2015 MATE ROV Competition Manual

NAVIGATOR CLASS

2015 MATE ROV COMPETITION:

ROVs in Extreme Environments: Science and Industry in the Arctic

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.**

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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, polar scientists, and offshore oil and gas industry executives 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: PRODUCT DEMONSTRATION

OVERVIEW

NAVIGATOR class companies will part in the following TWO product demonstrations that consist of distinct tasks:

DEMO #1: SCIENCE UNDER THE ICE
Maneuver through a hole in the ice to collect samples, identify and count species, deploy a sensor, and survey an iceberg to determine its volume.

DEMO #2: SUBSEA PIPELINE INSPECTION & REPAIR
Conduct a visual inspection to locate a corroded section of pipeline, remove that section of pipeline, and return it to the surface.

NOTE: Regional competitions may require companies to complete two demos during one product demonstration run. Regional competitions may give companies more than one attempt at a product demonstration. Contact your regional coordinator to determine what is required at your regional competition.

Regardless, the product demonstration scores will be added to your ENGINEERING & COMMUNICATION score to determine your total, overall score for the competition.

SCORING OVERVIEW

The competition consists of product demonstrations, technical documentation, sales presentations, and marketing displays with the following scoring breakdown:

- **Product Demonstrations**
  - 200 points (max), plus a time bonus
- **Engineering & Communication** – 150 points (max)
  - Technical documentation – 50 points (max)
  - Sales presentations – 50 points (max)
  - Marketing displays – 50 points (max)
- **Safety** – 10 points (max)

TOTAL POINTS = 360

NOTE: Regional contests may not require all three of these components. Contact your regional coordinator for more information.

TIME

The time that your company will have to complete the product demonstrations will depend on your regional event. Contact your regional coordinator to determine how your demos will be set up and how long you will have for the tasks.

Regardless of how the demos are set up and how much time you have, at any time during the product demonstration 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 of the 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 mission station has physically touched the vehicle. Your ROV is not required to return to the surface between tasks.

TIME BONUS

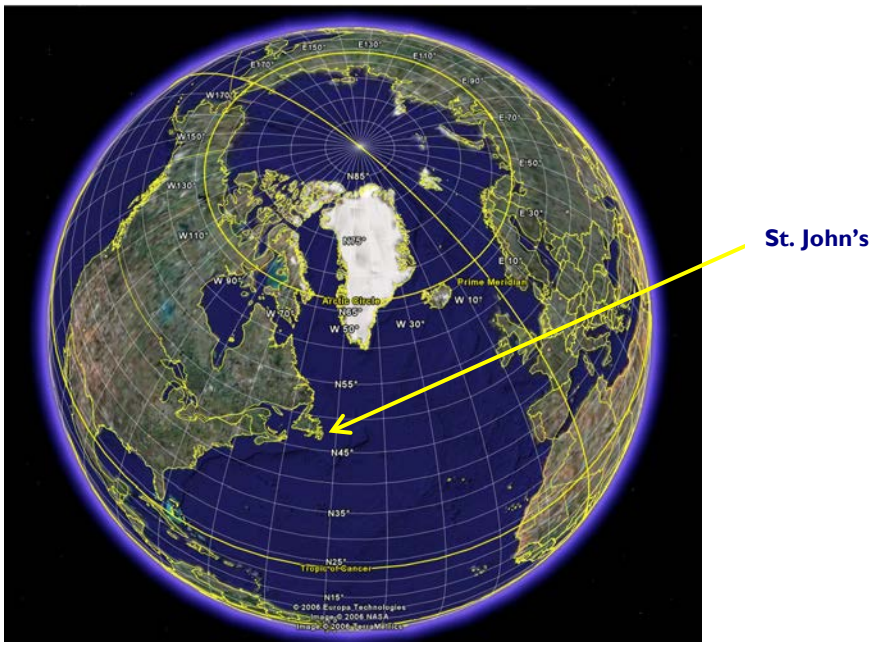
Your company will receive a time bonus if you:

1) successfully complete the three 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 demos will be set up and how much time you'll have to complete them.

CONTEXT

Located ~2,100 km south of the Arctic Circle, St. John's is the capital of the province of Newfoundland and Labrador, Canada. The oldest city in North America, St. John's offers a combination of old world charm, unique architectural, historic and natural attractions, and is located in close proximity to spectacular coastlines, historic villages, and a diverse selection of wildlife.



The city is also home to Memorial University of Newfoundland's Marine Institute (MI) and the National Research Council's Ocean, Coastal, and River Engineering (OCRE). MI houses the world's largest flume tank, with a water capacity of 1.7 million liters and water velocity ranging from 0–1 meters per second. The flume tank's viewing gallery has a 20 meter-by-2 meter viewing window and seats 150 people. The OCRE includes an ice tank and offshore engineering basin. In the ice tank, the water surface can be frozen and the air temperature maintained at –30 to 15 degrees Celsius to simulate the polar environment. The offshore engineering basin is used to simulate the extreme ocean environment; waves, wind, and currents can be generated to reach various sea states.

A number of scientists who work in polar environments are based in St. John's or use it as a starting point for their research in the Arctic. Likewise, several companies involved in oil and gas operations in the North Atlantic are headquartered in St. John's, while a number of others have offices there. Both polar researchers and oil and gas companies use the facilities at MI and the OCRE to test their equipment before heading out to sea. Both also employ technicians and engineers to design, build, and operate this equipment both in the "lab" and in the field.

NEED

The polar science community and the offshore oil and gas industry are in need of remotely operated vehicles that can conduct 1) ***SCIENCE UNDER THE ICE*** that includes counting species and sampling organisms, deploying an instrument, and collecting data about an iceberg to determine its volume and 2) ***SUBSEA PIPELINE INSPECTION & REPAIR*** that includes finding and removing a corroded section of oil pipeline.

Members of the polar science community and the offshore oil and gas industry have already contracted with MI and the OCRE to use their facilities for testing out the new vehicles before taking them into the field. The facilities are reserved for June 25-27, 2015.

However, regional testing will take place between March and May 2015. Certain regions may combine the two product demonstrations into one; in addition, regions may NOT require all three Engineering & Communication components. Contact your regional coordinator for the dates and requirements for your regional testing.

This is where your work begins.

REQUEST FOR PROPOSALS (RFP)

1. General

a. Science in Polar Seas

The Arctic Ocean is the smallest of the world's four ocean basins with a total area of about 1.4 million square kilometers (compare that to the Pacific, which has a total area of 179.7 million square kilometers). It is also the world's least explored ocean; its remoteness and harsh environmental conditions make working in it a challenge.

Scientists are planning an expedition to explore and study the Canada Basin, a 3.7-kilometer deep bowl adjacent to the Beaufort Sea, which is located north of the Northwest Territories, the Yukon,

and Alaska and west of Canada's Arctic islands. It often referred to as “The Hidden Ocean” because this part of the Arctic is covered with sea ice for most of the year.

The expedition will take place on board the U.S. Coast Guard (USCG) icebreaker *Healy*, which is designed to break four feet of ice continuously at a speed of three knots and can operate in temperatures as low as -45°C. The *Healy* can also handle a fly-away ROV system.

Scientists and the USCG Healy crew on the sea ice in the Canada Basin (photo credit Ian MacDonald, Texas A&M University)

The purpose of the expedition is to study the Canada Basin from the surface of the ice to the bottom of the deep sea. This includes identifying and sampling organisms and deploying sensors to track whales.

The organisms include algae that live on the “underside” of the ice cover. On average, more than 50% of the primary productivity in the Arctic Ocean comes from algae that live near the ice-seawater junction, making this interface an important part of the polar marine ecosystem. More than 200 species of algae are known to exist in the Arctic sea ice, but, with additional sampling, many more species are likely to be discovered.

Bowhead whales are an endangered species of baleen whale found exclusively in arctic waters. Scientists are studying their distribution and migratory patterns in the hopes that it will lead to a better understanding of their role within the arctic ecosystem and, possibly, conservation actions that could save the species.

In addition, scientists are working with a commercial company interested in using ROVs to collect data about icebergs. This company provides ice and other environmental services for the offshore oil and gas industry. The company currently uses satellites, aircraft, and specialized ice radar to detect and track icebergs. It is interested in expanding its tools to include ROVs, mainly to document and collect data on the more than 90% of an iceberg that is below water surface. Engineers and technicians from the company will join scientists during ROV testing in the OCRE’s ice tank.

b. Oil and Gas Operations along the North Atlantic Continental Shelf

The Atlantic Ocean has contributed considerably to the development and economy of the countries around it. Besides its transatlantic transportation and communication routes and fishing resources, the Atlantic Ocean has oil deposits in the sedimentary rocks of the continental shelves.

The North Atlantic continental shelf is particularly rich in oil. Total oil production from North Atlantic fields is about 3.2 million barrels per day (mbls/day), or roughly 3.5% of the global production (total world oil production is ~89.7 mbls/day). Currently there are three countries with oil-producing platforms in the North Atlantic – the United Kingdom, Norway, and Canada.

The Hibernia oil production platform, one of four oil platforms located off the coast of Newfoundland (www.hibernia.ca)

ExxonMobil Canada, Chevron Canada Resources, Canada Hibernia Holding Corporation, Murphy Oil, and, Statoil, Suncor Energy, Husky Energy, Nalcor, and Mosbacher are companies with investments in oil and gas fields in the North Atlantic Ocean offshore of St. John's. The Terra Nova field, operated by Suncor Energy, is one example. This field is located approximately 350 kilometers southeast of St. John's.

Suncor Energy's Floating Production Storage and Offloading (FPSO) vessel *Terra Nova* was designed for the polar environment. It is a double-hulled, ice-reinforced vessel with five thrusters (two forward and three aft) and a global dynamic positioning system, which is an automated system that allows the vessel to maintain its headings. This same system also reduces the impact of waves by allowing the FPSO to change to more favorable headings in high winds and storms.

The *Terra Nova* FPSO is one of the largest FPSO vessels ever built. It is 292.2 meters long and 45.5 meters wide, which is approximately the size of three football fields laid end to end. From the keel to the helideck, it stands more than 18 stories high. The *Terra Nova* FPSO can store 960,000 barrels of oil and house up to 120 personnel while producing. It can also handle ROV systems.

The FPSO Terra Nova (www.suncor.com/en/about/4001.aspx)

Suncor Energy is currently looking for ROVs that can perform routine maintenance and repair. Engineers and offshore personnel will evaluate the ROV's performance in the OCRE's offshore engineering basin as well as MI's flume tank. These facilities will allow the company to determine how the ROV handles working in the extreme environment of the North Atlantic.

c. Document Scope and Purpose

This and the following sections describe the technical specifications and requirements for ROV services needed by the polar science community and the offshore oil and gas industry. In 2015, ROV services include:

1) SCIENCE UNDER THE ICE

- Maneuver through a 60cm x 60cm hole in the ice.
- Collect a sample of algae from the underside of the ice sheet.
- Collect an urchin located on the seafloor.
- Use a species identification handbook to identify and count species of sea star.
- Deploy a passive acoustic sensor in a designated area.
- Measure the dimensions of an iceberg and calculate its volume.
- Use coordinates to map the location of the iceberg.

2) SUBSEA PIPELINE INSPECTION & REPAIR

- Conduct a CVI (close visual inspection) of an oil pipeline for corrosion.
- Turn a valve to stop the flow of oil through the pipeline.
- Examine a gauge dial to determine that the pipeline oil pressure is zero.
- Measure the section of corroded pipeline.
- Attach a lift line to the corroded section.
- Cut (simulated) the section of corroded pipeline.
- Remove the section of corroded pipeline and return it to the surface.

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 product demonstrations. 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 documentation
- **b.** Sales presentation
- **c.** Marketing display
- **d.** Product demonstration

6. References

Arctic Ocean
http://en.wikipedia.org/wiki/Arctic_ocean
http://en.wikipedia.org/wiki/Pacific_Ocean
http://en.wikipedia.org/wiki/Beaufort_Sea

Census of Marine Life
www.coml.org

Whales and passive acoustic sensing:
www.enchantedlearning.com/subjects/whales/species/Bowheadwhale.shtml
www.afsc.noaa.gov/nmml/CetaceanAssessment/bowhead/bmsos.htm
http://cetus.ucsd.edu/projects/pubs/BurtenshawDSRII2004.pdf

Ice and Environmental Services
www.provincialaerospace.com/

Offshore Oil and Gas
www.suncor.com
www.hibernia.com

IMPORTANT NOTE: Questions about production demonstrations and design and building specifications must be posted to the competition FAQs board located here. This allows all companies to see the questions and answers and helps to avoid duplicate questions. That said, please make sure that your question(s) has not already been asked – and answered – before posting.

PRODUCT DEMONSTRATIONS

DEMO 1: SCIENCE UNDER THE ICE

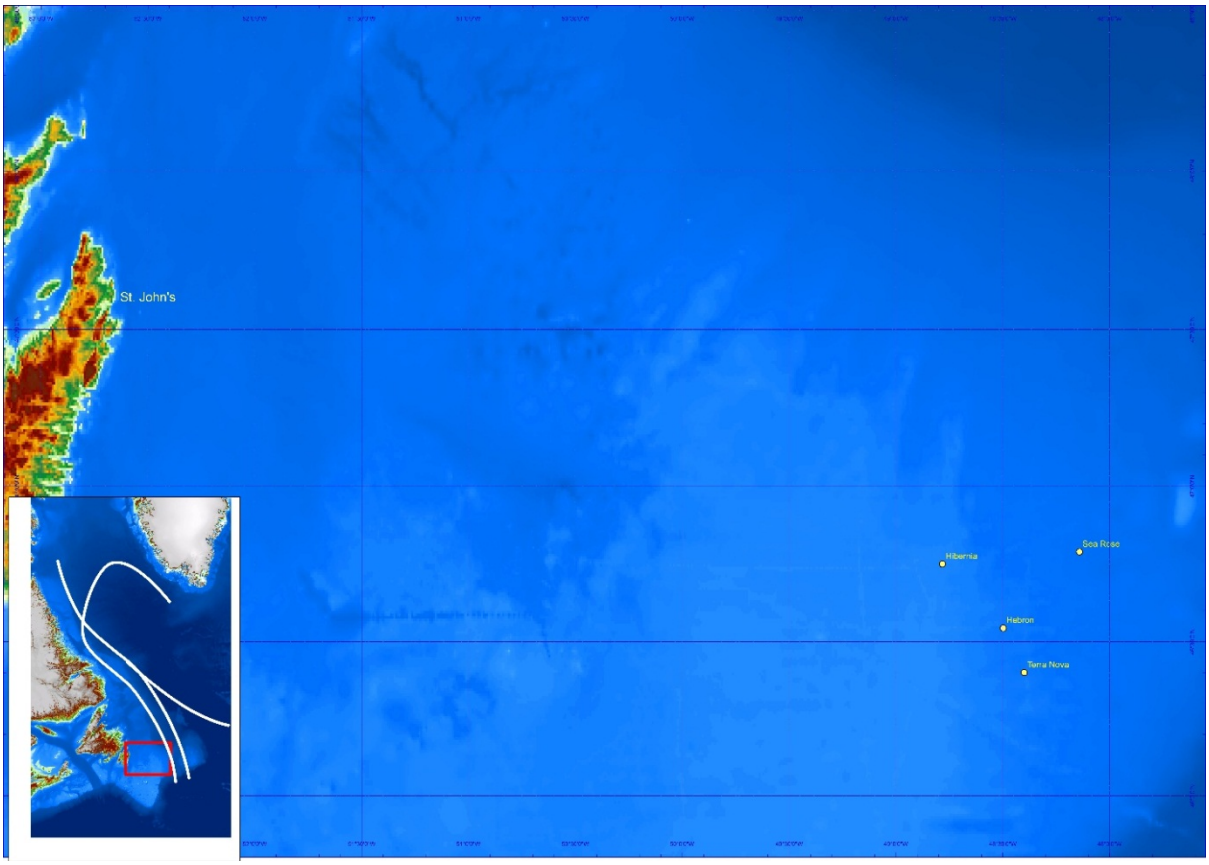
Your company is tasked with collecting an urchin from the seafloor and samples of algae from the underside of the ice sheet. You must also identify and count the number of sea star species on the seafloor. The MATE Center will provide a sea star identification handbook.

Algal "lumps" under Arctic Sea ice (www.arctic.noaa.gov/reportcard/sea_ice_biota.html)

Sea stars and urchins on the Arctic seafloor (www.arcodiv.org/seabottom/Asteroids.html and www.arcodiv.org/seabottom/Urchins.html)

Your company is also tasked with deploying a passive acoustic sensor on the seafloor underneath the ice sheet to monitor baleen whales. These sensors are essentially underwater hydrophones that "listen" for the whale calls. Communication cables will run from the sensor to a nearby oil production platform where the recorded calls will be processed.

Finally, your company must survey an iceberg. Surveying the iceberg will involve collecting data regarding the iceberg's coordinates and measuring its diameter and keel depth in order to calculate its volume. Using the coordinates, companies must also plot the location of the iceberg on a map provided by the MATE Center.



Map of the Grand Banks off of the coast of Newfoundland and Labrador showing the four offshore oil installations (Paul Brett, Chair, Ocean Mapping Program, School of Ocean Technology, Fisheries and Marine Institute of Memorial University)

This task involves the following steps:

- **Removing two samples of algae from the underside of the ice sheet – 5 points each, 10 points total**
- **Returning two samples of algae to the surface – 5 points each, 10 points total**
- **Removing a sea urchin from the seafloor – 5 points**
- **Returning a sea urchin to the surface – 5 points**
- **Using a species identification handbook to identify and count species of sea stars – up to 10 points**
    - **All sea star species properly identified and counted – 10 points**
    - **At least three sea star species properly identified and counted – 5 points**
    - **Less than three sea star species properly identified and counted – 0 points**
- **Deploying a passive acoustic sensor in a designated area – 10 points**
- **Surveying the iceberg at four points around its perimeter – 10 points**
- **Measuring the keel depth of the iceberg – up to 10 points**
    - **$\leq$ 10 cm from true depth – 10 points**
    - **> 10 cm from true depth – 0 points**
- **Measuring the diameter of the iceberg – up to 10 points**
    - **$\leq$ 10 cm from true length – 10 points**
    - **> 10 cm from true length – 0 points**

- **Using the dimensions of the iceberg to calculate its volume within 10% of true volume – 10 points**
- **Using the coordinates to map the location of the iceberg – 10 points**

TOTAL POINTS = 100

Mission Notes:

The tasks of the science under the ice product demonstration may be completed in any order. Regional competitions may combine the science under the ice product demonstration with the subsea pipeline inspection and repair product demonstration task. If that is the case, companies may alternate between science under the ice tasks and the inspection and repair tasks. Contact your regional coordinator for more information.

Companies will operate under a simulated sheet of ice. This simulated sheet of ice will be constructed from a sheet of foam. Companies must launch through a 60 cm x 60 cm hole in this simulated sheet of ice. If the science under the ice and the subsea pipeline inspection and repair production demonstrations are combined, companies must launch through the hole in the ice for BOTH demos.

Companies must collect two samples of algae from the underside of the ice sheet. The samples of algae will be simulated by ping pong balls. There will be 10+ samples of algae located on the underside of the ice sheet. Companies will receive 5 points when a sample is removed from the bottom of the ice, up to 10 points total. Removing a sample of algae from the underside of the ice sheet is defined as the ping pong ball being under control of the vehicle and no long in contact with the ice sheet. Companies will receive an additional 5 points when the sample of algae is returned to the surface, removed from the ROV, and placed on the pool deck, up to 10 points total.

Companies must collect the sample of algae without damaging it. If the ping pong ball is crushed (no longer a sphere) or cut (inside is open to the water), companies will not receive points for removing it from the underside of the ice sheet or returning it to the surface. Companies that damage a sample of algae may attempt to collect another sample.

Companies must collect a sea urchin from the seafloor. The sea urchin will be simulated by a 4-inch O-ball. There will be 3 sea urchins located on the seafloor; companies only need to collect one of them. Companies will receive 5 points when a sea urchin is removed from the bottom. Removing a sea urchin from the seafloor is defined as the O-ball being under control of the vehicle and no longer in contact with the bottom. Companies will receive an additional 5 points when the urchin is returned to the surface, removed from the ROV, and placed on the pool deck.

Companies must identify and count species of sea stars located on the seafloor. Sea stars will be constructed from ½-inch PVC. A sea star identification handbook will be provided at each mission station, although companies may choose to print and bring their own handbook. The sea star identification handbook will have pictures and scientific names of a variety of sea stars that are commonly found in polar waters. Companies must identify and count all of the sea stars on the seafloor. Companies do not need to collect or return any of

the sea stars to the surface. The mission station judges will have an accurate count of each sea star species in the mission area. Companies must report their species count (number of each species) to the mission judge once all of the sea stars have been identified and counted. Companies that successfully identify and count all the sea star species will receive 10 points. Companies that successfully identify and count at least three (but not all) sea star species will receive only 5 points.

Companies may only report one final sea star count (Genus & species name and number of each species) to the mission station judge. If the count is in error, companies may not go back and attempt to recount sea star species. The final report must be given to the mission station judge during the product demonstration time; however, the mission station judge may choose to evaluate the counts during the demobilization period. Companies should use both the common name and the scientific name (Genus and species) when reporting their sea star counts to the mission station judge. For example, a company should say they have identified six purple ochre stars, *Pisaster ochraceus*.

Companies must deploy a passive acoustic sensor into a 50 cm x 50 cm designated area. The passive acoustic sensor will be constructed out of ½-inch PVC pipe with a 3-inch PVC float; the passive acoustic sensor will be attached to the surface by a connecting cable. The passive acoustic sensor will be located on the surface, side of the pool at the start of the product demonstration. Companies may attach the passive acoustic sensor to their ROV during the 5-minute set-up period. The sensor must be transported to the designated area by the ROV; companies may NOT drop or throw the sensor into the water with the intention of recovering it on the bottom.

Companies will receive 10 points when the passive acoustic sensor is deployed by the ROV within the designated area. A successfully deployed sensor must have all four legs inside the designated area and be "right side up." Companies will not receive points if the sensor is on its side or upside down. The legs of the sensor may be touching the inside PVC edge of the designated area, but the legs cannot be on top of the PVC of the designated area. The cable connecting the passive acoustic sensor to the surface can lay over the PVC of the designated area.

The passive acoustic sensor will weigh less than 20 Newtons in water.

Companies must survey the iceberg at four points around its perimeter. The iceberg will be constructed of ½-inch PVC pipe. At regional competitions, the top section of the iceberg will be floating on the surface, covered by a section of foam sheeting or bubble wrap. At the international competition, the top section of the iceberg will be located on the underside of the ice sheet. The top section is comprised of four equal lengths of ½-inch PVC pipe inserted into a central PVC cross. At the end of each length of pipe is 30 cm length of pipe descending into the water column. A black ABS plastic rectangle will be positioned near the bottom of each of the four 30 cm lengths of PVC pipe. These four rectangles will be labeled A, B, C, and D.

To successfully survey the iceberg, companies must show the mission station judge, through a video display, the letter on all four labeled rectangles. Companies will receive 10 points when the iceberg is successfully surveyed. Once the iceberg is successfully surveyed, the mission station judge will release the coordinates of the iceberg.

These labeled rectangles will be approximately 20 to 30 cm below the surface of the ice. The lettering will be 3-inch black on white lettering.

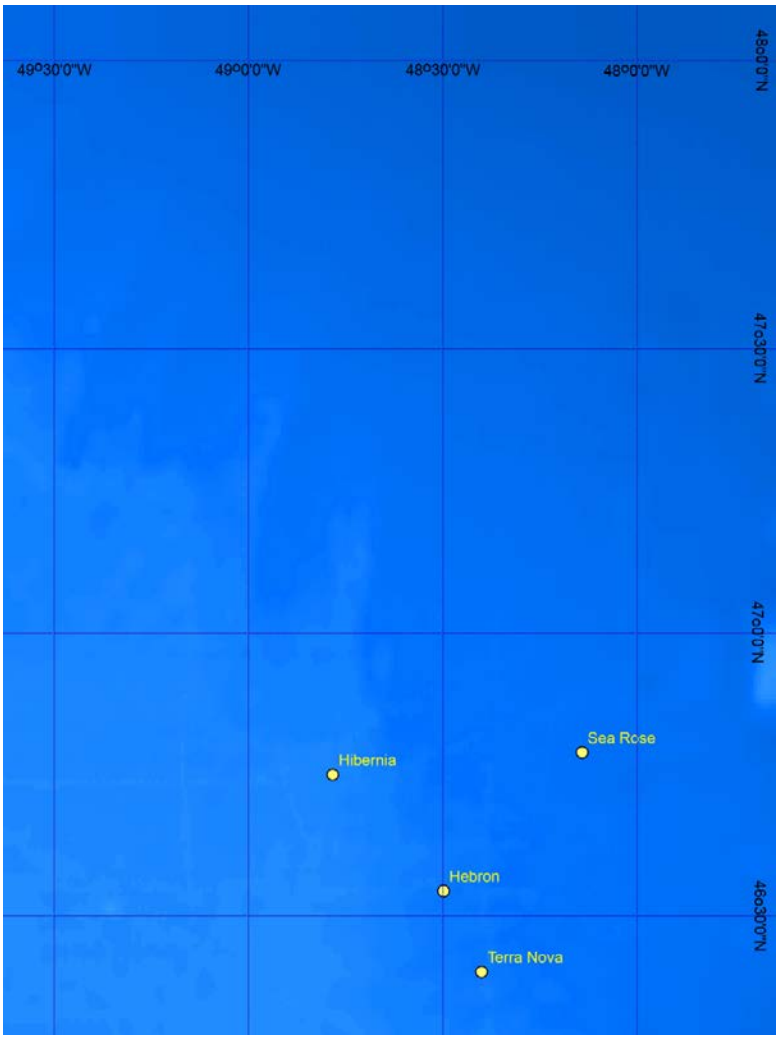
Companies must determine the diameter and keel depth of the iceberg. The diameter can be determined by measuring the length of one of the PVC pipes that make up the top section of the iceberg. Companies should measure the diameter from the outside edge of the 90^{o} elbows at the end of each length of pipe. Companies that successfully measure the diameter of the iceberg within 10 cm will receive 10 points.

Companies must also measure the keel depth of the iceberg below the water line. A length of ½-inch PVC pipe will descend into the water from a PVC tee next to the cross in the surface structure. The keel depth is the distance from the bottom edge of the PVC cross to the bottom end of this length of pipe. Companies that successfully measure the keel depth of the iceberg within 10 cm will receive 10 points.

Companies must report and show all measurements to the mission station judge or inform the mission station judge of how they are calculating the values; they cannot simply guess at the measurement. If companies report an incorrect diameter or keel depth to the mission station judge, they will not receive points for that measurement. Companies may elect to re-measure the dimension for calculating the volume of the iceberg. Although companies will not receive points, the mission station judge will inform companies if their subsequent measurements are correct or incorrect.

Once the dimensions of the iceberg are correctly determined, companies must use those values to calculate the volume of the iceberg. Companies MUST use the formula for a **CONE** to calculate the iceberg's volume. Companies will receive 10 points when they successfully report the volume of the iceberg within 10 percent to the mission station judge. If a company incorrectly calculates the volume (outside 10% of true volume) they will not receive points. Companies may not re-calculate the volume until they get a correct answer.

Companies must mark the location of the iceberg on the map. Companies will receive 10 points when they correctly map the location of the iceberg. The mark indicating the iceberg should be less than 1 mm by 1 mm and must fall within 0.5 cm of the actual map coordinates given to the company. The mission station judges will score the mark by overlaying a second map with the iceberg's actual position. The iceberg's location on the overlay must completely cover the mark made by the company. Companies must show the map with the location of the iceberg to the mission station judge during the mission time. The judge may choose to evaluate the map during the demobilization period.



Map of the oil installations.

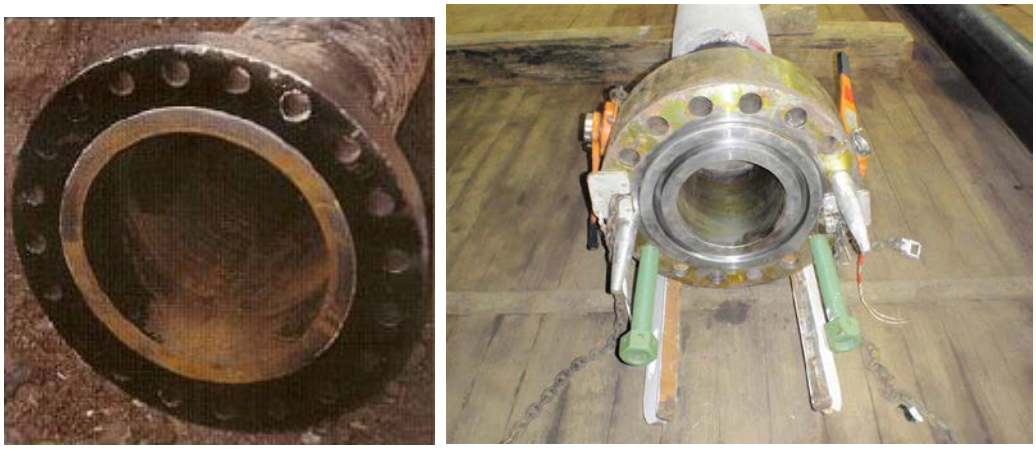
If a company has successfully completed all the tasks and is returning to the surface with the final items to be removed from the pool (the algae sample and a sea urchin), time will stop when a member of the company touches the vehicle. Samples on board the vehicle may be detached and set on the pool deck after the clock has stopped. If sample is subsequently dropped from the vehicle into the pool, time will not restart. That company will receive points for collecting the sample, but will not receive points for returning the sample to the surface and therefore cannot receive a time bonus.

DEMO 2: SUBSEA PIPELINE INSPECTION & REPAIR

Your company is tasked with conducting a close visual inspection (CVI) of an oil pipeline in order to locate a corroded section. Once the corroded section is found, companies must turn a valve to stop the flow of oil through the pipeline and examine a pressure gauge to verify that the pressure in the pipe is zero.

Corroded subsea pipeline (http://subseaworldnews.com/2014/04/01/baosteel-yantai-delivers-subsea-steel-pipes-for-bohai-oilfield/)

Your company must then measure the section of corroded pipeline, attach a lift line to that section, simulate cutting the pipeline, then remove the corroded section of pipeline and return it to the surface.



Examples of flanges on the ends of pipelines (http://epa.gov/gasstar/newsroom/partnerupdatespring2011.html and http://gasketinsertiontool.com/tooling-solutions/)

This task involves the following steps:

- **Conducting a CVI of an oil pipeline to locate the corroded section – 10 points**
- **Turning a valve to stop the flow of oil through the pipeline – 20 points**
- **Examining a gauge dial to determine that the pipeline oil pressure is zero – 10 points**
- **Measuring the section of corroded pipeline – up to 20 points.**
  - **≤ 5 cm off true length – 20 points**
  - **5.01 cm to 10 cm off true length – 10 points**
  - **> 10 cm from actual length – 0 points**
- **Attaching a lift line to the corroded section – 10 points**
- **Pulling two pins to simulate cutting the section of corroded pipeline – 10 points each, 20 points total**
- **Removing the section of corroded pipeline and returning it to the surface – 10 points**

TOTAL POINTS = 100

Mission Notes:

The tasks of the pipeline inspection and repair task must be done in order. Companies may choose to skip a step, but will not get points for that step even if it is completed at a later time. Regional competitions may combine the subsea pipeline inspection and repair product demonstration with the science under the ice product demonstration. If that is the case, companies may alternate between the subsea pipeline inspection tasks and repair and the science under the ice tasks. For example, a company may choose to conduct the CVI of the pipeline then move on to science under the ice. The company may then return and complete the pipeline inspection and repair.

REMINDER: If the subsea pipeline inspection and repair product demonstration is combined with the science under the ice product demonstration, companies must launch through the 60cm x 60cm hole in the ice sheet to complete all tasks.

Companies must conduct a CVI of a pipeline to locate a section of corroded pipe. The pipeline will be constructed out of 2 sizes of PVC pipe. 1 ½-inch inch PVC pipe painted gray will be used for the pipeline that companies must simulate cutting, lifting, and installing the flange. ½-inch pipe will be used for the remainder of the pipeline. Corrosion will be simulated by a brown circle, less than 3 cm in diameter. The corrosion may be located on the top, bottom, or on either side of the pipeline. There will only be one circle of corrosion on the pipeline. Companies will receive 10 points when they detect the corrosion and show it to the mission station judge, through a video display.

Once the section of corroded pipeline is located, companies must turn a valve to stop the flow of oil through the pipeline. The valve will be constructed from ½-inch PVC pipe and a brass gate valve. Turning the valve completely clockwise will close the valve. Valves may need to be turned up to 1170^{o} (3.25 times around) to be completely opened or closed. Companies will receive 20 points when they completely close the valve.

Once the valve has been closed, companies must examine a pressure gauge to verify that the pressure in the pipeline is zero. Companies must show the mission station judge, through a video display, that the dial on the pressure gauge is at zero. Companies will receive 10 points when they have viewed the pressure gauge at zero.

Companies must then measure the section of corroded pipeline. Companies that successfully measure the length of the pipe within 5 cm will receive 20 points. Companies must report and show all measurements to the mission station judge or inform the mission station judge of how they are calculating the values; they cannot simply guess at the length. If companies report an incorrect length to the mission station judge, they will not receive points for that measurement. Companies may not go back and re-measure the length of the pipe if their first measurement is not within 5 cm.

After measuring the length of the corroded section, companies must attach a lift line to the pipeline. Companies must design and build their own lift line; the MATE Center will not provide one. A U-bolt on the corroded section of pipe will serve as a grab point. Companies will receive 10 points when they have successfully attached a lift line around the corroded section of pipe.

Once the lift line has been attached to the corroded section, companies must pull two pins to simulate cutting the section of corroded pipeline. The two pins, each simulated by a U-bolt, will be located at either end of the corroded section of pipe. Companies will receive 10 points for each pin removed, 20 points for removing both. After removal, the pins may be left on the bottom of the pool without penalty or returned to the surface.

After both pins have been pulled, companies must remove and transport the section of corroded pipeline to the surface. Companies may use the lift line previously attached to the pipe and pull it to the surface by hand. If the subsea pipeline inspection and repair product demonstration is combined with the science under the ice product demonstration, the pipeline must be retrieved through the 60 cm x 60 cm hole in the ice. Companies will receive 10 points when the corroded section of pipeline is removed from the water and set on the pool deck. If the pipe falls to the seafloor during lifting, companies may attempt to reattach their lift line or move on to another task. If companies choose to move on, they will not be awarded 10 points for returning the corroded section of pipeline to the surface.

If a company has successfully completed all the tasks and is returning to the surface, and the corroded section of pipe has been removed from the pool, time will stop when a member of the company touches the vehicle.

The **NAVIGATOR Sea Star Identification Handbook** contains information and pictures of the sea star species.
The **NAVIGATOR Product Demonstration Photos** contains photos of completed props.
See the **NAVIGATOR SolidWorks** files for CAD representations of the props.

PART 2: MISSION PROP BUILDING INSTRUCTIONS & PHOTOS

By popular request, this section has been removed and made into its own, separate document. This document will be released and posted by December 20, 2014.

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-002N).

1.2 Documentation Required

The following documents should be included within your Technical Documentation. If your regional competition does not require technical documentation, these diagrams must still be submitted for review by safety inspectors on the day of the competition.

DOC-001: Companies must provide a system interconnection diagram (SID) of their vehicle control system. An SID is an electrical diagram of their wiring, including their control box, motors, and any other electrical systems on their vehicle. The SID should separate and show what systems are on the surface and what systems are on the vehicle. The SID should not exceed one page in length. **The diagram MUST show an ROV system fuse.** An example of an acceptable SID can be found here.

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.

DOC-004: All symbols used in documentation must be in ANSI, NEMA or IEC format.

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 documentation did not show a main fuse or circuit breaker.
- The ROV used pneumatics, but the technical documentation 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. Once the company successfully passes inspection, they will turn in their safety inspection sheet and be presented with a Green PASSED Flag. Companies must present the PASSED Flag to the pool practice/mission coordinator before their vehicles are permitted to enter the water. Each company's flag will be uniquely identified with company number on the flag.
2. At the start of the safety inspection, companies must submit a systems integration diagram or SID. Competition staff will conduct a safety inspection of the vehicle using the SID and 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 found

    companies 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 (technical documentation, sales presentation, and marketing display) component.
6. Reminder: All companies must present the Green PASSED Flag 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.

Your regional competition may use a system other than a Green PASSED Flag, but all companies must pass a safety inspection before entering the water. Contact your regional coordinator to determine if a Green PASSED Flag will be used for safety verification or another system will be used.

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. Lower light levels may exist underneath the ice sheet. Companies should plan accordingly.

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.

3.2.4 Size and weight

MECH-004N: ROV systems must be able to navigate through a 60 cm x 60 cm hole in the ice.

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 SID 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

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. Contact your regional coordinator to find out the type of monitors (NTSC or PAL) 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 teams will lead to penalty points or disqualification.

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

- The MATE ROV competition is 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 (especially in complex electrical and software areas) must be completed by the students. Adults should teach and advise students about design, electronics, software, and construction, but not complete the work for the students. Throughout the process adults are encouraged to focus on benefits to the students from the process and not simply winning. If it becomes apparent that adults exercised more than an advisory role, judges reserve the right to deduct points or, in extreme cases, disqualify companies from the competition.

  While at any MATE ROV competition (international and regional), **ALL** work done on the vehicle must be conducted by company members. Teachers, mentors, parents, and non-competing students are not permitted to work on the ROVs. They may provide advisory input, but they may not work on the ROV directly. All mechanical electrical and software modifications 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. Failure to show for your scheduled product demonstration or for your company's sales presentation will result in "no score" for that particular competition category. **No exceptions.** Assigned time slots will be sent out in advance so that any scheduling concerns can be addressed prior to the event.

*Regional contests may refer to the mission station as the control "station" or "shack."

- While there is no limit to the number of students who can compete as part of a company, **the product demonstration team (aka demo team) is limited to four students**. The demo team is defined as the team of students who operate the vehicle and its associated equipment during the product demonstration. The product demonstration is conducted at a "mission station." Only four students will be allowed to enter the mission station, launch, pilot, and perform the tasks. Instructors, mentors, and/or non-student members cannot participate as part of the demo team. **Companies may alternate students on the demo team for the two product demonstrations.** (All members of the company should participate in the engineering and communication components; see ENGINEERING & COMMUNICATION for more information.)

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

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

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

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

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

- Companies will compete in TWO product demonstrations that consist of distinct tasks. Companies may get up to **TWO** attempts to complete each product demonstrations. If that is the case, the **higher** of the two scores will be added to the engineering and score to determine the total, overall score for the competition.

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

Note: Regional contests may or may NOT offer teams two attempts at the product demonstration tasks. In addition, the product demonstration time frames for set-up, performance period, and demobilization may be different at your regional contest. Contact the regional coordinator in your area for more information.

- 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 product demonstration 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 product demonstration time will NOT stop and **5** points will be deducted from the final product demonstration 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 are otherwise disabled will not be "rescued" by a SCUBA diver until the product demonstration time 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.

- Companies are not allowed to leave any debris in the pool. Any debris must be recovered and returned to the pool deck before time has expired or the company will be penalized. Debris is defined as pieces of the ROVs, weights, floats or other items created by the company. Task components are not considered debris. The mission notes section may cover special items that can be left in the pool after time has expired.

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

- Communication between demo team members at the pool edge and demo team members piloting the vehicle 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 team members at the pool edge cannot give any

directional or mission task information to the pilot. Judges will issue one warning regarding illegal communication. Each future infraction will result in **5** points deducted from the final product demonstration 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 product demonstration, either between the demo team members at poolside or between any demo team member and anyone outside of the mission station.

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

DESIGN & SAFETY CONSIDERATIONS

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

- **ALL ROVS MUST PASS A SAFETY INSPECTION CONDUCTED BY COMPETITION OFFICIALS PRIOR TO ENTERING THE POOL.** These inspections will be conducted topside to ensure that ROV systems meet the design and building specifications and do not pose a risk to the integrity of the event venue. See VEHICLE DESIGN & BUILDING SPECIFICATIONS for additional information.

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

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

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

- **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.

- Personal flotation devices (PFDs) may be required when launching and recovering your vehicles. Contact your regional coordinator to determine whether this is a requirement at your regional event. If PFDs are required, they will be provided by the regional coordinator.

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:

- Technical Documentation (formerly known as the project report)
- Sales Presentation (formerly known as the engineering presentation)
- Marketing Display (formerly known as the poster display)

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.

For your Technical Documentation and Sales Presentation, you are communicating with technical audiences, such as potential future clients. The Marketing 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 technical documentation and sales 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 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 (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 documentation and presentation:

- What was your company'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.

TECHNICAL DOCUMENTATION

Your company is required to submit technical documentation 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 sales presentation.) Technical documentation 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 documentation will vary amongst regionals. Contact your regional coordinator to find out yours.

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

The guidelines and required components for the technical documentation 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, state, 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 documentation and the competition; however this must be a photo(s) of your completed, intact vehicle, not photos of individual part or tools.
- **Budget**
  Keep an accounting of how much money you raised and spent, items (building materials, equipment, travel stipends, etc.) that were donated, and items that were re-used from previous years. For donated items, make sure that you list the organization or individual who made the donation. For both donated and re-used items, make sure that you include an estimate of the item's present-day value.
  Tip: Ask your school's business or accounting office for examples of budget sheets.
- **Systems Integration Diagram (SID)**
  A SID is a system-level, connection diagram that includes electrical and, if applicable, fluid power wiring information. Board-level and component-level schematics should not be included; however, these may be brought to the sales presentation for reference purposes. The intent is to provide the competition judges with a one-line diagram showing how the various systems are interconnected without the detail of each and every wire.

  The SID must include a clear distinction between the surface controls and the ROV. Make sure to highlight safety features such as fuses. The SID may be NEATLY drawn by hand or created using a CAD software program. If the ROV uses pneumatics or hydraulics, the SID MUST include fluid power pathways. An example of an acceptable SID can be found here.
  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 comprise the bulk of your documentation. ***It should focus on the technical aspects of your vehicle and how your ROV was***

built to perform the specific tasks. See the questions under Sales Presentation below for an example of information that you should cover.

- **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 your sponsors (companies, organizations (including the MATE Center), professionals from industry, and/or mentors) and the type of support that they provided (funds, building supplies, equipment, site visits to facilities, time, and/or technical expertise). You can include organizations and/or individuals that provided logistical and/or moral support (e.g. your parents, siblings, or pets). Regional competition teams should also acknowledge regional contest supporters.

SALES 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 sales 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 building materials were donated, built, or bought? What techniques did your company use to fundraise?
- 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 sales presentation

- 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 submitted technical documentation, 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.

  NOTE: The sales presentation is designed to be a face-to-face interaction between students and industry professionals. MATE will not provide audio visual aids, such as slide projectors, computer projection screens, white boards, etc.; however, you are welcome to distribute handouts to help judges better understand the information that you are presenting. **PowerPoint presentations are**

NOT permitted. During the Q&A, all members of the company must be present and prepared to answer.

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

MARKETING DISPLAY

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

While some 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 display 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 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 marketing display:**

- 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 technical documentation.

- **Items that you MAY have on display include:**
  - Photo journals, pamphlets, business cards
  - Copies of your company's technical documentation
  - Resumes of the members of your company
  - Descriptions of mentoring or community outreach that your company participated in
  - Newspaper articles or other media featuring your company
- **Items that you MAY NOT include in your marketing display:**
  - 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 marketing display 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 marketing display). 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. You can view this section as a summary of your company information, ROV design, and theme.
- **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 marketing 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, and buoyancy systems, among others.
  - Highlight your vehicle's safety features.
  - 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 support scientific research and offshore oil and gas industry operations in the Arctic.

  Rather than repeating information that you find within the competition manual or on the Internet, take the time to think through the competition challenges and their significance in the real world. You can choose to focus on the technical, economic, or socioeconomic issue. In addition to the Internet, you are encouraged to contact individuals (such as a local scientist or industry professional) who can offer their views. You should include appropriate photos, diagrams, or sketches with captions. 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 your sponsors (companies, organizations (including the MATE Center), professionals from industry, and/or mentors) and the type of support that they provided (funds, building supplies, equipment, site visits to facilities, time, and/or technical expertise). You can include organizations and/or individuals that provided logistical and/or moral support (e.g. your parents, siblings, or pets). Regional competition teams should also acknowledge regional contest supporters.

Note: "Accessories" such as video footage, PowerPoint slide presentations running on laptop computers, video projections, etc. are permitted but should be used with discretion. Remember that the judges will have a limited amount of time to evaluate your marketing display 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.