MATE Underwater Robotics:

Providing Pathways to the STEM Workforce

Marine Advanced Technology Education
(**MATE**) Center
Monterey Peninsula College

MATE

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The **Marine Advanced Technology Education (MATE) Center** uses underwater robots (remotely operated vehicles or **ROVs**) as a way to get middle school, high school and college students excited about science, technology, engineering, and math (STEM). From ROV designing and building workshops to competitions that focus on real-world ROV missions, these activities expose students to STEM careers and help them envision pathways to these careers.

ROVs are also a great way to introduce engineering design, entrepreneurship, and project management to middle and high school students, as described in the ***Next Generation of Science Standards***. Designing and building an ROV for a specific mission takes students through the design process, encouraging them to think creatively and research, test, and evaluate solutions. It also challenges them to organize their time and resources, all the while working towards a deadline, just as if they were in the workplace.

There are few opportunities for students as real-world as the MATE ROV competition. For the past 12 years, the MATE Center and the Marine Technology Society (MTS) have worked together to create and carry out ROV competitions across the country and around the world. MATE's competitions use ROVs as a platform to instruct students in STEM and demonstrate how these disciplines are applied in the real world. The competitions challenge students to think of themselves as entrepreneurs and transform their teams into companies that manufacture, market, and sell "products and services." From developing ROVs to cap oil wells and survey WWII shipwrecks for environmental hazards, MATE's competitions require students to solve problems in new and innovative ways, work as part of a team, and develop an understanding of the breadth of business operations – all important 21st century workforce skills.

In addition to constructing an ROV, each year the students are required to submit technical documentation and deliver engineering presentations to STEM professionals who serve as judges, solidifying the connection to real-world industry practices as well as showcasing examples of potential careers. Students are also required to create a poster display that communicates to the layperson information about their vehicle design, their company (team), the problem they were tasked to solve, and how this problem relates to real-world events.

The program currently consists of one international and 23 regional competitions held annually. To date, the competitions and their supporting professional development workshops have impacted more than 15,000 students and 2,000 teachers at more than 2,000 formal and informal educational institutions (middle schools, high schools, home schools, community colleges, universities, 4-H clubs, and public aquaria, among others).

Visit http://vimeo.com/73115789 for a video overview of a MATE international competition and see page 4 of this document for the 2014 competition mission brief.

Knowledge and skills acquired while building a SCOUT ROV & participating in a MATE competition

Meets the Next Generation of Science Standards for Middle School Engineering Design

The MATE competition consists of four levels or classes: SCOUT > NAVIGATOR > RANGER > EXPLORER. The following learning objectives focus on knowledge and skills acquired at the first (or beginner-level), the SCOUT Class. Please visit http://www.marinetech.org/rov-competition-2/ for more information about MATE's ROV competition.

Engineering Design/Project Management

A student finishing the SCOUT class will be able to:

1. Form a mock company; function as entrepreneurs and develop products and services to solve real-world problems (see MATE ROV competition manual for example).
2. Describe and implement the engineering design process (spiral).
3. Identify specific strategies to address common design and building challenges (keeping on schedule, on budget, team dynamics, safety, etc.)
4. Define project criteria (e.g. competition mission) and constraints (time, money, expertise, vehicle depth and size, etc.) to ensure a successful solution.
5. Evaluate competing design solutions using a systematic process such as a tradeoff matrix.
6. Build a functioning, shallow diving ROV using hardware-store technology.

Technology and Society

A student finishing the SCOUT class will be able to:

1. Describe what a robot is and how robots are used to support work that has been traditionally performed by people.
2. Explain the common types and uses of modern underwater vehicles.
3. Conduct an underwater mission and relate this mission to what ROVs are doing in science and industry (see MATE Center ROV competition for examples).
4. Summarize the type of occupations that support the marine robotics industry.

Electrical Knowledge:

A student finishing the SCOUT class will be able to:

1. Define current, voltage, and resistance and explain their relationship to Ohm's Law.
2. Draw a complete circuit.
3. Summarize the operation of a switch.
4. Safely operate basic electrical tools (soldering iron, desoldering pump, multimeter).
5. Discuss how a battery works and how long you might expect your vehicle to run on a given battery.
6. Recognize the importance of good electrical connections.
7. Describe how an electric motor works.
8. Identify a method for changing the direction of rotation of a DC motor.
9. Describe the purpose of a fuse.
10. Assess basic electrical safety practices.

Mechanical Knowledge:

A student finishing the SCOUT class will be able to:

1. Demonstrate the ability to make accurate measurements by using plumbing pipe and fittings to build a simple ROV frame.
2. Safely operate basic hand-held tools (screwdrivers, wire cutters, PVC cutters, pliers, wire strippers, hot glue gun, heat gun).
3. Apply proper methods when attaching cables to the frame and preventing injuries from propellers.

Ocean Engineering/Physical Science Knowledge:

A student finishing the SCOUT class will be able to:

1. Apply Newton' Laws of Motion and Law of Gravity to building and operating ROVs.
2. Describe ways that the physical properties of water differ from those of air. Explain how each of those differences presents challenges and/or opportunities for those designing and operating underwater vehicles.
3. Explain why objects in water sink, float, or tip over and how buoyancy and ballast systems can be used to control these processes.
4. Determine the difference between positive, negative, and neutral buoyancy and explain why the designers of most underwater vehicles strive for near-neutral buoyancy.
5. Build a simple device to collect organisms or other samples.

Common Core Standards

Math is involved in many aspects of designing, building, and controlling an ROV. Ohm's law, for instance, is central to designing the electrical systems for ROVs, even at the most basic level. Measuring and cutting, calculating buoyancy requirements, all involve applied mathematics.

Language and Arts

Through the competition, the students gain a variety of additional knowledge and skill sets that are critical to making them employable. For example, students demonstrate 21st century skills such as communication, teamwork, leadership, entrepreneurship, creativity, critical thinking, problem-solving, motivation, and time and resource management. These skills are assessed by teachers, surveys, and competition judges. In addition, technical writing and oral communication are practiced and assessed during the competition via reports, posters, and presentations.

The **Marine Advanced Technology Education (MATE) Center** is a national network of educational institutions, professional societies, marine industries and working professionals. The MATE Center's mission is to create an interest in and improve science and technology education and to provide the marine workforce with well-educated technical professionals. A hallmark of all MATE's programs, products and services is that they are aligned with ocean workforce research and trends. The MATE Center was established with funding from the **National Science Foundation** in 1997.

2014 MATE ROV COMPETITION:
MISSION TASK AND SPECS BRIEFING FOR THE SCOUT CLASS

MATE Competition Philosophy

The MATE ROV competition is about **student learning**.

It is designed to be an event that challenges **students** to apply the physics, math, electronics, science, and engineering skills they are learning in the classroom to solving problems from the marine workplace.

Mentors (teachers, parents, working professionals) are expected to limit their input to educational and inspirational roles and encouraged to focus on the benefits of the **learning process** and not simply on "winning" the competition.

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

Located in northwestern Lake Huron, Thunder Bay is adjacent to one of the most treacherous stretches of water within the Great Lakes system. Unpredictable weather, murky fog banks, sudden gales, and rocky shoals earned the area the name "Shipwreck Alley." To date, more than 50 shipwrecks have been discovered within the Thunder Bay National Marine Sanctuary (TBNMS). From 19th century schooners and steamers to a modern ocean-going freighter, the shipwrecks of Thunder Bay represent a microcosm of maritime commerce and travel on the Great Lakes.

Ice, waves, and aquatic invasive species such as zebra mussels – as well as trash and debris generated by *Homo sapiens* – could potentially harm maritime heritage resources. The TBNMS is working with scientists and conservation groups to better understand how the chemical, biological, and physical conditions found around Thunder Bay's shipwrecks are affecting the corrosion and deterioration of these irreplaceable archaeological sites.

In addition to shipwrecks, TBNMS is home to some unique geologic features. Sinkholes resulting from the erosion of limestone sediments have been studied since 2001. Groundwater emerging from the sinkholes is depleted of oxygen, enriched in inorganic carbon, is 10 times more conductive, and contains 100 times more sulfate than the surrounding late water. Microbes thrive in several sinkhole environments. The sulfur provides fuel for chemosynthetic bacteria, which form patches of white mats with wavy filaments, while the inorganic carbon dioxide fuels photosynthetic cyanobacteria, which form extensive purple mats with finger-like projections.

The TBNMS staff and the scientists and conservationists who work within the sanctuary boundaries are in need of remotely operated vehicles that can 1) explore, document, and identify an unknown shipwreck recently discovered in sanctuary waters; 2) collect microbial samples and measure the conductivity of the groundwater emerging from a sinkhole; and 3) remove trash and debris from the shipwreck and surrounding area.

Summary of mission tasks for the SCOUT Class	Summary of the electrical and fluid power design and building specifications for the SCOUT class
SHIPWRECKS • Open a container and retrieve a cargo sample • Retrieve a ceramic dinner platter to determine the home port of the ship • Identify the ship using known parameters SCIENCE • Recover a sensor and deploy a new one CONSERVATION • Remove bottles	• 12 volts, 15 amps DC. Conversion to lower voltages is permitted topside and on the ROV. Onboard electrical power is not permitted. • Manually-powered hydraulics and pneumatics are permitted. Pneumatic systems cannot exceed ambient pool pressure and must follow the fluid power specifications included within the competition manual. • Lasers are NOT permitted.

Please see http://www.marinetech.org/rov-competition/ for the complete competition manual for each competition classes.