Utica T.U.R.R.E.T. Presents

Horatio

T.U.R.R.E.T.
Technical Underwater Robotics Research Engineering Team

Team Members: Zach Elie, Kara Marsh, Breanna Meyer, Jonathan Nguyen, Jenna Ross, Hayley Schuller, Kate Syms, Sebastian Szmitka, Kayla Wizinsky, Justin Wright, Joe Wyrzykowski, and Nick Zambelli

Team Mentors: Mr. Michael Attan, Mr. Geoffrey Clark, Mr. Scott Palmer, and Mr. Scott Spry

Location: Utica High School 47255 Shelby Road, Utica, MI 48317
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Abstract

The team goal for T.U.R.R.E.T.’s third year was to successfully build a Remote Operated Vehicle (ROV) that would efficiently complete the tasks for the Shedd Aquarium Midwest MATE ROV Regional Competition and qualify for the international competition in Hawaii. The ROV was improved from last year’s design to be lighter and smaller. This gave the team an advantage when maneuvering in tight spaces, while conserving resources. The smaller size is ideal for Task 2, which involves navigating in a small tunnel, much like the job of Jason Jr., the remote operated vehicle that explored the wreckage of the Titanic.

Because of the team’s hard work and dedication, the students worked on this project are proud to demonstrate how much they gained through this experience. They have done everything from designing in SolidWorks to wiring a custom control system. They also made a conscious effort to incorporate more sensors to familiarize themselves with a broader range of engineering fields. They analyzed the benefits of each task and from there determined the best approach toward the competition.

This report dives into the details explaining the mechanical and electrical design rationale, financial limitations, and potential improvements. The report also covers the challenges the team faced, the skills acquired, and reflects on all the success of the team’s efforts. Overall, the team feels the design was a success, and they are very proud of what they have accomplished.
Design Rationale: Body

Propulsion System:
The basis of an efficient ROV is being able to sufficiently control driving. The team kept this in mind when designing the propulsion system. The goal was to give the ROV the capability of tight pivoting and high speed. The ROV uses four motors strategically placed to accomplish this task. Two thrusters are set on the sides of the robot to power the robot horizontally. In the control system, the left control operates the left motor, while the right control operates the right motor. Therefore, the operators can run both thrusters in forward to obtain a maximum speed forward. To drive in reverse, the operators can run both thrusters forward horizontal in reverse pushing the ROV backwards. To pivot the ROV, the operators run each side in opposite directions and the ROV turns on the spot. There are also two thrusters, one in front and one in back, controlling the vertical movement. With these thrusters, the operators can control submerging and surfacing. Furthermore, by splitting the motors into two planes, the propulsion system compensates for this unequal weight distribution created when adding appendages.

Frame:
The frame is constructed from 1/2” PVC pipe. The team used PVC because it is cost effective, practical, and strong. They also used screws to hold the pipes together for ease of interchangeability for maintenance compared to glue. The unique design is small and optimizes the number of joints used in order to maintain a light weight. For safety, the team printed caution symbols around the frame to aware people of the dangers that may occur. The team also plans on encasing the vehicle in chicken wire to avoid chances of injuries with the motors and propellers.
Thrusters:
The ROV uses Rule bilge pump motors. It uses four 4164 liters per hour and 6 amp bilge pump motors. The two up and down bilge pump motors are 1893 LPH (500GPH) and 5 amps. All four of the bilge pumps motors run on 12 volts.

Ballast System:
The remote operated vehicle relies on a fixed ballast system. The ballasting tanks consist of 1.5” ABS pipe, which are located on the top of the sub in sets of two on each side, a total of four tanks. One ABS pipe on each side is moved slightly forward in order to give the sub more positive buoyancy in the front, compensating for any added weight resulting from mission task activities. This also allowed the team to add weight to the front of the sub.
Design Rationale: Appendages

Hydrophone:
The hydrophones are used in Task 1 to locate the rumbling site. The team constructed the apparatus by following the instructions provided by the University of Rhode Island. The entire device was built from scratch with components all easy to obtain at any electronics store. The team assembled two hydrophones and mounted one on each side of the vehicle. The intention was to allow the amplifiers on the surface to reproduce the sound in stereo, which gives the operators the ability to locate the source of the sound. The team considered using a stethoscope; however it was not as effective and out of our price range.

Hooks:
The team wanted to create an appendage that would be capable of accomplishing multiple tasks to maintain the ROV’s light weight frame. While a claw was a plausible option, it would have been difficult to control and added unnecessary weight. The team decided to place two pairs of PVC hooks and a “J hook” on the front of the robot to accomplish task 1. The “J hook” is used to remove the pin from the elevator, while the PVC hooks pick up and transport the High-Rate Hydrophone (HRH), carry the power/communication connector, and remove the cap from HUGO. The simplicity of this tool is the ROV’s greatest asset.

Thermocouple:
When presented with Task 3, the team found it is possible to combine a custom designed thermocouple with a multi-meter to create a temperature sensor. Through further research of the various thermocouple wires, the team decided to use the K series because it was within both the necessary temperature and price range. It is fastened off the hooks on the front of the vehicle to maximize visibility and control. In competition, the device monitors the temperature of the water released from the chimney. This information can then be read by the operators on the multi-meter display screen.
Design Rationale: Control

Tether:

The tether bundles ten 18-awg wires necessary to run power and signals each of the motors. Also included in the tether are two camera wires that attach directly from the camera to the screen, a thermocouple that connects to a multimeter on the surface, and two lengths of audio-cable for the hydrophone. On the surface, the audio-cable feeds to a speaker. To wrap the tether, the team used a polyethylene diamond braided mesh. The mesh can be tightened or loosened depending on how it is stretched. This allows the team to bundle the wires tightly so they do not cause a problem. The tether has foam ballasts, which are strategically placed in sections so the tether floats upright above the sub at all times, avoiding task interference.

Cameras:

The ROV uses two infrared underwater cameras. They have a 3.6 mm lens and a 22.86 cm focus. These cameras were chosen because they use infrared for viewing to allow the vehicle to work in about dark conditions without installing lights. They are also small, light, robust, and affordable. Two cameras were used which required two screens. The camera placements allow the operators to see the outside boundaries of the ROV. The back camera allows observation of surroundings, while the front camera allows for viewing attachments when in use.

Control Box:

The control box, a brief case that houses all electrical wires outside of the water, includes housing the fuses for each individual motor control. At the end of the tether, there is a quick connect to the surface and manufactured the other quick connect end into the side of a briefcase. Therefore, the tether can be quickly and easily connected and disconnected from the control box. A “set up and tear down” checklist for the drive team runs through all of the systems to check connections and make sure it’s safe before placing it into the water.
The electrical schematic for this year’s tether including: two cameras and five motors
Challenges

Challenge I: Bending PVC

In the early going, the design team considered possible shapes for the frame. When one of the team members mentioned bending PVC, it was decided to try the idea. The reason was that by bending the PVC, joints which would be eliminated thus reducing weight. However, after several weeks of experimentation, the team could not bend the PVC into an effective shape. The team faced time constraints and decided to leave the idea and went to the standard method using joints and PVC piping to make the ROV frame.

Challenge II: FIRST Robotics Team, The ThunderChickens

Out of the twelve members on the T.U.R.R.E.T. team, seven are on the ThunderChickens, a FIRST robotics team. Their time commitment was extensive and overlapped with the schedule of the ROV team. For the majority of the year, they had to meet their prior commitment to the ThunderChickens. However, after mid-April, when FIRST Robotics competitions, they were able to put their full effort into the ROV and with their help, the ROV was completed. The team later traveled to the Shedd Aquarium Midwest MATE ROV Regional Competition making great success.

Challenge III: Controls

The joystick idea did not work because of a number of factors. Much time and effort was spent on experimentation, but the results were not acceptable. The team's main programmers were on the FIRST robotics team, ThunderChickens, so they were not able to work on the controls as much as necessary. Also, the programming did not achieve successful standard. There were too many bugs to work out. In the end, with all the difficulties involved, the design team switched back to the control system from last year: the control box and switches.
Challenge IV: Money

Money was a big issue this year. Every year, the class receives a grant from Michigan Tech University through participation in the High School Enterprise program. However, this year most of the money went to the electrical plug-in go-kart team and T.U.R.R.E.T. received only part of this year's money which was combined with reserve money from last year. So this year, the team looked for corporations, the school district, and colleges to donate money. In order to address the money issue, the team did bottle drives throughout the school year and went to various companies for sponsorships. Team members created a brochure which helped with the efforts to gain sponsorships.
Troubleshooting

When encountering any problems the team used a ten step process:

1. Identify the process/problem
2. Define the working criteria/goals
3. Research and gather data
4. Brainstorm for creative ideas
5. Analyze
6. Develop models and test
7. Make the decision
8. Communicate and specify
9. Implement
10. Prepare post-implementation review and assessment

Team meetings, which were held weekly, solved issues the team faced in each of the group projects. The team discussions helped all team members have a voice in decisions therefore; errors were not the fault of one team member. A specific timeline was established for major steps of the overall mission. This kept development on track for the season, decreasing the stress.

Sources:

Students discussing ideas for camera placements.
Skills Gained

The team started off this season with many ideas and spent a lot of time trying to make them work. The team decided to bend PVC to eliminate joints and reduce the weight. After numerous attempts, the team was unable to find a way to create this frame. Eventually, they just ran out of time to continue down that path and had to resort to the original frame with joints. The team found that if they were going to be successful, the team would have to start using their time more efficiently. While the idea of bending the PVC was a good one, the team did not have the time needed to get it done this year.

The next task was to agree on the appendages they were going to use to efficiently accomplish the tasks. The team soon discovered that the only way they would be able to achieve anything is if everyone could share their ideas and each thought was taken into consideration. After a long discussion, the team decided to place hooks on the front of the ROV that could accomplish a number of tasks. However, even this decision required more thought on the orientation of the hooks. The team spent a long time testing a variety of orientations and finally found one that seemed to offer the most flexibility.

From this experience, the team has learned what it means to be a part of a team. They’ve realized that when working as a team, it is important to organize time well and allow everyone to have an input. Once the team began working together, things started to fall into place and they were able to create a ROV that they were all proud of. Communication was a key to the success this year. The team is basically a family of friends. Through the construction of the team, they worked in groups to complete the tasks which mimics the way a company runs. And since this was many of the members first year on a robotics team, many team members learned mechanical, electrical, and programming skills which they will take to engineering colleges. Overall, being a part of the MATE Underwater Robotics Team for the school was a very rewarding experience for all.
Loihi Seamount

The Loihi Seamount is the youngest volcano in the Hawaiian Emperor Seamount Chain created by the Hawaiian hotspot. Taller than Mount St. Helen, the Loihi Seamount was originally thought to be “dead” until seismic activity in 1970 led to investigations of the Loihi Seamount. In 1996, the largest recorded earthquakes in number and intensity were recorded from Loihi. This activity led to the birth of the first undersea volcano observatory—Hawaii Undersea Geological Observatory (HUGO). In October, the first high-temperature hydrothermal venting on an oceanic seamount was documented on Loihi. The hydrothermal venting was a result of the 1996 earthquakes. It was discovered that this venting allowed for bacteria colonization. When HUGO’s power and communication cable failed for a second time in 2002, it no longer was operational. Research was then mainly performed by the Hawaii Undersea Research Laboratory (HURL) and the Pisces V.

The ROV parallels the research done by the Pisces V. The ROV dives down to resurrect HUGO, deploy instruments (power and the HRH Connector), collect data (temperature and sound), and sample organisms (augur). Much like the researchers of Loihi, the team had a limited time to accomplish the necessary tasks. The team had many failed attempts in the design that forced them to take a new approach, similar to the problems faced by scientists and researchers after HUGO was damaged.

Sources:
http://www.soest.hawaii.edu/GG/HCV/loihi.html
http://en.wikipedia.org/wiki/Loihi_Seamount
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**TOTAL**  
$15,198.05

*Signifies a donated item.

**One DVD player was lent by a team member for the competition.

## INCOME

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**TOTAL**  
$14,800.00

| Income -                                         | $14,800.00   |
| Expenditure -                                    | $16,922.77   |
| GRAND TOTAL-                                     | ($2,122.77)  |

[15]
Future Improvements

Designing and constructing a competitive ROV has been a great engineering experience for the entire team. Not only did the project allow us to develop engineering skills, but it also inspired some lasting friendships. Being a team of seniors, the future of the team is unknown. With no one left to pass on what they’ve learned, next year’s team will have to start from scratch. Hopefully, the team will be able to come back as mentors to help the new students succeed.

Through experiences, the team has a lot of advice to pass on to the next T.U.R.R.E.T. members. Time management is very important and was a major source of conflicts this season. Prototyping needs to be started right away so that no ideas have to be tossed aside due to lack of time for development. Had the team practiced bending the PVC earlier, they may have been able to accomplish that design and ended with a more successful design. The team also could have gotten the original control system to work which would have given them better control. Creating a timeline was very useful to make sure that each group was done with their projects in a timely fashion.

In addition, fundraising needs to be started early in the year to allow businesses more notice thereby giving the team more opportunities. Many companies willing to sponsor the team couldn’t because they needed more time to apply to their corporate offices or had already sponsored other teams with their money. Overall, the team was able to achieve great success, but there are still many aspects of the team that need improvement. Hopefully, next year’s team can learn from the mistakes and benefit from them in the future.
Team Bios and Reflections

Utica T.U.R.R.E.T. has been competing for three years. The Underwater Robotics Team, who is part of the Engineering class, is made up of twelve high school seniors. The team is a part of the Michigan Tech’s Enterprise program, which emphasizes safety, innovation, creativity, teamwork, and communication. The team runs like a business under the authority of a student CEO. They divided into different groups to complete assigned tasks. The team consists of have electrical, programming, mechanical, and public relations sections.

Below is a brief biography of each team member’s contribution:

**Zach Elie: Mechanical**

College Selection: Oakland University

Intended Major: Biomedical Engineering

Reflection: “I think we were really successful this year. We worked well as a team, and during crunch time, we were amazingly productive and cohesive.”

**Kara Marsh: Mechanical and Public Relations**

College Selection: University of Michigan

Intended Major: Biochemistry

Reflection: “I liked how we didn’t just focus on the engineering aspects of the project; we had to analyze the business and teamwork aspects also.”

**Breanna Meyer: Mechanical and Public Relations**

College Selection: University of Michigan

Intended Major: Mechanical Engineering

Reflection: “This competition gave me a glimpse into the world of engineering. I feel like I am now prepared to become a mechanical engineer.”
Johnny Nguyen: Mechanical

College Selection: University of Michigan

Intended Major: Biomedical Engineering

Reflection: “It was just plain awesome. I don’t do much else outside of school so this helped to make me more of a team player. I loved the missions and I loved the objectives. I also really liked having fun with my teammates.”

Jenna Ross: Mechanical, Public Relations, and Drive Coach

College Selection: University of Michigan

Intended Major: Mechanical Engineering

Reflection: ”The regional competition introduced me to problems I didn’t even know existed.”

Hayley Schuller: Mechanical and Public Relations

College Selection: Kettering University

Intended Major: Mechanical Engineering

Reflection: “I thought it was great how many girls were on the team. It really showed that women can be engineers too.”

Kate Syms: Public Relations

College Selection: University of Pittsburgh

Intended Major: Fine Arts and Engineering

Reflection: “This program exposed me to another engineering process with which I was unfamiliar. I enjoyed the chance we had to work with the corporate world. This team really earned its cachet.”

Sebastian Sznitka: CEO

College Selection: Western Michigan University

Intended Major: Mechanical Engineering

Reflection: “The regional was a great experience. I enjoyed working with new people this year.”
Kayla Wizinsky: Public Relations

College Selection: University of Michigan
Intended Major: Aerospace Engineering

Reflection: “This is such a unique and challenging program. Because of the MATE competition, I have become more of a well-rounded engineer”

Justin Wright: Electrical and Programming

College Selection: Michigan Tech
Intended Major: Computer Engineering

Reflection: “I was excited to see all of our hard work come together. It was really fun to compete against people from around the country.”

Joe Wyrzykowski: Electrical, Programming, and Drive Team

College Selection: Michigan Tech
Intended Major: Chemical Engineering

Reflection: “Being on this team was a good experience. Seeing all the robots in Chicago was exciting.”

Nick Zambelli: Mechanical and Drive Team

College Selection: Saginaw Valley State University
Intended Major: Mechanical Engineering

Reflection: “It was a good time. I really liked getting to know everyone and becoming a team.”

Team Mission Statement:

“Our goal is to create our underwater remotely operated vehicle using the various processes involved with different engineering disciplines, such as Computer, Electrical, Mechanical, and System. Due to the design of the Michigan Tech Enterprise program, we will learn to manage a budget, delegate tasks, and use resources efficiently. Through the building process, we will learn the tasks and present ideas appropriately.”
Acknowledgements

And a special thanks to our families and mentors.