
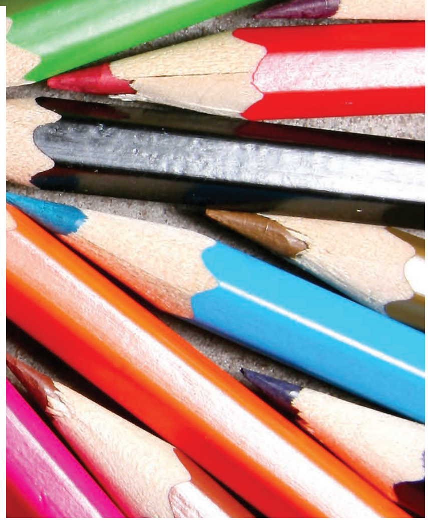

A High School Team's Hard Road to Success in an International Engineering Competition

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A team of New Jersey high school sophomores took part in a well-known international underwater-vehicle competition this year. The team members discuss their arduous journey as they designed and built a vehicle that then had to undertake several challenging tasks.

Behind every success is a journey, and that journey isn't necessarily a straight path. Instead, it can be filled with bumps, twists, and turns. Things might not go smoothly, but that's good because it helps you learn and improve. The journey isn't easy, but it pays off in the long run.

This sums up the experience of our MTL HydroTech team from Mt. Laurel, New Jersey, which competed in the 2017 Marine Advanced Technology Education (MATE) Center's international ROV (remotely operated underwater vehicle) competition.

PORT CITIES OF THE FUTURE

The MATE Center (www.marinetech.org) uses ROV-related activities to support STEM (science, technology, engineering, and math) education. Annually for 16 years, MATE has hosted a competition in which elementary through college students worldwide—divided into four classes based on project complexity and difficulty—design and build ROVs to tackle missions modeled on real-world tasks.

The 2017 competition's theme was "Port Cities of the Future." The final, international phase of the competition occurred 23–25 June at Long Beach (California) City

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College. The fictional scenario involved the Port of Long Beach issuing a request for proposals for development of an ROV system that would

- include an underwater hyperloop, a high-speed transportation system in which pods travel through a sealed vacuum tube that reduces friction and air resistance;
- maintain the port's water and light entertainment show to avoid interruptions;
- collect and identify samples of contaminated sediment and remediate environmental problems; and
- identify the contents of containers that fell off a cargo ship into the harbor and map the accident site to ensure safe port operations.

In addition to building an ROV, participants had to create a technical report, marketing display, and product presentation.

Figure 1. MTL HydroTech team. The MTL HydroTech team for the 2017 Marine Advanced Technology Education Center's international remotely-operated-underwater-vehicle competition consisted of high school students (left to right) Ethan Stillman, Andrew McCorkle, Anthony Cariello, Daniel Lam, Van Lam (mentor), and Ahmed Fouad.

MTL HYDROTECH

We began work in November 2016 and named our team (see Figure 1) MTL HydroTech (the MTL was short for Mt. Laurel). The MATE competition wasn't new for any of us. The year before, we participated in the event as students at Harrington Middle School. We had our share of problems last year but found solutions, and we designed and built a fully functional ROV. It was great when we found out we placed first in our regional MATE event in Villanova, Pennsylvania, which qualified us to move on to the international competition.

We worked hard to improve our ROV and our presentation, and finished third in the Ranger category (which primarily consisted of high school teams) in the international competition, held at NASA's Neutral Buoyancy Lab in Houston. This was satisfying because the deep water had stressed some of our components and hurt our vehicle's performance.

The experience made us want to continue participating in the competition this year. However, our high school didn't offer a MATE program. We decided to form an independent team as a fictitious company called MTL HydroTech. This let us work with fewer constraints than if we were on a school team, but it also had disadvantages. For example, we had to schedule team meetings outside of school on our own time.

Another problem we faced was that we initially didn't assign tasks to groups or individuals, forcing all of us to meet to discuss every activity, which wasted a lot of time. We later changed this practice, which let us accomplish work more quickly. We reserved full-team meetings for updates, task assignments, and work that required all members' participation. However, our early policy reduced the amount of time we had to work on other aspects of our project.

Before the MATE regional competition, we weren't making good progress, so we discussed leadership, time-management, and other problems. We even considered dropping out of the competition but then decided to continue, making team member Ahmed Fouad our new CEO.

THE 2017 MATE COMPETITION

We knew that if we wanted to improve and succeed in the 2017 competition, we'd have to build on the knowledge and experience gained in 2016. Team members thus studied the previous year's activities and lessons. We also analyzed the competition's manual, rules, and guidelines.

Figure 2. MTL HydroTech's remotely operated underwater vehicle. MTL HydroTech's ROV, on the left, has on-board electronics in a central, transparent, buoyant enclosure. It also has two rotating manipulators arms with claws that could grab objects, four vertical and two horizontal thrusters, and a light. The control box is on the right.

Initial design

From the start, we had big decisions to make. For example, we chose to use a watertight enclosure for our electronic components and then place most of our electronics on the ROV, rather than locating them on land and connecting them via wires to the vehicle. This approach was more expensive, and a leak would ruin the electronics. However, the enclosure let us use the electronic speed controllers necessary for better thrusters. It also allowed us to add a camera and distribute power more efficiently, with fewer delays and less interference. Instead of sending power individually for each component to the vehicle from land, we sent all the power directly to the ROV and distributed it inside the enclosure.

After our research, brainstorming, and planning, we started building the vehicle (see Figure 2). Our first frame—built by our mechanical engineering team: Andrew McCorkle, Anthony Cariello, and Ethan Stillman—was similar to that in the Triggerfish Vector PVC frame design, which MATE sells as part of an ROV kit.

We made several changes to the design, such as removing the center support strut and adding a horizontal beam for mounting our four Blue-Robotics' T-100 thrusters, two for horizontal movement and two for vertical movement. This design utilized 3D printed parts for integrating our commercial off-the-shelf components with one another and for securely wrapping the thrusters around our PVC frame.

We already had experience using 3D-printed parts in underwater vehicles, and our 2017 ROV used more of these parts than the other MATE entries in our class. We used acrylonitrile butadiene styrene (ABS), an oil-based plastic, because it's strong and more water- and heat-resistant than alternative materials such as polylactic acid (PLA), which is organic. We coated each part with acetone for additional water resistance.

Buoyancy and ballast were essential to ensure the ROV stayed stable and at the proper height and orientation in the water to perform the necessary tasks. Our enclosure tube, which contained trapped air, was our vehicle's center of buoyancy and was in the middle of our ROV. We thus added lengths of rebar along the bottom to move the center of mass below the center of buoyancy, which kept the ROV from flipping over. However, this also added weight and reduced speed, which was a big problem. We made it through the 2017 regional event but we knew we had to improve to have any chance to do well at the international competition.

Subsequent improvements

To better distribute our ROV's weight and control directional movement, we added two more vertical-motion thrusters. We placed all four vertical thrusters on the support struts at the frame's corners, concentrating the weight at the ROV's bottom and strengthening the placement of the center of mass below the center of buoyancy. And because the thrusters were at the bottom, nothing blocked them, which improved their water flow.

We placed our horizontal thrusters on the center of the sides of our frame's base, which helped stabilize the frame.

Fouad worked on our electrical system, including our topside controls. The system combined the electronics in the MATE Triggerfish Kit and some of our own components such as Arduino Uno microcontrollers. In addition, he wrote software so that our Blue Robotics Lumen Subsea Light could work with the microcontrollers.

Daniel Lam, who handled software engineering, programmed and worked on our servo—which could open or close valves as needed—so that it would continuously rotate 360 degrees. He also tested the software for our thrusters and got our system to function with the joysticks we used the previous year. This saved money and allowed us to work with familiar equipment.

Our vehicle also had a manipulator arm that could rotate 180 degrees, with a claw that could precisely grab objects.

After redesigning and fixing our ROV, practicing with both our vehicle and our presentation, and improving our marketing display and technical documentation, we were ready for the international competition. However, we continued practicing until the event began because we learned from our earlier MATE experience that "the job is never done."

At the internationals, our hard work paid off, as we placed first for our technical documentation and sixth overall. We didn't do quite as well as we had hoped, but we were more than happy with the result. And the best part is that the success resulted from our hard work.

Our journey this year had plenty of hardships and challenges. It required research, problem solving, teamwork, and perseverance. It was challenging but also fun. We worked hard and learned a lot about engineering, as well as professional skills such as how to document technical data, how to market, and how to create a functional company.

Our MATE experience has inspired us to become engineers. And it has given us knowledge and taught us lessons that will stay with us for our entire lives. ◼

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