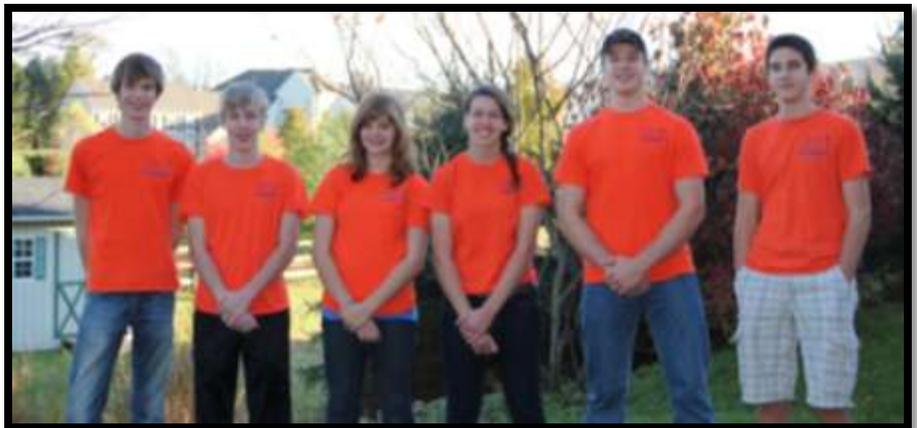
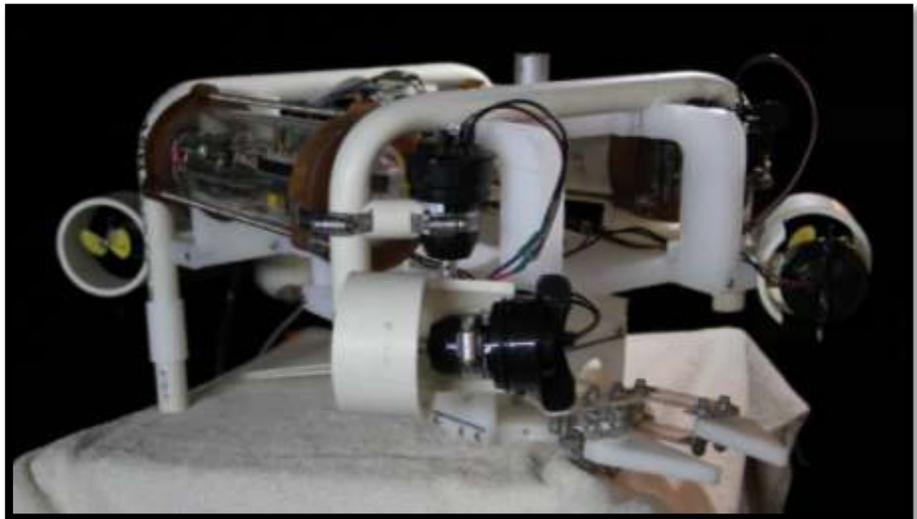


Pennsylvania ROV Engineers

▪ Allentown, PA ▪



Team Members

- | | |
|--------------------------------------------------------------|--------------------------------------------------------------------------------|
| ▪ David Sampsell
Chief Executive Officer, Grade 12 | ▪ Timothy Gahman
Tool Engineer, Grade 10 |
| ▪ Ben Green
Lead Programmer, Grade 11 | ▪ Natalie Sampsell
Tool Engineer, Graphic Designer, Editor, Grade 10 |
| ▪ Stephen Gahman
Design Engineer, Grade 12 | ▪ Hannah Smith
Graphic Designer, Photographer, Grade 11 |

MATE
International
Competition

Technical
Report
2014

Mentors

- Dave Sampsell
- Scott Gahman

Coaches

- Robin Sampsell
- Christine Gahman



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Abstract

A relatively young company currently in its third year of operation, Pennsylvania ROV Engineers, or pROVe, was originally incorporated to build a remotely operated vehicle capable of inspecting shipwrecks for environmental hazards. This year, the team focused on designing a vehicle for the purpose of protecting shipwrecks, researching sinkholes, and conserving national maritime heritage sites in the Thunder Bay National Marine Sanctuary. Our ROV (Remotely Operated Vehicle), Poseidon Mk III, incorporates a custom, fully proportional lateral and vertical control system that allows for bidirectional control of every propeller on the ROV. This thruster arrangement, coupled with custom Python programming, a Raspberry Pi, and two Xbox 360 controllers, provides a seamless connection between the pilot and the vehicle. Other special features include a modular design, grab points for easy transportation, and a rotary tool mount to provide easy access to a variety of custom-made payload tools. The end result is a powerful, highly maneuverable, and fast ROV fully prepared to take on this year’s mission tasks.



Shipwreck in Thunder Bay



The Team

Our homeschool-educated team includes the following members for our third year of competition:

David Sampsell is an 18-year-old high school senior. David has been the leader of team pROVE since the beginning. When he's not working on the ROV, he enjoys working on his Toyota Land Cruiser, skiing, guitar, and eating pancakes. He plans to attend Rose-Hulman Institute of Technology in the fall, and get a degree in Mechanical Engineering.

Natalie Sampsell is 16-year-old sophomore in high school. She likes to listen to music, play various instruments, act, play various sports, and read. She is the technical report editor, a tool designer, and a graphic designer for the team. Her future plans include a career in engineering, and a possible degree in computer science.

Hannah Smith is a 16-year-old junior who has been homeschooled all her life. When not doing work, she particularly enjoys playing a variety of sports, especially soccer and frisbee, playing the piano and guitar, listening to good music, and taking pictures. Hannah helped with graphic design, created the spec sheet, helped with tech report, was the tether manager, and was also a team photographer.

Stephen Gahman is a 17-year-old high school senior from Pennsylvania. Stephen has been a member of team pROVE since its inception in 2011 as a member of the core design team. In his spare time, Stephen enjoys baseball, snowboarding, lifting, music, and eating food. In the fall of 2014, Stephen will be entering Grove City College as a freshman in the department of Mechanical Engineering.

Timothy Gahman is a 15-year-old sophomore from Pennsylvania. Tim has been on the team for two years. He enjoys golf, hunting, gaming, karate, and snowboarding in his spare time. In the future, he wishes to pursue a career in engineering, possibly biomedical engineering.

Benjamin Green is a 17-year-old junior who enjoys board and card games, recreational sports, and airsoft. He is planning on earning a major in Computer Science, specifically Computer Programming. He is in charge of pROVE's public relations and fundraising, as well as being the Senior Programmer.



Team Meetings



Working on Props



Safety

Our team has always been concerned about safety above all else. Basic safety practices were regularly followed during all stages of ROV fabrication and use. This included wearing safety glasses and closed-toes shoes, using power tools properly, and taking precautions when using tools or doing any testing. Also, to ensure our team's safety, as well as the safety of bystanders, we go through all the crucial steps on our safety checklist before operating the ROV. For the physical characteristics of our ROV, we incorporated a main power switch that will immediately turn off the ROV wherever it is. Within 30 cm of the power supply, there is a 25-amp fuse in case of a short circuit. If there is no fuse, the circuit will break at the weakest point, possibly a point exposed to water. The fuse acts as the weakest point, and can be easily replaced. We attached thruster guards on the horizontal propellers and we designed the frame to protect the vertical propellers, which in turn protects body parts, wires, or anything in the water from getting caught from the spinning blades. The vehicle was designed with grab handles on the top and the sides to help maneuver the vehicle in and out of the water efficiently and safely. Our whole ROV was designed to maximize safe operating features. A copy of our team's safety checklist has been included as Appendix 1.

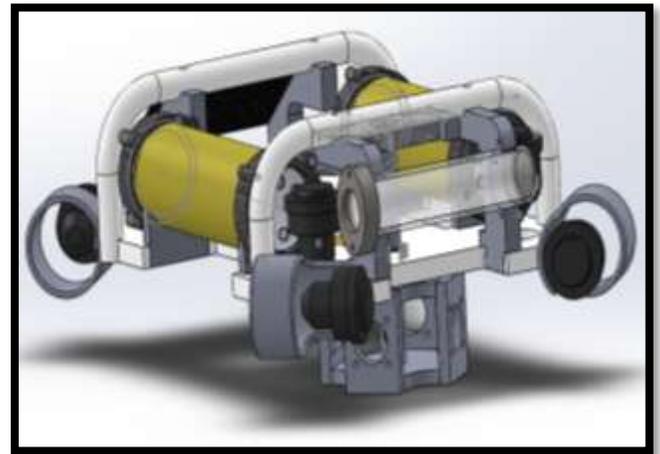
Design Rationale: ROV Components

Frame

Last year, we decided to try something a little different and mount all of our ROV's components on a flat panel, a professional cutting board. We really liked this design, because it was strong, reasonably light, and allowed access to all of the important pieces of the ROV design for upgrades and maintenance. The only things it lacked were good handholds and a superstructure that protected the ROV in case something was placed on top of it or it fell over. We decided that by incorporating 'roll bars' into the flat panel design, we could remedy these problems. The

bars, made out of PVC that we bent using heat, allow the ROV to be placed upside down for maintenance, and also provide an easy and safe place from which to lift the vehicle.

Another major feature of our ROV's frame is the Rotating Tool Mount, or RTM. The RTM basically consists of a 'carriage' or 'cage' that rotates horizontally beneath the ROV. It is controlled by a gear motor, and can rotate a full 360 degrees. It has four sides, each one containing a different tool. This way, the RTM can be rotated 90 degrees to switch which tool is beneath the camera at the front of the ROV, effectively allowing us to have four tools in only one spot on the ROV. We have found this device to be a major timesaver, as it allows us to design each tool as if it is the only tool on the vehicle. The RTM is attached to the frame by a central shaft that runs the full height of the ROV and uses two acetal glass ball bearings. This allows it to support the weight of the ROV if need be.



Poseidon Mk. III

Electrical

PROVE has always focused on two main items with its approach to ROV electronic design: a microcontroller on board the ROV, and proportional control. The microcontroller allows for a very thin tether - advantageous for maneuverability - and proportional control allows for a much greater dexterity than afforded by a simple on/off control scheme. In



light of these goals, the team decided after much discussion that the best setup would be to run an Ethernet connection through the tether, connecting a laptop on the surface to a Raspberry Pi on board the ROV. The Raspberry Pi would query the laptop for the most recent speed and direction values for each thruster, and forward that data on to an Arduino Mega via I2C. We chose this setup because the Ethernet connection between the Raspberry Pi and the laptop topside provided a reliable method for long distance data transmission, while the I2C bus between the Raspberry Pi and the Arduino Mega gave the Raspberry Pi the means to communicate its wishes to the hardware on our ROV. Additionally, the I2C bus allows for easy future expansion of the ROV electronics, since multiple devices can be attached to it.

Because we wanted proportional control of the ROV, we knew we would need some sort of motor controllers. When we researched commercial options, we found that it would be quite expensive to purchase as many motor controllers as Poseidon would require. Because of this, and also because we always like to make things ourselves whenever possible, team PROVE decided to build its own custom motor controllers. We wanted each controller to be easily replaceable in case of upgrades or a failure, so we decided to build each controller on its own board, with a microcontroller managing the control electronics which operated the large power MOSFETS which did the actual switching of the current. Though it took a lot more time and effort than expected, the end result was a highly versatile motor controller design that was cost effective and capable of controlling up to four 1000gph bilge pump motors in parallel if the need arose. A System Interconnection Diagram (SID) that details the electrical wiring information has been included in Appendix 2.

Ballast

The tools attached to our RTM have some weight, and we have added a little more weight to the bottom of the ROV. This provides a significant amount of ballast. For flotation, we

have the pressure housings and some extra foam to counteract the ballast. The pressure housing design provides natural buoyancy, and the foam adds extra flotation. The reason for the added ballast and flotation is for stability. When the ballast and flotation are separated, the ROV tends to balance itself in an upright position.

Video Systems

One of our goals this year was to have an HD camera for the main ROV video system. Unfortunately, we were not able to achieve this goal. Our plan was to use the Raspberry Pi to stream HD video over our network connection to a computer topside. While this would certainly be possible, we soon realized that we could better spend our time elsewhere, as getting a system that worked and had low enough latency to be used for navigation would take more time and know-how than we had available to us. Because of the necessity of low latency, we decided that a simple analog board camera system would be the best fit, as board cameras are small, easy to mount, and provide good video at a reasonable price. For our main navigational camera, we have one of these board cameras mounted on a servo at the top-front of the ROV, providing a clear view of what is in front of the ROV. It is also able to tilt down to view the payload tools. We also have the option to run a second camera if needed.

Pressure Housing

For this year's design, PROVE decided to use three main pressure housings, with one for our microcontrollers and other control electronics, one for our motor controllers, and one for our main camera system. We chose multiple pressure housings because they afford greater mounting options than a single large pressure housing, because they provide redundancy in case of failure, and lastly because they allowed us to keep the delicate control electronics physically separate from our high-current motor controllers.



For the actual design of the pressure housings, in all three cases we opted for a cylindrical design with o-rings and Lexan end caps at either end. The cylinders themselves were made out of either Acrylic or PVC. For our two large electronic pressure housings, we machined grooves for the o-rings into the end of the cylinders, but we found this to be unnecessary for our smaller camera housing and simply ran that housing with the o-rings directly between the end of the pressure housing and the end cap. To allow wires to enter and exit the pressure housings, we devised a bulkhead fitting that utilized an o-ring from parts we found in the plumbing supply section of the hardware store. This system allows for many different wires to pass through the end caps. It also allows us to remove the caps in only a few minutes in case of a repair or upgrade.

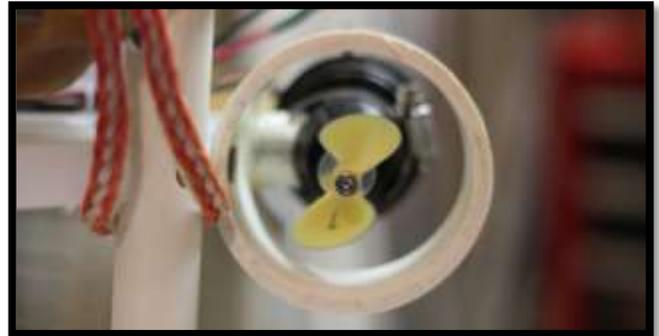
Tether

Our tether was designed to be thin, flexible, and maneuverable. Our control scheme is such that it only requires one category 5 cable for control of the whole ROV, as well as video capabilities for up to four cameras. Also in the tether are two 12 American Wire Gauge power wires that provide power to everything on the vehicle, apart from the cameras, which are powered through the category 5 cable. The three wires, one communication and two power, are braided together in a standard three rope braid. This keeps the tether flexible and compact at the same time. Twelve gauge wires were chosen because they were not too expensive, flexible, but still maintained adequate voltage levels on-board the ROV. The communication protocol was made faster this year by increasing the bandwidth from a 9600 baud rate to 100 megabits/second. The current setup is more reliable and alleviated problems with the serial connection not sending consistently.

Propulsion

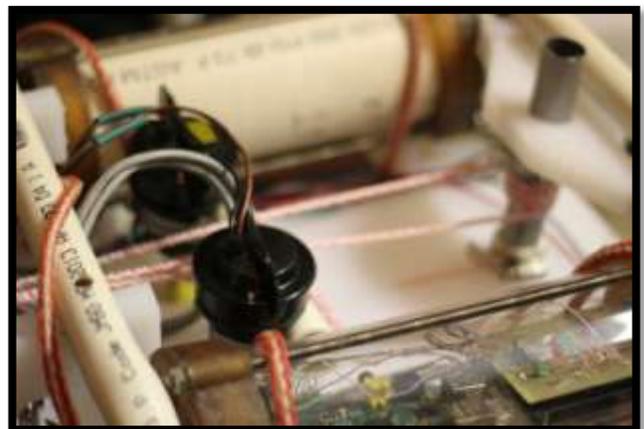
For propulsion of the ROV, the team opted to use Johnson bilge pump cartridges outfitted with Octura propellers. While a custom motor and

housing setup might have yielded more power and efficiency, the team deliberated and decided that the Johnson cartridges provided quite adequate thrust at a reasonable cost and very low time investment. This allowed us to spend that time working on other ROV systems that enhanced the performance of the ROV more than custom thrusters would have.



Front View of Propeller

After testing several different propellers for thrust, current draw, and price, we found that the Octura propellers provided the best mix of power, efficiency, and economy. One thing that we had noticed in previous years was that some of our prop adapters were not balanced correctly, and that caused the ROV to vibrate whenever the thruster spun. To remedy this problem, the team chose to order new adapters and propellers as well as to use higher quality stainless steel parts in this year's thrusters.



Top View of Vertical Thrusters



Programming

Because we needed proportional control, we chose to use an Xbox 360 controller. This controller provides multiple proportional-value inputs and several button inputs. We wanted to have proportional control for practically everything, but one Xbox controller was insufficient, so we added a second controller for the extra proportional control. This allows a pilot to control the ROV movements, and a co-pilot to control the tools.

The basic functioning of the program is that it reads input data from the controller, manipulates the data, and sends values down to the ROV. The program also runs a Graphical User Interface (GUI) that provides easy troubleshooting and awareness of the state of the ROV. A major feature we incorporated into the program this year was threading, which means that several processes are all occurring at the same time. The threads use global variables, so they can share the values. The Input/Calculations thread receives input from the Xbox controller, determines the proper values, and assigns these values to the global variables. The GUI and Server threads can then access the values stored in those variables for their respective tasks.

On the ROV, we have a Raspberry Pi, which is the client in the client-server relationship between it and the main program. Several times a second, it sends a request to the main program, which then sends down the variables. The Pi sends these variables to an Arduino Mega, which then transfers the variables to the proper motor controllers. A summary of the computer's control scheme is provided on page 8 of this report.

Troubleshooting Techniques

As this was our third year of competition, our team already had considerable troubleshooting experience. Mainly, troubleshooting was necessary in the design of the electronics and

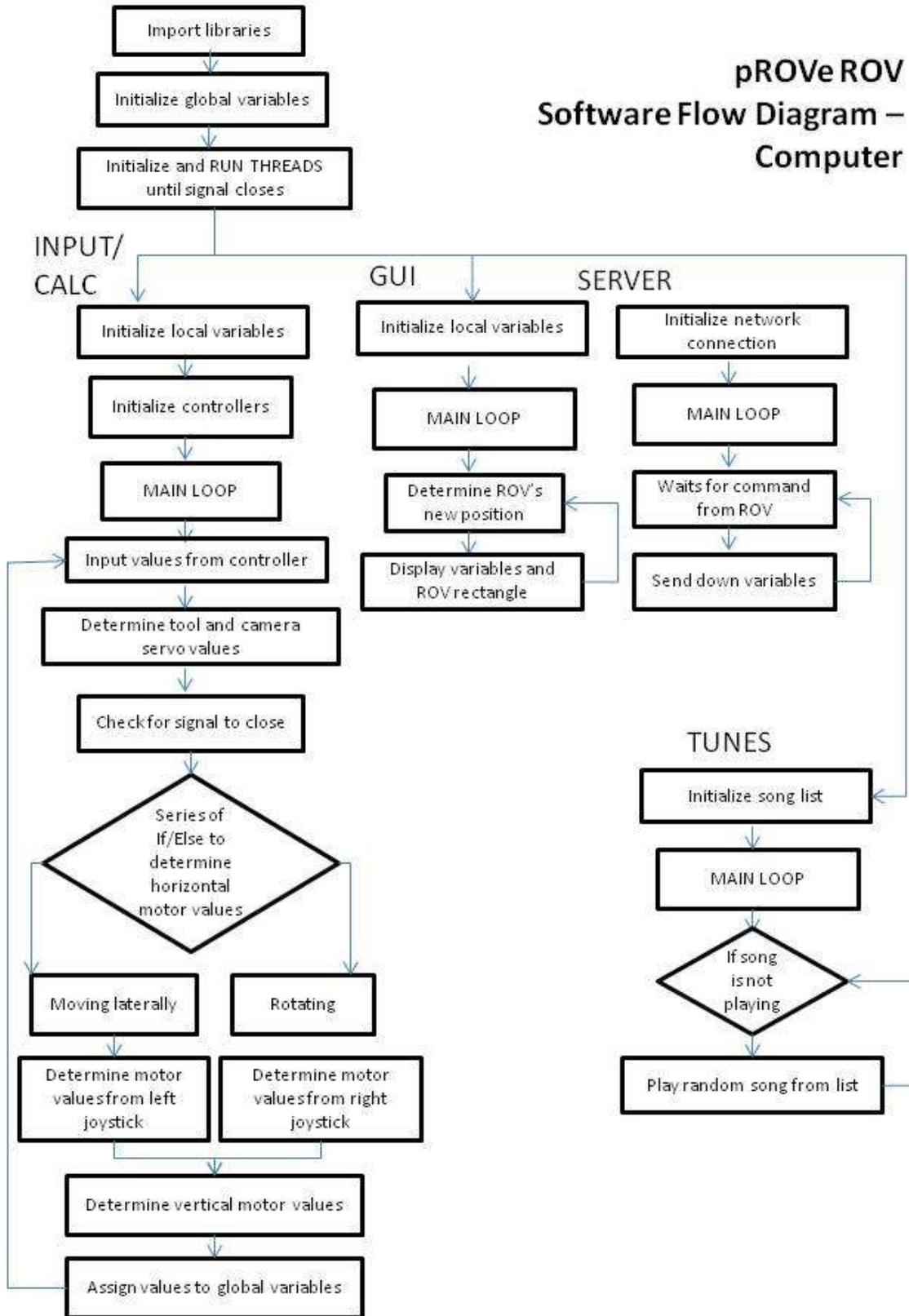
computer programs. When we ran into a problem, we broke it down logically. Each step of the process was then tested and analyzed, until the offending portion of code, electronic circuitry, or other problem was identified. At this point, we decided whether we could fix the problem, or whether or not a different overall approach was necessary. For example, we ran into a problem programming our motor controllers. At a certain position in the program, several variables were being reset. By breaking down the problem and eliminating extraneous information, we were able to determine exactly where in the program this was happening and fix the problem. When we ran into problems in other areas, such as video systems, that we were unable to resolve efficiently, we opted to cease troubleshooting in favor of a simpler design to provide more time for other areas of the ROV. Throughout the process of building the ROV, we were presented with many chances to test both individual components and the ROV as a whole. Smaller components, such as individual tools, were tested in a plastic water tank. This allowed us to make sure smaller components were watertight before testing the entire vehicle. We tested our ROV in a local pool both to configure ballast and flotation, and to practice this year's mission tasks.



Testing the ROV



**pROVe ROV
Software Flow Diagram –
Computer**

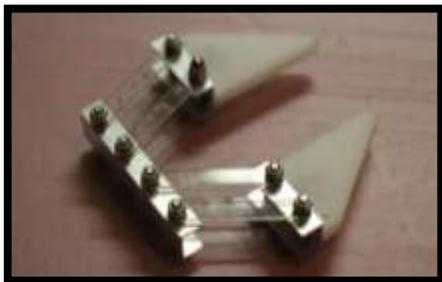




Payload Description

Mission Task 1: Shipwrecks

After studying the missions, the design team decided that a well-functioning manipulator would be critical to maximize our score. In this mission, tasks requiring a manipulator include unlocking and opening a container to determine the cargo, removing debris from the shipwreck, and retrieving a ceramic dinner plate from inside the wreck. The past two years we have had difficulty constructing a reliable manipulator, so this year we decided to devote considerably more time to its design and fabrication. We decided to construct this year's manipulator completely from scratch. The major problem we needed to overcome was obtaining a sufficient clamping power, while maintaining complete control over the device. Our past models worked very well in theory, but they would often get jammed once clamped down upon an object. However, by implementing a geared motor and moving the clamping force of the motor in parallel with the jaws of the manipulator, we improved grip strength and control, while simultaneously consolidating the size. The main structure is composed of c-channel aluminum, Lexan, and cutting board, providing needed rigidity and precision.



Jaws of the Manipulator

Other tasks in this mission included measuring the shipwreck's length, width, and depth, and conducting a sonar scan of the wreck. To measure the shipwreck, our quadrat doubled as a measuring tool. We decided to place the

quadrat on top of the shipwreck and take a screen shot of it. Then we were able to find a program that would use ratios to determine the length and width of the wreck. Using the same method, we were able to place a PVC box we constructed to carry items on the floor of the pool, and use it as a measuring tool to determine the depth of the wreck.

Because our ROV is highly maneuverable and stable, it was definitely qualified to conduct the sonar scans of the shipwreck.

Mission Task 2: Science

This mission task involved measuring the conductivity of a groundwater sample, collecting a sample of a microbial mat, recovering and deploying a sensor, and estimating the number of zebra mussels on the shipwreck. For our conductivity sensor, we assembled a circuit by attaching two paper clips on the end of a PVC pipe and running wires attached to the clips through the pipe into the pressure housing, using a 3 amp fuse for safety. We decided to use paper clips because they were thick and sturdy enough to easily break through the plastic wrap on top of the groundwater sample. The wires which we ran into the pressure housing were then connected to the Arduino Mega, which digitized the values, which were then displayed on the computer. This system gave us readings as soon as the ROV enters the groundwater sample, which allows us to complete this task very efficiently.



Conductivity Sensor



The agar sampler was a tool that took quite a lot of planning. We started out by making sample cups of agar and testing how much pressure was needed to collect a sample. After this, we started brainstorming ideas on how we could get a large enough sample of the agar. We eventually decided to take a core sample with a section of pipe. Our agar sampler uses two pieces of cutting board to hold the pipe upright. After several tests, we decided that the best way to ensure success was to turn the pipe while pressing down in order to cut through the top layer of agar. To do this, we attached a motor to turn a shaft next to the pipe, which in turn was attached to a band that went around both the pipe and a gear.



Agar Sampler

The other tasks in this mission could be completed using the manipulator detailed in Mission Task 1.

Mission Task 3: Conservation

Similar to some of the items under the other mission tasks, mission task three involves different activities that use the manipulator, including picking up two different bottles, and removing an anchor line rope. With the camera located in such a way that we will be able to see what we are doing with the manipulator at all times, these tasks are not difficult for our ROV to complete.

Challenges

Project - Our team encountered numerous challenges this year, some of which could have been avoided. Work on our ROV commenced in late November, not leaving us with as much time as we needed. Finding days for our entire team to assemble together has been a challenge. As a result, only a few team members could meet at a time. Although this posed a problem, our mentors always had their house open to work at and someone was almost always working on some aspect of the ROV. Also, last year, two of our principal team members graduated and left for college. Younger team members had to be mentored into those former team members' positions, while also working on the assignments they had had in previous years. In addition, the two seniors on this year's team had a hard time finding time for ROV work among their other activities and college plans. Our younger team members have tried to help out and our senior members have clearly set aside time to get the ROV into good working condition.

Technical - One major challenge that we ran into while building the I2C interface between the Arduino Mega and the Raspberry Pi, was that the connection would occasionally be disrupted for no apparent reason, and both devices had to be reset in order for it to be reestablished. To fix the problem, we systematically tested both devices to see where the problem might lie. We finally narrowed it down to an Arduino problem, as the Pi seemed to be functioning properly during the loss of connection. At first, we thought that the Arduino code might be hanging up somewhere, so we inserted a simple blinking LED to see if this was the case. This, however, was not the case, and we then narrowed it down to a problem with Arduino I2C library. We eventually came up with a solution in which the Arduino would look at all the data it received, and, if the data indicated that the I2C connection between the Arduino and the Pi had been lost, it would use the Arduino's function to initialize the I2C connection to 'reset' the connection from the Arduino's end.



Budget

The initial budget was \$500 for total project spending, with actual expenses being very close to this target. We were able to reuse our tether, some propellers, the Arduino Mega, electronic components, bilge pump cartridges, pressure housings, and camera from last year. This saved us a lot of money, with new expenses for propellers and propeller adapters, motors, cutting boards for the frame, electronics, plastic housing, tools, and a Raspberry Pi. We were also able to save on tools and other components by designing them ourselves and making them from basic building materials. Since everyone actively contributed to the project, there were many opportunities for ingenuity, which led to greater efficiency with our available funds. This year, our team also worked quite a bit on fundraising. Through multiple fundraisers, we were able to raise over \$300 and get donated motor cartridges and software so out-of-pocket expenses were less than \$300, for a total ROV cost of \$507. The estimate for our international competition participation is \$2,400. Following are the income summary and the budget and expense summary. Refer to Appendix 3 for expense details and Appendix 4 for our team's schedule.

INCOME SUMMARY

Sponsors	Donations	Value
SPX Johnson	Bilge Pump Motor Cartridges - 2	\$80
DSS - Solidworks	Free Software w/ FMV ~ \$99	\$99
Individual	Fundraising	\$310
Individuals	Monetary Gifts	\$197
Total		\$507

BUDGET AND EXPENSE SUMMARY

Category	Poseidon Mk. II Re-use Value	Expenses	Budget
Electronics & Cameras	\$180	\$86.18	\$100.00
Frame	\$25	\$96.93	\$80.00
Pressure Housing	\$180	\$71.11	\$100.00
Propulsion	\$265	\$121.93	\$140.00
Tools	N/A	\$130.85	\$80.00
ROV Subtotal	\$650	\$507	\$500.00
Administrative	N/A	\$75	\$75
MATE 2014 - Total		\$582	\$575.00
Estimated Value of Poseidon Mk. III		\$1,157	



Teamwork

Our team has learned much about teamwork over the past year. Since two of our team members graduated and left the team, other team members needed to be trained to fill those positions. As a result, the senior members of our team took time out of their busy schedules to mentor the younger team members. Their desire to share their engineering knowledge and teach their younger teammates was a clear example of teamwork. Additionally, our team had several groups for different tasks (i.e. Tool Design Team, Graphic Design Team, Fundraising Team, etc.). Each small group had a leader who would formulate a plan for the rest of their group to carry out after each meeting, allowing our team to accomplish many fundamental responsibilities in a shorter time period. With such a small team, most of our teammates were involved in multiple groups, allowing them to learn about the different components of the ROV and, in the long run, learning more about the field of engineering. Working in these groups also allowed our team members to communicate with one another and better develop the significant role of teamwork.



Brainstorming Session

Lessons Learned

This whole competition has taught our team a great deal about business and the field of engineering. Procrastination has been a clear

problem for our team, but after this year, we have learned that we need to start working on the ROV earlier on in the year. By doing this, we would have more time for testing the ROV and improving it. On the other hand, one thing we fixed from previous years was our problem of not getting enough money to support our endeavor. With someone new in charge of fundraising this year, we were able to get back about one-third of the money we spent on our ROV. Fundraising was much more successful this year.

Future Improvements

There are always things that we would like to add to the ROV. While we did have lights on the front of the ROV, more auxiliary lighting would definitely be beneficial. Additionally, given the time and funds, we would like to upgrade our camera system to the type that we had initially planned to install this year, an HD system streamed over the ROV's network connection. Thirdly, we would like to split up our four vertical thrusters onto two different motor controllers, with the fore and aft thrusters being controlled individually. This would allow us to control the pitch of the ROV, and also compensate by adding more thrust in the front if we had to pick up a heavy object with the manipulator. Lastly, one thing we would like to add is Windows 8 compatibility, which we belatedly discovered that our ROV lacks.

Reflections

"This year, I learned a lot about the field of engineering, and even more specifically, the importance of graphic design in this field. My understanding of graphic design basics has grown tremendously over these three years I have spent on this ROV team. Although the technical side of the ROV did not come easily to me, I learned a great deal of knowledge and am grateful for what this experience has taught me. It has been a great learning experience."

Hannah Smith



“Over the past three years, my knowledge of the field of engineering has greatly increased. I also know I will be very thankful for this experience as I move on to college in the fall.”

Stephen Gahman

“ROV has helped me learn how ROVs are built and how much work actually goes into the building process.”

Timothy Gahman

“This year, I did a bit more work on tools and design than in past years. I really enjoyed the practical experience this opportunity gave me and I hope this team can continue participating in this competition in the future. I really have enjoyed my work on the team and am glad to have had a part in this valuable experience.”

Natalie Sampsell

“Nothing ever works the first time, and though this is frustrating I have come to realize that is to be expected and is a part of creating something new. MATE has been an incredible three years and I have appreciated the practical engineering experience this competition has given me. This is my last year on the pROVe team, as I will be heading to college in the fall, and I know this experience has challenged me and prepared me for my future career in engineering.”

David Sampsell

“I started participating in the MATE Competition last year. I was really excited, because it was a chance to use my newfound computer programming knowledge. Not only did I enjoy the team bonding experience before, during, and after the competition, but I also enjoyed learning about ROVs and Oceanering. This year I'm working on fundraising. This is a new experience for me, and I have learned a lot. Overall, I have had a lot of fun learning and experiencing new things, and am grateful of the MATE Competition for giving me this opportunity.”

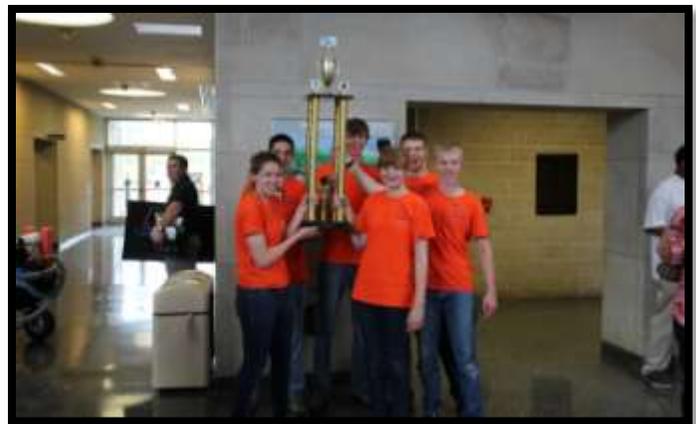
Ben Green



Working on the Tether



David Testing the ROV



Celebrating Win at PA Regional



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Acknowledgements

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Thanks to the following:

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XPS for donating supplies,
Kathy and Cyrus Nowroozani for generous pool access, and

We also thank:

God, for blessing us with an awesome team that was able to do their best, create lasting friendships, and put everything they had into this project, and our families who supported our work:

Gahman, Green, Sampsell, and Smith.

And as always, we would like to thank David Sampsell, our CEO, who spent countless days and hours working with our team and inspiring us when things didn't go right, which happened often.



Computer Setup When Testing



Testing the ROV



Appendix 1: Safety Checklist

Safety Protocol:

- Make sure that all electronics are not in the pool vicinity
- Confirm that all team members are wearing close-toed shoes
- Assure that no wires are hanging loose
- Make sure that all hands are safely away from the ROV
- Assure that communication between team members is operational
- Confirm that control box is properly connected and fully functioning

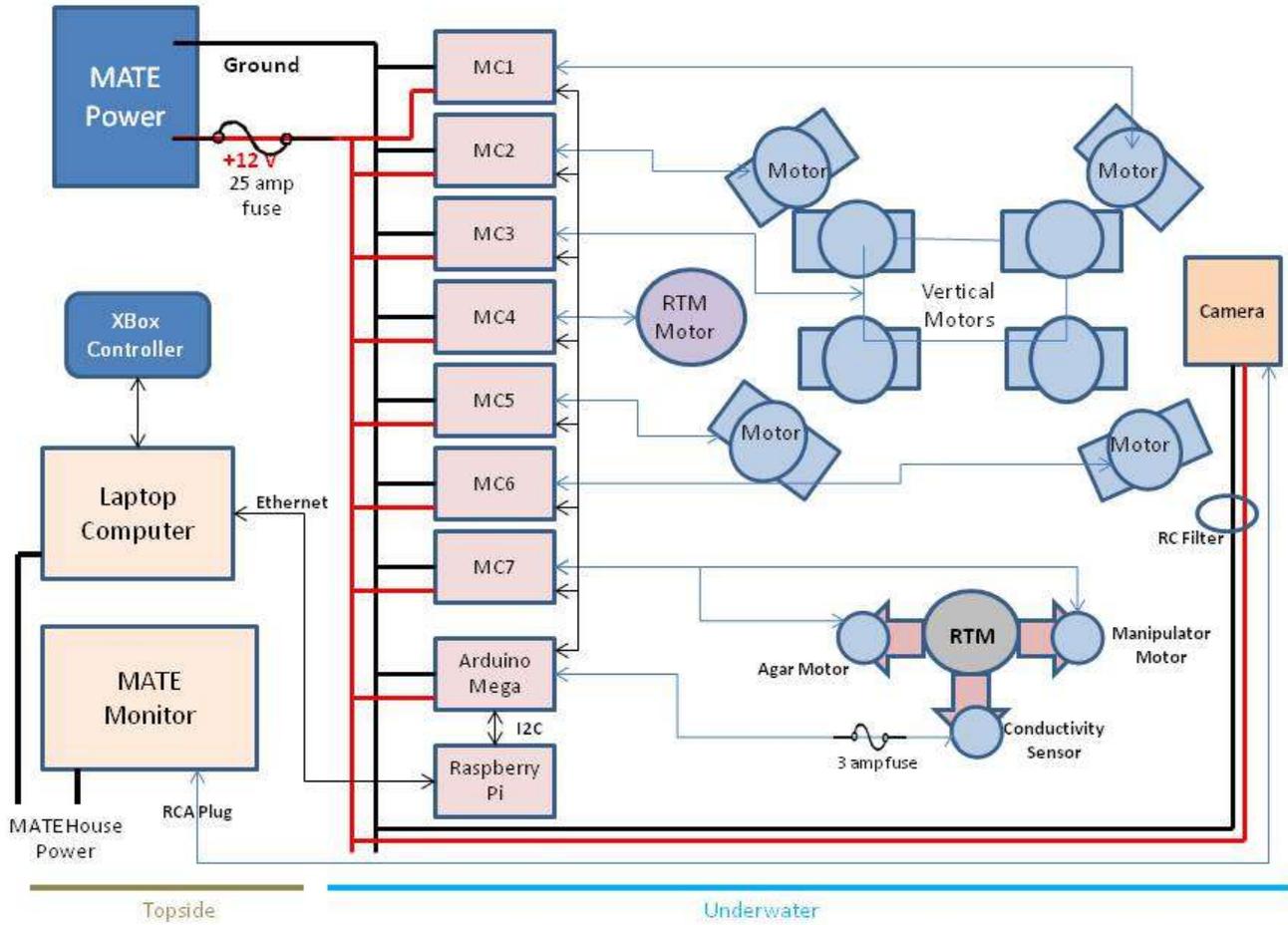
Tether Safety Protocol:

- Assure that the tether can be easily unraveled
- Confirm that no wires from the tether are hanging unattached
- Ensure that floats on tether are evenly spaced
- Make sure that the tether is not pulling on the control box
- Neatly coil the tether when testing is complete



Appendix 2: SID

pROVE – Systems Integration Diagram





Appendix 3: Expense Summary

Date	Supplier	Items	Category	Total Cost
7-Dec-13	Raspberry Model B	Raspberry Model B	Electronics	\$40.98
29-Mar-14	Bell Hardware	Fasteners, conduit, nuts, bolts	Frame, Tools	\$56.81
1-Apr-14	Chef Depot	Cutting Boards	Frame, Tools	\$106.44
5-Apr-14	Home Depot	PVC pipe, coupling, rope	Frame, Tools	\$15.60
7-Apr-14	Robot MarketPlace	Motors	Propulsion, Electr	\$60.00
15-Apr-14	FunRCBoats	Propellors	Propulsion, Electr	\$25.34
17-Apr-14	Amazon	USB car chargers	Electronics	\$13.95
18-Apr-14	DigiKey	Electrical components	Electronics	\$31.25
19-Apr-14	Sparkfun Electronics	Gear motors for RTM	Tools	\$39.41
19-Apr-14	Windsor Propeller Company	Propellor aadapters	Propulsion, Electr	\$36.59
21-Apr-14	McMaster-Carr	Housing, ball bearings, lipseals	Pressure Housing, Tools	\$71.11
24-Apr-14	Hobby Lobby	glue	Tools	\$9.52
				\$507.00



Appendix 4: Schedule

pROVe MATE Project Schedule 2014			Duration																
No	Description	Wks	Week 1 20-Jan	Week 2 27-Jan	Week 3 3-Feb	Week 4 10-Feb	Week 5 17-Feb	Week 6 24-Feb	Week 7 3-Mar	Week 8 10-Mar	Week 9 17-Mar	Week 10 24-Mar	Week 11 31-Mar	Week 12 7-Apr	Week 13 14-Apr	Week 14 21-Apr	Week 15 28-Apr	Week 16 5-May	
1	MATE 2014 Kickoff	1	█																
2	Overview of Competition and Goals	1		█															
3	MATE Rules/changes	1		█															
4	Marketing package to develop sponsors	1		█															
5	Budget	1		█															
6	Initiate design concepts & research	3			█	█	█												
7	Presentations to potential sponsors	3			█	█	█												
8	Frame, pressure housing, controls R&D	6				█	█	█	█	█	█								
9	Electronics Redesign and Build	11					█	█	█	█	█	█	█	█	█	█	█	█	█
10	Build ROV	4						█	█	█	█								
11	T-Shirt decision	2												█	█				
12	Finalize ROV	2														█	█		
13	ROV Testing and Practice	3															█	█	█
14	PA Regional Competition - 10 May 2014	0																	█