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. 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 three 48 cm lengths of PVC pipe and two 22.2 cm lengths of PVC pipe. Insert the two 22.2 cm lengths of pipe into the side openings of a 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 tee in the middle of one 48 cm length of pipe so they are horizontal, the middle opening parallel to the bottom of the pool.
3. Cut four 12 cm lengths and one 20 cm length 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.

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

4. Insert the 20 cm length of pipe into the middle openings of the tee. Attach a 90° elbow to the other end of the 20 cm length of pipe. Twist the elbow so the open end faces upwards.
5. Cut a 3.5 cm length of ½-inch PVC pipe. Insert the 3.5 cm length of pipe into the open end of each 90° elbow. Attach a 1 ½-inch to ½-inch reducer bushing to the end of the 3.5 cm length of pipe. Attach a 1 ½-inch PVC coupling to the other end of the reducer bushing.
6. Cut one 10 cm lengths of 1 ½-inch PVC pipe. Insert this length of pipe into the 1 ½-inch coupling.

NAVIGATOR 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 (actual rebar, not the simulated rebar below) inside the ½-inch pipe to weigh down the baseplate. Paint the rebar to reduce corrosion.

Rebar

The rebar will be simulated by ½-inch PVC. Two lengths of rebar will be available; only one needs to be inserted into the baseplate. To construct the rebar:

1. Cut two 15 cm lengths of ½-inch PVC pipe. Attach a tee to one end of each 15 cm length of pipe.

NAVIGATOR product demonstration build photo #3: Rebar.

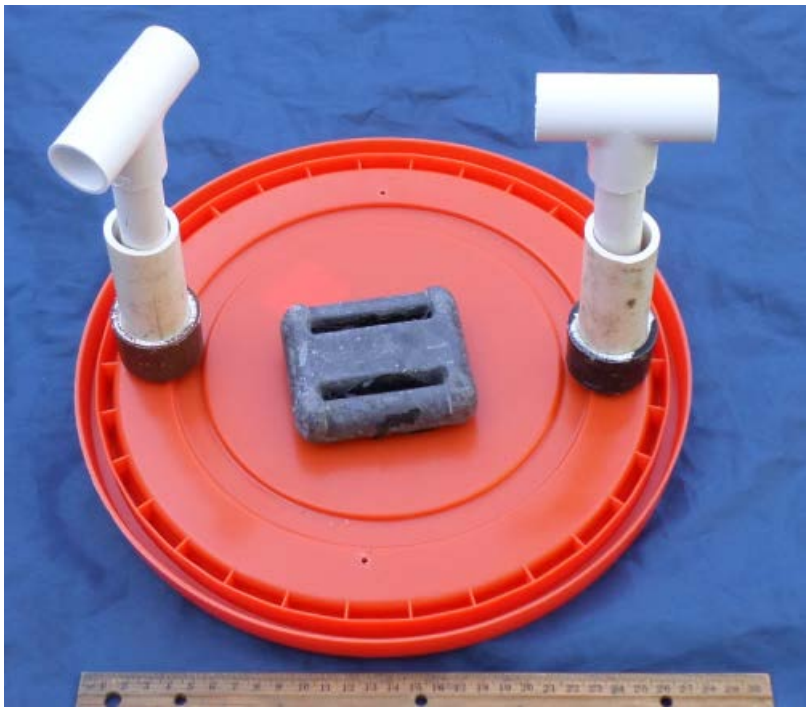
Elevator

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

1. Screw two 1-inch end caps into the bottom side of a 5-gallon bucket lid.
2. Cut two 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 two pieces of simulated rebar into the 1-inch pipe.

NAVIGATOR product demonstration build photo #4: The elevator.

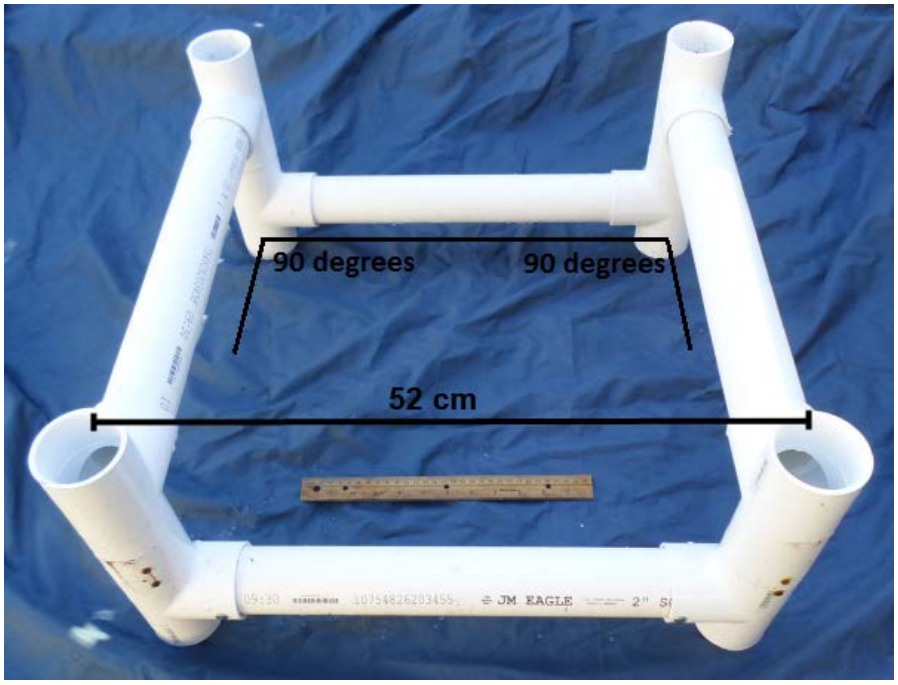


NAVIGATOR product demonstration build photo #5: Two lengths of rebar installed on the elevator.

Frame

The frame is constructed from 2-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:

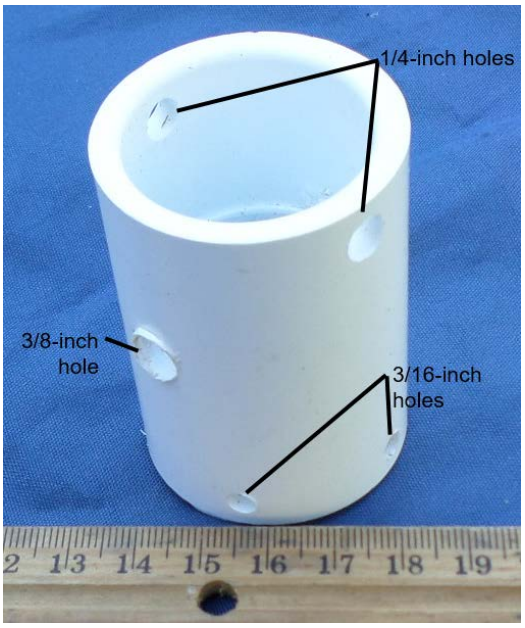
1. Cut four 7 cm lengths of 2-inch PVC pipe. Attach the side opening of a tee to each end of the 7 cm lengths of pipe, eight tees total. Twist the tees so that the middle openings of the two tees attached to each 7 cm length of pipe are perpendicular to one another. Use a framing square, T-square or other tool to confirm the angle between the two middle openings is 90°.
2. Cut four 45 cm lengths of 2-inch PVC pipe. Insert the 45 cm lengths of pipe into the middle openings of the eight tees, creating a square.



NAVIGATOR product demonstration build photo #6: The frame.

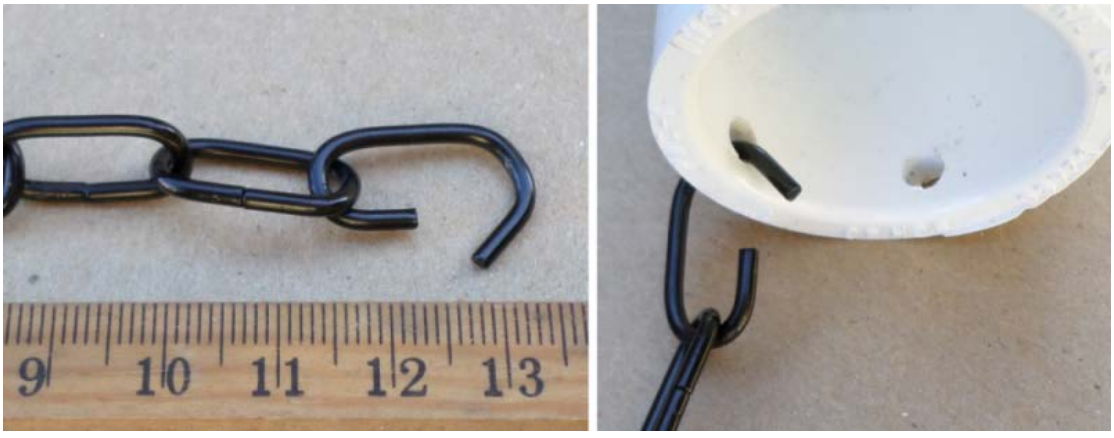
The measurements of the frame must be very precise. They must match the measurements of the baseplate (see above) exactly. The distance between the corners of the frame, measured from the exact center of the 2-inch PVC tees, should be 52 cm. Cut and adjust the lengths of the pipe to these precise measurements. The MATE Center recommends verifying that the frame fits over the baseplate, with the center of the 2-inch tees matching the 12 cm long 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 two 3/8-inch holes through opposite sides of the middle of 1-inch coupling.



NAVIGATOR product demonstration build photo #7: The coupling with holes drilled. Two 3/16-inch holes and one 3/8-inch hole are not seen in this view.

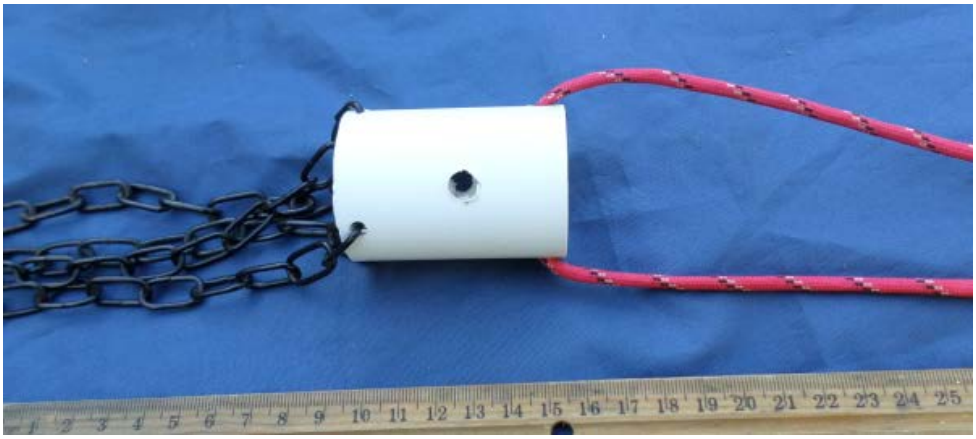
4. Cut four 1.5 meter lengths of #100 black chain (Home Depot model# 810016, internet# 204640736, Store SKU# 444895). Use pliers to open up the chain link at one end of the 1.5 meter length of chain. Insert this open link through one of the four 3/6-inch holes at one end of the coupling.



NAVIGATOR product demonstration build photo #8: 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.



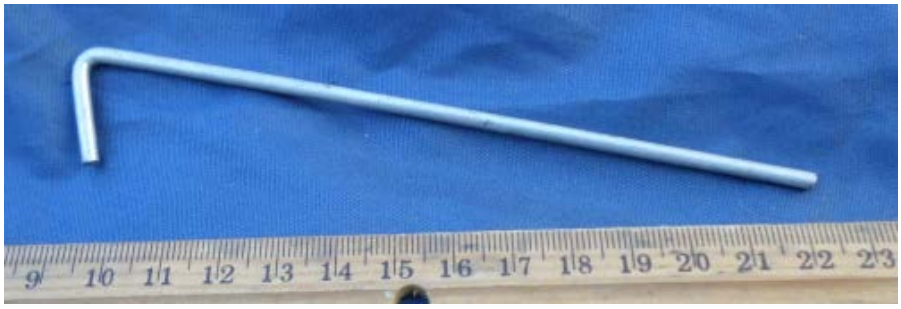
NAVIGATOR product demonstration build photo #9: Rope and chains through the coupling.

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.

NAVIGATOR product demonstration build photo #10: 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.

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



NAVIGATOR product demonstration build photo #12: Tent stake.

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

NAVIGATOR 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. Drill two ¼-inch holes 5.8 cm apart in the center of a 1-inch cross. 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.

NAVIGATOR 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.

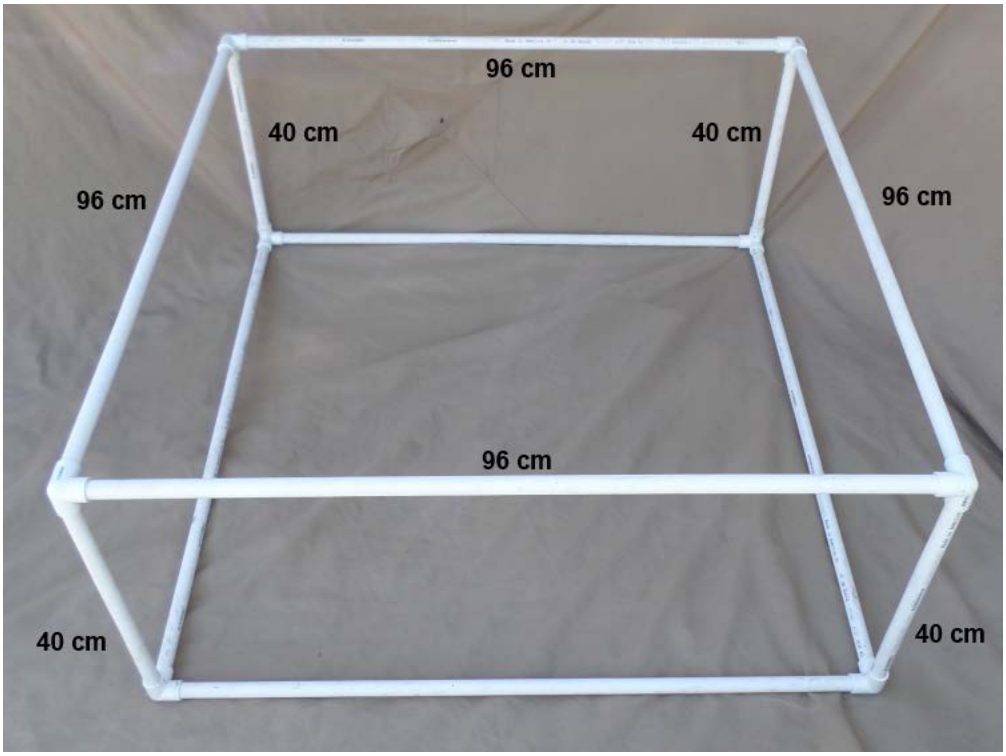
NAVIGATOR product demonstration build photo #16: Positioning beacon.

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 of the platform framework. To construct the platform framework:

1. Cut eight 96 cm lengths of ½-inch PVC pipe. Connect four of these 96 cm lengths of pipe into a square using ½-inch sideouts (corner pieces). Connect the remaining four of these 96 cm lengths of pipe into another square using four more ½-inch sideouts.
2. Cut four 40 cm lengths of ½-inch PVC pipe. These 40 cm lengths of pipe will go between the two squares created with the 96 cm lengths of pipe. Insert the 40 cm lengths of pipe into the remaining openings of the sideouts on each of the 96 cm pipe squares.



NAVIGATOR product demonstration build photo #17: Platform framework.

Power Cable Connector

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

Design note: The NAVIGATOR power cable connector is the 2016 ESP cable connector. The 4 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.

NAVIGATOR product demonstration build photo #19: The power port.

Attach the port to the bottom corner of the platform, into one of the 96 cm lengths, adjacent to a sideout. To attach the port:

1. Remove one of the 96 cm lengths of pipe on the bottom of the framework. Cut a 3.5 cm length from this 96 cm of pipe. Insert the 3.5 cm length of pipe into the side opening of a ½-inch tee. Insert the remaining 92.5 cm of pipe into the other side opening of the tee. Using a ruler to measure the overall length, cut the 92.5 cm length of pipe down until the entire length is 96 cm. Return this 96 cm length of pipe, now with a tee at one end, into the bottom of the framework.
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.

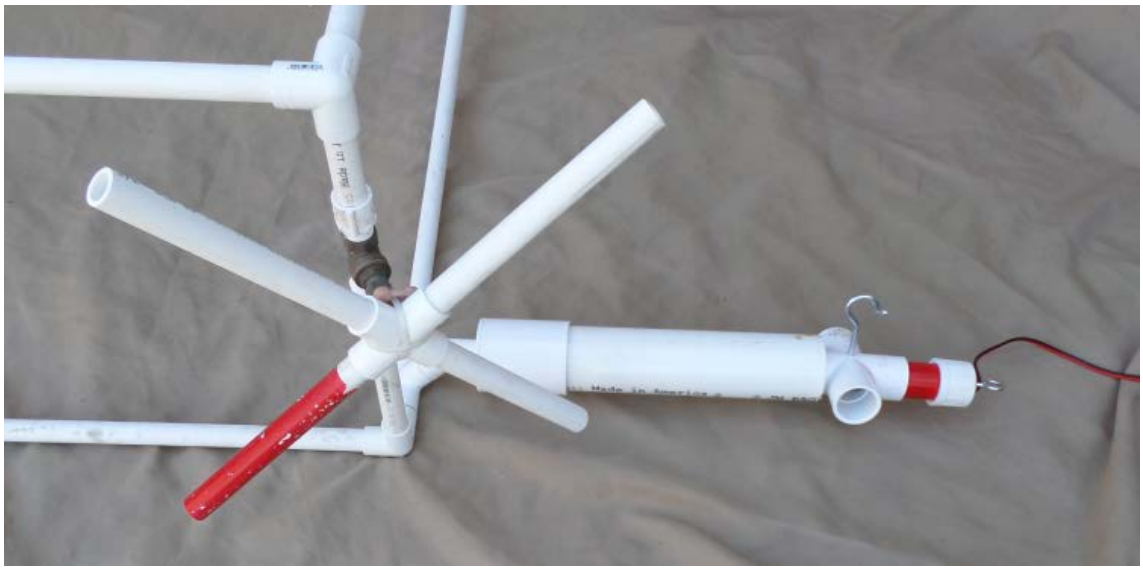
NAVIGATOR product demonstration build photo #20: The power port attached to the platform.

Valve

The valve is located on the same corner of the platform framework. The valve will be constructed from a ½-inch gate valve. A ½-inch cross with 20 cm lengths of pipe serve as a handle to turn the 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). Use zip ties to secure a ½-inch PVC cross onto the valve handle; use 2 or 3 zip ties to secure the cross tightly.
2. Cut four 20 cm lengths of ½-inch PVC pipe. Insert them into the four openings of the PVC cross. Paint one of the 20 cm lengths of pipe red, or other bright color. This will help in determining whether the valve has been turned 360^{o} (1 time around).
3. Remove the vertical, 40 cm length of pipe in the same corner where the power port is attached (see power port, above).
4. Cut 19 cm from the 40 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 21 cm of pipe into the male adapter on the other side of the gate valve. Cut this 21 cm pipe so the total length (19 cm, gate valve, 21 cm pipe) is 40 cm in length.
5. Insert this 40 cm combined pipe back into the sideouts where the 40 cm pipe was removed. The 19 cm length of pipe should go into the sideout on the bottom of the framework. Make sure that the four handles attached to the valve do not hit the bottom of the pool when turning the valve.

NAVIGATOR product demonstration build photo #21: The valve.



NAVIGATOR product demonstration build photo #22: The valve attached to the platform framework with the power cable connector installed.

Corrugated Plastic Sheeting

A 1 square meter sheet of corrugated plastic sheeting goes on top of the platform framework. Use screws to attach this 1 meter square sheet to the top of the framework.

NAVIGATOR product demonstration build photo #23: Corrugated plastic sheet on top of the platform framework.

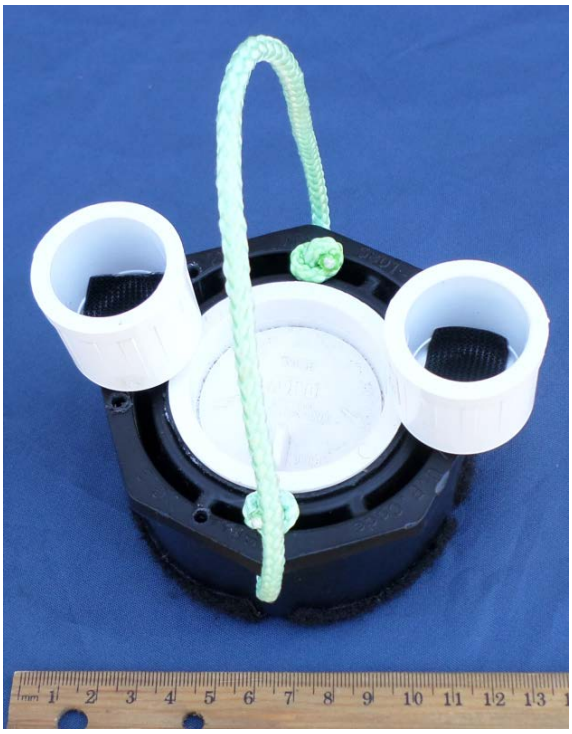
Fountain

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 two 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 one more time (two end caps total) at opposite sides of the bushing.
4. 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. 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.

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 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 two 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.



NAVIGATOR product demonstration build photo #24: The fountain.

A small piece of flotation can be added to the top of the rope to keep it upright in the water.

A small washer or other weight can be added inside the 2-inch knockout cap to provide additional weight if necessary.

NAVIGATOR product demonstration build photo #25: 1-inch end cap holder for fountain.

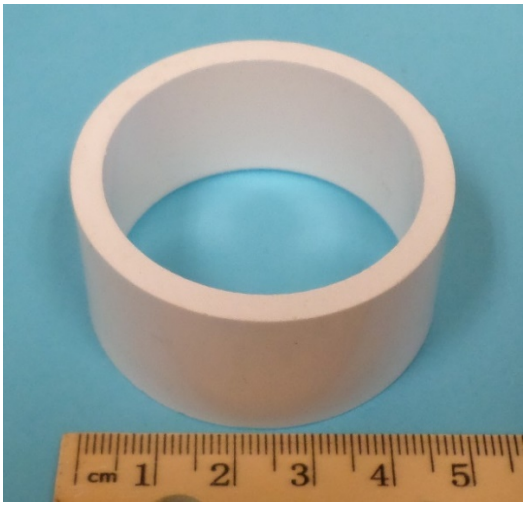
NAVIGATOR product demonstration build photo #26: The fountain on the platform.

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:

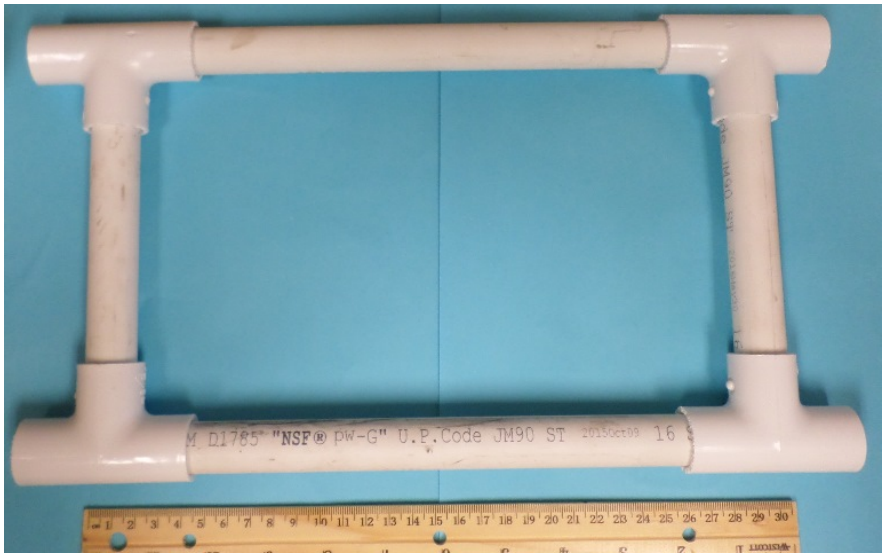
1. Cut 25 or more 2 to 3 cm lengths of 1 ½-inch pipe or 1 ¼-inch couplings.



NAVIGATOR product demonstration build photo #27: 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 total. 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.



NAVIGATOR product demonstration build photo #28: Clam bed.

NAVIGATOR product demonstration build photo #29: Clam bed with 28 clams.

Sediment Sample:

The sediment sample will be simulated by 4-inch PVC end cap. A 40 cm length of rope will be attached to the end cap. To construct the sediment sample:

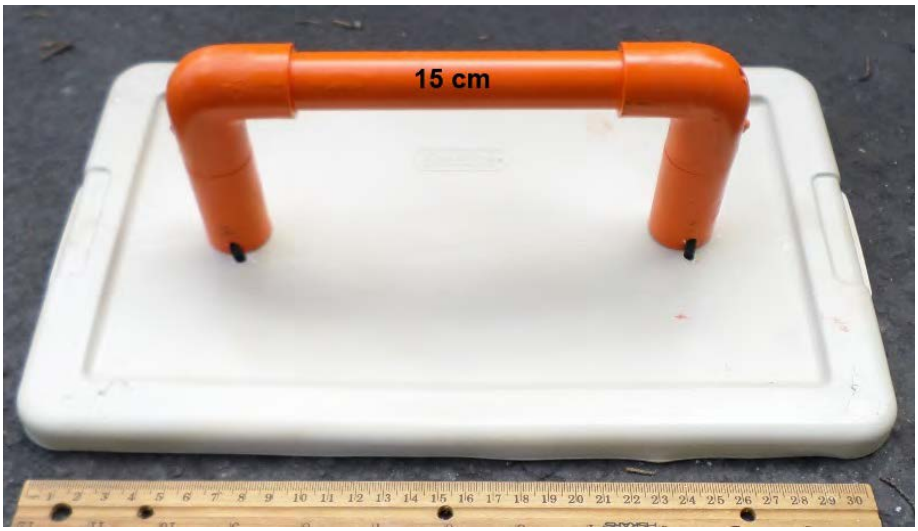
1. Cut a 40 cm length of 1/8-inch polypropylene rope (Home Depot part #72402, internet #205804755, Store SKU #402816). Drill two 3/16-inch holes through the top side wall of a 4-inch PVC end cap on opposite sides. Push the 40 cm length of rope through both 3/16-inch holes. Tie an overhand knot on the ends of each rope to secure the rope to the end cap.
2. Attach a small piece of flotation to the middle of the 40 cm length of rope.

NAVIGATOR product demonstration build photo #30: Sediment sample.

Cap:

The cap is constructed from the lid of a Sterilite 6 Qt. (5.7 L) plastic storage box with a non-latching lid. The lid will be outfitted with a handle constructed from ½-inch PVC pipe. To construct the lid:

1. Cut a 15 cm length of ½-inch PVC pipe. Attach a ½-inch 90° elbow to both ends of the 15 cm length of pipe. Rotate the elbows so both openings face the same direction.
2. Cut two 3 cm lengths of PVC pipe. Insert the 3 cm lengths of pipe into the openings of the 90° elbows. Attach a ½-inch PVC coupling to the other end of each 3 cm length of pipe.
3. Drill two holes at the end of each PVC coupling. The holes should be within 1 cm of the end of the coupling and be drilled straight through both walls of the coupling.



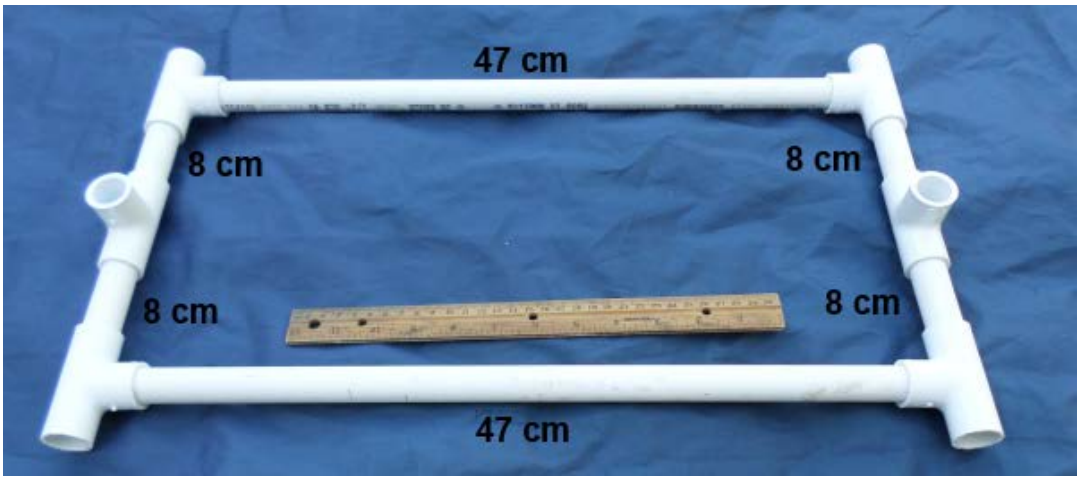
NAVIGATOR build photo #31: Cap with 1-inch PVC handle.

TASK 4: SAFETY: RISK MITIGATION

Containers

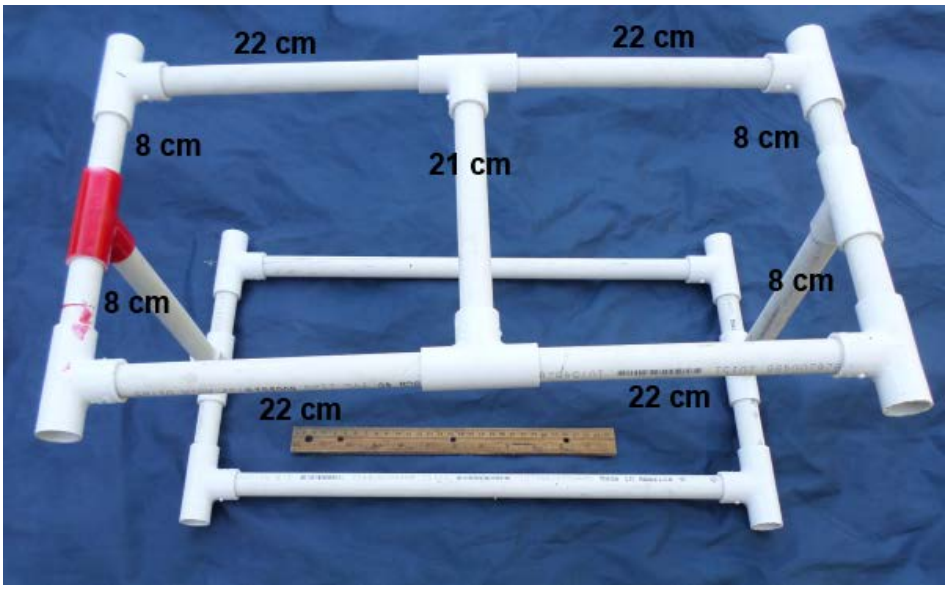
The two containers will be constructed from ½-inch PVC pipe. A #310 U-bolt at the top will be used to attach the buoy. To construct the containers:

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.



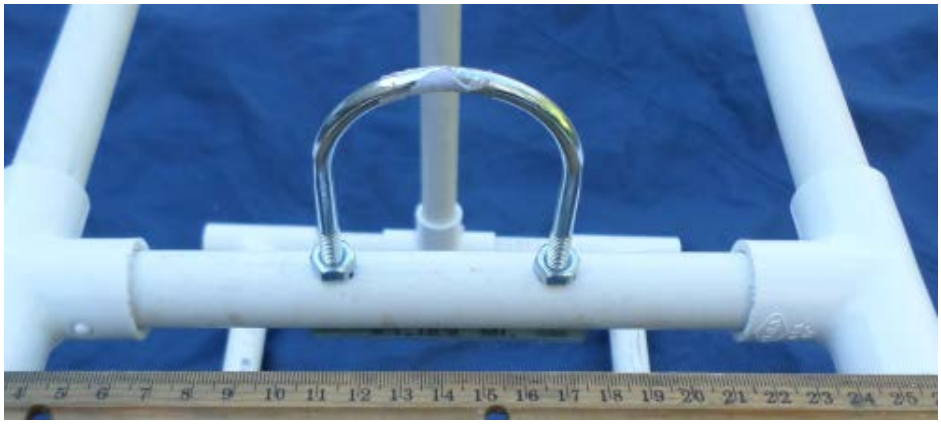
NAVIGATOR build photo #32: Bottom framework of a container.

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 the combined 47 cm lengths of pipe.
6. Remove one of the PVC tees between two 8 cm lengths of pipe on this second half of the framework and paint it red. When the paint has dried, return the tee to its position.
7. 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.

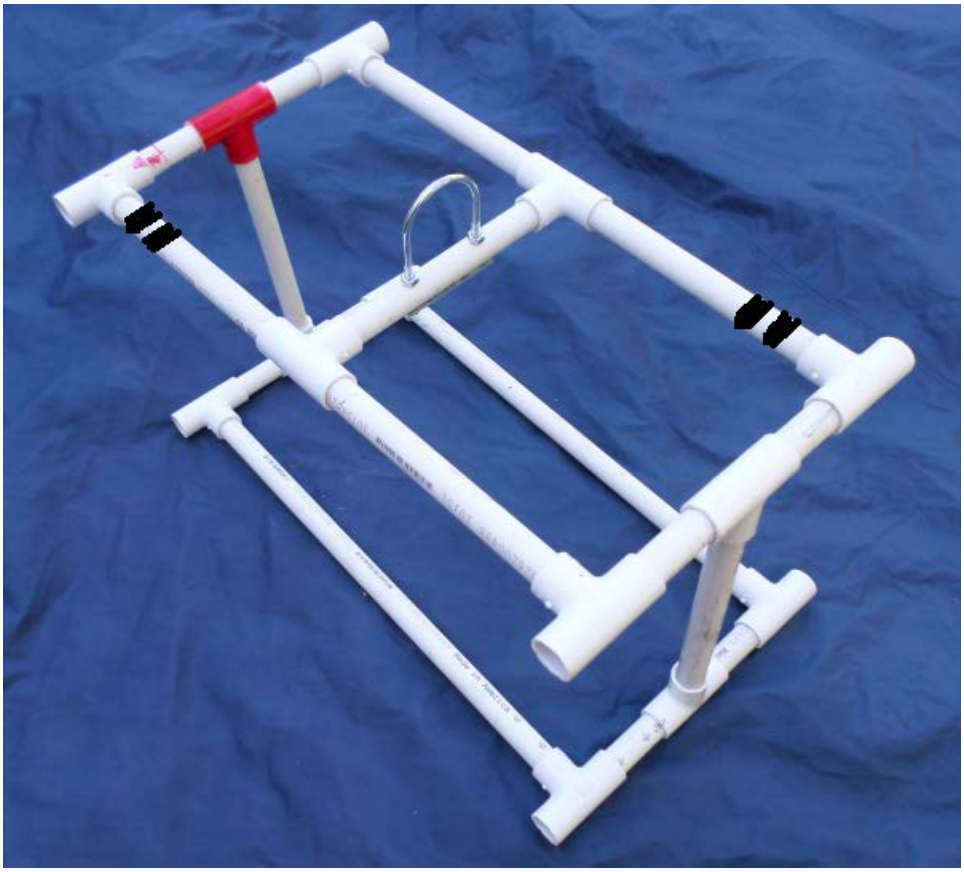


NAVIGATOR build photo #33: Framework of a container.

8. 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.



NAVIGATOR build photo #34: U-bolt installed at the top, center of the container.



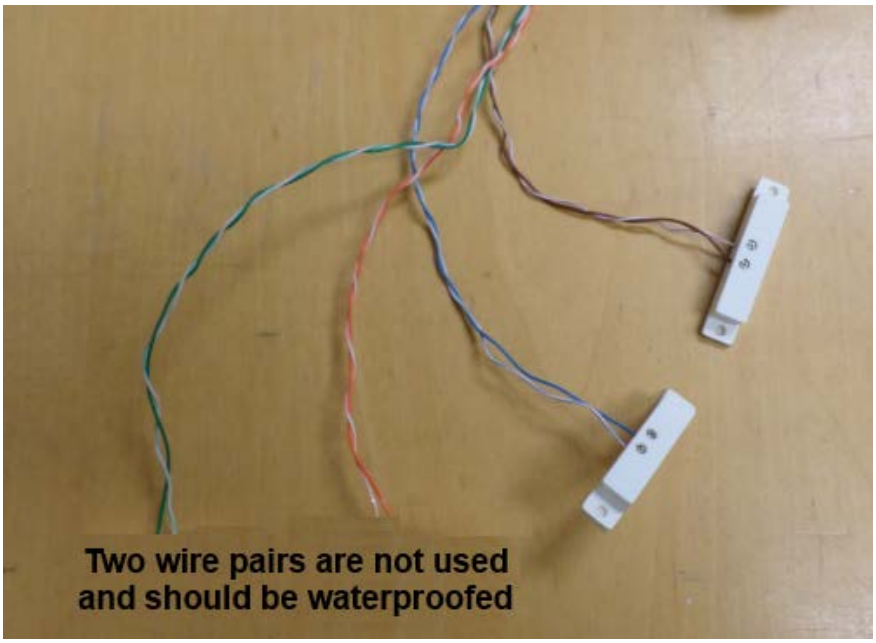
NAVIGATOR build photo #35: A cargo container.

Repeat steps 1 through 8 to construct another container. Mark two opposite upper corners on opposite sides of the container with strips of tape. These marks will designate the two different containers.

RFID and indicator

The RFID will be constructed from a magnetic reed switch (N-O). A magnetic reed switch (N-O) is a switch that is normally open, but closes and completes the circuit when in the presence of a magnet. Magnetic reed switches will be located on the two containers; the indicators for each switch will be located on the surface, side of the pool. The indicators will respond (buzz and light) when the switch is closed. To construct the RFID magnetic reed switches:

1. Cut a 15 meter length of CAT5 wire (8 strands inside). Strip away 2 meters of the plastic sheathing on the CAT5 cable. Choose two wire pair color combinations. The other two wire pair color combinations will not be used. Cover the ends of the unused color combinations with hot glue and shrink wrap to waterproof them. Strip 1 cm from the end of the two used wire pair color combinations, four wires total.
2. Attach a magnetic reed switch to each colored pair of wires that is being used. The MATE Center will use the magnetic reed switch located here https://www.amazon.com/dp/B0011W4YNK?smid=A29PFSLE3D9XFX&th=1, but any magnetic reed switch will work.
3. Insert one of the colored wire pairs into each of the terminal ports on the magnetic reed switch and tighten the screw to secure the wires into the switch. Repeat for the other colored wire pair using a different magnetic reed switch.
4. Secure a magnetic reed switch to the top of each container on the red colored PVC tee. The magnetic reed switch should be parallel with the long axis of the red colored PVC tee. To protect the CAT5 wires, consider running them through the ½-inch pipe at the top of the container and emerge through the pipe at the bottom corner of the container.
5. Use hot glue or epoxy to waterproof the connection where the wires attach to the magnetic reed switch.



NAVIGATOR build photo #36: Two magnetic reed switches on the CAT5 cable.

NAVIGATOR build photo #37: Magnetic reed switch mounted on container.

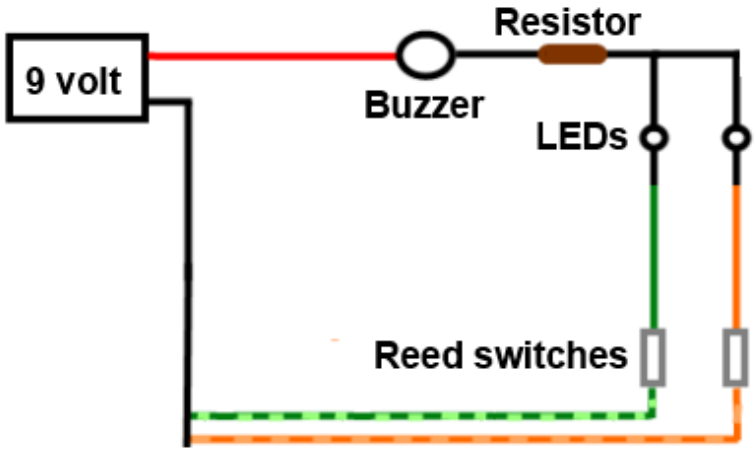
The MATE Center will use colored LEDs and buzzers as indicators, with a 1000 ohm resistor to protect the LED. The color of the LED indicator will identify the specific cargo container in the handbook. These indicators can be wired in series into a circuit, or incorporated into a circuit board specifically designed for this task. To wire the components into a series circuit:

6. Remove 8 cm to 10 cm of sheathing from the top end of the CAT 5 cable. Strip the ends of the two choses wire color combination pairs in the CAT5 cable. Using one colored pair of wires, attach a 1000 ohm resistor, an LED, a buzzer https://www.amazon.com/uxcell-Terminals-

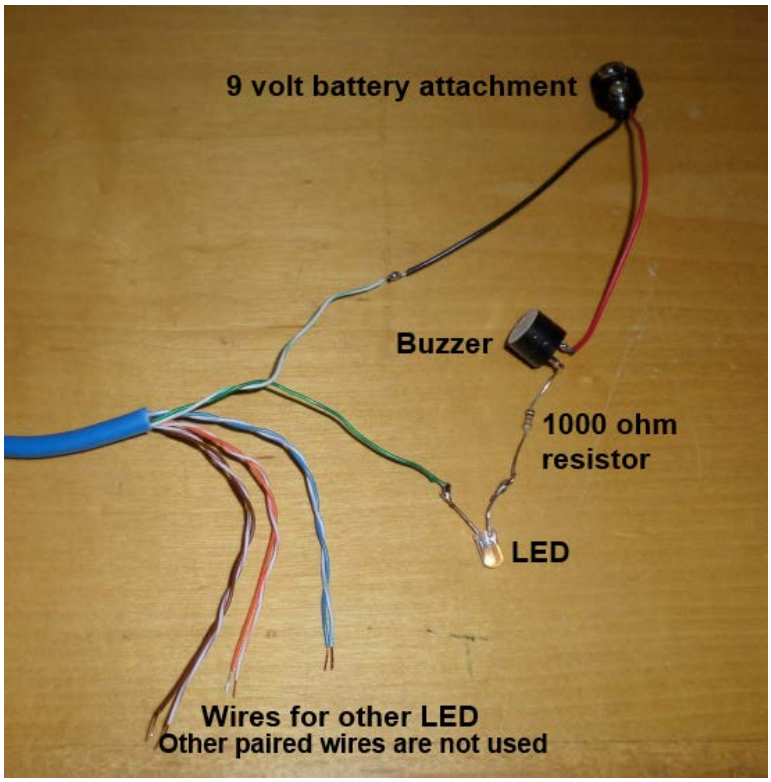
Electronic-Continuous-Buzzer/dp/B00B0Q4KKO/ref=sr_1_3?ie=UTF8&qid=1476297215&sr=8-3&keywords=buzzer, and a power source (9-volt battery) in series.

7. Repeat step 6 for the other colored pair of wire. Note that one power source can power both circuits. Use different colored LEDs (red, green) for each different circuit. Alternatively, white LEDs can be colored with a marker to construct different colored LEDs.

Design note: You can use a single buzzer and resistor to decrease the number of components needed. Each colored pair of CAT5 wires will need its own different colored LED for identification of the container.

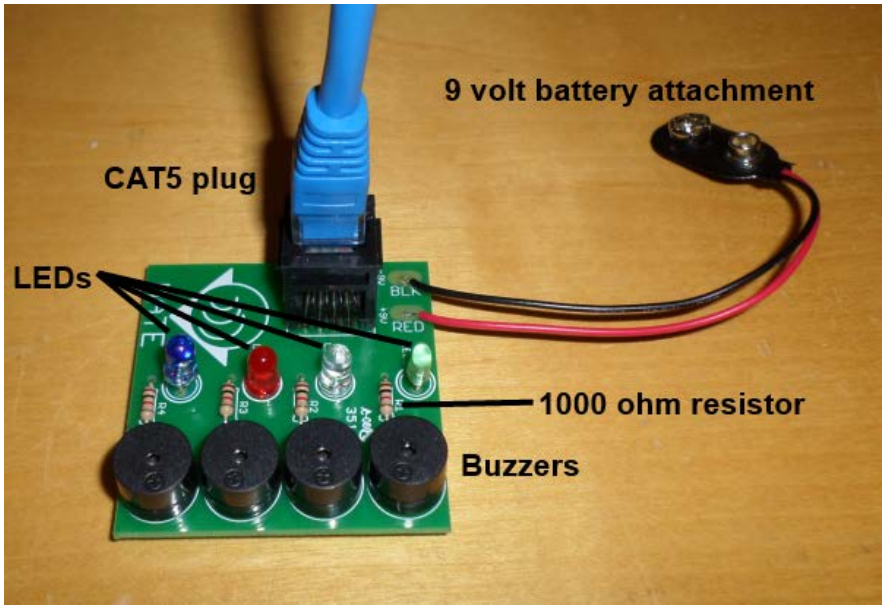


Circuit diagram for the two NAVIGATOR sensors with magnetic reed switches on the two containers with LED and buzzer indicators on the surface.



NAVIGATOR build photo #38: Resistor, LED, buzzer and power source wired in series.

Four resistors, four different colored LEDs and four buzzers will be wired into the printed circuit board. Only two LEDs and buzzers will activate. A plug for CAT5 wire and power leads are also incorporated into the board. NAVIGATOR class companies will see the circuit board at regionals and at the international competition.

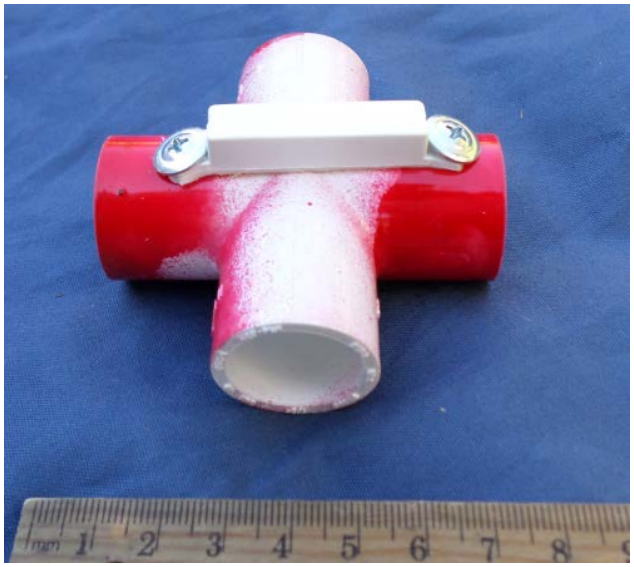


NAVIGATOR build photo #39: Resistors, LEDs, buzzers and power source mounted in circuit board. Only two LEDs will be active.

RFID sensor

The RFID sensor will be constructed from a ½-inch PVC cross. A magnet will be attached to the bottom of the cross. Two opposite openings of the cross will be painted red. The magnet will be positioned parallel to the two red painted openings on the cross. To construct the RFID sensor:

1. Paint two opposite openings of a ½-inch PVC cross red.
2. Attach a magnet to the bottom of the cross. A magnet is included with the magnetic reed switch; see https://www.amazon.com/dp/B0011W4YNK?smid=A29PFSLE3D9XFX&th=1. This rectangular magnet should be parallel to the two red painted openings. Secure the magnet to the cross.



NAVIGATOR build photo #40: Magnet mounted on PVC cross. Note that the cross should be positioned with the magnet facing downwards to make the best connection to the upwards facing magnetic reed switch.

Note that alignment may be important for magnets and magnetic reed switches. The magnet and magnetic reed switch work best when the two are parallel to each other. The MATE Center recommends practicing with the magnets and magnetic reed switches to determine the best orientation to complete the circuit.