



2016

mate roV

competition
manual

SCOUT

15th annual

mate roV
international
competition
2016

From the Gulf of Mexico to
Jupiter's Moon Europa:
ROV Encounters in Inner and Outer Space

MTS marine technology society NOAA NASA NSF OCEANEERING®

June 23-25, 2016 Δ NASA's Neutral Buoyancy Lab Δ Houston, Texas

2016 MATE ROV COMPETITION:

From the Gulf of Mexico to Jupiter’s Moon Europa: ROV Encounters in Inner and Outer Space

SCOUT 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.,

SCOUT CLASS

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, the NASA Johnson Space Center’s Neutral Buoyancy Lab, and Oceaneering International 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 product demonstration are included below.

PART 1: PRODUCT DEMONSTRATION

OVERVIEW

SCOUT class companies will take part in ONE product demonstration that consists of five distinct tasks:

TASK #1: OUTER SPACE: MISSION TO EUROPA

Connect an Environmental Sample Processor (ESP) to a power and communications hub.

TASK #2: INNER SPACE: MISSION-CRITICAL EQUIPMENT RECOVERY

Find and return mission-critical equipment to the surface.

TASK #3: INNER SPACE: FORENSIC FINGERPRINTING

Collect two samples of oil from the seafloor and return the samples to the surface for analysis.

TASK #4: INNER SPACE: DEEPWATER CORAL STUDY

Collect and return three coral samples to the surface.

TASK #5: INNER SPACE: RIGS TO REEFS

Install a cap to the top of a decommissioned wellhead, and secure the cap to the wellhead with a bolt.

NOTE: Regional competitions may give companies more than one attempt at the 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, product presentations, and marketing displays with the following scoring breakdown:

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

TOTAL POINTS = 380

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 demonstration will depend on your regional event. Contact your [regional coordinator](#) to determine how your demonstration will be timed and how long you will have to set up, complete the tasks, demobilize, and exit the station.

Regardless of how the demo is 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 product demonstration 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 SCOUT CLASS

product demonstration 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 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 product demonstration 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

Since its inception in 1958, the National Aeronautics and Space Administration (NASA) has accomplished many great scientific and technological feats in air and space. However, NASA's work and impact is not limited to aerospace. NASA technology also has been adapted for many non-aerospace uses by the private sector; the technique of freeze-drying food is one example.

The agency also plays a role in ocean science and exploration. NASA has been observing the earth's oceans from space for decades. NASA launched Seasat, the first civilian oceanographic satellite, on June 28, 1978. Seasat was followed by Tiros-N. Today there are several ocean-observing satellite missions and an extensive scientific research community studying this data. Satellite data and modeling techniques allow scientists to map and monitor seasonal changes in ocean surface topography, currents, waves, winds, phytoplankton content, sea-ice extent, rainfall, sunlight reaching the sea, and sea surface temperature. During the last decade, forecasting models used NASA's satellite data to improve the ability to predict events such as the El Niño climate oscillation phenomenon and other global and regional climate cycles.

Similarly, global oilfield services provider Oceaneering International's work is not only in subsea oilfield production; the company's Entertainment Systems division contributes to the cutting-edge development of theme park technologies (think Disney!), including dark ride vehicles and show systems. Oceaneering also has divisions that focus on land surveying and mapping, video and data collection and management, and outer space.

Oceaneering's Space Systems (OSS) division develops, integrates, and applies both new and existing technologies to the challenges of operations in space and other harsh environments. OSS specializes in the design, manufacturing, certification, maintenance, and testing of thermal protection systems for rockets; equipment for humans to use in space; and robotic systems for military, space, and biological research applications. The Space Systems division of Oceaneering also provides specialized engineering and support services in these areas and in astronaut training at NASA's Johnson Space Center's Neutral Buoyancy Laboratory (NBL) and Space Vehicle Mockup Facility (SVMF).

OSS is one of several in-house commercial tenants at the NBL/SVMF that supports NASA's programs. The company oversees astronaut training for extravehicular activities (EVAs or "spacewalks") and intravehicular activities (IVAs or activities that take place inside the spacecraft). OSS also teams with NASA scientists and engineers to find solutions to problems as well as ways to accomplish NASA priorities – such as recovering mission-critical equipment from the ocean floor and developing robots to explore oceans on other planets and natural planetary satellites in our galaxy.

In addition to working together, both NASA and Oceaneering partner with other organizations that have similar project interests and priorities. Given the location of their facilities, this includes organizations with scientific, commercial, and conservation efforts taking place in the Gulf of Mexico.

NEED

NASA and Oceaneering Space Systems (OSS) have issued a request for proposals (RFP) for a first-of-its-kind, dual purpose remotely operated vehicle that can operate in the harsh environments of both the deep ocean and outer space. Specifically, scientists and engineers at these organizations are in need of a robot that can 1) survive transport to Jupiter's moon Europa and operate in the ocean under its ice sheet to collect data and deploy instrumentation; 2) find and recover critical equipment that sank in the Gulf of Mexico after a recent series of testing programs; 3) collect samples and analyze data from oil mats located in the northern Gulf of Mexico to determine their origin ; 4) photograph and collect samples of deep-water corals to assess their health post-Deepwater Horizon oil spill; and 5) prepare a wellhead for decommission and conversion into an artificial reef.

Before launch and operations in inner and outer space, the robot must complete a series of "product demonstrations" staged in the 6.2-million gallon, 40-foot deep Neutral Buoyancy Lab (NBL). (Depth requirements vary depending on robot class; see [VEHICLE DESIGN & BUILDING SPECIFICATIONS](#) below.) Companies that successfully complete the product demonstrations and deliver exceptional engineering and communication components (e.g. technical documentation, product presentations, and marketing displays) will be awarded the contract.

This is where your work begins.

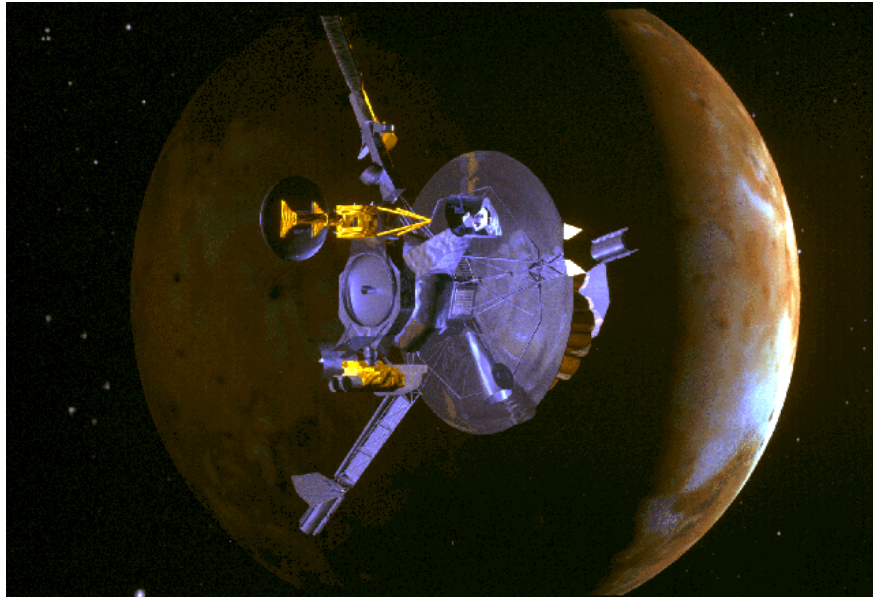
Visit www.youtube.com/watch?v=Tn-jUbpFV4A for sound advice from MATE judge Marty Klein. He references 2015, but his words still hold true for this competition season!

REQUEST FOR PROPOSALS (RFP)

1. General

a. Mission to Europa

NASA's Galileo mission to Jupiter in the late 1990s produced strong evidence that Europa, one of Jupiter's moons that is about the size of Earth's moon, has an ocean beneath its frozen crust. In 2012, NASA's Hubble Space Telescope found additional evidence when it observed water vapor above Europa's south pole. If proven to exist, this ocean could hold more than twice as much water as Earth. More importantly, it could hold the ingredients needed to support life.



On December 16, 1997, the Galileo spacecraft flew within 200 km of Europa's surface, allowing its cameras to resolve details as small as 6 meters.

Photo credit: http://physics.weber.edu/carroll/europa/galileo_mission_to_europa.htm

All systems are go for a reconnaissance mission to Europa. NASA will launch a spacecraft to Jupiter in the 2020s. When it arrives several years later, the spacecraft will enter into a long, looping orbit around Jupiter to perform close flybys of Europa. The mission plan currently includes 45 flybys at altitudes varying from 2,700 to 25 kilometers.

The spacecraft's payload will include cameras and spectrometers to produce images of Europa's surface and determine its composition. An ice-penetrating radar will determine the thickness of the moon's icy shell and search for subsurface lakes similar to those beneath Antarctica's ice sheet. The mission will also carry a magnetometer to measure the moon's magnetic field, which will allow scientists to determine the depth and salinity of its ocean.

Based on the findings gathered from this reconnaissance, NASA will propose a second mission to Europa, this one with the goal of landing on the moon's icy surface. The mission plan would include penetrating the ice sheet to perform detailed, long-term studies of the waters and seafloor below, with the hope of finding evidence of life elsewhere in our galaxy.

b. Mission-Critical Equipment Recovery

CubeSats are miniaturized satellites; they are part of a class of research spacecraft called nanosatellites. The idea for CubeSats was developed in 1999 by professors at California Polytechnic State University, San Luis Obispo and Stanford University's Space Systems Development Lab. Their goal was to allow graduate students to design, build, test, and operate a spacecraft similar to that of the first spacecraft, Sputnik.

The first CubeSat was launched in 2003. Today, more than 60 universities and high schools participate in the CubeSat Project managed by these two universities.



Student-built CubeSats are released from the international space station's Kibo module.

Photo credit: NASA.

The CubeSat that was initially proposed did not set out to become the “standard,” but over time it became just that. CubeSats are built to standard dimensions (Units or “U”) of 10cm x 10cm x 11cm. They can be 1U, 2U, 3U, or 6U in size, and typically weigh less than 1.33 kg (3 lbs) per U. CubeSats are most commonly put in orbit by deployment systems on the International Space Station or as a payload on a launch vehicle.

Over the last 16 years, these tiny, box-shaped spacecraft have become a quick, inexpensive way to test components and techniques that, if proven, can be applied to much larger, more complicated missions. The price tag for each CubeSat mission is one-tenth the cost of the least-expensive traditional launcher.

Universities and high schools accounted for the majority of CubeSat launches until 2013, when over half of the launches were for non-educational purposes. By 2014, most newly launched CubeSats were for a commercial or amateur project. CubeSats have been built by large and small companies alike; some have been the subject of Kickstarter campaigns. These mini-satellites are revolutionizing the space industry by putting the ability to do space science and exploration in the hands of students, teachers, working professionals, and Makers of all ages.

Recognizing the benefits to the space community, NASA supports CubeSat development and research through its CubeSat Launch initiative (CSLI). The CSLI provides opportunities for CubeSats to fly on rockets planned for upcoming launches. The CubeSats “piggyback” as secondary payloads on previously planned missions, collecting information, testing new technologies, and expanding what we know about outer space.

c. Forensic Fingerprinting

The Deep-C (Deep Sea to Coast Connectivity in the Eastern Gulf of Mexico) Consortium was created as a result of the Deepwater Horizon oil spill in 2010. While its primary goal is to study the long-term effects of the spill, new technologies used by the Consortium's scientists have global impacts on scientific research. One technology is the ability to thoroughly "fingerprint" oil samples.

The term fingerprinting has become commonly used shorthand for determining a substance's origin or source. For example, in DNA fingerprinting such as seen in TV shows like CSI, investigators match the presence or absence of specific gene sequences to that seen in DNA samples of known origin.

Oil is a mixture of various hydrocarbons (carbon-containing compounds of different molecular weights) and associated impurities. Some of these hydrocarbons have molecular weights that cause them to be gaseous at temperatures and pressures found in the ocean, while others are liquids of various viscosity or "stickiness." Oil from different sources contains different hydrocarbons as well as different amounts of these hydrocarbons (and impurities). Therefore, in a manner similar to DNA, oil can be fingerprinted to a specific source or origin.

Chromatography is a scientific tool that separates mixtures based on their different chemical and physical properties such as molecular weights. In general, gas or liquid chromatography works by combining a sample with some type of non-reactive carrier molecule that transports the sample through a column. The column contains chemical compounds that retain the various components of the sample based on their properties, such as molecular weight. The resulting data can be represented in a chromatogram, a graph of the abundance of the various components versus retention time in the column.

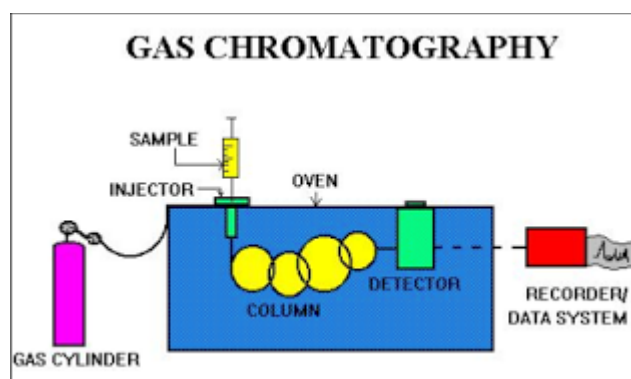


Photo credit: <https://sites.google.com/site/advancedmagicrofforensicscience/lesson-3>

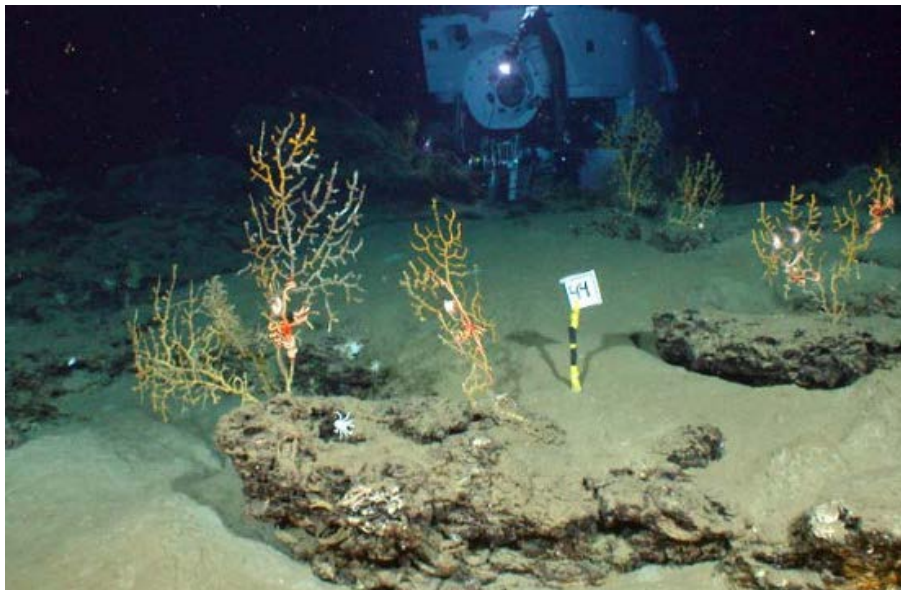
Trying to separate oil mixtures of very similar molecular weight compounds requires a more involved process, known "GC x GC" (gas chromatography x gas chromatography). In the GC x GC technique, there are two columns; after the sample flows through the first column, parts of the

sample are collected and injected into the second column, which results in greater separation. This powerful new technique is allowing scientists to produce a more detailed fingerprint and, as a result, more accurately determine the origin of events like an oil spill.

d. Deepwater Coral Study

During the three months between the Deepwater Horizon oil rig explosion and when the Macondo wellhead was capped on July 15, 2010, approximately 4.1 million barrels (~650,000 m³) of crude oil were released into the Gulf of Mexico. Because of the physics of the spill, as well as the extensive use of dispersants, much of the oil and gas remained at depth. In addition, weathering, burning, and dispersants applied to surface slicks resulted in a return of hydrocarbons to the deep sea. These hydrocarbons and dispersants had the potential to harm deep-sea communities that are, by nature, difficult to access and assess. These communities include species of colonial, cold-water corals.

Most deepwater corals, including *Paramuricea* species, are slow-growing; individual gorgonian colonies (also known as sea whips or sea fans) can live for hundreds to thousands of years. As a result, these corals and the communities that form on and around with them are unlikely to recover quickly from events that are lethal to the corals.



Shortly after the spill, researchers found coral at the bottom of the Gulf of Mexico covered with “black scum” and a gooey brown mixture of material 11 km southwest of the Macondo wellhead.

Photo credit: Chuck Fisher, Penn State University, and Tim Shank, Woods Hole Oceanographic Institution; www.cnn.com/2012/03/26/us/gulf-oil-coral/

Scientists began studying the effects of the Deepwater Horizon spill on Gulf of Mexico deepwater coral species within three months after the well was capped. In addition to colonies of *Paramuricea* species, they investigated scleractinian, also called stony or hard, coral species.

Scientists collected samples to analyze in the laboratory. They also collected and digitized still

images so that the images could be analyzed for signs of visible impact and compared to later photos to assess the spill's effect on the corals over time.

e. Rigs to Reefs

“Rigs-to-Reefs” refers to the practice of converting decommissioned offshore oil and gas platforms into artificial reefs for marine habitat. In the United States, where the practice started and is most common, Rigs-to-Reefs is a nationwide program developed by the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) of the U.S. Department of the Interior.

Oil platforms make ideal reefs because they are environmentally safe, are constructed of durable and stable material, and already support a thriving reef ecosystem below the waterline since many of the structures have been in the water for 30 years or longer. From a rig to a reef the transformation begins quickly. Marine species, including fish, find the structure immediately. Invertebrates settle within a month, and after six months to a year, the site is well established as an artificial reef.



Scuba divers are yet another species that benefits from the Rigs-to-Reef program.

Photo credit: www.rig2reefexploration.org/

Before converting to a reef, oil platforms are inspected in order to locate any environmental hazards. All decks (where oil production occurs) are removed and taken to shore for recycling or reuse. All equipment associated with the deck is removed (such as drilling equipment, tanks, pumps, buildings, etc.). The insides of the platform's legs are inspected to make sure that they don't contain oil. All wells below the structure are “plugged” – or capped – by the company that owns the platform. Once the cap is secured, the structure's life as oil platform ends and its time as a home to marine species officially begins.

f. Document Scope and Purpose

This and the following sections contain the technical specifications and requirements for ROV services needed to support both the space and ocean science and technology community. In 2016, ROV services include:

1) MISSION TO EUROPA

- Connecting the Environmental Sample Processor (ESP) to the power and communication hub.
 - Retrieving the ESP's cable connector from the elevator.
 - Opening the door to the port on the power and communications hub.
 - Inserting the cable connector into the port on the power and communications hub.

2) MISSION CRITICAL EQUIPMENT RECOVERY

- Recovering mission-critical NASA equipment and placing it in a collection basket.
- Returning the collection basket to the surface.

3) FORENSIC FINGERPRINTING

- Retrieving oil samples from the seafloor.
- Returning the samples to the surface.
- Analyzing a gas chromatograph of each sample to determine its origin.

4) DEEPWATER CORAL STUDY

- Collecting three samples of coral.
- Returning the samples to the surface.

5) RIGS TO REEFS

- Retrieving a wellhead cap from an elevator.
- Installing a cap over the top of the wellhead.
- Retrieving a bolt from an elevator.
- Securing the cap to the wellhead with a bolt.

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. Product presentation
- c. Marketing display
- d. Product demonstration

6. References

- a. www.nasa.gov
- b. www.nasa.gov/europa
- c. <http://science.nasa.gov/earth-science/oceanography/>
- d. www.oceaneering.com
- e. www.nasa.gov/press-release/all-systems-go-for-nasas-mission-to-jupiter-moon-europa
- f. www.cubesat.org/
- g. www.nasa.gov/mission_pages/cubesats/index.html
- h. <https://en.wikipedia.org/wiki/CubeSat>
- i. <http://deep-c.org/>
- j. <https://elementascience.org/articles/12>
- k. www.pnas.org/content/111/32/11744
- l. www.bsee.gov/Exploration-and-Production/Decommissioning/Rigs-to-Reefs/
- m. <https://en.wikipedia.org/wiki/Rigs-to-Reefs>
- n. http://tpwd.texas.gov/landwater/water/habitats/artificial_reef/rigs-to-reefs.phtml

IMPORTANT NOTE: Questions about production demonstrations and design and building specifications must be posted to the competition FAQs board located at www.marinetech.org/forums/. 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. It is up to the companies to read, comprehend, and comply with ALL rulings posted on the FAQ board.

NEW IN 2016!!!

SIZE RESTRICTIONS

Launching payloads into orbit can cost NASA in excess of ~\$20,000 USD per kilogram;* limiting the size of objects launched into space is very important. In 2016, SCOUT class under a certain size will be awarded bonus points.

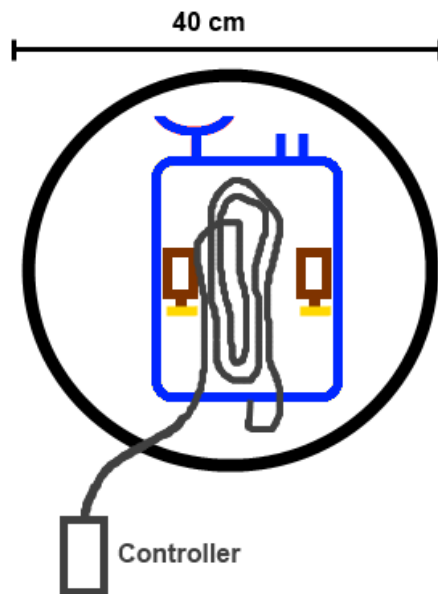
Vehicles will be measured in the SCOUT on-deck circle 30 minutes prior to the company's product demonstration runs. Note that the vehicle will be measured before all product demonstration runs. The size bonus, if any, will be added into the product demonstration score.

Size Measurements

Size measurements will be made using the two largest dimensions of the ROV. Two flat sheets with 40 cm and 48 cm diameter holes cut into their centers (one hole per sheet) will be located on a table in the on deck circle. Companies will place their vehicles on the measuring table and, when ready, ask a MATE Center judge to make the size measurement. The vehicle measurement must include the vehicle, all manipulators/tools to be used

in the product demonstration, and the vehicle's tether. The control system and 1 meter of tether may be outside of the measurement circle. Companies must present their completely assembled ROV for measurement; companies may NOT detach manipulator arms or other equipment for the measurement.

The hole in the flat sheet must fit over the two largest dimensions of the ROV. If the ROV and all its equipment fit within the hole of 40 cm in diameter, the company will receive +10 bonus points. If the ROV and all its equipment fit within the hole of 48 cm in diameter, the company will receive +5 bonus points. If the ROV and all its equipment do not fit within the hole of 48 cm in diameter, the company will receive no bonus points, but can still compete in the product demonstration.



A SCOUT class vehicle, with tools attached and tether coiled on top, inside the 40 cm diameter circle. This vehicle would earn the company +10 bonus points on the product demonstration score.

Only the four designated product demonstration team members will be allowed into the on-deck circle during and after the measurement and weigh in. Once a company's vehicle has been measured, no new equipment (equipment that was not included in the size measurements) may be added to the vehicle. If it is discovered that a company added equipment that was not included in the measurements, that company will not be permitted to compete in that product demonstration run.

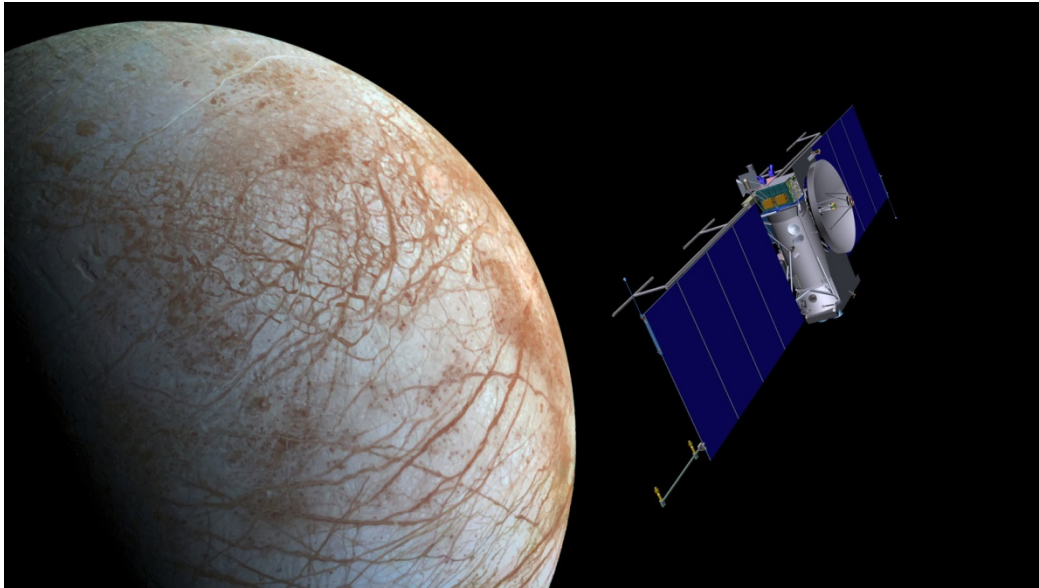
*Reference: www.nasa.gov/centers/marshall/news/background/facts/astp.html

PRODUCTION DEMONSTRATION

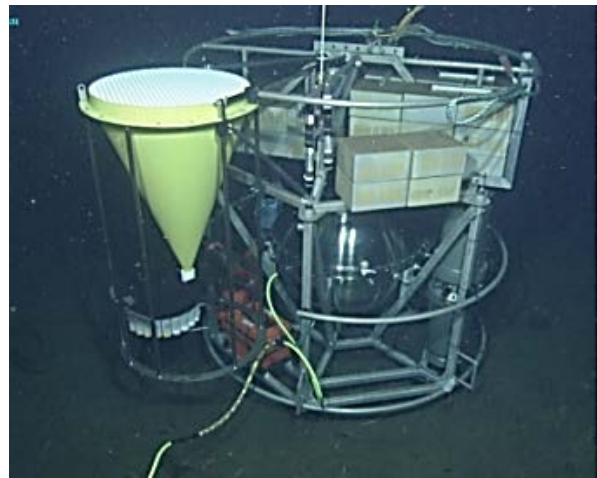
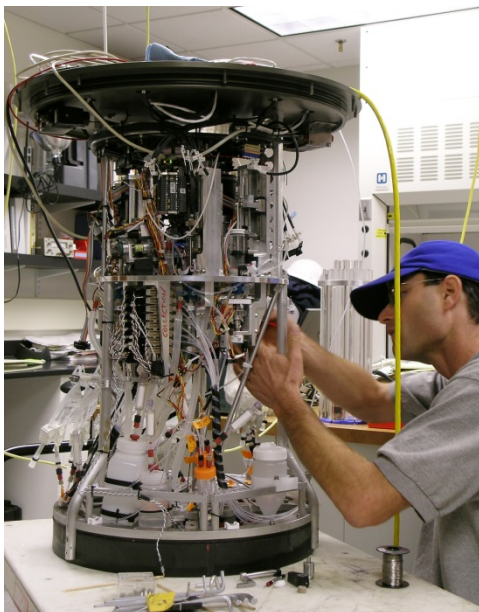
TASK 1: OUTER SPACE: MISSION TO EUROPA

Your company must descend to the bottom of the ocean on Jupiter's moon Europa. Once there, your company must connect an Environmental Sample Processor (ESP) to the power and communications hub.

Both the ESP and the power and communications hub have already been deployed on the sea floor. Your vehicle must retrieve the cable connector from the ESP's elevator, open the door on the power and communications hub, and insert the cable connector into the port on the hub.



Artist concept of NASA's Europa mission spacecraft approaching its target for one of many flybys.
Photo credit: NASA.



An ESP being prepared for deployment and later connected to the MARS (Monterey Accelerated Research System) cabled observatory, 900 m deep in Monterey Bay.
Photo credit: Monterey Bay Aquarium Research Institute, Moss Landing, CA.

This task involves the following steps:

- **Connect the Environmental Sample Processor (ESP) to the power and communications hub – up to 50 points maximum**
 - **Retrieving the ESP's cable connector from the elevator – 10 points**
 - **Opening the door to the port on the power and communications hub – 20 points**
 - **Inserting the cable connector into the port on the power and communications hub – 20 points**

TOTAL POINTS = 50

Product Demonstration Notes:

The steps of the Mission to Europa task may be done in any order. Companies may alternate between the steps of the Mission to Europa task and other tasks.

The ESP will be secured to an elevator located on the bottom of the pool. The ESP and the elevator will be constructed of ½-inch PVC pipe. A cable connector attached to 3 meters of coiled line will also be located on the elevator. The cable connector will be constructed from ½-inch PVC pipe. Companies will receive 10 points when the ESP cable connector is successfully retrieved. A successful retrieval of the cable connector is defined as the cable connector under control of the ROV and no longer in contact with the elevator. Knocking the cable connector off the elevator does not count as a successful retrieval; it must be under control of the ROV.

The cable connector will weigh less than 5 Newtons in water.

The power and communications hub will be located on the bottom of the pool. The power and communications hub will be constructed from a milk crate. The door on the hub will be constructed from flat plastic sheeting and attached with hinges. A ½-inch PVC pipe handle will be attached to the door. Companies may use this handle to open the door or can open it by other means. Companies must open door on the hub to access the port inside. Companies will receive 20 points when the door is successfully opened. Successfully opening the door is defined as the door pushed at least 90° from the closed position. If the door closes after a company has successfully opened it, they will not lose points. However, the company may need to reopen the door to complete the task.

Once the door is opened, companies must insert the cable connector into the port located in the power and communications hub. The port inside the hub will be constructed of 3-inch PVC pipe. The port will be positioned vertically. Companies will receive 20 points when they successfully insert the cable connector into the port. A successful installation is defined as the tee of the cable connector flush with the top of the 3-inch pipe of the port inside the power and communications hub. The cable connector must stay inside the port for 5 seconds after being released by the vehicle to count as a successful insertion.

TASK 2: INNER SPACE: MISSION-CRITICAL EQUIPMENT RECOVERY

Your company is tasked with locating and recovering CubeSats that sank in the Gulf of Mexico after a recent NASA test launch. Your company must collect all four CubeSats and return them to the surface.



CubeSats undergo final inspection at NASA Ames Research Center in Moffett Field, California.

Photo Credit: NASA, Dominic Hart.

This task involves the following steps:

- **Recovering four CubeSats from the seafloor and placing them into a collection basket – 5 points each (20 points total).**
- **Returning the four CubeSats to the surface – 5 points each (20 points total).**

Total points = 40

Product Demonstration Notes:

Companies may complete the steps of the Mission-Critical Equipment Recovery task in any order. Companies may alternate between the steps of the Mission-Critical Equipment Recovery task and other product demonstrations.

Four CubeSats will be located on the bottom of the pool. The CubeSats will be constructed from ½-inch PVC pipe shaped into a square prism.

Companies must recover all four CubeSats from the seafloor and place them into the collection basket located on the bottom of the pool. The collection basket will be constructed from a 60 cm x 60 cm square of ½-inch PVC pipe. A 1 meter length of rope will be attached to each corner of the PVC square. These four lengths of rope will come together above the collection basket, with an additional line running to the surface. Companies will receive 5 points for each CubeSat recovered from the bottom and successfully placed into the collection basket, 20 points total. To receive points, the CubeSat must be entirely within the ½-inch PVC square. No portion of the CubeSat may be on top of or outside the PVC square.

SCOUT CubeSats will weigh less than 5 Newtons in water.

SCOUT CLASS

The CubeSats must be placed into the collection basket for transport to the surface; vehicles are not permitted to bring CubeSats to the surface. MATE will provide the collection basket; companies do not need to bring their own. Companies can choose to place all four CubeSats into the basket before lifting it to the surface, or they can choose to place only some of the CubeSats into the basket before lifting it to the surface. The collection basket may be lowered to the bottom of the pool as many times as needed to recover any remaining CubeSats. Company members may hand lift the collection basket to the surface. Companies will receive 5 points for each CubeSat returned to the surface and placed on the pool deck, 20 points total. If a CubeSat falls out of the basket while lifting, the company may lower the basket and place that CubeSat back into the collection basket.

Only CubeSats may be placed in the MATE collection basket. Items from other tasks may not be placed into this basket and lifted to the surface.

TASK 3: INNER SPACE: FORENSIC FINGERPRINTING

Your company must collect a sample from two different oil mats located on the seafloor and return them to the surface. Once at the surface, your company must analyze a gas chromatograph – or “fingerprint” – of each sample to determine the oil’s origin.



An oil mat around a natural seep on the sea floor.

Photo credit: www.newenergyandfuel.com.

This task involves the following steps:

- **Collecting one sample of two oil mats on the seafloor – 5 points each (10 points total)**
- **Returning the samples to the surface – 5 points each (10 points total)**

- **Analyzing a gas chromatograph of each sample to determine the oil's origin – 10 points each (20 points total)**

Total points = 40

Product Demonstration Notes:

Companies may collect, return, and analyze one sample at a time or both samples at once. Companies may alternate between the steps of the Forensic Fingerprinting task and other tasks.

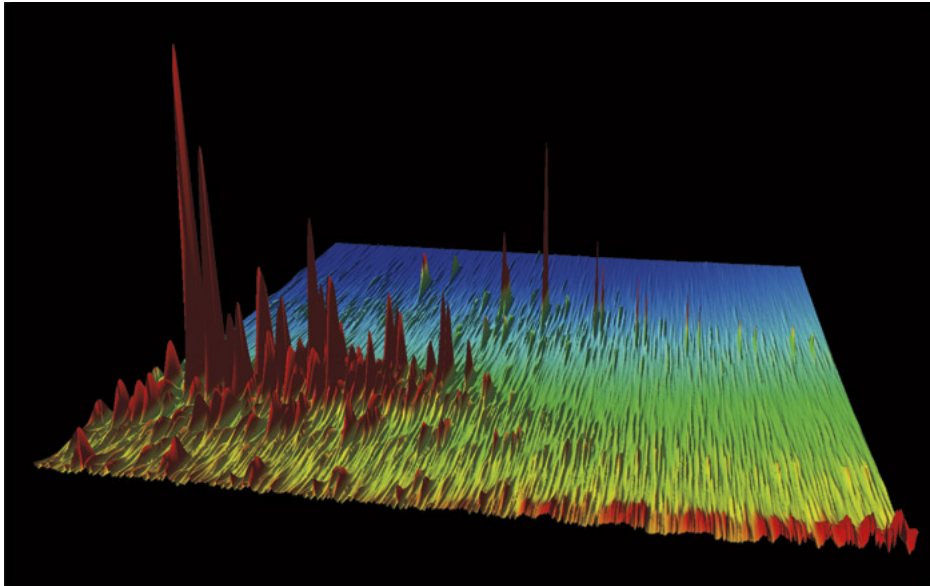
Two oil "mats" will be located on the bottom of the pool. The mats will be simulated by a 5-gallon bucket lid with a sample set in the middle. Oil samples will be constructed from a 2-inch PVC tee that is painted black. A U-bolt will act as a grab point on each oil sample. The sample will be positioned upright around a 1 ¼-inch end cap in the center of the 5-gallon bucket lid. Companies must collect the sample of oil from each mat and return it to the surface. Companies will receive 5 points for each oil sample collected, 10 points total. Collecting an oil sample is defined as having the oil sample under control of the vehicle and no longer in contact with the end cap and 5-gallon bucket lid. Once collected, the oil samples must be returned to the surface, side of the pool. Companies will receive 5 points for each oil sample returned to the surface and placed on the pool deck, 10 points total.

Once an oil sample is at the surface, companies can retrieve the oil's gas chromatograph, or fingerprint. The gas chromatograph will be printed on a laminated sheet and rolled up inside the 1-inch pipe. Companies must compare the sample's fingerprint to fingerprints of samples of known origins to determine its origin.

A handbook of gas chromatographs of oil samples from known origins will be provided at each product demonstration station, although companies may choose to print and bring their own handbook. To successfully determine the origin of an oil sample, companies must compare the sample's fingerprint to one of the known oil fingerprints and find a match.

Companies must determine the origin of each oil sample and report their findings to the product demonstration judges during the timed product demonstration run. Companies will receive 10 points when they successfully determine each oil sample's origin, 20 points total. If a company incorrectly identifies the origin of an oil sample, they may not re-analyze the gas chromatograph and try again. Companies may not guess at the origin if they have not retrieved an oil sample.

SCOUT class companies' oil fingerprint handbook will gas chromatographs of three known samples.

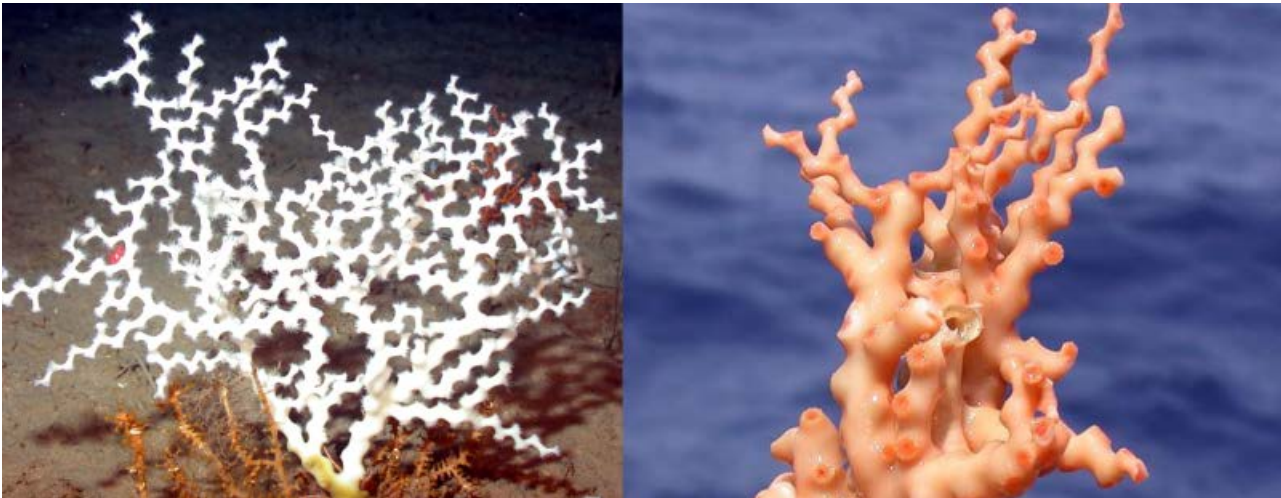


A 3-D chromatogram of oil that leaked from the Macondo well during the Deepwater Horizon oil spill. Each peak represents one of thousands of individual chemical compounds in the oil. The taller the peak, the more of that particular compound is in the oil.

Photo credit: Bob Nelson, Woods Hole Oceanographic Institution, and the Deep-C Consortium (<http://deep-c.org/>).

TASK 4: INNER SPACE: DEEPWATER CORAL STUDY

Your company is tasked with collecting and returning to the surface three colonies of the scleractinian coral species, *Madrepora prolifera*, for laboratory analysis.



Madrepora corals from the Gulf of Mexico.

Photo credit: left, https://en.wikipedia.org/wiki/Madrepora_oculata; right, https://en.wikipedia.org/wiki/Deep-water_coral.

This task involves the following steps:

- Collecting three coral samples from the seafloor – 5 points each (15 points total)

- **Returning three coral samples to the surface – 5 points each (15 points total)**

Total points = 30

Product Demonstration Notes:

The steps of the Deepwater Coral Study task may be done in any order. Companies may alternate between the steps of the Deepwater Coral Study task and other product demonstrations.

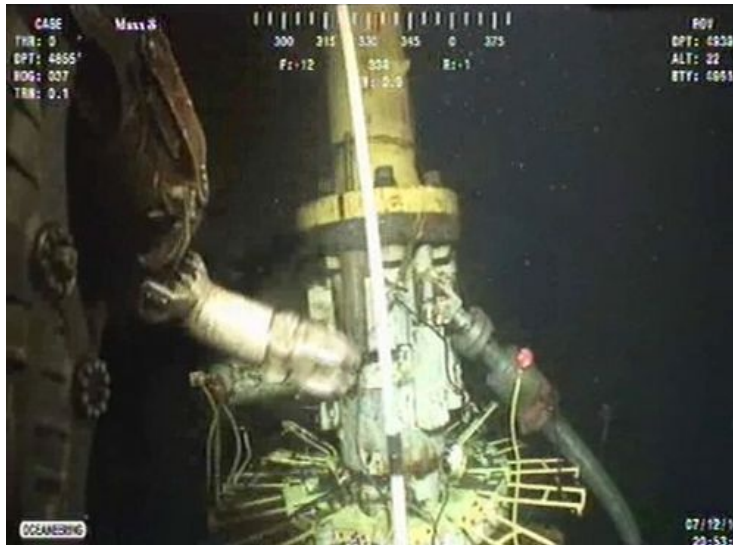
Companies must collect a scleractinian coral, *Madrepora prolifera*. *Madrepora prolifera* coral colonies will be constructed out of red, brown, and pink chenille pipe cleaners mounted into a PVC base. Companies will receive 5 points for each *Madrepora prolifera* coral colony collected, 15 points total. Collecting the coral colony is defined as having the coral under control of the vehicle and no longer in contact with the bottom of the pool. Once collected, the coral colonies must be returned to the surface, side of the pool. Companies will receive 5 points for each coral colony returned to the surface and placed on the pool deck, 15 points total.

TASK 5: INNER SPACE: RIGS TO REEFS

An oil platform in the Gulf of Mexico’s Green Canyon lease block #272 no longer produces enough oil to make it economically feasible to continue drilling operations. The plan is to decommission the platform and turn it into an artificial reef. Before removing the top of the platform and converting the base into an artificial reef habitat, the oil well must be capped.



An artificial reef created from an obsolete oil and gas platform in the Gulf of Mexico.
Photo credit: State of Louisiana, Department of Wildlife and Fisheries, Artificial Reef Program.



An ROV placing a cap on a wellhead.
Photo Credit: Oceaneering International.

Your company is tasked with securing a cap to the wellhead. This task involves installing a cap and securing it onto the wellhead with a bolt.

This task involves the following steps:

- **Retrieving the wellhead cap from the elevator – 10 points**
- **Installing the cap over the wellhead – 10 points**
- **Retrieving the bolt from the elevator – 10 points**
- **Securing the cap to the wellhead with one bolt – 10 points**

Total Points = 40

Production Demonstration Notes:

The steps of the Rigs to Reef task must be done in order. The cap must be installed over the wellhead before the bolt is retrieved from the elevator. Companies may not attach the bolt to the wellhead cap first.

Both the cap and the bolt will be positioned on an elevator platform located on the bottom of the pool. The elevator platform will be located within 1 meter of the wellhead.

Companies must retrieve the wellhead cap from the elevator. The wellhead cap will be constructed from a 4-inch PVC end cap. Flotation on the inside, top of the cap will reduce the weight of the end cap in water. Companies will receive 10 points when they successfully retrieve the wellhead cap from the elevator. A successful retrieval is defined as the end cap under control of the ROV and no longer touching the elevator or the pool bottom. Pushing the wellhead cap so it falls off the elevator does not count as a successful retrieval.

Companies must then install the wellhead cap over the wellhead. The wellhead will be constructed of a ½-inch PVC framework. The top of the wellhead will be constructed from a 3-inch to 2-inch converter. A 2-inch to ½-inch reducer bushing will connect the wellhead framework and the top of the wellhead. Companies will receive 10 points when they install the wellhead cap over the wellhead. Successfully installing the wellhead cap is defined as the cap sitting flush on the top side of the wellhead.

The wellhead cap will weigh less than 5 Newtons in water.

After installing the wellhead cap, companies must retrieve the bolt from the elevator. The bolt will be constructed from a 3-inch knockout cap, and ½-inch PVC. Velcro hooks are located on the bottom of the 3-inch knockout cap. Companies will receive 10 points when they retrieve the bolt from the elevator. A successful retrieval is defined as the bolt under control of the ROV and no longer touching the elevator or the pool bottom. Pushing the bolt so it falls off the elevator does not count as a successful retrieval.

Finally, companies must secure the wellhead cap by placing the bolt on top of the cap. The Velcro hooks on the bottom of the bolt will attach to the Velcro loops on the top of the wellhead cap. Companies will receive 10 points when the bolt is placed and the cap is secured to the wellhead. Successfully securing the cap to the wellhead means that the Velcro hooks on the bolt are secured against the Velcro loops on the cap. The bolt must stay on the cap and the cap must stay on the wellhead for at least 5 seconds after the ROV releases the bolt.

The bolt will weigh less than 5 Newtons in water.

TIME BONUS

If a company has successfully completed all product demonstration tasks and is returning to the surface with CubeSats on the lift basket or corals on the ROV, the product demonstration time will stop when a member of the company touches the PVC framework of the basket or vehicle. CubeSats on the basket or corals on board may be detached and set on the pool deck after the clock has stopped. If a CubeSat or coral is subsequently dropped, time will not restart. The company will not receive points for returning items dropped after time has stopped, and therefore cannot receive a time bonus. Note: The analysis of the oil fingerprint must be completed during the product demonstration time period.

PRODUCT DEMONSTRATION RESOURCES

The [SCOUT Oil Fingerprint Handbook](#) contains gas chromatographs of oil samples from three locations.

The [SCOUT Product Demonstration Photos](#) contains photos of completed product demonstration props.

See the [SCOUT Product Demonstration SolidWorks](#) files for CAD representations of the product demonstrations.

PART 2: PRODUCT DEMONSTRATION 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 4th, 2016.

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 \(www.marinetech.org/forums/\)](http://www.marinetech.org/forums/). 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-002S).

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**. All symbols must be standard symbols as specified by ANSI, NEMA, or IEC.

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. SIDs that do not show a fuse, utilizing an ANSI, NEMA or IEC symbol, with the size of the fuse marked, will not pass their safety check.**

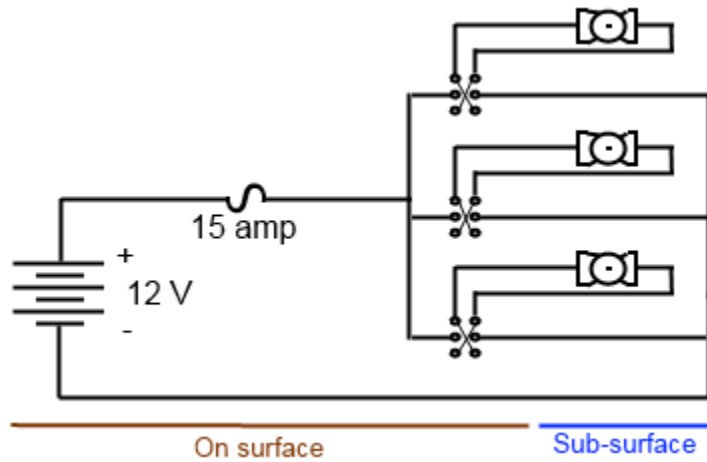


Diagram: An example of an acceptable switchbox SID.

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



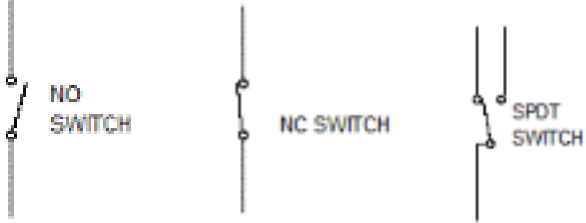

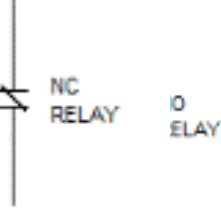

Note: Companies may use free drawing software such as [OpenOffice](https://www.openoffice.org/) to create their diagrams.

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.

DOC-005: The following ANSI and IEC symbols are acceptable symbols for all MATE required documentation

Item	ANSI	IEC
FUSE		

<p>CIRCUIT BREAKER</p>		
<p>SWITCH</p>		
<p>RELAY CONTACT</p>		

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:

- No SID was provided at the safety check.
- The SID 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 product demonstration 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/product demonstration 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 interconnection 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 product demonstration 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 product demonstration component of the competition. However, companies can still participate in the engineering and communication (technical documentation, product presentation, and marketing display) component.
6. Reminder: All companies must present the Green PASSED Flag to the pool practice or product demonstration coordinator before placing their vehicles in the water. In addition, product demonstration station judges and competition officials can pause or stop a product demonstration 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 product demonstration 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 product demonstration 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. However, wind, divers, or ROVs may create ripples on the surface that affect visibility. 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 product demonstration team 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-001S: ROVs must be capable of operating in a maximum pool depth of 4 meters (13 feet). All underwater product demonstrations will take place within 6 meters (20 feet) from the side of the pool. Tether lengths should be calculated accordingly.

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

3.2.2 Vehicle Deployment and Recovery

MECH-002S: The product demonstration team (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-003S: 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-001S: 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 supply AND the single fuse in your wiring.

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

ELEC-003S: Voltage may never be increased above the nominal 12 volts anywhere in the ROV system.

Current

ELEC-004S: 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-005S: ROV systems are allowed two replacement fuses during the product demonstration run. In the event that the ROV system blows the third fuse during the product demonstration, the product demonstration run will be over and no additional points will be earned. Note: Companies must provide their own replacement fuses. MATE will not provide replacement fuses.

NEW in 2016/2017!!!

Power Connections

ELEC-006S: Over the next two years, the MATE Center will be transitioning from banana plug connections to Anderson power pole connections (www.andersonpower.com/us/en/products/powerpole/pp15-to-45.aspx). While they are NOT required in 2016, in 2017 all SCOUT class competition vehicles will be required to use Anderson power pole connectors.

Companies can choose to switch to Anderson power pole connectors in 2016 provided that their regional can accommodate them. Some regional competitions may REQUIRE Anderson power pole connections in 2016. . Contact your regional coordinator for more information.

Anderson power pole connections are two-piece connectors as shown in the picture below.



Part specification and part numbers

Anderson Power Pole – Red and Black connector with 30 amp contacts

Red is connected to power supply positive.

Black is connected to power supply negative.

Since Anderson sells the connectors in 2500 and 200 piece quantities, these connectors are available from distributors.

For those who want more information on Anderson power pole connectors:

Distributor Part Number:

Connector & Pins: Powerwerx WP30-10 (This is a kit with 10 connector sets and 30 amp pins for approx \$12 USD)

Recommended Crimper: TR1crimp

<http://www.powerwerx.com/crimping-tools/tricrimp-crimping-powerpole-contacts.html>

Connector Sources:

<http://www.powerwerx.com/anderson-powerpoles/powerpole-sets/30-amp-permanently-bonded-red-black-anderson-powerpole-sets.html>

<http://www.aesham.com/power-distribution/powerpoles/powerwerx-wp30-10/>

http://www.gigaparts.com/Product-Lines/Power_2/Powerwerx-WP30-10.html

<http://www.hamradio.com/detail.cfm?pid=71-001833>

Powerpole related links

Powerpole Data Sheet

http://www.andersonpower.com/_global-assets/downloads/pdf/ds-pp1545.pdf

Powerpole Description

https://en.wikipedia.org/wiki/Anderson_Powerpole

Powerpole Assembly Instructions

<http://www.powerwerx.com/assembly.asp>

<http://www.wb3w.net/powerpoleinst.htm> (see the section on using the TriCrimp tool)

YouTube video for Assembly

Part 1: https://www.youtube.com/watch?v=8_DPPuQN8R4

Part 2: <https://www.youtube.com/watch?v=EsSsr2zGFqI>

ELEC-007S: The power supply may be located up to 1 meter from the station table and may be located on either side of the table. MATE recommends a power cable long enough to reach the power supply up to 2 meters from your control system.

Exposed connections and disposable motors

ELEC-008S: 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. Taping a connection only with electrical tape does not constitute a sealed connection. The process of sealing electrical connections must include methodologies such as, but not limited to, silicone RTV, hot melt glue, epoxy, self-vulcanizing tape, and enclosing the connection inside a housing.

3.4 Onboard Electrical Power

ELEC-009: 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-010S: 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-001S: 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-002S: Companies may only use WATER as their hydraulic fluid. Companies may only use AIR as their pneumatic fluid.

FLUID-003S: 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.

NEW in 2016!!!

ELEC-011S: Control systems must be built in a neat and workmanship like manner. Loose components and unsecured wires may not pass safety inspection. All wires entering and leaving the control system must have adequate strain relief and wire abrasion protection as the wires pass through the box.

3.7 Cameras and monitors

CAM-001: Cameras are not required in the SCOUT class. However, if a company chooses to use cameras on their ROV, they are limited to one video display screen. This monitor must be provided by the company, MATE will not provide a video display monitor for you.

CAM-002: All cameras and the one monitor MUST be powered from the MATE 12 volt supply. Companies may not plug cameras or the monitor into AC wall sockets. Companies may not use their own battery packs or USB to run cameras or monitors. NO EXCEPTIONS.

3.8. Lasers

SCOUT 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.

- With learning at its core, the MATE competition encourages students to utilize and build upon their skill sets to find creative solutions to designing and building their ROV. As they move through the process of analyzing their designs and identifying building materials, students may decide to either build a component from “scratch” or purchase it from a commercial vendor. While original solutions are encouraged, the use of commercial components is acceptable, provided 1) that the components adhere to the design and building as well as safety specifications for the particular competition class and 2) more importantly, that the students can provide a reasonable, logical explanation for buying versus building.

The competition scoring rubrics are designed to reflect this; points are awarded based on students’ abilities to explain and justify how all of the components and systems work together as an integrated ROV, regardless if they purchased them, pulled them from public libraries, or made them themselves.

That said, it should be noted that purchasing and competing with commercial ROVs are not permitted.

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 product 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. Contact your [regional coordinator](#) 4 weeks before the competition if you have a known scheduling concern.

*Regional contests may refer to the product demonstration 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 "product demonstration station." Only four students will be allowed to enter the product demonstration 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 product demonstration 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 product demonstration 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.
- Companies will compete in ONE product demonstrations that consist of five 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 communication score to determine the total, overall score for the competition.

In general, the product demonstration time consists of a 3-minute set-up period, a 10-minute performance period, and a 2-minute demobilization period. If the demo team and all of their equipment are not out of the product demonstration station at the end of the 2-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 product demonstration points can be received. Contact the [regional coordinator](#) in your area to determine if your regional will have SCUBA diver support during your product demonstration run.
- 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 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 product demonstration station.
- **Product demonstration 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 product demonstration 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.**
- Cameras and monitors are permitted, but aren't needed as companies are allowed to look into the pool to pilot the ROV. If your company chooses to use a camera(s), the camera(s) and monitor must be powered off of the 12-volt battery provided by the contest organizers. **NO AC POWER IS PERMITTED WHATSOEVER.** In other words, you can't plug your ROV into a wall socket!
- Radio transmitters that operate on a separate battery are permitted. No batteries are permitted to be in or on the water. No exceptions. Note that although wireless controllers are allowed, MATE is not responsible for wireless interference. Adjacent wireless controllers with a battery that has a higher charge may "hijack" control signals. MATE will not stop the clock to resolve wireless control issues under any circumstance. Companies deciding to utilize wireless controllers do so at their own risk.
- 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, 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:

- Company Spec Sheet
- Technical Documentation (formerly known as the technical report)
- Product Presentation (formerly known as the engineering presentation)
- Marketing Display (formerly known as the poster display)

NOTE: Regional contests may not require all of the Engineering & Communication components. Contact your [regional coordinator](#) for more information.

The Company Spec Sheet, Technical Documentation, and Product Presentation are components where you are communicating with technical audiences, such as potential future clients. (Examples of spec sheets and technical documentation from previous competitions can be found www.marinetech.org/tech-reports. Examples of product presentations can be found on [MATE’s Vimeo channel](#).) The Marketing Display should be thought of as part of your marketing (or sales) strategy and aimed at general (including non-technical) audiences.

TIPS FOR EFFECTIVE WRITTEN AND ORAL COMMUNICATION

Communicating ideas about how to solve a problem and evaluating those ideas 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 product 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 product demonstration 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 product 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 among regionals. Contact your [regional coordinator](#) to find out your specific deadline.

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**
Include photo(s) of your completed vehicle and other photos or sketches that capture the vehicle's design features. Captions should accompany all photos.

You are permitted to make modifications that may change the look of your vehicle between the time you submit your report and the competition; however, in your technical documentation you must include a photo(s) of your completed, intact vehicle, not photos of individual systems and/or payload.

- **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 product 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.*** It should include information about your planning and design

process, how you thought through ideas, and why you made the design choices that you did. It should explain any troubleshooting techniques and note any skills that you gained. See the questions under [Product 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 challenges** that your company faced and how you overcame them. This should include both a technical challenge and a challenge related to working as a team. Be sure to explain how you overcame these challenges.
- **Description of lessons learned and skills 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.

PRODUCT 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 product demonstration 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 product 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?
- Why did you decide to buy rather than build certain items – and vice versa? Can you justify your decision(s)?
- Did you reuse any components that you had built for a previous competition ROV? How did you decide which components to reuse and why?
- What design trade-offs did you make? Can you explain why?
- What type of tool(s) did you design to accomplish the product demonstration 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 product 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 product 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 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 background. 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 the technology (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
 - Copies of your company's technical documentation
 - Resumes and business cards 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 product demonstration tasks. Make sure to relate the product demonstration 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 tasks. 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 "Features and Benefits." Features are the physical aspects or specifications for your vehicle, and benefits are what those features provide for the customer. For example, a feature might be a one horsepower thruster; the benefit would be the ability to make headway in a 2 knot current.
- 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 product demonstration 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 technologies for inner space can be used in outer space – and vice versa.

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/Market Assessment**

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**

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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.