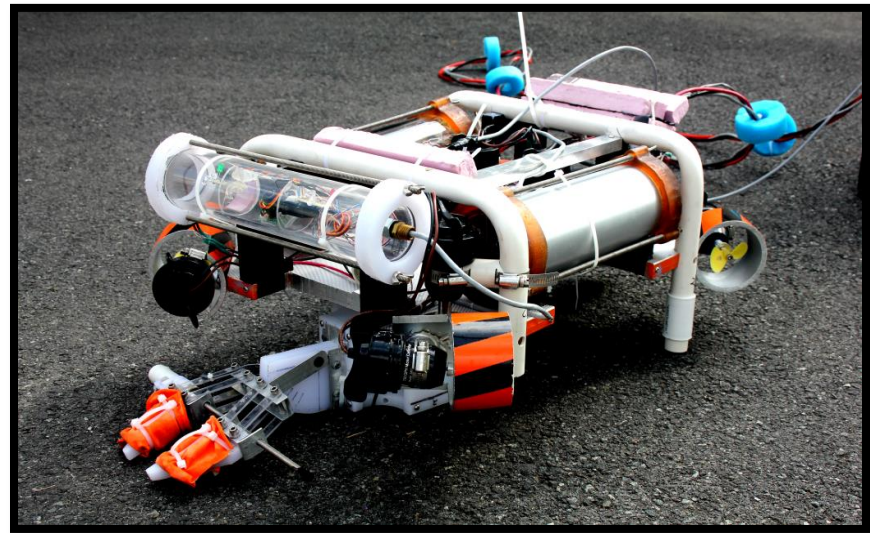


Pennsylvania ROV Engineers

▪ Allentown, PA ▪



Team Members

- | | |
|--|---|
| ▪ Natalie Sampsell
Chief Executive Officer, Grade 11 | ▪ Hannah Smith
Graphic Designer, Photographer, Grade 12 |
| ▪ Ben Green
Lead Programmer, Grade 12 | ▪ Noah Jarratt
Props Designer, Fundraising, Grade 11 |
| ▪ Timothy Gahman
Design Engineer, Grade 11 | ▪ John Sampsell
Props Designer, Safety Officer, Grade 8 |

MATE
2015
International
Competition
Technical
Report

Mentors

- Dave Sampsell
- Robin Sampsell
- David Green

Coaches

- David Sampsell
- Stephen Gahman

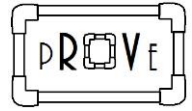


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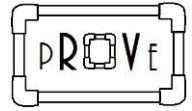
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Abstract

A company currently in its fourth 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 capable of performing a variety of tasks associated with the polar science community and the offshore oil and gas industry, including but not limited to data collection, instrument deploying, replacing pipeline, and preparing a wellhead. Our ROV (Remotely Operated Vehicle), Poseidon Mk 3.14, 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 Graphic User Interface, 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.



Team Alumnus Using Prototype to ROV Under the Ice



The Team

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

Natalie Sampsell is a 17-year-old high school junior. Although she has been on the team since the beginning, she only started leading the team this year. She enjoys acting, reading, listening to music, playing piano, skiing, and playing sports. Her future plans include pursuing a STEM career in college, with a possible major in Computer Science.

Benjamin Green is an 18-year-old high school senior. He has been homeschooled since Kindergarten, and some of his favorite hobbies include Ultimate Frisbee, board games, airsoft, acting, and Netflix. Since he first took a Computer Programming class a few years ago, he has been fascinated by Computer Science, which is his intended major.

Timothy Gahman is a 16-year-old high school junior. He enjoys golf, hunting, gaming, karate, and snowboarding in his spare time. In the future, he wants to pursue a career in engineering, possibly biomedical engineering.

Hannah Smith is a 17-year-old high school senior. In her spare time, she enjoys playing sports, hanging out with friends, watching movies, playing piano and guitar, and taking pictures. In the fall of 2015, Hannah plans to attend Liberty University to pursue a degree in nursing.

Noah Jarratt is a 17-year-old high school junior. This is his first year with pROVe. Some of his hobbies include snowboarding, running, gaming, playing piano, and relaxing with friends. He hopes to go to college and graduate with a major in business and a minor in communications.

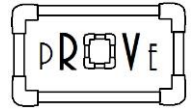
John Sampsell is a 14-year-old eighth grader. Although he has been around since the beginning of pROVe, this is his first year officially on the team. In his spare time, he enjoys gaming, playing football, watching sports, listening to music, and reading.



Noah Building Props



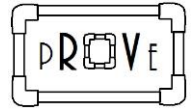
Hannah Helping Test the Camera



Budget

The initial budget was \$680 for total project spending, with actual expenses being just a bit under this projection. We were able to use our entire ROV from last year, so our only expenses were for tools, props, electronics, and administrative costs. Reusing last year's ROV saved us a lot of money, and 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. After taking into account free CAD software from Solidworks and donations from Home Depot, the total cost for this project was \$452.50. The estimated cost of attending the International Competition is \$7,700.00 for airfare, lodging, and miscellaneous travel expenses. All the funds for these expenses were privately donated by the families involved in this project, and any fundraising done by the team was for the purpose of paying back these families. Fundraising efforts commenced after the Regional Competition, and these have raised \$250.00 thus far. Following is the expense and budget summary. Refer to Appendix 1 for expense details.

EXPENSE AND BUDGET SUMMARY - 2015				
Category	Purchased	Donated	Re-used	Budget
Frame			\$125.00	\$120.00
Electronics & Cameras	\$100.22	\$90.00	\$375.00	\$120.00
Tools	\$82.44	\$25.00		\$150.00
Props	\$59.84	\$25.00		\$50.00
ROV Subtotal	\$242.50	\$140.00	\$500.00	\$320.00
Administrative (entrance fee, t-shirts, domain name, poster)	\$210.00		\$17.00	\$360.00
Project Total	\$452.50	\$140.00	\$517.00	\$680.00



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 when working on the ROV, 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. Outside of the electrical box, there is a small 25-amp fuse in case of a short circuit. If there is no fuse, the circuit will break at the weakest point, possibly being exposed to water. The fuse acts as this weakest point, and can be easily replaced. We attached black-and-orange colored kort nozzles to the horizontal propellers, and we designed the ROV's frame to surround the vertical propellers. This design protects body parts, wires, or anything in the water from getting caught in the spinning blades. The vehicle was designed with grab handles on both sides and the back 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 2.

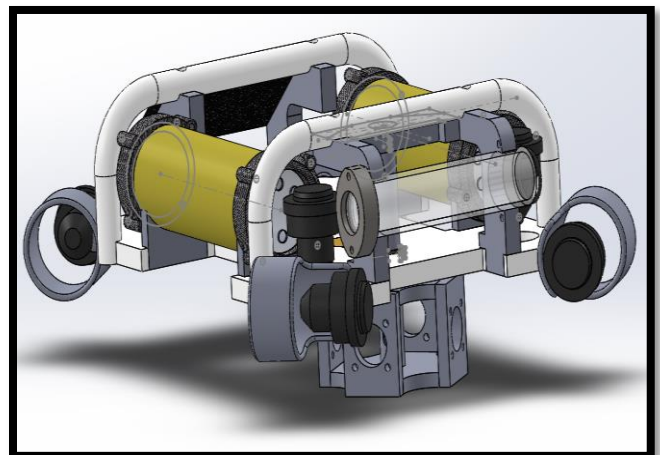
Design Rationale: ROV Components

Frame

A couple years ago, 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 by 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.

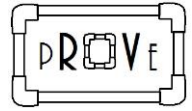
Another major feature of our ROV's frame is the Rotating Tool Mount, or RTM. The RTM basically consists of a 'carriage' or 'cage' that is controlled by a gear motor and rotates horizontally a full 360 degrees beneath the ROV. It has four sides, which allows us to mount four different tools. This way, 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.



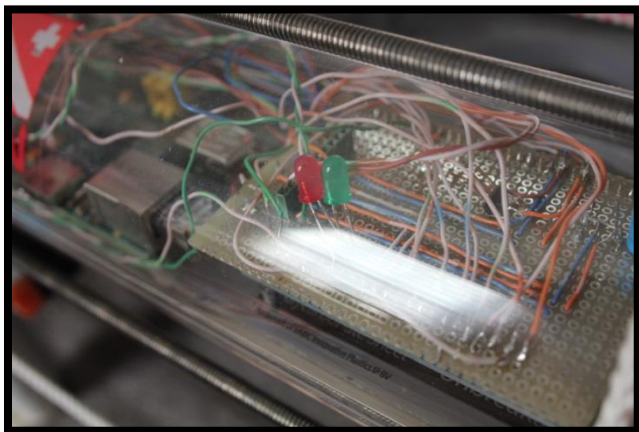
CAD of ROV Frame

Electrical

Team 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.



Arduino/Raspberry Pi Pressure Housing

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

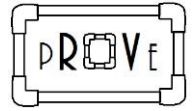
its own board, with a microcontroller managing the control electronics which operated the large power MOSFETS which did the actual switching of the current. Though it took a lot more time and effort than expected, the end result was a highly versatile motor controller design that was cost effective and 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 3.

Ballast

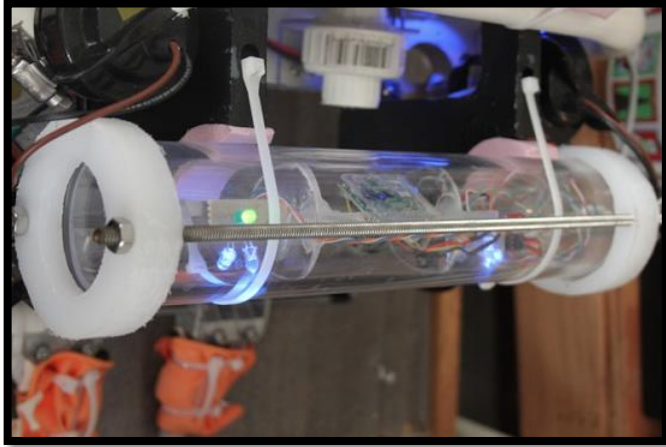
The tools attached to our RTM have some weight, and we have added a little more weight to the bottom of the ROV. This provides a significant amount of ballast. For flotation, we have pressure housings and some extra foam to counteract the ballast. The pressure housing design provides natural buoyancy, 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.



Camera Housing

Pressure Housing

Our ROV's design includes three main pressure housings: 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. This is because they provide redundancy in case of failure, and also because they allow 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 custom 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

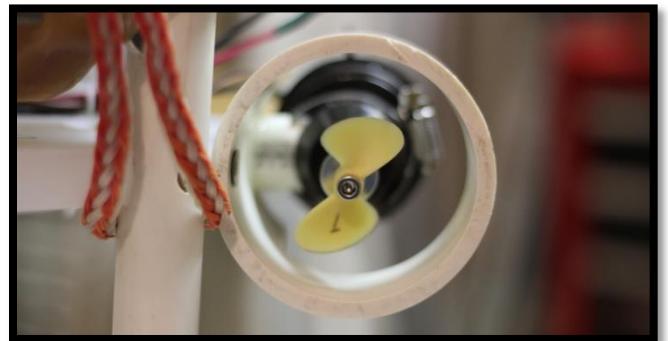
remove the caps in only a few minutes in case of a repair or upgrade.

Tether

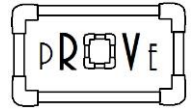
Our tether was designed to be thin, flexible, and maneuverable. Our control scheme is such that it only requires one category 5 cable for control of the whole ROV, as well as video capabilities for up to four cameras. Also in the tether are two 12 American Wire Gauge power wires that provide power to 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 affordable and flexible, but still maintained adequate voltage levels on-board the ROV. The communication protocol was made faster by increasing the bandwidth from 9600 baud to 100 megabits/second. The current setup is more reliable and alleviated problems with the serial connection not sending the signals consistently.

Propulsion

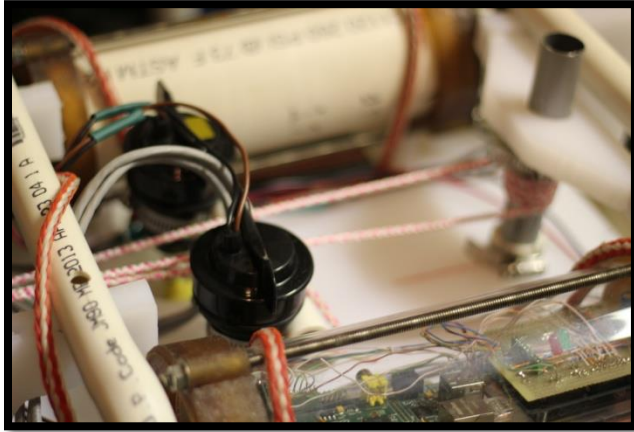
For propulsion of the ROV, the team opted to use Johnson bilge pump cartridges outfitted with Octura propellers. While a custom motor and housing setup might have yielded more power and efficiency, the team deliberated and decided that the Johnson cartridges provided quite adequate thrust at a reasonable cost and very low time investment.



Horizontal Thruster



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.



Vertical Thrusters

Our ROV uses eight thrusters, four vertical and four horizontal. This setup provides our ROV with enough thrust to move quickly in every direction. 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. These 1000gph thrusters produce 14N of forward thrust and 13N of backward thrust each, while drawing 5.75A running forward and 5.55A in reverse. Each thruster uses 69 Watts at full rpm while running forwards, and 66.6 Watts while running backwards. The vehicle draws less than 300 Watts of power when all the thrusters are in use. One thing that we 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, last year the team chose to order new adapters and propellers as well as to use higher quality stainless steel parts in our thrusters.

Programming

Realizing the importance of proportional control, we used an Xbox 360 controller. This controller provides multiple proportional-value inputs and several button inputs. We wanted to have

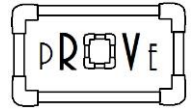
proportional control for practically everything, but one Xbox controller was insufficient, so we added a second controller for the extra proportional control. This requires a pilot to control the main movements, and a co-pilot to control the tools.

The main program running on our laptop was based off of the program we used last year, as the basics of the control were the same. The program 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. We added a major feature into the program last year. The program incorporates 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.

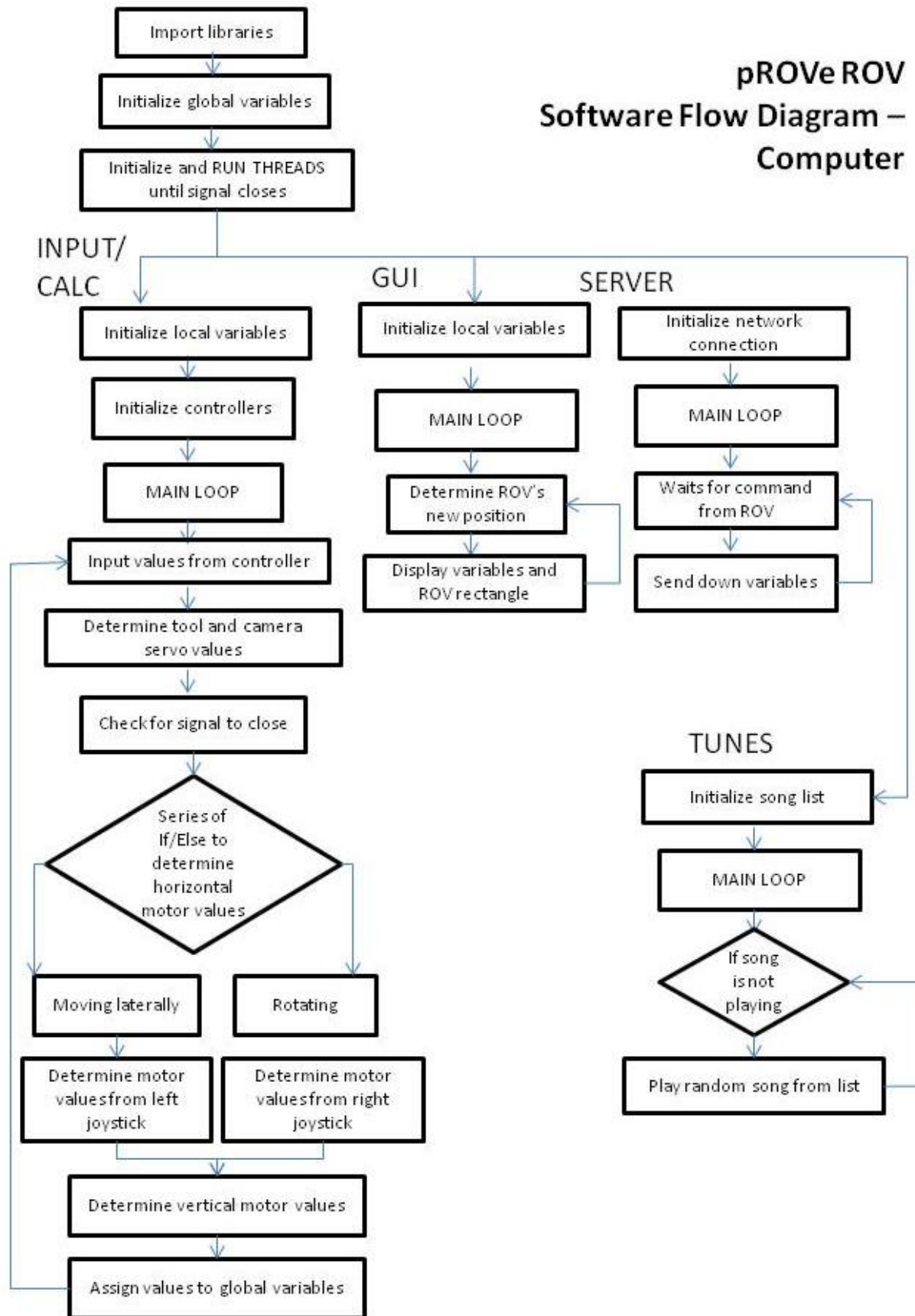
On the ROV, we have a Raspberry Pi, which is the client in the client-server relationship between it and the main program. Several times a second, it sends a command to the main program, which then sends down the variables. The Pi sends these variables to an Arduino Mega, which then transfers the variables to the proper motor controllers. A summary of the computer's control scheme is provided on page 9 of this report.

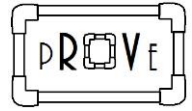


Ben Programming



**pROVe ROV
Software Flow Diagram –
Computer**



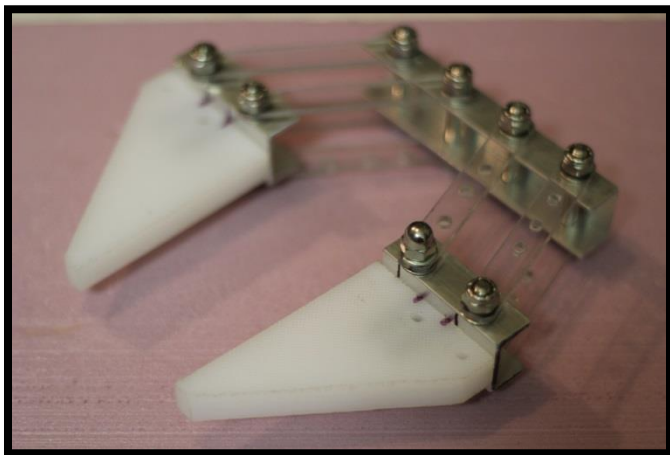


Payload Description

Mission Task 1: Science Under the Ice

This first task in this mission required teams to maneuver through a certain size hole in the simulated ice. Our ROV was built to be highly-maneuverable *and* compact, so no special provisions had to be made to keep the ROV small enough to fit through the hole. Whenever we designed a tool, however, we made sure to keep the overall size of the ROV in mind, just to make sure that nothing would make the length or width of the ROV exceed 75 cm.

After studying the rest of the missions in this task and the others, the design team decided that, similar to previous years, a well-functioning manipulator would be the key to maximizing our score. In this mission, tasks requiring a manipulator include collecting a sample of algae, collecting an urchin, and deploying a passive acoustic sensor. We have tried a variety of manipulator designs over our years being involved in this competition, and our current design is by far the most reliable and effective.



Manipulator Jaws

Our current design allows us complete control over the device while also providing us with sufficient clamping power. Our current manipulator uses a geared motor attached to a threaded rod. This setup allows us to move the clamping force of the motor in parallel with the

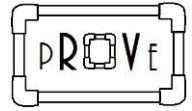
jaws of the manipulator. The main structure is composed of c-channel aluminum, Lexan, and cutting board, providing needed rigidity and precision.

Another task in this mission included measuring the dimensions of an iceberg and calculating its volume. To measure various aspects of the iceberg, we used a system that worked well for us last year. We found an image measurement program online called KLONK, which allows users to choose something in the image to use as a scale, and then proceeds to calculate any unknown distance the user chooses. We opted to use the widths of the iceberg's PVC as our scale, so all we would have to do was take a screen shot of the iceberg through our ROV's video feed and upload it into the program. This would give us all the measurements we needed without making us bring anything else down to act as our scale.

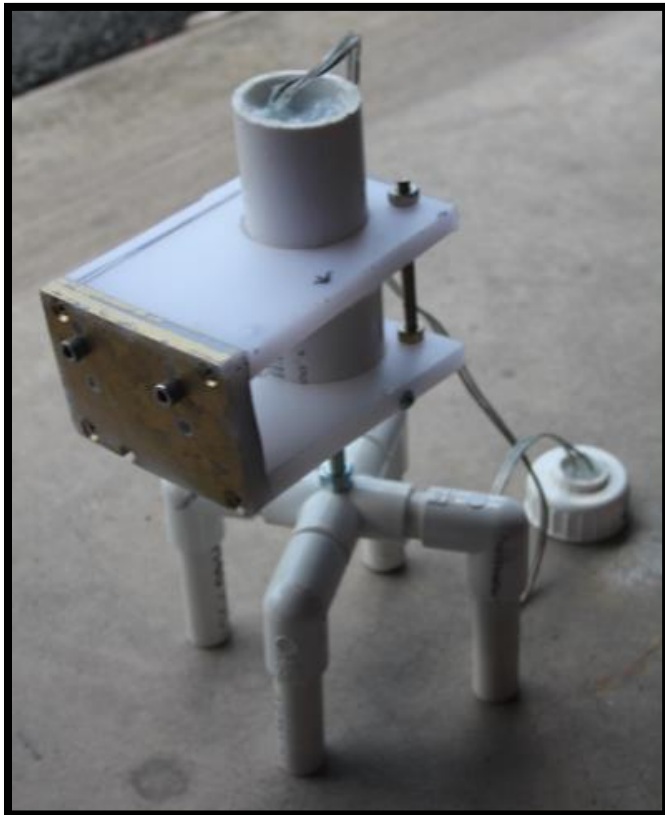
The last task in this mission required teams to determine the threat level of an iceberg. Our team opted to write a program in Python that would ask for the iceberg's keel depth and automatically determine the threat level. This program allows our team to complete this task quickly so that we can focus on other things during the missions.

Mission Task 2: Subsea Pipeline Inspection & Repair

This mission task involved conducting a close visual inspection of an oil pipeline, turning a valve, examining a gauge dial, measuring a length of pipeline, designing and attaching a lift line, "cutting" and removing a section of pipeline, and installing various pieces of the pipeline and a wellhead. The majority of these tasks could be completed with either the well-designed manipulator or the distance measuring technique already detailed under Mission Task 1. The two unique tasks in this mission were turning the valve and designing a lift line, both of which required new techniques.



Between the valve turning in this mission and the valve turning in Mission Task 3, we thought it would be in our best interests to design a tool for the sole purpose of turning valves. We did this by constructing a sort of “claw” out of PVC and attaching it to the end of a shaft attached to a waterproofed gear motor. We waterproofed this motor by putting it in a tight-fitting PVC pipe and sealing the pipe with a piece of Lexan and a cup seal on one end, and marine glue on the other end. We then attached the motor and extended claw to two pieces of cutting board to hold the tool upright. These pieces of cutting board attach to one of the four sides of our RTM. We powered the motor for this tool by attaching it to our “quick connect,” a plug that feeds right into one of our pressure housings. This setup allowed us to power the tool without feeding another line up the tether.



Rotating Tool

For our lift line, we wanted something that used a simple design, but could also be operated by our manipulator. Eventually, we used two “v”

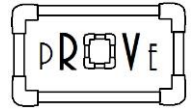
shaped pieces of cutting board connected by a bolt and attached to either side of a halved PVC coupling in such a way that the tool could be “opened” by pressing the two pieces of cutting board together. We then glued a magnet to each edge of the coupling. To attach the lift line to the pipe, our manipulator just has to hold this tool slightly open until it is around the grab point for the pipeline. When the manipulator lets go, the magnets cause the tool to snap shut. As the ROV moves on to complete other tasks, we can pool the pipeline up by pulling on the rope attached to either side of the lift line.



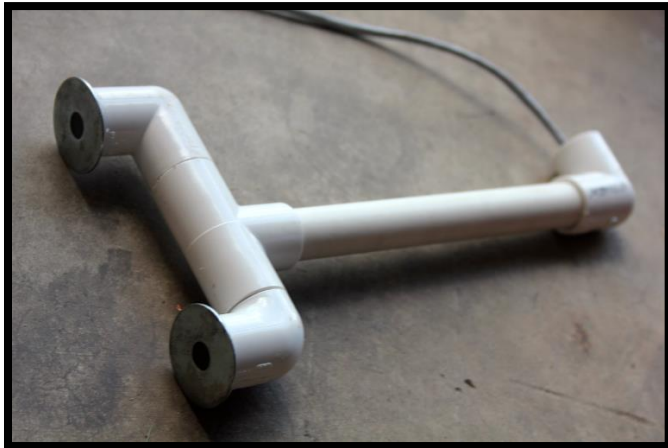
Lift Line

Mission Task 3: Offshore Oilfield Production & Maintenance

This mission task required teams to test the grounding of anodes by measuring voltage at specified points, measuring the height and length of a wellhead, turning valves to ensure a correct flow of oil through a pathway, and moving water through the pipeline system. The majority of the tasks in this mission could be completed using the manipulator and distance measuring technique detailed in Mission Task 1, or the rotating tool detailed in Mission Task 2. The two tasks unique to this mission were testing the grounding of the anodes and moving water through a pipeline system.



Our “anode sensor” is comprised of two wires of a category 5 cable split between two PVC probes. At the end of each of these probes, we attached a washer in such a way that the stripped end of each wire was pressed between the washer and the end of the PVC pipe. This tool was attached to one of the four sides of our RTM, and we sent the category 5 cable up through our tether to attach to a voltage meter at the surface. To use this tool, we just have to touch one washer to the test point and the other to the common ground. At the surface we will get a reading that will allow us to determine whether the anode is properly grounded.



Anode Sensor

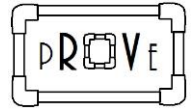
To move water through the pipeline system, we decided to use a technique rather than a tool. We plan to move the water by positioning one of our thrusters directly in front of the start of the pipeline. We thought that this would provide enough force to push the water through the system.

Challenges

Our biggest challenge this year was more team-related than technical. Our CEO (also the electronics specialist) and our lead designer graduated from high school last year, so our principal challenge this year was working together without their massive amount of knowledge and experience. Our current CEO and our current lead designer had much smaller roles on the team in previous years, and when

they decided to step up into the roles left behind by the graduates, they really had to jump right into working with a lot of systems that they previously had had little knowledge of. To give the new lead team members time to adjust to their new responsibilities, our team focused on designing ways to complete the mission tasks that would be both simple and effective. Although the loss of two of our major team members was difficult, our team members were able to overcome this by focusing on learning and by challenging themselves to use their previous experience and engineering skills to tackle new parts of the project. By being forced to expand and implement their knowledge and skills, our team members were able to both grow as engineers and leaders, and realize that they knew a lot more about engineering than they thought they did.

Our other main challenge this year had to do with scheduling and timing in general. Work on the ROV really started in late December, which did not leave us with as much time as we might have liked. With two seniors and a few very busy juniors on our team, we had a lot of trouble finding time for the entire team to meet. We were able to overcome this by doing a lot of work in small groups. This system worked fairly well, as our mentors always had their garage open for work, and so team members were able to come and work whenever they had some time. The last problem we faced was really caused by the weather. Our main testing area for the past few years has been our neighbor’s outdoor pool, which they always have opened just before we need to start testing the ROV. Unfortunately, we had a very cold and late spring this year, and so our neighbors opened their pool a bit later than usual. Although this was a bit inconvenient, we were able to test a lot of systems out of the water, and we spent more time working on mission props and tools, so that when the pool opened, we could make the most of our time.



Lessons Learned

This competition has taught our team a variety of both technical and non-technical lessons. This year in particular, as our team had to adjust to the loss of our key engineers, we learned a lot about the design process. As a result of this competition year, our new key team members learned how to analyze mission tasks, come up with effective solutions, and see the actual fabrication process through from start to finish. Problem solving is a key skill for any engineer, and our team learned to use a variety of resources to design solutions that both solve immediate problems and work with the ROV as a whole.

In addition, Team pROVe has learned many things about time management. 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. Our team has learned that creating a schedule and sticking to it is important, and we hope to implement this fix into our future years of competition.

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 for operating in low-light conditions. 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. Although our current camera system has worked well for our purposes, an upgraded system would be the next step in improving our company's visuals. Lastly, we would like to add Windows 8 compatibility, which we belatedly discovered that our ROV lacks.

Reflections

"This year, I had to take on a lot more responsibility on the team, and I also had to work in some areas of engineering that I didn't have as much knowledge of. I'm really glad I was able to participate in this year's competition because it pushed me to learn new skills and try my hand at some fields of engineering (mechanical, electrical, etc.) that I hadn't had a lot of experience with before."

Natalie Sampsell

"The MATE Competition has had a significant impact on my life for the past three years: my programming knowledge and experience has increased significantly, working on a team has helped me improve my collaboration skills, and this year I was able to build and host a professional website that our team is currently using. This year may be my last year with the MATE Competition, as I am graduating, but I will always remember these years as some of the most intellectually exhilarating of my life."

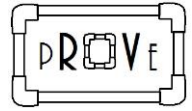
Ben Green

"I made fantastic friends on the pROVe team, and I've really enjoyed working with people who share my interest in engineering. This experience really helped realize that I want to pursue a STEM career in college."

Timothy Gahman

"After being on Team pROVe for four years, I have learned a lot about ROVs and marine careers. I've particularly enjoyed working alongside my teammates and collaborating with them on such an impressive project. Although I am not planning on pursuing a marine technology career, I feel like this experience has expanded my knowledge and will prove helpful in the future."

Hannah Smith

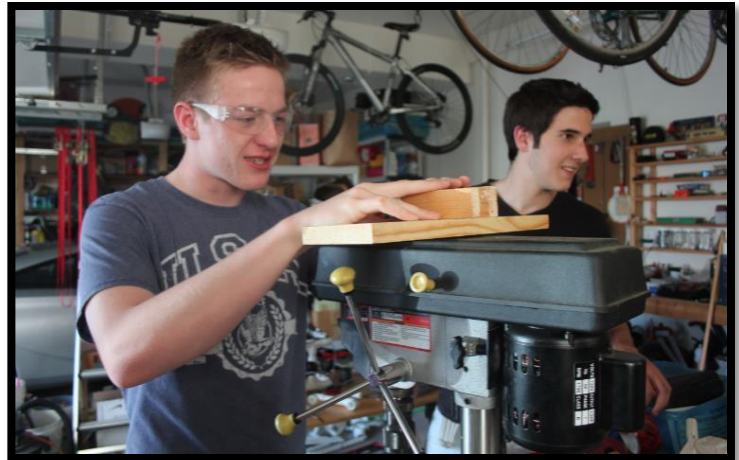


“This is my first year on Team pROVE, and I thought it was a very good experience for me, as it introduced me to ROVs and to more practical engineering.”

Noah Jarratt

“I learned many technical things during my experience with the ROV. As the youngest sibling of this team’s starting family, I’ve been around for the first three competitions this team has participated in, but this is my first year actually being on the team. I had a lot of fun helping out where I could, and I’m glad I could participate on the team this year.”

John Sampsell



Noah and Tim Working



Natalie Sketching Tool Designs



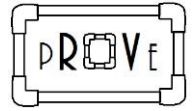
Sales Presentation at Regional Competition



Mission Run at Regional Competition



Winning at Regional Competition



References

- *Underwater Robotics: Science, Design, and Fabrication* by Steven Moore, Harry Bohm, and Vickie Jensen
- *Make: Electronics* by Charles Platt
- *Encyclopedia of Electronic Components Volume 1: Resistors, Capacitors, Inductors, Switches, Encoders, Relays, Transistors* by Charles Platt
- *Beginner's Guide to SolidWorks 2011 Level 1* by Alejandro Reyes
- <http://www.arduino.cc/playground/Interfacing/Processing>
- <http://www.solidworks.com>
- <http://www.homebuiltrovs.com>

Acknowledgements

Thanks to the MATE Center, the National Science Foundation, Velda Morris, Jane White, Video Ray, Villanova University, and many others for hosting the Pennsylvania Regional ROV Challenge.

Thanks to Jill Zande, the Marine Institute of Memorial University of Newfoundland, the National Research Council's Ocean, Coastal, and River Engineering facility, and many others for making the MATE International Competition possible.

Thanks to the following:

DSS SolidWorks for their awesome CAD software,
Home Depot for donated supplies,
Ed O'Reilly from Air Products for troubleshooting help,
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, Jarratt, Sampsell, and Smith.



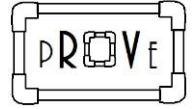
Soldering



Tether

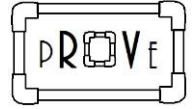


ROVing Under the Ice



Appendix 1: Expense Summary

Date	Type	Supplier	Items	Category	Cost
1-Dec-14	Re-use	pROVe Team	main ROV body	Frame, Electronics	\$500.00
1-Jan-15	Purchase	Domain	Domain name	Admin	\$35.00
15-Jan-15	Purchase	MATE	Competition Fee	Admin	\$100.00
20-Jan-15	Donated	DSS SolidWorks	CAD Software	Electronics	\$90.00
22-Jan-15	Purchase	Dan Green	XBOX Controller (used)	Electronics	\$20.00
28-Jan-15	Purchase	Home Depot	Props - PVC, Cord, etc.	Props	\$17.18
28-Jan-15	Donated	Home Depot	Props - PVC, Cord, etc.	Props	\$50.00
30-Jan-15	Purchase	Bell Hardware	PVC Coupling	Props	\$1.05
7-Feb-15	Purchase	Sparkfun Electronics	Couplers, Shaft	Tools	\$18.50
7-Feb-15	Purchase	Robot Marketplace	Motor	Tools	\$31.35
13-Feb-15	Purchase	Home Depot	Nuts and Bolts	Tools	\$3.99
14-Apr-15	Purchase	Bell Hardware	PVC, Magnets, Marine Glue, etc.	Props, Tools	\$33.21
17-Apr-15	Purchase	Amazon	Raspberry Model B	Electronics	\$44.44
25-Apr-15	Purchase	WalMart	SD Card	Electronics	\$15.78
29-Apr-15	Purchase	Sparkfun Electronics	Coupler	Tools	\$9.00
29-Apr-15	Purchase	Robot Marketplace	Motor	Tools	\$27.99
1-May-15	Purchase	Amazon	Raspberry Model B (used)	Electronics	\$20.00
7-May-15	Re-use	pROVe Team	Poster Board	Admin	\$17.00
7-May-15	Purchase	Staples	Poster Printing	Admin	\$75.00
					\$1,109.49



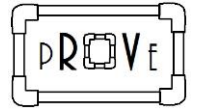
Appendix 2: Safety Checklist

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 3: SID

pROVe – Systems Integration Diagram

