2006 MATE Center/MTS ROV Committee ROV Competition
For High School & College Students
www.marinetech.org/rov_competition/index.php

Challenging Teams to Design & Build Vehicles for the Next Generation of
Ocean Observing Systems

Competition Scenarios & Mission Tasks
EXPLORER& RANGER

COMPETITION OVERVIEW

Teaming up with **Ocean.US** and the **Ocean Research Interactive Observatory Networks (ORION) Program**, the 2006 ROV competition challenges students to design and build vehicles to accomplish tasks associated with developing and deploying the next generation of ocean observing systems.

The competition is divided into two competition classes: **RANGER** and **EXPLORER**. The **RANGER** ROVs operate at a maximum of 13 volts, 25 amps. **EXPLORER** vehicles have a higher power limit (51 volts and 40 amps surface power). Eligibility requirements for both classes are listed within the 2006 **General Information** document. Please review these requirements carefully.

In addition to the underwater mission tasks, both classes will be challenged with engineering evaluation interviews, technical reports, and poster displays. The scoring breakdown is as follows:

- Mission
  - **EXPLORER** – 170 points (max), plus a time bonus
  - **RANGER** – 170 points (max), plus a time bonus
- Engineering & communication – 170 points (max)
  - Engineering evaluation – 100 points (max)
  - Technical reports – 50 points (max)
  - Poster displays – 20 points (max)

Information about both **RANGER *and* EXPLORER** class competition scenarios and mission tasks is included in ***this*** document; the **Engineering & Communication** document contains information about the evaluation, report, and display requirements. The **Design & Building Specifications and Competition Rules** document contains information about ROV specifications and competition rules. Detailed task specifications, including information about mission "props," are included in the **Mission Task Specifications** document.

OCEAN OBSERVATORIES

What is Ocean Observing?
All human understanding is based – at some level – on observation. What we know about the land, the air, and space is based on shared observations over time.

Our ability to see into the ocean and to measure its properties improved dramatically during the 20th century. Just as the science of meteorology has given us the means to quickly observe and forecast the weather, ocean science and engineering are giving us the means to quickly detect and foresee changes in the marine environment. The establishment of the National Weather Service's network of atmospheric measurements has produced rapid advances in meteorology. A network of ocean observations has the same potential to produce rapid advances in ocean science and engineering.

Today, many changes are occurring in the oceans that have profound effects on our society. From sea level rise and coastal flooding to harmful algal blooms that contribute to dead zones and fish kills. At present, we do not fully understand the magnitude of these changes, their causes, and their consequences. Recently, the U.S. Commission on Ocean Policy Report called for the establishment of an ocean observing system that both advances our knowledge of the ocean and puts those advancements to work to provide practical and economic benefits to the nation. The National Ocean Research Leadership Council has called for the full implementation of an integrated ocean observing system by 2010.

The planning and implementation of the research and operational components of an ocean observing system are under way. These systems will efficiently link regional, national, and international networks of observatories and the data, information management systems, analyses, and models that result from these observatories. The long-term goal is to improve our understanding of ocean climate and the ocean environment so that we can better predict and prepare for changes that will impact the nation's citizens – along the coasts, estuaries, and Great Lakes and in the heartland, and, ultimately, all the peoples of Earth.

The deployment of the Ocean Research Interactive Observatory Networks (ORION), the in-water research component, will focus on coastal, regional, and global observatories that advance our understanding of oceanographic processes. ORION will use cutting-edge, in-water automated measurements from stationary and mobile platforms and advances in modeling of oceanographic processes.

The initial deployment of the Integrated Ocean Observing System (IOOS), the operational component, will focus on complete coastal and Great Lakes coverage for the exclusive economic zone (or EEZ, which extends 200 nautical miles from the coast) of the US and its territories, and complete coverage of the global ocean. IOOS will result in improvements in the following seven areas:

- predictions of climate change and its socio-economic consequences;
- the safety and efficiency of maritime operations;
- the mitigation of effects of natural hazards such as tropical storms;
- national and homeland security;
- reduction of public health risks;
- protection and restoration of healthy marine ecosystems; and
- ecosystem-based management of natural resources.

When coupled with the in-water research component and a space-based research component, sustained and continuous improvements in these seven areas are anticipated over the long-term. These improvements will, in-turn, lead to long-term advances in socio-economic prosperity.

For more information...
An overview of ORION's anticipated in-water physical assets and the anticipated science questions to be addressed using these in-water observatory facilities can be found in the Ocean Observatories Initiative (OOI) Science Plan (www.orionprogram.org/documents/default.html).

A detailed description of the initial plan for IOOS is provided in The First IOOS Development Plan, while the U.S. GOOS National Report provides a broader perspective (see www.ocean.us for both of these documents). Detailed information for the developing IOOS Regional Associations can be found on the National Federation of Regional Associations web site at http://usnfra.org.

CABLED OBSERVATORIES

Cabled observatories are one example of the observatory systems that are currently operating or will be put in place under the ORION and IOOS umbrellas. Cabled observatories are designed around a submarine fiber optic/power cable that connects a central node (or "hub") on the seafloor to shore-based power and communications. The cable allows the transfer of power to and enables communication between the shore-based station and the central node, and between the central node and instruments that make up the observatory.

The Long-term Ecosystem Observatory (LEO) was one of the first cabled observatories installed and operated in U.S. waters. Located off the central coast of New Jersey, LEO has delivered power to and provided communication with instruments deployed on the seafloor since 1996. For researchers, LEO has allowed their experiments to move beyond self-contained instruments that were limited by battery power and data storage capacity, enabling them to answer key questions about sediment transport processes occurring along the coast, for example. Today, LEO is the cornerstone of the Northeastern Observing System (NEOS), which is part of the expanding network of regional ocean observatories that are forming the basis of the national observatory network envisioned by ORION and IOOS.

The Monterey Accelerated Research System (MARS) will soon join LEO as a cabled observatory operating in U.S. waters. MARS is currently being installed in Monterey Bay, California, where it will become a key component of the Central California Ocean

Observing System, or CenCOOS. MARS will also serve as the test bed for future, large-scale cabled observatory systems, such as the proposed Northeast Pacific Time-series Undersea Networked Experiments (NEPTUNE), which will consist of a 3,000-km network of fiber-optic/power cables that will encircle and cross the Juan de Fuca tectonic plate in the northeast Pacific Ocean.

Like LEO, MARS will consist of a central node that will be deployed on the seafloor of the Monterey Canyon. More than 51 km of submarine fiber optic cable will connect the node to the Monterey Bay Aquarium Research Institute (MBARI), which will serve as "mission control" for the MARS observatory. The submarine cable will provide both power and communications to the central node and the capability to place and power instruments in areas of scientific interest in various geographical sites.

The MARS central node has two parts – a removable inner module that contains all of the wiring and electronics and an outer metal frame that protects the node from damage due to fishing nets. This trawl-resistant frame is about twelve feet wide, fifteen feet long, and four feet tall, and weighs 2,000 lbs. A cable laying ship will deploy the frame and lay the submarine cable that will connect the node to MBARI.

Once the submarine fiber optic cable is connected to an open port on the electronics module, the node will be capable of providing up to 8 "science ports" that can deliver power and facilitate communications to other instruments. Each port will have a 100-Mbit-persecond, bi-directional telemetry channel. The node will have the ability to deliver a total of 10 kW of power to the 8 ports.

Fiber optic "extension cables" can then be plugged into any science port to provide power and communications to instruments – Acoustic Doppler Current Profilers (ADCPs), Conductivity, Temperature, and Depth (CTD) instruments, for example – deployed up to 4 km away from the central node. The end result will be the capability for real-time, continuous, long-term monitoring – and a step towards making the vision of an integrated, sustained national ocean observation system a reality.

ROVs will play a critical role in the installation of the MARS infrastructure and the deployment, networking, and maintenance of the instruments that make up the observatory system. Beyond MARS, ROVs will play a critical role in the installation of future cabled observatories, such as NEPTUNE, especially as these observatories are installed in deep water.

Here's where your mission begins.

References

- Blanche Meeson, Education Liaison, Ocean.US
- Chave, Waterworth, Maffei, and Massion. *Cabled Ocean Observatory Systems*. Marine Technology Society Journal, Vol. 38, No. 2, pages 31-43, 2004.
- MARS web site – www.mbari.org/mars
- Rutgers University Coastal Ocean Observation Lab, LEO web site – http://marine.rutgers.edu/cool/LEO/LEO15.html

- Schofield, Kohut, and Glenn. *A Short History of the Long Term Ecosystem Observatory (LEO).* ORION Newsletter, June 2004, Vol. 1, No. 1

EXPLORER

EXPLORER class teams will get one attempt at the mission tasks. That score will be added to the engineering and communication score to determine the total, overall score for the competition.

The time allotted to complete the mission tasks (i.e., the mission performance period) is 30 minutes, plus 5 minutes to set up your system and 5 minutes to demobilize your equipment and exit the control shack. Your team will receive a time bonus for successfully completing the missions and returning your ROV to the surface and touching the side of the pool by the control shack before the mission performance period ends. You may complete the missions in any order, but the door on the central node's trawl-resistant frame must be opened before you can complete mission #2. Your ROV does not need to return to the surface between mission tasks.

MISSION TASKS

Task #1 – Complete the central node.

A cable-laying ship deployed the central node's trawl-resistant frame and installed the submarine fiber optic cable from the frame to the shore station.

To complete the central node, your ROV must transport the electronics module to the trawl-resistant frame, install the electronics module in the frame, open the frame door, and insert the submarine power/communications cable connector into one of the open ports on the module.

This will involve:

- **Transporting the electronics module from the surface to the frame.**
- **Placing the electronics module in the frame.**
- **Opening the door of the trawl-resistant frame adjacent to the submarine cable.**
- **Retrieving the submarine power/communications cable connector from the seafloor.**
- **Inserting the connector into the appropriately labeled open port on the electronics module.**

The electronics module will weigh no more than 1.5 kg when submerged. It will have up to 5 lift rings located on its top, flat, horizontal surface. Cable (or other items) will not be attached to the module.

There will be only one operational door (made of mesh) located on a vertical side of the frame. The door will be made of mesh with a solid frame. This door will be hinged so that it opens sideways (i.e., such as a kitchen cupboard door). Once the door is opened, your ROV should have access to the two open ports on the electronics module provided that you have inserted the electronics module correctly. The ports will be labeled. The power/communications connector must be inserted into the appropriately labeled port. The open port on the electronics module will be a round opening. The closed end of the port will have Velcro hooks.

The submarine power/communications cable connector will be located on the side of the frame near the operational door. It will sit on a platform so that it is 5cm above the seafloor. The connector will be 1-inch diameter PVC pipe, with one lift ring on its top, horizontal surface and a lift ring on one vertical end where the cable attaches to it. The other vertical end will have Velcro loops. Once the connector is inserted into the open port, these loops will secure it to the Velcro hooks at the closed end of the port.

Scoring – 110 points

- 20 points – transporting the electronics module from the surface control shack to the frame under the control of your ROV.
- 30 points – placing the electronics module in the hole located on the top, horizontal surface of the trawl-resistant frame so that it fits completely in the hole and remains there once your ROV has released it.
- 20 points – opening the door of the trawl-resistant frame to gain access to the open ports located on the electronics module.
- 20 points – retrieving the power/communications connector from its position on the seafloor.
- 20 points – inserting the power/communications connector into the correct open port on the electronics module so that it remains in the port and attached to the closed end of the port once your ROV has released it.*

*No partial points will be given for a partial insertion. If the power/communications connector is inserted but comes out of the port once your ROV has released it, no points will be awarded. You are permitted to retrieve the power/communications connector and try the insertion as many times as needed to achieve a successful connection. The door of the trawl-resistant frame does NOT need to be closed once the power/communications connector is inserted.

Task #2 – Lay instrument cable through assigned waypoints and connect it to the central node.

An instrument package containing a CTD (conductivity, temperature, depth) profiler, an ADCP (acoustic Doppler current profiler), and a pH meter that was deployed on a previous mission must now be connected to the central node to establish power and communication links.

Your ROV must lay a cable along a route that consists of 4 waypoints.

This will involve:

- **Retrieving the instrument cable connector with its attached cable from the seafloor.**
- **Laying the cable through 4 waypoints.**

- **Inserting the instrument cable connector into the appropriately labeled open port on the electronics module.**

The cable will be coiled in a box that is located on the seafloor near the instrument package. The box will be open on top; it will not have a lid. The cable will be simulated by 1/8-inch, diamond braid, polyester rope; a connector will be attached to the end of the rope.

The instrument connector will sit on a platform so that it is 5cm off the seafloor. The platform will be located near the box. The connector will be 1-inch diameter PVC pipe, with one lift ring on its top, horizontal surface and one lift ring on one vertical end where the cable attaches to it. The other vertical end will have Velcro loops. Once the instrument connector is inserted into the open port, these loops will secure it to the Velcro hooks at the closed end of the port.

The waypoints will be simulated by "Xs" secured, horizontally, on the seafloor. The 4 tips of each X will protrude (vertically) no more than 20cm from the seafloor.

Provided that your ROV has successfully opened the door on the trawl-resistant frame (see Mission 1), your ROV should have access to the two open ports on the electronics module provided that you have inserted the electronics module correctly. Once the door is opened, your ROV should have access to the two open ports on the electronics module. The ports will be labeled. The instrument connector must be inserted into the appropriately labeled port. The open port on the electronics module will be a round opening. Velcro hooks will be located on the closed end of the port.

Scoring – 60 points
- 20 points – retrieving the instrument connector from its position on the seafloor.
- up to 20 points (5 points for each waypoint) for laying the cable through 4 waypoints.*
- 20 points – inserting the instrument connector into the correct open port on the electronics module so that it remains in the port and attached to the closed end of the port once your ROV has released it.**

*You may lay the cable through the waypoints in any order, but you must lay the cable through all 4 waypoints in order to receive full points. You may skip a waypoint(s); however, you will not receive points for the skipped waypoints. For example, if your ROV lays the cable through 2 waypoints before connecting it to the central node, you will only be awarded 10 points. You may "undo" a waypoint(s). However, once you remove cable from a waypoint(s) you lose the points that you received for that waypoint(s). Points will only be returned if your ROV re-lays the cable through the waypoint(s).

Your ROV may release the instrument connector, retrace its path to lift the cable into a missed waypoint(s), retrieve the instrument connector, and continue on to insert it into the open port. Your ROV may also first insert the instrument connector into the port then move the cable into a missed waypoint(s). Full points will only be given if, when the mission performance period ends, the cable is laid through all 4 waypoints and the instrument connector is successfully inserted into the port.

**No partial points will be given for a partial insertion. If the instrument connector is inserted but comes out of the port once your ROV has released it, no points will be awarded. You are permitted to retrieve the instrument connector and try the insertion as many times as needed to achieve a successful connection. The door of the frame does NOT need to be closed once the instrument connector is inserted.

Time bonus
Your team will receive 1 point for every minute and 0.01 point for every second under 30 minutes remaining. Your mission performance period ends when your ROV has successfully completed the two mission tasks and has returned to the surface and has physically touched the side of the pool in front of the control shack under its own power. Time bonus points will be awarded accordingly.

RANGER
RANGER class teams will get two attempts at the mission tasks. The higher of the two scores will be added to the engineering and communication score to determine the total, overall score for the competition.

The time allotted to complete the mission tasks (i.e., the mission performance period) is 20 minutes, plus 5 minutes to set up your system and 5 minutes to demobilize your equipment and exit the control shack. Your team will receive a time bonus for successfully completing the missions and returning your ROV to the surface, side of the pool before the mission performance period ends. Mission tasks can be done in any order. Your ROV does not need to return to the surface between mission tasks.

MISSION TASKS
Task #1 – Complete the central node.
A cable-laying ship deployed the central node's trawl-resistant frame and installed the submarine fiber optic cable from the frame to the shore station.

To complete the central node, your ROV must transport the electronics module to the trawl-resistant frame, install the electronics module in the frame, open the frame door, and insert the submarine power/communications cable connector into one of the open ports on the module.

This will involve:
- **Transporting the electronics module from the surface to the trawl-resistant frame.**
- **Placing the electronics module in the frame.**
- **Opening the door of the trawl-resistant frame adjacent to the submarine cable.**

- **Retrieving the submarine power/communications cable connector from the seafloor.**
- **Inserting the power/communications connector into the appropriately labeled open port on the electronics module.**

The electronics module will weigh no more than 0.5 kg when submerged. It will have up to 5 lift rings located on its top, flat, horizontal surface. Cable (or other items) will not be attached to the module.

There will be only one operational door (made of mesh) located on a vertical side of the frame. The door will be made of mesh with a solid frame. This door will be hinged so that it opens sideways (i.e., such as a kitchen cupboard door). Once the door is opened, your ROV should have access to the two open ports on the electronics module provided that you have inserted the electronics module correctly. The ports will be labeled. The power/communications connector must be inserted into the appropriately labeled port. The open port on the electronics module will be a round opening. The closed end of the port will have Velcro hooks.

The submarine power/communications cable connector will be located on the side of the frame near the operational door. It will sit on a platform so that it is 5cm above the seafloor. The connector will be 1-inch diameter PVC pipe, with one lift ring on its top, horizontal surface and a lift ring on one vertical end where the cable attaches to it. The other vertical end will have Velcro loops. Once the connector is inserted into the open port, these loops will secure it to the Velcro hooks at the closed end of the port.

Scoring – 110 points

- 20 points – transporting the electronics module from the surface control shack to the frame under the control of your ROV.
- 30 points – placing the electronics module in the hole located on the top, horizontal surface of the trawl-resistant frame so that it fits completely in the hole and remains there once your ROV has released it.
- 20 points – opening the door of the trawl-resistant frame to gain access to the open ports located on the electronics module.
- 20 points – retrieving the power/communications connector from its position on the seafloor.
- 20 points – inserting the power/communications connector into the correct open port on the electronics module so that it remains in the port and attached to the closed end of the port once your ROV has released it.*

*No partial points will be given for a partial insertion. If the power/communications connector is inserted but comes out of the port once your ROV has released it, no points will be awarded. You are permitted to retrieve the power/communications connector and try the insertion as many times as needed to achieve a successful connection. The door of the trawl-resistant frame does NOT need to be closed once the power/communications connector is inserted.

Task #2 – Trigger a malfunctioned acoustic release transponder to release an instrument package.

The acoustic release transponder for an instrument package previously deployed on an outcropping near the central node has malfunctioned. The instrument package contains a number of instruments, including a CTD (conductivity, temperature, depth) profiler, an ADCP (acoustic Doppler current profiler), and a pH meter.

Your ROV must manually trigger the release to free the instrument package. Once released, the instrument package will float to the surface. A support vessel will recover the package and download its data. The instrument package will then be reconfigured so that it can be redeployed and connected to the central node. This will allow the package to receive power from the shore station and allow data to be communicated to the shore station in real time.

This will involve:

- **Locating and attaching to the acoustic transponder's release loop.**
- **Removing the release loop from the acoustic transponder to free the instrument.**

The instrument package/acoustic release transponder will sit on top of an outcropping that is approximately 1m tall and 15cm wide. The base of the instrument package will be secured to the top of the outcropping. The instrument package will be far enough above the release loop so as not to interfere with your ROV operations.

Scoring – 60 points

- 30 points – Locating the instrument package and attaching your ROV to or through the acoustic transponder's release loop.
- 30 points – Removing the release loop from the acoustic transponder so that it frees the instrument.*

* The instrument package does not need to break the surface in order to receive points. Points will be awarded when it is evident that the release loop is removed completely from housing base and the package is rising above the outcropping.

Time bonus

Your team will receive 1 point for every minute and 0.01 point for every second under 20 minutes remaining. Your mission performance period ends when your ROV has successfully completed the two mission tasks and has returned to the surface and has physically touched the side of the pool in front of the control shack under its own power. Time bonus points will be awarded accordingly. Time bonus points will be awarded accordingly.

OceanCareers.com

Find it. Learn it. Earn it.

The MATE Center's **OceanCareers.com** web site contains a wealth of information about ocean and ocean-related careers, including those that support ocean observing activities.

Check out www.oceancareers.com to learn more about these careers and the knowledge and skills required to enter them.

Diving Deeper

On-line resources for learning more about ocean observing systems

- **Ocean.US: National Office for Integrated and Sustained Ocean Observations –** www.ocean.us
  Ocean.US was created by the National Oceanographic Partnership Program to coordinate the development of an operational, integrated, and sustained ocean observing system ("IOOS") that will:
    - improve predictions of climate change and weather impacts on coasts;
    - improve the safety and efficiency of maritime operations;
    - improve mitigation of natural hazards;
    - improve national and homeland security;
    - reduce public health risks;
    - improve protection and restoration of coastal ecosystems; and
    - enable the sustained use of ocean and coastal resources.

  IOOS is currently made up of 11 regional associations whose geographic areas include the Great Lakes, Northeast Atlantic Coast, Mid-Atlantic Coast, Southeast and Florida Atlantic Coast, Gulf of Mexico (including the Florida Gulf Coast), Southern California, Central California, Pacific Northwest, Alaska, Pacific Islands, and the Caribbean. See www.Ocean.US for more information about these regional associations.

- **ORION –** www.orionprogram.org
  Ocean Research Interactive Observatory Networks (ORION) is a program that focuses the science, technology, education, and outreach of an emerging network of science-driven ocean observing systems. Oceanography is beginning a new phase in which research scientists increasingly seek continuous interaction with the ocean environment to adaptively observe the earth-ocean-atmosphere system. This approach is crucial to resolving the full range of ocean processes that directly impact human society, our climate, and the incredible range of natural phenomena found in the largest ecosystem of the planet.

- **MARS –** www.mbari.org/mars
  The Monterey Accelerated Research System (MARS) is a cable-based observatory system that represents the next step toward harnessing new power and communication technologies to provide a remote, continuous, long-term, high-power, large-bandwidth infrastructure for multidisciplinary, *in situ* exploration, observation, and experimentation in the deep sea. MARS will be located in Monterey Bay offshore the Monterey Bay Aquarium Research Institute (MBARI).

- **NEPTUNE –** www.neptune.washington.edu

The goal of the North-East Pacific Time-Series Undersea Networked Experiments (NEPTUNE) project is to establish a regional cabled observatory in the northeast Pacific Ocean. The project's centerpiece will be a 3,000-km network of fiber-optic/power cables that will encircle and cross the Juan de Fuca tectonic plate in the northeast Pacific Ocean, an area roughly 500 km by 1,000 km in size.

- **VENUS: A Coastal Ocean Observatory –** www.venus.uvic.ca
  Victoria Experimental Network Under the Sea (VENUS) is an ambitious project that involves installing a network of instruments on the ocean floor to observe the marine waters around southern Vancouver Island in both Saanich Inlet and the Strait of Georgia.

- **The BRIDGE –** www.marine-ed.org/bridge
  The BRIDGE is a growing collection of the best marine education resources available on-line. The following BRIDGE Data Tip Activities feature data, either real-time or archived, from observing systems:

    - Conductivity (September 2005)
      http://www.vims.edu/bridge/index_archive0905.html
    - Wave Energy (October 2005)
      http://www.vims.edu/bridge/index_archive1005.html
    - Cold One Day, Warm Another (November 2005)
      http://www.vims.edu/bridge/index_archive1105.html