NAVIGATOR PROP BUILDING INSTRUCTIONS & PHOTOS

Companies should be aware that tolerances in lengths of cut pipe and length of pipe inserted into joints can change the overall dimensions of product demonstration tasks. Certain non-critical dimensions may be changed to better work within the pool venue. Companies should expect tolerances in all product demonstration props, and should build their ROVs and tools accordingly.

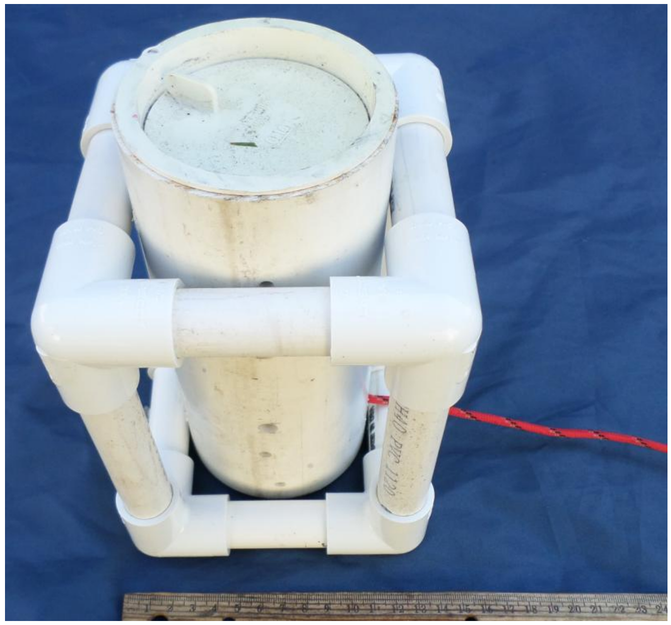
Home Depot part numbers are given for certain construction items. However, some Home Depot stores may not carry the listed items. If the local Home Depot does not carry the part in question, MATE recommends checking other local hardware stores or online sources, such as those listed below, for the required component.

http://www.pvcfittingsonline.com/
http://pvcpipesupplies.com/pvc-fittings/schedule-40-pvc-fittings/

Task 1: Outer Space: Mission to Europa

Environmental Sample Processor and Elevator
The Environmental Sample Processor is constructed from a 3-inch PVC pipe with a ½-inch framework around it. To construct the ESP:

1. Cut four 7.5 cm lengths of PVC pipe. Use four ½-inch side outs in combination with the 7.5 cm lengths of pipe to create a square. Make sure the remaining openings on the side outs all face the same direction.
2. Cut four 12 cm lengths of pipe. Insert a 12 cm length of pipe into each open end of the four side outs.
3. Repeat step 1 to make a second square of ½-inch PVC pipe and side outs. Attach this square to the four ends of the 12 cm lengths of PVC pipe.
4. Cut a 20 cm length of 3-inch pipe. Insert this pipe between the ½-inch PVC framework. One end of the 3-inch pipe should be flush with one side (the bottom) of the PVC framework. The other end of the 3-inch pipe should stick up approximately 3 cm from top of the framework.
5. Use 2-inch screws to secure the 3-inch pipe into the framework.
6. Insert a 3-inch knock out cap (Home Depot part #39102, internet #100122751, Store SKU #508260) into the top end of the 3-inch pipe.
7. Cut an 8 meter length of 1/8-inch polypropylene rope (Home Depot part #72402, internet #205804755, Store SKU #402816). Tie the rope securely around one 12 cm length of ½-inch pipe.

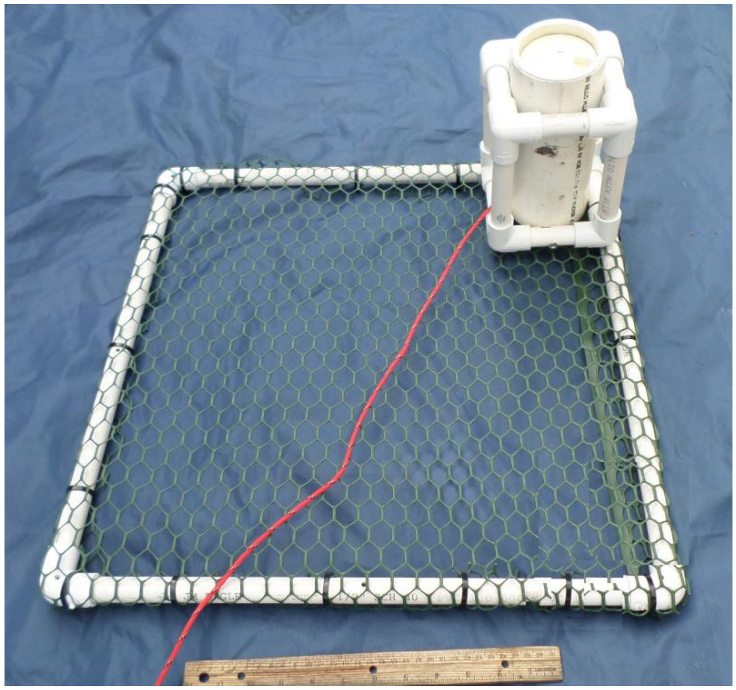


NAVIGATOR product demonstration build photo #1: The Environmental Sample Processor.

Design note: If you use side outs that are threaded in one opening, you will need to insert male adapters into those threaded openings. Make sure the threaded openings are open ends after creating the squares (step 1 and step 3). To compensate for the extended length, you will need to reduce the length of the 12 cm pipe. The entire length of the framework should be approximately 18 cm.

To construct the elevator:

1. Cut four 47 cm lengths of ½-inch PVC pipe. Use four ½-inch 90^{o} elbows to create a PVC square approximately 50 cm long on each side.
2. Cut a 60 cm x 60 cm square of plastic mesh (Home Depot part #090786, internet #100384027). Cover the top of the elevator with pipe, bending the sides of the mesh around the pipe and securing the mesh to the 50 cm square of pipe with zip ties. Design note: You want a smooth, top surface of the elevator so that the rope does not tangle on cut edges of the mesh. You may need to cut the corners of the mesh or snip off any excess once it is secured to the pipe of the elevator.
3. Use zip ties to secure the bottom of the ESP into one corner of the elevator.


NAVIGATOR product demonstration build photo #2: The elevator with the ESP attached.

Design note: Use rebar inside the ½-inch pipes of the elevator, or use dive weights, to keep the elevator stationary on the bottom of the pool.

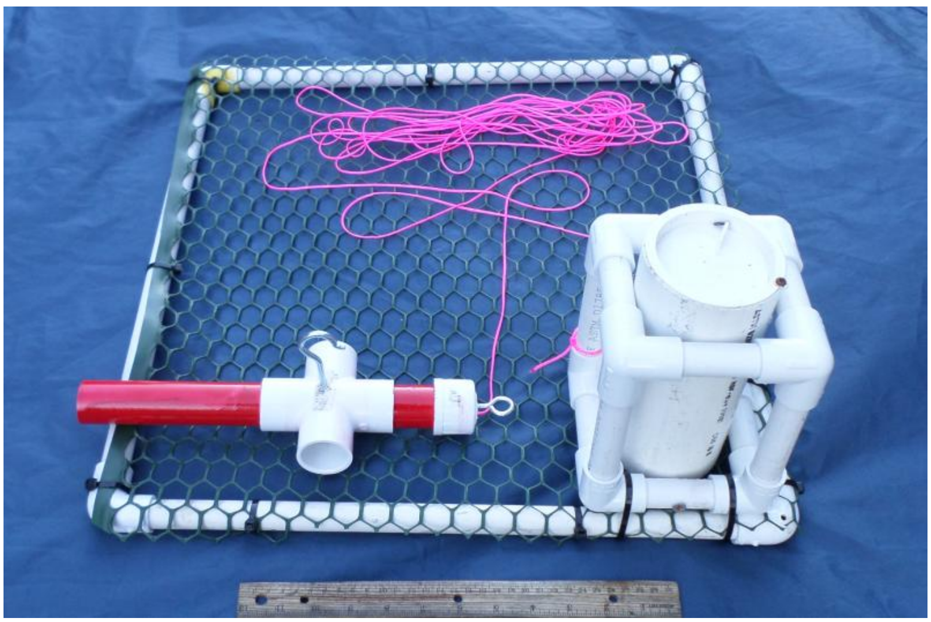
Cable Connector

The cable connector is constructed from 1-inch PVC pipe. A screw hook and a screw eye act as grab points for the cable connector. 8 meters of line attach the cable connector to the ESP. To construct the cable connector:

1. Cut a 16 cm length of 1-inch PVC pipe. Insert it into one opening of a 1-inch PVC cross.
2. Cut an 8 cm length of 1-inch PVC pipe. Insert it into the opposite opening of a 1-inch PVC cross. Attach a 1-inch end cap to the other end of this 8 cm length of PVC pipe.
3. Drill a 3/16 hole in the center of PVC end cap. Twist a #6 screw eye (Home Depot part # 803682, internet #204273860, Store SKU #727432) into the center hole until all but 1 to 3 mm of threads are inside the plastic of the end cap. The eye should be horizontal, parallel to the side openings of the central PVC cross.
4. Drill a 1/8-inch hole half way between the center of the end cap and the bottom edge of the end cap. Insert the remaining end of the 8 meters of line (the other end of the line is attached to the ESP) into this hole. Tie an overhand knot in the end of the line to secure it inside the end cap.
5. Screw a #8 screw hook (Home Depot part #803272, internet #204273853, Store SKU #727320) into the top center of the 1-inch plus. Insert the screw hook until all but 1 to 3 millimeters of thread are visible. Twist the screw hook until the top end faces the back of the cable connector, the 1-inch end cap.

NAVIGATOR product demonstration build photo #3: The cable connector.

The cable connector is placed on the elevator in a corner adjacent to the ESP. The 8 meters of cable (line) should be coiled neatly on the remaining open section of the elevator.



NAVIGATOR product demonstration build photo #4: The ESP, cable connector and 8 meters of coiled line on the elevator.

Power and Communications Hub

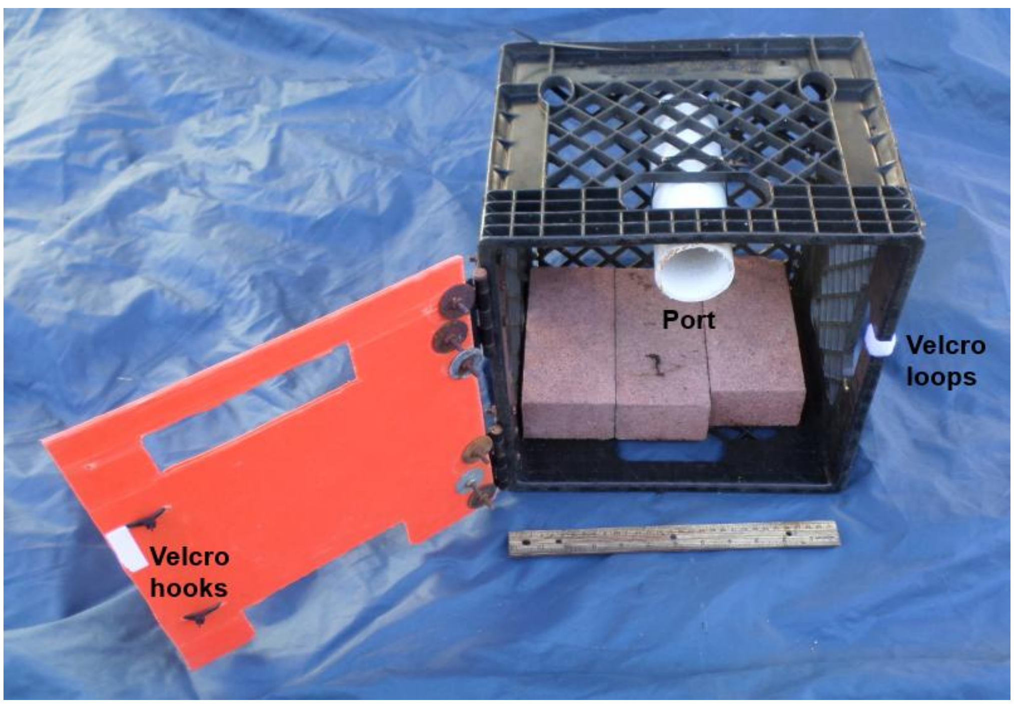
The power and communications hub is constructed from a milk crate. The door to the hub is constructed from corrugated plastic sheeting. The port on the power and communications hub is constructed from 2-inch PVC pipe.

Design note: The power and communications hub is based off the cargo container from the 2014 MATE competition. Remove the locking mechanism and stand from the 2014 cargo container and cut off 2 cm from the bottom of the corrugated plastic sheet making up the door (so the door opens easily without impacting the bottom of the pool).

To construct the power and communications hub:

1. Cut a 32 cm by 30 cm sheet of corrugated plastic. Position the corrugated sheet at the top of the open side of the milk crate. Use two 3-inch brass hinges to secure the corrugated plastic sheet over the open side of the milk crate. There should be a 2 cm gap at the bottom of the open side of the milk crate, so when the door opens, it does not impact the pool bottom.
2. Position the hinges along the edge of the milk crate and drill holes into the plastic of the milk crate and into the corrugated plastic.
3. Use #10-24 1-inch long bolts instead of the screws that come with the hinges. This will eliminate the sharp points of the screws and allow for tighter connections with the plastic. Use a 10-24 nut to secure the bolts through the hinges. When attaching the bolts through the corrugated plastic, use a 1 ¼-inch x ¼-inch fender washer on the two outside bolts of each hinge. This will increase the surface area against the corrugated plastic and prevent damage.
4. Cut a 9 cm length of ½-inch PVC pipe. Attach a ½-inch 90^{o} PVC elbow to each end. Drill two 5/32-inch holes into the open end of each 90^{o} PVC elbow. This is the handle to open the corrugated plastic top of the power and communications hub.
5. Place the handle on the side of the corrugated plastic opposite the hinges, 3 cm from the edge of the plastic. The handle should be positioned so the open ends of the 90^{o} PVC elbow are flat against the corrugated plastic and the handle is located centrally between the two holes cut into the corrugate plastic.
6. Drill four holes into the corrugated plastic, each one adjacent to the holes drilled into the open end of the 90^{o} PVC elbow. Insert cable/zip ties through the holes of each 90^{o} PVC elbow, through the holes in the corrugated plastic. Tighten the ties to secure the handle to the corrugated plastic.
7. Cut a 5 cm x 1 cm length of Velcro hooks and a 5 cm x 0.5 cm length of Velcro loops. Attach the Velcro loops around open end of the milk crate on the opposite wall from the hinges. Attach the Velcro hooks to the inside of the door so that when the door is closed, the Velcro hooks attach to the Velcro loops.
8. Cut a 20 cm length of 2-inch PVC pipe. Insert a 2-inch knock out cap (Home Depot model #39101, Internet #100137732, Store SKU #508257) into one end of the 20 cm length of pipe. Use glue or screws to secure the knock out cap into the 2-inch pipe.
9. Use zip tie to secure the 2-inch pipe to the inside, center, top of the milk crate. The open end of the pipe should be facing the door and flush with the opening of the milk crate.

NAVIGATOR product demonstration build photo #5: The power and communications hub with the door closed.



NAVIGATOR product demonstration build photo #6: The power and communications hub with the door opened, exposing the 2-inch port.

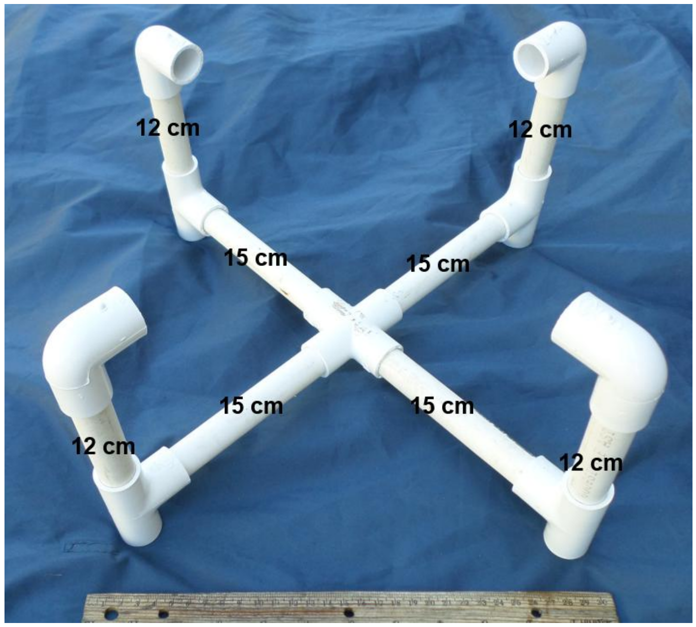
Design note: The rectangular openings on the corrugated plastic door are optional. They are remnants from the 2014 competition props.

NAVIGATOR product demonstration build photo #7: The cable connector successfully inserted into the port on the power and communications hub.

Waypoint

The two waypoints are constructed from ½-inch PVC pipe. To construct a waypoint:

1. Cut four 15 cm lengths of ½-inch PVC pipe. Insert the four lengths of pipe into the four openings of a ½-inch PVC cross. Attach the middle opening of a PVC tee to the other end of each 15 cm length of pipe, 4 tees total. Rotate the tees so they are perpendicular to the cross.
2. Cut four 12 cm lengths of ½-inch PVC pipe. Insert the four lengths of pipe into one side opening of the four PVC tees. All four lengths of pipe should be on the same side of the waypoint. Attach a ½-inch 90^{o} PVC elbow to the other end of each 12 cm length of pipe. Rotate the open ends of the elbow to face the PVC cross in the center.



NAVIGATOR product demonstration build photo #8: A waypoint.

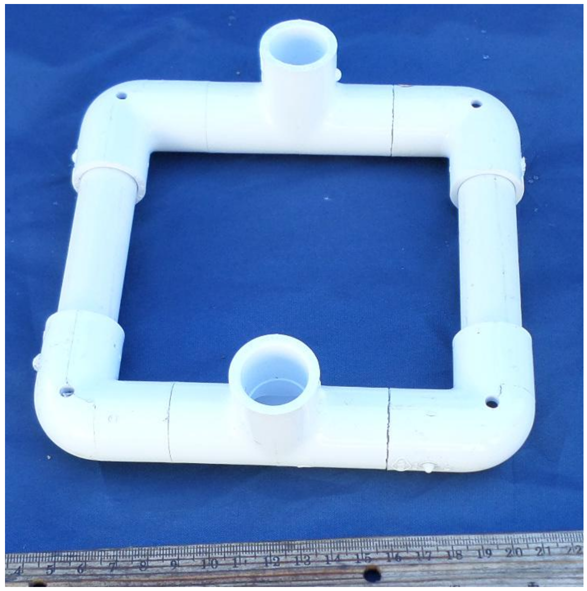
Use dive weights to secure the waypoints to the bottom of the pool.

Task 2: Inner Space: Mission-critical equipment recovery

CubeSats

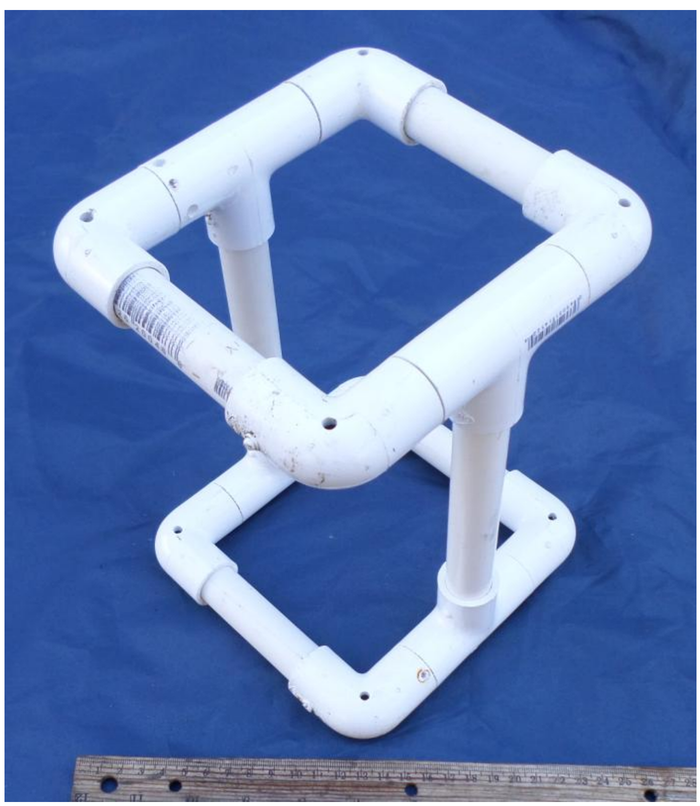
The CubeSats are constructed from ½-inch PVC pipe and corrugated plastic sheeting. All six CubeSats are identical in construction, but each will have a different serial number. To construct a CubeSat:

1. Cut two 3 cm lengths of ½-inch PVC pipe. Insert these two lengths into the two side openings of a ½-inch PVC tee. Attach a ½-inch 90° elbow to the end of each 3 cm length of pipe.
2. Cut two 10 cm lengths of ½-inch PVC pipe. Insert the lengths of 10 cm pipe into the middle opening of the two PVC elbows on the ends of the row.
3. Repeat step 1 to create a second side with a PVC tee in the middle and two elbows on the end.
4. Attach the openings of the two PVC elbows to the other ends of the 10 cm lengths of pipe. This should create a ½-inch PVC square approximately 17 cm per side. Set the rectangle flat on the ground and rotate the middle opening of the two middle tees so the opening faces up.
5. Repeat steps 1 through 4 to create the other end of the CubeSat.



NAVIGATOR product demonstration build photo #9: One end of a CubeSat.

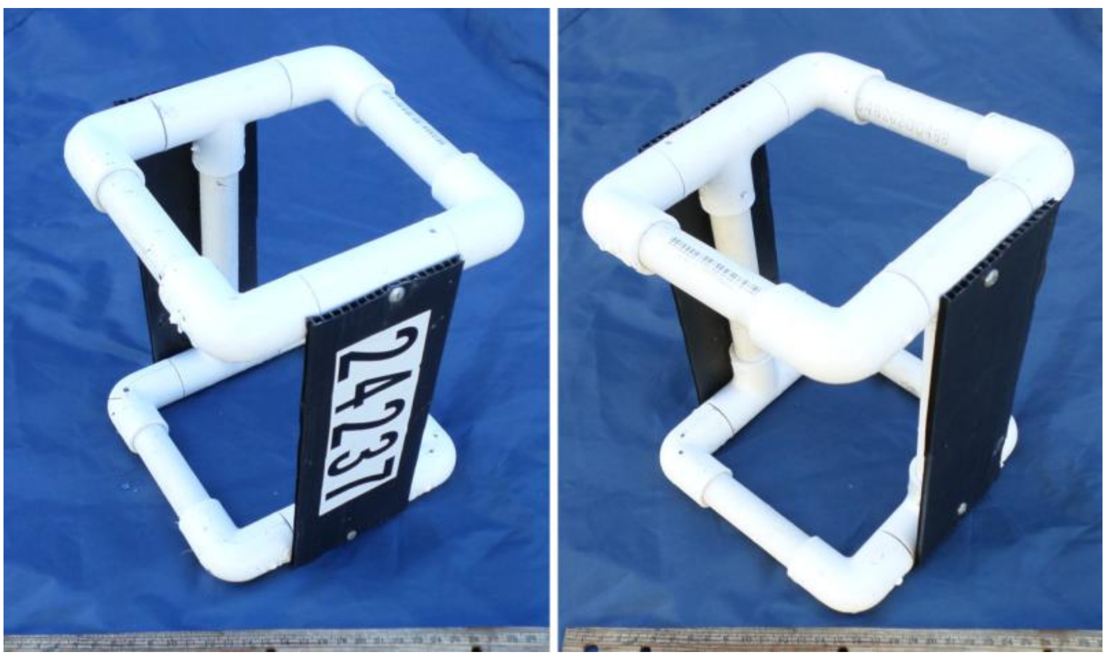
6. Cut two 16 cm lengths of ½-inch PVC pipe. Insert these lengths of pipe into the middle openings of the two PVC tees on one end of the CubeSat. Attach the middle openings of the PVC tees of the other end of the CubeSat to the 16 cm lengths of pipe. This should create a rectangular prism 17 cm x 17 cm x 23 cm.



NAVIGATOR product demonstration build photo #10: The framework of a CubeSat.

7. Cut two 20 cm x 8 cm rectangles from corrugated plastic sheeting. Attach the 20 cm x 8 cm rectangles of corrugated plastic sheeting onto one side of the CubeSat with the 16 cm length of PVC pipe running down the center. Use screws to secure the plastic rectangle to the CubeSat framework.
8. Using 2-inch, black on white lettering (Home Depot part #842282, Internet #100186676, Store SKU #836196), attach the serial number to the outside of one of the 20 cm x 8 cm rectangles of corrugated plastic sheeting.

Repeat these steps to create six CubeSats, each with a distinct serial number. Serial numbers at the international competition will be five digits long and may include numbers and letters. Serial numbers at regionals may be different. The serial number does not matter, as long as each CubeSat has a different set of numbers.



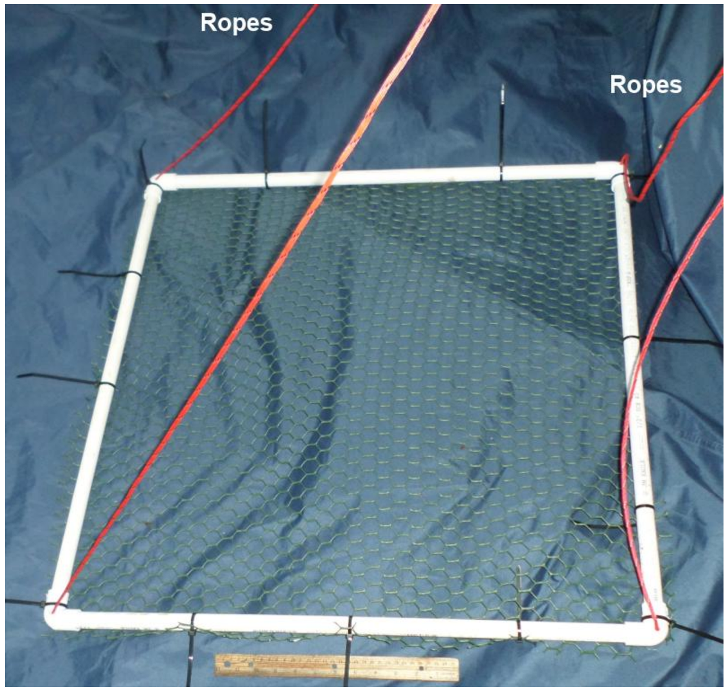
NAVIGATOR product demonstration build photo #11: A finished CubeSat, serial #24237, from two angles.

Lift Basket

The lift basket is constructed from ½-inch PVC pipe and plastic mesh. To construct the lift basket:

1. Cut four 72 cm lengths of ½-inch PVC pipe. Use four ½-inch 90^o elbows to create a square that is 75 cm per side.
2. Cut a 77 cm x 77 cm square of plastic mesh (Home Depot part #090786, internet #100384027). Use zip ties to attach the square of plastic mesh to the 75 cm PVC square.
3. Cut four 2 meter lengths of 1/8-inch polypropylene rope (Home Depot part #72402, internet #205804755, Store SKU #402816). Drill a 3/16-inch hole into each 90^o elbow at the corners of the PVC square. Insert a 2 meter length of rope into each hole. Tie an overhand knot to secure the rope inside the elbow.

4. Bring the four loose ends of the ropes together and tie a knot to secure them. Attach a small float to keep the ropes suspended above the lift basket.



NAVIGATOR product demonstration build photo #12: The lift basket for the four mission-critical CubeSats. Ropes at each corner come together at a float above the lift basket.

Use rebar inside the PVC pipes or dive weights to secure the lift basket to the bottom of the pool.

Task 3: Inner Space: Forensic Fingerprinting

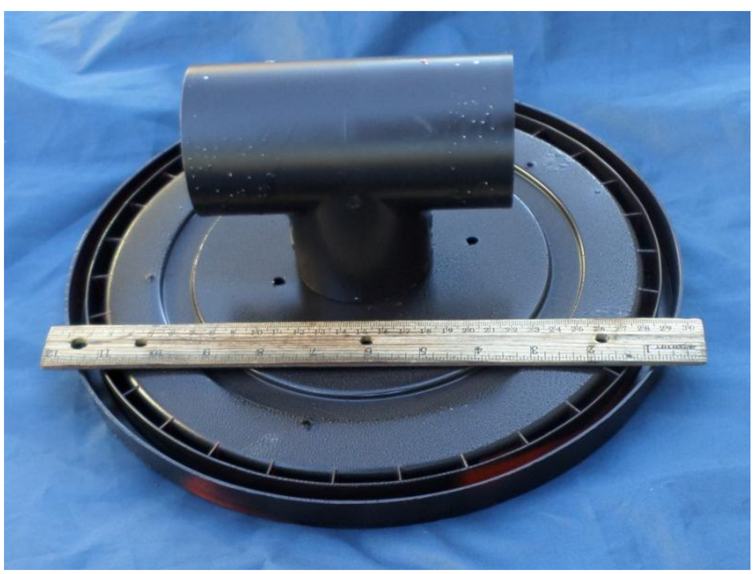
Oil mat
The oil mats are constructed from a 5-gallon bucket lid. One oil sample will sit on top of each 5-gallon bucket lid. To construct the oil mat, paint the top side of one 5-gallon bucket lid black.

Oil samples
The oil samples are constructed from a 2-inch PVC tee. The oil samples are painted black. To construct an oil sample:

1. Paint a 1 ¼-inch end cap black. Use two screws to attach the end cap, open side up, to the center of the painted bucket lid.
2. Paint a 2-inch tee black. When the paint has dried, place the middle opening of the 2-inch PVC tee over the 1 ¼-inch end cap attached to the 5-gallon bucket lid.

NAVIGATOR product demonstration build photo #13: An oil mat without an oil sample.

NAVIGATOR product demonstration build photo #14: An oil sample.



NAVIGATOR product demonstration build photo #15: Oil mat with oil sample.

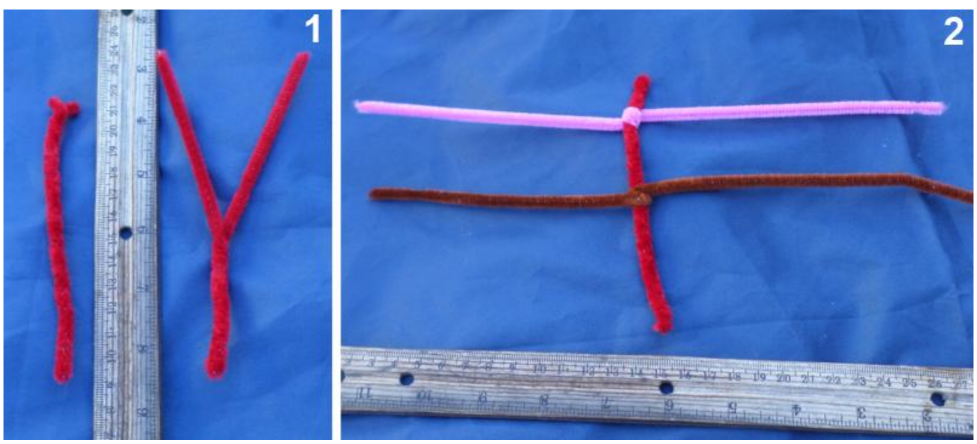
A gas chromatograph will be rolled up inside each oil sample. The gas chromatograph will be printed on a laminated sheet approximately 22 cm by 12 cm. Examples of gas chromatographs can be seen in the **NAVIGATOR Oil Fingerprint Handbook**.

Task 4: Inner Space: Deepwater coral study

***Madrepora* Coral**

The scleractinian coral colony *Madrepora prolifera* is constructed from brown, red and pink chenille pipe cleaners. Colors may vary in different coral colonies. The base of the coral colony is a ½-inch PVC tee. To construct the *Madrepora* coral:

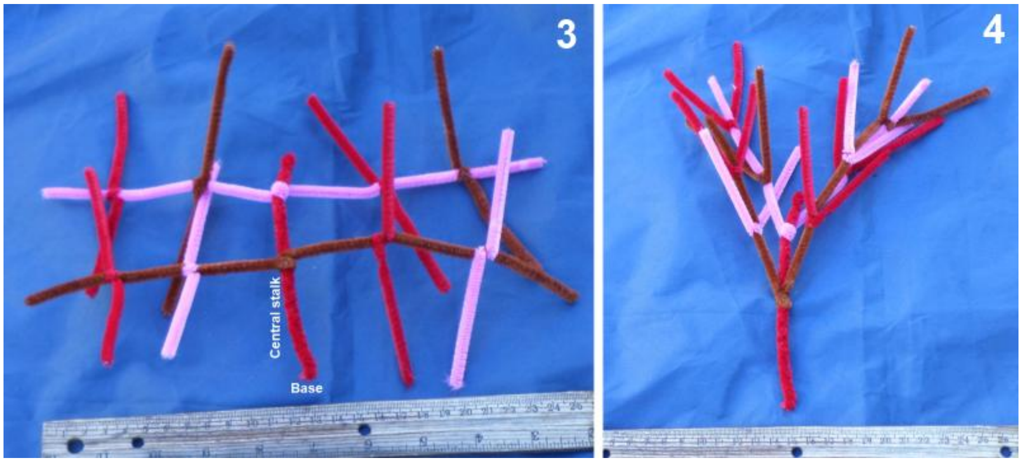
1. Fold a red chenille pipe cleaner in half and twist it tightly together. This double strength pipe cleaner is the central stalk of the coral colony.
2. Take a brown pipe cleaner and wrap it three times around the red central stalk pipe cleaner, about half way between the two ends. Take a pink pipe cleaner and wrap it three times around the red central stalk pipe cleaner, about halfway between the brown pipe cleaner and one end.



NAVIGATOR product demonstration build photo #16: 1) The central stalk of the coral. Completed central stalk on left of ruler, half twisted central stalk on the right of the ruler. 2) Additional brown and pink chenille pipe cleaners added to the central stalk of the coral colony.

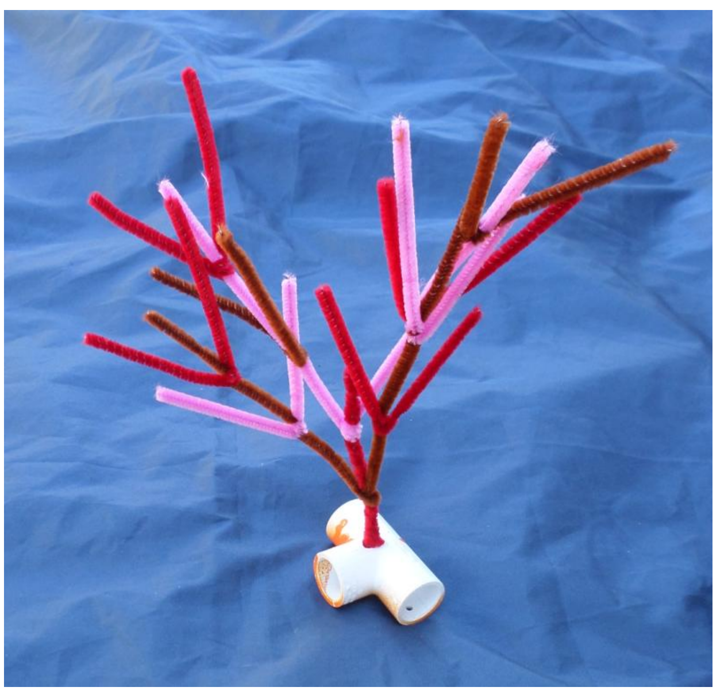
3. Cut a red pipe cleaner in half (two 15 cm lengths). Cut a pink pipe cleaner in half (two 15 cm lengths). Wrap a red pipe cleaner three times around one side of the brown pipe cleaner, about 5 cm from the central stalk. Wrap a pink pipe cleaner three times around the same side of the brown pipe cleaner, about 10 cm from the central stalk. Use the other 15 cm red and pink pipe cleaners on the brown pipe cleaner on the other side of the central stalk.
4. Cut a red pipe cleaner in half (two 15 cm lengths). Cut a brown pipe cleaner in half (two 15 cm lengths). Wrap these around the pink pipe cleaner that is wrapped around the central stalk, using the same method as step 3.
5. Twist all the pipe cleaners so the branches bend in one direction. Design note: The easiest way to do this is to grab the base with one hand, form a circle with your thumb and index finger of

your other hand and run it up the central stalk two or three times. The base of the stalk is the side of the central stalk that does not have the second pipe cleaner (the longer side of the central stalk).



NAVIGATOR product demonstration build photo #17: 3) Eight additional side branches added to the coral. Note the central stalk and base of the coral. 4) Coral colony with all branches positioned.

6. Drill two 3/16-inch holes into the center side of a ½-inch PVC tee. The holes should be 0.5 cm apart. Push the base of the center stalk into one hole and bend it out the other. Twist the ends of the base together to form a tight, strong base. The tight, strong base should be able to hold the coral colony upright in air.



NAVIGATOR product demonstration build photo #18: Completed scleractinian coral colony with base.

Optional design 1: Cut a few more 15 cm lengths of various colored pipe cleaners. Add them into the coral colony to fill it out.

Optional design 2: Attach small bits of pink or red flotation to the top ends of a few coral branches. This flotation will help hold the coral upright in the water.

Task 5: Inner Space: Rigs to Reefs

Wellhead

The wellhead is constructed from 2-inch PVC pipe and couplings set into a cement base. To construct the cement base, fill a 40 cm oil pan with cement. Before the cement dries, set a 2-inch PVC coupling into the cement and let the cement dry.

1. Cut a 40 cm to 75 cm length of 2-inch PVC pipe. Insert this length of 2-inch pipe into the 2-inch coupling in the dried cement. Attach another 2-inch coupling to the top end of the pipe.
2. Insert a 2-inch to 1 ¼-inch coupling (Home Depot model #PVC021083000HD, Internet # 204836418, Store SKU # 744965) into the other end of the 2-inch coupling. Cut an 8.5 cm length of 1 ¼-inch PVC pipe. Insert the length of pipe into the reducer bushing.
3. Cut a length of 5 cm wide industrial strength Velcro hooks. The length of this Velcro should stretch all the way around the 1 ¼-inch pipe. Adhere the Velcro 1 cm below the top of the 8.5 cm pipe in the top of the wellhead.

NAVIGATOR product demonstration build photo 19: The wellhead.

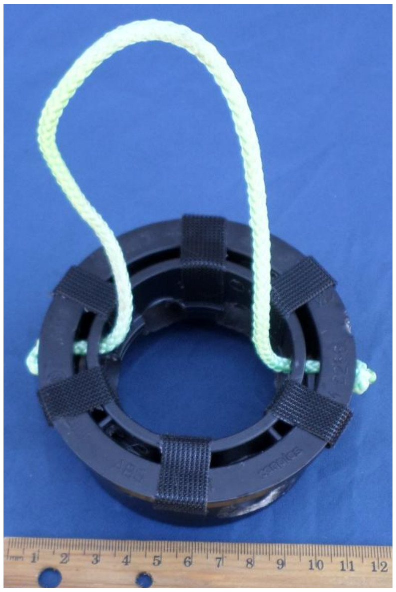
Flange

The flange is constructed from an ABS 3-inch to 2-inch reducer bushing (Home Depot model #C58012FHD32, Internet #100343802, store SKU # 188301). Holes are drilled through the walls of the flange. Bolts inserted through these holes will secure the flange to the end of the pipeline. To construct the flange:

Design note: There are two 3-inch to 2-inch ABS reducer bushing designs available in Hardware stores, one with a round top and beveled edge, or one with an octagonal cap and angled edge. The part number given refers to both designs. Either reducer bushing design can be used to complete the product demonstration task. Your regional coordinator will inform you which bushing design will be used at your regional competition.

1. Drill six 5/8-inch holes through the side wall of the flange at 60^{o} angles around the 360^{o} circumference. These holes should go all the way through the wall, from the outside to the middle of the reducer bushing.
2. Cut six 1 cm x 5 cm lengths of Velcro hooks. Attach these six rectangles of Velcro to the top of the flange, centering each rectangle between two of the six holes drilled into the flange.
3. Cut a 40 cm length of 1/8-inch polypropylene rope (Home Depot part #72402, internet #205804755, Store SKU #402816). Drill two 3/16-inch holes through the top side wall of the flange on opposite sides. These holes should go all the way through the wall, from the outside to the middle of the reducer bushing.
4. Push the 40 cm length of rope through both 3/16-inch holes. Tie an overhand knot on the ends of each rope to secure the rope to the flange.

Design note: The overhand knots must be on the outside of the flange in order for the flange to fit over the 1 ¼-inch wellhead pipe.

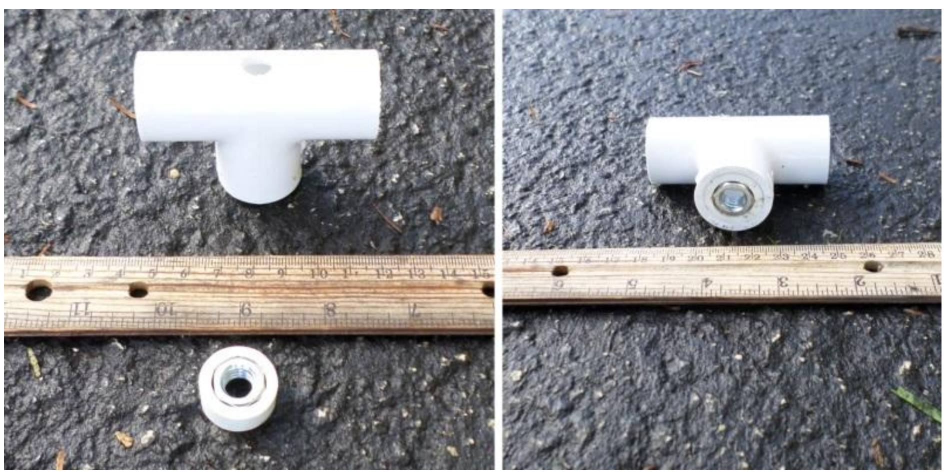


NAVIGATOR product demonstration build photo #20: Flange with Velcro strips attached.

Bolts

The bolts are constructed from 3-inch long 3/8-inch x 16 thread bolts through a ½-inch PVC tee, which serves as a holder for the bolts. Velcro loops around the end of the bolt will secure the bolt to the Velcro hooks on the end of the wellhead pipe. To construct a bolt:

1. Drill a 3/8-inch hole through the center of the middle opening of a PVC tee.
2. Cut a 1 cm long length of ½-inch PVC pipe. Use a hammer to force a 3/8-inch nut inside the 1 cm length of PVC pipe. Insert the 1 cm length of pipe into the middle opening of the PVC tee.
3. Push a 3-inch long 3/8-inch bolt through the hole in the tee and screw it into the nut inserted into the middle opening of the tee. The bolt should extend approximately 2.5 cm beyond the middle opening of the tee.
4. Cut a 5 cm x 1 cm rectangle of Velcro loops. Attach the middle of the Velcro loop rectangle to the end of the 3/8-inch bolt. Secure the 2 cm Velcro on either side of the middle of the rectangle to the sides of the bolts. Wrap plastic tape tightly around the ends of the Velcro loop rectangle to secure it to the end of the bolt.



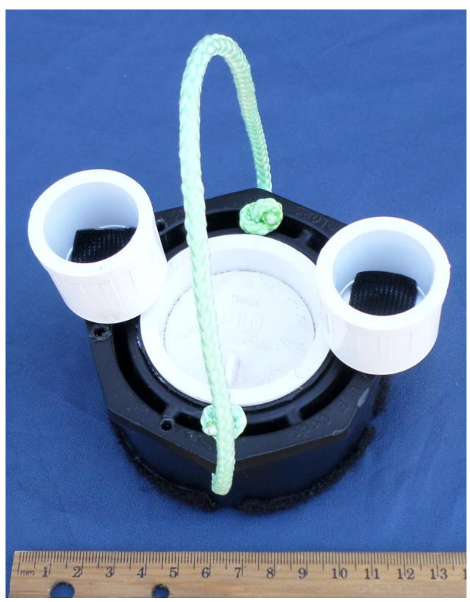
NAVIGATOR product demonstration build photo #21: PVC base of the bolt with 3/8-inch nut inserted.

NAVIGATOR product demonstration build photo #22: Completed bolt without Velcro. Completed bolt with Velcro.

Wellh1ead cap

The wellhead cap is constructed from an ABS 3-inch to 2-inch reducer bushing (Home Depot model #C58012FHD32, Internet #100343802, store SKU # 188301). It has two ½-inch PVC end caps screwed into the top side to serve as ports for the bolts. To construct the wellhead cap:

1. Cut a 2 cm length of 2-inch PVC pipe. Insert the 2 cm length of pipe into the 2 cm opening on the reducer bushing.
2. Insert a 2-inch knockout cap (Home Depot model #39101, Internet #100137732, Store SKU #508257) into the 2-inch pipe.
3. Use a screw to secure a ½-inch PVC end cap to the outside of the top edge of the 3-inch to 2-inch ABS reducer bushing. The screw should go straight down into the side wall of the bushing. Repeat this again to add a second end cap on the opposite side of the bushing.
4. Cut two 1.8 cm x 1.8 cm squares of Velcro hooks. Adhere the sticky side of the Velcro to the inside bottom surface of the four end caps, over the screw heads holding them in place.
5. Cut four 5 cm x 3 cm lengths of Velcro loops. Attach them around the bottom, angled end of the 3-inch to 2-inch reducer bushing.
6. Cut a 40 cm length of 1/8-inch polypropylene rope (Home Depot part #72402, internet #205804755, Store SKU #402816). Drill two 3/16-inch holes through the top side wall of the wellhead cap on opposite sides.
7. Push the 40 cm length of rope through both 3/16-inch holes. Tie an overhand knot on the ends of each rope to secure the rope to the wellhead cap.



NAVIGATOR product demonstration build photo #23: Wellhead cap with four ports for bolts.

Elevator

The elevator is constructed of an 80 cm x 15 cm rectangle of corrugated plastic sheeting and ½-inch PVC framework. Flanges and wellhead caps will rest upright on the plastic sheeting. ½-inch end caps will hold the bolts upright above the plastic sheeting. To construct the Rigs to Reefs elevator:

1. Cut an 80 cm by 15 cm rectangle of corrugated plastic sheeting.
2. Cut two 77 cm lengths and two 9 cm lengths of ½-inch PVC pipe. Use four tees combine the PVC pipes into a rectangle 80 cm by 15 cm. Screw the corrugated plastic sheeting on top of the PVC pipe rectangle.
3. Screw three end caps into the corrugated plastic sheeting, 5 cm from one short edge. Two of the end caps should be 3 cm from each long end, the third end cap should be in the center, 7.5 cm from each long end. Cut three 2 cm long lengths of ½-inch PVC pipe and insert them into each end cap.
4. Repeat this process, screwing 3 end caps into the corrugated plastic sheeting, 14 cm from the same short edge (9 cm from the other end caps).
5. Cut six 1 cm lengths of ½-inch PVC pipe. Insert a 1 cm length of pipe into each end cap, making the edge of the 1 cm length flush with the end of the end cap.

NAVIGATOR product demonstration build photo #24: The elevator holding one flanges, one wellhead cap and four bolts.

The elevator will have a total of 6 bolts available to NAVIGATOR class companies. Each elevator will have 2 flanges and 2 wellhead caps available for NAVIGATOR class companies.

6. Attach weights to the underside of the elevator to keep it from moving on the pool floor.

Design note: The weights may increase the distance between the pool bottom and top of the elevator. Companies should not rely on a set height for the elevator.