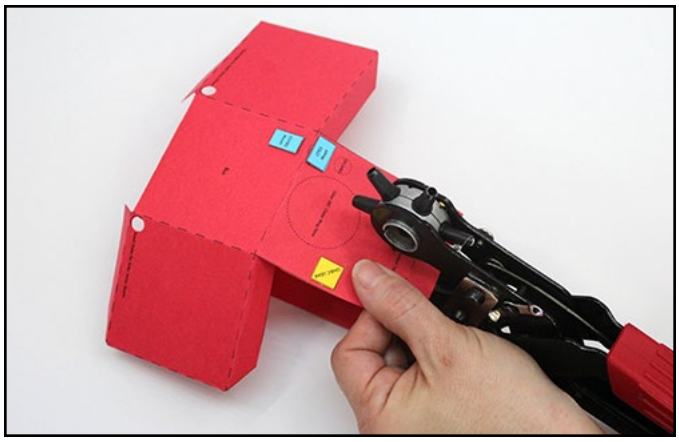
STEP 7: Glue Small Parts

- Mission Manager should take out small rectangular parts - OTES Mount (blue), OVIRS (blue), GN&C & LIDAR (yellow)
- Glue small rectangular pieces on the Bus with glue stick or Elmers glue on the corresponding rectangles.
- It's easier to glue these small shapes while the Bus is flat.



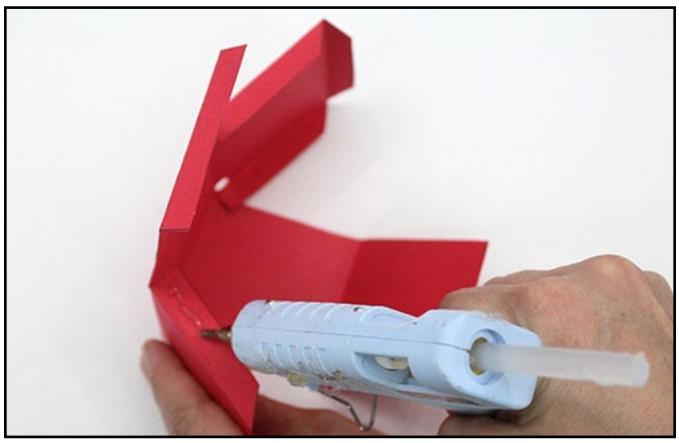
STEP 8: Punch Holes for Solar Arrays

- Use your regular hole punch to punch holes in the Bus for the Solar Arrays.
- These are indicated with large circles and punch instructions.



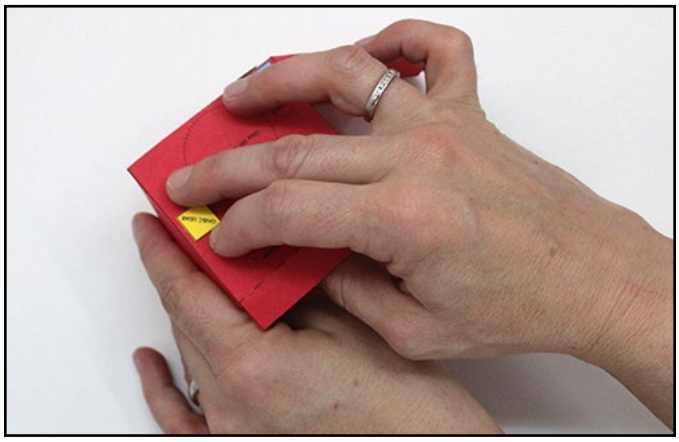
STEP 9: Punch Hole for TAGSAM

- Use the small setting of the adjustable hole punch to punch the hole for the TAGSAM arm on the small circle.
- If you do not have an adjustable hole punch, you can use an push pin or thumb tack to poke the small holes.
- *Note: Do NOT use a large hole punch as it is too big to secure your brads.*



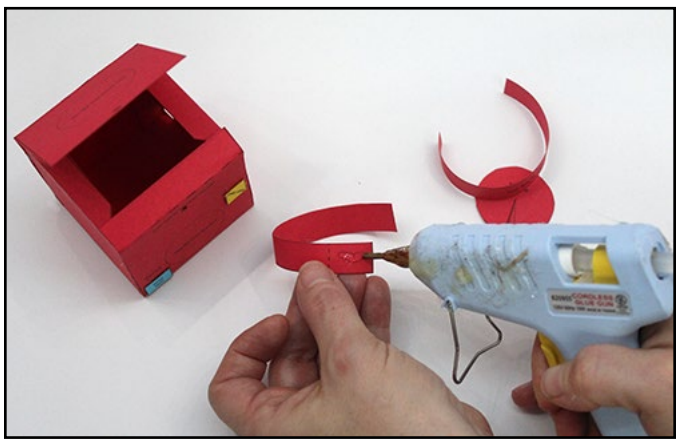
STEP 10: Glue the Bus Box Together

- Place hot glue on the edge of a Bus tab and close side.
- Make sure to leave the side that says “LID” unglued so that you can attach the TAGSAM arm later.



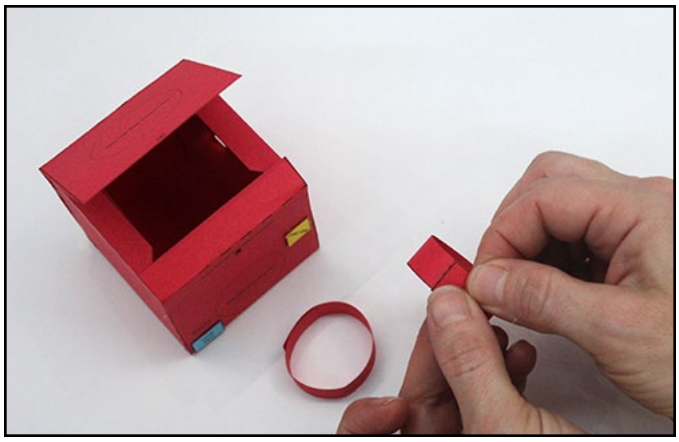
STEP 11: Gluing the Bus Box

- Glue one side of the Bus at a time making sure to line up the edges.
- Make sure to leave the side that says “Lid” unglued.
- You will need to get to the small hole so that you can attach the TAGSAM Arm later.



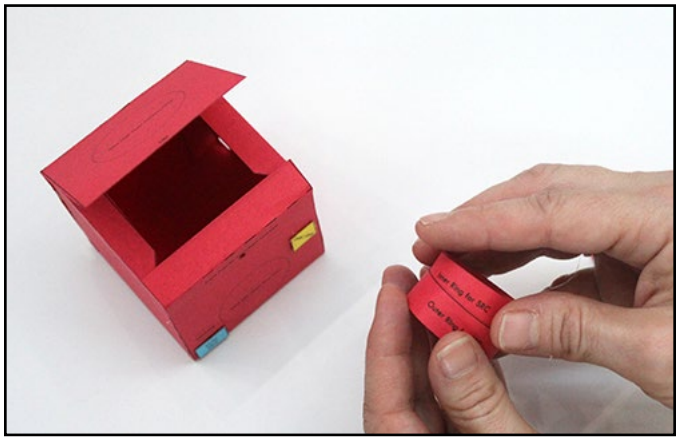
STEP 12: Glue Outer SRC Ring

- Place hot glue between the dashed line and the edge of the Outer Ring for SRC.
- Roll the Outer Ring for SRC into a circle and place end on the glue up to the dashed line.



STEP 13: Glue Inner SRC Ring

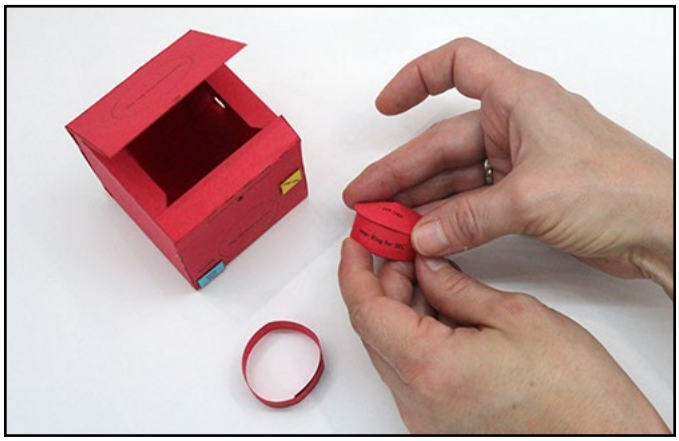
- Place hot glue between the dashed line and the edge of the Inner Ring for SRC.
- Roll the Inner Ring for SRC into a circle and place end on the glue up to the dashed line.



MISSION MANAGER

STEP 14: Test Fit

- Once the hot glue has dried on the SRC Inner and Outer Ring, the Mission Manager should test that the Inner SRC Ring fits snuggly inside the Outer SRC ring, but can still be removed easily.
- If it does not work, adjust the Inner SRC ring and re-glue.

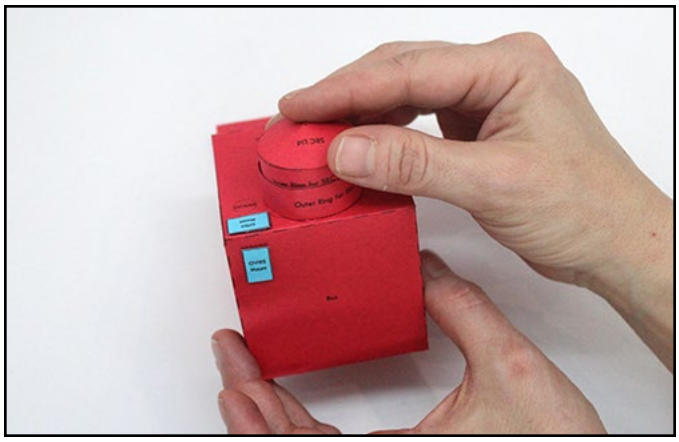


STEP 15: Assemble SRC Capsule

- Glue the SRC cone lid to the Inner Ring for SRC to make your Sample Return Capsule.
- It will look like a little silo.

STEP 16: Glue SRC Ring to Bus

- Place hot glue on dashed circle on the Bus that says “Glue SRC Outer Ring Here.”
- Secure the Outer Ring SRC to the hot glue.

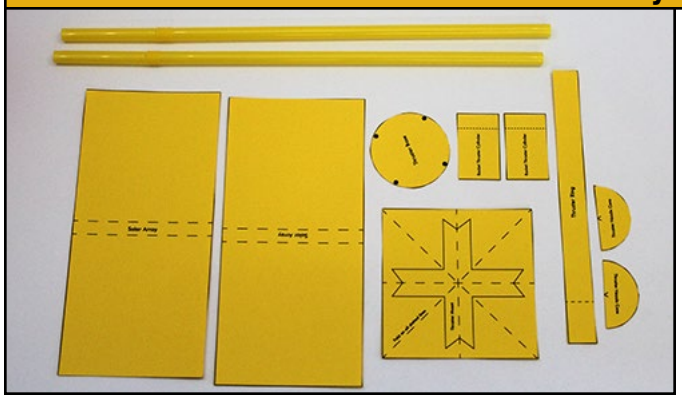


MISSION MANAGER

STEP 17: Insert SRC Capsult into Ring

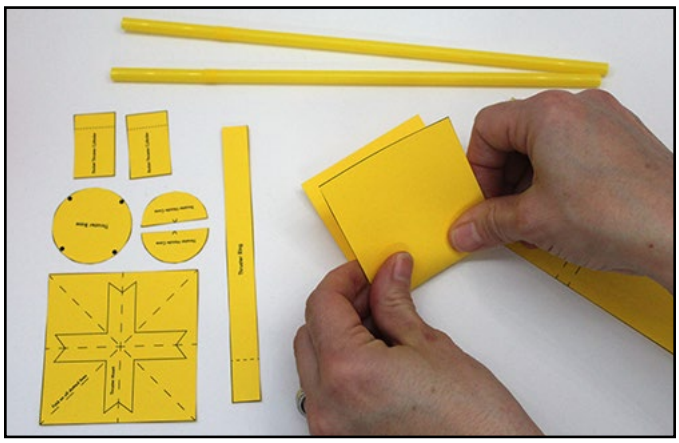
- Once the hot glue is dry, the Mission Manager should check that the SRC Capsule fits inside the Outer SRC Ring glued to the Bus.
- It should be able to slip in and out.

FLIGHT TEAMS: Yellow Parts - Thruster System, Solar Arrays, GN&C & LIDAR



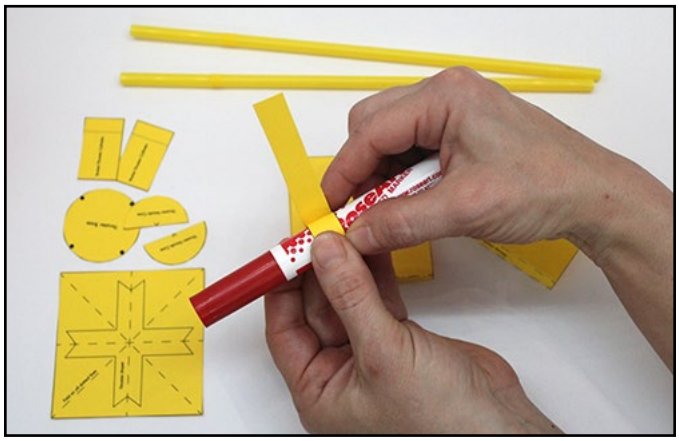
STEP 1: Collect all Yellow Parts

- Remove all Flight Team yellow parts from Zip-lock bag.
- You should have (2) Solar Array Panels, Thruster Base, Thruster Mount, Thruster Ring, (2) Thruster Cylinders, (2) Nozzle Cones, and (2) Plastic Straws.
- *Note: The yellow GN&C & LIDAR part has already been attached to Bus.*



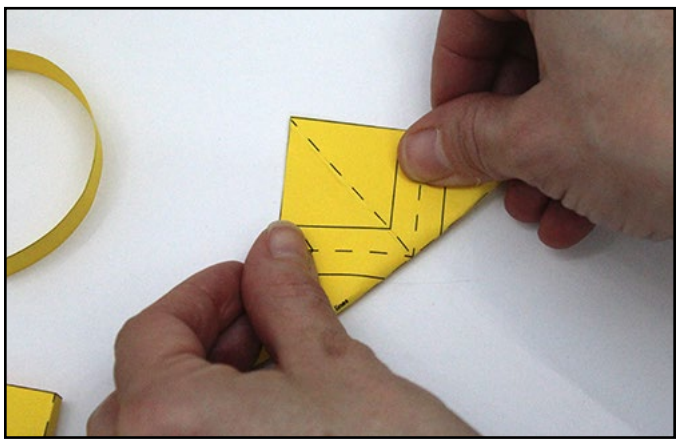
STEP 2: Pre-Fold & Pre-Roll Parts

- You will pre-fold and pre-roll yellow Flight Team parts.
- Fold both Solar Array Panels on the (2) dashed lines so they fold over like a book.



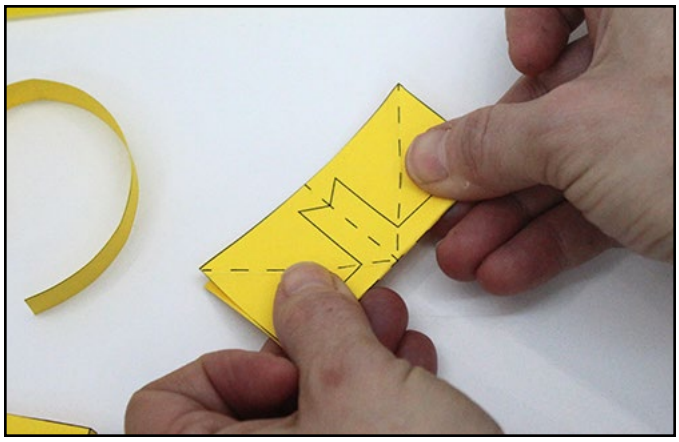
STEP 3: Pre-Roll Thruster Ring

- Pre-roll the Thruster Ring by wrapping it around a large marker.



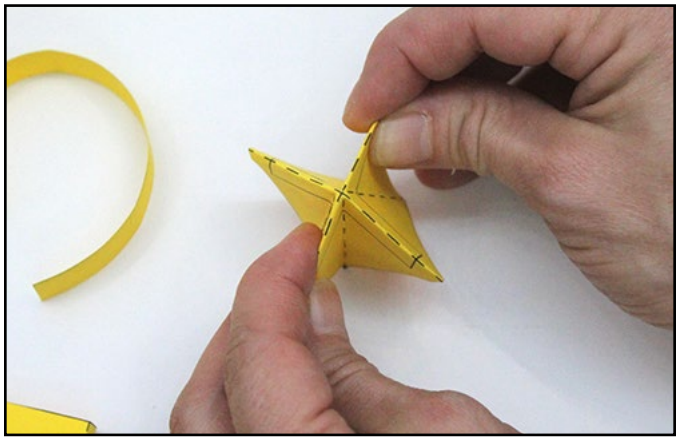
STEP 4: Folding the Thruster Mount

- For the Thruster, think oragami “cootie catcher”!
- Start by making 2 folds on dashed diagonal lines.
- Fold along 1 diagonal. Unfold. then fold on the 2nd diagonal. Unfold.



STEP 5: Folding Thruster Mount Cont.

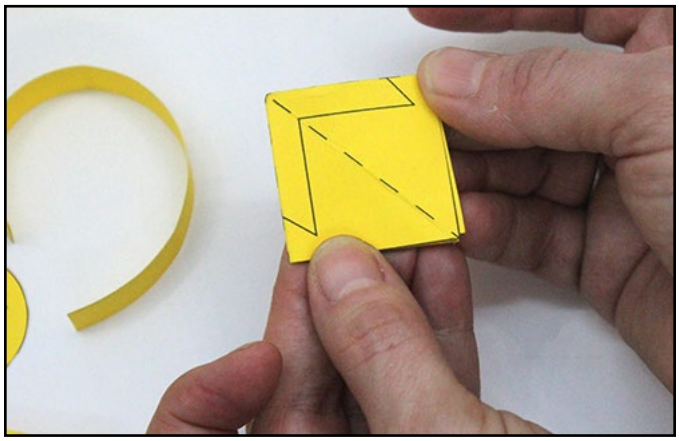
- Fold the Thruster on the two dashed lines make a “+” shape.



MISSION MANAGER

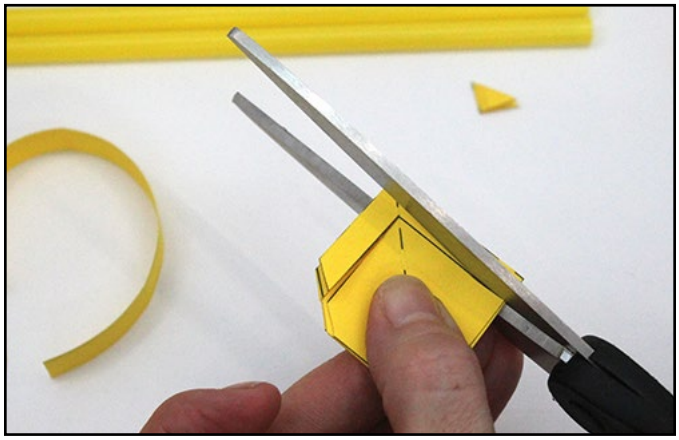
STEP 6: Test Thruster Mount

- The Mission Manager should check that there are 4 folds properly done.
- Work together to bend the “+” fold into a 3D shape.
- The “+” folds will face out as the edges. The diagonal folds will make the valleys.



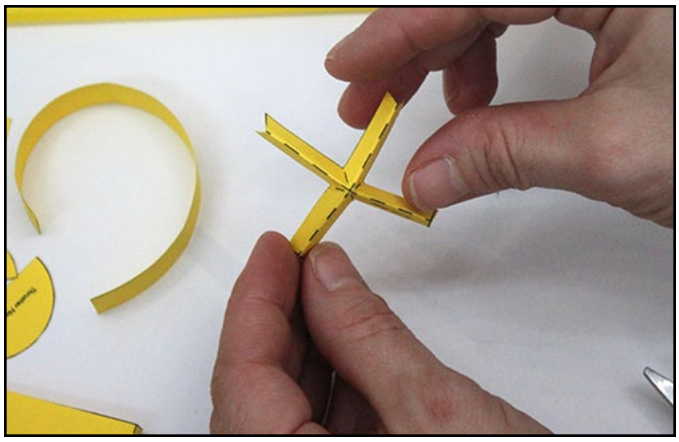
STEP 7: Fold Thruster Mount

- Unfold and re-fold on “+” lines to form a small square as shown in picture.



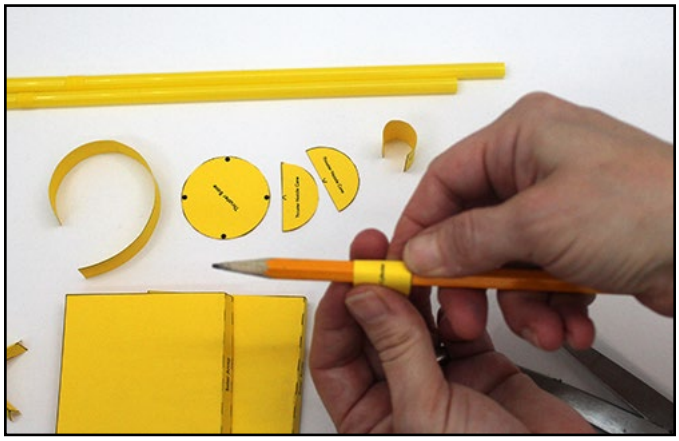
STEP 8: Cut Thruster Mount

- Cut the Thruster Mount along the solid black lines to form an “L” shape with pointed ends.



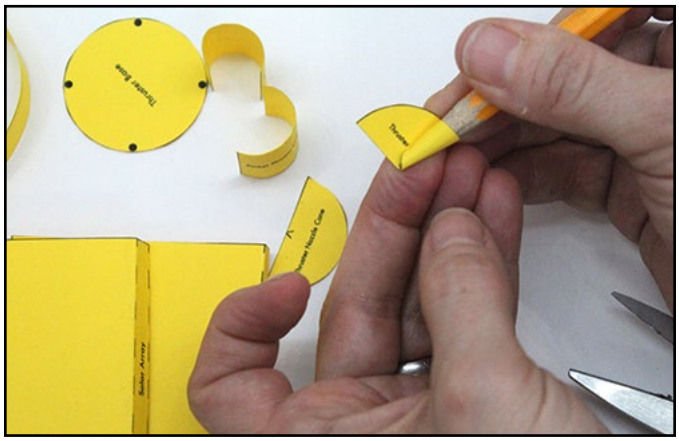
STEP 9: Unfold Thruster Mount

- Unfold the Thruster Mount to make a cross shape as shown in picture.
- Set aside for assembly later.



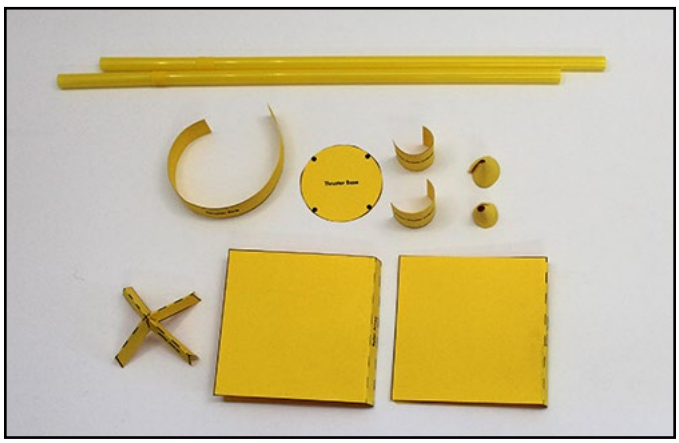
STEP 10: Pre-Roll Thruster Cylinders

- Pre-roll both Thruster Cylinders by wrapping around a No. 2 pencil.
- *Note: Younger kids can cut 2 pieces of yellow straw about 1" long if these cylinders are too small.*



STEP 11: Pre-Roll Thruster Nozzles

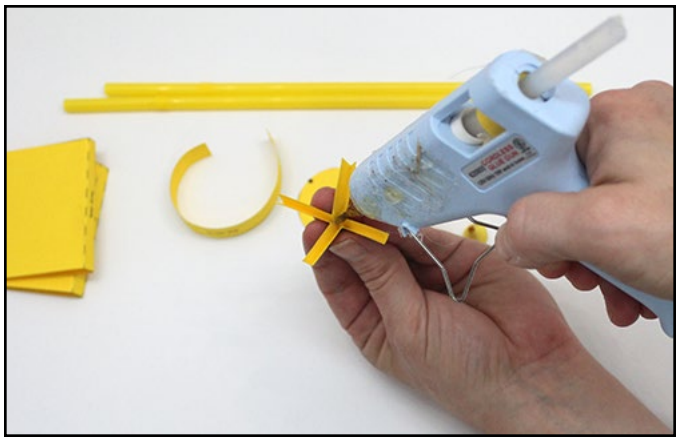
- Line a pencil point up with the small arrow on the center of the Thruster Nozzle Cone.
- Pre-roll Thruster Nozzle Cones by wrapping around a pencil point to make a cone shape.



MISSION MANAGER

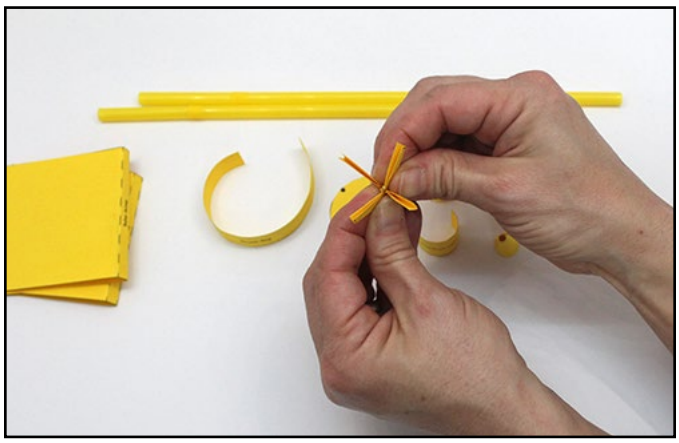
STEP 12: Check Point

- The Mission Manager should check that all Flight Team parts have been pre-folded and pre-rolled.



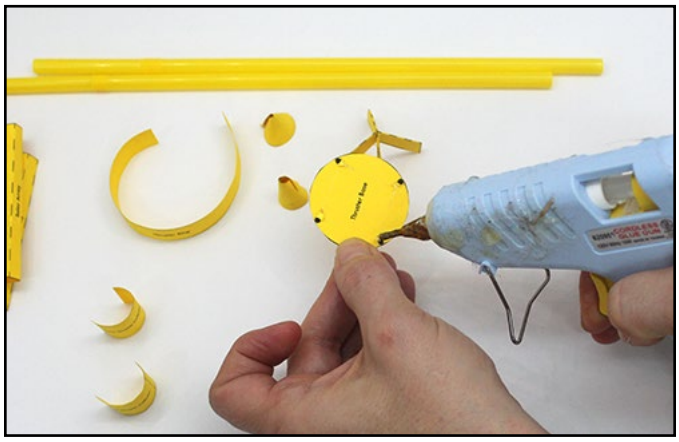
STEP 13: Gluing the Thruster Mount

- Place hot glue inside the point of the folded Thruster Mount.



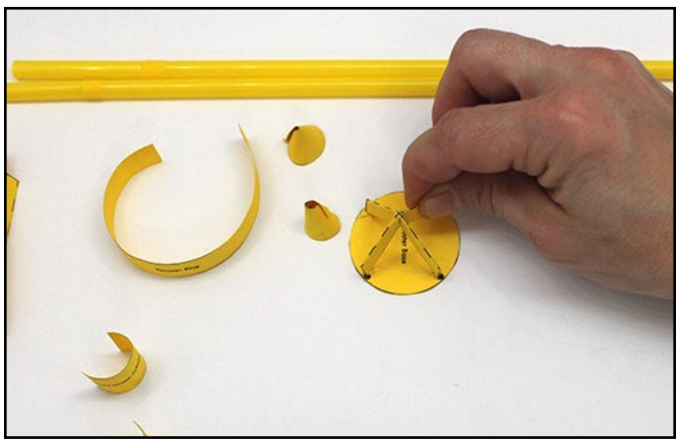
STEP 14: Secure Thruster Mount

- Squeeze the sides of the Thruster Mount together to forme a point and squared cross shape.
- Hold until dry.



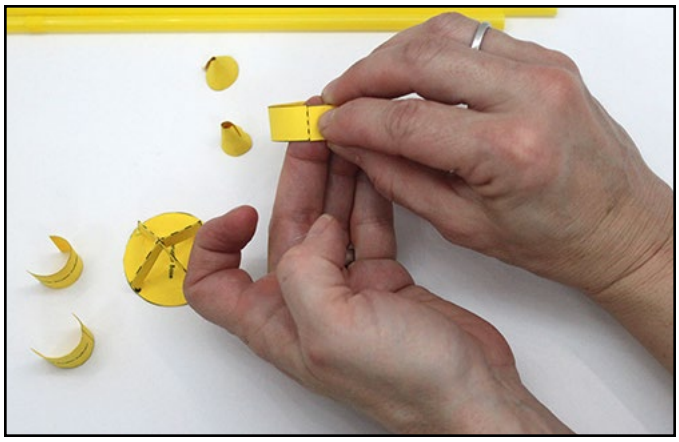
STEP 15: Glue Thruster Base

- Place 4 dabs of hot glue on the 4 black circles on the Thruster Base.



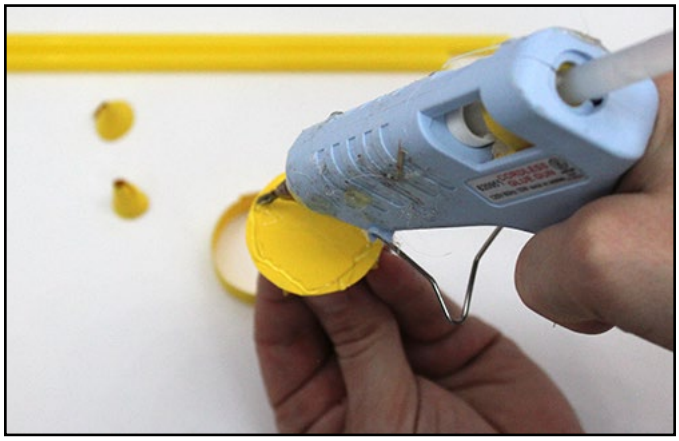
STEP 16: Secure Thruster Mount

- Place the 4 leg points of the Thruster Mount onto the 4 dabs of hot glue and hold to secure.
- To secure it add a drop of hot glue to each joined point.



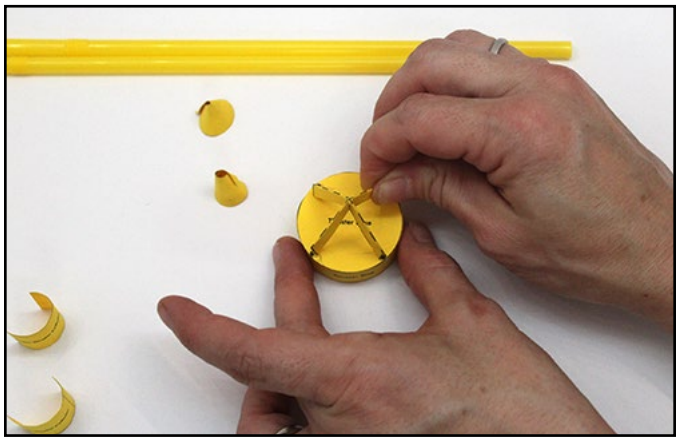
STEP 17: Secure Thruster Ring

- Place hot glue between the dashed line and edge of thruster ring.
- Wrap other end of thruster ring around to make a circle and secure it to glue up to the dashed line.



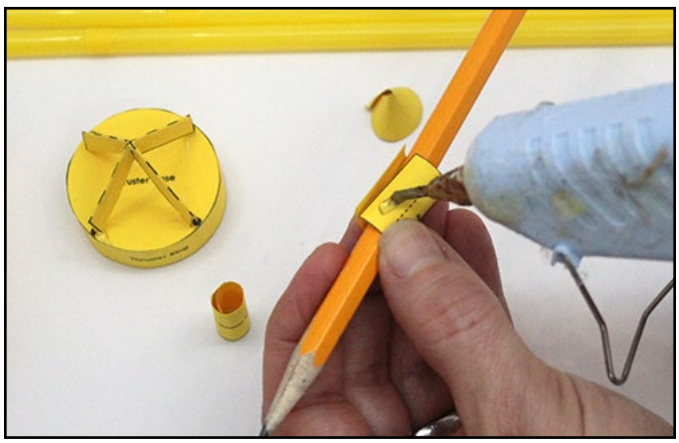
STEP 18: Glue Thruster Base to Ring

- Hold Thruster base by the Mount and place hot glue in a circle around the edge of the bottom side of the Thruster Base.



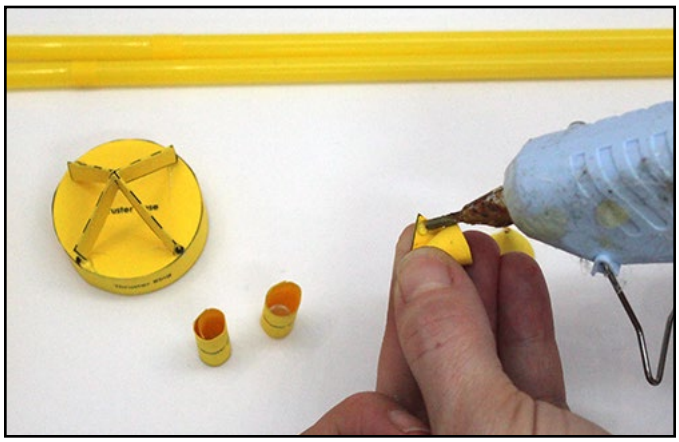
STEP 19: Glue to Thruster Ring

- Place the Thruster Base with hot glue on the Thruster Ring and hold to secure.
- Add more glue if needed to secure it.
- You now have a short cylinder with the Thruster Mount gluded on top.



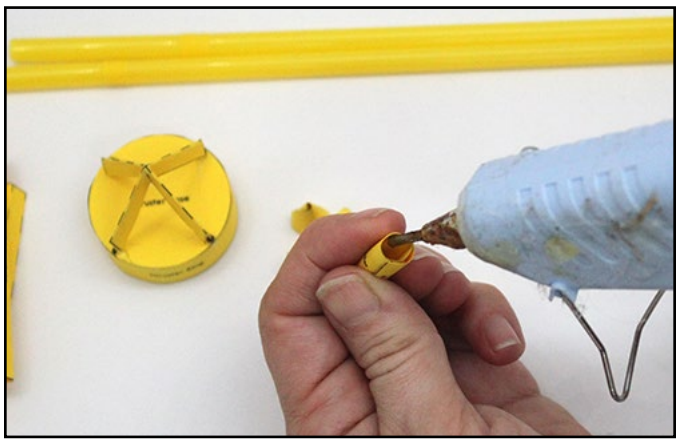
STEP 20: Glue Thruster Cylinders

- Wrap the Rocket Thruster Cylinder around a No. 2 pencil and secure end with hot glue up to dashed line.
- Repeat to glue 2nd Thruster Cylinder.
- *Note: Younger kids can use (2) 1" pieces of cut straw for the Thruster Cylinders.*



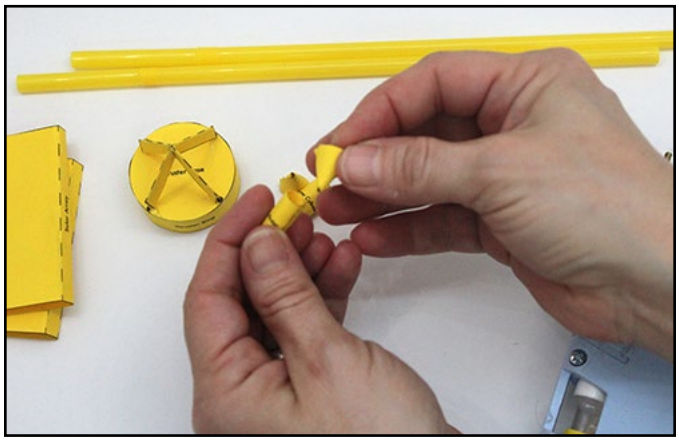
STEP 21: Glue Nozzle Cones

- Wrap Nozzle Cone into a small cone shape and secure end with hot glue
- Repeat to glue 2nd Nozzle cone.



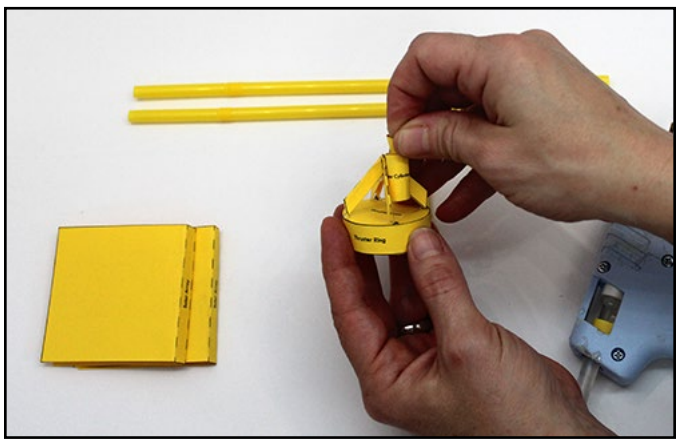
STEP 22: Glue Thrusters Together

- Take a Rocket Thruster Cylinder and place hot glue inside one end.
- *Note: Younger students will place glue into one end of their "1" straws.*



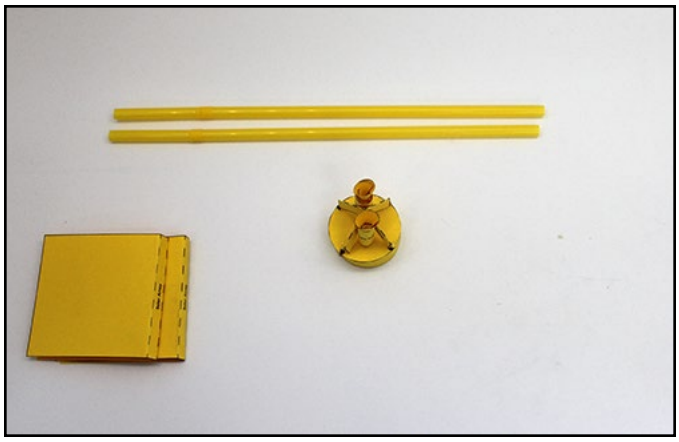
STEP 23: Secure Nozzle Cone

- Stick the point of the Nozzle Cone into the Thruster Cylinder with hot glue and hold to secure.
- Repeat with 2nd Nozzle Cone and Thruster Cylinder.
- *Note: Younger students will stick the tip of their Nozzle Cones into the 1" straws.*
- You should now have (2) completed Thruster rockets.



STEP 24: Glue Thrusters to Mount

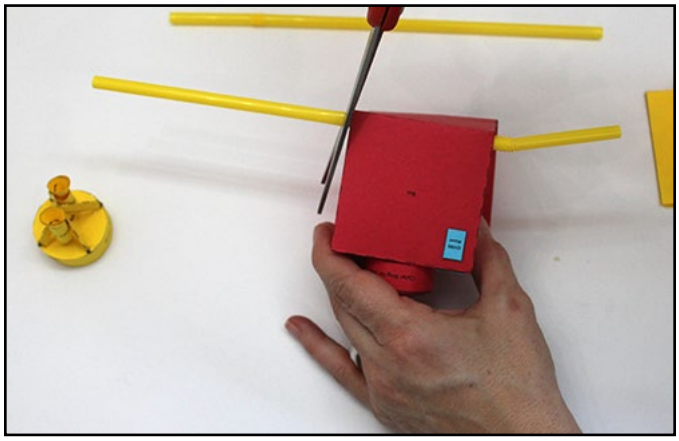
- Place hot glue in the pointed crease at the end of the Thruster Mount.
- Place Thruster Cylinder on hot glue and hold to secure.
- Make sure the open end of the Nozzle Cone is facing upward.
- Repeat to glue 2nd Thruster on the opposite side of Thruster Mount.



MISSION MANAGER

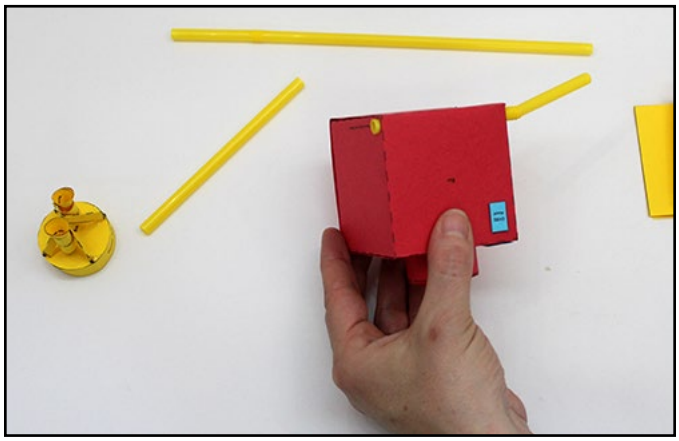
STEP 25: Check Point

- Mission Manager should check that the team has a finished Thruster System, (2) folded Solar Arrays and (2) Plastic Straws.



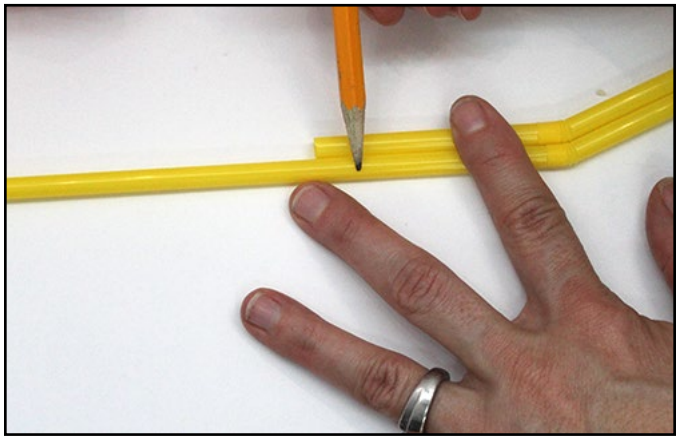
STEP 26: Making Solar Arrays

- Stick a flexible straw through both sides of the body of the Bus through the pre-punched holes.
- The flexible end should stick out one side with the accordion section flush against the Bus body.



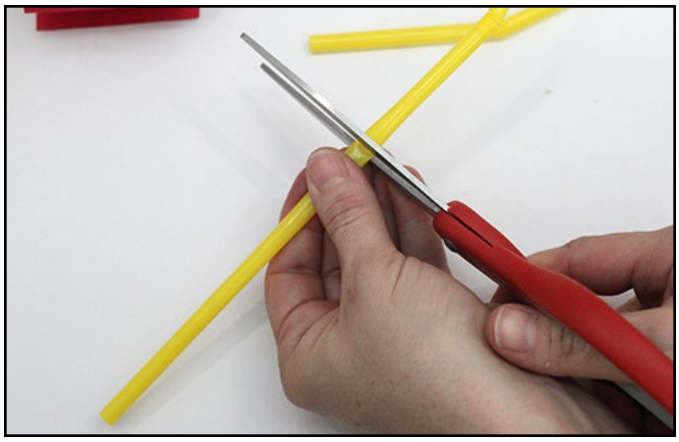
STEP 27: Cut the End

- Cut the **non-flexible** end of the straw that sticks out of the Bus flush with the body of the Bus.



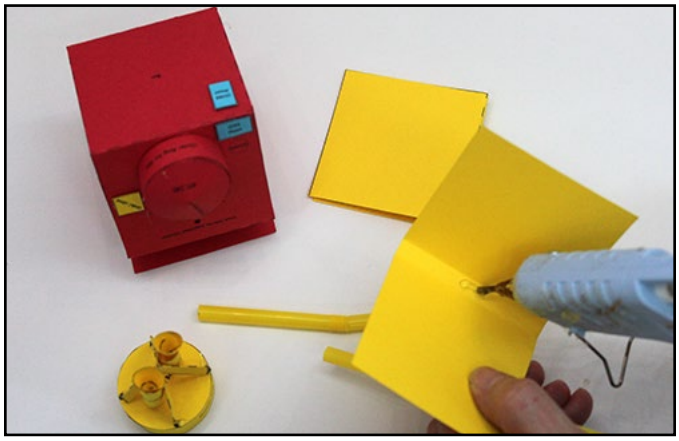
STEP 28: Measure 2nd Straw

- Take the cut straw out of the Bus.
- Line the cut straw up with the 2nd straw so that the flexible ends are in the same place.
- Make a mark about 1/2” shorter on the 2nd straw.
- You will **NOT** cut the flexible end *(end you drink out of.)*



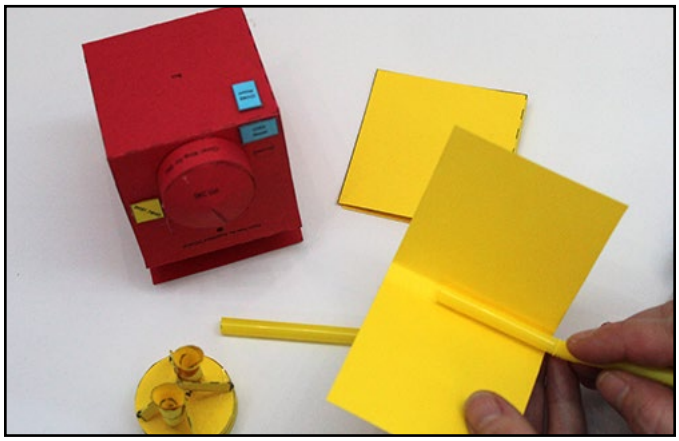
STEP 29: Cut 2nd Straw

- Cut the 2nd straw on the pencil mark so that it is shorter than the 1st straw.
- You should now have two straws with a flexible end, one about 1/2”shorter.



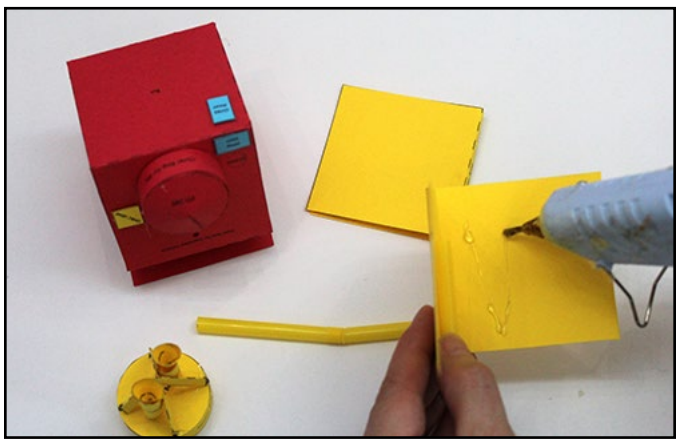
STEP 30: Glue Straws to Solar Arrays

- Open a Solar Array like a book.
- Place hot glue in the small rectangular crease.



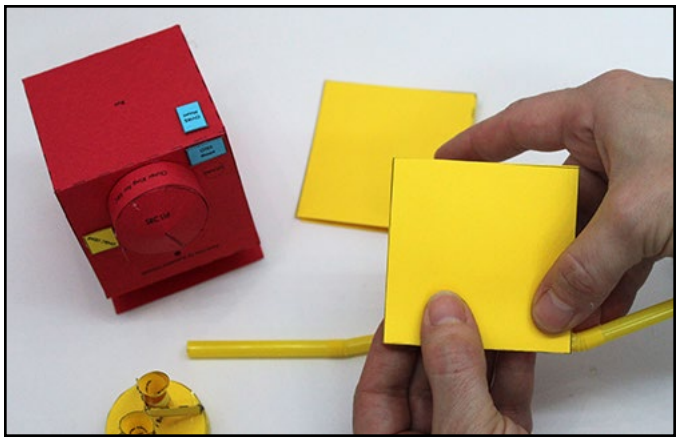
STEP 31: Secure Straw

- Secure the flexible end of the straw on the hot glue in the crease. *(This is the part you would drink out of.)*
- Make sure the flexible accordion part is **NOT** in the glue and is just sticking out at the end.



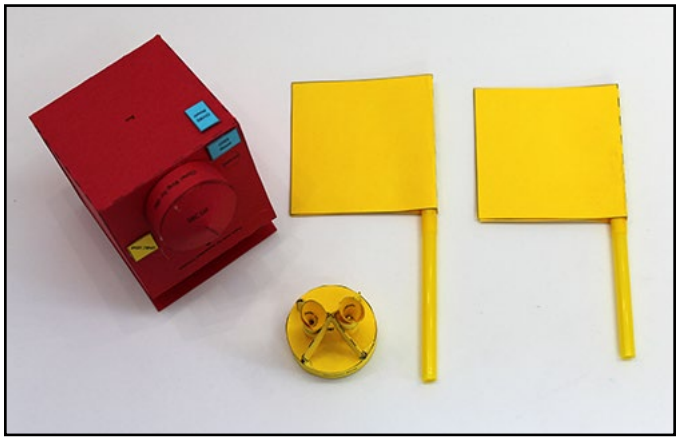
STEP 32: Glue Solar Panel

- Place hot glue back and forth on the inside of the Solar Array rectangular panel.



STEP 33: Secure Solar Panel

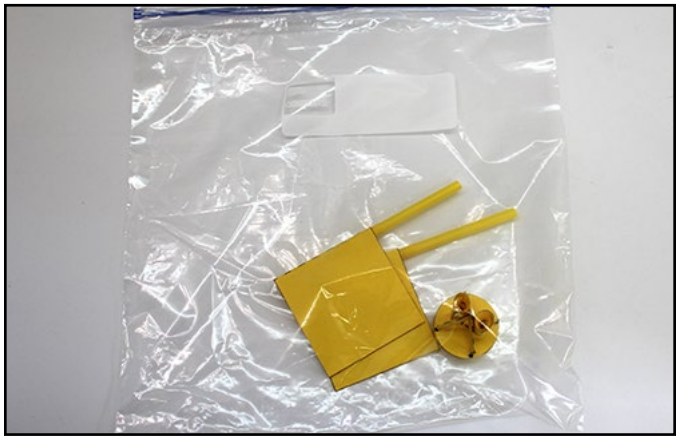
- Fold the Solar Panel closed, lining up the squares, and hold to secure.
- Your glued Solar Array will look like a small flag with the flexible end showing.
- Repeat Step 30-33 to glue straw to 2nd solar panel.



MISSION MANAGER

STEP 34: Check Point

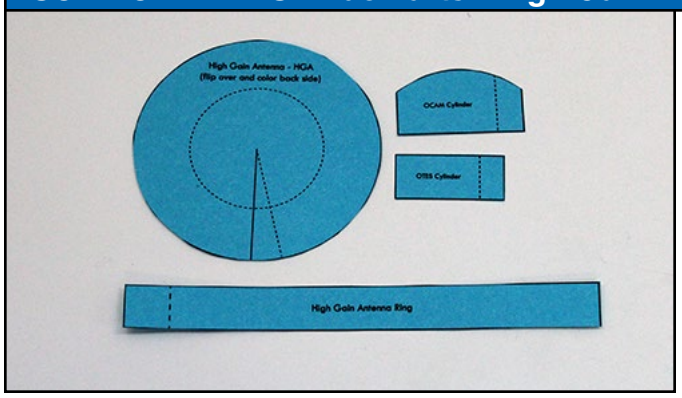
- Mission Manager should check that the team has (2) Glued Solar Arrays that look like little flags.
- One Solar Array straw will be 1/2" shorter than the other.
- You will also have and assembled Thruster System and a Bus.
- *Note: The Bus still has the Lid open.*



STEP 35: Store Parts

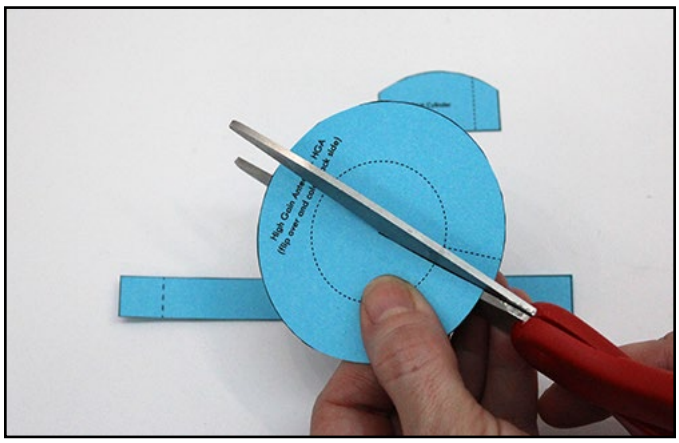
- Place the Thruster System and Solar Arrays in yellow in Zip-lock bag.
- They will be connected to the Bus later so that the Bus is not hard to manipulate with all the parts sticking out.

SCIENCE TEAMS: Blue Parts - High Gain Antenna (HGA), TAGSAM, Science Payload



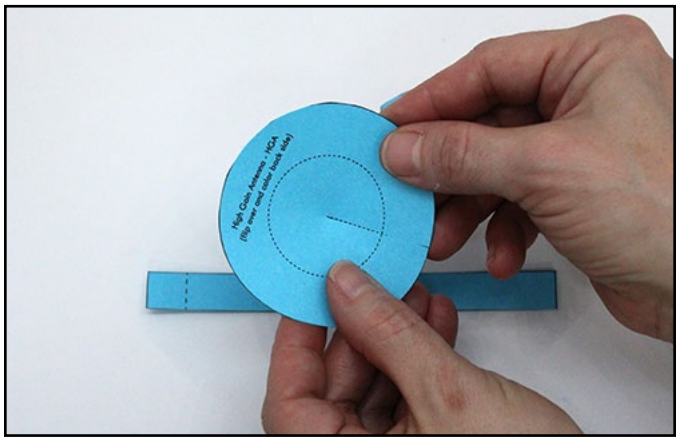
STEP 1: Collect All Parts

- Take the High Gain Antenna (HGA), HGA Ring, OCAM Cylinder and OTES Cylinder out of your Zip-lock bag.
- Leave your TAGSAM parts in your bag for now.



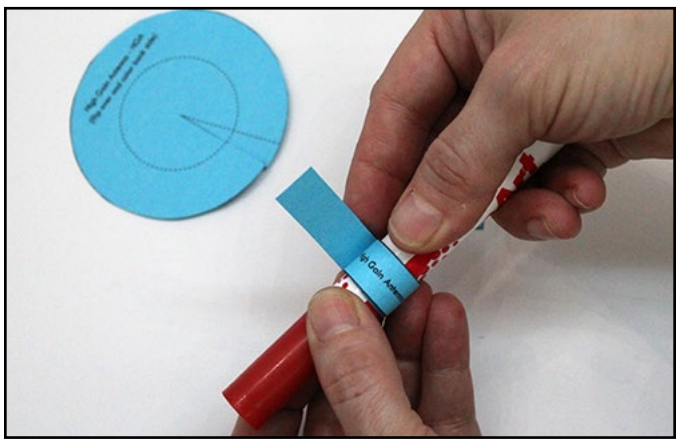
STEP 2: Pre-cut & Roll Parts

- You will pre-cut, fold and roll all pieces again to aid in assembly.
- Start by cutting the HGA along the radius on the solid black line.



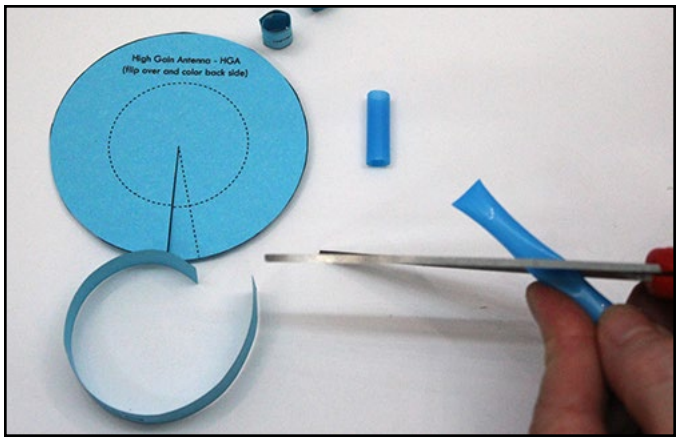
STEP 3: Roll Into Cone

- Roll the HGA into an shallow concave cone shape.
- The dashed line marks will be on the inside of the cone.
- *Note: If you have a white template and have NOT colored the back side with blue marker, do that now.*



STEP 4: Pre-Roll HGA Ring

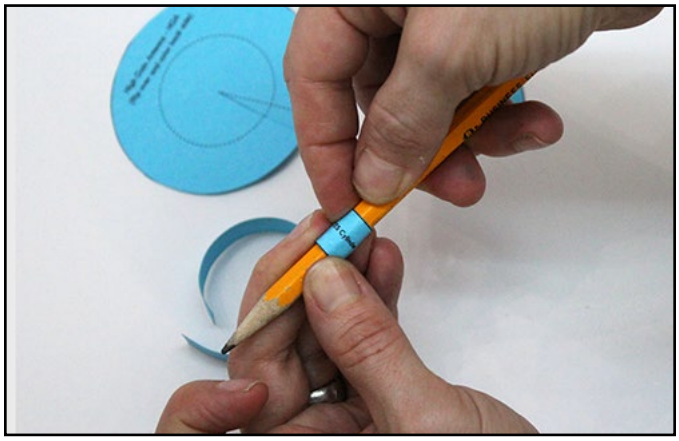
- Pre-roll the HGA Ring by wrapping around a large marker.



STEP 5: *Younger Students*

Cut Camera Cylinders

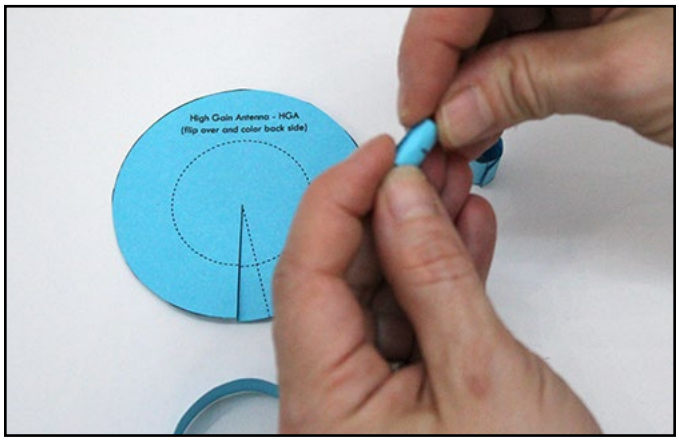
- The OCAM and OTES Cylinders are small.
- For younger students cut two pieces of blue straw for the OCAM and OTES.
- The OCAM should be cut at an angle as shown in the picture.
- Skip to Step 8.



STEP 6: *Older Students*

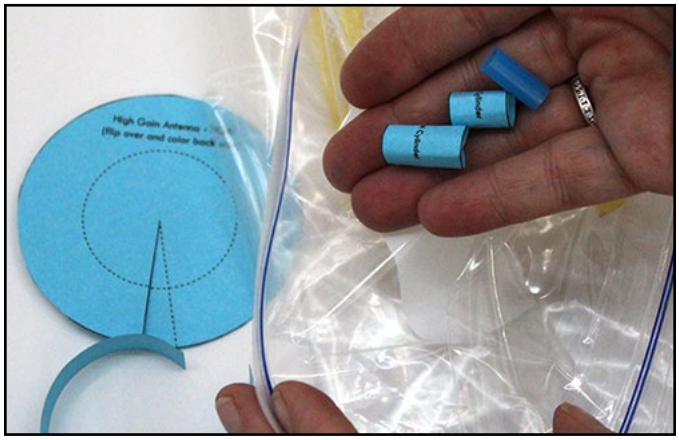
Pre-Roll Cameras

- Pre-roll the OCAM & OTES Cylinders around a pencil.



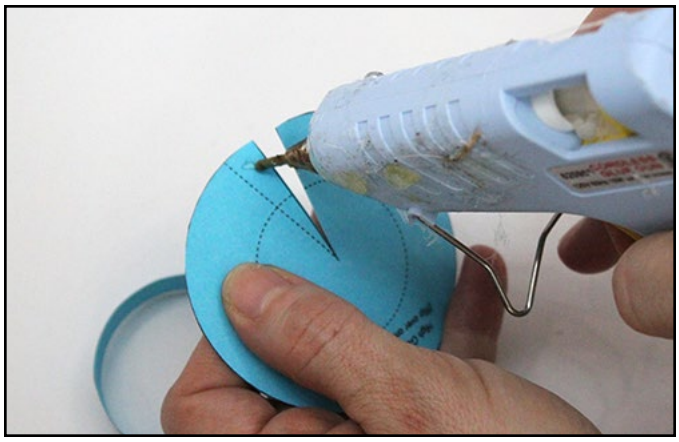
STEP 7: Glue Cylinders

- Roll and hot glue the OCAM and OTES Cylinders closed.
- *Optional: If these cylinders are too small for younger students, they can cut two small pieces of blue straw.*



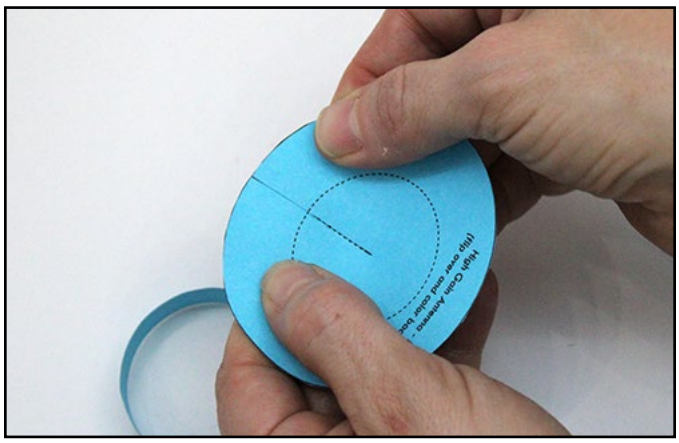
STEP 8: Store Cameras

- Place OCAM and OTES Cylinders (or blue straws) into Zip-lock bag for assembly later.



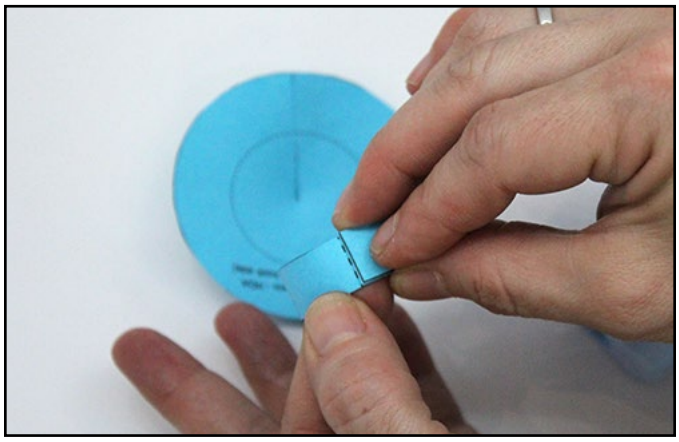
STEP 9: Glue HGA Cone

- Place hot glue on inside of HGA on the wedge between the dotted line and cut edge.



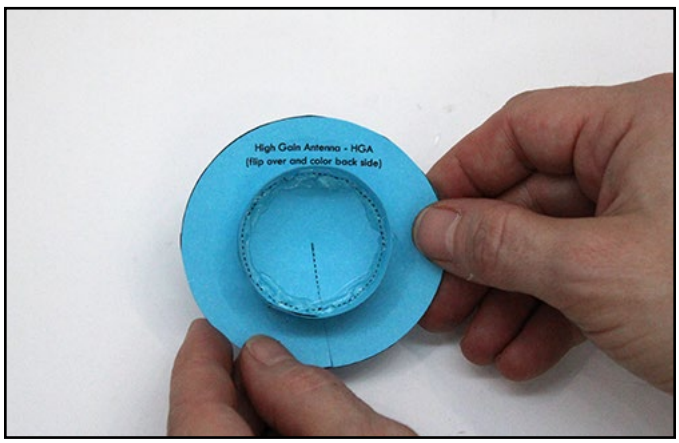
STEP 10: Secure HGA Cone

- Roll HGA into a convex cone and secure cut edge along the dashed line.



STEP 11: Secure HGA Ring

- Place hot glue on HGA Ring from dashed line to edge.
- Roll HGA ring into a circle and secure end to hot glue along the dashed line to make a circluar ring.

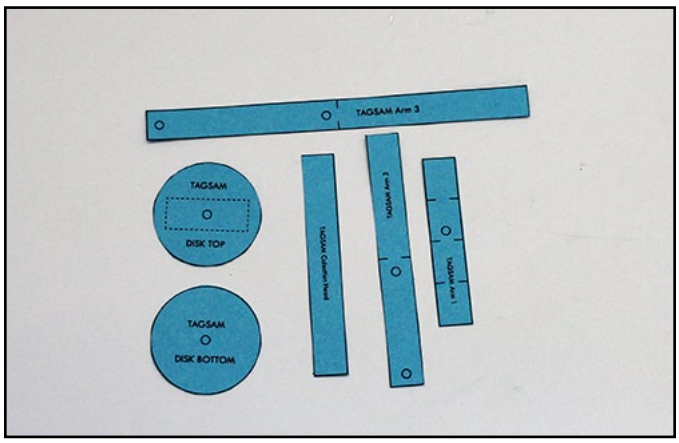


STEP 12: Glue HGA Ring to Cone

- Place hot glue along dashed circular line on inside of HGA cone.
- Place the HGA Ring circle on the hot glue to complete the High Gain Antenna.

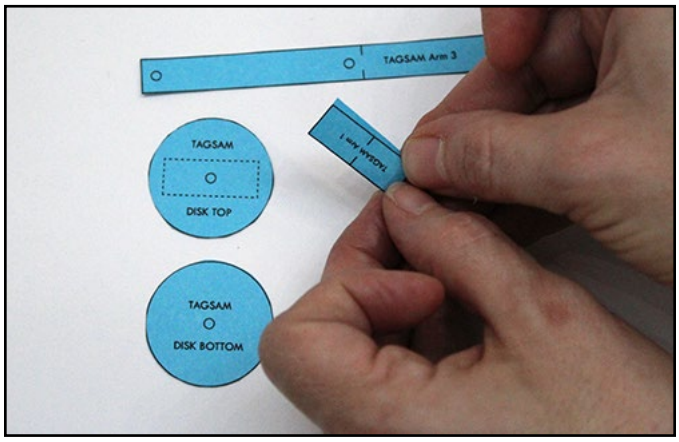
STEP 13: Store High Gain Antenna

- Place HGA in Zip-lock back to assemble on Bus later.
- *Note: It is easier to assemble the HGA and yellow Flight Team parts after completing the TAGSAM arm.*
- *Note: Teachers can chose to have all students make a TAGSAM arm to investigate levers and basic mechanics in creating movable instruments.*



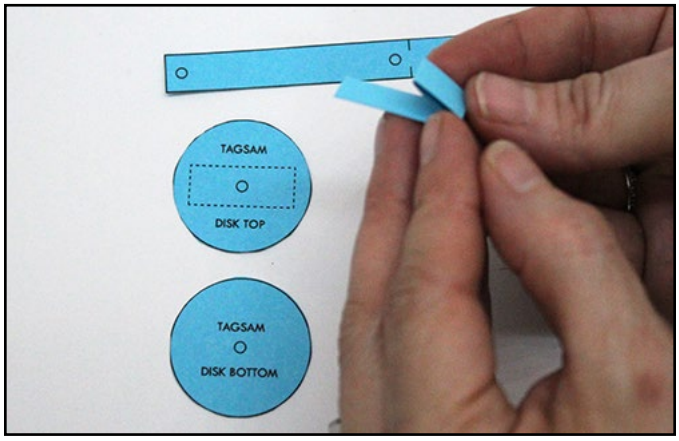
STEP 14: Collect All TAGSAM Parts

- Take out all parts for the TAGSAM from you Zip-lock.



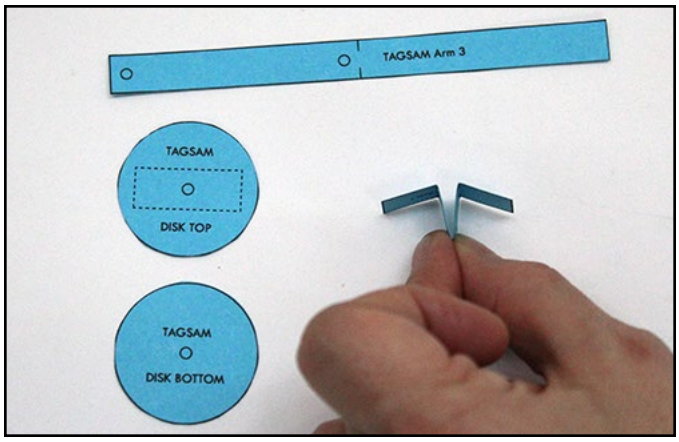
STEP 15: Pre-Fold All Parts

- You will again pre-fold and pre-roll all parts to aid in assembly.
- The dashed lines on all Arm parts indicate fold marks.
- Start by folding your TAGSAM Arm 1 in 1/2 along dashed line.



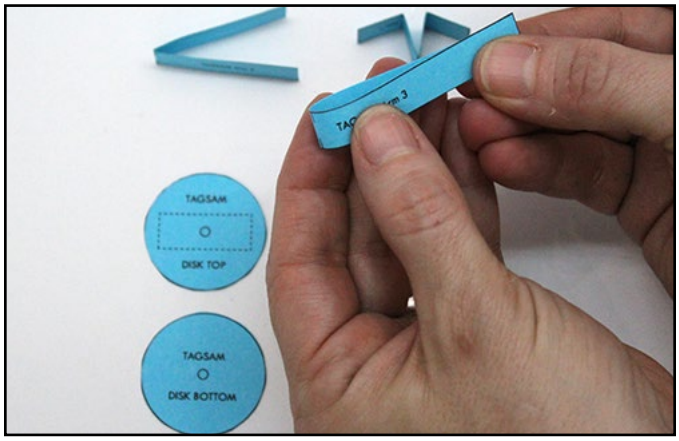
STEP 16: Folding TAGSAM 1

- Take the end of the TAGSAM Arm 1 and fold back in the other direction on dashed line to the center fold.
- This fold is 1/4th of the full arm.
- Repeat by folding the other end in the other direction.



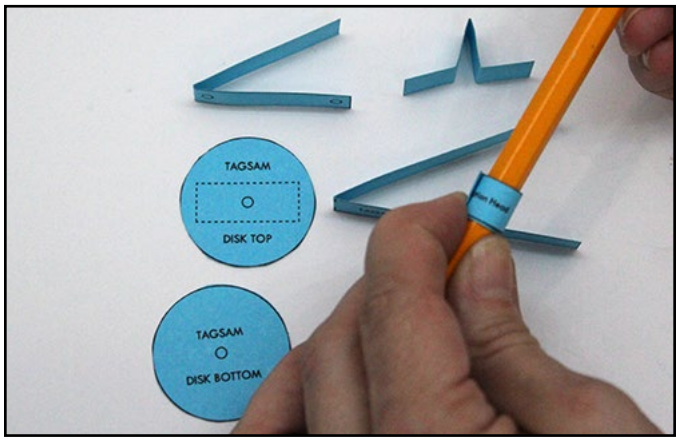
STEP 17: Check Folding for TAGSAM 1

- Your folded TAGSAM Arm 1 will make a small “T” shape like shown in the photo.



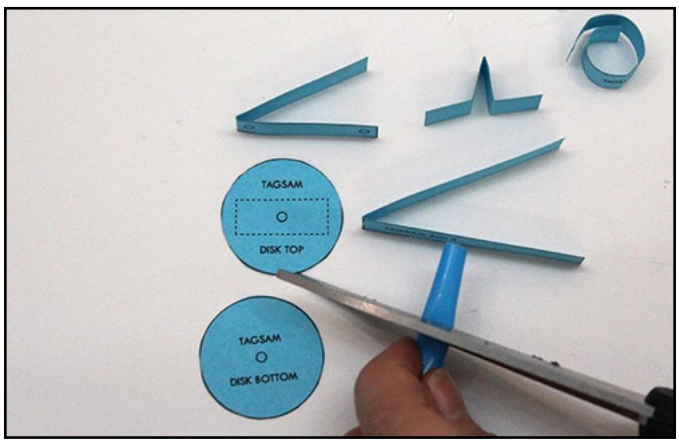
STEP 18: Fold TAGSAM 2 & 3

- Fold the TAGSAM Arm 2 in 1/2 on the center dashed line.
- Fold TAGSAM Arm 3 in 1/2 on the center dashed line.



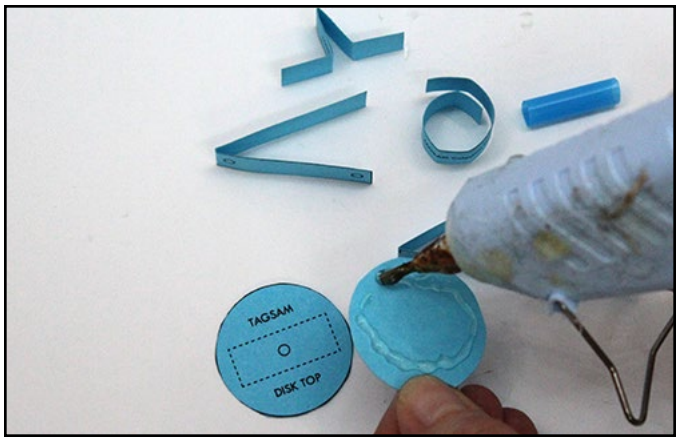
STEP 19: Pre-Roll TAGSAM Head

- Pre-roll the TAGSAM Collection Head strip of paper around a No. 2 pencil to make a cylinder.



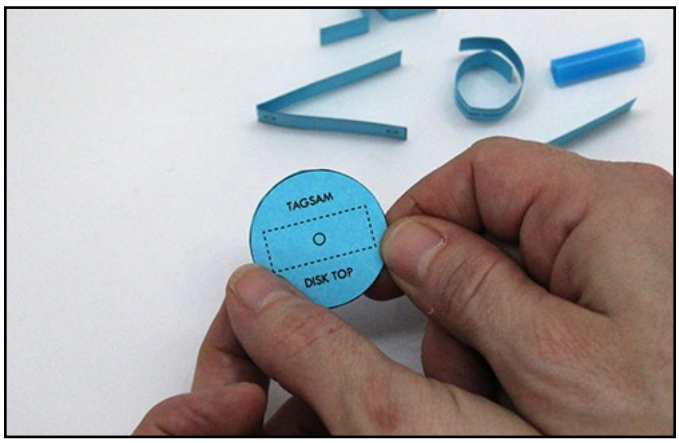
STEP 20: Cut Straw Connector

- Cut a 1” piece of blue straw (or you can cut a 1” piece from your remaining yellow straw from your solar arrays).
- This will form a connector from TAGSAM Arm 3 to the TAGSAM Collection Head.
- Mission Manager should check that all TAGSAM Parts have been pre-folded and pre-rolled properly.



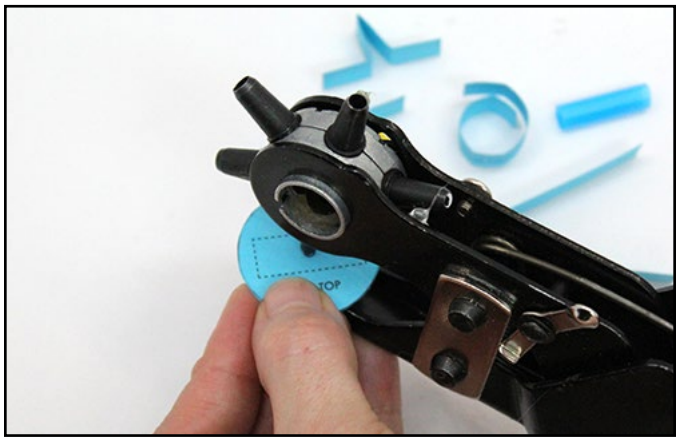
STEP 21: Glue TAGSAM Disk

- Place hot glue in a circle on the backside of the TAGSAM Disk Bottom.



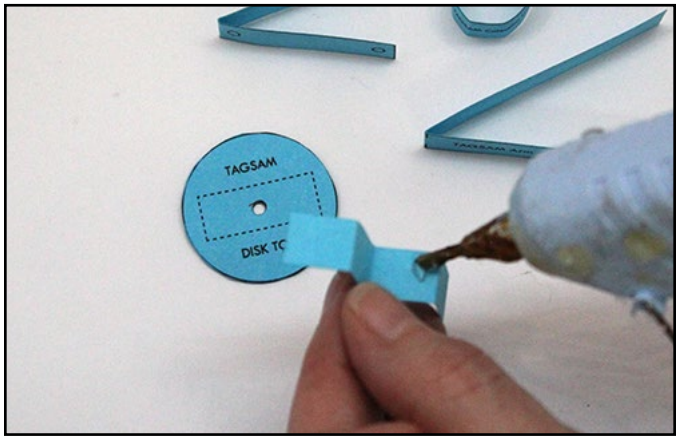
STEP 22: Secure TAGSAM Disk

- Place TAGSAM Disk Top on hot glue and make sure your circles are lined up.
- Your TAGSAM Disk is now two pieces of card stock glued together to make it extra strong.



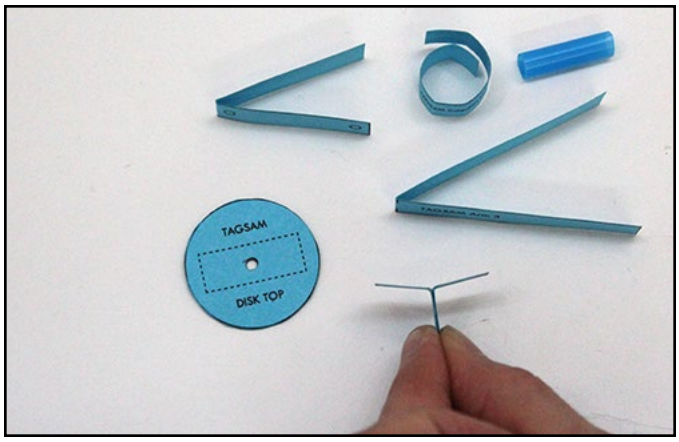
STEP 23: Punch Hole in Disk

- Punch a hole with the small setting of an adjustable hole punch or a push pin (thumb tack) in the circle mark of the TAGSAM Disk Top.



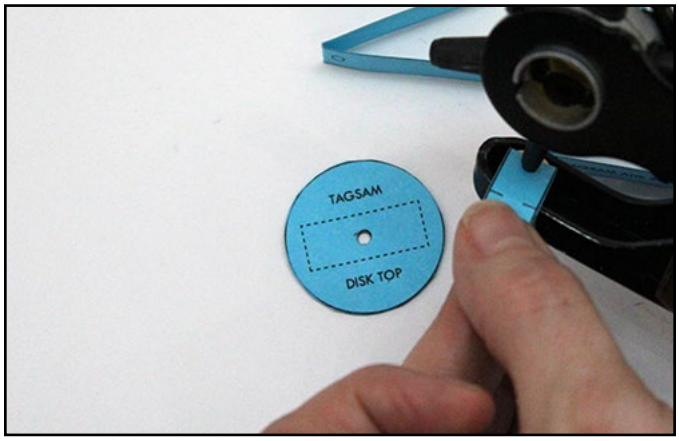
STEP 24: Glue TAGSAM 1

- Place hot glue along the center fold of the TAGSAM Arm 1.



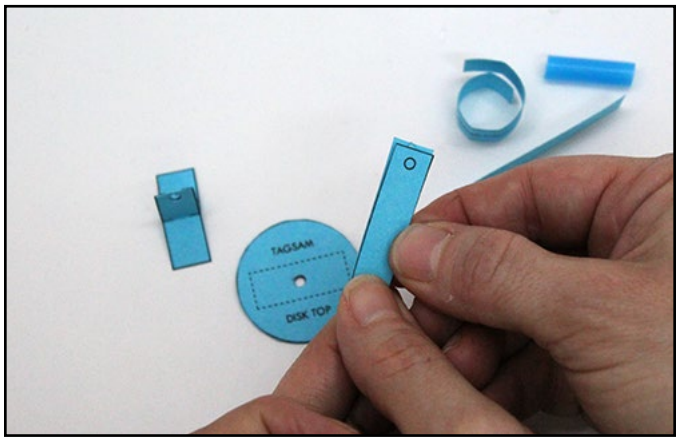
STEP 25: Secure TAGSAM 1

- Squeeze the center fold of TAGSAM Arm 1 to secure the hot glue and make a small “T” shape.
- This perpendicular “T” shape will connect to the disk to make your TAGSAM Arm rotate in 360 degrees.



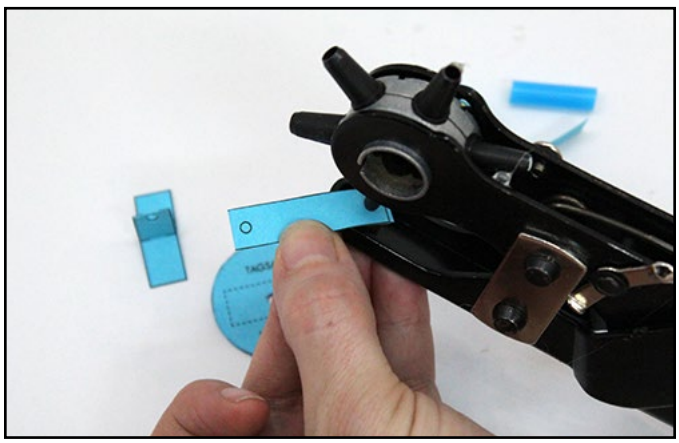
STEP 26: Punch a Hole in TAGSAM 1

- Punch a small hole where the little circle is printed on the TAGSAM Arm 1.
- You can use a push pin or thumb tack instead of a hole punch.



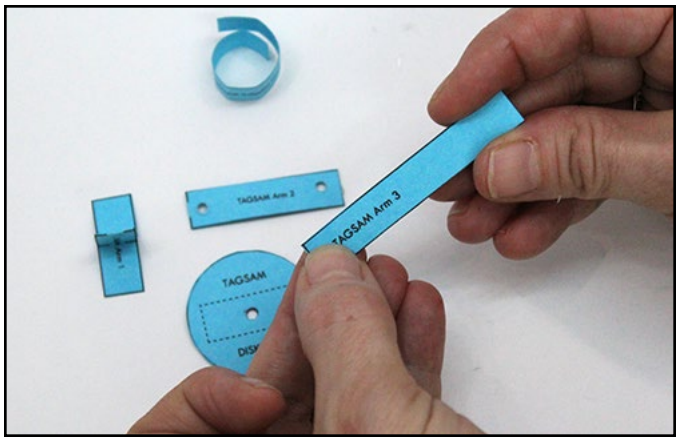
STEP 27: Glue TAGSAM 2

- Place hot glue on the inside of TAGSAM Arm 2 and fold in 1/2 to secure.
- The double-card stock will make it stronger for a moveable arm.



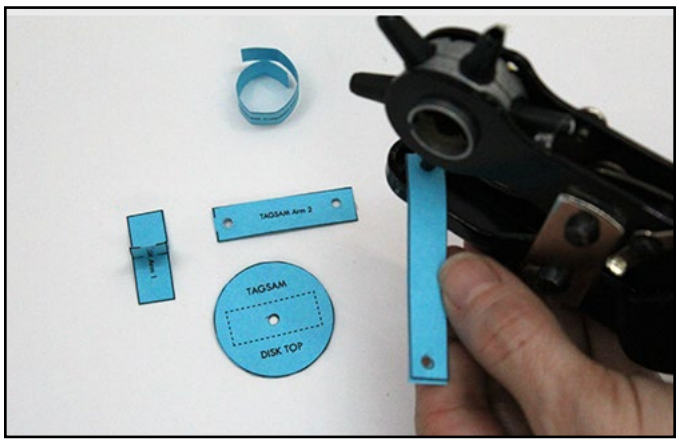
STEP 28: Punch Holes in TAGSAM 2

- Punch small holes where the 2 small circles are printed on both ends of the TAGSAM Arm 2.
- You can use a push pin or thumb tack instead of a hole punch.



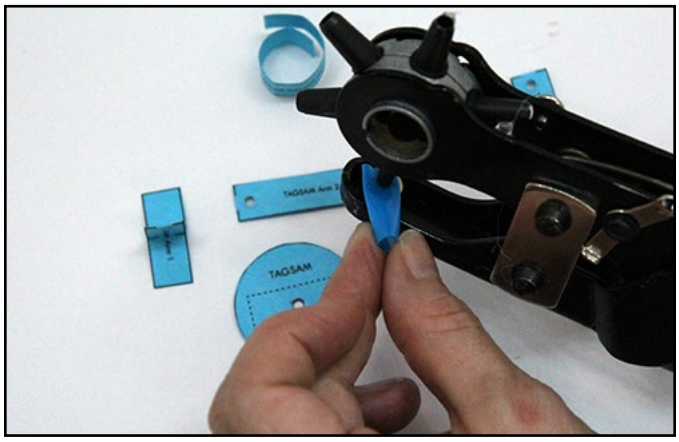
STEP 29: Glue TAGSAM Arm 3

- Place hot glue on the inside of TAGSAM Arm 3 and fold in 1/2 to secure.
- The double-card stock will make it stronger for a moveable arm.



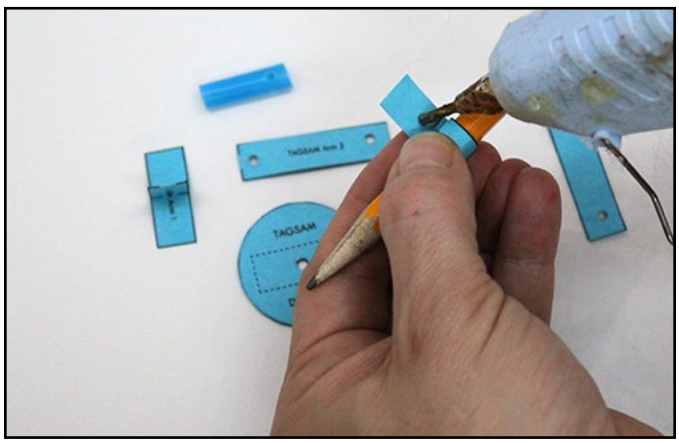
STEP 30: Punch Holes TAGSAM 3

- Punch small holes in each end of TAGSAM Arm 3 where the small circles are printed.
- You can use a push pin or thumb tack instead of a hole punch.



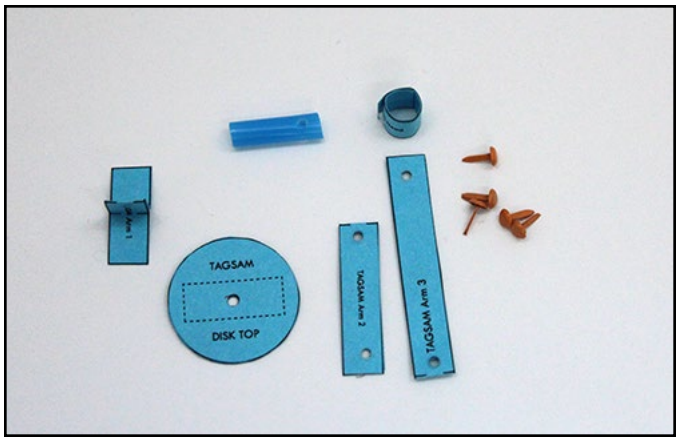
STEP 31: Punch Hole in Straw

- Squeeze the end of your 1”straw flat and punch a hole in the end.
- You can use a push pin or thumb tack instead of hole punch.



STEP 32: Glue Collection Head

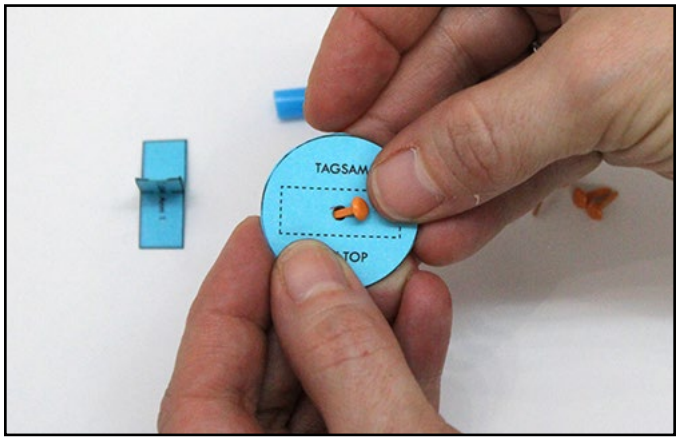
- Gently Roll the TAGSAM Collection Head around a No. 2 pencil and secure the end with hot glue to form a cylinder.



MISSION MANAGER

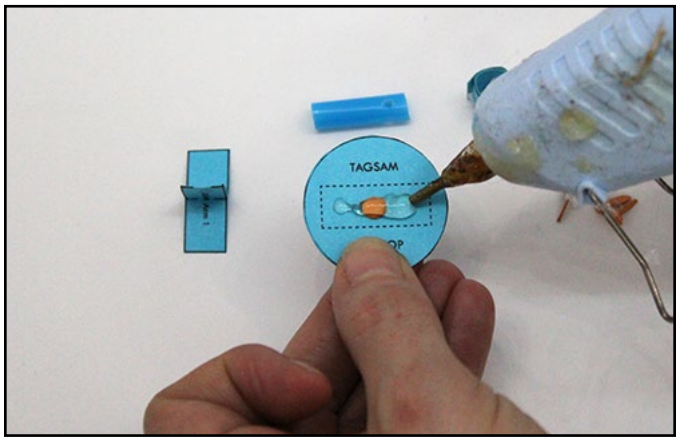
STEP 33: Check Point

- Mission Manager should check that all TAGSAM Arm pieces have been folded (double paper), glued and have holes punched.
- The straw should have a hole and the TAGSAM Collection Head should be glued to make a small cylinder.
- You should also get out 4 small brads.



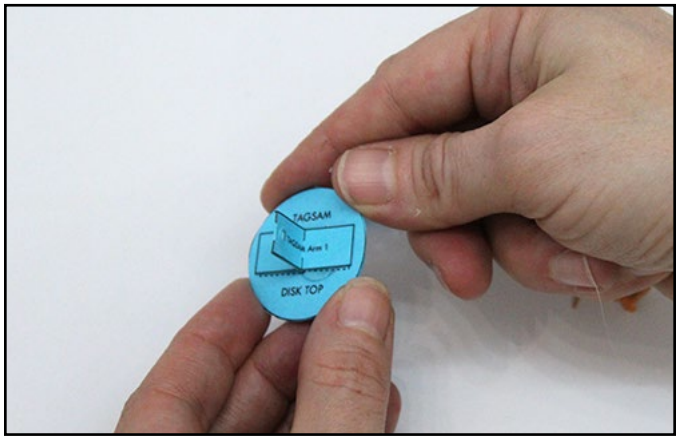
STEP 34: Assemble TAGSAM

- Place a small brad through the TAGSAM disk from the top.



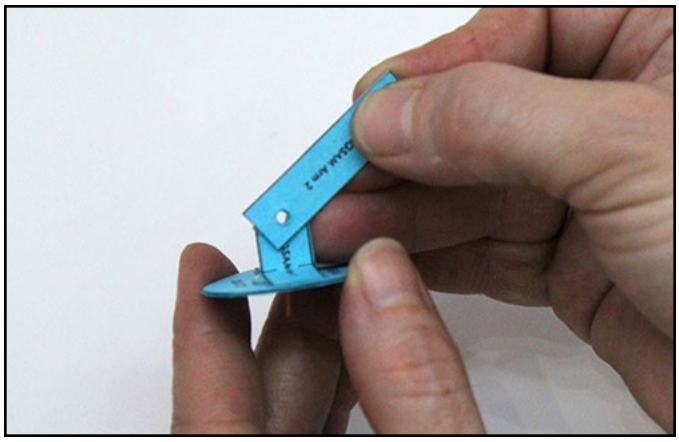
STEP 35: Place Hot Glue

- Place hot glue over the brad top and in the dashed rectangle printed on the TAGSAM Disk Top.



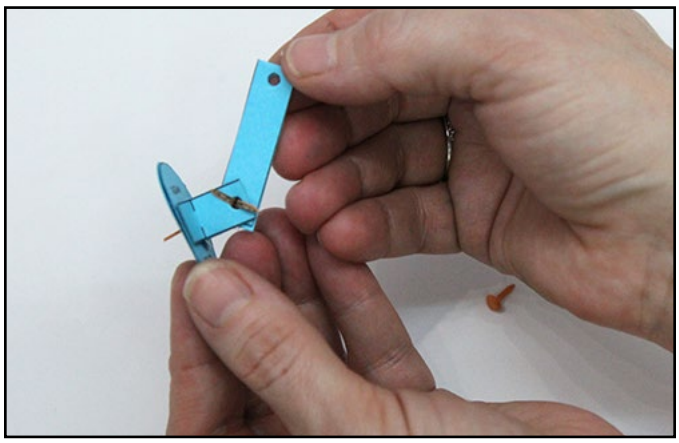
STEP 36: Secure TAGSAM Arm 1

- Place the TAGSAM Arm 1 “T” shape on top of the rectangle with hot glue.
- The TAGSAM Arm should stick out of the disk at a perpendicular angle.



STEP 37: Connect TAGSAM 1 & 2

- Line up 1 hole at the end of TAGSAM Arm 2 with the hole in TAGSAM Arm 1.
- *Note: Make sure the small brad end is sticking out of the bottom of the TAGSAM Disk.*

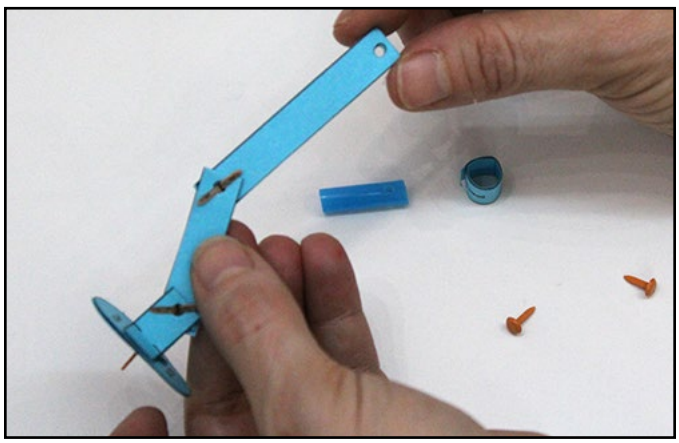


STEP 38: Place a Small Brad

- Put a small brad through the holes connecting TAGSAM Arm 1 with TAGSAM Arm 2.
- Flatten and secure from the other side.

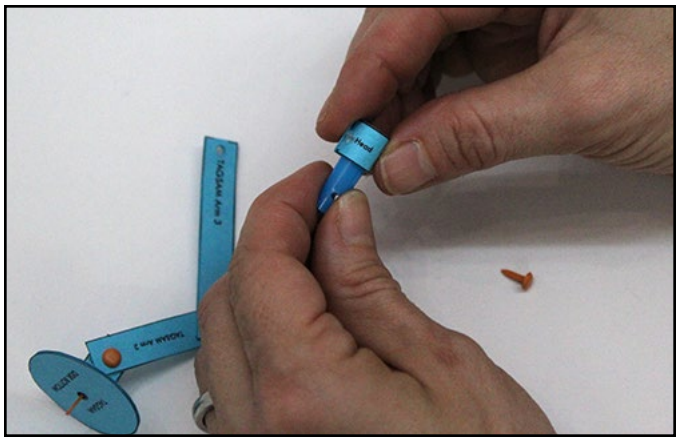
STEP 39: Connect TAGSAM 2 & 3

- Line up 1 hole at the end of TAGSAM Arm 3 with the hole in TAGSAM Arm 2.



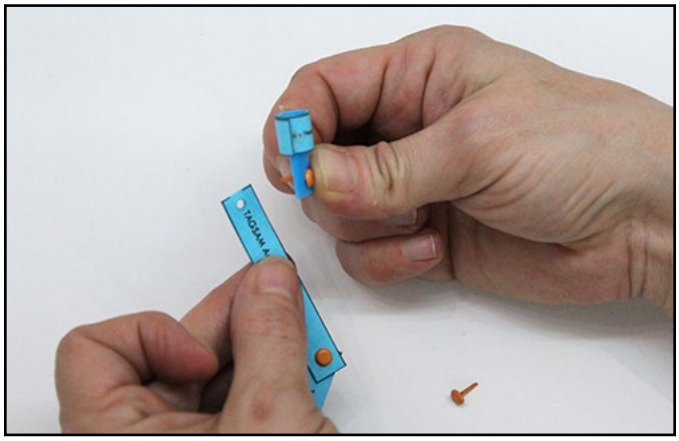
STEP 40: Secure TAGSAM 2 & 3

- Place a small brad through holes and secure from the back to connect TAGSAM Arm 3 to TAGSAM Arm 2.



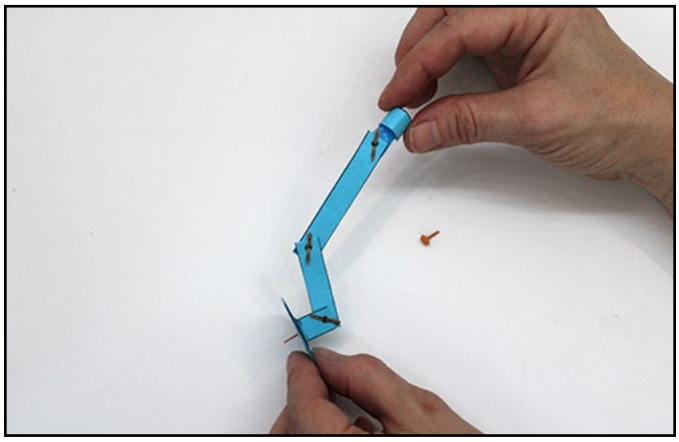
STEP 41: Glue Straw & Collection Head

- Place hot glue around the end of the 1” straw that does NOT have a hole.
- Place the TAGSAM Collection Head over the end of the straw and onto the hot glue.
- Hold to secure.



STEP 42: Connect Head with Arm

- Place a small brad through the holes in the straw and through the last hole of the TAGSAM Arm 3.

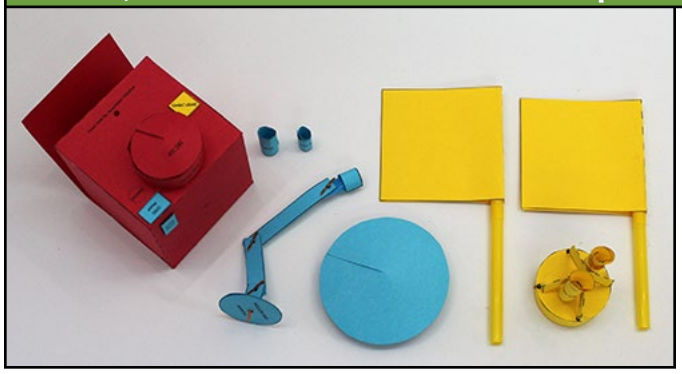


STEP 43: Secure TAGSAM

- Secure the last brad from the other side.
- You now have a finished TAGSAM Arm!

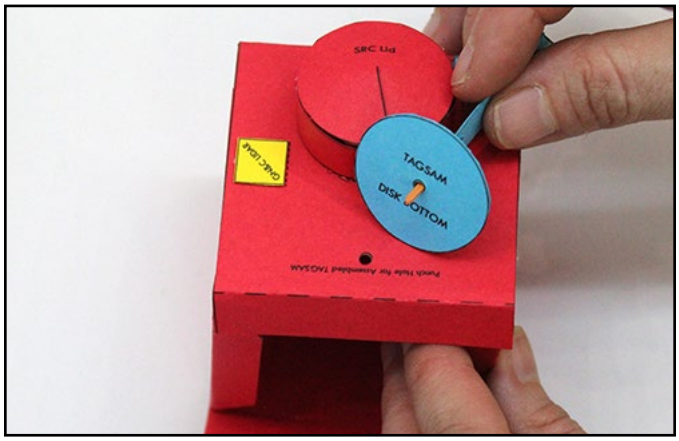
- ***Your team has finished making all their Team parts and are ready to go to final assembly with the Mission Manager.***

MISSION MANAGER: Trouble Shooting & Final Assembly - You also support other teams, so look for Green Band Checkpoints in other team instructables.



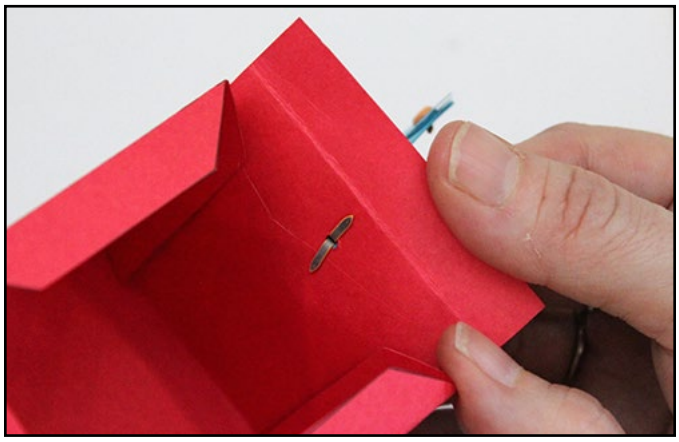
STEP 1: Collect Parts

- The Mission Manager will complete the final assembly of the spacecraft.
- Collect the TAGSAM Arm, High Gain Antenna, Solar Arrays, Thruster System and OCAM & OTES Cylinders from your Zip-lock bag.
- *Note: Your LID should still be open to complete this assembly.*



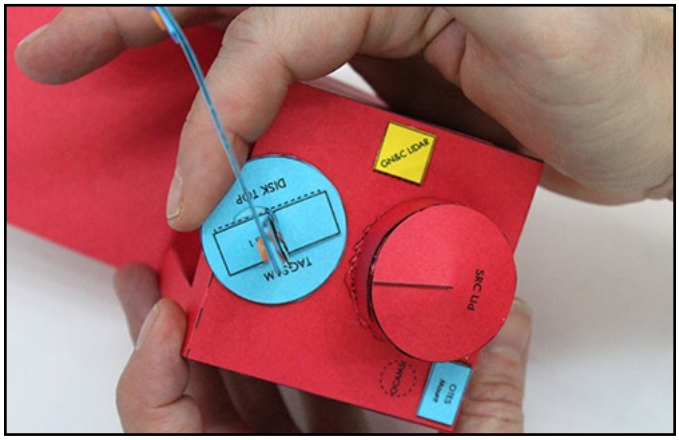
STEP 2: Connect TAGSAM Arm

- Hold the TAGSAM by the lever arm and stick the little brad ends through the small hole on the Bus.



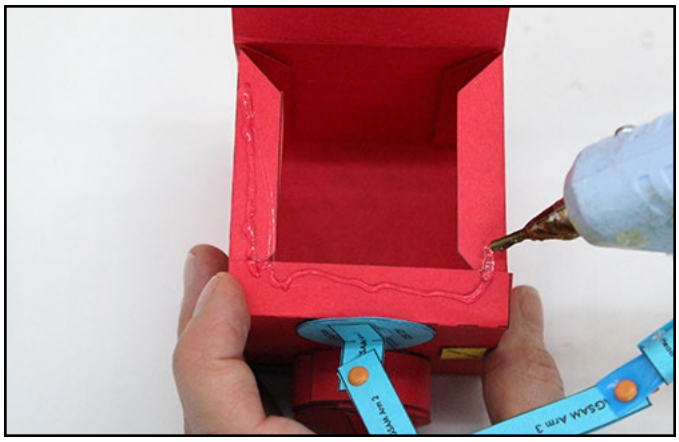
STEP 3: Secure the TAGSAM ARM

- Press the brad ends firmly to the inside of the Bus to secure.
- Your brad should be flat against the inside of the Bus.



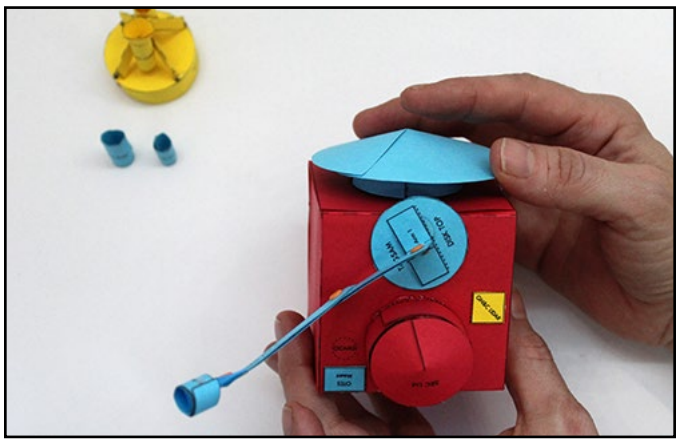
STEP 4: Test the Lever Disk

- Test that the TAGSAM Disk rotates around 360 degrees.
- The TAGSAM is now attached and the lever arm is movable with the brads.



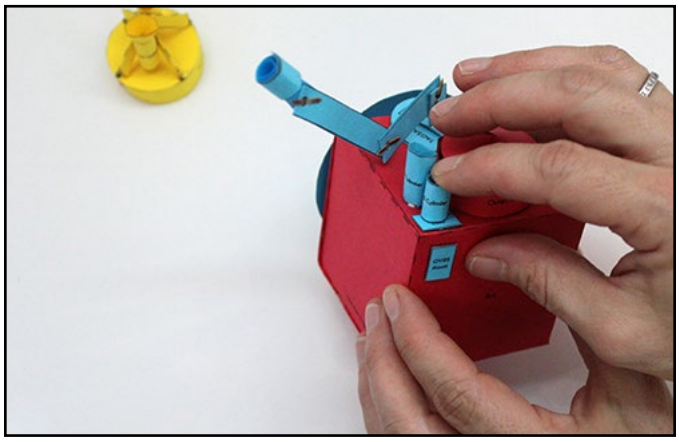
STEP 5: Glue the Lid

- Place hot glue on the last (3) open tabs of the Bus box.
- Close the Lid and hold to secure.
- Your Bus is now closed and complete.



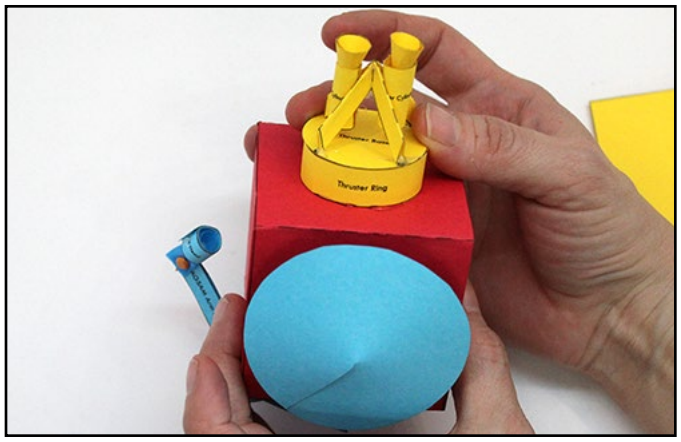
STEP 6: Glue High Gain Antenna

- Place hot glue around the dashed circle on the Bus top for the HGA.
- Place the HGA Ring on the hot glue to secure the HGA to the Bus.



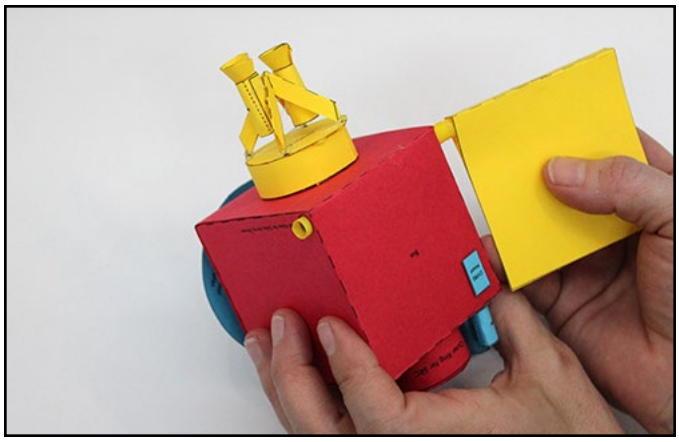
STEP 7: Place Camera Cylinders

- Hot glue the OCAM Cylinder to the OCAM dashed circle on the Bus.
- Hot glue the OTES Cylinder to the blue OTES Mount, the little rectangle already glued to the Bus.
- *Note: Younger students will place two small blue straws they pre-cut. The straw with the angled end is the OCAM.*



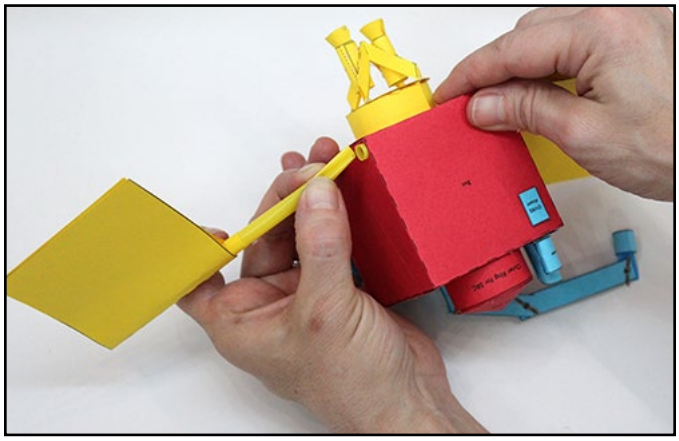
STEP 8: Glue Thruster System

- Place hot glue in a circle on the dashed lines on the Bus for the Thruster Ring.
- Place the bottom of the Thruster Ring on the hot glue and hold to secure to the Bus.



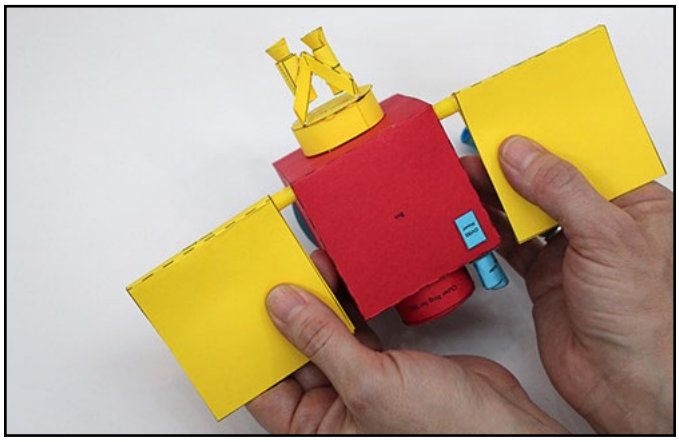
STEP 9: Assemble Solar Array

- Stick the Solar Array with the longer straw through both large holes in the Bus.
- Make sure the flexible accordion part of the straw is against the body of the Bus.
- Get a team member to hold the Bus if you need help.



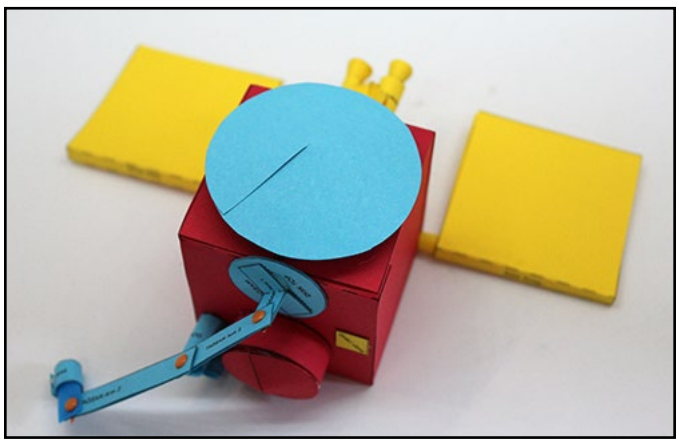
STEP 10: Secure 2nd Solar Array

- Pinch the shorter straw of the Solar Array to make it thin enough to fit inside a full sized straw.
- Slide this straw into the straw that is already in the Bus until the accordion parts are against the Bus and flexible.



STEP 11: Test Solar Arrays

- Test that your Solar Arrays are movable with the flexible accordion sections flush against opposite sides of the Bus.



STEP 12: Your Finished!

- You now have a finished model of OSIRIS-REx with movable Solar Arrays, rotating TAGSAM Arm and removable Sample Return Capsule.
- Play, Show & Share!