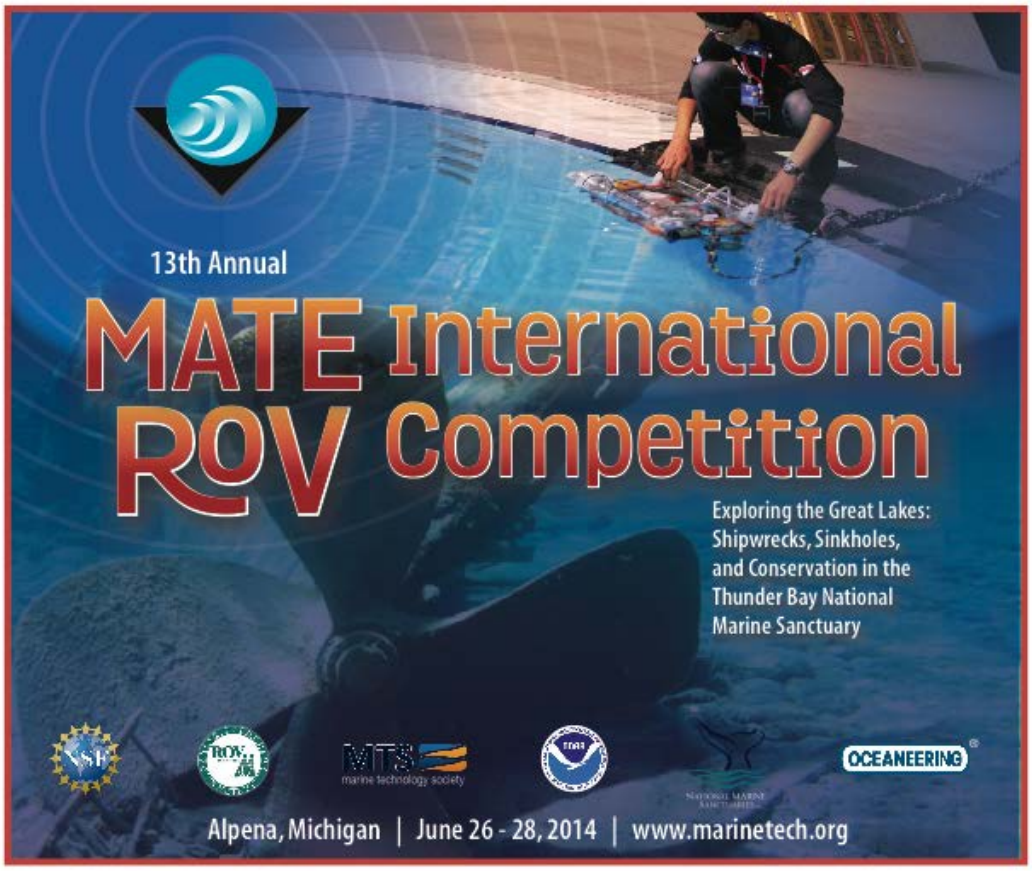
2014 MATE ROV Competition Manual

EXPLORER CLASS



2014 MATE ROV COMPETITION:

Exploring the Great Lakes: Shipwrecks, Sinkholes, and Conservation in the Thunder Bay National Marine Sanctuary

EXPLORER CLASS COMPETITION MANUAL

For general competition information, including a description of the different competition classes, eligibility, and demonstration requirements, see GENERAL INFORMATION. You can also find information by visiting Team Info.

CONTENTS

OVERVIEW

THINK OF YOURSELVES AS ENTREPRENEURS

From deepwater oil drilling to the exploration of shipwrecks and installation of instruments on the seafloor, individuals who possess entrepreneurial skills are in high demand and stand out in the crowd of potential job candidates. What are entrepreneurial skills? They include the ability to understand the breadth of business operations (e.g., finances, research and development, media outreach), work as an

integral part of a team, think critically, and apply technical knowledge and skills in new and innovative ways.

To help you to better understand and develop these skills, the MATE ROV competition challenges you to think of yourself as an entrepreneur. Your first task is to create a company or organization that specializes in solutions to real-world marine technology problems. Use the following questions as a guide.

- What is your company name?
- Who are its leaders – the CEO (chief executive officer – the leader) and CFO (chief financial officer who oversees the budget and spending)?
- Who manages Government and Regulatory Affairs (i.e. who's in charge of reviewing the competition rules and making sure that they are understood and followed by everyone)?
- Who is responsible for research and development (R&D)?
- Who is responsible for system(s) engineering? Design integration? Testing? Operations?
- Who is responsible for fund-raising, marketing, and media outreach?
- What other positions might you need? (Depending on your personnel resources, more than one person may fill more than one role.)
- What products and services do you provide?
- Who are your potential clients?

In this case, the MATE Center and the Thunder Bay National Marine Sanctuary are your "clients" who recently released a request for proposals. A request for proposals (RFP) is a document that an organization posts to solicit bids from potential companies for a product or service. The specifics of your product design and rules of operation – as well as the specifics of your mission – are included below.

PART 1: MISSION SCENARIO & TASKS

MISSION OVERVIEW

EXPLORER class companies will compete in ONE mission that consists of the following three tasks:

Task #1: SHIPWRECKS
Explore, document, and identify an unknown shipwreck recently discovered in sanctuary waters.
Task #2: SCIENCE
Collect microbial samples, measure the conductivity of the groundwater emerging from a sinkhole, deploy a sensor, and estimate the number of zebra mussels found on the wreck.
Task #3: CONSERVATION
Remove trash and debris from the shipwreck and surrounding area.

Companies may choose to do the three tasks in any order they wish. Your company will get up to **TWO** attempts to complete this single mission. The higher of the two scores will be added to your ENGINEERING & COMMUNICATION score to determine the total, overall score for the competition.

SCORING OVERVIEW

The competition consists of underwater missions, technical reports, engineering presentations, poster displays, and safety with the following scoring breakdown:

- **Mission**
  - 300 points (max), plus a time bonus
- **Engineering & Communication** – 250 points (max)
  - Technical reports
    - 100 points (max)
  - Engineering evaluations
    - 100 points (max)
  - Poster displays
    - 50 points (max)
      - International competition ONLY – 5 bonus points for media outreach
- **Safety**
  - 30 points (max)

TOTAL POINTS (not including the media bonus) = 580

TIME

The mission performance period includes:

- 5 minutes to set up at the mission station
- 15 minutes to attempt the mission tasks
- 5 minutes to break down and exit the mission station

Your company will have 5 minutes to set up your system, 15 minutes to complete the mission tasks, and 5 minutes to demobilize your equipment and exit the control shack. During the 5-minute set-up, you may place your vehicle in the water for testing and/or trimming purposes, provided that a member of your company has a hand on the vehicle at all times and uses extreme caution. The 15-minute mission period will begin after the full 5 minutes of set up time expires, regardless of whether you are ready to start the mission. It may begin sooner if your CEO notifies the mission judges that your company is ready to begin.

At any time during the mission, you may pilot your ROV to the surface and remove the vehicle from the water for such things as buoyancy adjustments, payload changes, and troubleshooting, but the 15-minute mission clock will only be stopped by a judge who determines it is necessary for reasons beyond your control. Otherwise, the clock will only stop after all mission tasks are successfully completed, the ROV has returned to the surface under its own power so that it touches the side of the pool, and a

member of your company at the launch station has physically touched the vehicle. Your ROV is not required to return to the surface between mission tasks.

Your 5-minute demobilization will begin as soon as the 15-minute mission time ends, regardless of where your ROV is located (i.e., still at depth, on the surface, etc.).

TIME BONUS

Your company will receive a time bonus if you:

1) successfully complete the three mission tasks,
2) return your ROV to the surface under its own power so that it touches the side of the pool, and
3) physically touch your vehicle before the mission time ends.

Your company will receive 1 point for every minute and 0.01 point for every second under 15 minutes remaining.

MISSION SCENARIO

Located in northwestern Lake Huron, Thunder Bay is adjacent to one of the most treacherous stretches of water within the Great Lakes system. Unpredictable weather, murky fog banks, sudden gales, and rocky shoals earned the area the name "Shipwreck Alley." To date, more than 50 shipwrecks have been discovered within the Thunder Bay National Marine Sanctuary (TBNMS). From 19th century schooners and steamers to a modern ocean-going freighter, the shipwrecks of Thunder Bay represent a microcosm of maritime commerce and travel on the Great Lakes.

Map of the Great Lakes with Thunder Bay highlighted

Map of Thunder Bay, highlighting the TBNMS and its shipwrecks

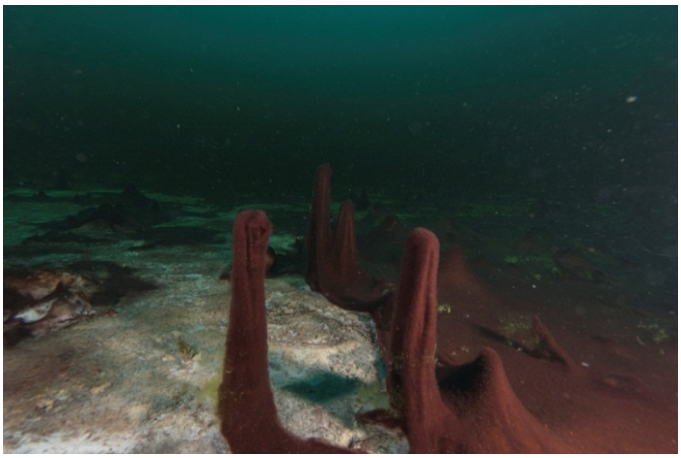
Ice, waves, and aquatic invasive species such as zebra mussels – as well as trash and debris generated by *Homo sapiens* – could potentially harm maritime heritage resources. The TBNMS is working with scientists and conservation groups to better understand how the chemical, biological, and physical conditions found around Thunder Bay's shipwrecks are affecting the corrosion and deterioration of these irreplaceable archaeological sites.

The propeller of the freighter Monohansett, which sank in Thunder Bay in1907

Zebra mussels engulf a shipwreck

In addition to shipwrecks, TBNMS is home to some unique geologic features. Sinkholes resulting from the erosion of limestone sediments have been studied since 2001. Groundwater emerging from the sinkholes is depleted of oxygen, enriched in inorganic carbon, is 10 times more conductive, and contains 100 times more sulfate than the surrounding lake water. Microbes thrive in several sinkhole environments. The sulfur provides fuel for chemosynthetic bacteria, which form patches of white mats with wavy filaments, while the inorganic carbon dioxide fuels photosynthetic cyanobacteria, which form extensive purple mats with finger-like projections.

A diver investigating a sinkhole in Thunder Bay



Finger-like projections of sinkhole cyanobacteria

The TBNMS staff and the scientists and conservationists who work within the sanctuary boundaries are in need of remotely operated vehicles that can 1) explore, document, and identify an unknown shipwreck recently discovered in sanctuary waters; 2) collect microbial samples and measure the conductivity of the groundwater emerging from a sinkhole; and 3) remove trash and debris from the shipwreck and surrounding area.

This is where your mission begins.

REQUEST FOR PROPOSALS (RFP)

1. General

a. Thunder Bay National Marine Sanctuary

The National Oceanic and Atmospheric Administration's (NOAA) Office of National Marine Sanctuaries (ONMS) serves as the trustee for marine protected areas that encompass more than 170,000 square miles (440,300 square kilometers) of ocean and Great Lakes waters from Washington State to the Florida Keys, and from Lake Huron to American Samoa. The network includes a system of 13 national marine sanctuaries and the Papahanaumokuakea Marine National Monument.

The Thunder Bay National Marine Sanctuary (TBNMS) was designated in 2000 to conduct and coordinate research and monitoring of its maritime heritage resources to ensure their long-term protection. Encompassing approximately 448 square miles (1169 square kilometers), the Sanctuary currently contains 45 shipwrecks, with an additional 47 sites being considered for sanctuary expansion. The historical record suggests that as many as 100 shipwrecks are yet to be found in this northwestern region of Lake Huron.

The sanctuary also promotes and assists research aimed at better understanding the environmental and natural aspects of Lake Huron. From real-time weather observations to invasive species monitoring to understanding the complex micro-environment

of submerged sinkholes, the sanctuary works with a variety of academic, government, and community partners to accomplish this.

b. SHIPWRECKS

For more than 12,000 years, people have traveled on the Great Lakes. From Native American dugout canoes to wooden sailing craft and steel freighters, thousands of ships have made millions of voyages across the Great Lakes. The last 150 years have been particularly explosive, transforming the region into one of the world's busiest waterways. Coal, copper, grain, and lumber are just some of the goods that have made their way through Great Lakes ports.

Yet, with extraordinary growth comes adversity. More than 200 pioneer steamboats, majestic schooners, and huge steel freighters are wrecked near Thunder Bay alone. The cold, fresh waters of Lake Huron make these shipwrecks among the best preserved in the world. With masts still standing, deck hardware in place, and the crews' personal possessions often surviving, sites located in deeper waters are true time capsules. Other wrecks lay well-preserved but broken up in shallower waters.

Marine archaeologists and other scientists continue to study Thunder Bay's shipwrecks to gain a better understanding of the wreck sites, add information to the area's maritime history, and help to preserve and protect this underwater cultural heritage for future generations. While known wrecks sites are documented and monitored, the potential for discovering new, yet-to-be-identified shipwrecks exists.

c. SINKHOLES

Lake Huron, the third largest of the Great Lakes, is contained within a basin underlain by 400 million year old limestone, dolomite, and gypsum bedrock — rock that was formed from the remains of saltwater seas that once covered the continent. Over time, movement of groundwater in and around these bedrocks gradually dissolved them, forming underground caves and cracks called karst formations. Further erosion of bedrock along the cave ceilings caused collapses leaving visible sinkholes.

As groundwater travels through faults in the underlying bedrock, it dissolves salt captured in the rock layers. The result is that groundwater emerging from the floor of the sinkhole has a higher salt content, and therefore conductivity, than the surrounding lake water. It also has a steady temperature (~ 9 degrees Celsius) throughout the year, compared to the much more variable temperature of the overlying lake water. Because the venting groundwater is cold and ion-rich, it is denser than surrounding lake water and forms a distinct layer on the lake floor that, near its source, is as much as 5 meters (17 feet) thick, or 22% of the overall water depth.

In addition to salt, the groundwater also dissolves other chemicals, such as sulfate, from the underlying rock formations. A telltale sign of venting groundwater rich in sulfur emerging

within a sinkhole is the presence of white, filamentous microbial mats. Some of these microbes convert sulfate to sulfide, while others convert the sulfide back to sulfate. Both use the energy from this process to fix carbon into organic matter – food.

Purple filamentous mats of cyanobacteria are also found at sinkholes that are within the photic zone. These organisms harvest light energy and create organic carbon from carbon dioxide that is dissolved in the venting groundwater. In some cases these microbes are so abundant that the mats form finger-like projections that extend into the water column.

Scientists have studied sinkholes in TBNMS since 2001, investigating their geology, chemistry, hydrography, and microbial ecology. Given the relatively shallow depth of Lake Huron, most of their measurements and sampling have been carried out by divers. However, given the delicate nature of these sinkhole systems and the potential for features to collapse, not to mention seasonal decreased visibility, scientists are increasingly interested in having ROVs assist in their work.

d. CONSERVATION

Thunder Bay's shipwrecks are magnificent, yet vulnerable. Natural processes and human impacts threaten the long-term sustainability of its underwater maritime heritage. While scientists look after the effects of physical (waves and ice), biological (invasive species such as zebra mussels), and chemical (venting groundwater) processes, it is up to all of us – scientists, engineers, policy-makers, and the general public – to look after the impacts of modern-day *Homo sapiens*. The technology and expertise to retrieve and remove trash and debris exists, even from the deepest point of the Great Lakes.

e. Document Scope and Purpose

This and the following sections contain the technical specifications and requirements for ROV services needed to support the shipwreck, science, and conservation mission tasks. In 2014, ROV services include:

- SHIPWRECK
    - Measure the shipwreck's length, width, and depth
    - Conduct a sonar scan of the wreck
    - Create a photomosaic
    - Unlock and open a container to determine the cargo
    - Remove debris from a hole in the wreck
    - Enter the wreck through this 75 cm x 75 cm hole
    - Search for the date the ship was built on an internal beam
    - Retrieve a ceramic dinner plate from inside the ship to determine its home port
    - Identify the ship using known parameters
- SCIENCE
    - Measure the conductivity of the groundwater

    - Collect a sample of a microbial mat
    - Recover a sensor and deploy a new one
    - Place a quadrat on the top surface of the shipwreck, count the number of zebra mussels inside the quadrat, and estimate the total number of zebra mussels on the shipwreck using the wreck's dimensions
- CONSERVATION
    - Remove bottles, discarded anchor lines, and a Danforth anchor with chain

2. Specifications

See the specific tasks described below as well as the VEHICLE DESIGN & BUILDING SPECIFICATIONS and COMPETITION RULES sections.

3. Maintenance and Technical Support

The company shall warrant the ROV and associated systems and equipment for at least the duration of the competition event. Repair or replacement shall be at the company's expense, including the cost of shipping the ROV to and from the competition facility.

During regional events, the company shall provide at least one day of technical support to resolve hardware, software, and operational issues. They shall provide at least three days of the same for the international event.

4. Shipping and Storage

Refer to Shipping Information for specifics on shipping to the international competition site.

Delivery of the ROV and associated systems and equipment shall be no later than the date of the geographically closest regional contest or by June 26, 2014, which is the start date of the international competition.

5. Evaluation Criteria

a. Technical report
b. Engineering presentation
c. Poster display
d. Performance

6. References

- NOAA's National Marine Sanctuaries – http://sanctuaries@noaa.gov
- Thunder Bay National Marine Sanctuary – http://thunderbay.noaa.gov/
- Thunder Bay Wrecks – http://www.thunderbaywrecks.com/index.php
- NOAA's Ocean Explorer – http://oceanexplorer.noaa.gov/explorations/08thunderbay/logs/summary/summary.html

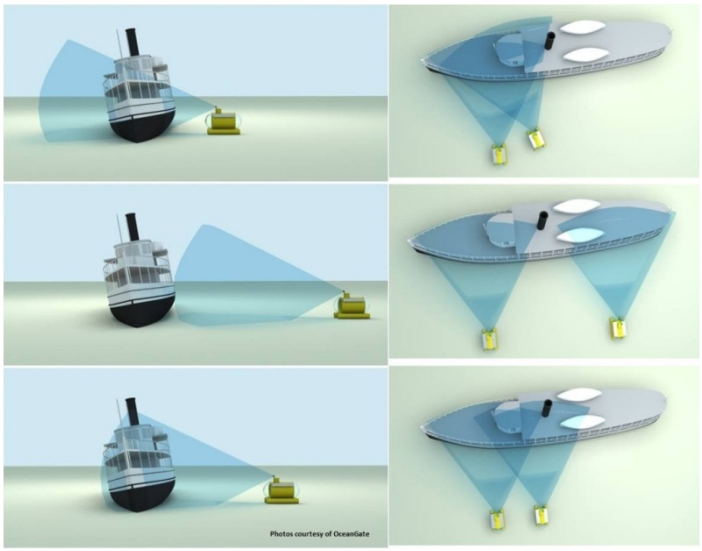
- Rock, Water, Microbes: Underwater Sinkholes in Lake Huron are Habitats for Ancient Microbial Life – http://www.nature.com/scitable/knowledge/library/rock-water-microbes-underwater-sinkholes-in-lake-24270250
- Lake Huron Sinkholes Give Clues to Ancient Life – http://greatlakesecho.org/2009/07/15/lake-huron-sinkholes-provide-clues-to-ancient-life/
- NOAA's National Marine Sanctuaries – http://sanctuaries.noaa.gov/missions/2006fknms/photomosaicgallery.html
- Great Lakes Fact Sheet – http://www.epa.gov/glnpo/factsheet.html
- Observations of the Middle Island Sinkhole in Lake Huron – A Unique Hydrogeologic and Glacial Creation of 400 Million Years – http://www.glerl.noaa.gov/pubs/fulltext/2009/20090012
- Photos courtesy of NOAA Ocean Explorer, NOAA Thunder Bay National Marine Sanctuary, Great Lakes Restoration – Muskegan Lake Observatory, and OceanGate.

MISSION TASKS

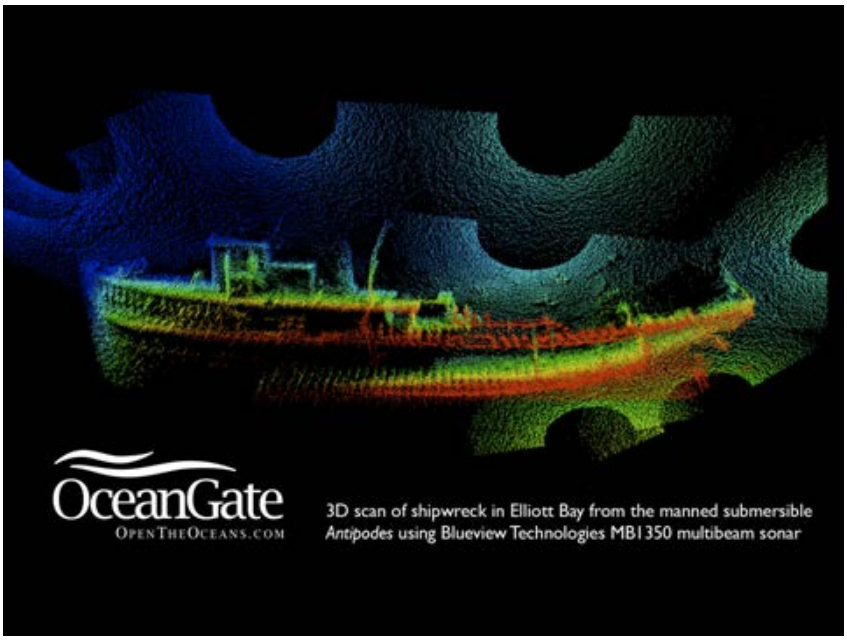
Task 1: SHIPWRECKS

Your company is tasked with exploring, documenting, and identifying a newly discovered, unknown shipwreck. This includes measuring the length, width, and height of the wreck. You will use the information that you collect about the ship's dimensions in Task #2.

Your company is also tasked with scanning the wreck with "sonar" and creating a photomosaic from digital images. You will use your ROV's video camera to simulate the sonar scans. When scanning the wreck, distance matters. If your sonar is too far away, the beams will not reach the target. If your sonar is too close, the beams will survey a small area and miss much of the target. Spacing of the surveys is also important. Your sonar scans should be done so that there is minimal overlap.

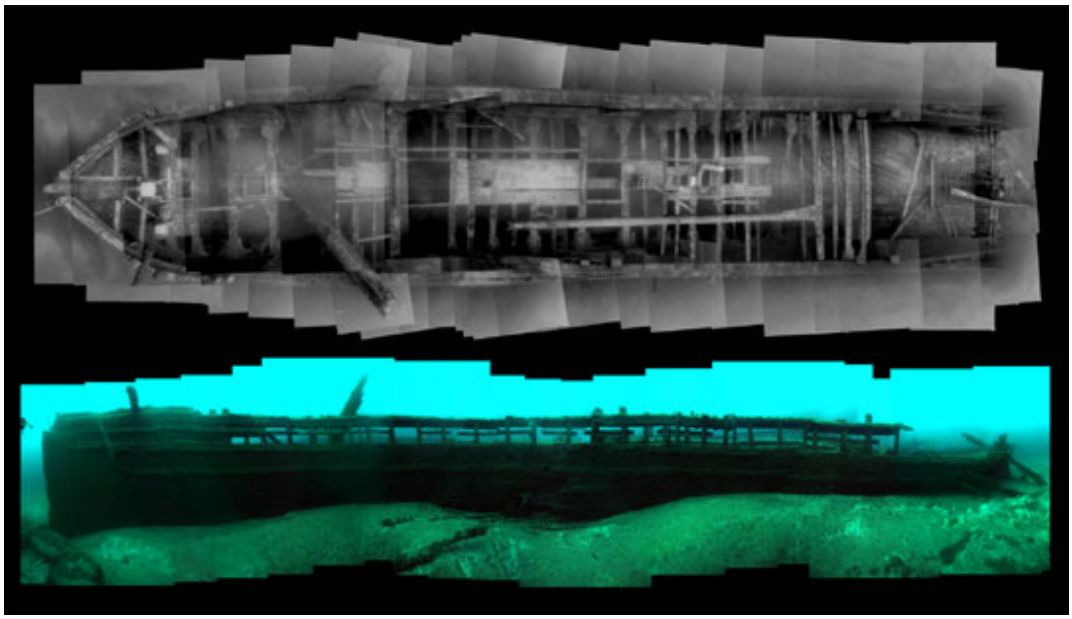


Side view looking at the shipwreck *View looking down on shipwreck*



The result

Similarly, distance and spacing matter when creating a photomosaic. A photomosaic is a large-scale, detailed picture made up of many individual photographs. Along with sonar images, photomosaics are another "tool" used by archaeologists to document shipwrecks, especially when it is difficult to capture an entire wreck in one photo. To create a photomosaic of the shipwreck, your company must take and "stitch" together five digital photos of the wreck so that the images match up without duplicating areas where the photos may overlap.



A photomosaic of the EB Allen, which sank in the Thunder Bay in 1871

Your company must also determine the type of ship and the cargo that it contains; find and determine the date the ship was built; and recover a ceramic plate to determine the ship's home port. Your company will then use all of these features to identify the wreck from a list of known, but previously undiscovered, shipwrecks.

Identifying features will be located both outside and inside the shipwreck. Your company must find a feature on the outside of the wreck that will allow you to determine the type of ship: wooden sailing schooner, stream-driven paddlewheel ship, or propeller driven bulk freighter. A cargo container located outside of the shipwreck must be unlocked and opened to determine the type of cargo that the ship was carrying. Your company must remove debris (see Task #3) that is blocking a 75cm x 75cm hole in the side of the wreck to venture inside to locate the build date of the ship and recover a ceramic dinner plate. The home port of the shipwreck is "stamped" on this plate.

This task involves the following steps:

- **Determining the length, width, and height of the shipwreck – up to 30 points**
    - **Measuring the length of the ship**
        - **≤ 5 cm off true length – 10 points**
        - **5 cm to 20 cm off true length – 5 points**
        - **> 20 cm off true length – 0 points**
    - **Measuring the width of the ship**
        - **≤ 5 cm off true length – 10 points**
        - **5 cm to 20 cm off true length – 5 points**
        - **> 20 cm off true length – 0 points**
    - **Measuring the height of the ship**
        - **≤ 5 cm off true length – 10 points**
        - **5 cm to 20 cm off true length – 5 points**
        - **> 20 cm off true length – 0 points**
- **Correctly "scanning" the ship at three target locations – 5 points for each target (15 points total)**
- **Creating a photomosaic from five distinct images – 5 points for each image correctly "stitched" together (25 points total)**
- **Determining the type of ship– 5 points**
- **Determining the shipwreck's cargo – up to 25 points**
    - **Unlocking the cargo container – 5 points**
    - **Opening the door of the cargo container –5 points**
    - **Determining the type of cargo carried by the ship – 5 points**
    - **Closing the door of the cargo container – 5 points**
    - **Locking the cargo container – 5 points**
- **Entering the shipwreck through the 75 cm x 75 cm hole –5 points**
- **Locating and determining the date the ship was built– 5 points**
- **Recovering a ceramic dinner plate from inside the shipwreck – up to 20 points**

- **Lifting the dinner plate from the floor of the shipwreck – 5 points**
- **Returning the dinner plate to the surface – 10 points**
- **Identifying the home port of the ship – 5 points**

- **Identifying the shipwreck using the four known features – 20 points**

Total points = 150

Mission notes:

Companies may complete the steps of Task #1 in any order and may alternate between this and the other tasks.

Companies will measure the length, width, and height of the shipwreck. Companies will receive 10 points for each measurement if the values are within 5 cm of the true dimensions of the shipwreck. The true length and width measurements will be based on the distance between 2 ½-inch wood screws inserted into the four top corners (port bow, starboard bow, port aft, starboard aft) of the shipwreck framework. These wood screws will serve as marker points for the length, width, and height measurements. The head of each wood screw will protrude 2 cm above the PVC joint. The screws will be set at a 45^{o} angle from the top and rear plane of the shipwreck framework. The screws will be painted yellow. The true height measurement will be based on the distance between the wood screw and the bottom of the pool. Note: Companies do not need to use these screws to make measurements, they are inserted for convenience.

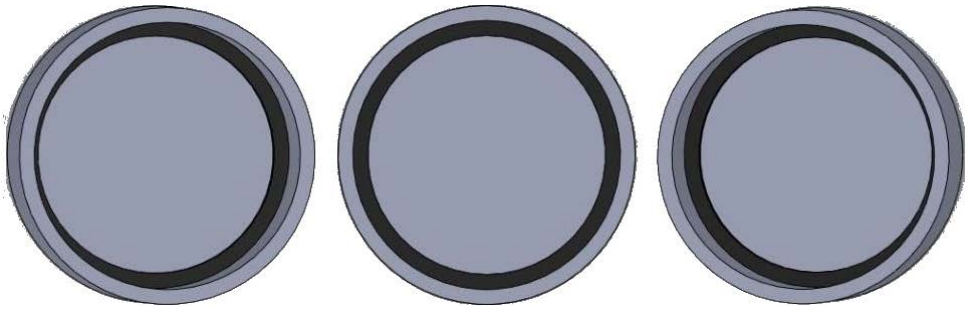
Companies must report and show all measurements to the mission station judge. The mission station judge must see the company measurement reading; they cannot simply guess at the measurement. If companies report an incorrect length, width, or height to the mission station judge, they will not receive points for that measurement. Companies may elect to re-measure the dimension for other tasks (see Task #2). Although companies will not receive points, the mission station judge will inform companies if their subsequent measurements are correct. See the MISSION PROP BUILDING INSTRUCTIONS & PHOTOS for general shipwreck dimensions.

At the international competition, the shipwreck will be located on a sloping bottom. All dimensions, especially the height measurement of the shipwreck, should be measured as if the ship were sitting on a flat bottom, from the top plane of the ship to the bottom plane of the ship. In addition, the shipwreck's length measurement should be measured from the stern of the ship to the front bulkhead of the ship; the bow point of the ship is not included in the length measurement.

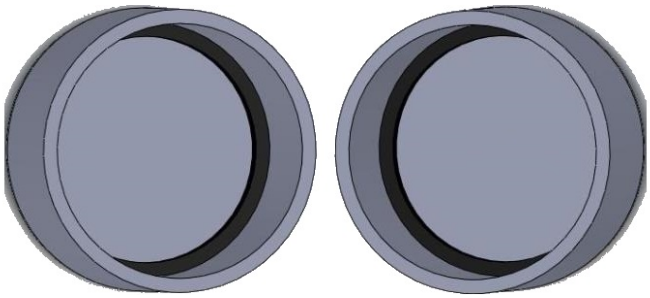
Companies will simulate scanning the shipwreck with sonar by visualizing a target area. Companies will have three target areas to scan, all on the same side of the shipwreck. Each target area will consist of a black ring of 2-inch ABS pipe set inside a 2-inch white PVC end cap and a black mark set 25 cm to one side of the target. To effectively scan the shipwreck, an ROV must align a single camera so that the mission station judge can see on one video display the entire black ring within the end cap as well as a

mark on the side of the target. The vehicle must maintain this alignment for 5 seconds. If at any time the mission station judge is unable to see the entire black ring or both colored marks, companies must realign their vehicle and start the scan again. Companies will receive 5 points for each successful target scanned.

Targets will sit at least 30 cm off the pool bottom.



EXPLORER figure #1: Three "successful" scans. The left target depicts the ROV a little to the left, but still successfully scanning target. The middle target is a successful scan looking directly at the target. The right target depicts the ROV a little to the right, but still successfully scanning the target. In all three scans, the complete black ring inside the target can be seen.

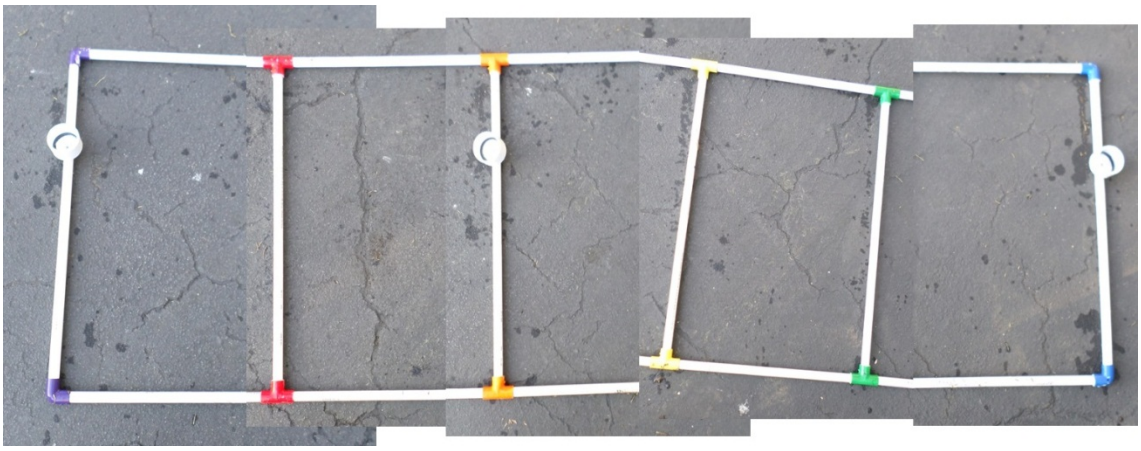


EXPLORER figure #2: Two "unsuccessful" scans. The left target depicts the ROV too far to the left. The right target depicts the ROV too far to the right. In both scans, portions of the black ring cannot be seen.

Companies must also compile a photomosaic of five, overlapping digital "snapshot" locations. The five snapshot locations will be adjacent to each other. Each snapshot location will be approximately 60 cm wide and up to 1 meter in height. Snapshot locations will be bordered by two pairs of colored PVC joints (tees or 90^{o} elbows) positioned in the four corners of the snapshot location. Each snapshot should contain the two pairs of colored PVC joints, but should not contain any of the other pairs of colored PVC joints (6 pairs in all, outlining 5 snapshot locations).

Companies must compile and display a photomosaic of all five snapshot areas to the mission station judge. This photomosaic must be compiled within the 15-minute mission period. The mission station judge may evaluate the photomosaic during the 5-minute demobilization, but companies must submit the image during the mission time. Companies may display the photomosaic on a color video display or print out a colored hard copy. Note that the MATE Center WILL NOT provide a printer at the

international event; companies must provide their own if they wish to display the photomosaic as a hard copy. Companies will receive up to 25 points for their photomosaic display, five points for each image that is correctly "stitched" into the photomosaic.



EXPLORER figure #3: A photomosaic example of the MATE Center shipwreck. Note that the fourth photo from the left is incorrectly "stitched" in place.

Companies must use the following four features to identify the ship from a list of 24 possible wrecks:

1. Type of ship
2. Cargo that the ship carried
3. Date that the ship was built
4. Ship's home port

Two of these features will be located outside the shipwreck and two will be located inside the shipwreck. Companies will receive 20 points when they correctly identify the ship to the mission station judge. Companies must identify the shipwreck during the 15-minute mission time.

The first feature is the type of ship. The shipwreck may be one of three types: a wooden sailing schooner, a steam-driven paddlewheel ship, or a propeller driven bulk freighter. Companies will need to use visual clues from around the wreck site to determine the type of ship.

- A wooden sailing schooner will have a mast head;
- A steam-driven paddlewheel ship will have an octagonal paddlewheel;
- A propeller-driven bulk freighter will have a propeller.

The mast head, paddlewheel, or propeller must be shown on a video display to the mission station judge. Companies are not allowed to guess at the type of shipwreck without making the visual determinations. Companies will receive 5 points when they correctly identify the type of ship to the mission station judge.

The second feature is the cargo that the ship carried. A milk crate will serve as the cargo container. To determine the contents of the container, companies must unlock the hatch on one side of the container then open the cargo container. The hatch of the cargo container will be constructed of corrugated

plastic sheeting. A PVC handle can be used to open the hatch. Companies will receive 5 points for unlocking the hatch of the cargo container and 5 points for opening the door of the container to reveal the cargo contents.

The cargo will consist of either grain or coal. Bags of grain will be represented by PVC tees painted yellow, while coal will be represented by PVC tees painted black. A smaller, secondary container inside the milk crate will hold the cargo and prevent the cargo from being seen before opening the door. Companies will receive 5 points when they correctly identify the cargo to the mission station judge. Note that companies do not need to retrieve or return any cargo to the surface.

Once the cargo is identified, companies must close the door and lock the container. Companies will receive 5 points for closing the door of the container and 5 points for locking the hatch.

The PVC handle used to unlock the hatch will take less than 2 Newtons to turn. The door will take less than 2 Newtons to open.

The third and fourth features are found inside the shipwreck. Companies can access the inside through a 75 cm x 75 cm hole near the bow. Debris, in the form of discarded anchor lines, will be positioned over this hole. Companies must remove these anchor lines from the shipwreck site (see Task #3). Companies will receive 5 points when their vehicle enters the shipwreck. Entering the shipwreck is defined as having the vehicle completely within the shipwreck; no parts of the vehicle, other than tether, can be outside of the wreck.

The third feature is the build date stamped onto an internal beam. The framework for the shipwreck will be constructed from PVC pipe. The date the ship was built will be written on a 5 cm x 15 cm rectangle of black plastic. This black rectangle will be screwed into the PVC framework of the shipwreck. Companies will receive 5 points when they display the date, on a video monitor, to the mission station judge.

The fourth feature is the home port of the ship, which will be printed on a ceramic dinner plate found within the wreck. The ceramic dinner plate will be simulated by a negatively buoyant plastic plate. The home port of the ship will be covered by a black plastic rectangle attached to the plate with Velcro. The black plastic rectangle simulates mud that has accumulated over time. Companies must retrieve and return the dinner plate to the surface and remove the plastic cover in order to determine the home port. The plate will be sitting on the bottom inside the shipwreck. Companies will receive 5 points for lifting the plate so it is under control of the ROV and no longer touching the bottom of the pool. Companies will receive an additional 10 points when the plate is returned to the surface side of the pool. Returning the plate to the surface, side of the pool is defined as the plate being removed from the ROV and placed on the pool deck. Companies will receive 5 points when they remove the plastic cover and report the home port to the mission station judge. The home port will either be Detroit, Michigan, or Sault Ste. Marie, Canada.

The ceramic dinner plate will weigh less than 5 Newtons in water.

The **MISSION PROP BUILDING INSTRUCTIONS & PHOTOS** contains prop building instructions.
See the **EXPLORER mission SolidWorks** files for CAD representations of the missions.
See **EXPLORER shipwrecks** for the list of 24 possible wrecks.

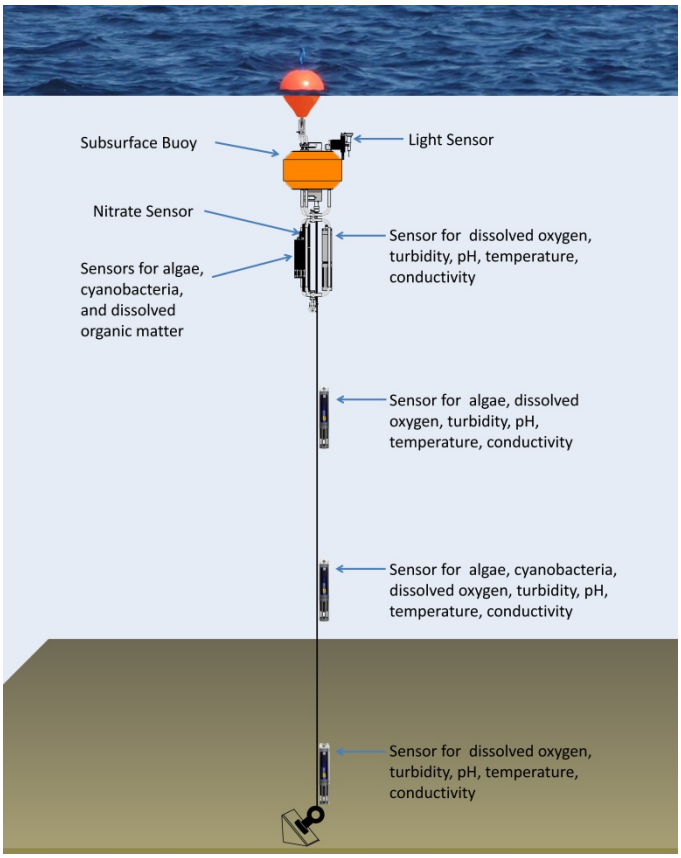
Task 2: SCIENCE

Your company must investigate a sinkhole discovered near the wreck site to determine the conductivity of the groundwater emerging from the hole and to collect a sample of a microbial mat thriving on the chemicals found in the groundwater.

Your company must design and deploy a sensor to accurately measure the conductivity of the venting groundwater. The conductivity of the groundwater will be higher than the ambient pool water.

In addition to retrieving a sample of the microbial mat, your company must return at least 150 ml of the sample to the surface. An adequate sample is important since it will be used by scientists to determine species of microbes inhabiting this particular sinkhole environment.

You must also retrieve a sensor string previously deployed at the sinkhole site and replace it with a new string of sensors. The sensor string includes sensors to determine dissolved oxygen, pH, temperature, conductivity, light penetration, and algae. It is being used by scientists to collect long-term data on the sinkhole environment. After returning the old sensor string to the surface so that its data can be recovered, your company must install a new string of sensors in the same location.



Sensor string

Invasive zebra mussels are populating the shipwreck from bow to stern. Your company is tasked with estimating the total number of zebra mussels on the entire wreck. You must place a 0.5 meter x 0.5 meter quadrat on the top of shipwreck's hull and count the number of zebra mussels within the quadrat. Using that mussel count and the measured dimensions of the shipwreck (obtained during Task #1), you must estimate the entire number of mussels on the shipwreck.

This task involves the following steps:

- **Measuring the conductivity of the groundwater – up to 20 points**
  - **Within 10% of benchmark conductivity – 20 points**
  - **Within 20% of benchmark conductivity – 5 points**
  - **Greater than 20% of benchmark conductivity – 0 points**
- **Retrieving a sample of a microbial mat – up to 30 points**
  - **Collecting a sample of a microbial mat– 10 points**
  - **Returning the sample to the surface – up to 20 points**
    - **> 150 ml – 20 points**
    - **50 ml to 150 ml – 10 points**
    - **< 50 ml – 0 points**
- **Recovering the old sensor string with replacing it with a new one – up to 20 points**
  - **Returning the old sensor string to the surface – 10 points**

    - **Deploying the new sensor string to the designated area – 10 points**
- **Estimating the number of zebra mussels on the wreck – up to 20 points**
    - **Placing the quadrat into position on top of shipwreck – 5 points**
    - **Counting the number of zebra mussels within the quadrat – 5 points**
    - **Using the length, width, and height data, estimate the number of zebra mussels on the shipwreck – up to 10 points**
        - **Within 5% of total number of mussels – 10 points**
        - **Between 5.01% and 10% of total number of mussels – 5 points**
        - **>10% of total number of mussels – 0 points**

Total points = 90 points

Mission Notes:

Companies may complete the steps of Task #2 in any order and may alternate between this and the other tasks.

Companies are responsible for constructing their own conductivity sensor; the MATE Center will NOT provide conductivity sensors at the competition.

The groundwater emerging from the sinkhole will be simulated by a 2-gallon bucket with a 1 ½-inch hole at the top. The bucket will be located on the pool bottom within the mission area. Saline water will be slowly filling this bucket from a source on the surface and spilling out over the top of the 2-gallon bucket to simulate the flow of groundwater out of the sinkhole. Companies must measure the conductivity of the water inside the 2-gallon bucket. To ensure a conductivity reading of salt water that has not mixed with pool water, companies should insert their sensor at least 7.5 cm into the 2-gallon bucket.

Companies will receive 20 points when they accurately measure the conductivity, in milli Siemens (mS). Companies must show a mission station judge the conductivity reading on a video or other display screen.

At the international competition, a calibration station will be available so that companies may calibrate their sensor to the conductivity sensor used by the MATE Center to determine the benchmark conductivity reading.

Companies must design and construct their own conductivity sensor. This sensor may be incorporated into the ROV or independent of the vehicle.

Sensors that are independent of the vehicle must be powered from the surface; no onboard batteries of any type are allowed. Companies may use USB to connect their sensor to a computer. Companies may also use surface battery packs (limited to 12 volts maximum) or the MATE supply to provide power for

their conductivity sensor. The independent sensor may only contain the intended sensor; thrusters, cameras or other systems **MAY NOT** be attached to the independent sensor.

NOTE: A conductivity sensor independent of the ROV is the only allowable exception to the rule that all electrical power must be provided by the MATE Center 48-volt power supply.

Companies that use an independent sensor must provide a 3 amp (or less) fast blow fuse on the positive side of their connection. If companies are using the 48 volt MATE supply to power their sensor, both the ROV and the sensor must run through the single 40 amp fuse before splitting off to the 3 amp sensor fuse. Companies using USB only to power an independent sensor may utilize the built-in current limiting of USB and do not need to add an additional fuse.

The microbial mats will be simulated by plastic cups full of agar. The cups of "used" agar will be replaced between each mission attempt so that each company samples from a full container of fresh, undisturbed agar. If the sample is disturbed or a company loses their agar sample while returning it, the company will NOT receive another cup of fresh agar.

Companies will receive 10 points when they successfully remove a sample of agar from the cup. Removing agar from the cup is defined as the sample being under control of the ROV and no longer touching the sample cup of agar. Companies will receive up to an additional 20 points when they return that sample to the surface. Companies returning more than 150 ml of sample will receive 20 points; companies returning between 50 ml and 150 ml of sample will receive 10 points; companies returning less than 50 ml of agar will receive 0 points. Companies are not permitted to lift the entire cup of agar to the surface; companies that return the entire cup of agar to the surface will receive 0 points.

A sensor string will be located in a designated area on the bottom of the pool. The designated area will be simulated by a 50 cm x 50 cm square constructed from ½-inch PVC pipe. A 2.25 kg (5 lb) dive weight will be attached to the bottom of the sensor string to secure it to the lake floor. A float will be attached to the top of the sensor string to provide positive buoyancy. The sensor string must be returned to the surface and a new sensor string deployed in its place within the designated area. The new sensor string will be located at the surface, side of the pool. Both sensor strings will be simulated by a 2 to 3 meter length of rope with PVC pipe "sensors" located at various intervals along the length.

Companies may attach the new sensor string to their vehicle during the 5-minute set up. Companies will receive 10 points when the ROV returns the old sensor string to the surface, side of the pool. Companies will receive 10 points when the new sensor string is deployed by the ROV within the designated area. A successfully deployed sensor string has the dive weight completely inside the designated area and no tangles in the string. The dive weight can be touching the inside PVC edge of the designated area, but the weight CANNOT be on top of the PVC of the designated area. Companies may grab the sensor string at any point along its length to move it.

Both sensor strings will weigh less than 25 Newtons in water.

Companies must calculate the total number of invasive zebra mussels on the wreck. Companies are tasked with designing their own 0.5 meter x 0.5 meter quadrat to place on the top of the shipwreck. The inner dimensions of the quadrat **MUST** be 50 cm x 50 cm square. Companies that do not have a quadrat within 1 cm of those dimensions will be penalized 5 points.

The quadrat must be placed on the top of the shipwreck. The top of the shipwreck is constructed of both a corrugated plastic sheet (approximately 1.2 m x 1.2 m in size) and shade cloth. Companies will receive 5 points when the 50 cm x 50 cm measurement section of their quadrat is placed completely on the corrugated plastic sheet; no portion of the quadrat may rest over the side of the corrugated plastic sheet.

Companies must count the number of zebra mussels inside the 50 cm x 50 cm quadrat. The zebra mussels will be simulated by small plastic disks. Companies must show the mission station judge the quadrat and report the zebra mussels within that quadrat. Companies should count every mussel that has any part of its body inside the dimensions of the quadrat. For example, if only a small section of the plastic disk (zebra mussel) shows inside the quadrat, it still should be counted as within the 50 cm x 50 cm quadrat. Companies will receive 5 points when they correctly count the number of zebra mussels completely inside the quadrat.

Companies receive one chance to count the mussels; if the company count is incorrect (not the same as the judge's count), companies will receive 0 points for counting the mussels. If the count is incorrect, the mission station judge will inform the team they are incorrect. Companies may recount the mussels within the quadrat to do their estimation calculations.

Companies will use their mussel count and the wreck's length, width, and height measurements from Task #1 to estimate the total number of zebra mussels on the shipwreck. Companies will receive 10 points if their estimation is within 5% of the number of mussels on the shipwreck. The MATE Center will calculate the total number of mussels using the true length, width, and height of the shipwreck and the number of mussels counted by the company within the quadrat. Companies will receive 5 points if their estimation is between 5.01% and 10% of the total and zero points if their estimation is greater than 10% from the total.

When calculating the OUTSIDE surface area of the shipwreck using length, width, and height, companies should calculate the area of the two sides of the wreck, the front and back panels of the wreck, and the top of the wreck. Companies should NOT include the angled bow of the shipwreck or the bottom of the wreck. Companies do NOT need to subtract the area of the 75 cm x 75 cm hole in the side of the shipwreck.

> **For example**:
> If the shipwreck has measurements of 2.5 meters long, 1.2 meters wide, and 1 meter high, the surface area calculations would be as follows:

Two sides: 2.5 m length x 1 m height x 2 sides = 5 square meters
Front: 1.2 m width x 1 m height = 1.2 square meters
Back: 1.2 m width x 1 m height = 1.2 square meters
Top: 2.5 m length x 1.2 m width = 3 square meters
Total surface area: 5 + 1.2 + 1.2 + 3 = **10.4 square meters**

If 9 zebra mussels were counted within the 0.5 meter x 0.5 meter quadrat, that would be 36 zebra mussels per square meter (9 x 4). The total mussels on the shipwreck would be **374.4** (36 mussels per square meter x 10.4 square meters).

The **MISSION PROP BUILDING INSTRUCTIONS & PHOTOS** contains prop building instructions. See the **EXPLORER mission SolidWorks** files for CAD representations of the missions.

Task 3: CONSERVATION

Companies are tasked with removing modern debris from the wreck site. The debris consists of two bottles, rope, and a Danforth anchor with chain.

Two different bottles will be located within the wreck site. One bottle will be a plastic water bottle without a cap; the other will be a simulated glass bottle constructed from 2-inch PVC. In addition, the anchor line rope will be located in front of the 75 cm x 75 cm hole your company must use to access the inside of the shipwreck (see Task #1). The final piece of debris is an 8-lb Danforth anchor with a length of chain attached. This anchor and chain will NOT be attached to the anchor line rope, but will be a separate item.

This task involves the following steps:

- **Removing two bottles– up to 20 points**
  - **Removing the plastic water bottle– 5 points**
  - **Returning the plastic water bottle to the surface – 5 points**
  - **Removing the glass bottle– 5 points**
  - **Returning the glass bottle to the surface – 5 points**
- **Removing the anchor line rope – up to 15 points**
  - **Lifting the rope off the bottom – 5 points**
  - **Returning the anchor line rope to the surface – 10 points**
- **Removing the Danforth anchor and chain– up to 25 points**
  - **Lifting the anchor off the bottom – 10 points**
  - **Returning the anchor and chain to the surface – 15 points**

Total points = 60

Mission Notes:

Companies may complete the steps of Task #3 in any order and may alternate between this and the other tasks.

The plastic water bottle will be a commercially available bottle with a volume between 500 ml and 1 L. The bottle will be open and filled with water. The water bottle will not have a cap. Companies will receive 5 points when the plastic water bottle is removed from bottom. Removing the bottle from the bottom is defined as the water bottle being under control of the vehicle and no part of the bottle is in contact with the bottom. Companies will receive an additional 5 points when the plastic water bottle is returned to the surface, removed from the ROV, and placed on the pool deck.

The glass bottle will be simulated with PVC joints and pipe. The bottle will be open at one end and filled with water. Companies will receive 5 points when the simulated glass bottle is removed from the bottom. Removing the bottle from the bottom is defined as the glass bottle being under control of the vehicle and no part of the bottle is in contact with the bottom. Companies will receive an additional 5 points when the simulated glass bottle is returned to the surface, removed from the ROV, and placed on the pool deck.

The anchor line rope debris will be 3/16-inch rope strung between a ½-inch PVC framework. The anchor line rope debris will be positioned in front of the 75 cm x 75 cm hole on the side of the shipwreck. The anchor line rope debris will not be attached to the Danforth anchor. Companies will receive 5 points when the rope debris is lifted off the bottom. Lifting the debris off the bottom is defined as having the debris under control of the ROV and having no part of the rope debris touching the bottom or the shipwreck. Companies will receive an additional 10 points when the anchor line rope debris is returned to the surface, removed from the ROV, and placed on the pool deck.

The anchor line rope debris will weigh less than 10 Newtons in water.

The Danforth anchor will be located on the bottom, with a length of chain attached to the anchor. The length of chain attached to the anchor will be less than 1.5 meters long. The chain will be piled next to the Danforth anchor, but will not be positioned on top of the anchor. Companies will receive 10 points when the anchor is lifted off the bottom. Lifting the anchor off the bottom is defined as having the anchor in control of the ROV so no part of the anchor is touching the bottom. The attached chain may still be lying on the bottom, but the anchor must be held completely above the bottom. Companies will receive an additional 15 points when the Danforth anchor and chain are returned to the surface, removed from the ROV, and placed on the pool deck.

The Danforth anchor and chain will weigh less than 100 Newtons in water.

The **MISSION PROP BUILDING INSTRUCTIONS & PHOTOS** contains prop building instructions. See the **EXPLORER mission SolidWorks** files for CAD representations of the missions.

If a company has successfully completed all 3 mission tasks and is returning to the surface with the final items to be removed from the pool (such as ceramic plate, agar, sensor string, bottles, the Danforth anchor & chain, etc.), mission time will stop when a member of the company touches the vehicle. Items on board the vehicle may be detached and set on the pool deck after the clock has stopped. If an item is subsequently dropped from the vehicle, time will not restart. That company will receive points for what they have accomplished but will not receive points for returning the dropped item, and therefore may not receive a time bonus.

PART 2: MISSION PROP BUILDING INSTRUCTIONS & PHOTOS

Task 1: SHIPWRECKS

There are three types of shipwrecks: wooden sailing schooners, steam-driven paddlewheel ships, and propeller-driven bulk freighters. Each shipwreck is constructed in the same way EXCEPT for the one feature that distinguishes it from the others.

Shipwreck type	**Distinguishing feature**
Wooden sailing schooner	Mast step
Steam-driven paddlewheels	Paddlewheel
Propeller-driven bulk freighters	Propeller

Shipwreck

The shipwreck is constructed out of ½-inch PVC. However, the exact diameter of the PVC framework is not important. Companies located outside of North America that do not have access to ½-inch PVC may substitute local PVC for ½-inch PVC pipe and connectors.

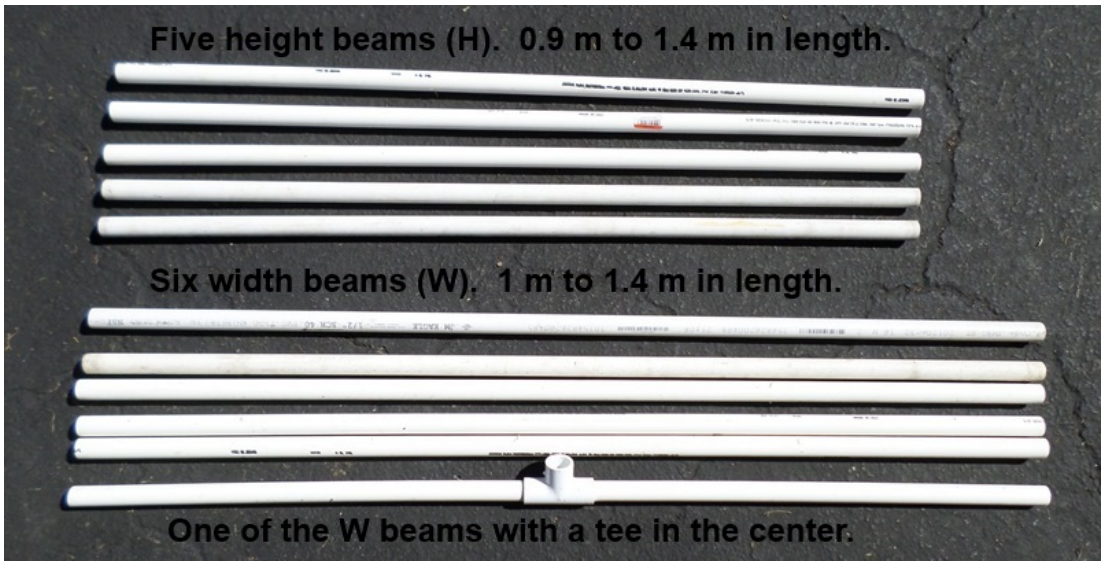
Since companies must measure the length, width, and height of the shipwreck, the lengths of PVC will vary throughout the construction. However, to keep the ship symmetrical, many lengths of ½-inch PVC pipe will be the same length.

1. Cut five equal lengths of ½-inch PVC pipe. The length of these pipes should be between 1 meter and 1.4 meters; all five pipes should be the same length.
2. Cut two lengths of ½-inch PVC. These lengths should be half the length of the previously cut pipe minus 2 cm. Insert both lengths of pipe into the side openings of a ½-inch PVC tee. The total length of these two shorter lengths of PVC pipe, inserted into the PVC tee, should be the same length as the five PVC lengths previously cut.
3. These six lengths of PVC pipe will serve as the horizontal cross beams of the ship, giving it its width. For future reference, the width of the horizontal cross beams will be referred to as W.

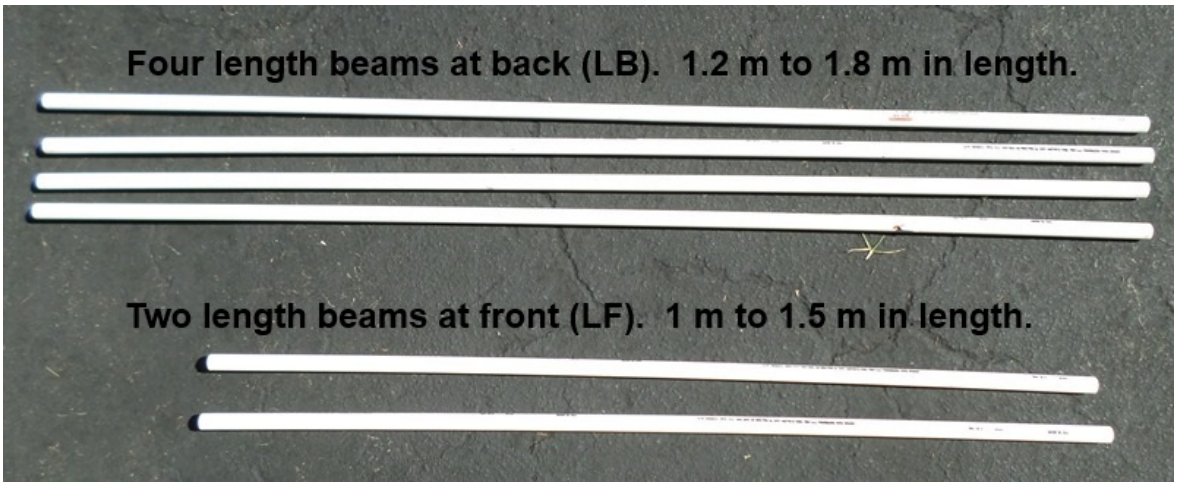
4. Cut five equal lengths of ½-inch PVC pipe. The length of these pipes should be between 0.9 meters and 1.4 meters; all five pipes should be the same length.
5. These five lengths of PVC pipe will serve as the vertical beams of the ship, giving it its height. For future reference, vertical beams will be referred to as H.

6. Cut two equal lengths of ½-inch PVC pipe. The length of these pipes should be between 1 meter and 1.5 meters; all three pipes should be the same length.
7. These three lengths of PVC pipe will serve as the horizontal length beams at the front of the ship, giving it part of its length. For future reference, the length of the horizontal beams at the front of the ship will be referred to as LF.

8. Cut four equal lengths of ½-inch PVC pipe. The length of these pipes should be between 1.2 meters and 1.8 meters; all four pipes should be the same length.
9. These four lengths of PVC pipe will serve as the horizontal length beams at the back of the ship, giving it the other part of its length. For future reference, the length of the horizontal beams at the back of the ship will be referred to as LB.



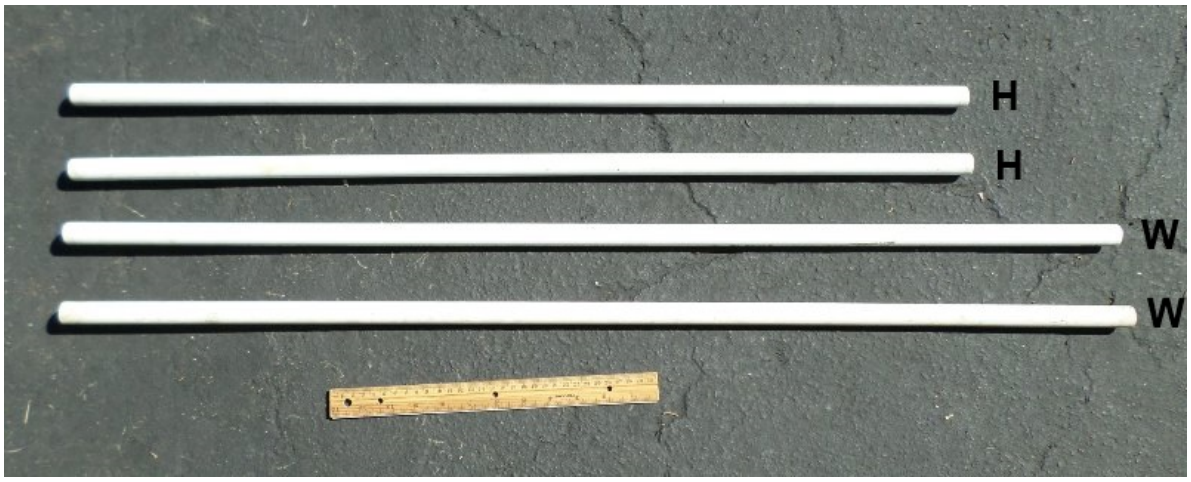
EXPLORER build photo #1: W and H beams.



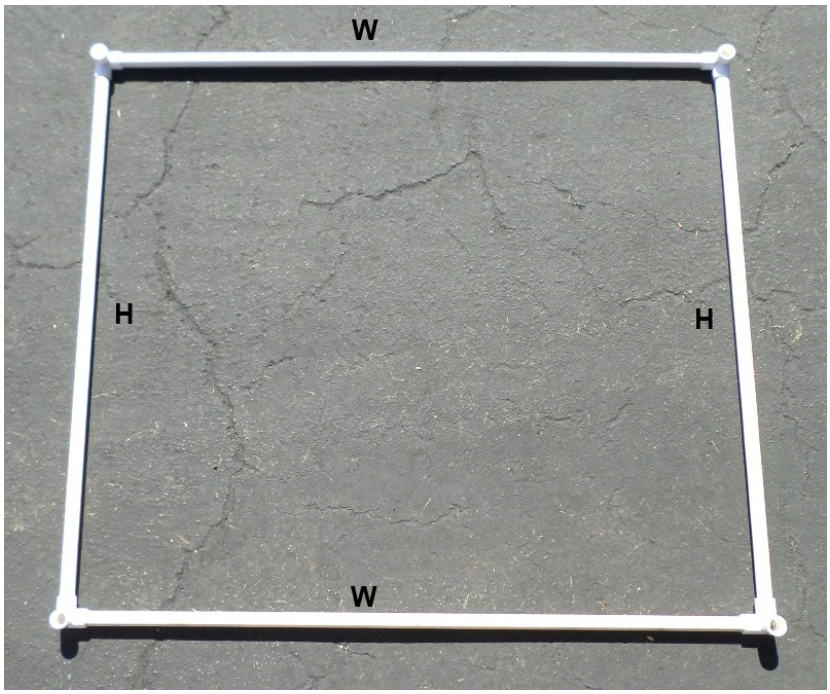
EXPLORER build photo #2: LF and LB beams.

To construct the shipwreck, start construction at the stern of the ship.

1. Take two W lengths of PVC pipe and two H lengths of PVC pipe. Connect them into a rectangle using ½-inch PVC side outs. The remaining opening on each ½-inch PVC side out should be facing the same direction.
2. Use small screws to secure the pipe into the PVC side outs.



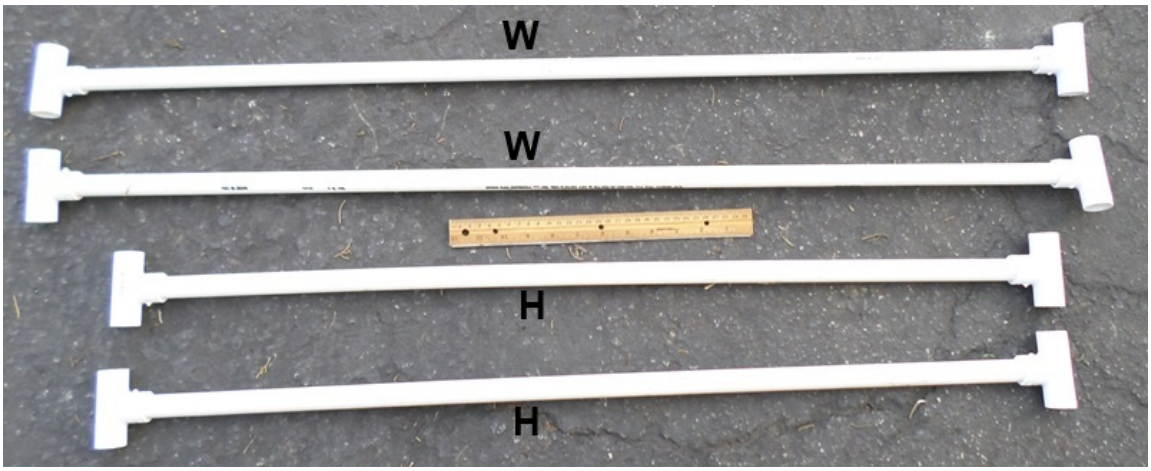
EXPLORER build photo #3: Components of stern cross section.



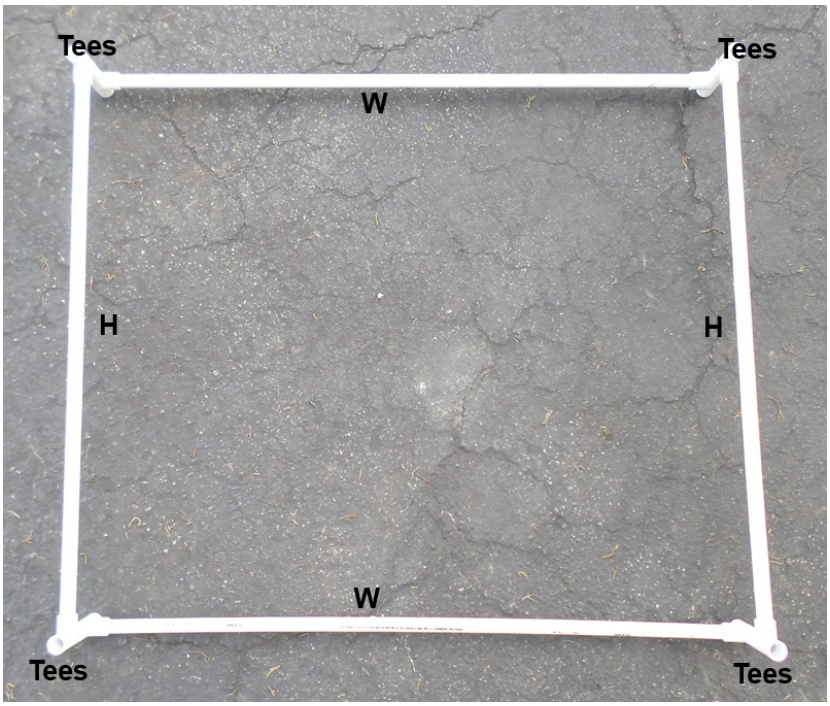
EXPLORER build photo #4: Stern cross section.

Next, construct the center cross section of the ship.

1. Take two W lengths of PVC pipe and two H lengths of PVC pipe. Attach the middle opening of a ½-inch PVC tees to each end of each length of pipe. There will be eight PVC tees attached to the ends of the four lengths of PVC pipe.
2. Cut four 3 cm length of ½-inch PVC pipe. Insert these 3 cm lengths of PVC pipe into one side opening at each end of the W lengths of PVC pipe.
3. Connect the side opening of the PVC tees on the H lengths of PVC pipe to the other end of the 3 cm lengths of PVC pipe. When connected properly, the center cross section should form a rectangle.
4. Use small screws to secure the pipe into the PVC tees.



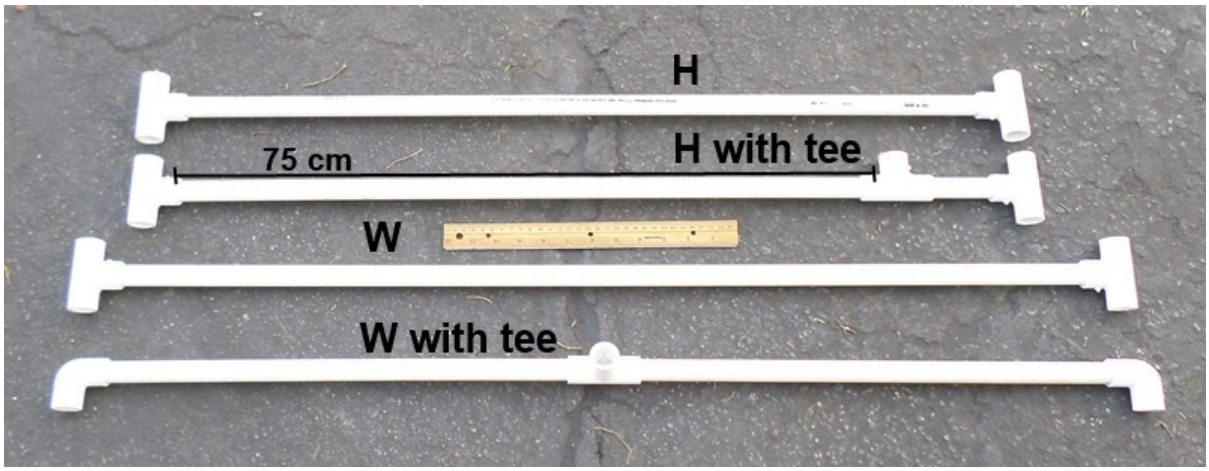
EXPLORER build photo #5: Components of center cross section.



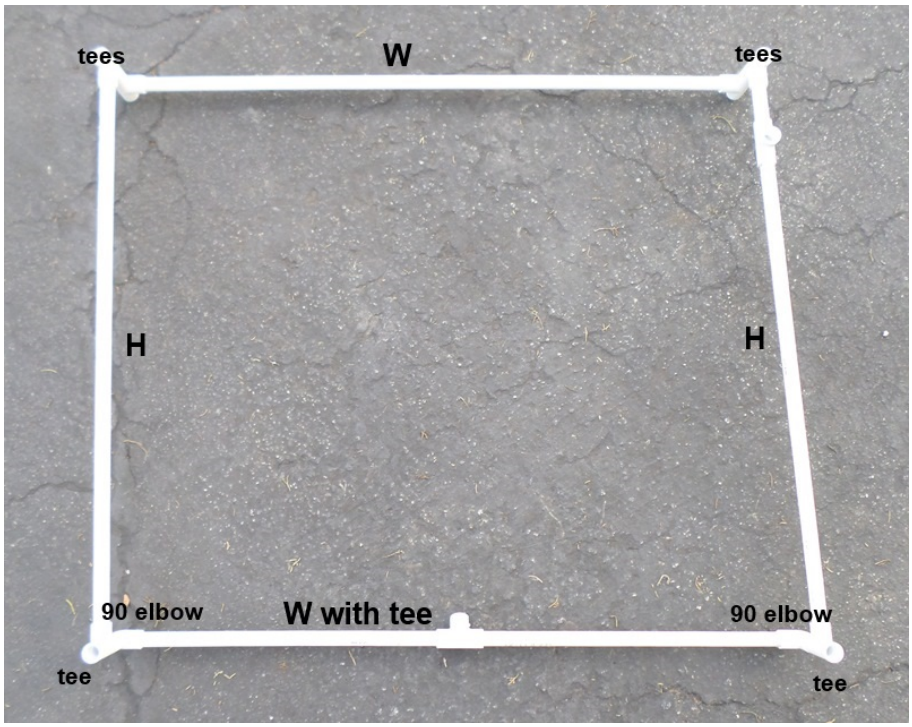
EXPLORER build photo #6: Center cross section.

Next, construct the bow cross section of the ship.

1. Take two W lengths of PVC pipe, including the W length with the ½-inch tee in the center, and one H length of PVC pipe.
2. Cut a 75 cm length of PVC pipe. Cut another length of PVC pipe equal to the length of the H pipe minus 79 cm. Attach the side opening of a PVC tee to this length of pipe; insert the 75 cm length of PVC pipe into the other side opening of the PVC tee. When both lengths are inserted into the PVC tee, the total length should equal the length of the H beams of PVC pipe. This combined length of PVC will be the sixth H length of PVC pipe.
3. Attach the middle opening of a ½-inch PVC tee to each side of both H lengths of PVC pipe. This will be four PVC tees attached to ends of the two H lengths of PVC pipe.
4. Cut four 3 cm lengths of ½-inch PVC pipe. Insert these 3 cm lengths of PVC pipe into one side opening at each end of the H lengths of PVC pipe.
5. Take the W length of PVC pipe with the ½-inch tee in the center. Attach a ½-inch 90^{o} PVC elbow to both ends of this W length of PVC pipe.
6. Take the final W length of PVC pipe and attach the middle opening of a ½-inch PVC tee to both ends.
7. Connect the side opening of the PVC tees on the W length of PVC pipe to the other ends of two of the 3cm lengths of pipes on the two different H lengths of pipe. Connect the remaining opening of the ½-inch 90^{o} PVC elbows to the other two lengths of 3 cm pipe. When connected properly, the bow cross section should form a rectangle.
8. Use small screws to secure the pipe into the PVC tees and elbows.



EXPLORER build photo #7: Components of bow cross section.

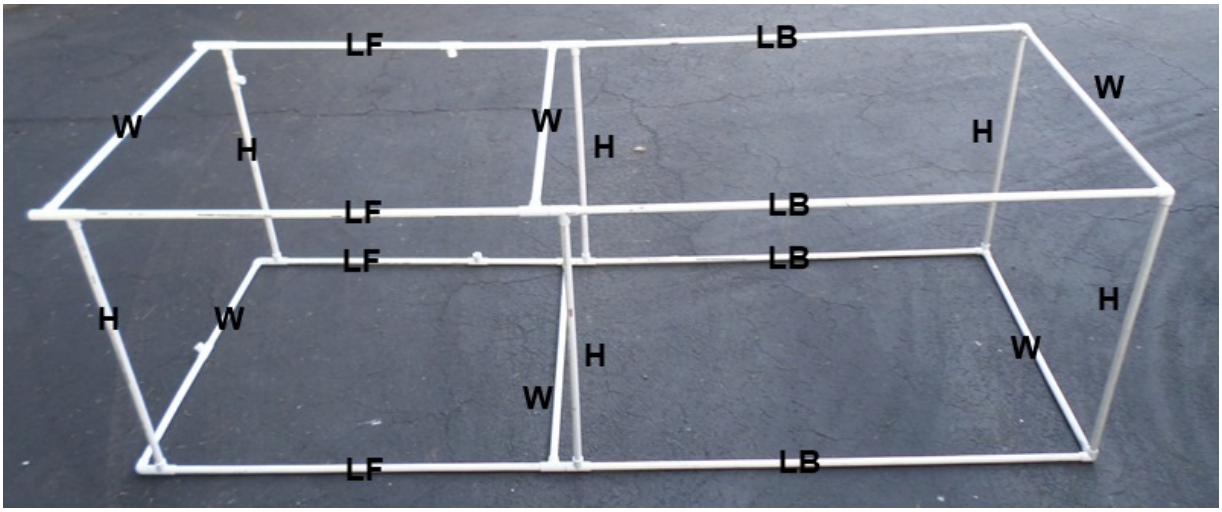


EXPLORER build photo #8: Bow cross section.

Continue building the shipwreck by adding the length beams.

1. Set the stern of the shipwreck with the opening of the ½-inch sideouts pointing up.
2. Take the four LB lengths of PVC pipe and insert them into the openings on the four ½-inch side outs.
3. Attach the center cross section of the shipwreck to the top of the four LB lengths of PVC pipe. Align the center cross section so the W and H lengths of pipe are symmetrical.

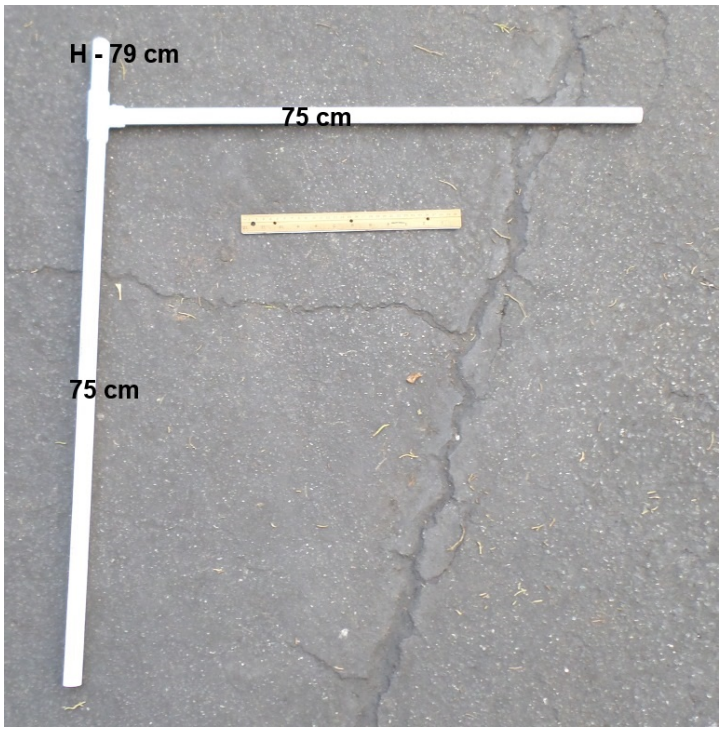
4. Cut two 75 cm lengths of ½-inch PVC pipe. Cut two lengths of PVC pipe equal to the length of the LF pipe minus 79 cm. Attach the side opening of a PVC tee to one end of each of these lengths of pipe (LF – 79 cm); two tees, one on each end of the two lengths of pipe. When combined with the PVC tee, these lengths of pipe should equal the LF length.
5. Insert the two combined LF pipes into one side of the shipwreck (into tees on either side of an H length of pipe on the center cross section). Insert the two LF lengths of pipe into the other two openings on the center cross section of the shipwreck.
6. Attach the bow cross section of the shipwreck to the four LF lengths of PVC pipe. Align the bow cross section so the W and H lengths of pipe are symmetrical. For the bow cross section, the W length of pipe with the ½-inch tee in the middle, and two 90° elbows, is considered the bottom of the ship.



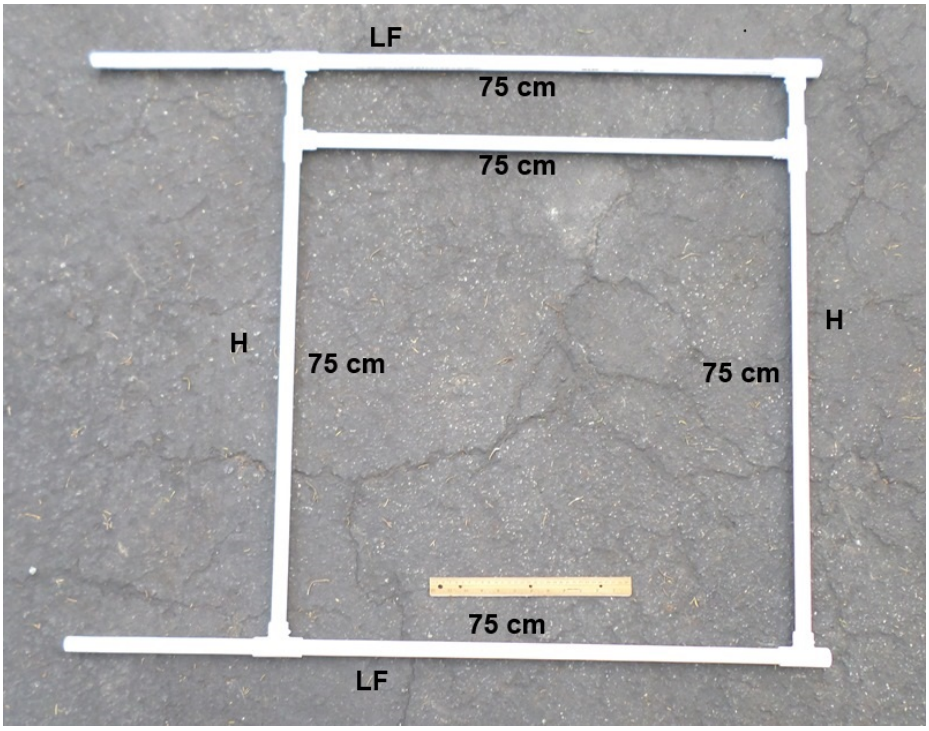
EXPLORER build photo #9: Shipwreck framework including the bow cross section (left), the center cross section (center), the stern cross section (right), the back lengths beams, and the front length beams.

Next, construct the 75 cm x 75 cm opening of the shipwreck.

1. Cut two 75 cm lengths of PVC pipe. Insert them in the side opening and the middle opening of a single PVC tee.
2. Insert the other side of one of the 75 cm lengths of PVC pipe into the middle opening of the tee on the H length of pipe in the bow cross section. Insert the end of the other 75 cm length of PVC pipe into the middle opening of the tee on the bottom LF length of PVC pipe. See #6 above for the "bottom" of the shipwreck. The remaining side opening of the PVC tee should be facing upwards (away from the bottom of the shipwreck).
3. Cut a length of pipe equal to H length minus 79 cm. Insert one end of this length of pipe into the tee on the top LF length of PVC pipe. The other end should fit into the open end of the tee on the 75 cm x 75 cm opening of the shipwreck.



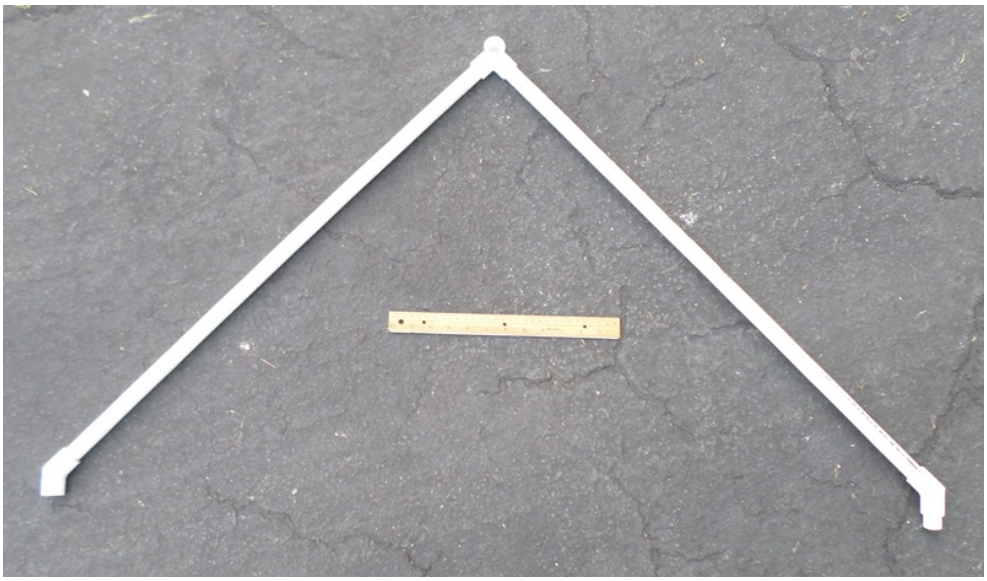
EXPLORER build photo #10: 75 cm x 75 cm opening components.



EXPLORER build photo #11: 75 cm x 75 cm opening.

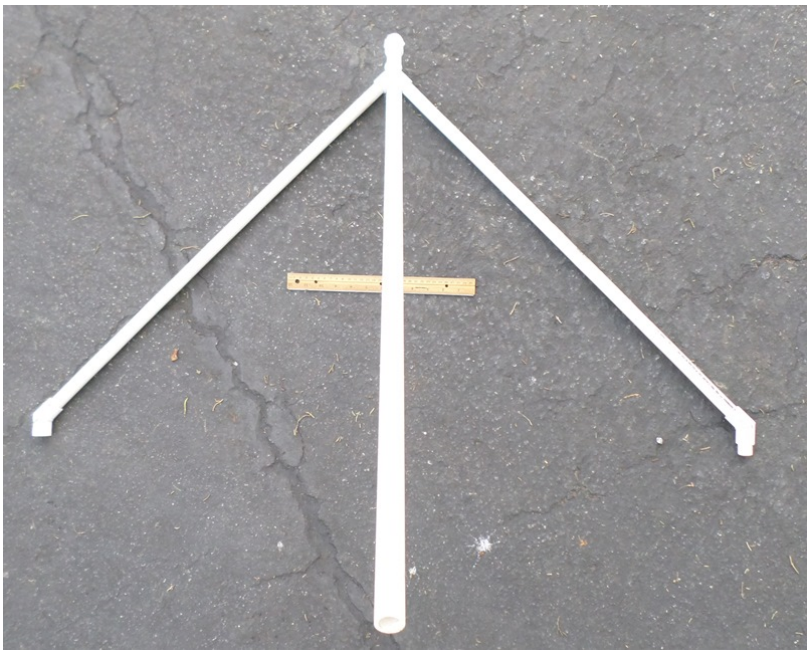
Next, add a point to the bow of the ship. To do this, the frame of the shipwreck should be positioned upright, so the 75 cm x 75 cm hole is on side of the shipwreck, at the bottom of the side panel. The bottom cross bar of the bow section should have a tee in the middle of it.

1. Cut two 3 cm lengths of PVC pipe. Insert these lengths of PVC into the side openings of the tees at the top, front corner of the shipwreck. Attach a ½-inch 45° PVC elbow to the other side of each 3 cm length of pipe. Rotate the open ends of the 45° elbows towards each other.
2. Cut two lengths of PVC pipe. Insert them into open ends of the 45° elbows. The lengths of these pipes should be cut so that the ends come together at a 90° angle in front of the ship. Cut them approximately 70% of the entire width W of the shipwreck.
3. Attach a ½-inch PVC side out to the two lengths of PVC pipe. The third opening of the side out should be pointed downwards.

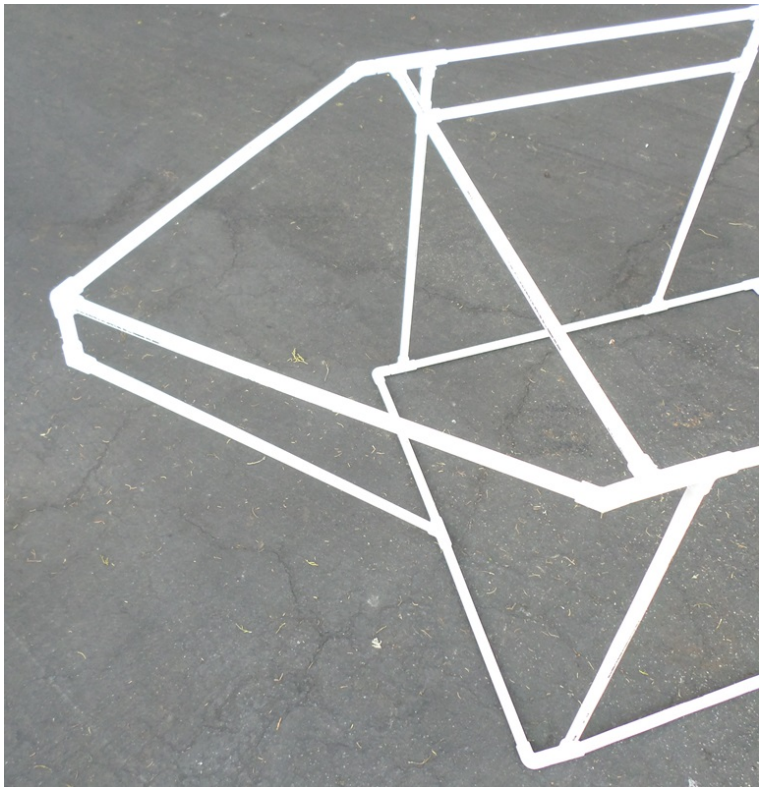


EXPLORER build photo #12: Bow point top components.

4. Cut a 10 cm length of PVC pipe. Insert this pipe into the downwards facing opening of the PVC side out. Attach a ½-inch 45° PVC elbow to the other end of this 10 cm length of pipe.
5. Cut a length of ½-inch PVC pipe. The length of this pipe should reach from the 45° elbow at the top front of the shipwreck frame to the tee in the center of the bottom cross bar of the bow section.



EXPLORER build photo #13: Bow point components.



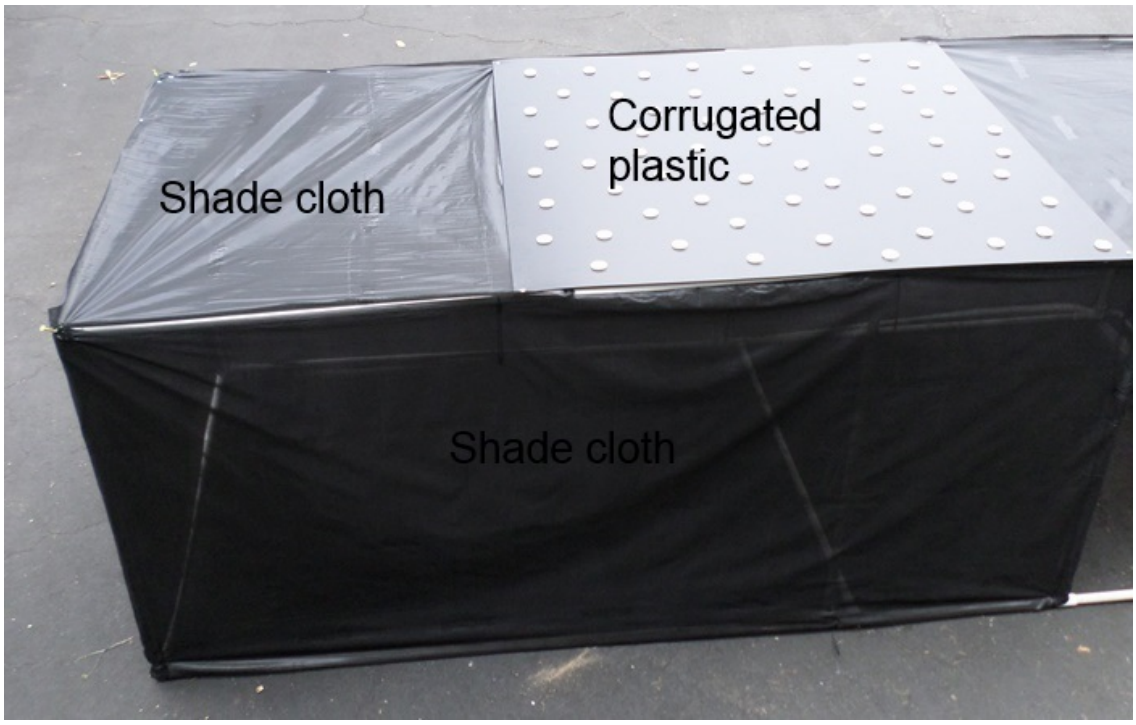
EXPLORER build photo #14: Bow point on shipwreck frame.

This completes the framework for the EXPLORER class shipwreck. To complete the shipwreck, add corrugated plastic sheeting and shade cloth to the top, sides, front, and back of the shipwreck frame.

1. Cut a 1.2 meter (or greater) by the width of shipwreck rectangle of corrugated plastic sheeting. A darker color (green, blue or black) of corrugated plastic works best.
2. Attach this rectangle of corrugated plastic to the top center of the shipwreck framework. Position it so it is braced by the top beam on the center cross section. Use small set screws to secure the corrugated plastic on the top of the shipwreck.
3. Cover the remaining top, sides, front and back of the shipwreck framework with black shade cloth. Make sure that the 75 cm x 75 cm hole is completely clear of shade cloth.

Design note: 1/8-inch ABS sheeting may be substituted for the corrugated plastic rectangle. Black plastic sheeting, corrugated plastic, or other plastic sheeting may be substituted for shade cloth.

Design note: We recommend using small set screws to hold the stern cross section, the center cross section and the bow cross section together. However, we do not recommend inserting small set screws into the pipes that give the shipwreck its length (LF and LB). That way these lengths can be easily removed to break down the shipwreck into smaller pieces for transport.



EXPLORER build photo #15: Shade cloth and corrugated plastic covering for shipwreck.

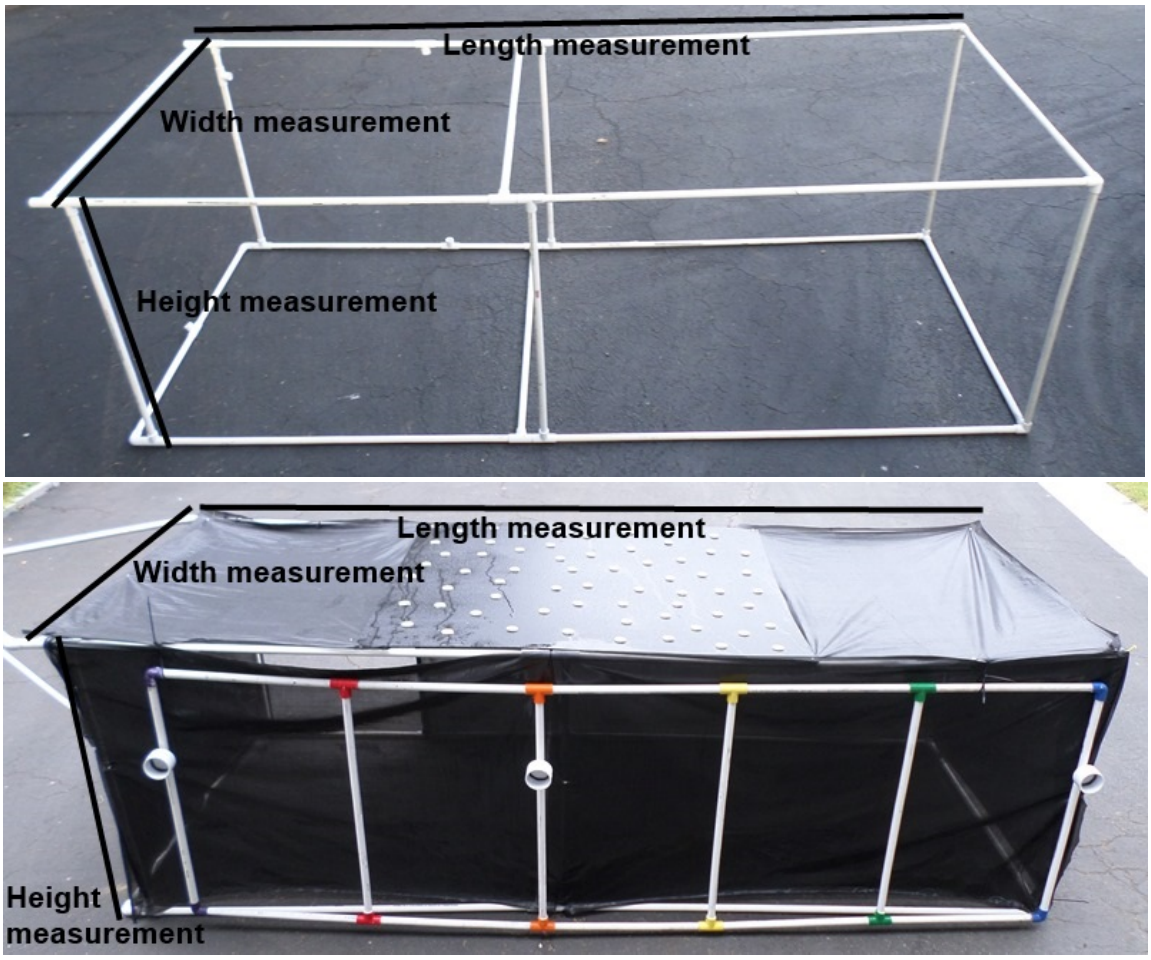
EXPLORER build photo #16: Shade cloth covering a corner of the shipwreck.

2 ½-inch wood screws will be set in the four top corners of the shipwreck framework. Insert four 2 ½-inch wood screws into corners of the shipwreck to serve as marker points.

1. Paint four 2 ½-inch wood screws with yellow paint and let them dry.
2. Insert two of the 2 ½-inch wood screw into the center of each PVC tee at the top corners of the bow cross section. The screw should go into the forward most tee at the top of bow cross section. Set the screw in at a 45^{o} angle to the top and side of the shipwreck.
3. Insert two of the 2 ½-inch wood screws into the ½-inch PVC side outs at the top corners of the stern cross section. Set the screw in at a 45^{o} angle to the top, side, and stern of the shipwreck.

EXPLORER build photo #17: 2 ½-inch, yellow painted wood screw inserted into stern corner of shipwreck.

Design note: The instructions given are the minimal amount of PVC needed for the shipwreck. Add extra W beams and H beams for added stability.



EXPLORER build photo #18: Dimensions to measure on the shipwreck.

Next, create the distinguishing features for each type of shipwreck.

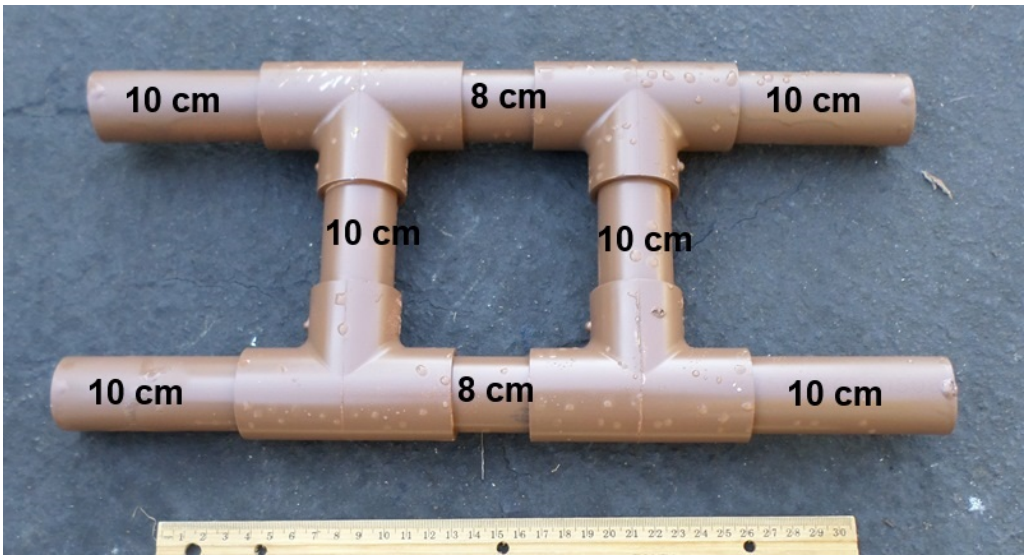
Masthead:

The mast head is constructed of 1-inch PVC pipe and four 1-inch PVC tees. To construct the wooden sailing schooner's mast head:

1. Cut six 10 cm lengths of 1-inch PVC pipe and cut two 8 cm lengths of 1-inch PVC pipe.
2. Attach the side opening of two 1-inch PVC tees to both ends of the 8 cm lengths of pipes, four tees in all. Twist the middle opening of the tees on each end of the pipe so they face the same direction.

3. Insert a 10 cm length of 1-inch PVC pipe into the middle openings of two tees on either side of one 8 cm length of pipe. Attach the two middle openings of the other 1-inch PVC tees to the other ends of these 10 cm lengths of pipe.
4. Insert the remaining four 10 cm lengths of 1-inch pipe into the four remaining side openings of the 1-inch PVC tees.
5. Paint the entire mast head brown.

Attach or set the mast head along the centerline of the top of the ship. The mast head should not be positioned on the corrugated plastic rectangle on the top of the ship.



EXPLORER build photo #19: Mast head.

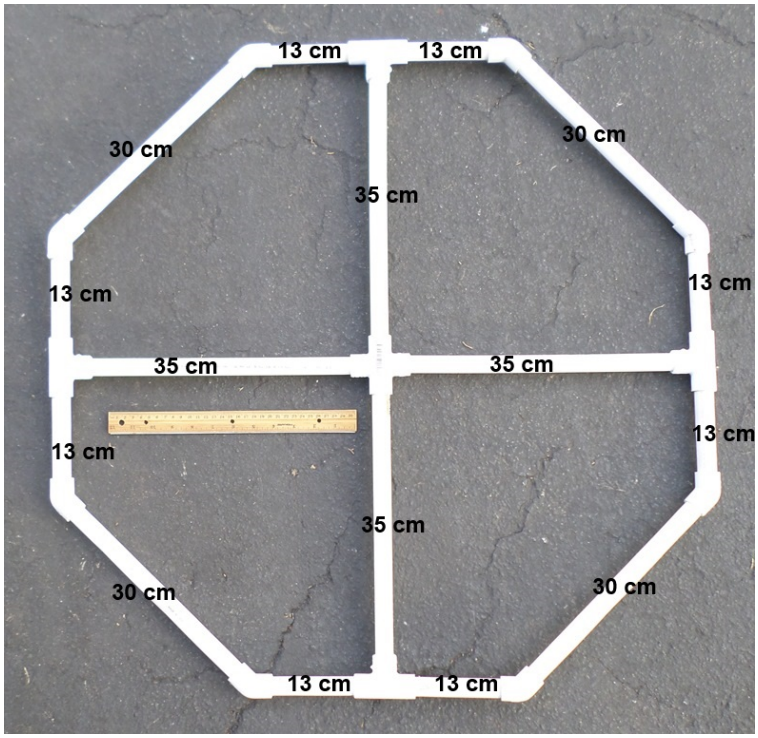
EXPLORER build photo #20: Mast head on top surface of the shipwreck.

Paddlewheel:

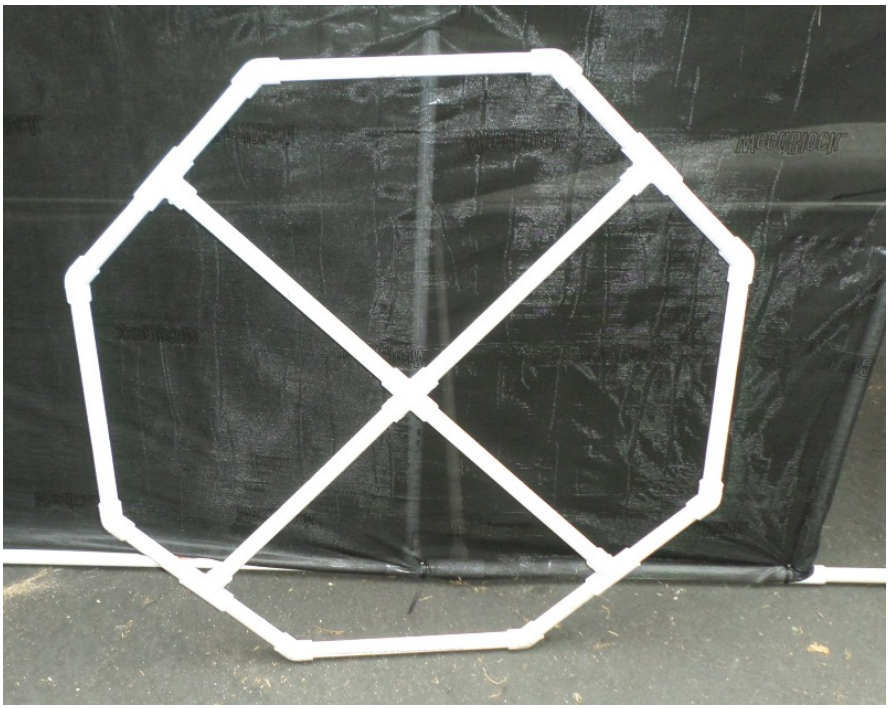
The paddlewheel is constructed of ½-inch PVC pipe connected with ½-inch 45° elbows. Four tees and a ½-inch PVC cross complete the paddlewheel. To construct the steam-driven paddlewheel ship's paddlewheel:

1. Cut four 30 cm lengths of ½-inch PVC pipe. Cut four 35 cm lengths of ½-inch PVC pipe. Cut eight 13 cm lengths of ½-inch PVC pipe.
2. Insert two 13 cm lengths of pipe into the side openings of a PVC tee. The two 13 cm lengths of pipe joined with a tee should equal the length of 30 cm. Repeat this process for the other 13 cm lengths of pipe, creating four 30 cm joined pipes total.
3. With the eight 30 cm lengths of PVC pipe, four cut to 30 cm, four joined with a tee, create an octagon using eight ½-inch 45° PVC elbows. When creating the octagon, alternate between the 30 cm cut pipes and the 30 cm joined pipes.
4. Rotate the four PVC tees so their middle openings all face inwards. Insert the four 35 cm lengths of PVC pipe into the four middle openings of the PVC tees.
5. Attach a ½-inch PVC cross at the center point of the octagon, where all four 35 cm lengths of pipe come together.

Position the octagon on the side of the shipwreck. It should be placed on the same side as the 75 cm x 75 cm opening, but should not block or in any way cover the opening. Companies will not have to move the paddlewheel to gain access to the inside of the shipwreck.



EXPLORER build photo #21: The paddlewheel.



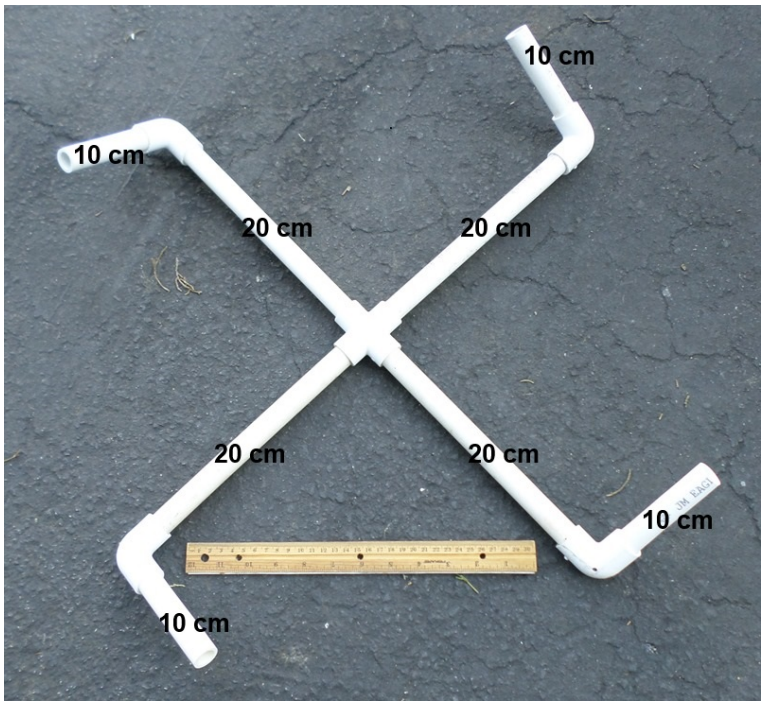
EXPLORER build photo #22: The paddlewheel on the side of the shipwreck, positioned near the 75 cm x 75 cm opening.

Propeller:

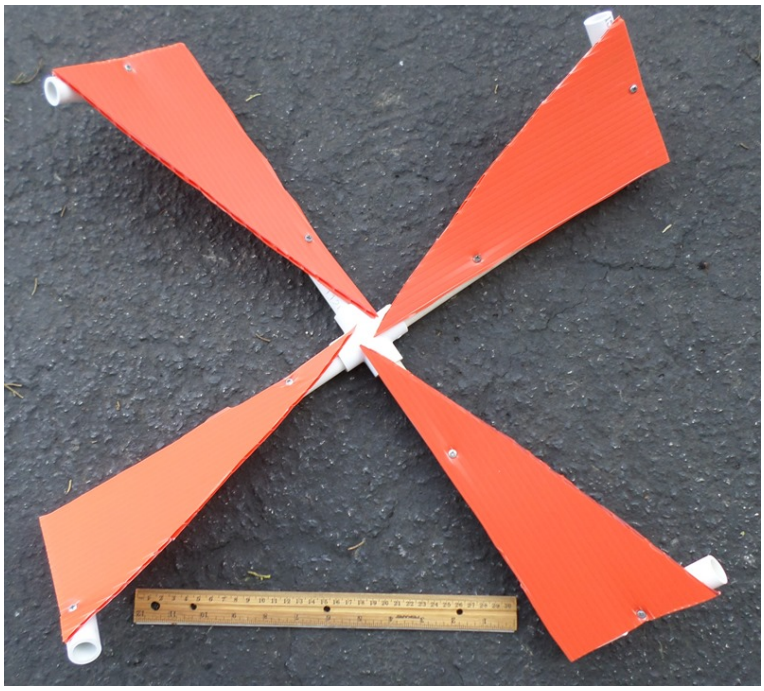
The propeller is constructed out of ½-inch PVC pipe and corrugated plastic sheeting. To construct the propeller driven bulk freighter's propeller:

1. Cut four 25 cm lengths of ½-inch PVC pipe. Cut four 10 cm lengths of ½-inch PVC pipe.
2. Insert the four 25 cm lengths of pipe into the four openings of a ½-inch PVC cross. Attach a 90^{o} PVC elbow to the other end of each length of pipe. As the cross sits flat on the ground, rotate each elbow so the other opening is facing counterclockwise to the 25 cm length of pipe. Also rotate the elbow so it faces approximately 20^{o} up from the ground. Use small set screws to secure the angles on all of the pipes.
3. Cut four right triangular sections of corrugated plastic sheet. The dimensions of the sides adjacent to the 90^{o} angle of the right triangle should be 25 cm x 10 cm.
4. Use screws to secure the corrugate plastic to the PVC pipe.

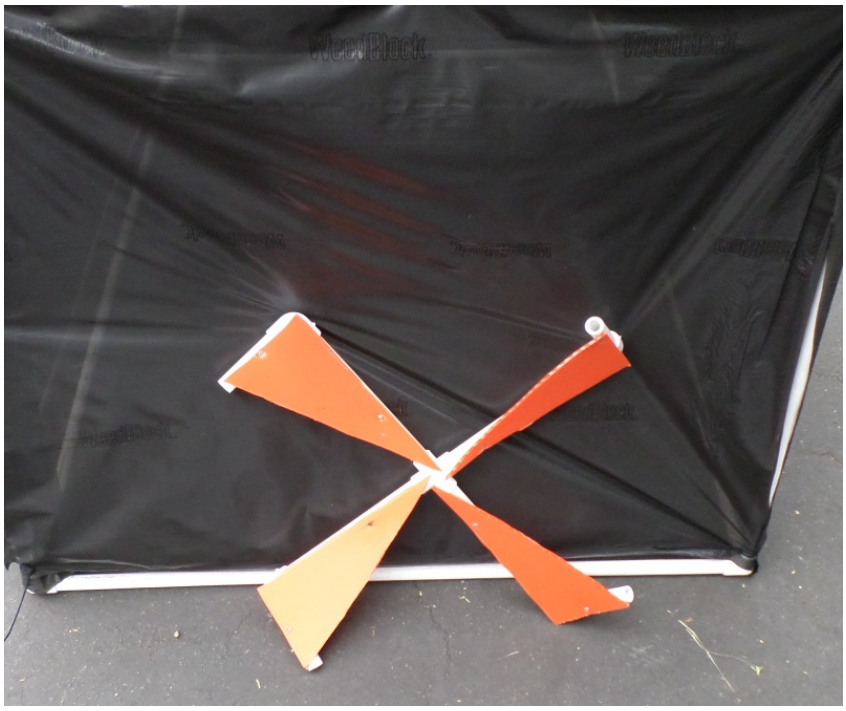
Position the propeller on the stern of the shipwreck.



EXPLORER build photo #23: The framework of the propeller.



EXPLORER build photo #24: The propeller.



EXPLORER build photo #25: The propeller at the aft of the shipwreck.

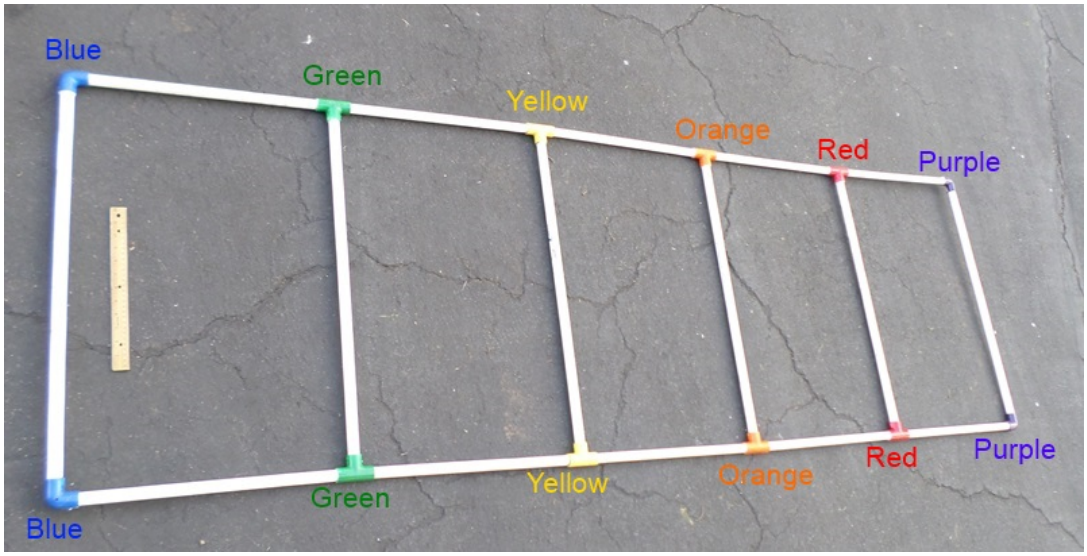
Photomosaic snapshot locations:

The five snapshot locations are a grid constructed of white ½-inch PVC pipe with colored joints at the four corners of each snapshot location.

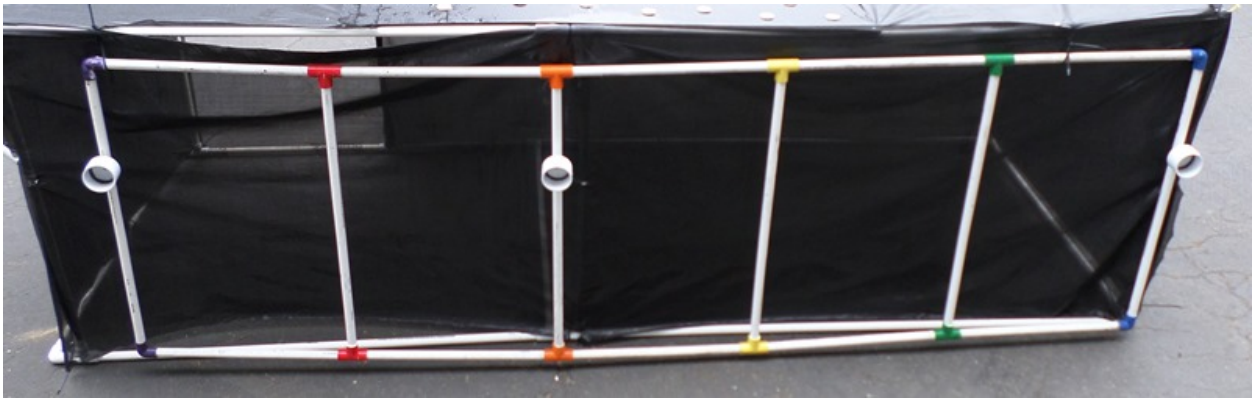
1. Paint two ½-inch PVC 90^{o} elbows purple.
2. Paint two ½-inch PVC tees red.
3. Paint two ½-inch PVC tees orange.
4. Paint two ½-inch PVC tees yellow.
5. Paint two ½-inch PVC tees green.
6. Paint two ½-inch PVC 90^{o} elbows blue.
7. Cut six 75 cm lengths of ½-inch PVC pipe. Attach the two purple elbows to the ends of one 75 cm length of PVC pipe. Attach the middle opening of the two red PVC tees to the ends of one 75 cm length of PVC pipe. Attach the middle opening of the two orange PVC tees to the ends of one 75 cm length of PVC pipe. Attach the middle opening of the two yellow PVC tees to the ends of one 75 cm length of PVC pipe. Attach the middle opening of the two green PVC tees to the ends of one 75 cm length of PVC pipe. Attach the two blue elbows to the ends of one 75 cm length of PVC pipe.
8. Cut ten 50 cm lengths of ½-inch PVC pipe. Insert two of the 50 cm lengths of pipe into the open ends of the purple 90^{o} PVC elbows. Attach the side openings of the two red PVC tees to the other ends of these 50 cm pipes.
9. Insert two of the 50 cm lengths of pipe into the remaining side openings of the red PVC tees. Attach the side openings of the two orange PVC tees to the other ends of these 50 cm pipes.

10. Insert two of the 50 cm lengths of pipe into the remaining side openings of the orange PVC tees. Attach the side openings of the two yellow PVC tees to the other ends of these 50 cm pipes.
11. Insert two of the 50 cm lengths of pipe into the remaining side openings of the yellow PVC tees. Attach the side openings of the two green PVC tees to the other ends of these 50 cm pipes.
12. Insert two of the 50 cm lengths of pipe into the remaining side openings of the green PVC tees. Attach the open ends of the two blue 90° PVC elbows to the other ends of these 50 cm pipes.

Position the grid on the vertical side opposite the 75 cm x 75 cm opening.



EXPLORER build photo #26: The photomosaic grid.

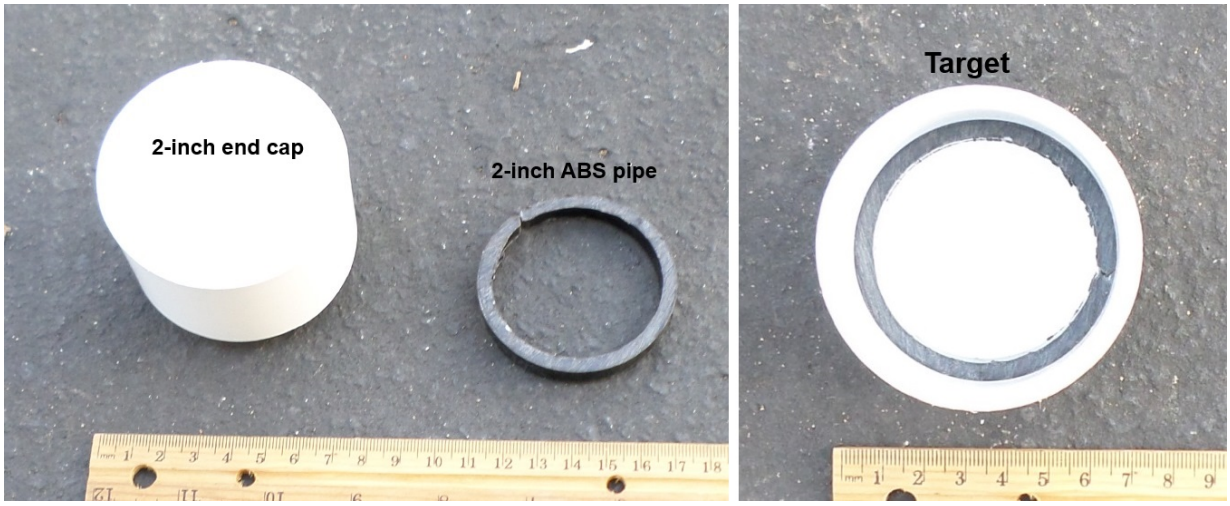


EXPLORER build photo #27: The photomosaic grid attached to the side of the shipwreck.

Targets:

Sonar scan targets are constructed from a white, 2-inch PVC end cap with a ring of black, 2-inch ABS pipe set inside the cap.

1. Cut a 1 cm length of 2-inch black ABS pipe. Use a saw or heavy wire cutters to cut a 1 to 2 mm section from ABS ring.
2. Insert this ABS ring into the end cap, as close to the bottom as possible.
3. Repeat this process two more times to create three targets.

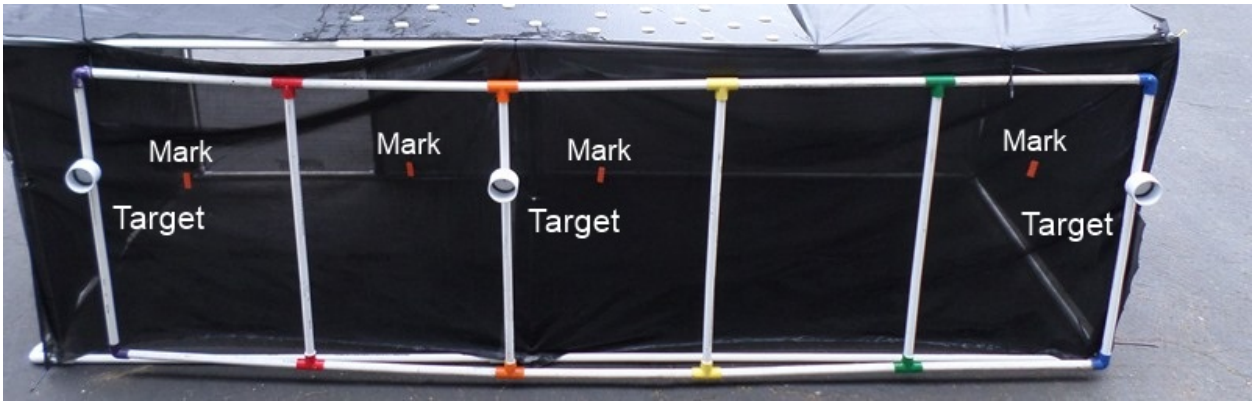


EXPLORER build photo #28: Scan target.

Design note: If ABS is unavailable in your area, cut a 1 cm length of 2-inch PVC and paint it black before inserting it inside the 2-inch PVC end cap.

4. Use a screw to fasten the first target onto the PVC pipe of the photomosaic grid. The first target should go on the left most vertical beam, between the two purple 90^{o} PVC elbows. Position the target approximately halfway between the two purple elbows.
5. Use a screw to fasten the second target onto another vertical beam of the photomosaic grid. The second target should go on a beam in the center, either between the two yellow tees or the two green tees. Position the target approximately half way between the two tees.
6. Use a screw to fasten the third target onto another vertical beam of the photomosaic grid. The third target should go on the right most vertical beam, between the two blue 90^{o} PVC elbows. Position the target approximately half way between the two blue elbows.
7. Cut four 3 cm x 1 cm rectangles of red, yellow or orange corrugated plastic. Glue/epoxy them to the shade cloth 25 cm on either side of the targets. The middle target has a rectangle mark 25 cm on either side. The two other targets only have one rectangle mark 25 cm on one side of them.

EXPLORER build photo #29: The "scan" target with a mark (orange) 25 cm to the side.



EXPLORER build photo #30: Three "scan" targets attached to the photomosaic grid.

Cargo container:

The cargo container is constructed from a milk crate. These specifications use a *Dean Foods* milk crate with a diamond pattern of holes on the sides. If your milk crate has different specifications, or you do not have access to a milk crate, you may need to modify your design. Contact the Competition Technical Manager if you need assistance in making modifications.

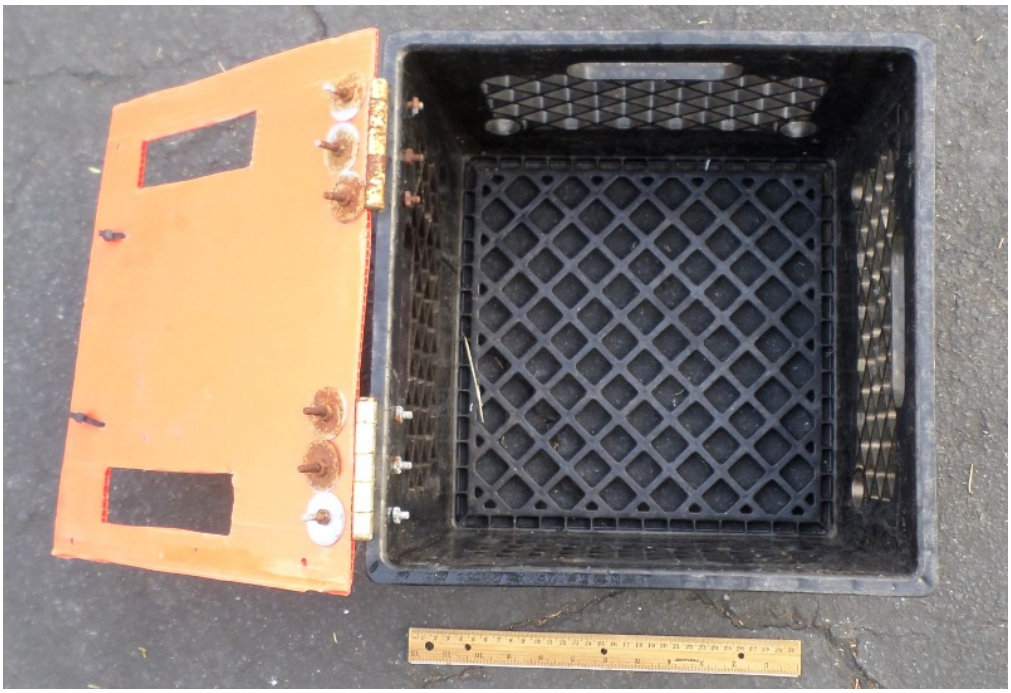
Design note: The cargo container is similar to, and uses many of the same pieces as, the mooring platform from the 2013 mission.

To construct the cargo container:

1. Cut a 34 cm by 32 cm sheet of corrugated plastic.
2. Draw a line 4.5 cm from one edge of the plastic sheeting towards the center. Draw another line 19.5 cm from the same edge towards the center. Draw a line 3.5 cm and 7.5 cm from each adjacent edge of the corrugated plastic towards the center. There should be lines marking two

4 cm by 15 cm rectangular areas. Use a box cutter to cut out these two 4 cm by 15 cm rectangular holes into the corrugated plastic.

3. Use two 3-inch brass hinges to secure the corrugated plastic sheet over the open side of the milk crate. These hinges should be placed on the edge furthest away from the holes.
4. 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.
5. 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.
6. 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 to the mooring platform.
7. 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.
8. 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.



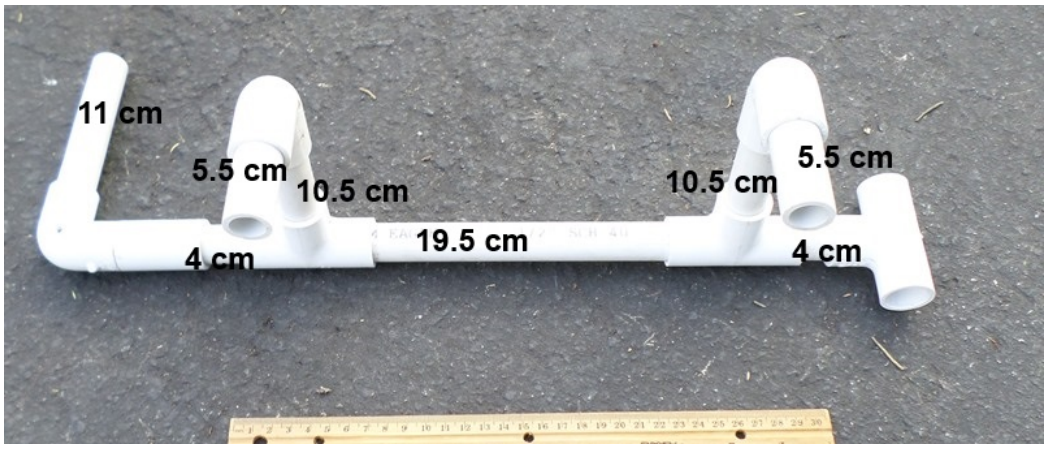
EXPLORER build photo #31: Cargo container without the locking mechanism or the stand.

Handle and locking mechanism:
The door of the cargo container includes a handle and locking mechanism, which are constructed from ½-inch PVC pipe. The handle must be turned to remove the locking mechanism before the top hatch can be opened.

To construct the locking mechanism and handle:

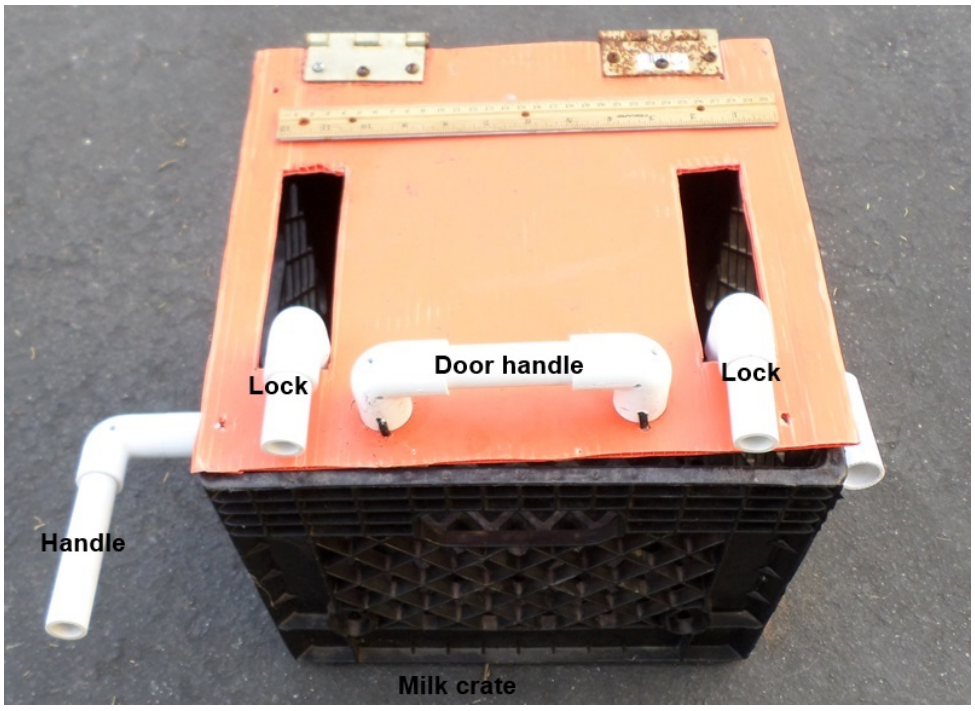
1. Cut a 19.5 cm length of ½-inch PVC pipe. Attach the side opening of a ½-inch PVC tee to each end of the 19.5 cm length of pipe. Align the PVC tees so their middle openings face the same direction.
2. Cut two 10.5 cm lengths of PVC pipe. Insert these 10.5 cm lengths of pipe into the middle openings of each PVC tee. Attach a ½-inch 90^{o} PVC elbow to the end of each 10.5 cm length of PVC. Insert a 5.5 cm length of ½-inch PVC into the open end of each elbow. Align the 90^{o} PVC elbows so that as the PVC tees lay flat on the ground, the 5.5 cm lengths of PVC stick straight up into the air.
3. Cut two lengths of 4 cm length of ½-inch PVC pipe and insert them into the side openings of the two PVC tees. As the locking mechanism lies flat on the ground, with the 5.5 cm lengths of pipe sticking straight up, a middle opening of a PVC tee will attach to the 4 cm length of PVC pipe on the right hand side of the locking mechanism. A ½-inch PVC coupling will attach to the 4 cm length of PVC pipe on the left hand side of the locking mechanism.
4. Before attaching the tee and coupling, fit the locking mechanism inside the milk crate. The 4 cm lengths of PVC pipe should fit into a diamond shaped hole on the sides of the *Dean Foods* milk crate. The PVC pipe should fit into the top most full diamond hole under the handle of the top hatch of the mooring.
5. Attach the middle opening of the PVC tee to the 4 cm length of pipe on the right side of the locking mechanism. Attach the ½-inch coupling to the 4 cm length of pipe on the left side of the locking mechanism.
6. Cut a 3 cm length of ½-inch PVC pipe and insert it into the open end of the ½-inch coupling. Attach a ½-inch 90^{o} PVC elbow to the other end of the 3 cm length of pipe.
7. Cut an 11 cm length of ½-inch PVC pipe. Insert this 11 cm length of pipe into the open end of the 90^{o} PVC elbow.
8. Twist the 90^{o} PVC elbow until the 11 cm length of pipe is parallel two 5.5 cm length of pipes.

As an ROV turns the handle, the locking mechanism should rotate into or out of the holes cut into the corrugated plastic sheeting. If the corrugated plastic hinders the PVC locking mechanism, readjust the position or enlarge the holes. The locking mechanism should engage and disengage freely without brushing against the corrugated plastic top.



EXPLORER build photo #32: Locking mechanism for the cargo container.

EXPLORER build photo #33: Locking mechanism inside the milk crate.

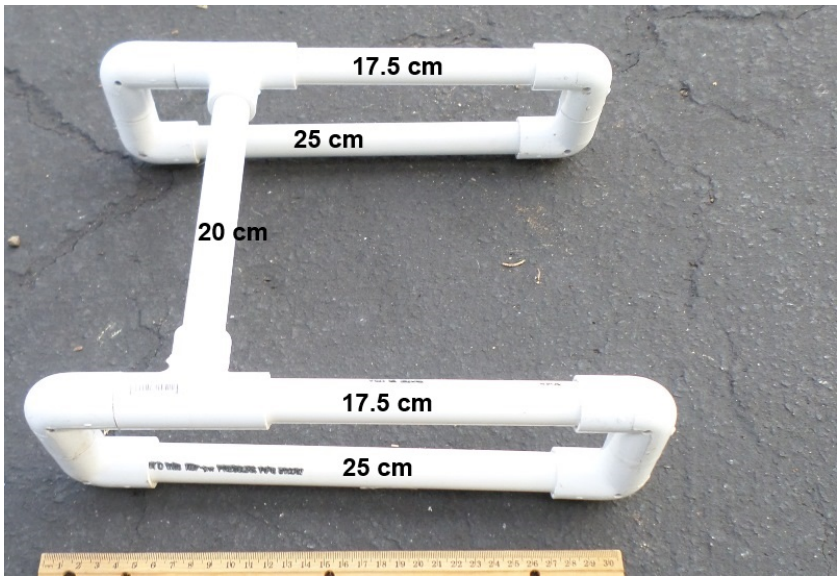


EXPLORER build photo #34: Cargo container, closed and locked.

The cargo container will be positioned so the door is located on the side of the container. The handle of the locking mechanism will be on top of the cargo container. Construct a small platform for it to sit on so the locking mechanism can move unhindered. To construct the platform:

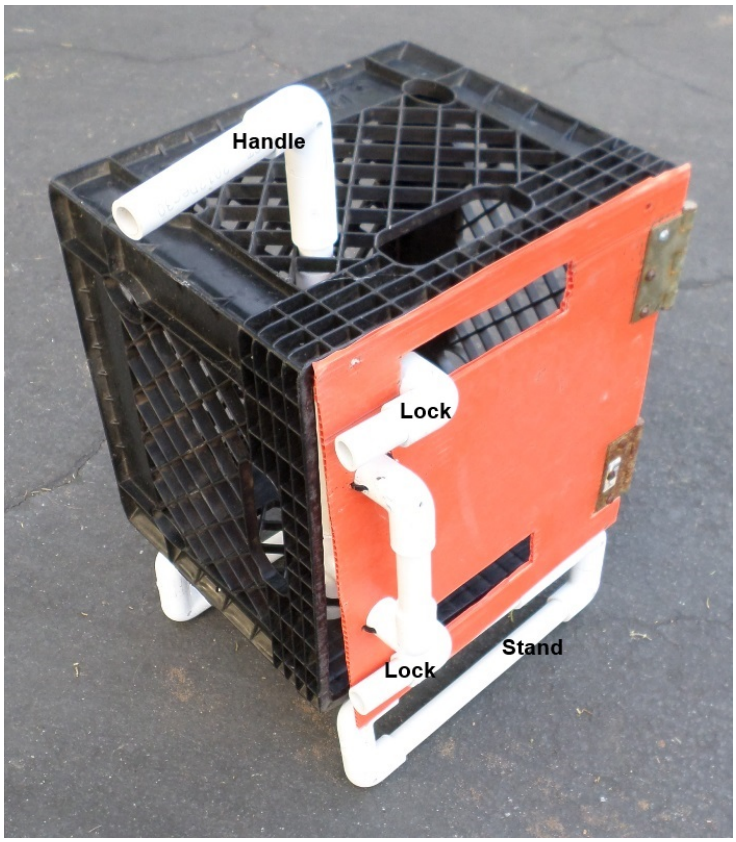
1. Cut two 25 cm lengths of ½-inch PVC pipe. Attach a 90° PVC elbow to each end of the 25 cm lengths of pipe, four elbows in all. Twist the elbows on each end of pipe so the open end faces the same direction.
2. Cut four 3 cm lengths of ½-inch PVC pipe. Insert these four lengths of pipe into the open ends of each of the four 90° elbows. Attach another 90° PVC elbow to the end of each 3 cm length of PVC pipe.
3. Cut two 3 cm lengths of ½-inch PVC pipe. Cut two 17.5 cm lengths of ½-inch PVC pipe.
4. Insert a 3cm length and a 17.5 cm length of PVC pipe into the side openings of a PVC tee. Repeat this process with the other 3 cm and 17.5 cm length of pipe. This combination of 17.5 cm pipe, tee, and 3 cm length of pipe should measure 25 cm in length. Insert this combination 25 cm length of PVC pipe into the two open ends of the 90° elbows. Twist the tees so the middle openings face each other.
5. Cut a 20 cm length of PVC pipe. Attach the two middle openings of each PVC tee to the ends of this 20 cm length of pipe.

This should form a small stand approximately 10 cm tall that can be attached to the bottom of the milk crate. Add weight to secure the cargo container to the pool bottom.



EXPLORER build photo #35: Stand for cargo container.

6. Use small set screws to keep the PVC pipe from moving inside the joints. Attach this stand to side of the milk crate cargo container that has the PVC tee side of the locking mechanism. This will be the bottom side of the cargo container that sits on the pool bottom.



EXPLORER build photo #36: Cargo container, locked, on stand.

Cargo:

The cargo consists of black painted ½-inch PVC tees for coal and yellow painted ½-inch PVC tees for grain. The painted tees will sit inside a smaller container inside the milk crate. The smaller container can be created from a coffee can, large plastic butter tub or other easy to find container. The container must be small enough that it does not interfere with the locking mechanism. The smaller container will be painted black on the outside so the contents, colored tees, will not be visible until the cargo container is opened. The inside of the container will be painted the corresponding color as the cargo (yellow for grain, black for coal).

1. Paint the outside of the container black.
2. Paint the inside of the container the color corresponding to the cargo.
3. Use a cable tie to attach the container to the back of the milk crate. Make sure the container does not interfere with the locking mechanism.
4. Paint 5 PVC tees the color that corresponds to the cargo. Glue the 5 PVC tees inside the container.

EXPLORER build photo #37: Cargo container open with grain cargo (yellow) inside.

Rope debris:

Construction of the rope debris will be described in mission Task #3.

Ship build date:
The ship build date is constructed from 2-inch lettering set onto a 15 cm x 4 cm plastic rectangle. The plastic can be corrugated plastic, 1/8-inch ABS sheeting, or other flat plastic surface.

1. Cut a 15 cm x 4 cm rectangle from a flat plastic sheet.
2. Attach 2-inch lettering to in the center of the 15 cm length to specify the build date of the ship.
3. Attach with screws, the plastic rectangle onto an inner beam of the shipwreck so the date faces the back (stern) of the shipwreck.

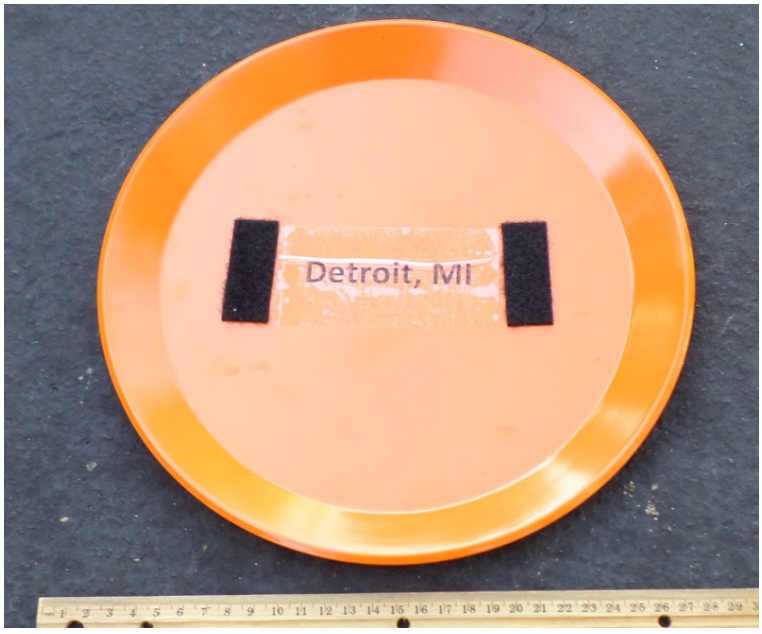
EXPLORER build photo #38: Ship build date.

Ceramic dinner plate:
The ceramic dinner plate is simulated by a dense, negatively buoyant, plastic plate. These specifications use an orange, hard plastic plate found at Target stores, but you can also find these types of plates at other stores or online. The home port city of the shipwreck is printed on the plastic plate and covered by a 15 cm x 6 cm rectangle constructed from 1/8-inch ABS sheeting. The ABS rectangle is held onto the plate by small Velcro strips and completely covers the printing on the plate itself. The plastic plate will be sitting on bottom of the pool inside the shipwreck.

To construct the plate:

1. Print out a 10 cm x 5 cm sticker that is labeled with the home port city. Apply the sticker to the center of the plastic plate. Alternatively, use a sharpie to write the home port city on the center of the plate, staying within a 10 cm x 5 cm area.
2. Cut two 5 cm x 2 cm rectangles of Velcro loops. Attach the Velcro loop rectangles on either side of the printed sticker.
3. Cut a 15 cm x 6 cm rectangle of 1/8-inch ABS sheeting.
4. Cut two 5 cm x 1 cm rectangle of Velcro hooks. Attach the Velcro hook rectangles on the ends of the rougher side of the 1/8-inch ABS rectangle.
5. Attach the ABS rectangle over printed sticker, connecting the Velcro loops to the Velcro hooks.

EXPLORER build photo #39: Ceramic plate with cover on.



EXPLORER build photo #40: Ceramic plate with cover off.

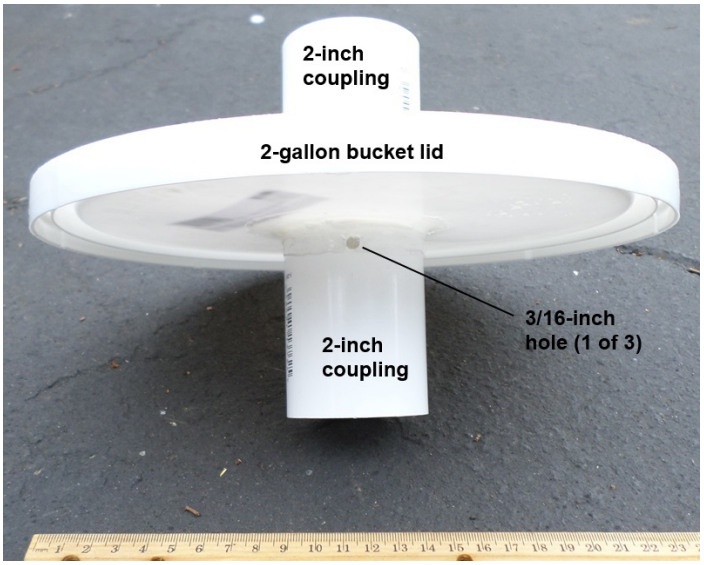
Task 2: SCIENCE

The sinkhole consists of venting groundwater and microbial mats.

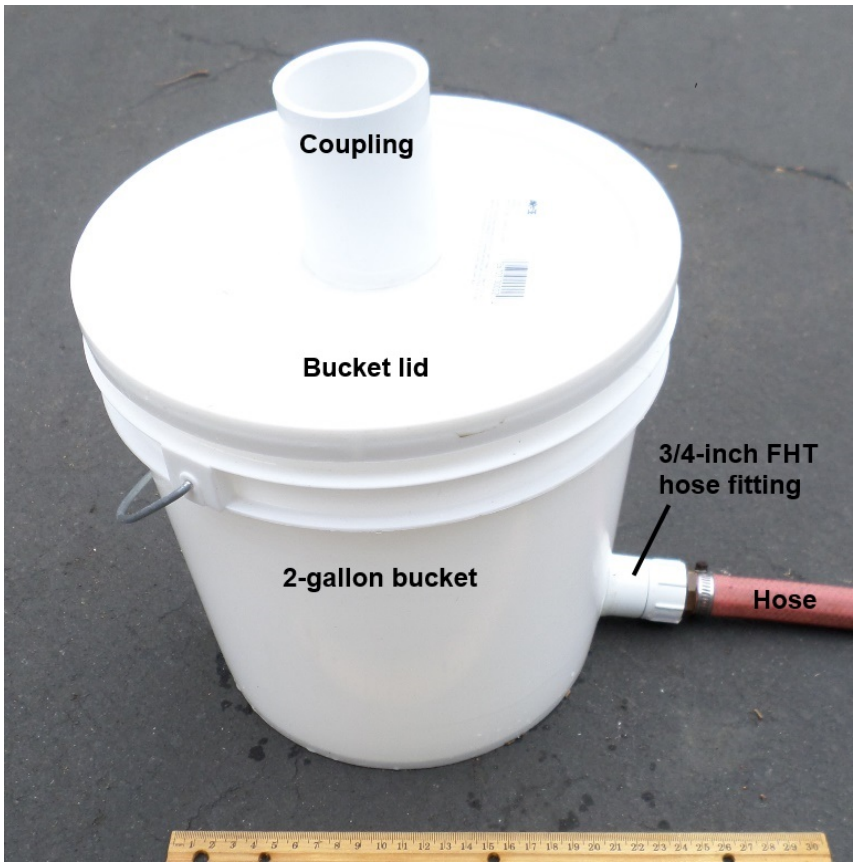
Groundwater venting from the sinkhole:

The groundwater venting from the sinkhole is simulated by a 1 ½-inch coupling and pipe set into the lid of a 2-gallon bucket. Saline water will slowly fill the bucket through a hose coming down from the surface. A bilge pump set into a reservoir of salt water on the surface, in a 5-gallon bucket or other container, will be used to continuously and slowly fill the 2-gallon bucket on the pool bottom. As salt water is denser than pool water, the salt water will slowly spill out over the top as it is pumped into the bottom of the bucket. To construct the groundwater venting from the sinkhole:

1. Cut or drill a hole in the top center of a 2-gallon bucket lid. The hole should be just large enough to fit a length of 1 ½-inch PVC pipe.
2. Cut a 5 cm length of 1 ½-inch PVC pipe. Attach a 1 ½-inch coupling to one side of the 5 cm length of pipe. Push the pipe through the hole in the lid of the 2-gallon bucket. Attach another 1 ½-inch coupling to the other end of the pipe. This will secure the couplings to both sides of the bucket lid.
3. Use silicone sealant or caulking to make the outside of the 1 ½-inch pipe water tight.
4. Cut or drill a hole in the side of a 2-gallon bucket near the bottom edge. The hole should be just large enough to fit a length of ¾-inch PVC pipe.
5. Cut a 4 cm length of ¾-inch PVC pipe. Attach a ¾-inch coupling to one side of the 4 cm length of pipe. Push this length of pipe through the hole in the side wall of the bucket from the inside out; the coupling should be inside the bucket.
6. Attach a ¾-inch slip x FHT PVC hose fitting to the other size of the 4 cm length of ¾-inch PVC pipe. This will secure the pipe to the hole through the wall of the bucket.
7. Use silicone sealant or caulking to seal outside the pipe so that water cannot escape through the hole drilled or cut into the side of the bucket.
8. Drill 3/16-inch holes into the 1 ½-inch coupling just inside the bucket lid. This will prevent air from being trapped inside the bucket when it is first deployed into the water.



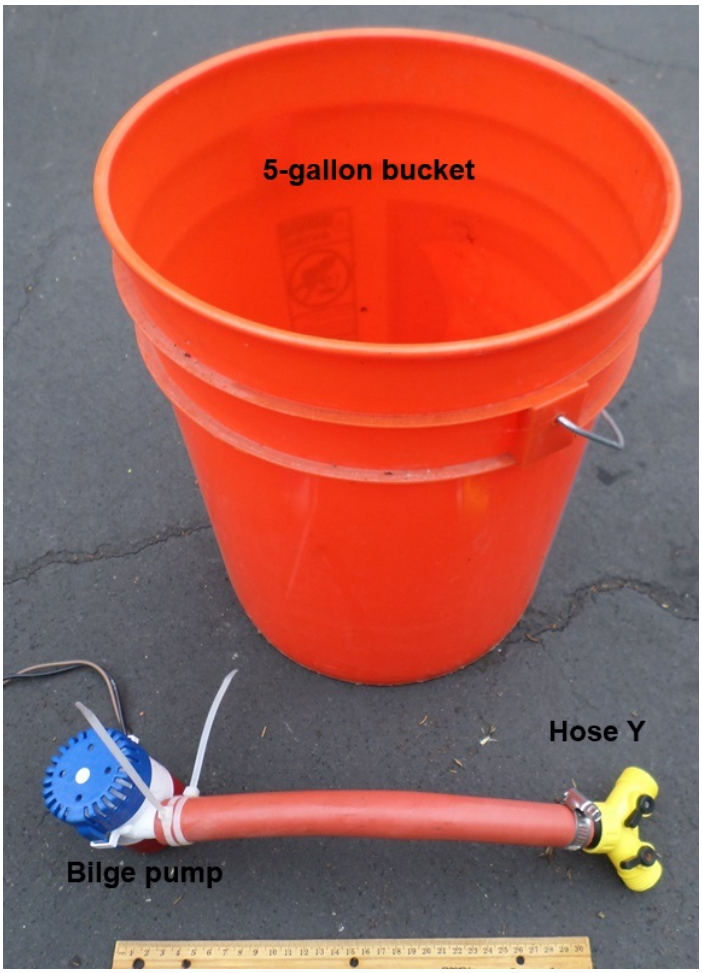
EXPLORER build photo #41: The top of the groundwater vent.



EXPLORER build photo #42: The groundwater vent.

On the surface, side of the pool, fill a 5-galllon bucket or other container with salt water. To make the salt water, add table salt to the 5-gallon bucket of ambient pool water. Stir the mixture until the salt is completely dissolved. Red food coloring is used to color the water.

A bilge pump is used to pump the salt water from the 5-gallon bucket on the surface to the vent (2-gallon bucket) on the bottom. Attach a hose-Y to the outflow of the bilge pump motor or other pump. Attach the top end of the hose to one of the hose-Y outlets. Open each outlet partway. Insert the bilge pump into the 5-gallon bucket of salt water and turn it on. The goal is to restrict the salt water moving down the hose and into the bottom of the 2-gallon bucket. The flow rate of salt water into the 2-gallon bucket and out the top of the 2-gallon bucket should be minimal.



EXPLORER build photo #43: Bilge pump, hose Y and container (5-gallon bucket) that will pump salt water down to the vent. Attach a hose to one opening on the hose Y to control flow rate.

Microbial mat:

The microbial mat is 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).

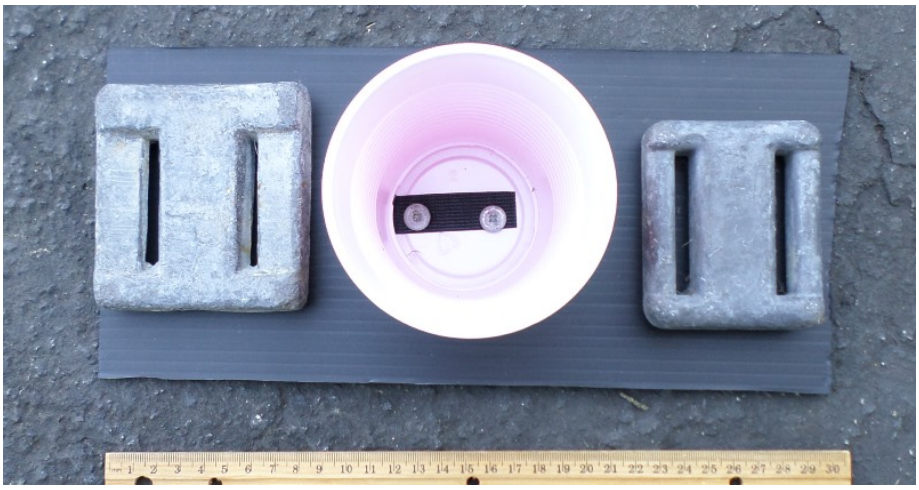
1. Using a cooking pot or other container that can be heated, soak the agar in water for 10 to 15 minutes.
2. Bring the water to a gentle boil and simmer while stirring until the agar dissolves completely. To completely dissolve the agar takes about 5 minutes for powder, 10 to 15 minutes for flakes.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

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.
8. Cut a 5 cm x 1 cm length of Velcro loops. Attach the loops to the outside bottom of a different 550 ml, (16 oz) plastic cup. Fill this cup with agar once it has cooled for five minutes.

Plastic cups containing agar can be fitted into the holding cup for each mission 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.



EXPLORER build photo #44: Top view of empty agar cup holder.

EXPLORER build photo #45: Side view of empty agar cup holder.

EXPLORER build photo #46: Full agar cup sitting next to empty agar cup holder.

EXPLORER build photo #47: Full agar cup nestled into agar cup holder.

Sensor string:
The sensor string is simulated by a length of rope, approximately 2.5 meters long, with three sections of 1-inch PVC pipe tied at intervals to simulate sensors. A dive weight provides that ballast and makes the entire sensor string negatively buoyant. A float at the other end of the sensor string provides positive buoyancy. The rope used is 3/16-inch diamond braid polypropylene rope. The float is constructed of ABS pipe and filled with foam. A 3-inch knockout cap covers one end of the ABS pipe.

To construct the sensor string:

1. Cut a 3 meter length of 3/16-inch rope.
2. Cut two 20 cm lengths of 1-inch PVC pipe. Cut one 15 cm length of 1-inch PVC pipe.
3. Drill a ¼-inch hole into the tops of six 1-inch PVC end caps. Attach an end cap to both ends of each length of 1-inch PVC pipe.
4. Start with a 20 cm section of pipe with end caps. Insert one end of the 3/16-in rope through the hole in one of the end caps. Run the rope through the pipe and out hole on the other end cap.

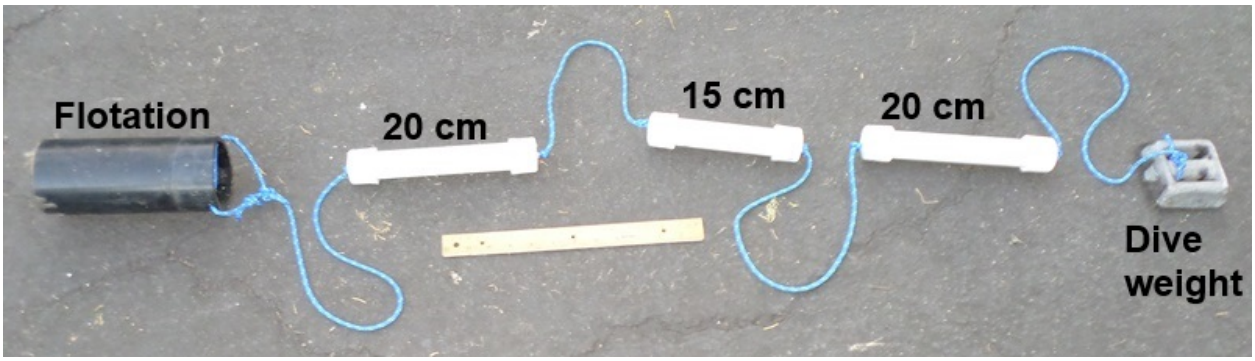
Design note: It is much easier to do this when the end caps are not attached to the 1-inch pipe.

5. Position the length of pipe approximately 80 cm from the end of the rope. Tie an over hand knot in the rope, within 1 cm of each end cap. This will secure the pipe to the rope.
6. Next use the 15 cm section of pipe with end caps. Insert one end of the 3/16-in rope through the hole in one of the end caps. Run the rope through the pipe and out hole on the other end cap.
7. Position the 15 cm length of pipe at the approximate center of the 3 meter length of rope. Tie an overhand knot in the rope, within 1 cm of each end cap.
8. Next use the remaining 20 cm section of pipe with end caps. Insert one end of the 3/16-in rope through the hole in one of the end caps. Run the rope through the pipe and out hole on the other end cap.
9. Position this 20 cm section of pipe 80 cm from the other end of the length of rope. Tie an overhand knot in the rope, within 1 cm of each end cap.
10. Attach a dive, or other weight, to one end of the rope.
11. Cut a 20 cm length of 3-inch ABS pipe. Glue a 3-inch knock-out cap to one opening of the 25 cm length of ABS pipe. Drill two ¼-inch holes in the other side of the pipe, approximately 0.5 cm from the end. Insert foam flotation into the 20 cm length of ABS pipe.

Design note: 3-inch PVC pipe can be used instead of ABS pipe. More flotation may be needed when using PVC pipe.

12. Cut a 20 cm length of 3/16-inch polypropylene rope. Insert the ends of this length of rope into the ¼-inch drill holes in the ABS pipe, from the outside of the pipe to the inside of the pipe. Tie an overhand knot in each end to secure it through the holes.

13. Tie the 20 cm ABS flotation pipe to the end of the rope opposite of the dive weight.



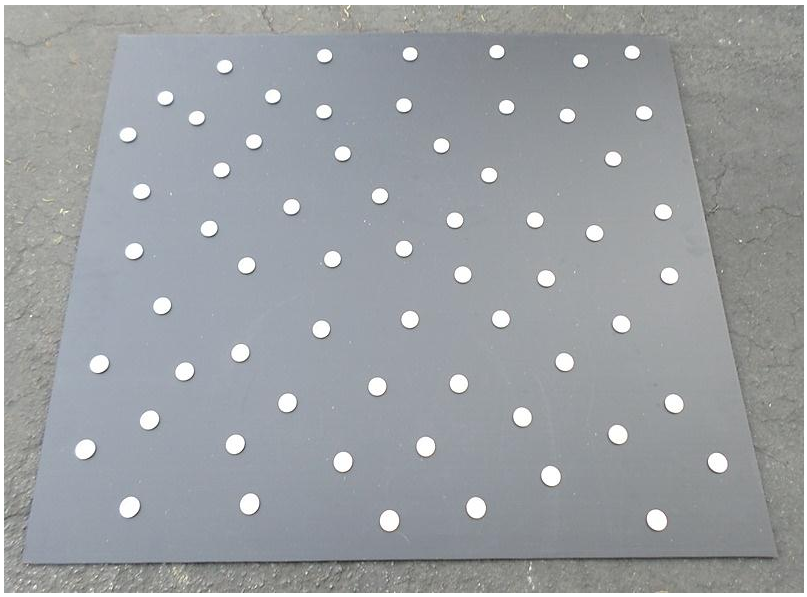
EXPLORER build photo #48: Sensor string.

Zebra mussels:

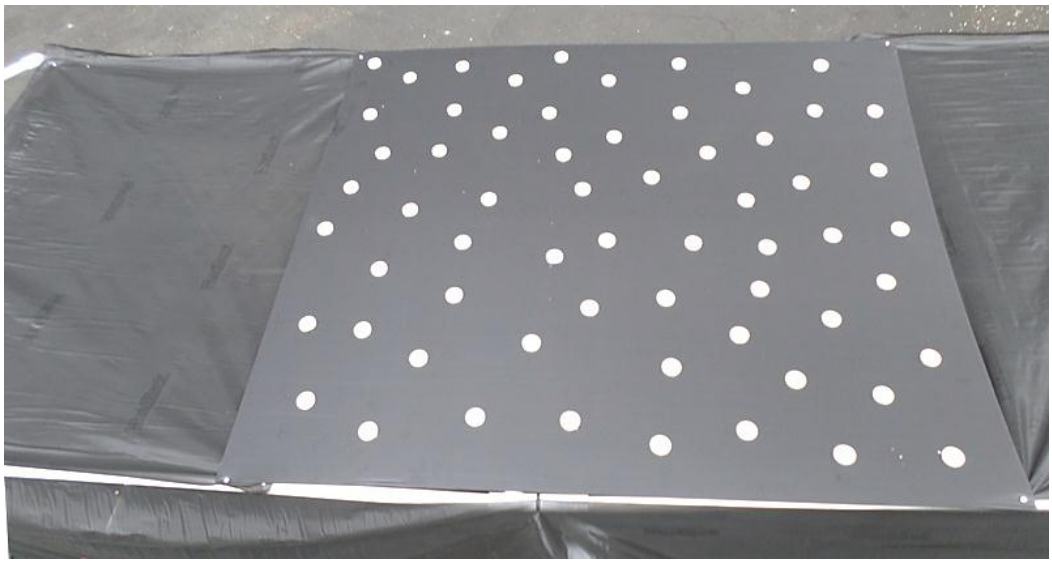
The zebra mussels are simulated by small plastic 2.5 cm (1-inch) checkers. They will be painted almond/ivory/tan and glued randomly to the corrugated plastic sheet on top of the shipwreck.

1. Using an off-white, almond, tan color, paint the top and sides of 64 checkers.
2. Glue them in a random distribution around the corrugated plastic on the top surface of the shipwreck.

EXPLORER build photo #49: Painted checkers simulate zebra mussels.



EXPLORER build photo #50: Zebra mussels distributed on corrugated plastic sheet.



EXPLORER build photo #51: Corrugated plastic sheet with zebra mussels on shipwreck.

Task 3: CONSERVATION

Plastic water bottles:

The plastic water bottles will be a 500 mL or 1 L plastic water bottle. All the plastic water bottles at the international competition will be identical, but the diameter and length of the bottles will not be known until the first day of the international competition. The water bottle will not have a cap and will be completely full of water. A 10 cm length of 3/8-inch rebar will be inserted inside the plastic water bottle to provide additional negative buoyancy and to lessen the chance of the bottle rolling on the uneven

bottom. A 10 cm length of chenille (pipe cleaner) will be inserted through the bottle to prevent it from rolling as well.

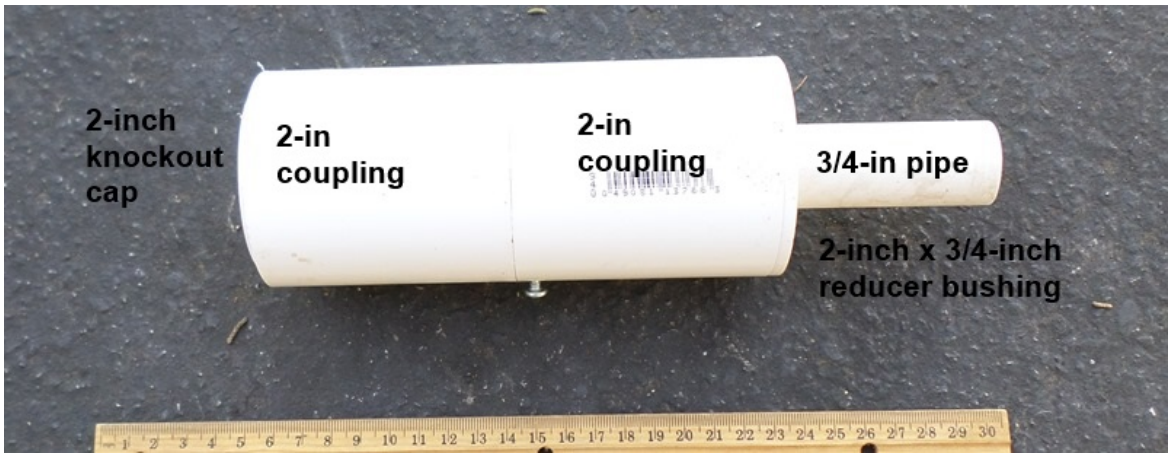
1. Drill two ¼-inch holes through the water bottle approximately 2.5 cm apart.
2. Cut a 10 cm length of a chenille (pipe cleaner) strip. Insert the strip into one hole and out the other. Position the chenille strip approximately halfway through the two holes.
3. Bend the ends of the chenille strips back onto themselves.
4. Cut a 10 cm length of 3/8-inch rebar. Insert the length of rebar into the plastic water bottle.

EXPLORER build photo #52: Plastic water bottle.

Glass bottle:

The glass bottle will be simulated with 2-inch and ¾-inch PVC. A 2-inch knockout cap and a 2-inch to ¾-inch reducer bushing are the two ends of the simulated bottle. A small set screw will lessen the chance of the bottle rolling on the uneven bottom. To construct the glass bottle:

1. Cut a 5 cm length of 2-inch PVC pipe. Attach a 2-inch PVC coupling to both ends of this length of pipe. Push the couplings together so they are flush with each other, completely covering the 2-inch pipe.
2. Insert a 2-inch knockout cap into the coupling on one end of the bottle. Insert a 2-inch to ¾-inch reducer bushing into the coupling on the other end of the bottle.
3. Cut an 8 cm length of ¾-inch PVC pipe. Insert the 8 cm length of pipe into the opening of the reducer bushing.
4. Insert a small set screw into the coupling with the reducer bushing, approximately 1 cm from the joint between the two bushings. Do not screw the set screw all the way into the 2-inch coupling, instead leave it approximately 2 mm out from the pipe.



EXPLORER build photo #53: Simulated glass bottle.

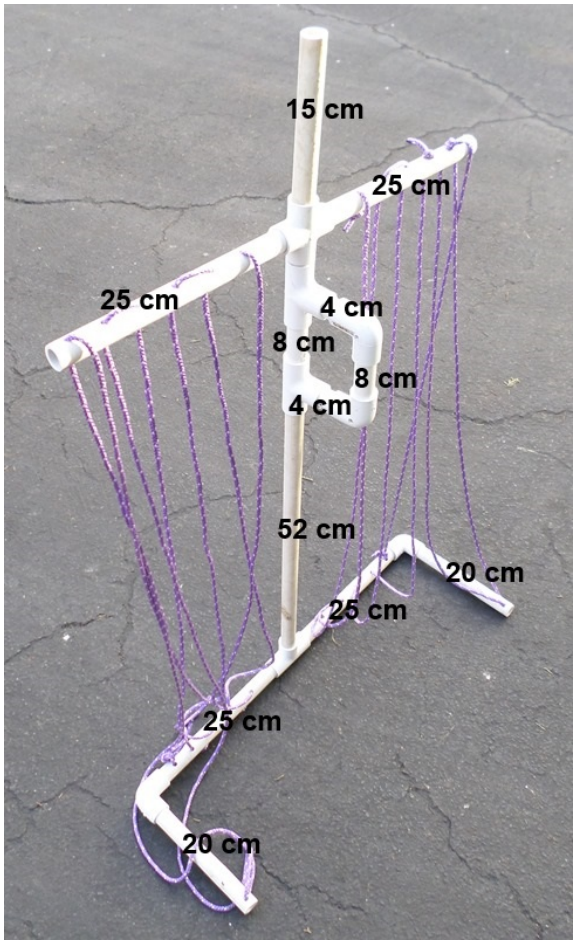
Anchor line rope debris:

The anchor line rope debris is simulated by 3/16-inch polypropylene rope strung around a ½-inch PVC framework. To construct the anchor line rope debris:

1. Cut four 25 cm lengths of ½-inch PVC pipe. Using a ¼-inch drill bit, drill six holes in two of the lengths of pipe and drill five holes in the other two lengths of pipe. When drilling, make the holes completely through both sides of the ½-inch PVC pipe. Do not drill holes within 2 cm of either end of the pipes.
2. Cut a 52 cm length of ½-inch PVC pipe. Attach the middle opening of a tee to one end, the side opening of a PVC tee to the other end. The end of the 52 cm length of pipe inserted into the middle opening of the tee will be the bottom.
3. Insert the two 25 cm lengths of pipe with five holes drilled into them into the two side openings of the PVC tee at the bottom of the 52 cm length of pipe. Attach a ½-inch 90^{o} PVC elbow to the other end of each 25 cm length of pipe.
4. Cut two 20 cm lengths of PVC pipe. Insert them into the remaining openings of each 90^{o} PVC elbow. Drill a ¼-inch hole approximately 1 cm from the end of the PVC pipe that is not inserted into the 90^{o} elbow, drilling completely through both sides of the pipe. Position the two elbows when the two 25 cm and two twenty cm length of pipe are flat on the ground, the 52 cm length of pipe sticks straight up into the air.
5. Cut two 8 cm lengths of PVC pipe. Cut two 4 cm lengths of PVC pipe. Insert the 8 cm length of pipe into the remaining side opening of the PVC tee at the top of the 52 cm length of pipe. Attach the side opening of another PVC tee to the other end of this 8 cm length of pipe. Position the middle openings of both PVC tees so they are parallel with the 20 cm lengths of PVC pipe at the bottom of the anchor line debris.
6. Attach two ½-inch 90^{o} PVC elbows to both ends of the other 8 cm length of pipe. Twist the elbows so they are parallel. Insert a 4 cm length of pipe into the remaining openings on each 90^{o} elbow. Insert the 4 cm lengths of pipes into the two middle openings of the PVC tees at the top of the anchor line debris.

7. Cut a 15 cm length of pipe and 3 cm length of pipe. Insert both of these pipes into opposite openings on a ½-inch PVC cross. Insert the two 25 cm lengths of pipe with six holes drilled into them into the other two openings of the PVC cross.
8. Insert the 3 cm length of PVC pipe into the side opening of the PVC tee at the top of the anchor line debris. Position the PVC cross so that all 25 cm lengths of pipes with holes drilled into them are parallel.
9. Use 3/16-inch polypropylene rope to connect the six holes on the top pipes with the six holes on the bottom pipes (five in the 25 cm length of pipe, one on the end of the 20 cm length of pipe).

The anchor rope debris is positioned across the 75 cm x 75 cm opening in the shipwreck. The 20 cm "feet" at the bottom of the anchor rope debris should be facing away from the shipwreck.



EXPLORER build photo #54: Rope debris.

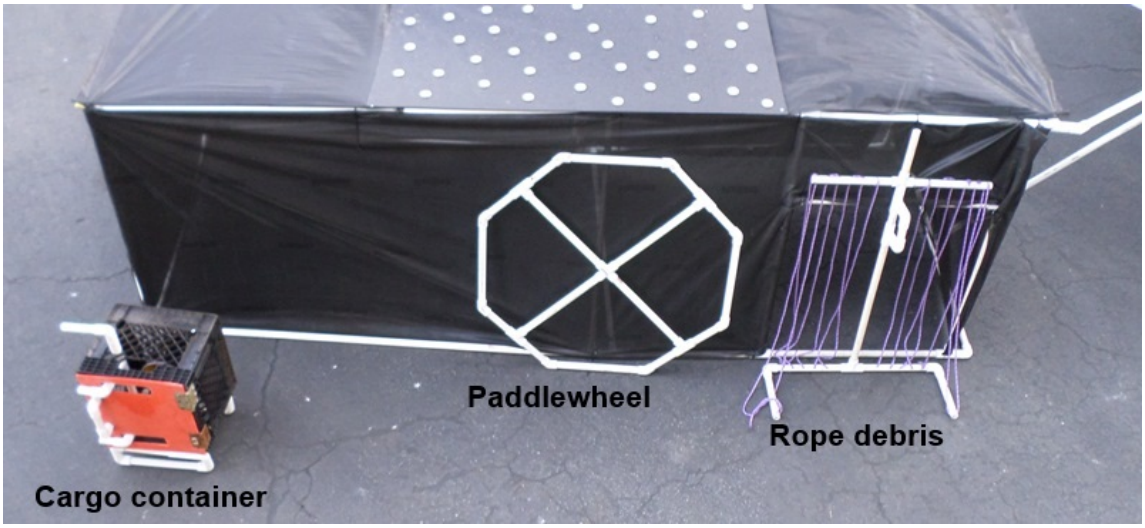
Anchor:

The anchor will be an actual, 8-lb Danforth anchor. Up to 1.5 meters of #2 zinc-plated steel chain will be attached to the Danforth anchor.

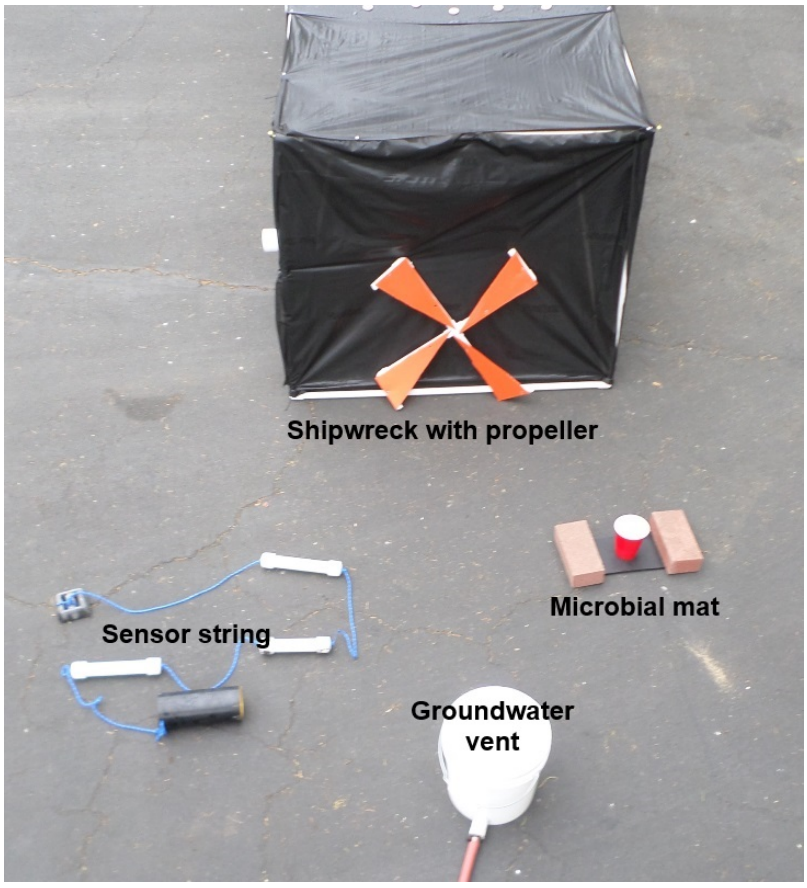
EXPLORER build photo # 55: 8-lb Danforth anchor.

EXPLORER build photo # 56: #2 zinc-plated steel chain.

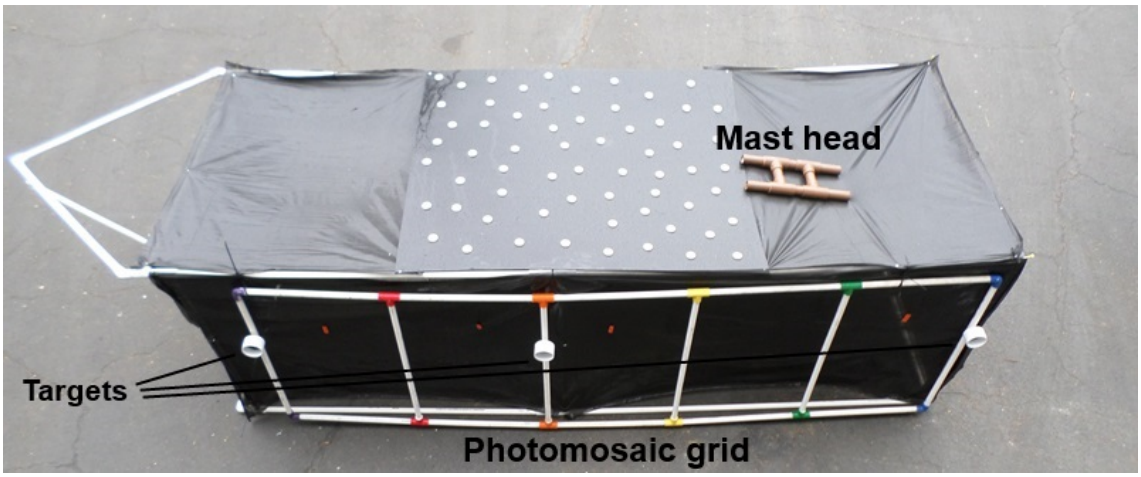
MISSION PHOTOS



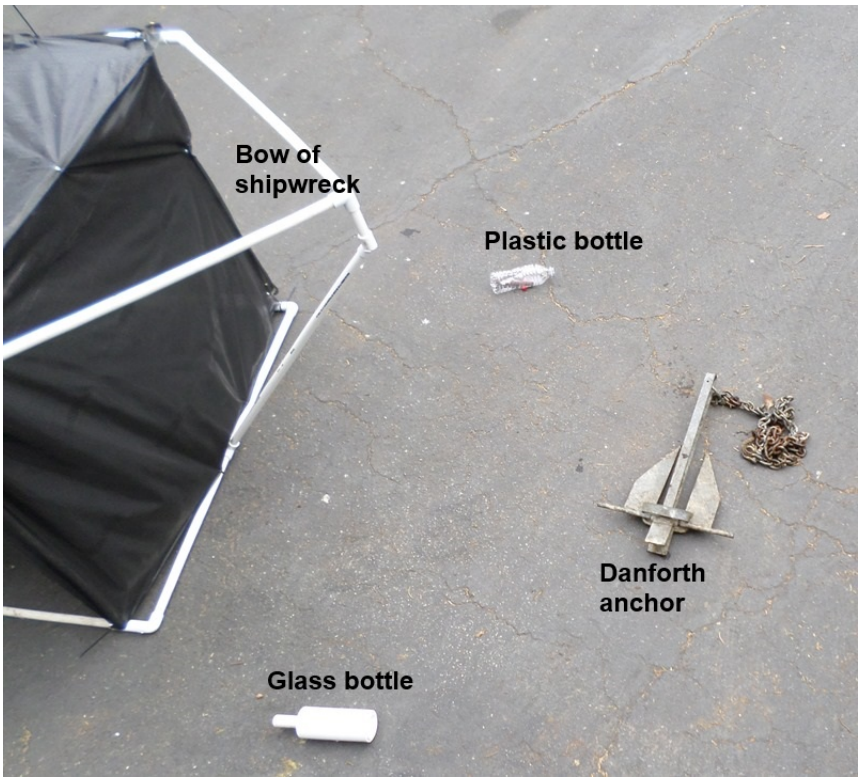
EXPLORER mission photo #1: Side of shipwreck with cargo container, paddlewheel and rope debris over the opening.



EXPLORER mission photo #2: Stern with propeller. Agar, 2-gal bucket, and sensor string behind ship.



EXPLORER mission photo #3: Port side of shipwreck. Photomosaic grid with 3 targets attached. Mast head on top of ship.



EXPLORER mission photo #4: Bow of shipwreck. Bottle #1, Bottle #2, and anchor near front.

PROP PARTS LIST

This is a list of all of the parts needed to construct the props.

PART 3: VEHICLE DESIGN & BUILDING SPECIFICATIONS

1.0 GENERAL

Questions about vehicle design and building specifications, as well as competition rules, should be posted to Competition Help within the MATE Forum Hub. That ensures that all companies can view the questions and answers and helps to avoid duplicate questions. That said, companies should make sure that their questions have not already been asked – and answered – before posting. When posting their question, companies should reference the specific specification (e.g. ELEC-002E).

1.1 Glossary and Acronyms

ANSI	American National Standards Institute
Company	Teams providing a ROV System for evaluation purposes
HD	High-Definition
IEC	International Electrotechnical Commission
Instrument	A device that contains one or more sensors and a method for converting the information from the sensor into a transmittable and storable form
NEMA	National Electrical Manufacturers Association
LARS	Launch and Recovery System
Operate	Correctly performing designed functionality
PWM	Pulse Width Modulation, a method to electronically vary the effective voltage delivered to an electrical load.
SID	System Interconnection Diagram

1.2 Conventions

All values contained in this document are threshold values unless specifically stated otherwise. All water depths are given in meters (m). All dimensions and measurements will utilize SI units.

1.3 Documentation Required

As part of the Technical Report, the following SIDs are required. All diagrams must be drawn with a CAD (computer assisted drawing) program. Hand drawn figures are not permitted. All symbols must be standard symbols as specified by ANSI, NEMA, or IEC.

DOC-001: SID Electrical: One figure must be an electrical diagram for all the systems above the waterline. This diagram should show the ROV system fuse, controls, and tether connections. A second figure should be an electrical diagram showing the ROV sub-systems and their connections. Both diagrams should not exceed one page in length. The diagrams should not be component level schematics, but a higher level interconnection diagram.

DOC-002: SID Fluid Power: If a company is using fluid power, fluid power diagrams must be provided. The first figure must document the components on the surface. The second figure must document the components located onboard the ROV.

DOC-003: Independent Sensor Devices: If a company is utilizing an independent sensor device that will be installed and released by the ROV, a SID must be included for this device. This diagram must be completed to the specifications listed in DOC-001.

2.0 SAFETY

Safety is the competition's primary concern and guiding principle. Any system that is deemed unsafe by competition officials will not be allowed to compete. If a safety concern is identified during the initial inspection, companies are permitted to modify their system and have it re-inspected. Companies are permitted to have their vehicle re-inspected twice. If a company fails to pass its third and final safety

inspection, it is disqualified from the underwater competition portion of the event. There are NO APPEALS once an ROV has been disqualified.

Examples of safety violations from previous ROV competitions include:

- The electrical schematic included in the technical report did not show a main fuse or circuit breaker.
- The ROV used pneumatics, but the technical report did not include a pneumatics diagram.
- The ROV used pneumatics, but the company had not passed the fluid power quiz two weeks prior to the competition.

2.1 Safety inspection protocol

1. Before entering the water for practice or a mission run, the ROV system **must** go through a safety inspection. Companies must present a SIGNED safety inspection sheet to the pool practice/mission coordinator before their vehicles are permitted to enter the water
2. Competition staff will conduct a safety inspection of the vehicle using the safety inspection sheet.
3. If the safety inspector(s) identify a safety violation, companies will have the opportunity to address it. The pool practice or mission run schedule will NOT change to allow companies more time.
4. If during the second safety review the
    a. violation has not been properly addressed or
    b. another violation is revealed

   companies will have ONE additional opportunity to address the issue.
5. If during the third safety review a violation still exists, companies will not be permitted to participate in the underwater mission component of the competition. However, companies can still participate in the engineering and communication (technical report, engineering presentation, and poster display) component.
6. Reminder: All companies must present a signed safety inspection sheet to the pool practice or mission coordinator before placing their vehicles in the water. In addition, mission station judges and competition officials can pause or stop a mission run at any time if they feel that there is a potential safety concern.

2.2 Safety Pre-inspection

Prior to the competition, safety inspectors will review companies' spec sheets, SIDs, and/or technical reports to identify potential safety violations. Companies with violations will be notified via e-mail. Once notified, companies must:

a. respond acknowledging receipt and
b. lay out a plan to address the violation.

For companies participating in the international competition, safety inspectors will compile a list of the safety violations and publish them to the competition web site. This is not done to "call out" or embarrass companies in any way. It is to emphasize the fact that EVERYONE is responsible and accountable for ensuring a safe, successful event.

2.3 Safety Inspection Completed

Companies must complete their initial safety inspection on the first day of the competition. Companies will be assigned to a safety inspector(s). The inspector will reference the list of violations as he/she conducts the safety inspection of the vehicle using the safety inspection sheet.

2.4 Safety Inspection Points

The safety inspection is worth 30 points. Each time a company fails its safety inspection it loses 10 points. After a company fails its second inspection, it must meet with the chief safety inspector to discuss a plan of action prior to returning to its workstation. THREE STRIKES and a company

a. receives 0 points for the safety inspection and
b. is disqualified from the underwater mission component.

3.0 SPECIFICATIONS

The ROV system (or "system") must meet the following requirements:

3.1 Operational

3.1.1 Multiple Vehicles

OPER-001: MULTIPLE VEHICLES ARE NOT PERMITTED. Companies are required to design and build ONE ROV that can complete the necessary mission tasks. "Floating eyeballs" or other vehicles that are not hard connected to the frame of the main vehicle are NOT permitted. Cameras designed to provide a "birds-eye view" are permitted provided that these cameras are hard connected to the frame of the main vehicle. "Hard connection" does not include the wiring between the camera and the ROV.

3.1.2 Environmental

OPER-002: The ROV system must be able to function in fresh, chlorinated water with temperatures between 15°C and 30°C. The water should be considered conductive of electrical currents.

OPER-003: The pool will not be covered or purposefully darkened in any way, although the specific mission tasks may require that your ROV operates in low-light.

OPER-004: No water currents will be intentionally created. However, depending on the venue, pressurized pool filtration system outlets may cause unexpected currents.

OPER-005: The international competition pool has a sloped bottom, ranging from 3.5 m to 5.5 m deep, and may have small bottom features. Companies should be prepared to deal with a sloping bottom and some bottom topography.

3.1.3 Service Requirement

OPER-006: Companies shall provide a crew of 3 to 6 persons on the pool deck to operate the ROV System. Companies can send a larger crew complement, but no more than six can be on the deck at any time. More information about this "mission team" is provided in the COMPETITION RULES.

3.1.4 Calibration Requirement

OPER-007: All measurement devices shall be calibrated according to manufacturer recommended calibration procedure and performed by company members only. Company mentors or advisors are not permitted to perform calibration procedures. More information about mentor restrictions is provided in the COMPETITION RULES.

3.1.5 Maintenance

OPER-008: System maintenance during field operations shall be conducted by ROV personnel at their MATE assigned workstations. Work of any kind must not be done by company mentors or advisors. All maintenance parts and equipment necessary to meet the operation requirements shall be provided by the company. More information about these regulations is provided in the COMPETITION RULES.

3.2 Mechanical/Physical

This section of the document provides specifications for the mechanical properties of the ROV system.

3.2.1 Materials

MECH-001: Any electronics housings on the ROV shall be capable of operating in fresh water to depths of 6 meters.

3.2.5 Size and weight

MECH-002: ROV systems must be able to navigate through a 75 cm x 75 cm opening. Companies must be able to personally transport the vehicle and associated equipment to the mission station and to the engineering evaluation room. ROV systems must be capable of being safely hand launched.

3.2.7 Tether Length

MECH-003E: ROVs must be capable of operating in a maximum pool depth of 6.5 meters (20 feet). All underwater missions will take place within 10 meters from the side of the pool. The mission station will be no more than 3 meters from the side of the pool. Tether length should be calculated accordingly.

3.2.8 Vehicle Deployment and Recovery

MECH-004: The ROV system must be launched and recovered manually; no powered winches or portable cranes can be used. Hand-powered lifts and levers may be used to launch and recover the vehicle. The vehicle and any associated equipment must not damage any part of the pool or pool deck.

MECH-005: Any hand-powered lift or levers that are used as a LARS must be part of the safety inspection procedure. Any LARS equipment that is deemed as unsafe at the safety inspection will not be allowed. Ladders, tripods, or other bracing equipment are not permitted as part of a LARS.

3.3 Electrical

ELEC-001: All power provided to the ROV system through an external connection for any purpose during the competition must be obtained from the MATE competition power supply. This includes

dedicated lines for cameras, manipulators, and any other devices. This is a singular point of connection; all power to the ROV must pass through the MATE-provided fuse AND the single in-line fuse or circuit breaker as specified in this section.

The exception to this rule is an independent sensor. If a MATE Center mission allows an independent sensor, that sensor may be powered by other means. Sensors that are independent of the vehicle must be powered from the surface; no onboard batteries of any type are allowed. Companies may use USB to connect their sensor to a computer. Companies may also use surface battery packs (limited to 12 volts maximum) or the MATE supply to provide power for their conductivity sensor. The independent sensor may only contain the intended sensor; thrusters, cameras or other systems **MAY NOT** be attached to the independent sensor.

Companies that use an independent sensor must provide a 3 amp (or less) fast blow fuse on the positive side of their connection. If companies are using the 48 volt MATE supply to power their sensor, both the ROV and the sensor must run through the single 40 amp fuse before splitting off to the 3 amp sensor fuse. Companies using USB only to power an independent sensor may utilize the built-in current limiting of USB and do not need to add an additional fuse.

ELEC-002E: The ROV system must be capable of operating off the power provided by a MATE supply with a nominal voltage of 48 VDC. This voltage may be as high as 56 volts. Any power supplies used will be set at 50.8±0.5 Volts. At the international competition, power will be provided by isolated power supplies. Power supplies will be a fixed output voltage and will not be "turned down" to accommodate other than the specified voltage for the class.

ELEC-003E: The ROV system must deliver the supply voltage to the ROV as provided and without modification. No conversion of this voltage is allowed prior to it arriving at the ROV system bus. Methods on the surface such as DC/DC converters, voltage drop resistors, and Pulse Width Modulation (PWM) are not allowed to be used between the ROV and the power source.

ELEC-004E: ROV systems may use any voltage desired up to 48 Volts, but any conversion to a lower voltage must be made on board the ROV. Companies will not be permitted to operate an ROV that reduces the voltage on the shore-side/top-side end of the ROV tether.

ELEC-005E: Voltage may not be increased above the nominal 48 volts anywhere in the ROV system.

ELEC-006E: Sonar or other systems that may have DC/DC conversion resulting in voltages above 48V nominal are not permitted.

ELEC-007E: Voltages in excess of the class parameters set forth in this specification are not allowed on the ROV system at any time other than the brief moment of back electromotive forces (back EMF) from collapsing magnetic motor fields typical in any electrical motor situation.

Current

ELEC-008E: The ROV system must have a 40A maximum fuse or circuit breaker in the positive power supply line within 30 cm of the power supply attachment point. Electrical diagrams must show the fuse or circuit breaker and include the amperage of the overcurrent protection.

ELEC-009E: ROV systems are allowed one replacement fuse during the mission run. In the event that the ROV system blows the second fuse during the mission, the mission run will be over and no additional points will be earned.

Power Connections

ELEC-010E: Power supply connections will be via terminal posts –a 1/4" bolt with a wing nut. Companies' ROV system tether must have proper cable-lugs with 1/4" ring connectors for these posts to obtain power.

Tether Voltages

The signals in the tether must meet the following specifications:

ELEC-011E: Low voltage, low current AC or DC control or sensor signals. Low voltage is defined as a voltage equal to or less than the maximum supply voltage per class specification. Low current is defined as being less than 500mA.

ELEC-012E: DC main-supply at a nominal voltage of 48VDC as provided by the MATE power supply.

ELEC-013E: Ethernet, USB, or other ANSI or IEC accepted serial protocol signals.

ELEC-014E: NTSC or PAL Video signals

NOTE: PAL signals must be converted to NTSC if a MATE monitor will be used.

ELEC-015E: Fiber optic cabling of any type may be used.

3.3.2 Exposed connections and disposable motors

ELEC-016: ROVs with electrical connections that are exposed to water and not sealed are not permitted to enter the water.

ELEC-017: "Disposable motors" are not permitted; these are exposed motors with no waterproofing.

3.4 Onboard Electrical Power

ELEC-018: Onboard electrical power (i.e., power not provided by the tether): Onboard battery powered devices are NOT allowed under any circumstance.

NOTE: *Water leaking into a closed battery container can result in the generation of hydrogen gas. This gas can build up inside a pressure housing and create an unsafe situation. For this reason, onboard batteries are NOT allowed under any circumstance. Any device that needs power must obtain that power directly from the ROV tether. For devices that operate at a voltage other than the tether voltage, an onboard ROV converter may be included. The converter must be sealed and not exposed to water. This rule includes commercial "watertight" battery containers; no battery of any type is permitted on any competition vehicle.*

3.5 Power Shutdown

ELEC-019: For safety purposes, any ROV system that is disconnected from the surface supply must stop functioning in less than 5 seconds. This applies to electrical, pneumatic, and hydraulic power sources. Any filters, capacitors or accumulators must be sized accordingly to meet this specification.

3.6 Fluid Power

3.6.1 Documentation

FLUID-001: Documentation required must include a fluid power diagram using industry standard symbols, showing all items, regulators, and control valves.

3.6.2 Hydraulic Power

FLUID-002: Hydraulic fluid: Water or biodegradable food-grade fluid, only.

FLUID-003: If a biodegradable food-grade fluid is used, a Material Safety Data Sheet (MSDS) must be provided at the safety inspection. The MSDS must show the type of fluid used and its compatibility with the Biodegradable Food-Grade specification. Companies using water do not need to provide an MSDS.

FLUID-004: The following fluids are approved for use in hydraulic systems:

a. Water
b. Mineral oil
c. Biodegradable Food-Grade Hydraulic Oil ISO Grade 32/46, SAE Grade 20, McMaster-Carr part# 3499K22

FLUID-005: Maximum Hydraulic pressure allowed: 10.33 bars (150 psig).

FLUID-006: Hydraulic system: All lines, fittings, and hydraulic devices must be rated for a minimum pressure of two (2) times the maximum supply pressure.

3.6.3 Pneumatic Power

FLUID-007: Pneumatic fluid: Compressed air or inert gas only

FLUID-008: Maximum pressure allowed: 2.75 bars (40 psig)

FLUID-009: Pneumatic system: All lines, fittings, and pneumatic devices must be rated for a minimum pressure of two and a half (2.5) times the maximum supply pressure. For example, if an 83 bar (1200 psig) tank is regulated to 2 bars (30 psig), then all system components must have a minimum rating of 5.17 bars (75 psig).

3.6. 4 Pressurized Cylinders

FLUID-010: Pressurized cylinders may be used, but must remain above the water surface and meet the following specifications:

a. Approved by US DOT (Department of Transportation) or TC (Transport Canada). For regional competitions taking place outside of the US, check with your regional coordinator for approval.
b. Have a current official inspection/test sticker and/or stamp.
c. Stamped with the maximum allowable pressure.
d. Contain a pressure relief safety device.
e. May be filled up to the maximum allowable pressure of the cylinder.
f. Must be regulated at its output to a maximum of 2.75 bar (40 psig).
g. Must have an easily accessible shut-off valve that is clearly marked with instructions.
h. May only be stationed on the surface, not on the ROV.
i. Must be secured in a safe manner such that they will not fall or roll around. If the judges feel that a cylinder is unsafe, they have the discretion to prevent its use.
j. SCUBA tanks are permitted. They must meet all the above specifications and have a current visual inspection sticker, or "fill permit" visible.

3.6.5 Pressure Storage Devices (Pressure Accumulators)

FLUID-011: Pressure storage devices are allowed on the ROV if they do not exceed 1.25L in total storage and do not store pressure higher than the allowed pressure for air or hydraulics. It is recognized that a company may not be able to purchase a pressure accumulator that has the proper rating and fits in the space needed. In that case, the company must show that their designed accumulator is capable of withstanding the specified pressures without rupture.

3.6.6 Fluid Power Quiz

FLUID-012 EXPLORER class companies planning to use hydraulics and/or pneumatics (i.e., fluid power) are required to take and pass an online quiz with a score of 100%.

NOTE: The quiz was developed by MATE Center technical support staff and competition judges and is designed to ensure that companies understand basic information on these topics and can apply that knowledge to safe practices. The intention is not to add yet another "requirement," but rather to provide a safe and successful learning experience and competition environment.

The quiz can be completed by one (or more) STUDENT company members. The company's instructor or mentor can provide guidance and advice, but the questions should be answered by the students

participating on the company. The quiz will be scored and the results provided instantaneously. ***A score of 100% is considered a passing grade. Companies can take the quiz as many as 5 times to achieve this score.***

The quiz must be completed with a passing grade by March 1, 2014. *Companies failing to complete this quiz within the given time frame will NOT be permitted to use fluid power during their competition event.*

The following are sources of information on hydraulics and pneumatics. This is not intended to be an exhaustive list, but rather a starting point to encourage Companies to seek out additional information and resources.

- ***Underwater Robotics: Science, Design & Fabrication***, published by the MATE Center (see www.marinetech.org/underwater_robotics)
- http://www.fxsupply.com/pneumatics/psafety.html
- http://mining.state.co.us/safety/downloads/ppoint/HydraulicPressureIntensification.ppt
- National Fluid Power Association – http://www.nfpa.com/education/mini-book.asp
- Parker Hannifin Corporation – http://www.parker.com/ (look for technical literature links)

3.7 Command, Control, & Communications (C3)

3.7.1 Power Provided

CCC-001: Surface power: MATE will provide one GFI-protected outlet with a nominal 115 Volts AC (60 Hertz) and 15 amps maximum. This outlet is intended to provide power for pumps and other surface support equipment (e.g. video monitors & control boxes). This AC power source CANNOT be used to directly or indirectly power the vehicle.

CCC-002: If hydraulic or pneumatic power is used for vehicle thrust, the power for the pump must come from the MATE supplied DC power supply.

CCC-003: In addition to electric pumps, hydraulic, and pneumatic systems can be powered by manual pumps (e.g. bicycle tire pump) or supplied from a pre-pressurized cylinder.

3.7.2 Displays

CCC-004E: Companies are not limited to the number of display screens used for video feeds or ROV status information. Display devices may be made up of any combination of TVs, monitors, laptops, and/or computer displays.

CCC-005E: These display devices may be powered by the MATE provided GFI-protected 115-Volt AC (60-cycle) and 15-amp AC power source described in CCC-001, Surface power.

CCC-006E: A company's C3 station may include devices like video recorders. All C3 devices must be able to run on the single AC power outlet provided or on its own internal battery power. Any device plugged into this AC power outlet can only provide C3 functions and cannot provide power to the ROV.

MATE Provided Equipment

MATE will provide ONE video monitor at each control station that may be used by the company. This monitor will be powered by the GFI-protected 115-Volt AC (60-cycle) and 15-amp AC power source. This monitor will have both RCA and RF inputs. **NOTE: Only NSTC monitors will be available at the international competition.**

NOTE: Companies must supply any additional monitors (including monitors for practice sessions), video recorders, etc. These additional video devices and/or any repair tools (but NOT ROV payload tools) can be powered by the GFI-protected power strip. Only video monitors, video recording devices, and repair tools can use this AC power.*

**MATE cannot guarantee that the practice area will have power for your video monitor.*

3.8 Laser Safety Rules

LASR-001: Companies using a laser at the international event must inform the MATE Center and provide the laser specifications at least 2 weeks before the technical reports are due. If a company is using a laser at a regional event or pool practice (for a demonstration), the company must inform the MATE Center and provide the laser specifications at least 2 weeks before the event. Information and laser specifications should be sent to the Competition Technical Manager.

Specifications will be forwarded to the MATE Center safety inspection team for evaluation. Once the laser specifications are reviewed, a notification will be sent to the company. If the laser is being used at a regional event or pool practice, notification will also be sent to the regional competition coordinator.

LASR-002: All lasers must operate in the visible range at either the 630-680 nm (red) or near the 532 nm (green) wavelength. All lasers must fall into the Class I, Class II, or Class IIIa category. Red lasers must operate at 5mW or less. Green lasers must operate at 1mW or less.

LASR-003: Companies should include detailed specifications of their laser in their technical report as well as have that information ready and available during their safety inspection and engineering evaluation presentations.

LASR-004: Lasers must have an on/off switch. This switch must be on the surface controller.

LASR-005: All lasers must be powered by the MATE surface power supply. Batteries, including batteries for powering lasers, are not permitted on the vehicle.

LASR-006: Companies using lasers cannot increase the voltage or the current to increase the power of their lasers. Lasers must use the voltage and current set in their specifications.

LASR-007: When out of the water, the laser should have a shield or enclosed beam stop attachment within 30 cm of the laser. This means that the laser beam should not travel more than 30 cm before reaching the shield. This is a requirement at all times when the laser is out of the water. The shield does not need to be attached to the ROV while it is in the water. The shield must be painted with FLAT BLACK paint.

LASR-008: At no time should the laser be focused or deviate from a collimated beam.

LASR-009: When testing the laser at a workstation, companies must display a sign telling others that a laser is being operated.

LASR-010: Operators working with the laser while the ROV is out of the water should wear appropriate laser safety glasses at all times. This requirement is for all laser types. Search online to find laser safety glasses.

PART 4: COMPETITION RULES

GENERAL

- All members of the company and their supporters must follow the safety regulations of the ROV competition, pool facility, and event venue.

- All company members and their supporters are expected to conduct themselves in a professional and responsible manner during the competition. Disrespectful behavior towards the judges, officials, pool staff, audience, or other teams will lead to penalty points or disqualification.

- Sabotaging, stealing, or pilfering equipment of other companies will lead to disqualification. Companies found cheating will also be disqualified.

- The MATE ROV competition is, at its core, designed to be an educational and inspirational event for **STUDENTS**. It is designed to challenge them to apply the physics, math, electronics, and engineering skills they are learning in the classroom to solving practical problems from the marine workplace. (See the MATE Competition Philosophy.)

It is expected that all "adults" (non-students; e.g. teachers, mentors, parents) involved in the competition limit their input to educational and inspirational roles. Actual construction of the ROV (particularly in the complex electrical and software areas) must be completed by the students. Adults should teach and advise students about design, electronics, software, and construction, but not complete the work for the students. Throughout the process adults are encouraged to focus on benefits to the students from the process and not simply winning the competition. If during the engineering judging or mission execution it becomes apparent that adults exercised more than an advisory role, judges reserve the right to deduct points or, in extreme cases, disqualify companies from the competition.

While at any MATE ROV competition (international and regional), **ALL** work done on the vehicle must be conducted by company members. Teachers, mentors, parents, and non-competing students are not permitted to work on the ROVs. They may provide advisory input, but they may not work on the ROV directly. This includes writing or editing software code. All mechanical electrical and software modifications and/or repairs to the ROV must be completed by students.

- To encourage student participation at all levels, MATE is discouraging the use of "off-the-shelf" technology. The rationale is that engineering involves integrating existing technology into new systems. As such, students are encouraged to turn to commercially-available technology where available (and affordable). Individual discrete "components" obtained commercially are acceptable, provided that they adhere to the design and building as well as safety specifications for the particular competition class. However, as this is an educational event, students are strongly discouraged from using commercially available "plug-and-play systems" within their ROVs. These devices violate the spirit of the competition in that they remove many of the technical challenges of electrical and software engineering. Thus, they eliminate much of the educational value of the event. An extreme example would be a team that focused its efforts on fundraising and simply purchased one of the low-cost ROVs available commercially. Such an entry would not be permitted.

  In summary:
  Multiple commercial components are **ENCOURAGED**.

  Systems designed to perform multiple, complex functions from one "black box" or a series of components designed to integrate with each other are **DISCOURAGED**.

  Examples of "components" versus "systems" are provided below. If companies are uncertain about the commercially-available items that they plan to use, they should contact the MATE Center early in their design phase. All such questions (and answers) will be posted to the FAQs section of the MATE competition web site.

The engineering evaluation and technical report score sheets will reflect MATE's effort to discourage the use of off-the-shelf systems. For example, both score sheets contain sections devoted to control systems. Companies that demonstrate control systems constructed from "scratch" versus complete control system purchased from a commercial vendor will be awarded higher scores. In addition, the originality of design and teamwork sections will be weighted more heavily.

Examples of commercially-sourced components:

- Tethers
- Thrusters
- Radio control transmitters and/or receivers
- RC servo and/or motor controllers
- Pressure housings
- Watertight connectors
- Cameras with or without watertight housings
- Structural materials

Examples of commercially-sourced systems:

- "Black box" controllers that provide for multiple power and control signal interconnections and manipulations (e.g. FIRST Robotics controller systems)
- Thrusters, motor controllers, cabling, and control box designed and sold as a "system"
- Commercially available ROVs, such as VideoRays or LBVs

PROCEDURAL

- Companies must compete during their assigned time slots. Your company is **NOT** permitted to switch time slots with another team. Failure to show at the mission station for your scheduled mission performance run or at the room assigned for your company's engineering evaluation interview will result in "no score" for that particular competition category. **No exceptions.** Assigned time slots will be sent out in advance so that any scheduling concerns can be addressed prior to the event.

- While there is no limit to the number of students who can compete as part of a company, **the pool mission team is limited to six students**. The mission team is defined as the team of students who operate the vehicle and its associated equipment during the mission performance period. Only six students will be allowed to enter the mission control area, launch, pilot, and perform the mission. Instructors, mentors, and/or non-student members cannot participate as part of the mission team. **Companies may alternate students on the mission team for the two mission attempts.** (All members of the company should participate in the engineering presentations; see ENGINEERING & COMMUNICATION for more information.)

- Only the mission team members and judges are allowed in the mission station during the mission period, which includes the set-up and demobilization periods. Other members of the company, instructors, mentors, audience members, and observers (press or special invited guests) must remain outside the mission station or in designated viewing areas.

- Instructors, mentors, parents, and "fans" are **NOT** permitted at the safety inspection stations or repair tables. Two warnings will be issued before individuals not heeding this rule will be asked to leave the venue.

- In addition, instructors, mentors, parents, and fans are **NOT** permitted to work on the ROV. Individuals who are seen working on the ROV who are not student team members will be issued a warning. Two warnings will be issued before individuals not heeding this rule will be asked to leave the venue. If companies choose to take their ROVs off the competition grounds for maintenance and repair, they are expected to observe this rule in the interests of the spirit of the competition.

- Video devices may be used to record the underwater activities for entertainment and learning purposes **only**. Video will not be used as an instant replay to review judges' decisions or to challenge mission timing.

- Mission stations will be roped off and marked. Mission stations will contain 2-3 chairs and one 6-foot table long table for teams to use. This table will be within 3 meters of the pool edge. Mission stations will be set up to prevent the pilot(s) from looking at the ROV in or under the water except through the ROV cameras.

- At the international competition, the mission station will be located below the wall of the mission tank. The wall may be up to 0.75 meters tall at the mission station.

- Companies will compete in ONE mission that consists of three distinct mission tasks. These tasks, in turn, consist of several components. Companies will get up to **TWO** attempts to complete this single mission. The **higher** of the two scores will be added to the engineering and communication score to determine the total overall score for the competition.

- The mission time consists of a 5-minute set-up period, a 15-minute mission performance period, and a 5-minute demobilization period. If the mission team and all of their equipment are not out of the mission station at the end of the 5-minute demobilization period, the team will be **penalized 1 point for each additional minute**.

- Manipulating the tether to free it from underwater obstacles is permitted. Pulling on the tether to speed up the recovery of items or to return your vehicle more quickly to the surface is not

permitted and will result in penalty points. Judges will issue one warning if tether pulling occurs. Each future infraction will result in **5** points deducted from the final mission score.

- If your vehicle is completely disabled and/or its tether tangled and unable to free itself from the underwater environment, SCUBA divers can be called in to assist. However, the mission performance period time will NOT stop and **5** points will be deducted from the final mission score**.**

- Pilots can only leave the mission station and move poolside to repair, adjust, or alter a vehicle if the ROV is surfaced and at the side of the pool.

- No mission team member shall enter the water to complete an object recovery. Only arms and hands are allowed into the pool to retrieve an object or to retrieve the vehicle. Companies will be disqualified or penalized depending on the severity of the infraction.

- Communication between mission team members at the pool edge and those in the mission station will be limited. Only tether management issues (e.g. how much tether is out, how much is remaining on the pool deck) can be discussed. Those mission team members at the pool edge cannot give any directional or mission information to the pilot. Judges will issue one warning regarding illegal communication. Each future infraction will result in **5** points deducted from the final mission score.

- Communication using cell phones, text messaging, and online social media tools such as Skype, Facebook, Twitter, instant messaging, etc. is NOT permitted during the mission period, either between mission team members at poolside or between any mission team member and anyone outside of the mission station.

- Mission judges and other competition officials will only communicate with students. Judges and officials will NOT communicate with mentors, parents, or other non-student members regarding mission information, challenges, or other issues except during pre- and post-competition briefing sessions.

DESIGN & SAFETY CONSIDERATIONS

- The competition coordinators and host venues stress the importance of safety practices and procedures to all companies. The score sheets will reflect the MATE Center's efforts to encourage and reward teams that demonstrate exceptional safety practices and procedures.

- **ALL ROVS MUST PASS A SAFETY INSPECTION CONDUCTED BY COMPETITION OFFICIALS PRIOR TO ENTERING THE POOL.** These inspections will be conducted topside to ensure that ROV

systems meet the design and building specifications and do not pose a risk to the integrity of the event venue. See VEHICLE DESIGN & BUILDING SPECIFICATIONS for additional information.

- Keep an eye out for tripping hazards in the mission station and at your company's work station. Make sure power cords are not laying in pools of water on the deck.

- During your mission period, be sure to secure any equipment so that it does not fall off the mission station table, damage the deck, or cause injury.

- Loose fitting clothing, jewelry, and long hair could all become safety issues. Consider securing long shirts or baggy pants, removing jewelry, and tying back long hair when working on or operating your ROV.

- ROVs may be constructed out of materials of your company's choice, provided they meet the design and building specifications and safety regulations. Warning labels should be posted on potentially hazardous components of your ROV system.

- All company members must wear close-toed shoes and safety glasses or goggles. **No one will be allowed into the work station area without close-toed shoes and safety glasses or goggles**. **No one will be allowed on the pool decks without close-toed shoes.** This includes company members, parents, mentors, and guests. Safety glasses/goggles are also recommended when working with your vehicle on deck.

PART 5: ENGINEERING & COMMUNICATION

The ability to effectively communicate information about your vehicle and the design and building process is equally as important as how well your vehicle performs. Strong communication skills are an essential part of good business practices. To emphasize this point, the competition requires the following four engineering and communication components:

- Spec Sheets
- Technical reports
- Engineering Presentations
- Poster Displays

The Company Spec Sheet, Technical Report, and Engineering Presentation are components where you are communicating with technical audiences, such as potential future clients. (Examples of spec sheets and technical reports from previous competitions can be found here. Examples of engineering

presentations will soon be available on MATE's Vimeo channel.) The Poster Display should be thought of as part of your marketing strategy and aimed at general (including non-technical) audiences.

TIPS FOR EFFECTIVE WRITTEN AND ORAL COMMUNICATION

Communicating ideas about how to solve a problem and evaluating those ideas against competing alternatives is a critical skill for anyone thinking about a career in marine technology. It is a skill that is directly linked to decision making about whether or not to hire (or fund) us and our ability to influence the work that we do.

The key to a successful technical report and engineering presentation is the way that critical thinking and engineering reasoning are communicated. You can think of the process as technical "storytelling."

Technical storytelling includes the use of text, images, schematics, and data to effectively communicate the "story" of how your company brainstormed and evaluated ideas to come up with your solution (e.g. ROV, payload tools, and operational strategies) to the problem at hand(mission tasks). It also involves organizing content to efficiently present your work and justify why you did what you did.

However, choose details with care. Each detail should help to answer the question "why is what you did the best solution for your team and for this competition?" Describe why a component in the system is critical and how you chose it. Include specifications or dimensions only if they help to explain the "why" and "how" you made choices. Keep in mind that a mechanical drawing with dimensions can replace a lot of text and in many cases do a better job telling details of the story than text.

Maintaining a project notebook is a good business practice that will help to capture ideas and document your company's progress – including your research, designs, trade studies, experiments, data, vehicle specifications, testing, expenditures, and donations. The notebook is also a place to keep track of your company member's contributions (time, support, etc.).

Along with your notebook, here are some items to consider as you prepare to tell your story via your report and presentation:

- What was your team's "work breakdown structure" (tasks, time, and people)?
- What were the greatest constraints (schedule, budget, equipment, labor, logistics, etc.) on your design process?
- How did the mission and rules influence your design and decisions?
- What systematic process, such as a tradeoff matrix, did you use to evaluate competing design solutions?
- What were the most important design decisions you made and why?
- How did you arrive at your final power budget? What concessions, if any, did you have to make and why?
- How do you calibrate your sensors?

- If your vehicle uses software, where does the code execute? Describe the flow and format of the data.
- Did you have a noteworthy troubleshooting experience? Any problem or procedure that takes more than 20 minutes to figure out is worth understanding and writing down.

COMPANY SPEC SHEET (ONE PAGE ONLY)

Your company is required to submit a one-page spec sheet along. The goal of the spec sheet is to provide the judges with a "snapshot" of your company. It includes basic information about your company and vehicle.

Companies must submit their spec sheets to the MATE Center 2 weeks prior to their demonstration. If the demonstration is via video, companies can submit their spec sheets when they submit their video. The spec sheet should be sent as a pdf file attached to an e-mail. The spec sheet should NOT exceed one page in length and should follow the font style requirements of the technical report.

Company spec sheets are reviewed by safety inspectors as well as judges, but not scored.

Spec sheets must include the following information:

COMPANY SPECS

- **Company and school, club, or community organization name**
- **Home state and/or country**
- **Distance required to travel to the international competition**
- **History of MATE ROV competition participation.** Be sure to specify if your company and/or the members of your company are "new" or "returning."
- **Company photo and caption indicating members' names and roles (e.g. CEO, CFO, Design Engineer, Pilot, etc.).** This photo should include all of the members of your company.
- **Range of grade/college levels represented by the members of your company**

ROV SPECS

- **ROV name** if applicable
- **Total cost.** You must include the approximate cost of any donated items.
- **Safety features**
- **Special features**
- **Photo of the vehicle**

TECHNICAL REPORT

Your company is required to submit a technical report that will be reviewed and evaluated by a panel of working professionals – individuals who represent science, exploration, government, and industry. (These individuals may not be the same judges who evaluate your company's engineering presentation.) The technical report is a means for your company to describe the design, operations, and features of

your vehicle. Your clients should gain a good technical understanding of your vehicle and your company's capabilities in addressing your client's needs for an ROV.

Companies must submit their technical reports to the MATE Center by May 23rd, 2014, which is 4 weeks prior to the competition date. The report should be sent as a pdf file attached to an e-mail. **The report should not exceed a file size of 8MB.**

Any changes or additions that you make to your ROV that differ from the information in the technical report that you submit should be presented to the judges during your company's engineering presentation. **NOTE: The judges will not review and rescore revised versions of your technical report during the competition.**

Each judge on the panel will award a technical report score (100 points max). Judges' report scores and comments will be returned to you shortly after the event.

The guidelines and required components for the report are:
NOTE: Make sure to label any and all figures, graphs, diagrams, and photographs. Also note that these components must be present in your report, but you must determine the best logical order for presenting you them.

- **Length is 25 pages or less – NO EXCEPTIONS**
- **Font size of at least 12 points (font type can vary)**
- **All measurements are in SI units (metric)**
  Exceptions include ½-inch PVC pipe and other items described or sold in imperial units.
- **Title page** that includes:
  - Your company's name
  - School, club, or community organization's name, city, and state. If you are an international company, include the city and country.
  - **COMPLETE** list of the members of your company and their role (CEO, CFO, Design Engineer, Pilot, etc.). You can also include degree/area of study (or what you plan to major in at college) and expected graduation date.
  - Names of your instructor(s) and/or mentor(s)
- **Abstract (250 words or less)** that is concise and clearly summarizes the project.
- **Table of contents**
- **Photograph(s) of your completed ROV**
  You are permitted to make modifications that may change the look of your vehicle between the time you submit your report and the competition; however this must be a photo(s) of your completed, intact vehicle, not photos of individual systems and/or payload.
- **Budget/expense sheet**
  Keep an accounting of your income and expenditures. In addition to funds, list any items (building materials, equipment, travel stipends, etc.) that were donated, the organization or

individual who made the donation, and an estimate of the item's value. Tip: Ask your school's business or accounting programs for examples of budget sheets.

- **System Interconnection Diagram (SID)**
  A SID is a system-level, connection diagram that includes electrical and, if applicable, fluid power wiring information. Board-level and component-level schematics should not be included; however, these may be brought to the engineering evaluation for reference purposes. The intent is to provide the competition judges with a one-line diagram showing how the various systems are interconnected without the detail of each and every wire.

  The SID must include a clear distinction between the surface controls and the ROV. SIDs must be computer-drawn; hand-drawn or scanned diagrams are not acceptable. Any electrical, hydraulic, or pneumatic symbols must be ANSI, NEMA, or IEC recognized symbols. VEHICLE DESIGN & BUILDING SPECIFICATIONS includes additional details about the SID.

  Note: Companies may use free drawing software such as OpenOffice to complete the SIDs.
- **Block-diagram or flow-chart of software in the ROV (if applicable)**
  This flow diagram should detail the software code written for your control system or other elements of your ROV. If you are using a purchased control system that utilizes software, you are encouraged to learn about its operation and describe it in a diagram.
- **Design rationale** presented in a clear and logical manner. This section should comprise the bulk of your report. It should focus specifically on the technical aspects of your vehicle and include a discussion of how your ROV was built/adapted to perform the specific mission tasks.
- **Safety.** This section should describe the steps that your company has taken to identify and address any safety concerns regarding the design, construction, maintenance, and operation of your vehicle.
- **Description of at least one challenge** that your company faced and what methods were used to overcome it. These can include both technical challenges and those related to working as a team. Be sure to explain how you overcame these challenges.
- **Description of at least one lesson learned or skill gained** during the design and building process.
- **Discussion of future improvements**
  In this case, the MATE Center is your "client" and has defined both the problem to be resolved and the products and services you need to provide. However, future clients could include research institutions, private companies, and government agencies. A synopsis of ideas for future improvements is essential to any entrepreneurial organization.
- **Reflections on the experience**
  This can be written from the point of view of your company as a whole or individual members of the company can contribute a reflection. It can include personal or professional accomplishments achieved as a result of participating in the competition.
- **References**
  List any books, journal articles, magazines, trade publications, web sites, and professional advice that you used as sources of information for your work.
- **Acknowledgements**

Please recognize the companies, organizations (including the MATE Center), professionals from industry, and/or mentors who helped to support your company by donating funds, building supplies, equipment, site visits to facilities, time, and/or technical expertise. You can include organizations and/or individuals that provided logistical and/or moral support (e.g. your parents, siblings, or pets). Companies competing in regional events should also acknowledge regional contest supporters.

ENGINEERING EVALUATION

During the competition, your company is required to give a 15-minute oral presentation to a panel of working professionals – individuals who represent science, exploration, government, and industry. (These individuals may not be the same judges who evaluate your company's technical report.) Your presentation should describe the engineering behind your vehicle's design and operation and address any possible safety issues. It should also highlight any design innovations or creative solutions to solving the mission tasks. After the presentation, the judges will take 10-15 minutes to ask the members of your company questions about your ROV. The judges will evaluate both your presentation and responses to their questions.

All student members of your company must participate in this presentation and question and answer period. You are required to have your ROV with you.

NOTE: The engineering presentation is designed to be a face-to-face interaction where students and representatives from industry become engaged in conversation. MATE will not provide audio visual aids, such as slide projectors, computer projection screens, white boards, etc.; however, you are welcome to distribute handouts to help judges better understand the information that you are presenting. **PowerPoint presentations are NOT permitted.** During the question and answer period, all members of the company must be present and prepared to answer.

Instructors, mentors, family members, friends, and members of other companies are permitted to attend this evaluation. However, we ask that those in attendance be respectful and courteous throughout the presentation and follow-up question and answer period. Be mindful that this evaluation may be a stressful time for the students who are presenting. If the room becomes crowded or the spectators become distracting, it is up to the judges' discretion to request that some or all spectators leave the presentation. **While they are permitted to attend, instructors and mentors are not allowed to participate in the interview process.**

Each judge on the panel will award an engineering score (100 points max). Judges' engineering scores and comments will be returned to you shortly after the event.

The judges will pay particular attention to whether or not the vehicle was built by the students from "scratch" or excessively uses complete, off-the-shelf systems. The use of complete, commercially-available systems is highly discouraged (the **COMPETITION RULES** includes more information on this

topic). Design originality and innovation as well as safeguards to prevent injury or damage to the underwater environment will be noted.

Here are some examples of questions that the judges may ask or observations they may make. **NOTE: These are only examples and may not be the actual questions asked.** Your team must be prepared to answer questions other than those examples listed below.

Structure

- How did you decide on the shape of the vehicle and the materials used to build it?
- What is the design depth rating of your ROV? Did you test this? How?
- Did you use any pressure housings in your design? Explain how you designed and built these.
- What are o-rings and how do they work?
- How much did it cost to build your vehicle?
- How much does your ROV weigh in air? In water?

Control system

- What type of control scheme have you used? Why?
- How does your control system work?
- How many conductors are in the tether?
- What devices/functions does your system control?
- Is there some unique feature of your control system?
- How did you waterproof your underwater electrical connections?

Propulsion

- How many thrusters does your vehicle have? Why?
- How much thrust does each produce?
- How many watts does one thruster use at full rpm?
- How many amps does one thruster draw under full load?
- Explain how you measured thrust.
- How is power (watts) used by one thruster related to the thrust it produces?
- Do you know the forward speed of your ROV? How did you measure this?

Ballast System

- How does your ROV ballast system work?
- Explain what stability is.
- Why is it important to consider stability in the design of ROVs?

Sensors

- What type of camera did you choose? How did you waterproof it?
- What do your sensors measure or detect?
- What unique features are incorporated into your sensors?
- What additional sensors (other than a camera) have you put on your ROV? Why?

Payload Tools

- What type of payload tool(s) did you design to accomplish the mission tasks and why?
- Explain how the tool(s) works.

Resources

- Did the project stay within budget?
- What equipment/building supplies were donated, built, or bought?
- Were you able to produce a functional vehicle?

System Design

- Can the vehicle accomplish the mission tasks?
- What are the strengths of the design?
- What are the weaknesses?
- Do the safety systems work?

Originality

- Does the design of the vehicle and its systems exhibit unique concepts and innovation?
- Does the vehicle make excess use of commercially-available systems?
- Are there any innovations or modifications that resulted in higher functionality and reduced costs?
- If you are using the same vehicle as last year, why? What are the advantages? What, if any, modifications or additions did you make?

Workmanship

- What is the overall quality of the workmanship?
- Are the electrical systems neatly contained and wired?
- Is it easy to access components for maintenance?
- Is the tether neatly bundled and protected?
- Can the tether withstand the strain from the vehicle weight, handling, and operation?
- Does the vehicle look aesthetically pleasing yet have practical functionality?

Safety

- What potential safety hazards did you identify then address?
- Are warning labels and safeguards posted on potentially hazardous components?
- Did your team develop a safety checklist or protocol?

Theme

- In the real world, what role do ROVs play in the competition theme?
- What types of organizations' or individuals' work relates to the competition theme?

Preparing for your engineering presentation and evaluation

- Make sure that every member of your company has a good, general working knowledge of your vehicle, even though they may have specialized in one specific aspect of its design and construction.
- Research the specifications of the components that you use in your vehicle. For example, look up the specs of your ROV's camera and be familiar with such numbers as the amount of propulsive force the thrusters produce, the weight of your ROV, etc.
- Make sure that all the members of your company are familiar with your technical report. Ask every member to read it over to catch any errors or omissions. This exercise will help to familiarize everyone with all aspects of the project.
- Generally, you will have more to say about your ROV than can be presented in 15 minutes. That is why it is critical to organize your material and practice communicating it. However, avoid coming across as having memorized your presentation verbatim. Judges want to see that you are prepared and understand the information, not that you can simply regurgitate a rehearsed speech from memory. Ask your instructors or mentors to give you feedback.

Other important items

- If during the engineering presentation it becomes apparent that instructors, mentors, and other adults associated with your company exercised more than an advisory role, judges reserve the right to deduct points or, in extreme cases, disqualify teams.
- Your company is discouraged from using off-the-shelf, plug-and-play systems. You are encouraged to demonstrate innovation and creativity in the construction of your vehicle and its systems. This will also be reflected in your engineering evaluation score.

POSTER DISPLAY

Your company is required to create a poster that will be on display during the competition event. Your poster display should be an informative, clear, and concise **marketing presentation** about your company and how you designed and built the specialized tools to effectively complete the mission tasks. During the competition, your company's display will be evaluated and scored by a completely different group of working professionals – individuals who will represent science, business, government, industry, and education/outreach.

While some poster judges will have a technical background, others will have a communications, marketing, or public relations backgrounds. In addition, there will be visitors to the competition who may not completely understand what an ROV is or how it is used. You can think of these visitors as potential future clients who may authorize funding for your work, but have a limited understanding of it (i.e., you need to explain your technology, the tasks at hand, and "sell" them on YOUR products and services). Design your poster to communicate to this type of audience.

Each judge will award a poster score (50 points max). Judges' poster scores and comments will be returned to you shortly after the event.

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INTERNATIONAL COMPETITION ONLY! MATE will provide each company with one 3-panel, free-standing presentation display board and an easel. Each display board is:

- Made out of black, corrugated cardboard
- 36" tall with a total width of 48"
- Comprised of three panels
    - One 24" wide by 36" tall center panel
    - Two 12" wide by 36" tall side panels

Note: You are welcome to bring your own poster display board, but the space that the text and photographs/graphics occupy CANNOT exceed 36" tall by 48" wide. For example, company names CANNOT be mounted above the poster board. NO EXCEPTIONS!

MATE will also provide scissors, tape, glue sticks, adhesives, and other means of attaching display items to the presentation board, although you are also welcome to bring your own.

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The guidelines and required components for the poster display are:
Note: Keep in mind that, with up to 60 posters to score, the judges will have approximately 10 minutes to evaluate your poster. Make key points. Be concise. Keep the general public in mind. Also, make sure to label any and all figures, graphs, diagrams, and photographs.

GENERAL GUIDELINES

- **Font size that is clearly legible from a distance of 1.5 m**
- **Choose a font style and use it throughout**
- **All measurements are in SI units (metric).** Exceptions include ½-inch PVC pipe and other items described or sold in imperial units.
- **Include headers (see REQUIRED COMPONENTS below)**
- **Photos should be clear and high-quality for the print sizes that you choose**
- **EVERY PHOTO MUST HAVE A CAPTION!** No caption = no credit for that photo. Also include photo credits if the photo was not taken by someone in your company.
- **Items that you MAY include on your poster:**
    - Diagrams or sketches (CAD drawings, for example). The diagrams should be clearly labeled with a brief explanation that is understandable to a general, non-technical audience. If they are overly complicated and require more technical knowledge, do not include them; technical drawings belong in the engineering reports.
- **Items that you MAY have on display include:**
    - Photo journals, pamphlets, business cards
    - Copies of your company's technical report
    - Resumes of the members of your company
    - Company Spec Sheet and safety manual

- MEDIA OUTREACH (international competition ONLY)

- **Items that you MAY NOT include in your poster:**
  - Flip charts on the poster board
  - Video screens on or in the actual poster board

REQUIRED COMPONENTS

Note: The following are REQUIRED headers. These headers not only assist the judges in evaluating your display, they also make your poster easy to read.

- **Company name and school, club, or community organization name (note that this is the only personalized header)**
  Make sure that your company name is in large, bold font (larger than any other font on your poster). Include your school, club, or community organization name as well as your company name. Include your geographic location (i.e. city and state). If you are an international company, include the city and country.
- **Abstract (concise – 250 word limit)**
  Include a written introduction to your company and how your company designed and built specialized tools to effectively complete the mission tasks. Make sure to relate the mission to how ROVs can be used in the real world. Don't assume that your audience knows what an ROV is or the details about the competition missions.
- **Company information**
  Include photo(s) (group or individual) of all of the members of your company. Provide a brief description of each member. This description should include the person's name, role in the company (e.g. CEO, CFO, design engineer, pilot, marketing and communications specialist, etc.) and their qualifications, such as grade level, major or area of expertise, career goals, etc.
- **Design rationale**
  This section should be the bulk of your poster display. It will be worth the most points.
  - Why did your company build your ROV the way that you did?
  - Present your ROV's "marketable" features. These can include power budgets, payload tools, buoyancy systems, and safety features, among others.
  - Include photos of your ROV. Make sure to highlight the various systems of your vehicle.
  - **Include photos or drawings of any special features of your vehicle and how these features relate to the mission tasks, safety, general operations, etc.** This is the most important part of your design rationale.
- **Theme**
  Describe this year's competition theme and how ROVs are used to document shipwrecks, conduct scientific research on sinkholes, and conserve national maritime heritage sites in the Thunder Bay National Marine Sanctuary.

  Rather than regurgitating information that you find within the competition manual or on the Internet, take the time to think through the competition challenges and their significance in the real world. You can choose to focus on the technical, economic, or socioeconomic issue of exploring and protecting shipwrecks, studying unique (and often fragile) environments, dealing with invasive

species, and removing (and preventing) man-made trash and debris. In addition to the Internet, you are encouraged to contact individuals (such as a local resource manager, scientist, or environmental activist) who can offer their views. Be sure to appropriately cite your references / sources at the bottom of this section.

- **Company evaluation**
  Answer the following questions:
    - How would you characterize your company's overall success?
    - What do you consider strengths of your company and the ROV you designed?
    - What areas do you see needing improvement?
    - What was the most rewarding part of this experience?
    - What would you do differently next time?
- **Acknowledgements**
  Please recognize any companies, organizations (including the MATE Center), professionals from industry, and/or mentors who helped to support your company by donating funds, building supplies, equipment, site visits to facilities, time, and/or technical expertise. You can include organizations and/or individuals that provided logistical and/or moral support (e.g. your parents, siblings, or pets). Regional competition teams should also acknowledge regional contest supporters.

Note: "Accessories" such as video footage, PowerPoint slide presentations running on laptop computers, video projections, etc. are permitted but should be used with discretion. Remember that the judges will have a limited amount of time to evaluate your poster and may find excessive use of audio or video presentations distracting.

However, if you do make a video of your ROV building or competition experience, please submit information about it to the MATE Center so that it can be shared via MATE's YouTube and Vimeo channels.

BONUS POINTS FOR MEDIA OUTREACH – INTERNATIONAL COMPETITION

Companies that participate in the international competition can earn bonus points by writing a press release and working with their local media to publicize their company's participation in the competition. This can help your company gain community support, media exposure, and local sponsorship.

Place your press release and the results of your media campaign in an envelope adjacent to your poster display. The media outreach component is worth 5 bonus points in addition to the 50 total points awarded for the poster display. ***We would like original copies of the articles, but if you don't have originals to spare, please place copies of the articles in the envelope.***

Media outreach consists of:

- Developing a list local media contacts

- Writing a press release about your participation in the MATE ROV competition
- Distributing it to your media contacts
- Following up with your media contacts to see if they're interested in your company and its ROV
- Compiling a summary of results
- Submitting your results electronically
- Including hard copies of your press release, press summary, and press articles/results in an envelope adjacent to your poster display.

Please submit a copy of your press release, a copy of your media contacts list, and a summary of news articles, TV or radio coverage, etc. that your team received. Include copies of articles and URLs, and list any television or radio coverage. Be sure to include name of outlet, date, and a summary of the coverage.

Media Relations Guidelines

Here are some general guidelines for working with the media.

1. You should begin your media effort about 4-5 weeks before the international competition (which is from June 26 – 28, 2014).
2. Write a press release highlighting your team's involvement in the upcoming MATE competition. If you participated in a regional, feel free to talk about it and how you performed. It doesn't have to be more than 1-1 ½ pages, double-spaced. Be creative.
3. Develop a list of community news media contacts, including newspapers, magazines, radio stations with public service announcements and local news, television news programs, and local online news reports or blogs. If your town is small and doesn't have any media outlets, reach out to those in the city or large town that's closest to you.
4. Try to find the name and email address of a reporter who covers education or technology—they're the ones that will be most interested in your story. You can often find this information online, or you may have to call the media outlet and speak with a receptionist to find out who the most appropriate contact is and how to reach them. Usually, email is the best way to contact a reporter.
5. Become familiar with the news outlets and the reporter that you're going to "pitch" your story to. For example, learn if they've written about your school before, or what kinds of news stories they tend to develop.
6. Compose an email introducing yourself, your team, and your school. Tell them that you're participating in the Marine Advanced Technology Education (MATE) Center's international ROV competition, which will be held in June 2014 in Alpena, Michigan, USA. Explain what ROV stands for, and tell them how ROVs are used in the real world. Give examples of the skills that you and your teammates have learned by designing, building, and piloting ROVs. You may have already written some of this information for your poster display or technical report.
7. Reporters are interested when a local team is participating in an international event. So make sure to let them know that the MATE competition is an international competition, funded by the National Science Foundation, the Marine Technology Society ROV Committee, and other international

organizations and businesses, and that teams from all over the world participate. Be sure to provide the link to the ROV competition web site.

8. Copy and paste the release below into your email. (Reporters in general prefer cut and pasted releases to opening up an attachment.) If you have any photos of your team and/or ROV, especially a photo of your vehicle in action, feel free to attach the photo to the email. Explain to the reporter what's going on in each photo you attach.
9. Make sure you include your name and a phone number where the reporter can reach you. Also include MATE's media contact information and let them know they can contact her if they want more specific information about MATE or the competition. MATE's media contact is Caroline Brown at cbrown@marinetech.org or (401) 338-8980.
10. After you've emailed your media contacts, wait for a week and email them a reminder if you don't hear back from them. You can simply forward the original message to them.
11. If a reporter calls and wants more information, be creative about how you provide it. Offer to give interviews with a few of the team members, your mentor, or even a key sponsor. Invite them to meet you at the pool to see your ROV in action. Ask them if they want to try piloting the ROV on their own. If they want to speak with someone from MATE, give them the MATE media contact information from above.
12. If your team receives media coverage, save a paper copy of print or Internet coverage. For radio or TV stories, include the URL to the video or audio if available. If not list the station, name of reporter, date and time of broadcast and summary of the broadcast.
13. To earn the five extra points, you must submit the following information in an envelope adjacent to your poster display (write school or organization name, team name and number, and city, state, and/or country on the outside of the envelope. You must also submit your results electronically.
    - a copy of your press release
    - a sample of your "pitch" email
    - your list of media contacts
    - copies or lists/summaries of media coverage

Below is the sample press release to help you get started.

East Lake Charter School Team to Participate in International Underwater Robotics Competition

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Local students develop underwater robots to explore shipwrecks, study sinkholes, and practice conservation at MATE International ROV Competition in the Great Lakes

May 15—Saginaw, Mich.—A team from the East Lake Charter School has been selected to compete the Marine Advanced Technology Education (MATE) Center's 13th Annual International Student ROV Competition. Remotely operated vehicles, or ROVs, are tethered underwater robots used to complete tasks in underwater environments. The East Lake team will compete against more than fifty teams from around the world, using an ROV that they designed and built during the past 6 months.

At the International ROV Competition, which will be held June 26 – 28 in Alpena, Michigan, East Lake Charter will compete against the top teams from MATE's network of regional competitions. East Lake Charter was one of the winners in the MATE Great Lakes Regional ROV Contest, which was held in April.

Each year, MATE's ROV competition encourages students to learn and apply science, technology, engineering, and math skills to complete tasks that simulate real-world problems from the ocean workplace. This year, the contest focuses on the role that ROVs play in exploring shipwrecks, conducting scientific research on sinkholes, and conserving our national maritime heritage sites in the Thunder Bay National Marine Sanctuary (TBNMS), which is one of 14 U.S. national marine sanctuaries.

Located in Lake Huron, TBNMS encompasses an area is known as "shipwreck alley" – and for good reason. The sanctuary is home to more than 50 shipwrecks and charged with protecting these wrecks from natural processes, including the invasive zebra mussels, and human impacts, including trash and debris. In addition to shipwrecks, the TBNMS is home to unique geologic features called sinkholes, which are formed from the erosion of limestone sediments deposited millions of years ago. Since 2001, scientists have been studying the groundwater venting from sinkholes as well as the mats of microbes that thrive on the chemicals contained in the groundwater.

Teams will participate in underwater mission tasks, piloting their ROV to document a fictitious shipwreck, using information that they collect about its cargo, build date, and home port (stamped on a ceramic dinner plate found onboard) to identify it. They will also take measurements of the groundwater and collect samples microbial mats from a sinkhole discovered near the ship and remove man-made debris littering the wreck site, among other tasks. In addition, teams must prepare an engineering report, make a presentation to a panel of judges, and create a poster display.

This is the fifth year that East Lake Charter has participated in the Great Lakes Regional ROV Contest, and the first year it has attended the MATE International ROV Competition.

East Lake Charter's ROV team is supported by local sponsors, including Tom's Hobby Shop, East Bay Marina, and Schaumberg Electronics.

For more information about the East Lake Charter School ROV team, please contact Matt Gardner at (831) 555-1234 or email@email.com.

For more information about the MATE ROV competition, visit www.marinetech.org/rov-competition/ or contact Caroline Brown at (401) 338-8980 or email@email.com.

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