2005 MATE Center/MTS ROV Committee ROV Competition for High School & College Students

www.marinetech.org/rov_competition/index.php

Competition Scenarios & Mission Tasks

EXPLORER Class
"Mission to Europa"

COMPETITION OVERVIEW

The 2005 ROV competition is divided into two competition classes: **RANGER** and **EXPLORER**. The **EXPLORER** class is suitable for those who are willing to design and construct an advanced, multi-functional ROV with a sophisticated control and payload system. **EXPLORER** vehicles have a higher power limit (48 volts and 40 amps surface power) and are usually more costly to build.

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

- Mission – 120 points (max), plus a time bonus
- Engineering & communication – 120 points (max)
    - Engineering evaluation – 80 points (max)
    - Technical reports – 25 points (max)
    - Poster displays – 15 points (max)

Information about **EXPLORER** class competition scenarios and mission tasks is included in ***this*** document; the ***Engineering & Communication*** document contains information about the interview, report, and display requirements. Task specifications, including information about mission "props," are included in the ***Mission Task Specifications*** document.

MISSION TO EUROPA

The **EXPLORER** class underwater competition sends teams on a simulated mission to Europa, one of the six known moons to orbit the planet Jupiter. Europa is believed to have an ocean of water beneath its icy surface.

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

The mission to Europa consists of 4 tasks. Each task is worth 30 points with the possibility of a time bonus score. The time allotted to complete these 4 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 1 point for every minute and 0.01 point for every second under 30 minutes remaining. Your ROV does not need to return to the surface between mission tasks.

Note: The following scenario story is a blend of fact and fiction. (Can you tell which is which?!) References include the web sites listed under ***Diving Deeper*** and a few of our own resident self-professed space "geeks."

Oceans in Space – Mission to Europa

In 1979, after traveling nearly a billion kilometers into outer space, Voyager spacecraft reached Jupiter and gave us our first close-up views of the planet and its moons Io, Ganymede, Callisto, and Europa. Voyager images revealed that Jupiter is surrounded by four rings, the innermost of which resembles a halo. Images of Europa showed pale-yellow icy plains with red and brown mottled regions and long cracks that ran for thousands of kilometers. Ever since planetary scientists first saw these icy plains and long cracks, they have been intrigued by what might lie beneath them.

In 1995, the spacecraft Galileo, equipped with improved imaging systems and a host of other instruments, began exploring the planet and its moons, focusing on Europa. Galileo revealed further details of Europa's fascinating features. The surface of Europa looks like broken glass that has been repaired by icy glue oozing up from below. Scientists were struck by the resemblance to images of sea ice here on Earth. They began to speculate that a liquid ocean of water – water as we know it – existed beneath Europa's solid surface of ice.

In 2000, an instrument probe gathered what scientists viewed as virtually undeniable evidence that Europa has a significant water ocean churning beneath its icy surface. The data, which was collected by Galileo's magnetic-field-detecting instruments when the spacecraft flew close to the icy moon, showed that there is an electrically charged layer of some substance stirring possibly as close as 7.5 kilometers below the moon's ice crust. Planetary scientists say the most likely explanation for this data is a liquid water ocean similar to oceans found on Earth. The space race to learn more was on.

In 2004, the NASA autonomous spacecraft Aurora made history when it landed on Europa and was able to drill a hole through the ice sheet, penetrating several kilometers before it reached liquid – the liquid water of Europa's ocean. Upon reaching the liquid, Aurora launched a smaller robot, Halo, from its payload bed. Halo was modeled after underwater robots – or ROVs – used by scientists to explore the oceans here on Earth. Like "ocean" ROVs, Halo was tethered to Aurora and received control signals through an umbilical leading to Aurora's onboard computers – the "brains" of the operation.

Armed with powerful thrusters, Halo began its descent through the water column. If scientists' calculations were correct, Halo had 30 minutes to reach the bottom and deploy a remote science package. This package was filled with sensors and instruments designed to measure physical and chemical parameters, such as current flow and dissolved oxygen and collect water samples that it stored in data probes for future analysis back on Earth. A fiber optic cable extending from the package to the surface would periodically transmit data to a topside "mother" unit for storage. In turn, the topside unit would periodically transmit data back to Earth, allowing scientists to monitor both the status of the unit and the remote science package below.

After powering its way through 10 kilometers, Halo reached bottom – a ghostly terrain, which was comprised of features that looked strikingly similar to the pillow lavas, calderas, ridges, and fault lines found in areas of volcanic activity on the Earth's seafloor. Finding a relatively flat area, Halo's payload bed opened and the science package emerged.

The science package deployed, Halo extended its retractable wheels and began to explore the bottom. Less than 10 meters from the science package, Halo stopped to investigate two features that were especially interesting. Images sent back to scientists in real-time allowed them to see a crevice filled with what appeared to be a red, highly viscous fluid. Less than one meter from the crevice, an opening into the ocean bottom was venting fluid – scientists could see the shimmering liquid as it exited the hole. Halo continued to transmit hundreds of images of these features before the danger of its hole to the surface refreezing forced it to move on.

Halo returned to the science package and inserted the cylindrical end of its fiber optic cable – known as the communications link – into one of two open "comms" ports located on the top of the package. It then made its way to the surface, paying out fiber optic cable as it ascended. Using its navigation sensors, the vehicle located the hole in the ice sheet, emerged topside, and connected the end of the fiber optic cable to the "mother" unit that Aurora, waiting on the surface, had installed on the ice sheet. Halo pushed the unit's power button and the unit immediately came to life, conducted a systems check, and began receiving test data from the remote science package.

Its mission completed, Halo maneuvered itself back into Aurora's payload bed. With its onboard propellant nearly depleted, Aurora powered up its thrusters. Freeing itself from Europa's gravitational field, Aurora launched into orbit. Following in the footsteps of its predecessor Galileo, the vehicle turned its trajectory and put itself on a collision course with Jupiter. This would eliminate any chances of an unwanted impact between the spacecraft and Europa or Jupiter's moon Io, which NASA hopes to explore in the near future. Mission accomplished.

Or so NASA thought. After regularly transmitting data from the remote science package to Earth for four straight days, signals from the topside unit suddenly stopped. The system indicated that it had power, but no communication with the science package below. Without this communication link, data collected by the science package was lost.

NASA is organizing a return mission Europa. Having already constructed Aurora II, the agency is looking for a second Halo – an ROV that can descend through a hole in the ice sheet, re-establish communications with the science package, and collect the data probes. Considering the costs involved with sending this pair of robots into outer space on a repair mission, the ROV must also be designed to accomplish two other tasks.

The vehicle must sample the red fluid from the crevice located near the science package. Comparing it to similar habitats here on Earth, NASA scientists believe that this fluid-filled crevice could contain bacteria that are metabolizing hydrogen sulfide and other chemical compounds that may also be found within the fluid. These chemosynthetic bacteria could prove to be similar to those found at hydrothermal vent sites on our own ocean floor.

The ROV is also tasked with measuring the temperature of the fluid venting from an opening near the crevice. An elevated temperature could confirm what scientists believe is one of the processes that is helping to keep the ocean from freezing solid – hydrothermal circulation taking place beneath Europa's ocean floor. This circulation is bringing up heat from a magma core, much like the way seawater seeps through cracks in our own seafloor, is heated by molten rock deep below the Earth's crust, and rises back through the seafloor to form vents of superheated fluid. Taking it one step further, Europa's venting fluid could be leaching sulfide and other chemical compounds from within Europa's crust and carrying it up to the seafloor where it fuels chemosynthetic bacteria – similar to the processes that drive hydrothermal vent environments here on Earth.

If this proves to be the case on Europa, and the red liquid does contain both bacteria and chemical compounds, Europa's ocean would prove to be more like our own than scientists ever imagined. More than that, it would mean that life exists on other planets besides Earth – a possibility that has extraterrestrial life-seekers reeling with excitement.

Like most of its space missions, practice "runs" are being conducted in the Sonny Carter Training Facility's Neutral Buoyancy Lab (NBL) at NASA's Johnson Space Center just outside of Houston. The underwater environment mimics the weightless conditions that both astronauts and robots experience in space.

The NBL has simulated the situation that the robot will face on Europa within its 6.2 million gallon, 40-foot deep pool. It has constructed a $60cm^2$ tunnel that simulates the hole in the ice the robot will have to descend through on Europa. A mock-up of the science package has been constructed and rests on the bottom of the pool. The science package mock-up has an open port for the communications link and a drawer that holds the data probes. A simulated crevice filled with red fluid is located on the bottom of the pool, the same distance from the science package as it is on Europa. A simulated vent is located near the crevice the same distance as it is on Europa's ocean. Like the previous mission, once Aurora II drills a hole in the ice sheet, the ROV will have 30 minutes to descend through this hole, reach the bottom, and complete the repair and science tasks.

Your mission is to:

1) **Re-establish the communications link to the science package.**
2) **Retrieve data probes located within a drawer on the science package.**
3) **Collect a sample of red fluid from the crevice.**
4) **Measure the temperature of the venting fluid.**

NASA scientists are losing valuable physical and chemical information every second the communications link is down. Samples contained within the data probes could yield clues about Europa's planetary processes. The red fluid and nearby vent could indicate the moon has hydrothermal vent environments similar to those found on the bottom of oceans here on Earth. Many scientists believe that life on Earth originated in these extreme environments. Could life as we know it also exist on Europa?! Only you can help NASA find out.

Task #1 – Re-establish the communications link to the science package.

- **Descend through the hole in the "ice" to transport the fiber optic cable and its attached communications link from the surface to the remote science package.**
- **Locate the open port on the science package.**
- **Insert the communications link into the open port on the science package.**

The open port will be located on the top, horizontal, flat surface of the simulated remote science package. The fiber optic cable and attached communications link will be long enough to reach the science package, and the link will be small enough to fit inside the port. The link will be a small cylinder and the cable will be attached to one end. A PVC ring will also be secured to this end. A strobe light flashing topside will indicate a successful connection.

Scoring – 30 points:

- 5 points – Descend through the hole in the "ice" with the cable and attached communications link
- 5 points – Locate the open communications link port on the science package
- 20 points – Successful link (a strobe light flashes topside)

Task #2 – Retrieve data probes located within a drawer on the science package.

- **Locate the data probe drawer on the science package.**
- **Open the drawer to expose the 3 probes located inside.**
- **Recover up to 3 data probes and return them to the surface.**

The drawer holding the data probes will be located on the side, vertical, flat surface of the simulated remote science package. The handle of the drawer will be located in the center of the drawer and oriented horizontally. It will protrude from the drawer. There will be 3 data probes inside the drawer. The probes will be sitting upright (vertically) in holes similar to those of a test tube rack. The probes will have small plastic rings secured to their tops. Each data probe is worth 5 points.

Scoring – 30 points:

- 5 points – Locate the data probe drawer on the science package
- 10 points – Open the drawer
- 5 points – Recover 1 data probe and return it to the surface (3 probes total)

Task #3 – Collect a sample of red fluid from the crevice.

- **Locate the crevice filled with red fluid.**
- **Collect a sample of this fluid (up to 500ml) and return it the surface.**

The crevice will be simulated by a plastic barrel with a pipe protruding from its top, horizontal, flat surface. The pipe leads to a flexible bladder within the barrel. At least one liter of red fluid – a dense saline solution – will be contained within this bladder.

Scoring – 30 points:

- 5 points – Locate the "crevice" filled with red fluid
- Up to 25 points for collecting a sample and returning it to surface
  - 401 – 500 ml 25 points
  - 301 – 400 ml 20 points
  - 201 – 300 ml 15 points
  - 101 – 200 ml 10 points
  - 0 –100 ml 5 points

5 points will be deducted for returning a diluted sample (i.e., a sample that is lighter in color when compared to the standard).

Task #4 – Measure the temperature of the venting fluid.

- **Locate the vent.**
- **Measure the temperature of the venting fluid and display the reading on a video monitor or as a digital readout on a control panel.**

The vent will be simulated by low velocity, upward-moving currents. The vent opening will be large enough to accommodate enough volume of moving fluid to allow a temperature sensor to be placed within the flow to obtain a reading.

Scoring – 30 points:

- 5 points – Locate the vent
- Up to 25 points for accuracy of the temperature reading
  - Temperature reading with 0.5^{o}C of benchmark – 25 points
  - Temperature reading with 1.0^{o}C of benchmark – 20 points
  - Temperature reading with 1.5^{o}C of benchmark – 15 points
  - Temperature reading with 2.0^{o}C of benchmark – 10 points
  - Temperature reading with 2.5^{o}C of benchmark – 5 points
  - Temperature Reading more than 2.5^{o}C off benchmark – 0 points

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 1) your ROV has completed all 4 of the mission tasks; 2) your liquid sample has been returned to competition officials; 3) all 3 data probes have been delivered to competition officials; and 4) your ROV has returned to the surface through the hole in the ice. Time bonus points will be awarded accordingly.

Your ROV does not need to return to the surface between tasks. However, make sure to leave enough time for competition officials to score your sample of red fluid. A sample returned after the 30 minute performance period is over will not be scored. Your ROV does not have to stay on deck at the control shack while the officials score your sample. You can return the sample, remove it from your ROV, then resume the mission while the sample is being scored.

Also make sure to show officials your temperature measurement of the venting fluid either on your ROV's video monitor or as a digital readout on your control panel within the 30 minute performance period. A temperature reading shown to officials after the 30 minute performance period is over will not be scored.

Diving Deeper:

On-line resources for learning more about Europa and other extreme environments

- Europa – www.nineplanets.org/europa.html
  Discovered by Galileo in 1610, Europa is the sixth of Jupiter's known satellites and the fourth largest. Learn more and view images on this "The Nine Planets" web site that includes the history, mythology, and current scientific knowledge of the planets and moons in our solar system.
- Galilean Moons: Europa – Another Water World?! – www2.jpl.nasa.gov/galileo/moons/europa.html
  More Europa facts and figures, including evidence for an ocean of water beneath this moon's icy surface.
- Voyager: the Interstellar Mission – http://voyager.jpl.nasa.gov
  For more than 27 years, Voyager spacecrafts have explored our solar system. Today they continue their ground-breaking journey with their current mission to study the region in space where the Sun's influence ends and the dark recesses of interstellar space begin.
- Galileo: Journey to Jupiter – www2.jpl.nasa.gov/galileo/
  The Galileo spacecraft has been exploring Jupiter and its moons since December 1995. Follow its journey from inception to destruction – and its exciting discoveries in between.
- Space.com – www.space.com/scienceastronomy/solarsystem/europa_ocean_000824.html
  Galileo shows signs of an ocean on Europa – what scientists call "virtually undeniable evidence that Jupiter's moon Europa has a significant water ocean churning beneath its icy surface."

- From the Gulf of Mexico to the Moons of Jupiter – http://oceanexplorer.noaa.gov/explorations/02mexico/background/edu/media/gom_moons.pdf
  Lesson plans from NOAA's Office of Ocean Exploration's "Gulf of Mexico" expedition that compare extreme environments here on earth to conditions believed to exist on Jupiter's moons. The activities also address the relevance of chemosynthetic processes in cold seep communities to the possibility of life on other planetary bodies.

Competition sponsors that support space science and exploration and expeditions to extreme environments here on Earth

- NASA – www.nasa.gov
- Sonny Carter Training Facility's Neutral Buoyancy Lab – www.jsc.nasa.gov/dx/dx12
- Oceaneering International, Oceaneering Space Systems – www.oceaneering.com/adtech/space/adtech_space.htm
- NOAA's Office of Ocean Exploration – http://oceanexplorer.noaa.gov/welcome.html

OceanCareers.com – Find it. Learn it. Earn it.

Did you know that engineers, electricians, mechanics, and technicians who work in ocean fields can apply their knowledge and skills to working in space? See The MATE Center's OceanCareers.com web site for information about these careers and the knowledge and skills they require that can be used from the depths of the oceans to the moons of Jupiter and the far reaches of outer space.