REVISIONS

Note: All revisions are highlighted in yellow within the document.

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TASK 2 – Valve – page 18

EXPLORER 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. Except where noted, companies should expect tolerances in all product demonstration props, and should build their ROVs and tools accordingly. In no case should the dimensions given in this document for a product demonstration prop be used to calibrate a measuring device.

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/

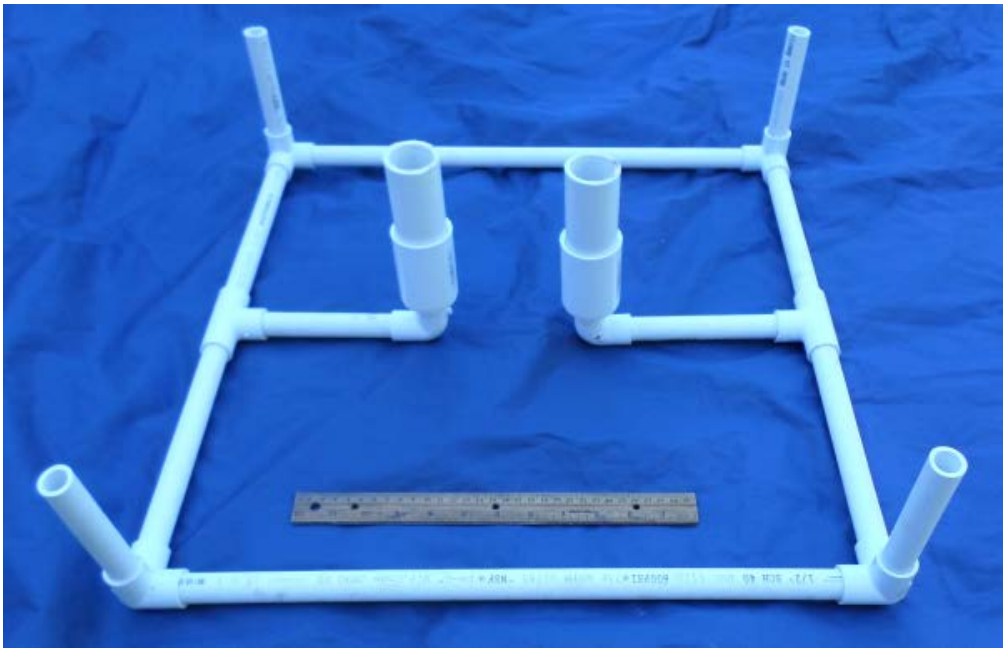
TASK 1: COMMERCE: HYPERLOOP CONSTRUCTION

Baseplate
The baseplate is constructed from ½-inch PVC pipe. To construct the baseplate:

1. Cut two 48 cm lengths of PVC pipe and four 22.2 cm lengths of PVC pipe. Insert two of the 22.2 cm lengths of pipe into the side openings of a tee. Insert the other two 22.2 cm lengths of pipe into the side openings of another tee. With the tee between them, the two 22.2 cm lengths of pipe should be 48 cm in overall length.
2. Attach a ½-inch sideout (corner piece) to the ends of the 48 cm lengths of PVC pipe to form a square. Orient all the sideouts so their remaining openings face upwards. Orient the two tees so they are horizontal, the middle opening parallel to the bottom of the pool.
3. Cut four 12 cm lengths and two 15 cm lengths of ½-inch PVC pipe. Insert four of the 12 cm lengths of pipe into the remaining openings of the four sideouts at the corners of the baseplate.

EXPLORER product demonstration build photo #1: The baseplate framework.

4. Insert the two 15 cm lengths of pipe into the middle openings of the two tees. Attach a 90° elbow to the other end of each 15 cm length of pipe. Twist the elbows so the open end faces upwards.
5. Cut two 3.5 cm lengths of ½-inch PVC pipe. Insert these 3.5 cm lengths of pipe into the open ends of each 90° elbow. Attach a 1-inch to ½-inch reducer bushing to the end of each 3.5 cm length of pipe. Attach a 1-inch PVC coupling to the other end of each reducer bushing.
6. Cut two 8 cm lengths of 1-inch PVC pipe. Insert the lengths of pipe into the 1-inch couplings.



EXPLORER product demonstration build photo #2: The baseplate.

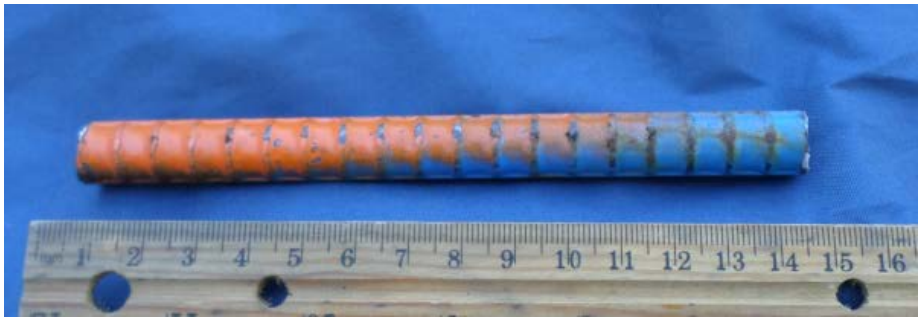
The measurements of the baseplate must be very precise. They must match the measurements of the frame (see below) exactly. The distance between the corners of the baseplate, measured from the exact center of the ½-inch PVC pipe, should be 52 cm. Cut and adjust the lengths of the pipe to these precise measurements.

Use 3/8-inch rebar inside the ½-inch pipe to weigh down the baseplate.

Rebar

The rebar will be constructed from 3/8-inch rebar. The rebar will be painted to reduce corrosion. Four lengths of rebar will be available; only two need to be inserted into the baseplate. To construct the rebar:

1. Cut four 15 cm lengths of 3/8-inch rebar. Insert them into the four holders on the elevator (see below).



EXPLORER product demonstration build photo #3: Rebar.

Elevator

The elevator will be constructed from a 5-gallon bucket lid. Four 1-inch end caps with 1-inch pipe inserted will hold the four lengths of rebar to be used in the construction. To construct the elevator:

1. Screw four 1-inch end caps into the bottom side of a 5-gallon bucket lid.
2. Cut four 8 cm lengths of 1-inch PVC pipe. Insert the 8 cm lengths of pipe into the four end caps attached to the bucket lid.

Use a dive or other weight to weigh down the bucket lid. Insert the four pieces of rebar into the 1-inch pipe.

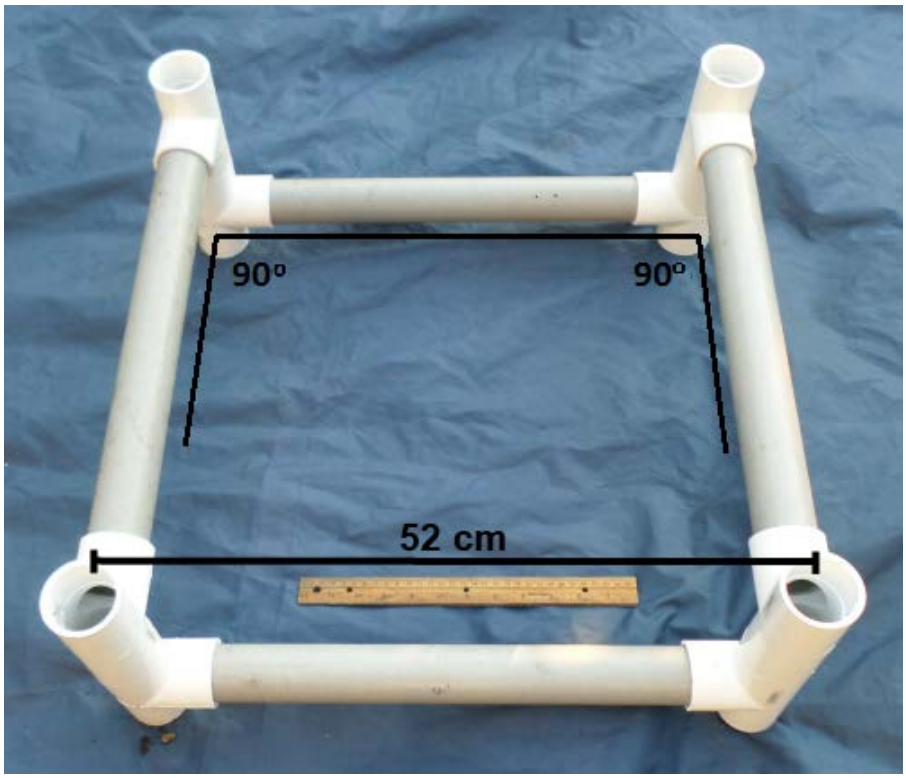
EXPLORER product demonstration build photo #4: The elevator.

EXPLORER product demonstration build photo #5: Four lengths of rebar installed on the elevator.

Frame

The frame is constructed from 1 ½-inch PVC pipe and fittings. Chains and ropes will connect to the frame and will allow the frame to be lowered down and manipulated from the surface, side of the pool. To construct the frame:

1. Cut four 6 cm lengths of 1 ½-inch PVC pipe. Attach the side opening of a tee to each end of the 6 cm lengths of pipe, eight tees total. Twist the tees so that the middle openings of the two tees attached to each 6 cm length of pipe are perpendicular to one another. Use a framing square, T-square or other tool to confirm the angle between the two middle openings is 90°. Use a framing square, T-square or other tool to confirm the angle between the two middle openings is 90°.
2. Cut four 46 cm lengths of 1 ½-inch PVC pipe. Insert the 46 cm lengths of pipe into the middle openings of the eight tees, creating a square.

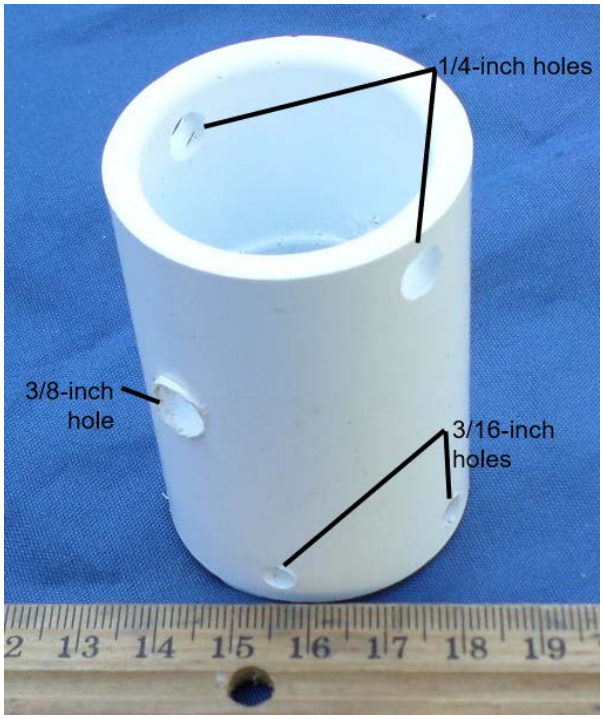


EXPLORER product demonstration build photo #5: The frame.

The measurements of the frame must be very precise. They must match the measurements of the baseplate (see above) exactly. The distance between the corners of the frame, measured from the exact center of the 1 ½-inch PVC tees, should be 52 cm. Cut and adjust the lengths of the pipe to these precise measurements. The MATE Center recommends verifying that the frame fits over the baseplate, with the center of the 1 ½-inch tees matching the ½-inch pipes at the corners of the baseplate and that the

angles of the frame are all 90°. Once the frame is properly aligned, insert screws into the frame at every tee/pipe connection to keep it from twisting out of alignment.

3. Drill four 3/16-holes at 90° angles around one end of a 1-inch PVC coupling. These four holes should be within 5 mm of the edge of the coupling. Drill two ¼-inch holes across from each other at the other end of the 1-inch coupling. Drill a 3/8-inch hole through the middle of 1-inch coupling.

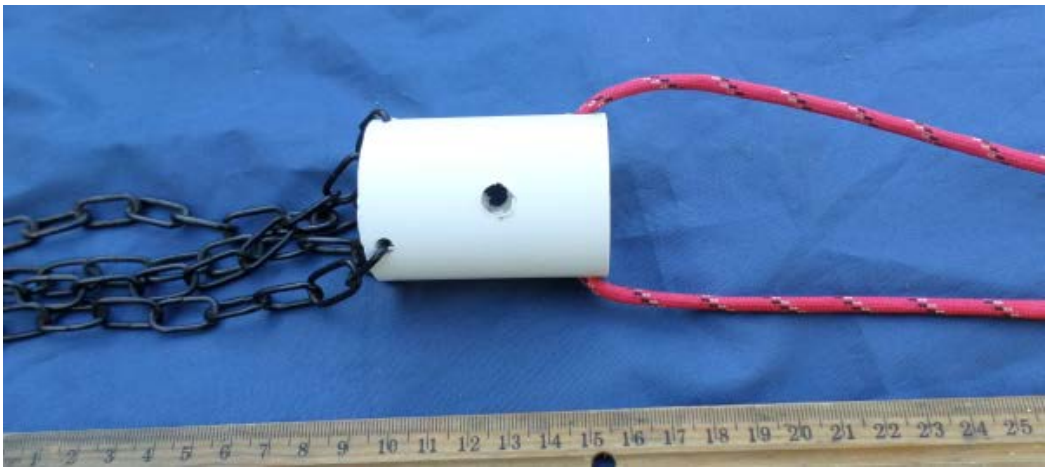


EXPLORER product demonstration build photo #6: The coupling with holes drilled. Two 3/16-inch holes and one 3/8-inch hole are not seen in this view.

4. Cut four 1.5 meter lengths of #100 black chain (Home Depot model# 810016, internet# 204640736, Store SKU# 444895). Use pliers to open up the chain link at one end of the 1.5 meter length of chain. Insert this open link through one of the four 3/6-inch holes at one end of the coupling.

EXPLORER product demonstration build photo #7: Opened chain link and the opened chain link through the coupling.

5. Once the link is inserted through the hole, use the pliers to close the link of the chain.
6. Repeat this process for the other three chains, inserting the open links into the other three 3/16-inch holes around the coupling. Close up each link after inserting it through the hole.
7. Cut a length of 1/8-inch nylon-poly blend rope (Home Depot model# 12715, Internet #203602865, Store SKU# 498533) equal to 2.5 times the depth of the pool. Insert this rope through the two ¼-inch holes at the other end of the 1-inch coupling.



EXPLORER product demonstration build photo #8: Rope and chains through the coupling.

8. Drill a 5/8-inch hole in the inside edge of the four 2-inch tees on the top of the frame. These holes should be approximately 3 cm from the top edge of the tees.

EXPLORER product demonstration build photo #9: Hole in the inside top of the frame.

9. Insert one of the four chains through each of the 5/8-inch holes, running the chain from inside the 2-inch tee, through the hole, and out towards the middle of the frame.
10. Bring all four loose ends of the chain and insert them inside the 1-inch coupling. Insert a galvanized steel tent stake (Amazon: https://www.amazon.com/10-Piece-Galvanized-Steel-Tent-Pegs/dp/B003TMPCT0/ref=sr_1_7?s=outdoor-recreation&ie=UTF8&qid=1477946450&sr=1-7&keywords=tent+stakes) through one 3/8-inch hole drilled into the middle of the coupling, through the final link of all four loose ends of the chain, and out the other 3/8-inch hole drilled in the opposite side of the coupling.

EXPLORER product demonstration build photo #11: Chain through hole in the frame.

EXPLORER product demonstration build photo #12: Tent stake.

EXPLORER product demonstration build photo #13: All four chains held in place in the coupling.

EXPLORER product demonstration build photo #14: The frame.

Hose

The hose for pouring concrete will be constructed from at least 3.5 meters of garden hose. A hose to PVC adapter will be attached to the end of the hose. A #310 U-bolt attached to a 1-inch PVC cross will provide a grab-point for the end of the hose. To construct the hose for pouring concrete:

1. Install a #310 U-bolt (Home Depot model# 806826, Internet# 204273753, Store SKU# 117996) into the middle of a 1-inch PVC cross. The U-bolt will go into two opposite openings of the PVC cross.
2. Insert a 1-inch to ½-inch PVC reducer bushing into one of the openings of the cross that does not have the U-bolt.
3. Cut a 3.5 cm length of ½-inch PVC pipe. Insert this pipe into the reducer bushing. Attach a ½-inch to ¾-inch hose fitting to the other end of this 3.5 cm length of pipe. Use a ½-inch x ¾-inch MHT fitting (Home Depot model#53362, Internet #202257137, Store SKU #685822) or a ½-inch x ¾-inch FHT fitting (Home Depot model #53368, Internet #100373244, Store SKU #879288). The type of hose fitting will depend on the end of the hose that will be attached.

4. Insert the hose into the hose adapter.

EXPLORER product demonstration build photo #15: The PVC end of the hose for pouring cement and the hose attached to the PVC end.

Positioning Beacons

The positioning beacons will be constructed from 1 ¼-inch PVC couplings. Two strips of industrial strength Velcro will be attached each coupling. To construct the positioning beacons:

1. Cut two 5 cm by 2 cm rectangles of industrial strength Velcro hooks.
2. Attach the Velcro hook strips to opposite sides of the coupling.

EXPLORER product demonstration build photo #16: Positioning beacon.

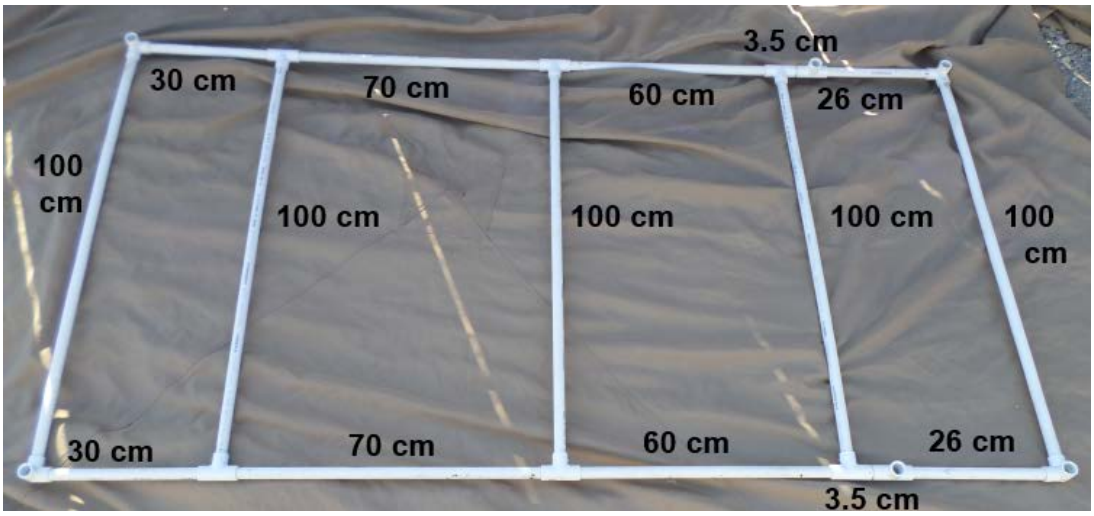
TASK 2: ENTERTAINMENT: LIGHT AND WATER SHOW MAINTENANCE

Platform

The platform framework will be constructed of ½-inch PVC pipe. A corrugated plastic sheet will cover the top and one side of the platform framework. To construct the platform framework:

1. Cut five 100 cm lengths, two 70 cm lengths, two 60 cm lengths, two 30 cm lengths, two 26 cm lengths, and two 3.5 cm lengths of ½-inch PVC pipe.
2. Take a 30 cm length and attach the side opening of a PVC tee to one end. Insert a 70 cm length of PVC pipe into the other side opening of the PVC tee. Attach the side opening of another PVC tee to the other end of the 70 cm length of pipe. Insert a 60 cm length of pipe into the other side opening of the PVC tee. Attach the side opening of another PVC tee to the other end of the 60 cm length of pipe. Insert a 3.5 cm length of pipe into the other side opening of the PVC tee. Attach the side opening of another PVC tee to the other end of the 3.5 cm length of pipe. Turn this tee perpendicular to the other tees. Insert a 26 cm length of pipe into the other side opening of the PVC tee.
3. Attach a ½-inch sideout (3-way) to the 30 cm pipe on one end of the combined segments of pipe. Attach a different ½-inch sideout to the 26 cm pipe on the other end of the combined segments of pipe.
4. Repeat steps two and three, making a second combined section of pipe. The sections should contain: a sideout, 30 cm pipe, tee, 70 cm pipe, tee, 60 cm pipe, tee, 3.5 cm pipe, tee, 26 cm pipe, sideout.
5. Use the five 100 cm lengths of pipe to connect the combined sections of pipe. Two of the 100 cm lengths go into the two sideouts on either end. The other three 100 cm lengths go into the tees between the 30 cm length and the 70 cm length, the tee between 70 cm length and 60 cm length, and the tee between the 60 cm length and the 3.5 cm length.

This will make one sidewall of the platform.



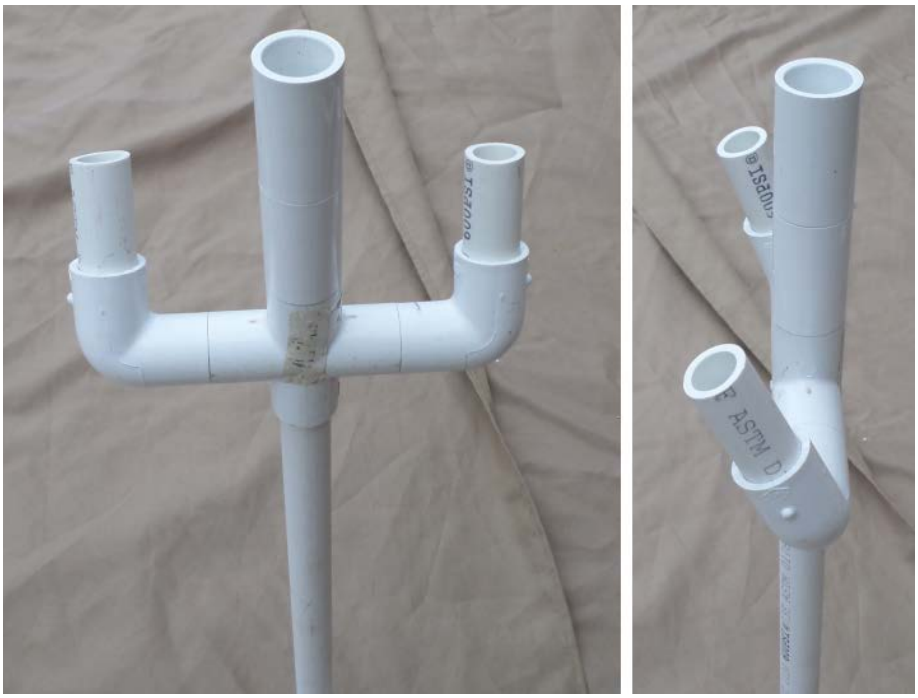
EXPLORER product demonstration build photo #17: Sidewall of the platform.

6. Repeat steps 1 through 5 to make a second sidewall of the platform.
7. Cut four 115 cm lengths and four 56 cm lengths of ½-inch PVC pipe.
8. Line up the two sidewalls of the platform so the 70 cm lengths and 60 cm lengths are across from each other (symmetrical). Use the four 115 cm lengths of pipe to join the two sidewalls at the corners, inserting the 115 cm lengths of pipe into the sideouts at each corner.
9. Insert two 56 cm lengths of pipe into the side openings of a ½-inch PVC tee. This should make a combined length of approximately 115 cm. Repeat this with the other two 56 cm lengths of pipe and a second tee.
10. Insert these combined 115 cm lengths of pipe into the remaining middle openings of the tees. These tees should be located between the 3.5 cm and the 26 cm length of PVC pipe.

EXPLORER product demonstration build photo #18: Framework of the platform.

Locking Mechanism:
The locking mechanism is located inside the platform framework. The locking mechanism will be constructed from a 1-inch PVC cross that rests on ½-inch PVC. The locking mechanism is located halfway up a vertical PVC pipe inside the platform framework.

1. Cut a 55 cm length, a 35 cm length, a 12 cm length, two 5.5 cm lengths, and four 2.5 cm lengths of PVC pipe.
2. Insert the 35 cm length of pipe into the middle opening of the tee (56 cm length, tee, 56 cm length) on the bottom crosspiece of the framework. Attach a PVC cross to the topside other end of the 35 cm length of pipe. Insert a 3.5 cm length of PVC pipe into the opening of the cross opposite of the 35 cm length. Attach a ½-inch PVC coupling to the other end of the 3.5 cm length of pipe. Insert another 3.5 cm length of pipe into the other end of the coupling. Attach another coupling to the other end of this 3.5 cm pipe.
3. Insert the remaining two 3.5 cm lengths of pipe into the two remaining side openings of the ½-inch cross. Attach a 90^{o} elbow to the other end of each 3.5 cm length of pipe. Insert the two 5.5 cm lengths of pipe into the open ends of the two 90^{o} elbows.
4. Twist the cross so it is perpendicular to the sidewalls of the framework, parallel to the closest back wall of the platform framework. Twist the two 90^{o} elbows so they angle about 20 degrees back towards the back wall of the platform framework (see photo #3).



EXPLORER product demonstration build photo #19: Locking mechanism internal, front and side view.

5. Install a 1-inch PVC cross over the two ½-inch couplings. It should fit over the couplings with the bottom opening resting against the ½-inch tee. Insert a 1-inch to ½-inch reducer bushing into a

side opening of the 1-inch PVC cross. Insert the 12 cm length of ½-inch pipe into the reducer bushing.

The 1-inch PVC cross should rotate 180° around the ½-inch couplings. The 5.5 cm lengths of pipe attached to the 90° elbows act as backstops to the rotation. Adjust the angle of the two 90° elbows as needed to create the stopping point for the 12 cm pipe at opposite ends of the 180° rotation.

6. Insert the 55 cm length of pipe into the open end of the ½-inch coupling. The top end of this 55 cm length of pipe should fit into the middle opening of the tee at the top of the platform framework.

EXPLORER product demonstration build photo #20: Locking mechanism; locked and unlocked.

Corrugated Plastic Sheeting

The framework should be approximately 2 meters long, 1.2 meters wide, and 1 meter tall. Cut a 2 meter by 1.2 meter rectangle of corrugated plastic sheeting. Use screws to attach this sheeting onto the top side of the platform framework. Cut a 1.2 meter by 1 meter rectangle of corrugated plastic sheeting. Use screws to attach this sheeting onto the back wall of the platform, the side closest to the locking mechanism.

EXPLORER product demonstration build photo #21: Platform.

Use screws to hold the platform framework together and to secure the corrugated plastic to the frame.

Power Cable Connector

The cable connector will be constructed from 1 ½-inch PVC pipe. A screw hook and a screw eye act as grab points for the cable connector. Two meters of 18-gauge red/black wire will be attached to the power cable connector. To construct the power cable connector:

1. Cut a 16 cm length of 1 ½-inch PVC pipe. Insert it into one opening of a 1 ½-inch PVC cross.
2. Cut an 8 cm length of 1 ½-inch PVC pipe. Insert it into the opposite opening of a 1 ½-inch PVC cross. Attach a 1 ½-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. Cut a 2 meter length of 18-gauge red/black power wire. Insert one end of this wire into this hole and tie an overhand knot in the wire to secure it inside the end cap. Tie the other end of the 2 meters of wire to a dive or other weight. This weight should be placed approximately 1 meter from the power cable connecter in the power port.
5. Twist a #8 screw hook (Home Depot part #803272, internet #204273853, Store SKU #727320) into the top center of the 1 ½-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 ½-inch end cap.

EXPLORER product demonstration build photo #22: The power cable connector.

Design note: The EXPLORER power cable connector is the 2016 ESP cable connector. The 8 meters of rope has been replaced with 2 meters of wire.

Power Port

The port will be constructed from a 20 cm length of 2-inch PVC. This 20 cm length of PVC pipe will be attached to the ½-inch platform framework. To construct the power port:

1. Cut a 20 cm length of 2-inch PVC pipe. Attach a 2-inch coupling to one end of the pipe. Insert a 2-inch to ½-inch reducer bushing (Home Depot model# C437-247, Internet #100343801, Store SKU# 744724) into the coupling.

EXPLORER product demonstration build photo #23: The power port.

Attach the port to the bottom corner of the platform, into the 30 cm length of PVC pipe. To attach the port:

1. Remove the 30 cm length of pipe on the bottom corner of the framework. Cut a 3.5 cm length from this 30 cm of pipe. Insert the 3.5 cm length of pipe into the side opening of a ½-inch tee. Insert the remaining 26.5 cm of pipe into the other side opening of the tee. Use a ruler to

measure the overall length. Cut the 26.5 cm pipe down until the entire length is 30 cm. Return this 30 cm length of pipe, now with a tee at one end, into the bottom corner of the framework. The tee should be adjacent to the sideout at the corner.

2. Cut a 3.5 cm length of pipe and insert it into the middle opening of the tee. Rotate the tee so it sticks up at a 45° angle. Attach a 45° elbow to the other end of the 3.5 cm length of pipe.
3. Cut another 3.5 cm length of pipe and insert it into the open end of the 45° elbow. Twist the elbow so the pipe is parallel to the bottom of the pool. Attach the 2-inch to ½-inch reducer bushing (part of the power port) onto the end of the 3.5 cm length of pipe. The power port should be parallel to the bottom of the pool and just above the bottom of the pool.

EXPLORER product demonstration build photo #24: The power port attached to the platform.

Valve

The valve is located on the same corner of the platform framework as the port. The valve will be constructed from a ½-inch gate valve. To construct the valve:

1. Attach a ½-inch male adapter into both ends of a ½-inch brass gate valve (Home Depot Model# 170-2-12-EB, Internet# 205816192, Store SKU# 867855).
2. Remove the vertical, 100 cm length of pipe in the same corner where the power port is attached (see power port, above).
3. Cut 40 cm from the 100 cm length of pipe removed from the framework. Attach one of the male adapters on the end of the gate valve to one end of the 40 cm of pipe. Insert the remaining 60 cm of pipe into the male adapter on the other side of the gate valve. Cut this 60 cm pipe so the total length (40 cm, gate valve, 60 cm pipe) is 100 cm.
4. Insert this 100 cm combined pipe back into the sideouts where the 100 cm pipe was removed. The 40 cm length of pipe can go either on the top end or bottom end of the 100 cm length. Rotate the valve so the handle is outside of the platform.

EXPLORER product demonstration build photo #25: The valve.

EXPLORER product demonstration build photo #26: The valve attached to the framework.

Fountain

The fountain (old and new) will be constructed from an ABS 3-inch to 2-inch reducer bushing (Home Depot model #C58012FHD32, Internet #100343802, store SKU # 188301). It has four ½-inch PVC end caps screwed into the top side. To construct the fountain:

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 three more times (four end caps total) at equal distances around the bushing.

Design note: The fountain for the 2017 task is almost identical to the wellhead cap from the 2016 product demonstration tasks. The 2017 fountains do not require the Velcro add-ons required for the wellhead cap. However, the Velcro does not affect the task in any way and may be included. If you wish to add the Velcro:

1. Cut four 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.
2. 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.

EXPLORER product demonstration build photo #27: The fountain.

EXPLORER product demonstration build photo #28: 1-inch end cap holder for fountain.

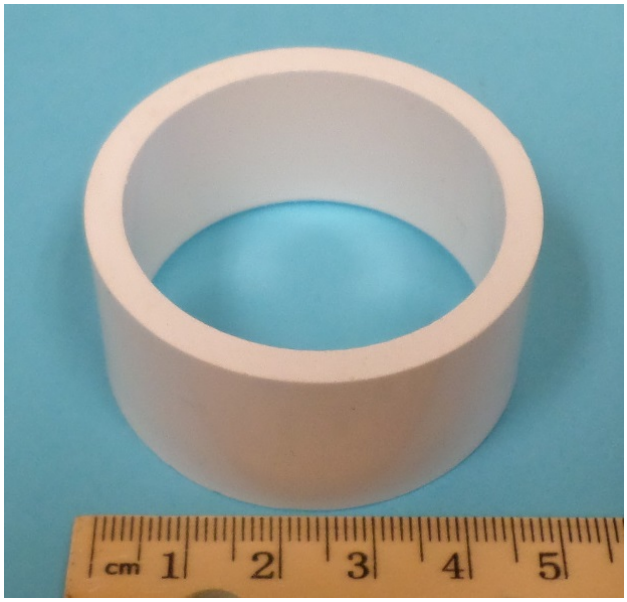
EXPLORER product demonstration build photo #29: The fountain on the platform.

TASK 3: HEALTH: ENVIRONMENTAL CLEANUP

Clams

The clams are constructed from 2 to 3 cm lengths of 1 ½-inch pipe or 2 to 3 cm lengths of 1 ¼-inch couplings. To construct the clams:

1. Cut 25 or more 2 to 3 cm lengths of 1 ½-inch pipe or 1 ¼-inch couplings.

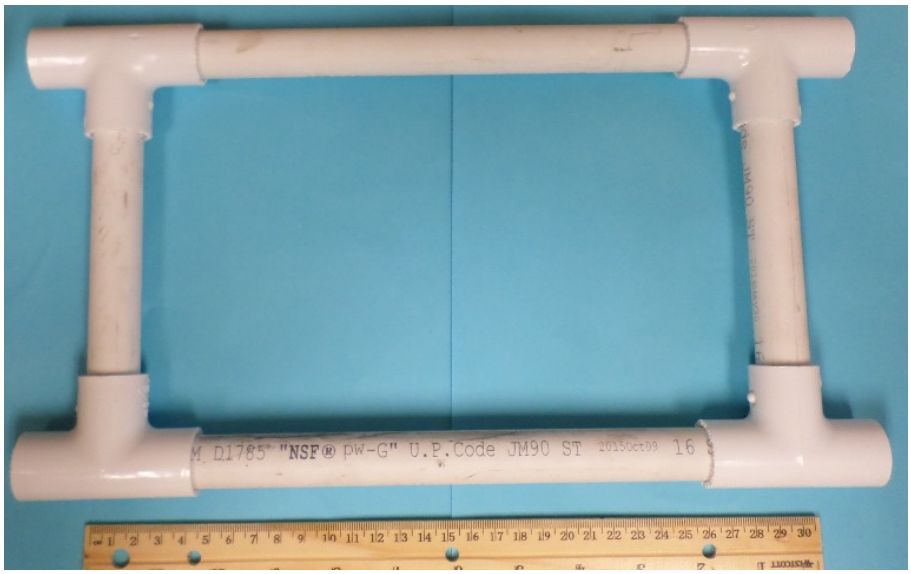


EXPLORER product demonstration build photo #30: One clam.

Clam Bed:

The 25 (or more) clams will be piled in a small clam bed constructed from ½-inch PVC pipe. The clam bed will be 33 cm by 20 cm. To construct the clam bed:

1. Cut two 24 cm lengths and two 13.5 cm lengths of ½-inch PVC pipe. Attach a side opening of a ½-inch PVC tee to each end of the 24 cm lengths of pipe, four tees in all. Insert the two 13.5 cm lengths of pipe into the middle openings of the four tees, creating a rectangle 33 cm in length and 20 cm wide.
2. Pile 25 or more clams randomly into the bed.



EXPLORER product demonstration build photo #31: Clam bed.

EXPLORER product demonstration build photo #32: Clam bed with 28 clams.

Sediment

The sediment sample will be simulated by agar. The "recipe" used to create the microbial mat is 2 teaspoons of agar per 550 mL of water. A few drops of food coloring can be used as well. The agar will be contained in a 16 oz., 550 ml, red plastic cup (check grocery and other stores). To make agar:

1. Using a cooking pot or other container that can be heated, soak the agar in water for 10 to 15 minutes.
2. Bring the water to a gentle boil and simmer while stirring until the agar dissolves completely. To completely dissolve the agar takes about 5 minutes for powder, 10 to 15 minutes for flakes.

3. Let the agar cool in the pot for about 5 minutes, and then pour the agar mixture into a 16 oz cup. Fill the 550 ml cup completely.
4. Cut a 2 cm x 2 cm square of Velcro hooks. Once the agar has cooled, attach this Velcro square to the bottom of the cup.

Note: The consistency of agar may vary with type of agar used and other factors. The agar sample should be solid, but easy to penetrate to retrieve samples. Modify the agar recipe as needed to get the consistency desired.

The cup containing the solidified agar is nested within a second plastic cup that has been secured to a sheet of plastic. The sheet of plastic, in turn, is weighted and set on the bottom of the pool.

5. Cut a 30 cm x 15 cm rectangle of corrugated plastic.
6. Cut a 2 cm x 5 cm square of Velcro hooks. Attach this Velcro square to the inside bottom of a 550 ml, (16 oz.) red plastic cup.
7. Position the cup in the center of the corrugated plastic square. Use two small screws (1/2-inch sheet metal screws) to attach the plastic cup to the center of the corrugated plastic. The heads of the screws should be inside of the plastic cup and penetrate down through the Velcro square, securing it to the cup, through the cup and through the corrugated plastic sheet.

EXPLORER build photo #33: Top view of empty agar cup holder

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EXPLORER build photo #34: Side view of empty agar cup holder.

EXPLORER build photo #35: Full agar cup sitting next to empty agar cup holder.

EXPLORER build photo #36: Full agar cup nestled into agar cup holder.

Plastic cups containing agar can be fitted into the holding cup for each product demonstration run. After a mission run, used agar containers can be easily removed and discarded. Use dive weights, bricks or other heavy objects to secure the corrugated plastic container to the pool bottom.

Each product demonstration station will have two plastic cups containing agar.

Cap

The cap is constructed from the lid of a Rubbermaid Roughneck plastic tote. The lid is 60 cm by 40 cm wide. A 1-inch PVC handle will be a lift point for the lid. To construct the lid:

1. Cut a 15 cm length and two 4 cm lengths of 1-inch PVC pipe. Attach a 1-inch 90^{o} elbow to each end of the pipe. Insert a 4 cm length of pipe into the other ends of the two 90^{o} elbows. Attach a 1-inch coupling to the other end of each 4 cm length of pipe. Insert a 1-inch to ½-inch reducer bushing into the other end of each coupling.
2. Cut two 3.5 cm lengths of ½-inch PVC pipe. Insert these two 3.5 cm lengths of pipe into the two reducer bushings.
3. Cut two 2.2 cm diameter holes in the Rubbermaid lid, 20 cm apart. These holes should be just large enough so the ½-inch PVC pipe fits through them. Push the two 3.5 cm lengths of ½-inch pipe through these holes.
4. Attach a 2-inch to ½-inch reducer bushing to the end of the 3.5 cm lengths of pipe that protrudes though the plastic lid.

Push the reducer bushings tightly against the plastic of the lid. The reducer bushings provide area to secure the handle to the lid.

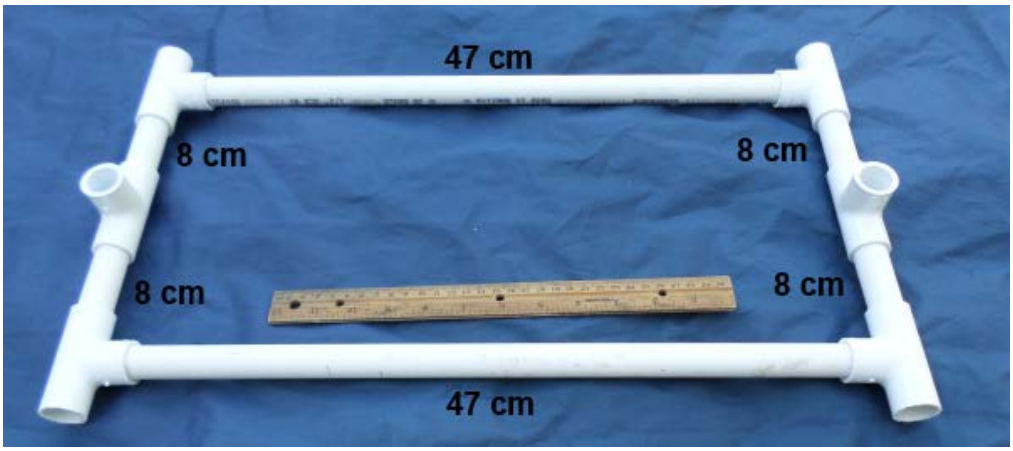
EXPLORER build photo #37: Cap with 1-inch PVC handle.

TASK 4: SAFETY: RISK MITIGATION

Containers

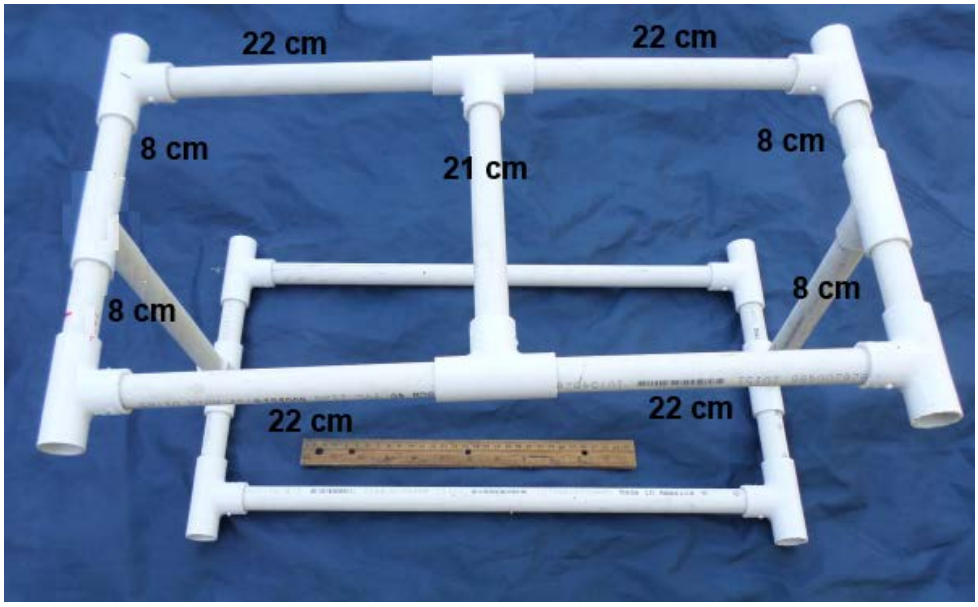
The four containers will be constructed from ½-inch PVC pipe. A #310 U-bolt at the top will be used to attach the buoy and to designate the center of the container for distance and direction measurements. To construct the containers:

1. Cut two 47 cm lengths and four 8 cm lengths of 1/2-inch PVC pipe.
2. Attach the middle opening of a PVC tee to each end of the 47 cm lengths of pipe, four tees total. Insert two of the 8 cm lengths of pipe into the side openings of a ½-inch tee. Insert the other two 8 cm lengths of pipe into the side openings of a second PVC tee.
3. Insert the other ends of each 8 cm lengths of pipe into one of the side openings of the PVC tees attached to each 47 cm lengths of pipe. This should make a rectangle approximately 50 cm x 30 cm. Rotate the middle openings of the two tees between the 8 cm lengths of pipe to face upwards.



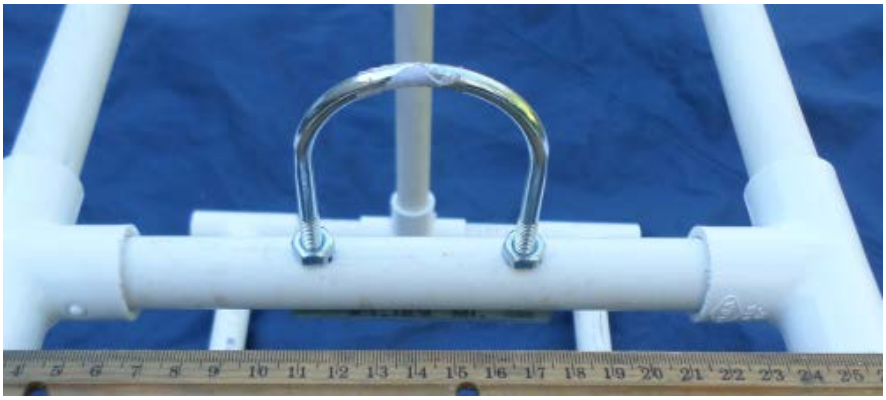
RANGER build photo #38: Bottom framework of a container.

4. Cut four 22 cm lengths of ½-inch PVC pipe. Insert two 22 cm lengths into the side openings of a PVC tee to make a combined 47 cm length of pipe. Repeat steps 1 through 3 to make a second half of the container framework, using these combined 47 cm lengths of pipe.
5. Cut a 21 cm length of pipe and insert it into the middle openings on the two tees in the center of each combined 47 cm lengths of pipe.
6. Cut two 24 cm lengths of ½-inch pipe. Insert these two 24 cm lengths of pipe into the middle openings of the two tees between the 8 cm lengths of pipe. This will make a container 50 cm x 30 cm x 30 cm.



RANGER build photo #39: Framework of a container.

7. Drill two ¼-inch holes 5.8 cm apart in the center of the 21 cm length of PVC pipe across the top center of the container. Insert a #310 U-bolt through these two ¼-inch drill holes. Use the ¼-inch – 20 nuts to secure the U-bolt in the top center of the container.

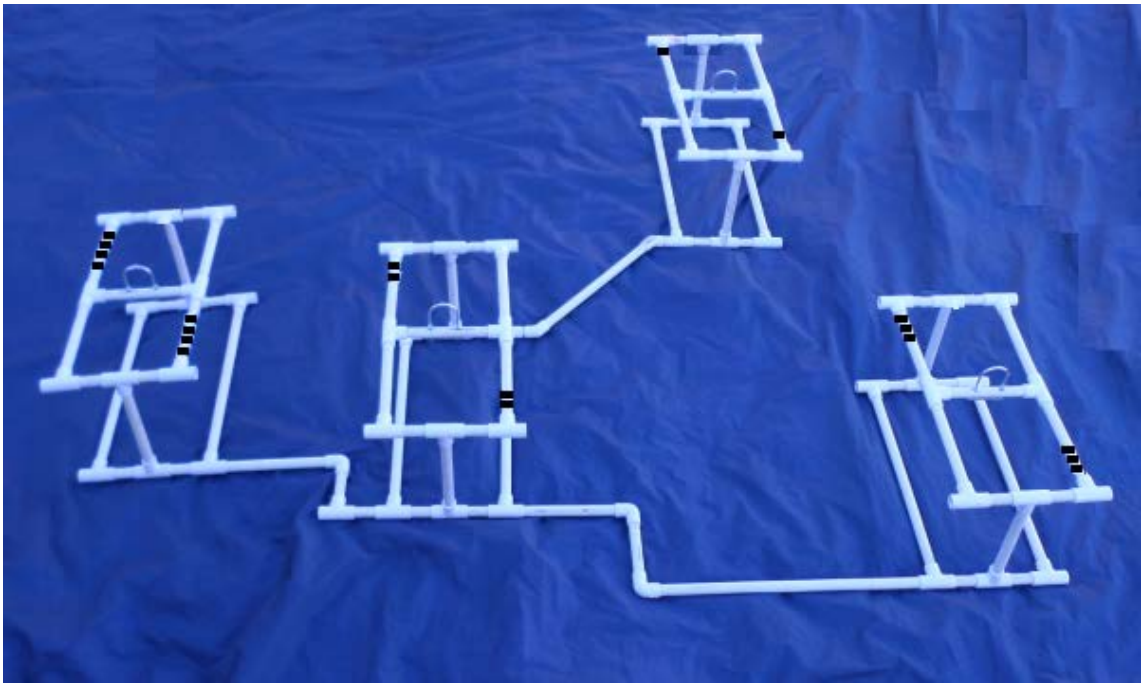


RANGER build photo #40: U-bolt installed at the top, center of the container.

RANGER build photo #41: A cargo container.

Repeat steps 1 through 8 to construct four total containers.

Design note: The four containers should be positioned at constant distances and directions from each other. MATE recommends using ½-inch PVC pipes to connect the four containers and keep them from moving. Cut the PVC on the bottom framework of the container and add a tee. Use variable lengths of pipe and elbows to hold the four containers in a spatial arrangement that keeps the distances and directions between the containers constant.



RANGER build photo #42: Four cargo containers.

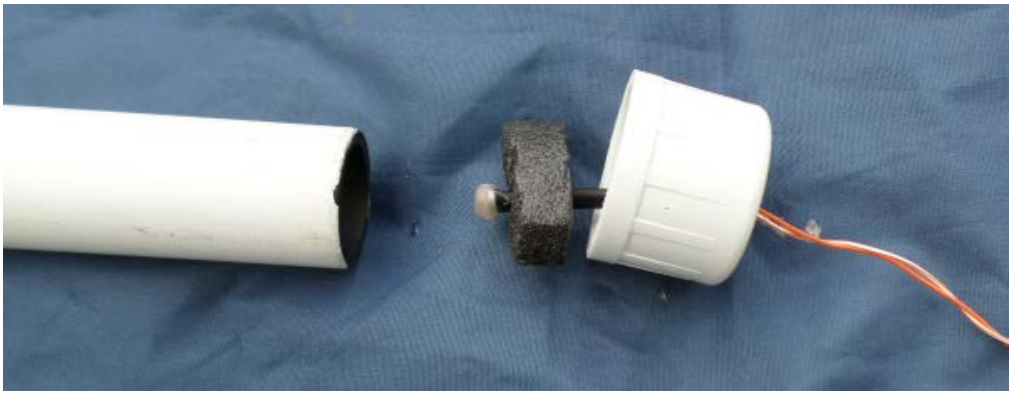
RFID activation port

The RFID activation port will be constructed from 1-inch PVC pipe. The inside of the pipe will be painted black. A light sensor (http://www.digikey.com/product-search/en?keywords=%09NSL-5152-ND) will be placed inside the port 15 cm from the opening. Shining a light into the port will activate the sensor. Once activated, the sensor will send a signal to an Arduino on the surface, which will then send a signal to the Bluetooth module located on the container to begin broadcasting the container ID number. To construct the port:

1. Cut a 17 cm length of 1-inch PVC pipe. Paint the inside of the pipe black.
2. Cut a 15 meter length of CAT5 wire (8 strands). Strip away 20 cm of the plastic sheathing on one end of the CAT5 cable. Attach a light sensor to one colored wire pair. Use shrink wrap and hot glue to waterproof the sensor and connections. The sensing end of the sensor should be covered by a thin layer of hot glue. This hot glue will provide a waterproof coating to the sensor, but should be thin enough not to restrict light hitting the sensor.

EXPLORER build photo #43: Sealed and waterproofed light sensor.

3. Drill a 3/8-inch hole in the middle of a 1-inch end cap. Insert the light sensor through this hole and into the end cap.
4. Cut a 1-inch diameter, 1 cm long ring of foam. Cut a ¼-inch hole in the center of the 1-inch diameter foam. Push the sensor through the foam ring so that only 1 cm of the sensor protrudes through the foam. Then push the foam ring into one end of the 17 cm length of 1-inch pipe with the black interior.
5. Affix the end cap onto the end of the 17 cm length of pipe. Use hot glue to secure the wires into the end cap and cover the hole with black electrical tape so that ambient light cannot reach the back side of the end cap.

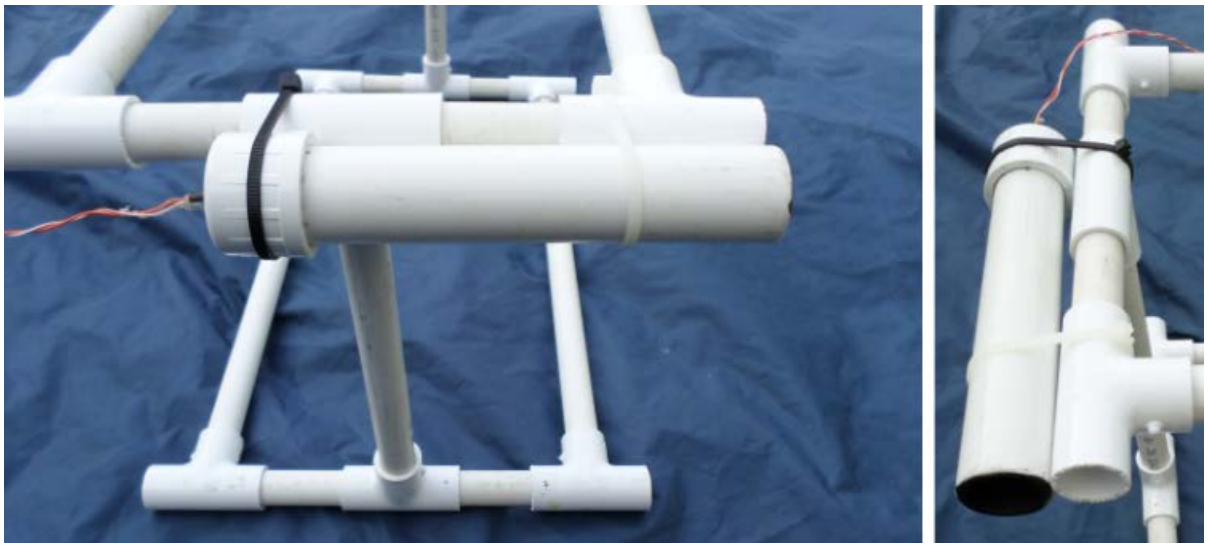


EXPLORER build photo #44: Light sensor inserted through end cap with foam attached.

EXPLORER build photo #45: Port with light sensor positioned 15 cm down length of pipe.

The light sensor should be held in the center of the 1-inch pipe, approximately 15 cm away from the open end.

6. Use zip ties to mount the light sensor port on the side of a top corner of the container.



EXPLORER build photo #46: The RFID port mounted on a container.

Bluetooth Module

The MATE Center will use an HC-05 Bluetooth module in Master (broadcast) mode. The module will broadcast "MATE 2017" as a standard signal. When the light sensor is activated, the message will change and broadcast a 7-digit container ID number. There will be four Master modules, one on each container. The Master modules will be waterproofed in a small cylinder approximately 3 cm in diameter and 8 cm long. The HC-05 Master will be epoxied into the cylinder with the antenna end facing outwards. This cylinder will be positioned directly over the light sensor port. To construct the Master module:

1. Cut 15 meters of CAT-5 cable. One wire pair is connected to the light sensor (see above) the other three wire pairs are connected to the Bluetooth module. It is up to EXPLORER companies to figure out how to properly wire and configure a Bluetooth module in Master mode.
2. When the Bluetooth module is properly wired and connected to an Arduino or other microcontroller topside, pot the Bluetooth module inside a 3 cm diameter, 8 cm long cylinder. This cylinder can be constructed out of thin-walled 1-inch PVC pipe or another thin-walled, round plastic device. For this description, 1-inch thin walled PVC will be used.

HC-05 Bluetooth module. From Amazon.com.

3. Waterproof the cylinder with a slow curing epoxy. For best results, the antenna end of the Bluetooth should be as close to the open water as possible, while still being inside the waterproofing epoxy.

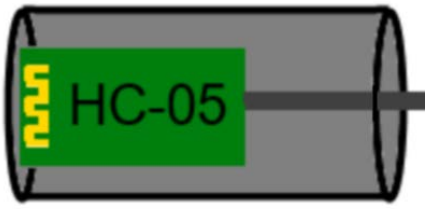


Diagram of an HC-05 Bluetooth module in a cylinder with antenna end close to opening.

4. Use zip ties to attach the cylinder with the potted Bluetooth Master module directly above the light sensor port on the top side of the container.

EXPLORER build photo #47: The RFID port and Bluetooth Master module cylinder mounted on a container.

Interface

Each light sensor will connect to an Arduino on the surface. The Arduino will also attach to the Bluetooth module on the containers. When the sensor is activated by light, the Arduino will switch the message from the standard "MATE 2017" to the 7 digit container ID number. The container ID number will consist of two letters followed by five numbers. If the light sensor is no longer being activated, the message will return to "MATE 2017."

EXPLORER build photo #48: Display shields showing the base message and the container ID number.

Companies will need to construct and waterproof a Bluetooth Slave (receiving) module on their ROV. Companies will need to position their Slave module so the ROV can shine a light into the port and have their Bluetooth Slave module within 10 cm (or closer) of MATE's Master Bluetooth module. Companies will also need to connect their Slave module to a display shield or other device to read out the 7-digit container ID number.