



# 2014 MATE ROV Competition Manual

## NAVIGATOR CLASS

13th Annual  
**MATE International  
ROV Competition**

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

NOAA  
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## 2014 MATE ROV COMPETITION:

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

## NAVIGATOR 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 .....	2
THINK OF YOURSELVES AS ENTREPRENEURS .....	2
PART 1: MISSION SCENARIO & TASKS .....	3
MISSION OVERVIEW .....	3
SCORING OVERVIEW .....	3
TIME .....	4
MISSION SCENARIO .....	4
REQUEST FOR PROPOSALS (RFP) .....	7
MISSION TASKS .....	11
Task 1: SHIPWRECKS .....	11
Task 2: SCIENCE .....	15
Task 3: CONSERVATION .....	18
PART 2: MISSION PROP BUILDING INSTRUCTIONS & PHOTOS .....	19
Task 1: SHIPWRECKS .....	19
Task 2: SCIENCE .....	33
Task 3: CONSERVATION .....	36
PROP PARTS LIST .....	38
PART 3: VEHICLE DESIGN & BUILDING SPECIFICATIONS .....	39
1.0 GENERAL .....	39
1.1 FAQs .....	39
1.2 Documentation Required .....	39
2.0 SAFETY .....	39
2.1 Safety inspection protocol .....	40
NAVIGATOR CLASS .....	1

2.2 Safety Inspection Completed.....	40
3.0 SPECIFICATIONS .....	40
3.1. Operational.....	41
3.2. Mechanical/Physical.....	41
3.3. Electrical.....	42
3.4 Onboard Electrical Power.....	43
3.5 Power Shutdown .....	43
3.6 Fluid Power.....	43
3.7 Cameras and monitors.....	44
3.8. Lasers .....	44
PART 4: COMPETITION RULES.....	45
GENERAL.....	45
PROCEDURAL.....	45
DESIGN & SAFETY CONSIDERATIONS.....	47
PART 5: ENGINEERING & COMMUNICATION .....	48
TIPS FOR EFFECTIVE WRITTEN AND ORAL COMMUNICATION.....	49
PROJECT REPORT.....	50
ENGINEERING PRESENTATION .....	51
POSTER DISPLAY.....	53

## OVERVIEW

### THINK OF YOURSELVES AS ENTREPRENEURS

From drilling for oil in deep water to exploring shipwrecks and installing instruments on the seafloor, individuals who have 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 business operations (e.g., finances, research and development, media outreach), work as an important 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? 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

**NAVIGATOR** class companies will compete in ONE mission that consists of the following three distinct tasks:

#### **Task #1: SHIPWRECKS**

Explore, document, and identify an unknown shipwreck recently discovered in sanctuary waters.

#### **Task #2: SCIENCE**

Recover a sensor and deploy a new one.

#### **Task #3: CONSERVATION**

Remove trash and debris from the shipwreck and surrounding area.

Companies can do the three tasks in any order. Your company will get up to **TWO** attempts to complete this mission. The higher of the two scores will be added to your [ENGINEERING & COMMUNICATION](#) score to determine your total, overall score for the competition.

### SCORING OVERVIEW

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

- **Mission**
  - 200 points (max), plus a time bonus
- **Engineering & Communication** – 140 points (max)

- Project reports – 40 points (max)
- Engineering presentations – 50 points (max)
- Poster displays – 50 points (max)
- **Safety** – 10 points (max)

**NOTE: Regional contests may not require all of these components. Contact your [regional coordinator](#) for more information.**

## TIME

The time that your company will have to complete the mission tasks will depend on your regional event. Contact your [regional coordinator](#) to determine how your missions will be set up and how long you will have for the mission tasks.

At any time during the mission, you may pilot your ROV to the surface and remove it from the water for things such as buoyancy adjustments, payload changes, and troubleshooting. However, the mission clock will NOT stop. The only time the clock will stop is if a judge determines that there is an issue that is 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.

## 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.

How the time bonus is calculated will depend on your regional event. Your regional coordinator will tell you this when he/she explains how your mission tasks will be set up and how much time you'll have to complete them.

## 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 storms, 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 19<sup>th</sup> century schooners and steamers to a modern ocean-going freighter, the shipwrecks of Thunder Bay represent the history of maritime commerce and travel on the Great Lakes.



Map of the Great Lakes with Thunder Bay highlighted

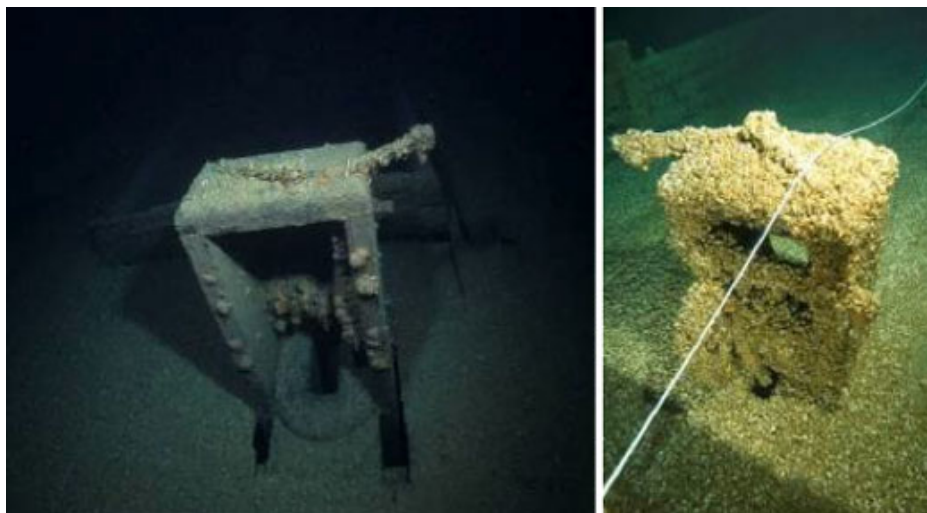


Map of Thunder Bay, highlighting the TBNMS and its shipwrecks

Ice, waves, and invasive species such as zebra mussels – as well as trash and debris generated by *Homo sapiens* – could potentially harm these 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 deterioration of these irreplaceable archaeological sites.



*The propeller of the freighter Monohansett, which sank in Thunder Bay in 1907*



*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 coming up from the sinkholes is low in oxygen, rich in inorganic carbon, 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 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 and identify an unknown shipwreck recently discovered in sanctuary waters; 2) recover a conductivity sensor and deploy a new one; and 3) remove trash 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) is the guardian for marine protected areas that cover 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 Papahānaumokuākea Marine National Monument.

The [Thunder Bay National Marine Sanctuary \(TBNMS\)](#) was designated in 2000 to study and monitor its maritime heritage resources to ensure their long-term protection. The Sanctuary is approximately 448 square miles (1169 square kilometers) large and 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 assists research aimed at better understanding the environmental and natural aspects of Lake Huron. From [weather observations](#) to invasive species monitoring and understanding submerged [sinkholes](#), the sanctuary works with a variety of academic, government, and other 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. Over the last 150 years, the region has become 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.

With more ships traveling the Great Lakes came more chances for disaster. Over 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 preserve and protect the shipwrecks for future generations. While known wrecks sites are documented and monitored, the potential for discovering new, yet-to-be-identified shipwrecks always exists.

#### **c. SINKHOLES**

The waters of Lake Huron are contained within a basin made up of layers of rock that are more than 400 million year old. These layers of rock were formed from the remains of saltwater seas

that once covered the continent. Over time, movement of groundwater in and around the rock gradually dissolved it, resulting in underground caves and cracks. Further erosion of the rock along the cave ceilings caused it to collapse, leaving sinkholes.

As groundwater travels through faults in the rock, it dissolves salt captured in the rock layers. As a result, the groundwater coming out 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 lake water. Because the emerging groundwater is cold and salty, it is denser than surrounding lake water and forms a layer on the lake floor that can be as much as 5 meters (17 feet) thick.

In addition to salt, the groundwater also dissolves other chemicals, such as sulfate, from the rock layers. Telltale signs of groundwater filled with sulfur coming out of a sinkhole are 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 turn carbon into organic matter – food.

Purple filamentous mats of cyanobacteria are found at sinkholes that are within the photic zone. These microbes use light energy to create organic carbon (food!) from the carbon dioxide that is dissolved in the groundwater. In some cases these microbes are so abundant that the mats form “fingers” that look like they are reaching into the water column.

Scientists have studied sinkholes in TBNMS since 2001. Given the relatively shallow depth of Lake Huron, most of their measurements and sampling have been done by SCUBA divers. However, given the how delicate these sinkholes are and the potential for caves and overhangs to collapse, scientists are becoming more and more interested in having ROVs help with their work.

#### **d. CONSERVATION**

Thunder Bay's shipwrecks are magnificent, yet vulnerable. Natural processes and human impact threaten their existence. While scientists look into 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 into the impacts of modern-day *Homo sapiens* on the wreck sites. We have the technology to retrieve and remove trash and debris from even the deepest point of the Great Lakes.

#### **e. Purpose of this Document**

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

- Conduct a sonar scan of the wreck
- Unlock and open a container to determine the cargo
- Search for the date the ship was built on the outside of the wreck
- Retrieve a ceramic dinner platter to determine the home port of the ship
- Identify the ship using known parameters
- SCIENCE
  - Recover a sensor and deploy a new one
  - Place a quadrat on a section of shipwreck, count the number of zebra mussels inside the quadrat, and estimate the total number of zebra mussels on the shipwreck using the dimensions provided
- CONSERVATION
  - Remove bottles and discarded anchor lines

## 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 will guarantee the ROV for the duration of the competition event. Repair or replacement will be at the company's expense. The company will provide at least one day of technical support to deal with any issues.

## 4. Shipping and Storage

Delivery of the ROV will be no later than the date of the nearest regional contest.

## 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>

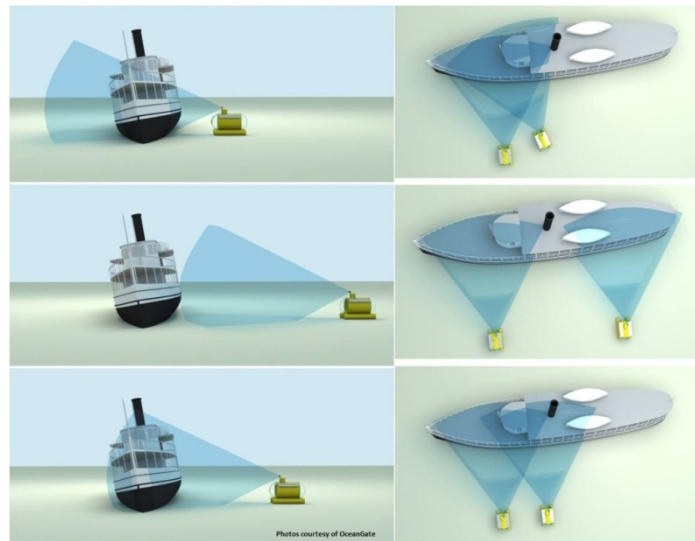
- Lake Huron Sinkholes Give Clues to Ancient Life – <http://greatlakesecho.org/2009/07/15/lake-huron-sinkholes-provide-clues-to-ancient-life/>
- NOAA’s National Marine Sanctuaries – <http://sanctuaries.noaa.gov/missions/2006fknms/photomosaicgallery.html>
- Great Lakes Fact Sheet – <http://www.epa.gov/glnpo/factsheet.html>
- 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

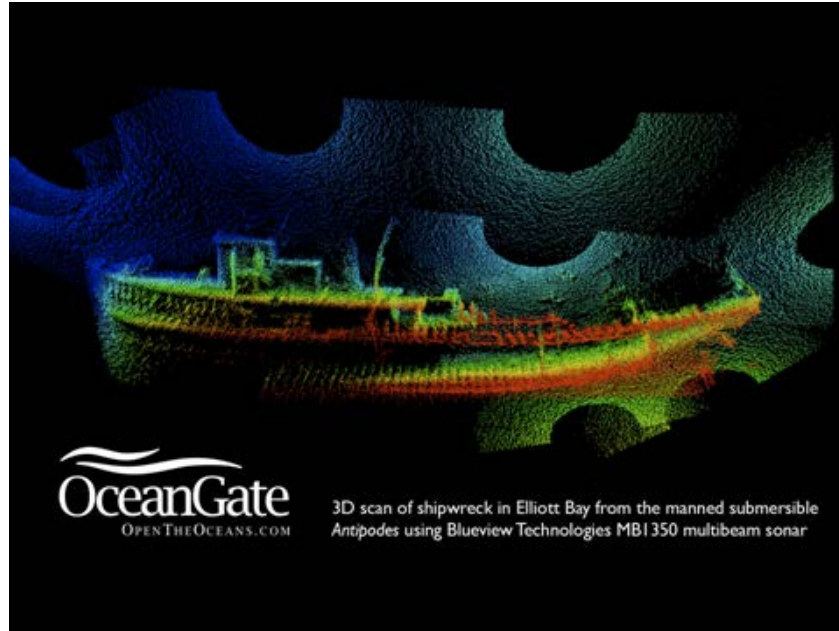
Your company is tasked with exploring, documenting, and identifying an unknown shipwreck.

Your company is also tasked with scanning the wreck with “sonar.” 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*

Your company must also find three features that you will use to identify the shipwreck from a list of known, but previously undiscovered, wrecks: 1) the type of cargo that the ship contained; 2) the date the ship was built; and 3) the ship's home port.

A cargo container and a ceramic dinner platter will be located outside of the shipwreck. The cargo container must be unlocked and opened to determine the type of cargo that the ship was carrying. The cargo container will hold one of two items: coal or wheat. The name of the ship's home port will be stamped on the ceramic dinner platter. The three possible home ports are: Detroit, Michigan, Sault Ste. Marie, Canada, or Chicago, Illinois. The build date of the ship will be stamped somewhere on the hull of the wreck.

**This task involves the following steps:**

- **Correctly "scanning" the ship at the target location – 20 points**
- **Determining the shipwreck's cargo – up to 40 points**
  - **Unlocking the cargo container – 5 points**
  - **Opening the door of the cargo container – 10 points**
  - **Determining the type of cargo carried by the ship – 10 points**
  - **Closing the door of the cargo container – 5 points**
  - **Locking the cargo container – 10 points**
- **Locating and determining the date the ship was built – 10 points**
- **Recovering a ceramic dinner platter – up to 20 points total**
  - **Removing the platter– 5 points**
  - **Returning the platter to the surface – 10 points**

- Identifying the home port of the ship – 5 points
- Identifying the ship using the three known indicators – 10 points

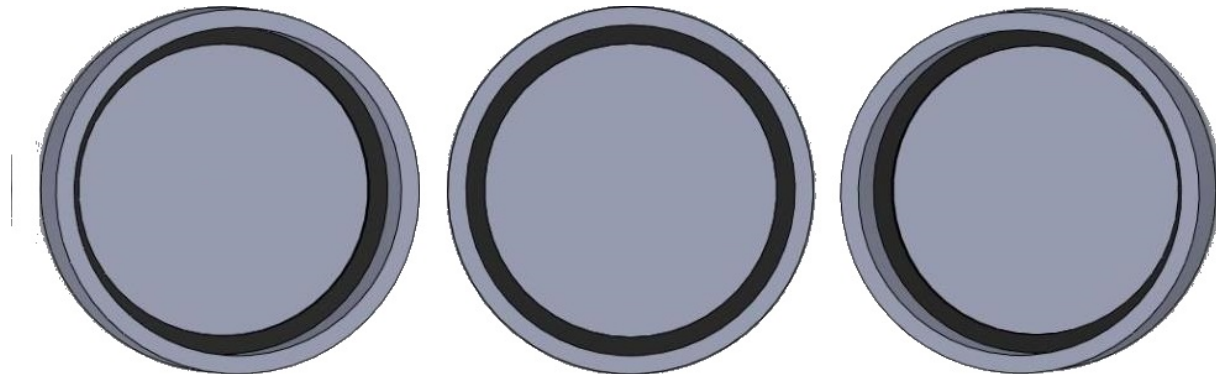
**Total points = 100**

**Mission notes:**

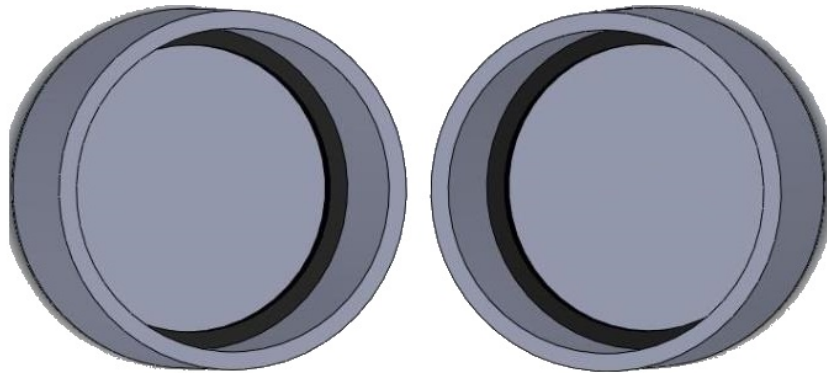
Companies may complete the steps of Task #1 in any order and may alternate between Task #1 and the other tasks.

Companies will simulate scanning the shipwreck with sonar by visualizing a target through a camera. Companies will have one target area to scan. The target will consist of a black ring of 2-inch ABS pipe set inside a 2-inch white PVC end cap. The target will be secured to the PVC framework of the shipwreck. There will be two marks, one on either side of the target. The marks will be 25 cm away from the target. To successfully 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 the two marks. The vehicle must maintain this alignment for 10 seconds. If at any time the mission station judge is unable to see the entire black ring or the marks on either side of the target, companies must realign their vehicle and start the scan again. Companies will receive 20 points for a successful target scan.

Targets will sit at least 20 cm off the pool bottom.



**NAVIGATOR figure #1:** “Successful” scans. The left target depicts the ROV a little to the left, but still successfully scanning the 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. Seeing the complete black ring, combined with seeing the marks on both sides of the target, is considered a “successful” scan.



**NAVIGATOR figure #2:** “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 find then use three features to identify the wreck.

**The first 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 it. 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 hatch 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 hatch. Companies will receive 10 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 container hatch. Companies will receive 5 points for closing the door of the container and 5 points for locking the hatch of the cargo container.

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 second feature is the build date stamped onto the framework of the shipwreck.** The framework of the shipwreck will be constructed from ½-inch PVC pipe. The date the ship was built will be written on a 5 cm x 15 cm rectangle of black plastic. The black rectangle will be screwed onto the framework of the shipwreck. Companies will receive 10 points when they display the date, on a video monitor, to the mission station judge.

**The third feature is a ceramic serving platter decorated with the name of the home port of the ship.** The platter is simulated by a 10-inch square plastic plate set on a PVC framework with two handles. The home port of the ship will be stamped on the plate, but will be completely covered by a 12 cm x 5 cm plastic rectangle. The platter will be located on the bottom of the pool. Companies must retrieve and

return the dinner platter to the surface and remove the plastic cover in order to determine the home port. Companies will receive 5 points for lifting the platter so it is under control of the ROV and no longer touching the platform or bottom of the pool. Companies will receive an additional 10 points when the platter is returned to the surface side of the pool. Returning the platter 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, Sault Ste. Marie, Canada, or Chicago, Illinois.

The platter will weigh less than 2 Newtons in water.

Companies must use these three features to identify the ship from a list of 12 possible wrecks. 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 [MISSION PROP BUILDING INSTRUCTIONS & PHOTOS](#) contains prop building instructions.

See the [NAVIGATOR mission SolidWorks](#) files for CAD representations of the missions.

See [NAVIGATOR shipwrecks](#) for the list of 12 possible wrecks.

## Task 2: SCIENCE

Your company is tasked with investigating a sinkhole discovered near the wreck site.

Your company must recover a sensor previously deployed at a sinkhole near the shipwreck. This sensor is being used by scientists to monitor the conductivity of the groundwater coming out of the sinkhole.

Your company must retrieve this sensor and replace it with a new one.

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. Companies will use the mussel count and the dimensions of the shipwreck, provided by the mission station judge, to estimate the entire number of mussels on the shipwreck.

**This task involves the following steps:**

- **Recovering the old conductivity sensor and replacing it with a new one – up to 20 points**
  - **Returning the old conductivity sensor to the surface – 10 points**
  - **Deploying the new conductivity sensor to the designated area – 10 points**
- **Estimating the number of zebra mussels on the wreck – up to 30 points**
  - **Placing the quadrat into position on top of the shipwreck – 10 points**
  - **Counting the number of zebra mussels within the quadrat – 5 points**



- Using the given dimensions to estimate the number of zebra mussels on the shipwreck – up to 15 points
  - Correctly estimating the number of mussels on the shipwreck – 15 points
  - Within 10% of the total number of mussels – 5 points
  - >10% of the total number of mussels – 0 points

**Total points = 50 points**

**Mission Notes:**

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

A conductivity sensor 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. The conductivity sensor must be returned to the surface and a new conductivity sensor deployed in its place within the designated area. Both sensors will be constructed from 3-inch PVC pipe with a ½-inch PVC pipe framework. A U-bolt at the top will serve as a “grab” point for the sensors. The new sensor will be located at the surface, side of the pool.

Companies may attach the new sensor to their vehicle while they are setting up at the mission station. Companies will receive 10 points when the old conductivity sensor is returned to the surface, side of the pool. Once the old conductivity sensor has been removed from the designated area, the new conductivity sensor must be placed completely within the designated area. The designated area will be represented by a 50 cm x 50 cm ½-inch PVC square. The new conductivity sensor must be deployed completely within this designated area. All four “feet” of the sensor must be resting on the pool bottom within the designated area. The feet may be touching the PVC of the designated area, but may not be sitting on top of or outside of the PVC. Companies will receive 20 points when the new conductivity sensor is successfully deployed within the designated area.

Each conductivity sensor will weigh less than 2.5 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 2 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 a corrugated plastic sheet 1.2 meters x 1.2 meters (4 feet x 4 feet) in size. Companies will receive 10 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 surface area of the wreck to estimate the total number of zebra mussels on the shipwreck. A mission station judge will provide the total surface area of the shipwreck when the company enters the mission station. Companies will receive 15 points if their estimation of the entire number of mussels on the shipwreck is correct. The MATE Center will calculate the total number of mussels using the surface area of the shipwreck and the number of mussels counted by the company within the quadrat. Companies will receive 5 points if their estimation is within 10% of the total and zero points if their estimation is greater than 10% from the total.

**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:  $2.5 \text{ m length} \times 1 \text{ m height} \times 2 \text{ sides} = 5 \text{ square meters}$

Front:  $1.2 \text{ m width} \times 1 \text{ m height} = 1.2 \text{ square meters}$

Back:  $1.2 \text{ m width} \times 1 \text{ m height} = 1.2 \text{ square meters}$

Top:  $2.5 \text{ m length} \times 1.2 \text{ m width} = 3 \text{ square meters}$

**Total surface area:  $5 + 1.2 + 1.2 + 3 = 10.4 \text{ square meters}$**

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 ( $9 \times 4$ ). The total mussels on the shipwreck would be **374.4** ( $36 \text{ mussels per square meter} \times 10.4 \text{ square meters}$ ).

The [MISSION PROP BUILDING INSTRUCTIONS & PHOTOS](#) contains prop building instructions. See the [NAVIGATOR 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 and anchor line rope debris.

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, anchor line rope will be located within the wreck site.

**This task involves the following steps:**

- **Removing two bottles– up to 30 points**
  - **Removing the plastic water bottle– 5 points**
  - **Returning the plastic water bottle to the surface – 10 points**
  - **Removing the glass bottle– 5 points**
  - **Returning the glass bottle to the surface – 10 points**
- **Removing the anchor line rope– up to 20 points**
  - **Lifting the rope off the bottom – 5 points**
  - **Returning the anchor line rope to the surface – 15 points**

**Total points = 50**

#### **Mission Notes:**

Companies may complete the steps of Task #3 in any order and may alternate between Task #3 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 10 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 10 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 60 cm x 60 cm hole on the side of the shipwreck. 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 15 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 5 Newtons in water.

The [MISSION PROP BUILDING INSTRUCTIONS & PHOTOS](#) contains prop building instructions. See the [NAVIGATOR mission SolidWorks](#) files for CAD representations of the missions.

If a company has successfully completed all the mission tasks and is returning to the surface with the final items to be removed from the pool (such as ceramic platter, conductivity sensor, bottles, rope debris, 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**

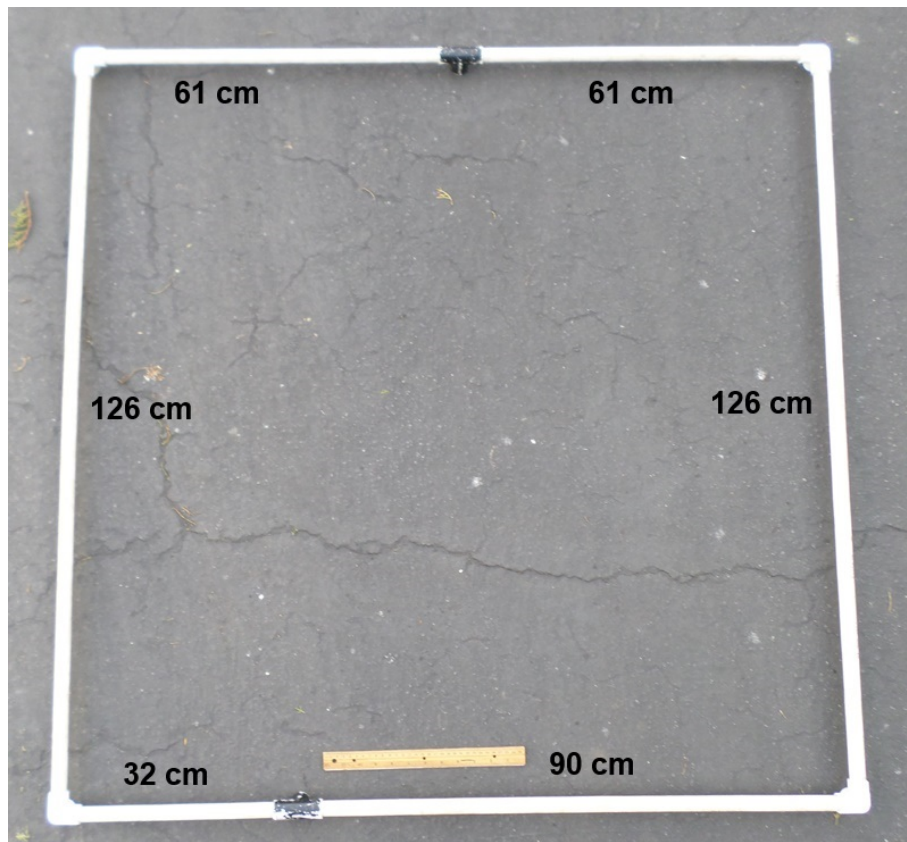
#### **Shipwreck**

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.

To construct the shipwreck:

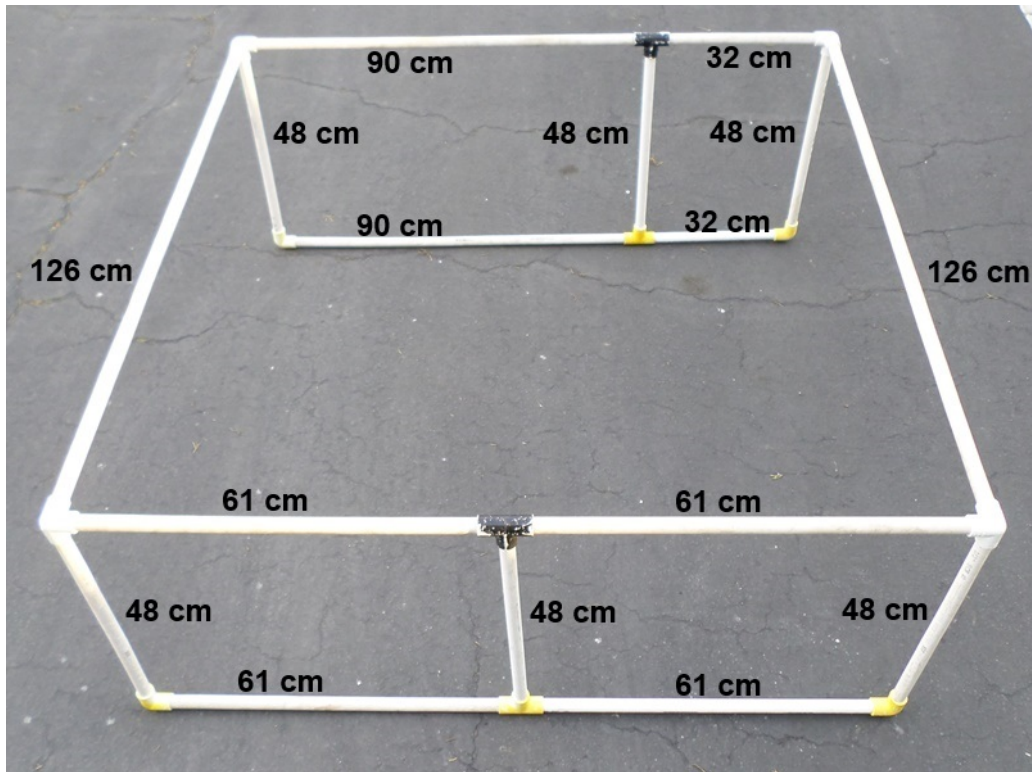
1. Cut two 126 cm lengths of ½-inch PVC pipe. Attach a ½-inch side out to each end of the two pipes, four side outs in all.
2. Cut one 90 cm length, two 61 cm lengths, and one 32 cm length of ½-inch PVC pipe. Attach the side opening of ½-inch tee to one end of the 90 cm length of pipe. Insert the 32 cm length of pipe into the other side opening of the ½-inch tee. Attach the side opening of another ½-inch tee to one end of one of the 61 cm lengths of pipe. Insert the other 61 cm length of pipe into the other side opening of the PVC tee. When combined, you should have two 126 cm lengths of PVC pipe, with a tee somewhere along its length.
3. Insert these combined 126 cm lengths of pipe into the sides outs on the 126 cm pipes cut to length. You should have a ½-inch PVC square approximately 132 cm x 132 cm. All the remaining

openings on the four side outs and the middle openings of the two tees should face the same direction.



**NAVIGATOR build photo #1:** The top square of the shipwreck.

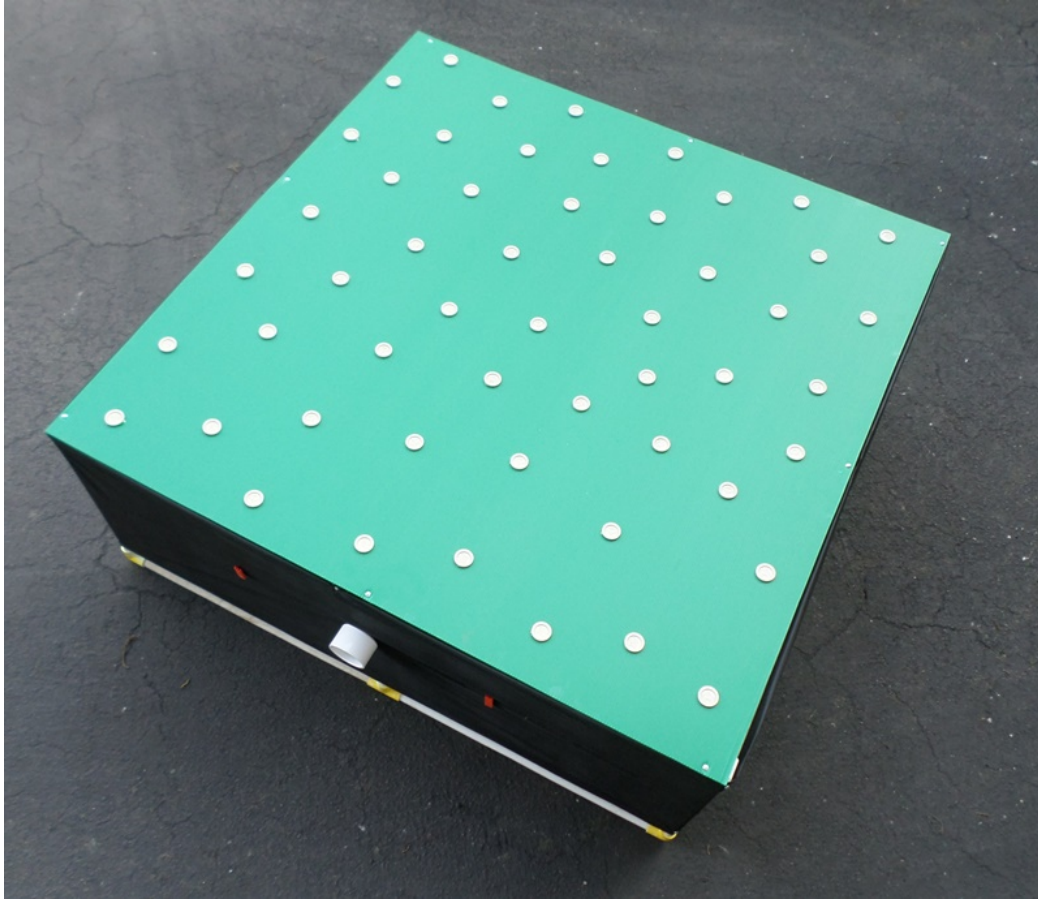
4. Cut six 48 cm lengths of PVC pipe. Insert the six lengths into the four side outs and the two tees.
5. Cut one 90 cm length, two 61 cm lengths, and one 32 cm length of  $\frac{1}{2}$ -inch PVC pipe. Attach the side opening of  $\frac{1}{2}$ -inch tee to one end of the 90 cm length of pipe. Insert the 32 cm length of pipe into the other side opening of the  $\frac{1}{2}$ -inch tee. Attach the side opening of another  $\frac{1}{2}$ -inch tee to one end of one of the 61 cm lengths of pipe. Insert the other 61 cm length of pipe into the other side opening of the PVC tee. When combined, you should have two 126 cm lengths of PVC pipe, with a tee somewhere along its length.
6. Attach a  $\frac{1}{2}$ -inch  $90^\circ$  elbow to each end of both 126 cm lengths of pipe. Attach the 90° elbows and the middle opening of the PVC tees to the six 48 cm lengths of PVC pipe.



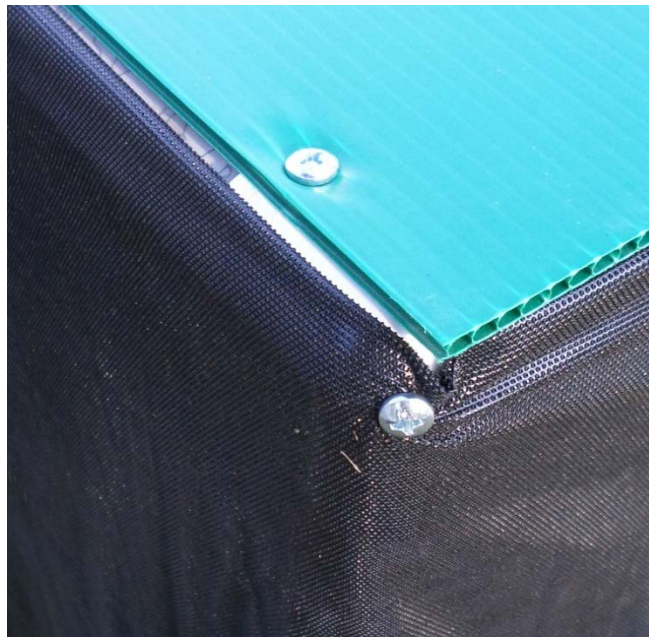
**NAVIGATOR build photo #2:** The shipwreck framework.

1. Cut a 130 cm x 130 cm (4 feet x 4 feet) square of corrugated plastic sheeting. A darker color (green, blue or black) works best.
2. Attach this rectangle of corrugated plastic to the top of the shipwreck framework. Use small set screws to secure the corrugated plastic on the top of the shipwreck.
3. Cover the sides of the shipwreck with black shade cloth.

**Design note:** If your corrugated sheet is too small to fit over the PVC framework, but down the PVC to ensure a secure fit.



**NAVIGATOR build photo #3:** The shipwreck with corrugated top and shade cloth sides.

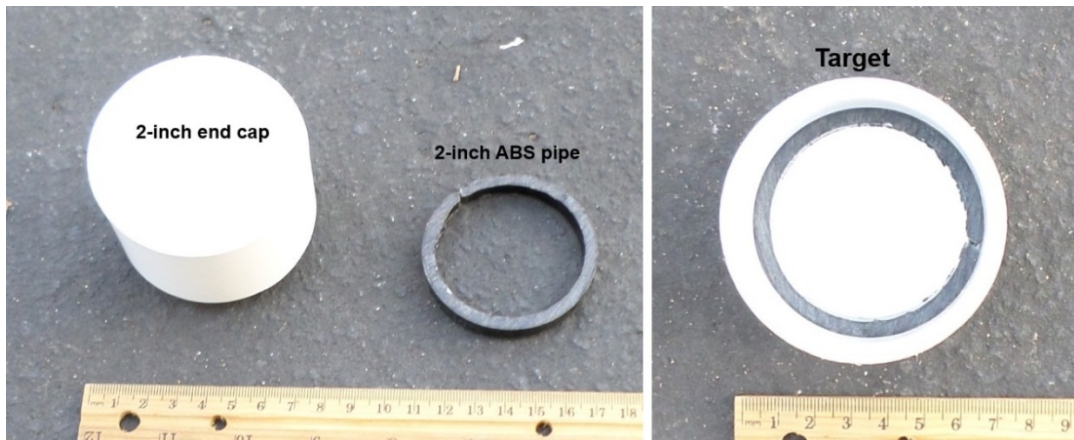


**NAVIGATOR build photo #4:** Screws are used to secure the shade cloth and corrugated plastic to the PVC framework.

## **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.

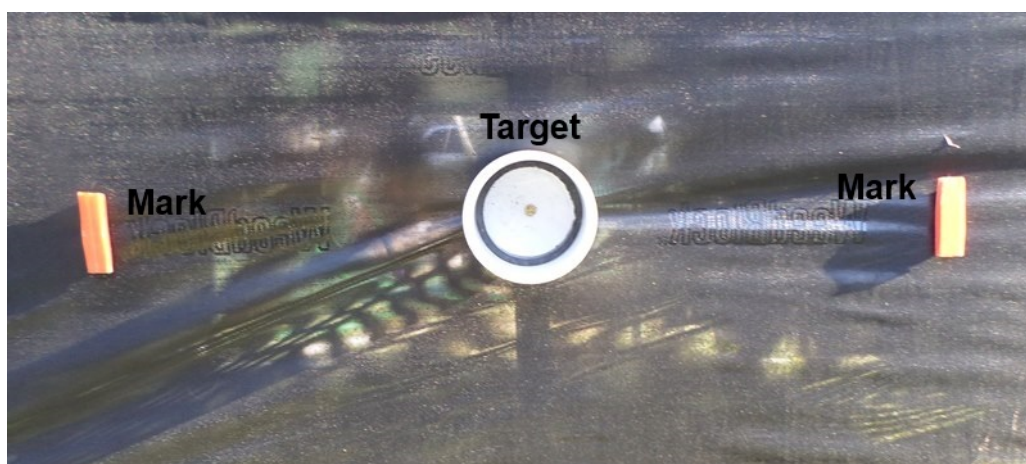
1. Cut a 1 cm length of 2-inch black ABS pipe. Use a saw or heavy wire cutters to cut a 1 to 2 mm section from ABS ring.
2. Insert this ABS ring into the end cap, as close to the bottom as possible.



**NAVIGATOR build photo #5:** 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.

3. Use a screw to fasten the target onto the PVC pipe of the shipwreck framework. The target should be positioned on one of the vertical beams connected by the two PVC tees. Position the target at least 20 cm from the bottom of the pool.



**NAVIGATOR build photo #6:** The target attached to the PVC framework of the shipwreck. Marks are 25 cm to either side of the target.



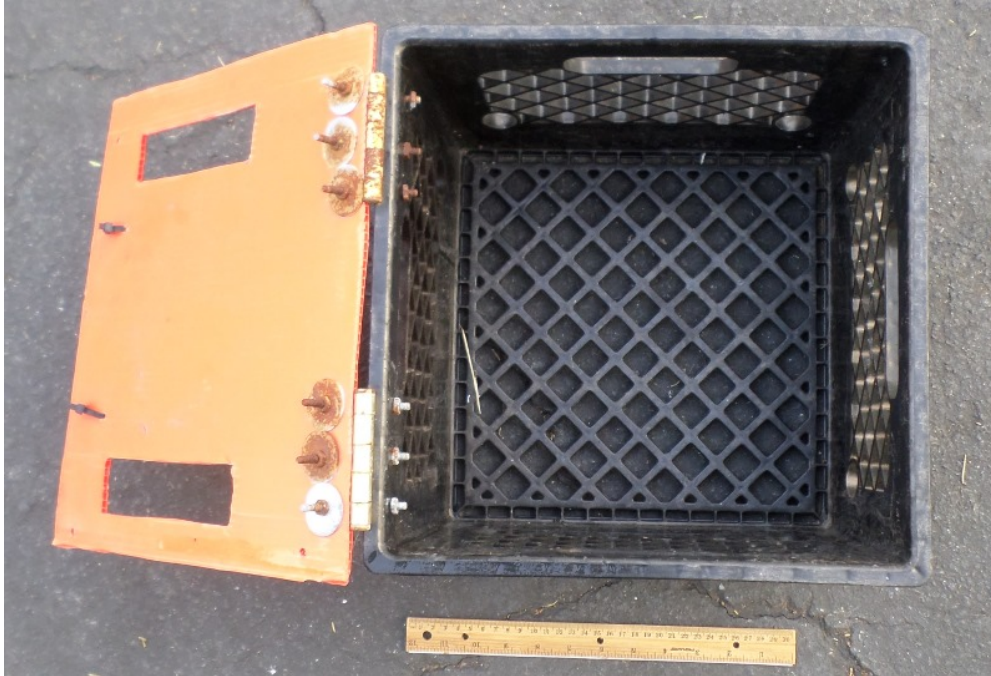
### **Cargo container**

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 RANGER and EXPLORER 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° PVC elbow to each end. Drill two 5/32-inch holes into the open end of each 90° 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° 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° PVC elbow. Insert cable/zip ties through the holes of each 90° PVC elbow, through the holes in the corrugated plastic. Tighten the ties to secure the handle to the corrugated plastic.



**NAVIGATOR build photo #7:** Cargo container without the locking mechanism or the stand.

### **Handle and locking mechanism**

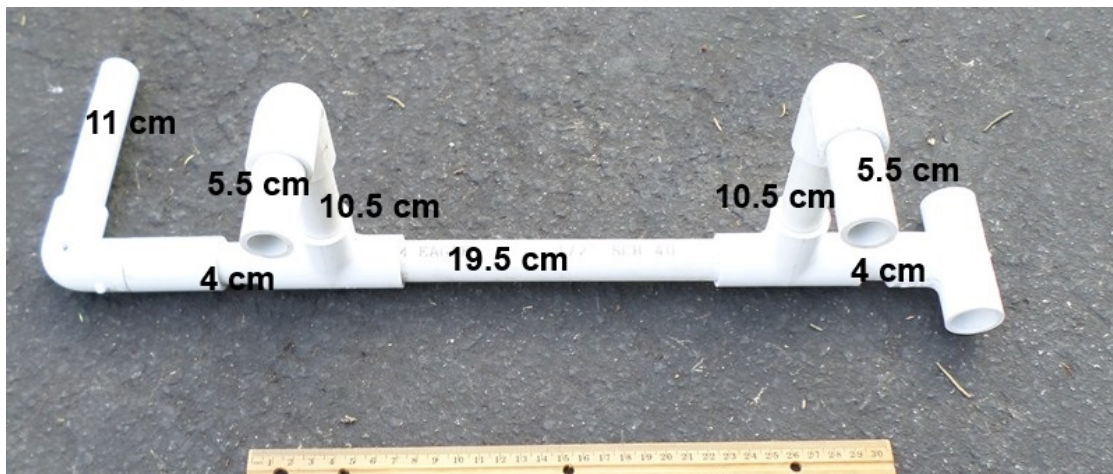
The door of the cargo container includes a handle and locking mechanism, which are constructed from ½-inch PVC pipe. The handle must be turned to remove the locking mechanism before the top hatch can be opened.

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° 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° 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° 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° PVC elbow.
8. Twist the 90° PVC elbow until the 11 cm length of pipe is parallel two 5.5 cm length of pipes.

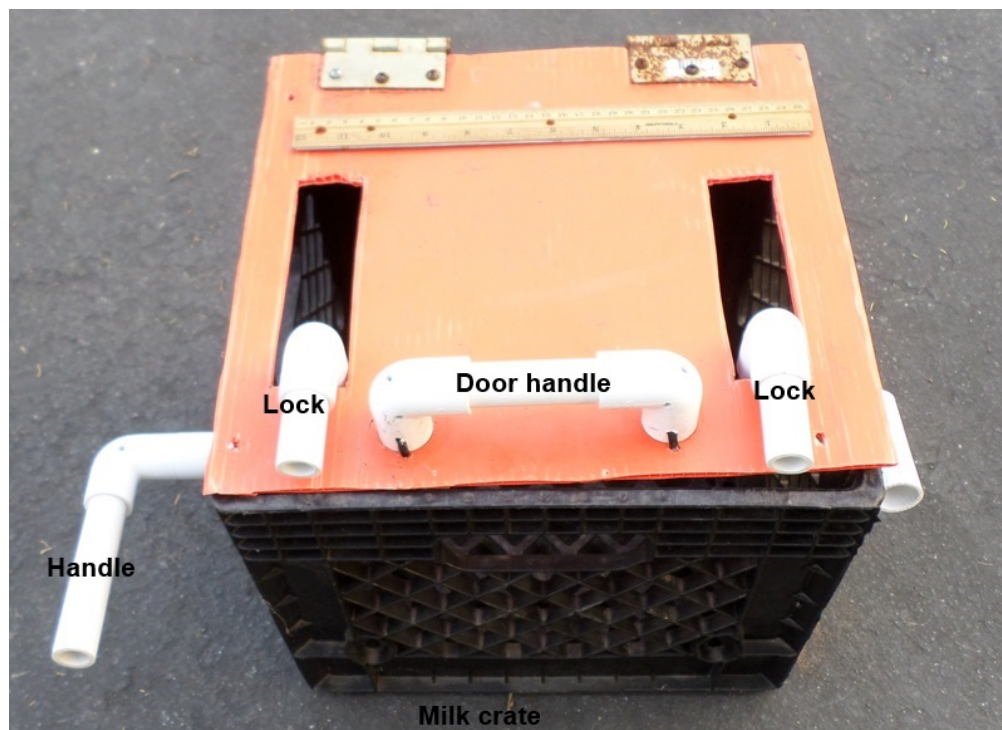
As an ROV turns the handle, the locking mechanism should rotate into or out of the holes cut into the corrugated plastic sheeting. If the corrugated plastic hinders the PVC locking mechanism, readjust the position or enlarge the holes. The locking mechanism should engage and disengage freely without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



**NAVIGATOR build photo #8:** Locking mechanism for the cargo container.



**NAVIGATOR build photo #9:** Locking mechanism inside the milk crate.

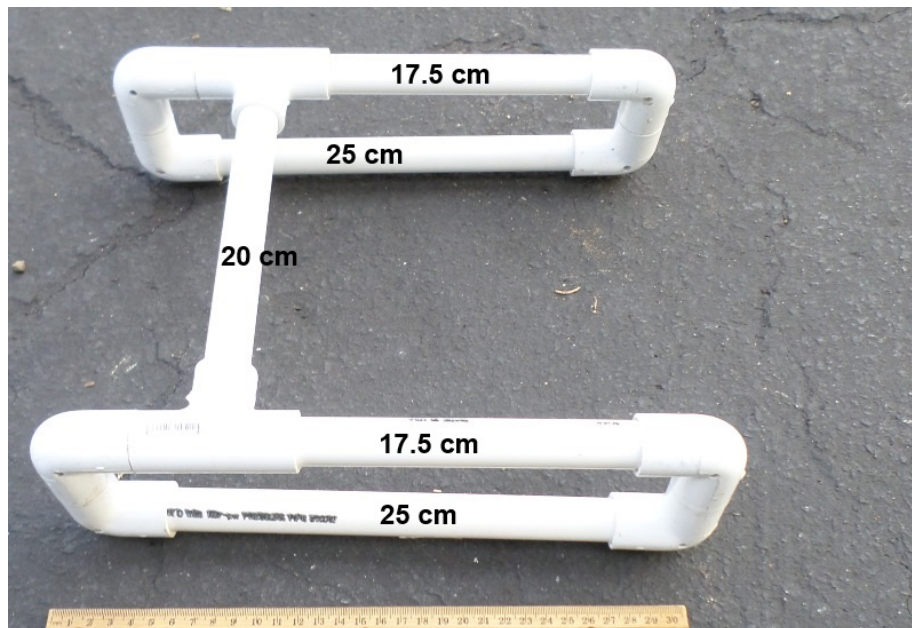


**NAVIGATOR build photo #10:** Cargo container, closed and locked.

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:

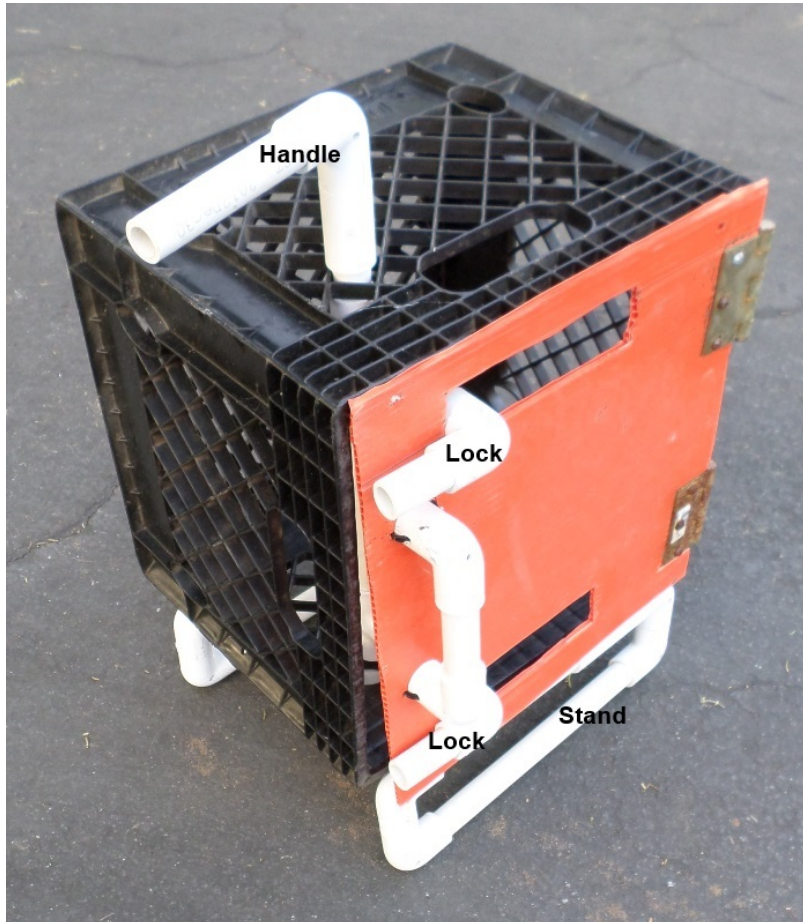
1. Cut two 25 cm lengths of ½-inch PVC pipe. Attach a 90° PVC elbow to each end of the 25 cm lengths of pipe, four elbows in all. Twist the elbows on each end of pipe so the open end faces the same direction.
2. Cut four 3 cm lengths of ½-inch PVC pipe. Insert these four lengths of pipe into the open 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.



**NAVIGATOR build photo #11: 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.



**NAVIGATOR build photo #12:** 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.



**NAVIGATOR build photo #13:** Cargo container open with grain cargo (yellow) inside.

### **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 the PVC framework of the shipwreck. The build date should be positioned on the opposite side of the shipwreck from the scan target.



**NAVIGATOR build photo #14:** Ship build date.

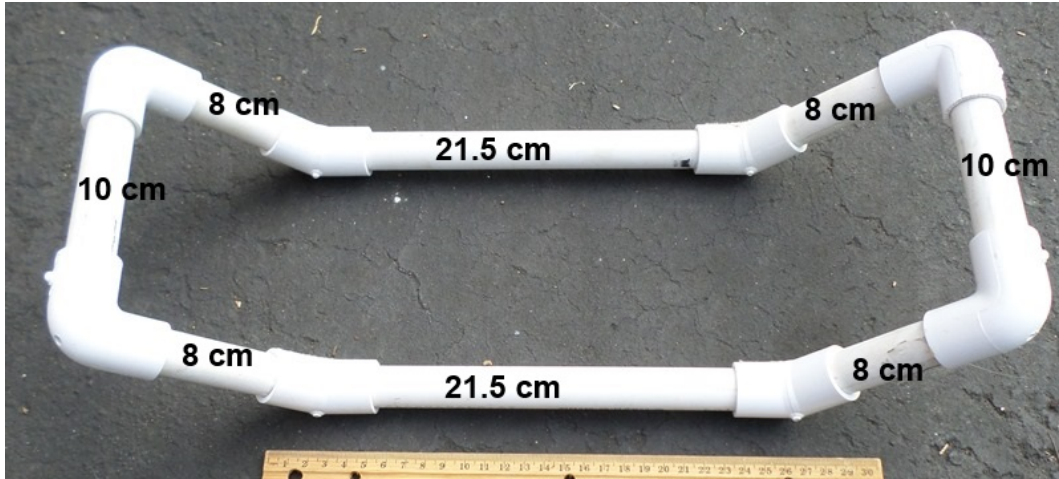
### **Ceramic platter**

The ceramic platter is simulated by a plastic 10.5-inch square dinner plate attached to a ½-inch PVC framework. The PVC framework provides two handles that can be used to lift the platter from the bottom of the pool. The home port of the shipwreck will be printed in the center of the platter. To construct the platter:

1. Cut two 10 cm lengths of ½-inch PVC pipe. Attach a ½-inch 90° PVC elbow to the end of each 10 cm length of pipe, four elbows in all.
2. Cut four 8 cm lengths of ½-inch PVC pipe. Insert one 8 cm length of pipe into the remaining opening on each of the four 90° elbows. Attach a ½-inch 45° PVC elbow to the other end of each 8 cm length of pipe.
3. Cut two 21.5 cm lengths of ½-inch PVC pipe. Attach the four open ends of the 45° PVC elbows to the four ends on both 21.5 cm lengths of PVC.
4. Set the 10.5-inch square plastic dinner plate into the center of the PVC framework. Drill four holes, and secure the plate to the PVC framework with four screws.

**Design note:** Be very careful drilling through the plastic plates, they tend to crack easily. Let the drill do the work of making the hole through the plastic plate.

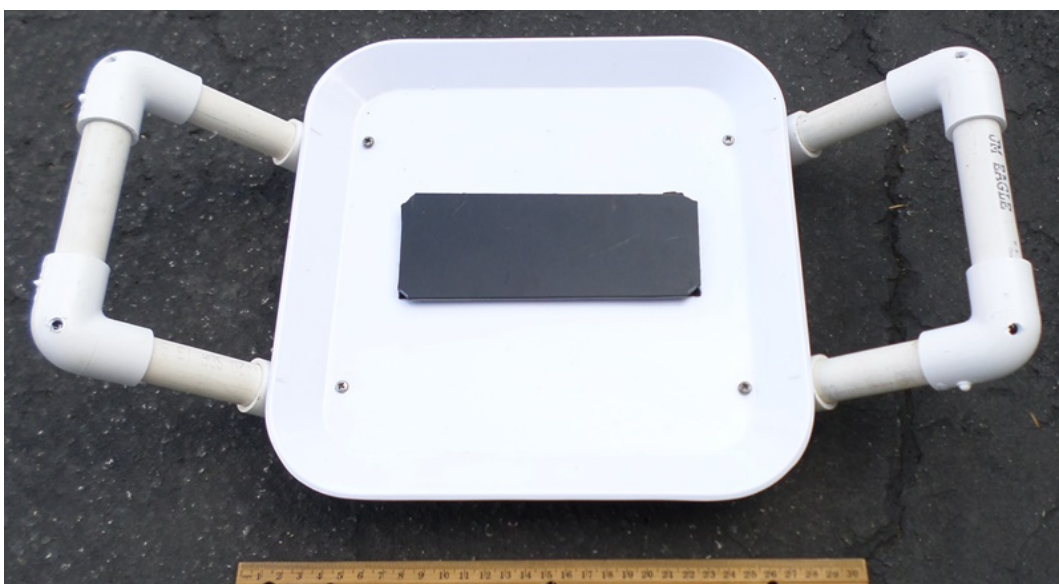




**NAVIGATOR build photo #15:** The ceramic platter ½-inch PVC framework.

5. 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.
6. Cut two 5 cm x 2 cm rectangles of Velcro loops. Attach the Velcro loop rectangles on either side of the printed sticker.
7. Cut a 15 cm x 6 cm rectangle of 1/8-inch ABS sheeting.
8. 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.
9. Attach the ABS rectangle over printed sticker, connecting the Velcro loops to the Velcro hooks.

**Design note:** Drill holes in the 90° PVC elbows and the 45° PVC elbows to allow air to escape from the PVC pipe framework.



**NAVIGATOR build photo #16:** The ceramic platter with the cover on.



**NAVIGATOR build photo #17:** The ceramic platter with the cover off.

## Task 2: SCIENCE

This task consists of two identical conductivity sensors and zebra mussels placed on the corrugated plastic sheet on top of the shipwreck.

### Conductivity sensor

The conductivity sensors are constructed of a 3-inch PVC housing capped on each end by a 3-inch knock out cap. A ½-inch PVC framework surrounds the 3-inch PVC housing. To construct the conductivity sensor:

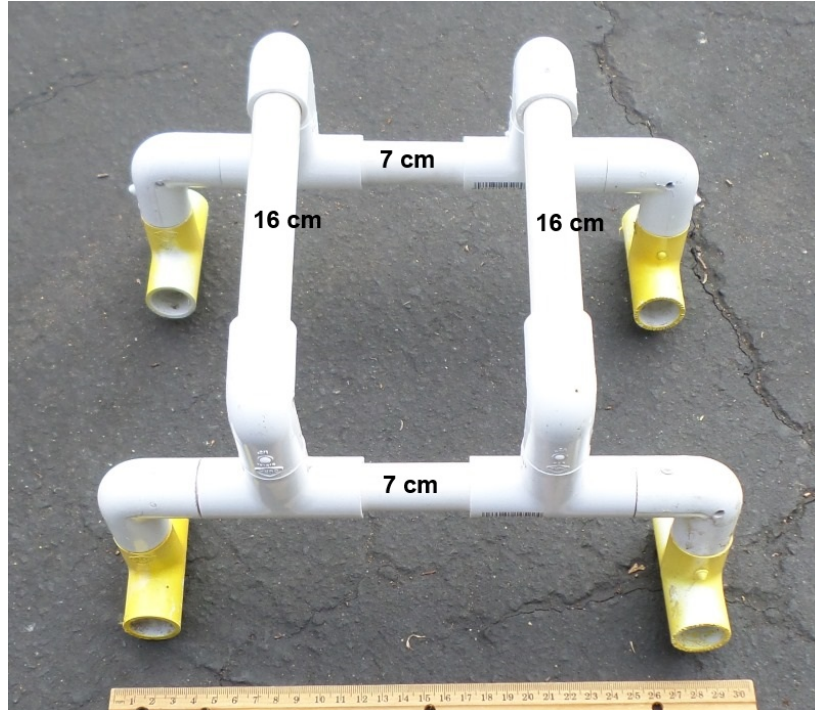
1. Cut a 20 cm length of 3-inch PVC pipe. Drill two 1/4-inch holes 5.6 cm apart in the middle of the 3-inch PVC pipe. Attach a #310 1 ½-inch pipe U-bolt through these two holes. The U-bolt should stick up 6 cm above the wall of the 3-inch pipe. The U-bolt will define the top of the conductivity sensor.
2. Drill small holes into the 3-inch PVC pipe so that it will fill with water when submerged.
3. Cut a 7 cm length of ½-inch PVC pipe. Attach the side opening of a PVC tee to each end of the 7 cm length of pipe.
4. Cut two 3 cm lengths of ½-inch PVC pipe. Insert two of the 3 cm lengths into the two remaining side openings of both PVC tees. Attach a ½-inch 90° PVC elbow to the end of each 3 cm length of pipe. Twist the elbows so they face in an opposite direction as the middle openings of the PVC tees.
5. Cut two 3 cm lengths of ½-inch PVC pipe. Insert the 3 cm lengths of PVC pipe into the other openings on the 90° PVC elbow. Attach the middle opening of a PVC tee to the other end of

each 3 cm length of pipe. Twist the tees so they are perpendicular to the other tees in the sensor, parallel with the 3-inch PVC pipe.

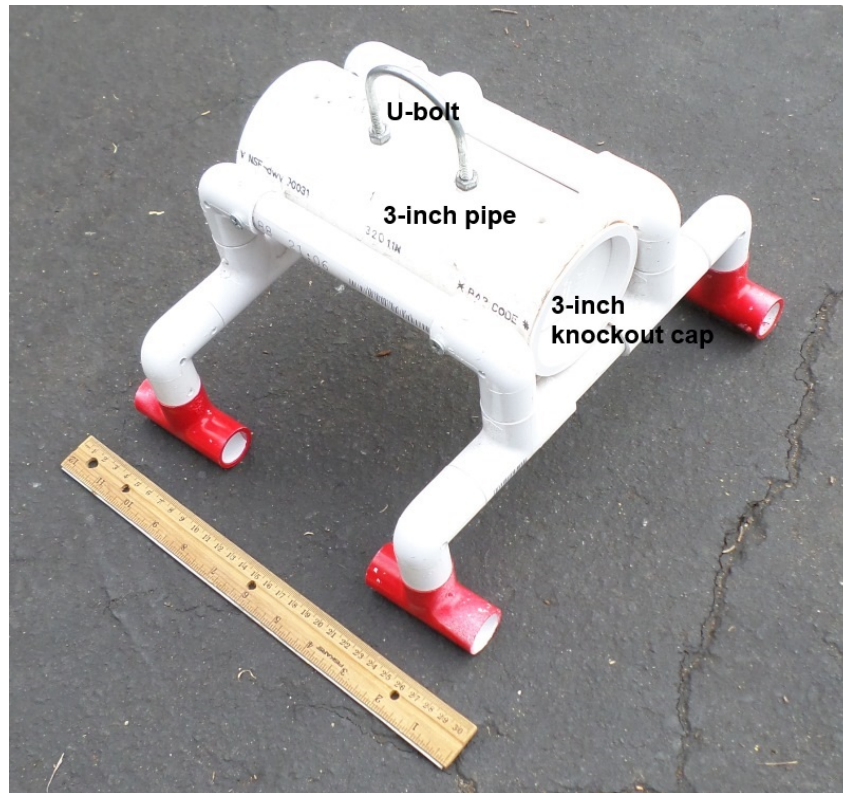
6. Cut two 3 cm lengths of pipe. Insert them into the middle opening of the PVC tees from step #3. Attach a ½-inch 90° PVC elbow to the end of each 3 cm length of pipe. Twist the elbows so they are perpendicular to the PVC tees.
7. Repeat steps 4 through 7 to create the other side of the ½-inch framework.
8. Cut two 16 cm lengths of ½-inch PVC pipe. Connect the 90° elbows from one half of the framework to the 90° elbows on the other half of the framework.
9. Position the 3-inch PVC pipe into the middle of the ½-inch framework, with the U-bolt facing straight up.
10. Use 2-inch screws through the 90° elbows and into the 3-inch pipe to secure the sensor in place.
11. There are eight ½-inch PVC tees used to construct the conductivity sensor. Twist the tees so all eight are parallel in orientation.
12. Insert flotation inside the 3-inch PVC pipe. Attach a 3-inch knock out cap to both sides of the 3-inch PVC pipe.

The amount of flotation inside the pipe can be altered to achieve the desired weight in water.

Two conductivity sensors need to be constructed. The four bottom tees make up the “feet” of the sensors. Paint the tees that make up the “feet” red on one sensor and yellow on the other sensor.



**NAVIGATOR build photo #18:** The framework for the conductivity sensor with yellow “feet.”



**NAVIGATOR build photo #19:** A completed second conductivity sensor with red “feet.”

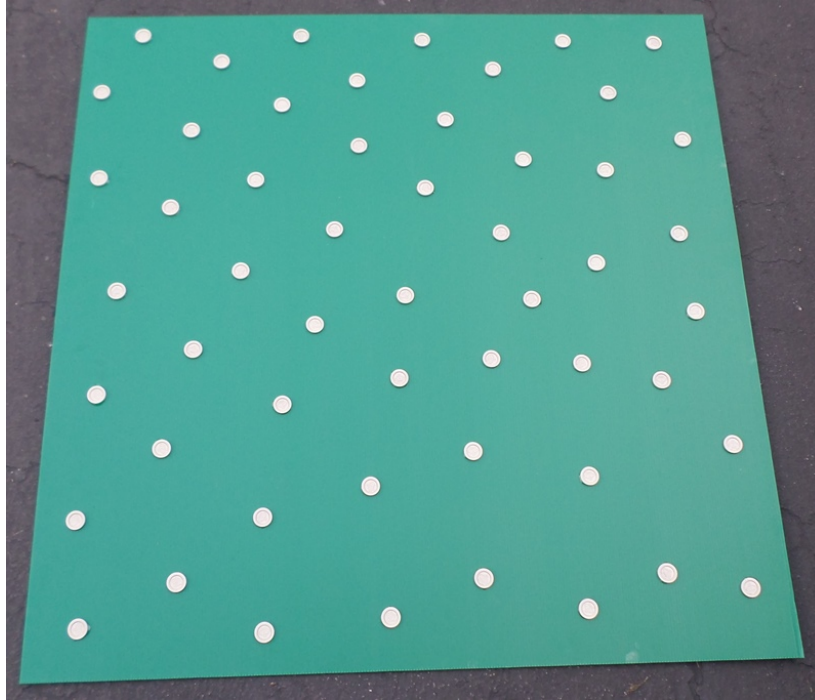
### Zebra mussels

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. You may not need to use all 64 painted checkers.



**NAVIGATOR build photo #20:** Painted checkers simulate zebra mussels.



**NAVIGATOR build photo #21:** Zebra mussels distributed on corrugated plastic sheet.

### **50 cm x 50 cm quadrat**

Companies are responsible for creating a bringing their own 50 cm x 50 cm quadrat to the competition.

## **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 competition will be identical, but the diameter and length of the bottles will not be known until the day of the 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.

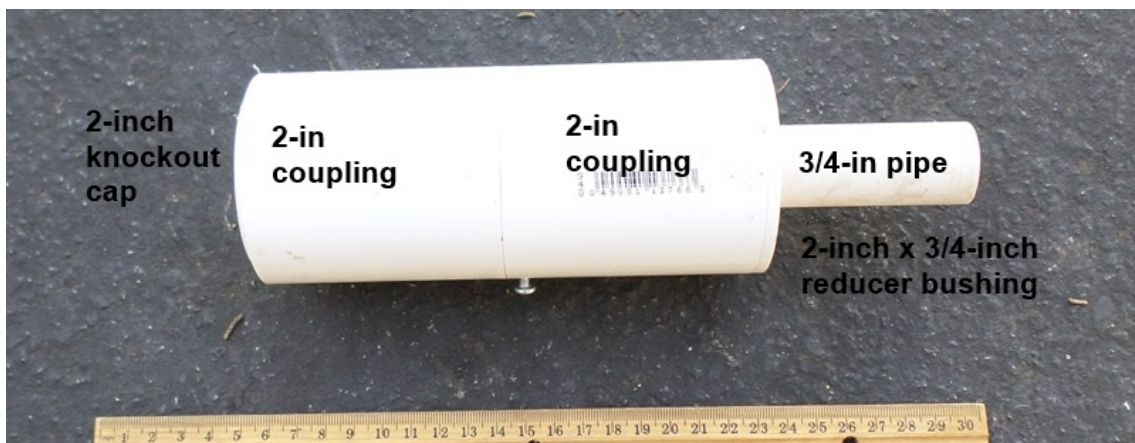


**NAVIGATOR build photo #22:** Plastic water bottle.

### Glass bottle

The glass bottle will be simulated with 2-inch and 3/4-inch PVC. A 2-inch knockout cap and a 2-inch to 3/4-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 3/4-inch reducer bushing into the coupling on the other end of the bottle.
3. Cut an 8 cm length of 3/4-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.

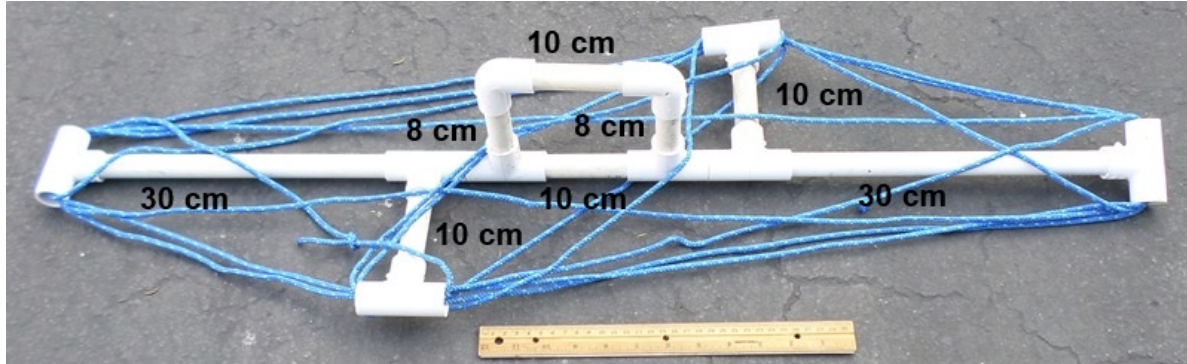


**NAVIGATOR build photo #23:** Simulated glass bottle.

### **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 two 30 cm lengths, four ten cm lengths, two 8 cm lengths, and two 3 cm lengths of ½-inch PVC pipe.
2. Attach the side openings of two PVC tees to both ends of a 10 cm length of pipe. Insert the two 8 cm lengths of pipe into the middle openings of the two PVC tees. Attach two 90° PVC elbows to both ends of another 10 cm length of PVC pipe. Attach the open ends of these elbows to the ends of the two 8 cm lengths of pipe.
3. Insert the two 3 cm lengths of PVC pipe into the remaining side openings of the two PVC tees. Attach the side opening of another tee to each of the 3 cm lengths of pipe. Insert the 30 cm lengths of pipe into the other side opening of the two PVC tees.
4. Insert the remaining two 10 cm lengths of PVC pipe into the middle openings of the two PVC tees.
5. Attach the middle opening of a ½-inch PVC tee to the four remaining ends of PVC pipe. Twist the pipes attached to four tees so they all lay flat against the ground.
6. String 3/16-inch polypropylene rope around the PVC framework, passing it through the four PVC tees. No rope should be run through the inside of the 10 cm x 8 cm rectangle at the middle of the rope debris.



**NAVIGATOR build photo #24: Rope debris.**

### **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

#### 1.1 FAQs

Questions about vehicle design and building specifications, as well as competition rules, should be posted to Competition Help within the [MATE Forum Hub](#). That helps to make sure 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 refer to the specific specification (e.g. ELEC-002E).

#### 1.2 Documentation Required

The following documents should be included within your [Project Report](#). If your regional competition does not require a project report, these diagrams must still be submitted for review by [safety inspectors](#) on the day of the competition.

DOC-001: Companies must provide an electrical diagram of their wiring, including their control box, motors, and any other electrical systems on their vehicle. The diagram should separate and show what systems are on the surface and what systems are on the vehicle. **The diagram MUST show an ROV system fuse.**

DOC-002: Any electrical diagram should use ANSI, NEMA, or IEC symbols. They should be neatly hand drawn or created using a CAD software program.

ANSI: American National Standards Institute

IEC: International Electrotechnical Commission

NEMA: National Electrical Manufacturers Association

Note: Companies may use free drawing software such as [OpenOffice](#) to create their diagrams.

DOC-003: Companies using fluid power (hydraulics or pneumatics) must provide a fluid power diagram. The diagram should separate and show what systems are on the surface and what systems are on the vehicle.

### 2.0 SAFETY

Safety is the competition's primary concern and guiding principle. Any system that is considered unsafe by competition officials will not be allowed to compete. If a concern is found during the first safety inspection, companies are permitted to attempt to correct it and have their ROV re-inspected.

However, the competition schedule will NOT change to allow companies more time. Companies are allowed 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 your 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.
- Sharp items, or potentially sharp items, (fishing hooks, glass bottles) were included on the vehicle.
- The vehicle motors were not waterproofed.
- Propellers were not protected inside the framework.

### 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 foundcompanies will have ONE more 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 (project 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 Inspection Completed

Companies must complete their safety inspection before entering the water for practice or a mission run on the day of the competition.

## 3.0 SPECIFICATIONS

The ROV must meet the following requirements to compete in the event:

## 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. All ROV components must be connected to 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: Visibility in the pool is unlimited. The pool will not be covered or purposefully darkened in any way.

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

**Note:** Contact your [regional coordinator](#) to learn more about the environmental operating conditions of the competition pool. Some pools may have sloping bottoms or other features that could affect ROV performance.

### 3.1.3 Service Requirement

OPER-005: Companies shall provide a crew of up to 4 people to operate the ROV on the pool deck. Companies may be composed of more than 4 people, but only 4 company members are allowed on the pool deck to operate the vehicle.

### 3.1.4 Maintenance

OPER-006: All work and system maintenance during operations shall be conducted by company personnel. Work of any kind must NOT be done by mentors or advisors.

## 3.2. Mechanical/Physical

### 3.2.1 Tether Length

MECH-001N: ROVs must be capable of operating in a maximum pool depth of 4 meters (13 feet). All underwater missions will take place within 8 meters (25 feet) from the side of the pool. Tether lengths should be calculated accordingly.

**Note:** Many NAVIGATOR class competitions are held in water less than 4 meters deep. Contact your [regional coordinator](#) to determine the maximum depth of the NAVIGATOR competition.

### **3.2.2 Vehicle Deployment and Recovery**

MECH-002N: The company deck crew (up to 4 people) must be able to carry the entire vehicle by hand. The crew must be able to hand launch and recover the ROV. No lifts or levers may be used to launch the ROV.

### **3.2.3 Propellers**

MECH-003N: Propellers must be enclosed inside the frame of the ROV or shrouded. Companies that have propellers protruding outside of their frame will not pass the safety inspection and will not be allowed to compete.

## **3.3. Electrical**

ELEC-001N: All power provided to your ROV system must be obtained from the MATE competition power supply. This is a singular point of connection; all power to your ROV must pass through the MATE-provided fuse on the battery AND the single fuse in your wiring.

ELEC-002N: MATE will provide a nominal 12 volt power source at the mission station. This power source may be a battery or a power supply. Nominal voltage may be as high as 14.8 volts.

ELEC-003N: Voltage may never be increased above the nominal 12 volts anywhere in the ROV system. Voltages in excess of the nominal 12 volts are not allowed on the ROV at any time other than the brief moment of back electromotive force (back EMF) from collapsing magnetic motor fields typical in any electrical motor.

### **Current**

ELEC-004N: The ROV **MUST** have a 15A maximum fuse in the positive power supply line within 30 cm of the positive banana plug. The electrical diagram must show this fuse and include the amperage rating of the fuse.

ELEC-005N: ROV systems are allowed two replacement fuses during the mission run. In the event that the ROV system blows the third fuse during the mission, the mission run will be over and no additional points will be earned.

### **Power Connections**

ELEC-006N: Power supply connections will be via standard banana plugs. Companies' ROV's tether must have male banana plugs to obtain power.

### **Tether Voltages**

The signals in the tether must meet the following specifications:

ELEC-011: 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-012: DC main-supply at a nominal voltage of 12VDC as provided by the MATE power supply.

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

ELEC-014: NTSC or PAL Video signals

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

### ***Exposed connections and disposable motors***

ELEC-007N: All electrical components going into the water must be waterproofed. ROVs with electrical connections that are exposed to the water and not sealed will not be permitted to enter the pool. Disposable motors (motors with no waterproofing) are not permitted.

### **3.4 Onboard Electrical Power**

ELEC-008: Onboard electrical power is not allowed. All power for the vehicle must come down the tether. Batteries (9-volt, AAA, AA, etc.) are **NOT** allowed under any circumstances.

**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-009N: Power shutdown: For safety purposes, any ROV that is disconnected from the surface power supply must stop functioning in less than 5 seconds.

### **3.6 Fluid Power**

Any vehicle using fluid power must provide a fluid power diagram. Fluid power is hydraulic pumps (water) or pneumatic pumps (air) on the vehicle or on the surface.

FLUID-001N: Electrical pumps of any sort are NOT allowed. Companies may only use manual pumps (hand or foot pumps) to push fluids down the tether and to their vehicle.

FLUID-002N: Companies may only use WATER as their hydraulic fluid. Companies may only use AIR as their pneumatic fluid.

FLUID-003N: Companies may not use pressure accumulators. Pressure inside any container must never exceed the ambient pool pressure. If air is pumped into a container on the vehicle, that container must be open to the water. Vent holes on the container must be at least ¼-inch (6.35 mm) in diameter.

For example: A company wants to fill a PVC pipe container on the vehicle with air. Companies may only use a manual pump (hand/foot powered bicycle pump) to push air down to the vehicle. The company drills four ¼-inch holes in the bottom of the pipe. As they pump air into the container, it will displace the water out of the holes in the bottom of the pipe. However, the pressure inside the container can never get above the ambient pool pressure; excess air will come out the holes on the bottom of the pipe once all the water has been displaced.

### 3.7 Cameras and monitors

CAM-001N: Companies are limited to ONE video display screen. This display screen may be powered by the MATE provided GFI-protected 115-Volt AC (60-cycle) and 15-amp AC power source described in CAM-002, Surface power.

CAM-002: 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 the video monitor. This AC power source CANNOT be used to directly or indirectly power the vehicle.

#### *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.** Contact your [regional coordinator](#) to find out the type of monitors that will be provided at the regional competition.

*NOTE: Companies must supply any additional equipment (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. Lasers

NAVIGATOR class companies may NOT use lasers on their vehicle.

## 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 companies 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 electrical area) must be completed by the students. Adults should teach and advise students about design, electrical components, 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. Your company’s ROV and control box must be built by the student members with only advice and guidance from teachers, mentors, and parents.

While at any MATE ROV competition, **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. All mechanical and electrical changes and/or repairs to the ROV must be completed by students.

### PROCEDURAL

- Companies must compete during their assigned time slots. Your company is **NOT** permitted to switch time slots with another team. **No exceptions.** Assigned time slots will be sent out in advance so that any scheduling concerns can be dealt with before 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 four students**. The mission team is defined as the group of students who operate the vehicle and its associated equipment during the mission performance period. Only four 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 company members, 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 to work on the ROV. Individuals who are seen working on the ROV who are not students will be issued a warning. Two warnings will be issued before individuals not heeding this rule will be asked to leave the venue.
- 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.
- Companies will compete in ONE mission that consists of three distinct mission tasks that involve several steps. Companies may 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.

**Note:** Regional contests may or may NOT offer teams two attempts at the mission tasks. Contact the [regional coordinator](#) in your area to determine if teams will receive one or two attempts.

- 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 time will **NOT** stop and **5** points will be deducted from the final mission score.

**Note:** Some regional events may not provide SCUBA diver support. If that is the case, ROVs that become tangled and unable to free themselves or otherwise disabled will not be “rescued” by a SCUBA diver until the mission performance period is over. Unfortunately, that means that no additional mission points can be received. Contact the [regional coordinator](#) in your area to determine if your regional will have SCUBA diver support during your mission run.

- 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 company 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, 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 the 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 competition companies. The score sheets will reflect the MATE Center’s efforts to encourage and reward companies 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.



- **ROV MOTORS MUST BE WATERPROOFED!** No exceptions. You may use already waterproofed motors (bilge pump motors, etc.) or you may choose to waterproof small electrical motors. Methods for waterproofing electric motors can be found on the competition web site [www.marinetech.org](http://www.marinetech.org) as well as in the little yellow book “Build Your Own Underwater Robot and Other Wet Projects.”
- Propellers must be enclosed inside the frame of the ROV or shrouded. **Companies that have propellers protruding outside of their frame will not pass the safety inspection and will not be allowed to compete.**
- Radio transmitters that operate on a separate battery are permitted. No batteries are permitted to be in or on the water. No exceptions.
- Safety must also be a priority when operating your ROV poolside. Keep an eye out for tripping hazards. Make sure that your connections to the battery or power supply are not lying in pools of water on the deck. 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.
- Your ROV may be built out of the materials of your choice. However, no parts may damage or leave a residue in the pool. Warning labels should be posted on potentially hazardous components of your ROV system.
- **Closed-toed shoes are required on the pool deck and anytime you are working on your ROV.** Safety glasses or goggles should be worn when working on your ROV.

## 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 three engineering and communication components:

- Project reports
- Engineering Presentations

- Poster Displays

**IMPORTANT NOTE:** Most regional events don't require all three of these engineering and communication components. Be sure to check with your [regional coordinator](#) about the requirements.

In the Project Report and Engineering Presentation, you are communicating with technical audiences, such as potential future clients. The Poster Display should be thought of as part of your marketing plan and geared towards general (including non-technical) audiences.

## TIPS FOR EFFECTIVE WRITTEN AND ORAL COMMUNICATION

Communicating ideas about how to solve a problem and evaluating those ideas 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 affect the work that we do.

The key to a successful project 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, diagrams, 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) to the problem at hand (mission tasks). It also involves organizing the information 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 keep track of 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 write down 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 limitations (schedule, budget, equipment, labor, logistics, etc.) on your design process?
- How did the mission and rules influence your design and decisions?
- What 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?

- 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.

## PROJECT REPORT

Your company is required to submit a project report that will be reviewed and evaluated by a group of judges who represent science, exploration, government, and industry. (These individuals may not be the same judges who evaluate your company's engineering presentation.) The project 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 ROV and your company's ability to address your client's needs for an ROV.

The deadline for submitting this report will vary amongst regionals. Contact your [regional coordinator](#) to find out yours.

Each judge will evaluate and award a score (40 points max). Judges' scores and comments will be returned to you shortly after the event.

The guidelines and required components for the project report are:

**Note: Make sure to label any and all figures, graphs, diagrams, and photographs.**

- **Length is less than 10 pages**
- **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, pilot, etc.). You can also include grade level/career goals and expected graduation date.
  - **Names** of your instructor(s) and/or mentor(s)
- **Abstract (150 words or less)** that is concise and clearly summarizes the project.
- **Photograph(s) of your completed ROV**  
You are permitted to make changes to 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 part or tools.
- **Budget/expense sheet**  
Keep an accounting of how much money you raised and/or spent. 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 office for examples of budget sheets.

- **Electrical diagram/fluid power diagram**

Make sure to highlight safety features such as fuses. This schematic may be NEATLY drawn by hand or created using a CAD software program. If the ROV uses pneumatics or hydraulics, a fluid power diagram MUST be included.

**Note:** Companies can use free drawing software such as [OpenOffice](#) to complete the diagrams.

- **Design rationale** presented in a clear and logical manner. This section should make up the bulk of your report. It should focus on the technical side of your vehicle and include a discussion of how your ROV was built or adapted to perform to the mission tasks.
- **Safety.** This section should describe the steps that your company has taken to identify and fix any safety concerns in order to make sure that your vehicle and its operation are **SAFE**.
- **Description of at least one challenge** that your company faced and how you overcame it. This can include both a technical challenge and a challenge related to working as a team.
- **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. How would you improve your ROV for a future client?
- **Reflections on the experience**  
This can be written from the point of view of your company as a whole or individual members of your company can contribute a reflection. It can include personal or professional accomplishments that you 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.
- **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 PRESENTATION

During the competition, your company will present to a group of judges who represent science, exploration, government, and industry. Your presentation should describe 1) the engineering behind your vehicle’s design; 2) how it operates; and 3) any possible safety issues. It should also highlight any innovations or creative solutions to solving the mission tasks. After the presentation, the judges will ask the members of your company questions about your ROV.

Each judge will evaluate both your presentation and responses to their questions and award a score (50 points max) based on your presentation and how you answer their questions. Judges' scores and comments will be returned to you shortly after the event.

All of the members of your company should participate in the engineering presentation and you should have your ROV with you. Be sure to organize your information and practice your presentation in advance. Ask your instructors, mentors, and parents for feedback. Practicing will help you to work out any "kinks" and be more comfortable talking in front of the judges.

Depending on your regional, this may be a presentation and a question and answer period OR a question and answer period ONLY. Either way, you should be prepared to talk about your vehicle and answer questions about it and your company.

Here are some examples of the questions that the judges might ask:

- How did you decide on the shape of your ROV and the materials to build it?
- How much did it cost to build your vehicle?
- What type of tool(s) did you design to accomplish the mission tasks and why? How does the tool(s) work?
- How many thrusters (motors) does your vehicle have? Why?
- How did you determine how much flotation to add to your vehicle?
- What is stability? Why is it important to think about stability when designing your ROV?
- If you are using the same vehicle as last year, why? What are the advantages? What, if any, modifications or additions did you make?
- Did you develop a safety checklist? What other safety precautions have you taken?

### **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. Be familiar with such numbers as the amount of propulsive force the thrusters produce, the weight of your ROV, etc.
- Encourage each member of your company to keep a project notebook. Before the competition, set up a time where you compare notebooks. One member might have written more information about your ROV's electrical system, while another might have included details about buoyancy that others forgot. This exercise will help to refresh everyone's memory about the design and building process. If your company created a project report, make sure all company members have read it and are familiar with it. 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 5 or 10 minutes. That is why it is critical to organize your material and practice communicating it. However, avoid coming across as having memorized your presentation. Judges want to see that you are

prepared and understand the information, not that you can simply recite a rehearsed speech from memory. Ask your instructors or mentors to give you feedback.

## 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 complete the mission tasks. During the competition, your company's display will be evaluated and scored by judges who represent science, business, government, industry, and education and 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 hire you, but have a limited understanding of it (i.e., you need to explain your technology, the tasks, and "sell" them on YOUR products and services.) Design your poster to communicate to this type of audience.

Each company will have a space approximately 3-feet x 3-feet for its display. Depending on your regional, tables may or may not be provided. Contact your [regional coordinator](#) for more information.

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

## GENERAL GUIDELINES

- **Font size that is clearly legible from a distance of 1.5 meters**
- **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 project report
  - Resumes of the members of your company

- **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 – 150 word limit)**

Include a written introduction to your company and how your company designed and built a specialized ROV and tools to 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, pilot, marketing and communications specialist, etc.) and their qualifications, such as grade level, career goals, etc.

- **ROV Design**

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 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 description.

- **Competition 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 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).

**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.