

---

## **AC 2011-1761: MATE ROV COMPETITIONS: PROVIDING PATHWAYS TO THE OCEAN STEM WORKFORCE**

### **Jill M. Zande, Marine Advanced Technology Education (MATE) Center**

Jill Zande Associate Director & ROV Competition Coordinator Marine Advanced Technology Education (MATE) Center

VP Education and Research Marine Technology Society (MTS)

Biography Jill Zande is the Associate Director and ROV Competition Coordinator for the Marine Advanced Technology Education (MATE) Center and the current VP of Education and Research for MTS. At the MATE Center, Jill's role is to work closely with industry to ensure that educational programs are aligned with workforce needs and to facilitate partnerships among educators, students, employers, and working professionals. Jill maintains relationships with well over 100 businesses, research institutions, government agencies, and professional societies and with the 400+ middle schools, high schools, colleges, and universities that participate in MATE ROV competitions each year.

Jill received her undergraduate degree in biology/minor in marine science from Penn State University and her Master's degree in Oceanography and Coastal Sciences from Louisiana State University. Jill has been with MATE since 1998 and through her position has actively promoted the inclusion of ocean science and technology in formal and informal educational arenas.

# **MATE ROV Competitions: Providing Pathways to the Ocean STEM Workforce**

## **Introduction**

The Marine Advanced Technology Education (MATE) Center organizes international and regional underwater robotics (remotely operated vehicle or ROV) competitions for students in grades 5-16 from around the world. The competitions use ROVs as a platform to excite, engage, and instruct students in science, technology, engineering, and math (STEM) and demonstrate how these disciplines are applied in the real world. The competitions include mission tasks that are based on practical problems from the ocean STEM workplace as well as technical reports, poster displays, and engineering presentations that are evaluated by working professionals from STEM fields. Through the process of preparing for the events, the students gain technical as well as troubleshooting, teamwork, project management, and communication skills. The program is a comprehensive “package” of learning that has the added benefit of exposing students to ocean-related career opportunities and showing them the pathways to those careers – a critical step to meeting ocean STEM workforce needs.

## **Background**

A number of prior reports have identified significant problems in educating, recruiting, and retaining U.S. workers for scientific, technological, and operational careers.<sup>1, 2, 3, 4, 5, 6, 7, 8</sup> The lack of appropriately educated workers is especially pronounced in rapidly evolving ocean fields, such as deep water ocean exploration (especially oil and gas); the engineering of specialized tools and instruments for remote, harsh environments; and the management and use of ocean resources (particularly, renewable resources).<sup>1,8</sup> The graying trend in the marine workforce adds to the urgency of educating new technical professionals who will adapt and excel in the continuously evolving ocean workplace.<sup>9</sup>

Workforce studies conducted by the MATE Center have identified more than twenty STEM-based ocean occupations that are currently limiting the growth of ocean industries because of the lack of qualified personal. At the top of the list are the following occupations: electronics/marine technicians (including ROV technicians); engineers (electrical, mechanical, civil/structural); and computer scientists (software application developers, computer programmers, hardware developers). However, these are not “just” engineers, technicians, and computer scientists; these are professionals that understand ocean applications within their field.

It was this information that encouraged the MATE Center and the MTS ROV Committee to develop a program that combined STEM education with ocean applications in order to 1) increase awareness of ocean STEM fields; 2) highlight ocean-related activities and career opportunities; 3) promote the development of technical, problem-solving, critical thinking, communication, and teamwork skills; 4) provide students and faculty with technical support; and 5) connect students with working professionals and potential employers (and vice versa). It was

with these goals in mind that the MATE Center and the MTS ROV Committee created the international ROV competition program.

## **History and evolution**

The competition program currently consists of one international and a network of 20 regional competitions that are held annually. Since the first pilot regional event in 2001, the MATE Center and its regional partners have carried out nine international and 98 regional events. The regional contests take place across the U.S. and in Canada, Hong Kong, Scotland, and Japan, with more planned both domestically and internationally in the future to accommodate the continued and growing interest.

To date, the competitions have impacted more than 9,000 students at formal and informal educational institutions (middle schools, high schools, home schools, community colleges, universities, 4-H clubs, and public aquaria, among others).<sup>10</sup> Figure 1 illustrates the growth in the number of schools participating in the MATE competitions from 2001 (the year of the pilot regional) through 2010 (the most recently completed competition “season”).

The extensive involvement of ocean and other technology-related organizations and individuals has been key to achieving the competition’s goals and promoting its growth and success. The competitions have garnered the financial and technical support of over 100 companies and organizations and more than 1,000 working professionals. Nearly \$1 million in funds and close to \$2 million in in-kind contributions of building materials, equipment, use of facilities, and technical expertise have been donated to support the international competition alone.<sup>10</sup> Working professionals have shared their time and technical expertise by mentoring student teams, serving as judges, and helping to develop the competition scenarios.

## **Competition theme**

Each year the competition focuses on a different theme in order to expose students and faculty to the many aspects of the ocean workplace and the scientific and technological advancements that are taking place. In addition to keeping the mission tasks new, exciting, and relevant, this allows the competition to introduce new technologies and career opportunities and potentially bring on new industry support.

The venue for the international competition also changes each year. Moving the venue provides students and faculty with the opportunity to experience different parts of the world and gain access to premier university, government, and industry facilities. For middle and high school students in particular, visiting universities and other post-secondary institutions allows them to experience life on a college campus and explore institutions where they can continue their STEM education. For these institutions, the competition can be a powerful recruiting tool.

## **Competition structure and requirements**

The competition consists of three levels or “classes” of vehicle and mission complexity: SCOUT (entry-level), RANGER (intermediate), and EXPLORER (advanced). This progressive class

structure complements the education pipeline by providing students with the opportunity to build upon their skills – and the application of those skills – as they engineer increasingly more complex ROVs for increasingly more complex mission tasks. Bringing together a range of grade levels at the competition events results in powerful interactions where the younger students build upon their knowledge and skills as they gain ideas for “next year,” while the older students solidify their knowledge and skills as they mentor the younger competitors. In this way, the competition again helps to expose middle and high school students to the schools and programs where they can continue with their ROV projects and, more importantly, STEM education.

The competition events consist of underwater missions and an engineering and communication component. The underwater mission tasks are modeled after real-world situations and how ROVs are used to resolve them. For example, the 2010 missions centered on an undersea volcano and how scientists, engineers, and technicians develop and deploy instruments, collect geological and biological samples, and use sensor technologies to understand the processes that created it. The 2011 missions are focused on the Deepwater Horizon oil spill and challenge the students to view themselves as entrepreneurs who are part of a company challenged with designing then installing a specialized cap to contain the spill, among other tasks. “Mission control officials,” volunteers from STEM professions, witness and score the teams as they proceed through the tasks.

The missions take place in a swimming pool, diving well, flume tank, wave tank, or other “contained” body of water. The mission props (or “game pieces”) are simulated using inexpensive and easily accessible materials (e.g. PVC and other supplies available at local hardware stores) so that the student teams can afford to build their own for practice.

The engineering and communication component consists of a technical report, poster display, and engineering presentation that require students to present information about their team and vehicle. The poster displays are distinct in that the students are encouraged to prepare these with the “general public” in mind. In this way, the posters help to inform and educate any visitors (or potential teams, mentors, or sponsors) to the event venue. The report, poster, and presentation are delivered to working professionals who review, evaluate, and score them. Examples of technical reports from previous competitions can be found at [www.materover.org/main/index.php?option=com\\_content&view=article&id=111&Itemid=170](http://www.materover.org/main/index.php?option=com_content&view=article&id=111&Itemid=170), while examples of the ROVs (and the students who created them) are presented in Figure 2.

### **Impact on student learning**

The Standards for Technological Literacy developed by the International Technology Education Association (ITEA) call for students to experience technology in settings where they develop practical design and problem-solving skills in the context of real-world examples.<sup>11</sup> MATE’s competitions answer this call by providing a venue for students to experience the very real applications of STEM. The events motivate students to seek out new knowledge and skills in order to create a functional ROV to accomplish a specified mission. The competitions give students the chance to put their education to the test while having fun, making new friends, and learning from each other and industry professionals.<sup>12</sup>

The competitions' impact is evident in the responses to surveys distributed post-event to both students and faculty. For example, 97% of the 239 faculty who responded to the 2008 – 2010 post-international competition surveys stated that the competition motivated their students to learn team building, problem solving, and/or critical thinking skills. They also agreed that the competition provided a valuable venue to prepare students for careers in marine science and technology.

Of the 996 students who responded to 2008 – 2010 post-international competition surveys, nearly all of them (97%) stated that they that they were more aware of careers in marine science and technology. Testimonials included in the technical reports (and in [www.youtube.com/watch?v=TeFctnv5vVI](http://www.youtube.com/watch?v=TeFctnv5vVI)) further demonstrate the positive effect:

*Some of the team members were unsure of what career they wanted to pursue. [...] These members have been inspired to pursue careers in engineering. The hands-on experience of designing and building the frame and the tools and programming a microcontroller has allowed us to learn various aspects of engineering. Some important lifelong skills we learned were teamwork and communication. [...] We did not know each other well so it was difficult to support each other and communicate efficiently. As the project progressed and we were working together toward a common goal we learned to communicate better and became friends.*

- High school teammates

*Working on [the ROV] was an incredible learning experience not only in the relevant disciplines of science, but also in effective teamwork. I learned that it's not enough to simply be a team player. Long-term projects of this complexity require more than willingness, but the ability to effectively communicate, and contribute to both team motivation and organization.*

- Community college student

*I learned about all sorts of things: soldering, wire gauges, schematics, and transistors. When my Electrical Design professor asked the class who had seen the inside of a computer, the majority of people were on the ROV team, and I was among them. The experience I have gained has given me confidence in my field, and in my decision to become an Electrical Engineer.*

- University student

### **Career connection**

Through the Ocean Career Expo and the participation of industry professionals as mentors and judges, students are exposed to both the individuals who do the jobs and the employers that hire them. The Ocean Career Expo was instituted in 2006 by the MATE Center and its Center for Ocean Sciences Education Excellence partners. Held each year in conjunction with the international competition, the Expo's goal is to provide employers with access to prospective employees and allow students to gain first-hand knowledge of and advice on careers and how to prepare for the field. Since 2006, one company alone has hired more than 20 students as a result. Recognizing the time and cost saved by access to a pool of talented, potential employees at a single venue, companies have made the competition and its Ocean Career Expo a part of their annual recruiting plans and budget.<sup>13, 14</sup>

## **Programs that support faculty and student participation**

The 2010-2011 competition season marks the 10<sup>th</sup> anniversary of the international event as well as the release of *Introduction to Underwater Robotics: Science, Design & Fabrication*, a 780+ page comprehensive textbook and guide to designing and building underwater vehicles. This textbook is written for advanced high school and college and university entry-level courses. Each chapter begins with a real-life scenario that sets the stage for the ocean STEM concepts that follow. The text includes step-by-step instructions for a basic ROV, as well as information on expanding its design to “go deeper.” (Excerpts from the textbook are posted at [www.marinetech.org/underwater\\_robotics](http://www.marinetech.org/underwater_robotics).) In addition to this *Underwater Robotics*, MATE has developed curriculum modules and instructional materials focused on underwater robotics for the secondary (middle and high school) level.

The textbook and instructional materials, combined with professional development workshops, provide faculty with the tools and training they need to implement ocean STEM projects in the classroom. MATE’s annual week-long Summer Institutes immerse faculty in intensive marine technology instruction and experiences. The institutes are taught by technical professionals and consist of lectures, hands-on activities, and field trips. The institutes emphasize ocean-related careers; disseminate workforce information to help align curricula, courses, and programs with workforce needs; and provide a forum to interact and share ideas. Since 1999, the MATE Center has provided 21 professional development institutes to more than 400 faculty members from community colleges, universities, high schools, middle schools, and informal education centers across the U.S.<sup>15</sup>

In addition, MATE’s regional partners coordinate one-to-three day professional development workshops that focus on STEM subjects as applied to ROV design and building. From 2003 – 2010, MATE partners offered more than 110 workshops at their institutions and organizations, impacting over 2,400 faculty, students, and community members.<sup>15</sup>

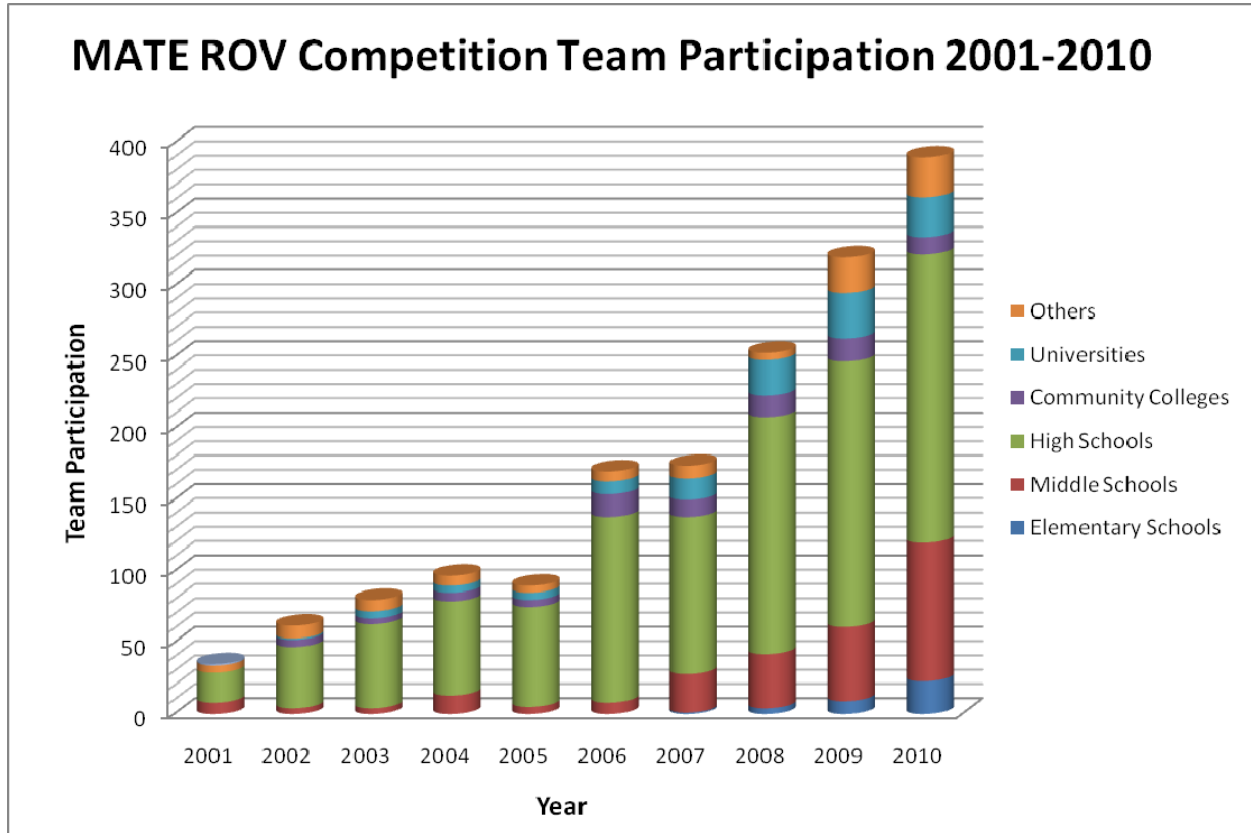
## **Conclusion**

The MATE ROV competition program’s overarching goal is to prepare students for the ocean STEM workplace and, in this way, to help meet ocean workforce needs. It was designed to expose students to ocean STEM careers, help them to develop the skills necessary to enter those careers, connect them with working professionals to mentor and inspire them, and introduce them to employers who may hire them. It was structured to parallel the educational pathway, with students progressing from one level to the next as they build upon existing and gain new skills and are motivated to tackle increasingly complex technical challenges. With support from the ocean STEM community and its regional partners, the MATE Center will continue to grow the competition program and provide students from around the world with opportunities to enter and continue along a career pathway that leads them to ocean STEM careers.

## Bibliography

1. Sullivan, D., T. Murphree, B. Ford, J. Zande. 2006. OceanCareers.com: Navigating your way to a better future. *Marine Technology Society Journal*. V. 39, n.4, p.99-104
2. Butz, W., T. Kelly, D. Adamson, G. Bloom, D. Fossum, and M. Gross, 2004. Will the Scientific and technical Workforce Meet the Requirements of the Federal Government? Rand Corporation report to the Office of Science and Technology Policy, 126 pp.
3. Streeter, J. State of the Society Address. IEEE/MTS Oceans Conference, Washington, DC. 19-23 September 2005.
4. National Commission on Mathematics and Science Teaching for the 21st Century, 2000. Before It's Too Late: A Report to the Nation, 500 pp.
5. Board on Chemical Sciences and Technology, 2004. Preparing Chemists and Chemical Engineers for a Globally Oriented Workforce: A Workshop Report to the Chemical Sciences Roundtable. National Academies Press, 78 pp.
6. Ocean.US, 2004. Promoting Lifelong Ocean Education, National Office for Integrated and Sustained Ocean Observations, Ocean.US Publication No. 4, 47 pp.
7. Manufacturing Institute, 2005. 2005 Skills Gap Report – A Survey of the American Manufacturing Workforce. Report from Manufacturing Institute Center for Workforce Success. 28 pp.  
<[http://www.nam.org/s\\_nam/bin.asp?CID=202426&DID=235731&DOC=FILE.PDF](http://www.nam.org/s_nam/bin.asp?CID=202426&DID=235731&DOC=FILE.PDF)>
8. Michel, D. 2008. Workforce shortages in the offshore industry. Presented at the Ocean Science, Technology and Operation Workforce Workshop. Monterey, California. November 10, 2008
9. Piktialis and Morgan. The Aging of the U.S. Workforce and Its Implications for Employers Compensation Benefits Review. 2003; 35: 57-63.
10. National Science Foundation Advanced Technological Education Center funding renewal request. Application Proposal # 1104310, NSF Program 07-530. Submitted 10/21/2010. DUE Division. DUNS # 019985063. Sullivan, Deidre and Zande, Jill.
11. Standards for Technological Literacy: Content for the Study of Technology. (2002). International Technology Education Association.
12. Sullivan, D., Zande, J., Butcher, S., Murphree, T., Ford, B. (2003). Using Marine Technology to Develop Ocean Literacy and Teach Workplace Competencies. *Current: The Journal of Marine Education*. Vol. 19, No. 3.
13. Summary Evaluation of MATE: The Marine Advanced Technology Education Resource Center For the Period May 1, 2004 – April 30, 2007, May 2007. 39 pp. Daniel Weiler Associates.
14. Evaluation of MATE: The Marine Advanced Technology Education Resource Center For the Period May 1, 2007 – April 30, 2008. June 2008. 38pp. Daniel Weiler Associates.
15. MATE Center Annual Report to the National Science Foundation, January 1, 2009 to December 31, 2009. Submitted March 2010. 20 pp. MATE Center.

**Figure 1: ROV competition participation 2001 – 2010**



**Figure 2: Examples of student teams and their ROVs**





