SURE Robotics

Seawolves Underwater Robotics Engineering

Seawolf VIII

2019 Technical Documentation

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I. Introduction

Abstract

The Seawolf Underwater Robotics Engineering (S.U.R.E) company has built a new and exceptional ROV capable of inspecting and repairing dams, preserving historical artifacts and maintaining healthy waterways. S.U.R.E is located in Wesson, Mississippi, and has over eight years' experience in building ROVs. Over the last year our company members met twice a week for two to three hours a meeting, brainstorming design ideas, building and tooling our latest ROV. Multiple testing and redesigns of tooling were completed to ensure a high-quality end product capable of satisfying the request for proposal (RFP) issued by the Eastman company. The team members designed several specialized tools to meet the requirements of the RFP. A Micro-ROV, cannon lift, and an automated benthic organism detection device are a few S.U.R.E's specialized tools developed for Eastman's RFP. The Micro-ROV is capable of inspecting 6" or 15.24 cm pipe, while the specialized cannon lift is capable of raising a one-hundred twenty Newton cannon to the surface. The automated benthic organism detection device is able to identify benthic organisms autonomously. The design of this year's ROV is to ensure that Eastman can maintain healthy waterways, easily repair and inspect dams, and continue to preserve our nation's history.

The S.U.R.E. team *(Figure 1)* is organized into groups responsible for public relations, design, programing, and electronics to ensure maximum productivity. Many tasks require the entire team, which helps to strengthen bonds and communication. The team must work together in order to ensure that the robot is built on time and safely. Safety is important to the company and each member is taught how to properly use equipment and conduct themselves in a working environment. The design, programming, and electrical components of *Seawolf VIII* were strenuously tested to ensure safety and success in the work place.

Seawolf VIII is specifically manufactured to meet all the requirements of the missions. The main frame of the ROV is made of aluminum ensuring a strong and durable ROV. The circuit boards, which were designed in house, are contained in cast acrylic tube with six thrusters securely mounted to the aluminum frame.

This technical report will explain in detail the process and elements that went into the design and manufacturing of *Seawolf VIII*.

Figure 1: S.U.R.E. Company Members (L to R) Front: Carey William(Mentor), Trey Dorsey, Jesus Marcelino, Austin Platt, Payton Davis, Austin Coleman, Andrew Tanksley, Jenner McInnis, and Kevin McKone(Mentor).

II. Safety

A. Safety Reasoning

Seawolves Underwater Robotics Engineering (S.U.R.E.) maintains high safety standards. Safety is the most important factor in the workplace and each company member is taught proper safety precautions and is expected to uphold them. S.U.R.E. was required to participate in an OSHA safety briefing on slips, trips, and falls at the beginning of the construction of the robot to make sure each company member was trained on proper safety standards and the prevention of accidents in the workplace. Not only does S.U.R.E maintain an organized workspace but also company members who are trained in proper safety behaviors. The S.U.R.E. corporation ensures a safe and efficient working environment.

B. Safety Standards

During the construction of the ROV, *Seawolf VIII*, the team was required to meet certain safety standards. When power equipment was in use, each person was required to wear eye and head protection, as well as appropriate footwear and clothing. Proper safety equipment is provided for each worker, and basic safety rules are hung throughout the workplace. First Aid kits are also readily available *(Figure 2)*. When working with circuits and live wires company members wear proper clothing and make sure the electrical components are shut off. Each company member is expected to withhold the safety standards of S.U.R.E.

Figure 2 Safety hats and kits

C. Safety Properties

The underwater robot *Seawolf VIII* was built with safety in mind. The design has many safety features such as thruster guards covering the external thrusters, rounded frame edges to prevent injury while handling the ROV, and a waterproof electrical housing of the circuit boards sealing with dual O-rings. The frame of the ROV is made of aluminum, which is strong and durable. The bottom of *Seawolf VIII* is flat to ensure stability when out of the water and/or being transported.

Before submersion and use of the ROV, the team goes through the safety checklist (Appendix part A) to make sure each component of the robot is fully functional and there is a low risk of mechanical issues. During the use of *Seawolf VIII*, the robot continuously sends sensor readings to the pilot. These sensors report internal temperature telling the pilot if the robot is functioning properly. If the robot dysfunctions, the pilot can remotely shut it down.

III. Design Rationale

A. Overview

S.U.R.E spent many hours working together to create and assemble *Seawolf VIII (Figure 3)*. The main aspects of the construction were design, machining, and assembly. Teamwork and diligence were essential during the creation and testing of the ROV.

Figure 3 Seawolf VIII

B. Design

Several features of *Seawolf VIII* were inspired by *Seawolf VII*, S.U.R.E's previous ROV, which the company had great success with. The latest design of *Seawolf VIII* is for the RFP issued by Eastman, a company located in Kingsport, Tennessee. The design team created the ROV and tooling with great care, ensuring it would go above and beyond when completing the requirements specified by Eastman. *Seawolf VIII* is compact and light *(Figure 4)*, built for maneuverability in rivers and lakes. The ROV was built with tool such as the ability to deploy a lift bag and move heavy objects to the surface. Tools can also be quickly switched out, allowing for easy shifts from one task to another.

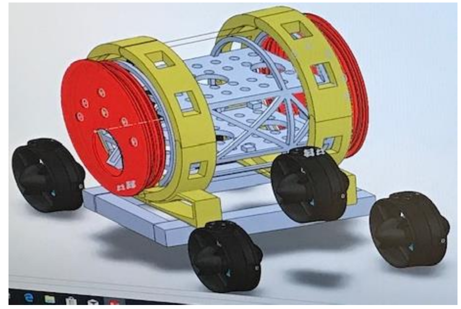
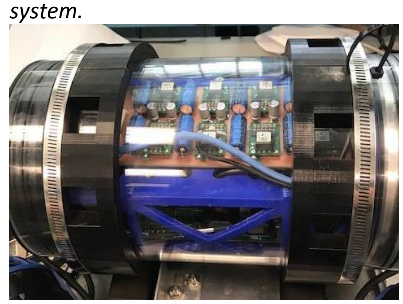


Figure 4: Early SeaWolf VIII design including plate, thrusters, end caps, electronic housing tube, and support structure.

S.U.R.E. had great success with Blue Robotics thrusters on *Seawolf VII* and chose to employ Blue Robotics again on *Seawolf VIII.* These thrusters are elegantly designed and cost friendly. The company previously used T200 thrusters for *Seawolf VII* but opted for T100 thrusters on *Seawolf VIII* because the ROV has six thrusters and electrical power concerns. These thrusters provide plenty of power to maneuver the ROV through any strong currents that it may endure.

Figure 5: Main ROV housing highlighting 3D printed ABS shelving system.



The design team opted to use one acrylic tube to house the electrical components of *Seawolf VIII*. All electrical components can be accessed with the removal of one end cap.

Figure 6: End cap of HDPE. Also pictured is small acrylic camera dome.

The tether of *Seawolf VIII* connects to the electrical elements through the end cap of the acrylic tube. This tube houses all electronics. Circuit boards are held in place inside the ROV by 3D printed shelves made of acrylonitrile butadiene styrene (ABS) *(Figure 5)*. The company chose this material because it is a strong and inexpensive plastic. One end cap of the ROV is made of HDPE *(Figure 6)*, which was milled in house using a CNC mil and the other is made of aluminum, also milled in house.

C. Machining

The ROV was designed in SolidWorks and machined in house with a combination of CNC and manual machines. The acrylic tube, which houses the electrical components, is the main structure of the ROV. Beneath the tube is an aluminum mounting plate that attaches the thrusters and tooling to the ROV. This plate was manually machined using a combination of bandsaw and hand tools. The feet are aluminum round bar stock machined on a CNC lathe (Figure 7).

Figure 7: A SURE technician constructing ROV feet on a CNC lathe.

D. 3-D Printing

Several components of *Seawolf VIII* were constructed using 3D printing. All electronics shelving, thruster guards, support assemblies, and camera tilt mechanisms were printed using ABS plastic. The shelf was designed and printed after the electronics of the ROV had been determined. All 3D printed components were painted blue for aesthetics and assistance for water proofing.

IV. Buoyancy

Seawolf VIII was designed to be its own source of buoyancy. While the ROV design was in SolidWorks, the complete ROV was changed to water to find the center of buoyancy. The material of the robot itself was then changed to aluminum, ABS and acrylic to find its center of mass. Finding the distance between the center of buoyancy and the center of mass helped S.U.R.E. conclude the amount of stability needed for the ROV. This, along with a vat test and pool test, helped determine that to be neutrally buoyant, *Seawolf VIII* would need to weigh approximately 22 N. The completed robot with tooling weighs 25 N. Experience has shown that the ROV needs to have a low center of mass to increase the stability of the vehicle. The low center of mass coupled with a higher center of buoyancy resulted in a very stable ROV. Using the mass properties identified and the understanding that additional tooling would be included later, S.U.R.E confirmed that this design would be stable and fit the needs of Eastman's RFP. Initial buoyance calculations were performed by the multiplying the volume of the ROV * 9.81 * 1,000kg/m^3.

V. Thrusters

Figure 8: T100 Blue Robotics Thrusters

S.U.R.E. selected Blue Robotics T100 thrusters *(Figure 8)* for *Seawolf VIII*. This model of thruster was preferable due to increased functionality, reduced finances, self-lubrication, size and power consumption. Each motor is run on an individual DC to DC converter due to current limitations. The motors run on 15V DC which is supplied to them via the converters. Each motor is capable of drawing 11.5A, which is 0.5A less than the output of a converter. The motor output is software limited to decrease current draw to a total of 16A for all 6 thrusters. A power budget was calculated using P=I*V=48V*30A, providing the total power usage allowed for the robot. This helped the company decide that these motors could be effectively used. The company previously used Blue Robotics T200 thrusters on *Seawolf VII* and were extremely satisfied with them. S.U.R.E. chose T100 thrusters for *Seawolf VIII* because the ROV is smaller and the T100s do not require as much current as the T200 thrusters. These Blue Robotics thrusters are also much more economical and user friendly than *Seawolf V's* Crust Crawler thrusters. T100 thrusters use water as a lubricant, which is cleaner and simpler than using grease. The thrusters are compact and work well with the small size of the robot; one thruster weighs only 120g in water. The ROV has 6 thrusters: 4 horizontal for forward, reverse, turning motions, and crabbing motions, and two vertical for up and down. Each thruster receives input via Blue Robotics penetrators. Several previous *Seawolf* models have used detachable bulkheads, but using penetrators has improved overall performance and cost. This year we decided to use a combination of bulkheads and penetrators.

VI. Tooling

A. Overview

The S.U.R.E. company created a series of specialized tools which diversify the abilities of *Seawolf VIII*. Tooling of the ROV includes a manipulator, a multi-tool, two electromagnets, and a cannon lift cradle. Tooling is located at the front and back of the ROV depending on optimal visibility and maneuverability. These tools set *Seawolf VIII* apart as it is called upon to assist in the needs of Eastman.

Figure 9: Blue Robotics Manipulator

B. Manipulator

A Blue-Robotics manipulator is installed on the front of the *Seawolf VIII*. It is the main tool for tedious operations such as installing new trash racks. This manipulator was chosen for its reliability and cost effectiveness.

Figure 10: Electromagnet incorporated into the trout fry release system.

C. Electromagnets

There are two electromagnets installed on *Seawolf VIII* to assist in the releasing of Trout Fry *(Figure 10)* and grout installation for dam repair.

Figure 11: Custom designed cannon lift cradle.

D. Cannon Lift Cradle

A custom manufactured lift cradle *(Figure 11)* was specifically designed to lift the cannon and other historical artifacts carefully to the surface. The lift bag sits deflated on the lift cradle ready to be deployed once the object has been safely obtained. The lift bag will be manually inflated to bring the cradle with the cannon to the surface safely and successfully.

E. Autonomous Image Recognition

Video input from the ROV front camera is routed to a surface laptop running OpenCV in Python. The video frames are captured, converted from color to gray, blurred, and then converted to a binary image. The binary image has an adjustable threshold to allow for different lighting. Using OpenCV's ContourArea, only objects on the video frame with non-zero pixels greater than 300 are looked at. These objects are then analyzed by OpenCV's ApproxPolyDP which approximates a contour shape to another shape with fewer vertices depending upon the precision specified. Once a shape has been found, all similar shapes are counted and displayed.

F. Micro-ROV

The Copiah-Lincoln Community College Seawolves have designed a Micro-ROV capable of traversing a 6” diameter tube with a maximum length of 2.4-m and minimum bending radius of 152 cm.

Figure 12: DOM Transducer

The micro-ROV is powered by two 9V batteries in parallel mounted inside the Micro-ROV. There is no power from the main ROV, Seawolf VIII, or the surface. The fiber transmits video from a USB camera on the micro-ROV to a mini media converter on Seawolf VIII, where the signal leaves through a cat5 cable to an Ethernet switch. The video signal is routed to a screen on the surface. All thruster control of the Micro-ROV is done using an X-box controller with control signals transmitted via Ethernet and fiber to the micro-ROV. All thruster signals are processed on the Beaglebone Black on the Micro-ROV. The software to process the thruster control was written in Python.

Figure 13: Mini Media Convertor

VII. Materials

A. Aluminum

The main ROV end cap (*Figure 14*) is made out of aluminum to help with heat dissipation and to assist with weight distribution. The base plate of the ROV is made out of aluminum. It was chosen because it is durable, easy to modify, and allows technicians to make easy adjustments at the worksite. It also provides flexibility in tool mounting.

B. Acrylic Tubing

All electronic components of *Seawolf VIII* are housed in one acrylic tube *(Figure 14)*. The company chose acrylic because of its durability and clarity. It is also more lightweight and scratch resistant than other plastics and glass. Acrylic is a thermoplastic; it can withstand a fair amount of pressure and cold temperatures. The clarity of the tubing allows the ROV cameras to have excellent visibility, and the company can easily check wiring inside the ROV without taking it apart.

Figure 14: Seawolf VIII acrylic tube and the main rear ROV end cap.

C. Plastics

S.U.R.E. chose HDPE marine grade high-density polyethylene as the material for front ROV end cap. The design team chose HDPE because of its superior strength, flexibility, and weight. The mounting structure for the ROV's acrylic tube is 3-D printed ABS plastic. Plastics are easy to work with and cost efficient.

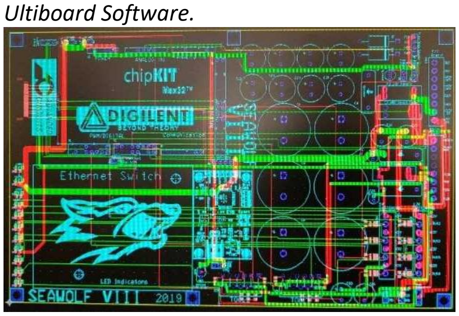
VIII. Electronics

A. Printed Circuit Boards

Seawolf VIII operates with two custom in-house designed circuit boards. These allow the Seawolf VIII to efficiently work on water dams. One board is four layer, and one is dual layer. The four-layer board which includes power filtering and low voltage control, was manufactured by Advanced Circuits because S.U.R.E. did not possess the means to easily make such a board while maintaining the quality of the design. The second board, manufactured in-house, contains all of the power supply conversions. A third board in the ROV is a purchased video encoder board.

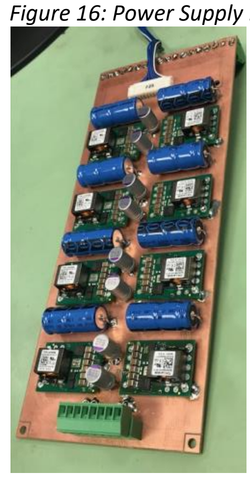
Main Board: This four-layer board (*Figure 15*) was designed in house, manufactured by Advanced Circuits and is responsible for receiving the supplied 48V DC and filtering the incoming voltage. It also houses the main onboard microcontroller, a Diligent ChipKit Max32. Other items found on this board are an Ethernet Switch, Razr IMU, connections for 4 temp sensors, two connections for servo outputs, connection for the Blue Robotics temp/pressure sensor, lighting outputs, actuator controls, and an ambient temperature sensor. This board is powered by the 5V and 12V DC to DC converters found on the power supply board. It has a 30A fuse for incoming voltage and fuses for both the 5V and 12V supplies.

Figure 15: Seawolf VIII Main board from NI Ultiboard Software.



Power Supply Board: This is a dual layer board (*Figure 16*) that was designed and manufactured in house. This board sits above the Main Board and is responsible for all voltage conversions. This board receives filtered 48V from the Main Board where it is then converted to the required voltages. There is a 5V and 12V DC to DC converter and six 15V DC to DC converters located on this board. It also houses the outputs for each motor. These include a Vout (15V), GND (ground), and PWM (pulse width modulation). A 13-pin connection to the main board receives the PWM signals and passes them to the output pin for the motors.

Figure 16: Power Supply Board



Video Encoder Board: This board was purchased and removed from its casing to reduce weight and size. It is powered via the Main Board and has two cameras connected to it. The video encoder allows for display of the ROV's two cameras. The encoder also contains a slot for a micro SD card that permits recording and downloading of video footage from the robot. This can be useful for documenting work while locating and recovering historic artifacts like Civil War era cannons and ordnance for Eastman in Northeast Tennessee.

B. Cameras

Seawolf VIII contains two standard definition CCTV style 1.2mm cameras *(Figure 17),* one located in the front of the ROV and the other in the rear, each in its own acrylic dome. This gives each camera plenty of room for a full range of motion. Both cameras receive power from the Main Board. Live video footage is sent through the tether of the ROV to a router, allowing the pilot visibility. As the surface controls are powered on, the video decoder connects to the ROV's video encoder board via the Ethernet communications link. This signal is then displayed on the TV. Having two cameras allows the pilot increased visibility as he is attempting to maneuver the ROV in compact spaces and through debris.

Figure 17: One of two cameras housed in Seawolf VIII

C. Tether

Figure 18: Outland Tether modified for Seawolf VIII

The tether provides power, GND, and Ethernet communications to the robot via 8 and 3 pin Seacon bulkheads. There is a 30A in-line fuse within 30cm of the surface power supply. Both ends of the tether have strain relief provided by carabineers secured to *Seawolf VIII* and the control station. The network router provides standard Ethernet connectivity to all the main parts of the control system. The tether also supplies air to the lift bag via an air tube. The company uses an Outland's Technology tether *(Figure 18),* which is already neutrally buoyant and durable, making it ideal for use while working on the water dams in Northeast Tennessee.

D. Depth/Pressure Sensor

The depth/pressure sensor on *Seawolf VIII* is made by Blue Robotics and uses a penetrator designed to be waterproof. The sensor also allows the ROV to hover at a specific depth while inspecting and making repairs to a hydro-electric dam.

E. Surface Controls

Figure 19: Router attached to TV where video footage is viewed

The ROV's surface electronics equipment includes an Outland Technologies tether, an Axis IP video decoder, a TV, a network router *(Figure 19),* and two laptop PCs.

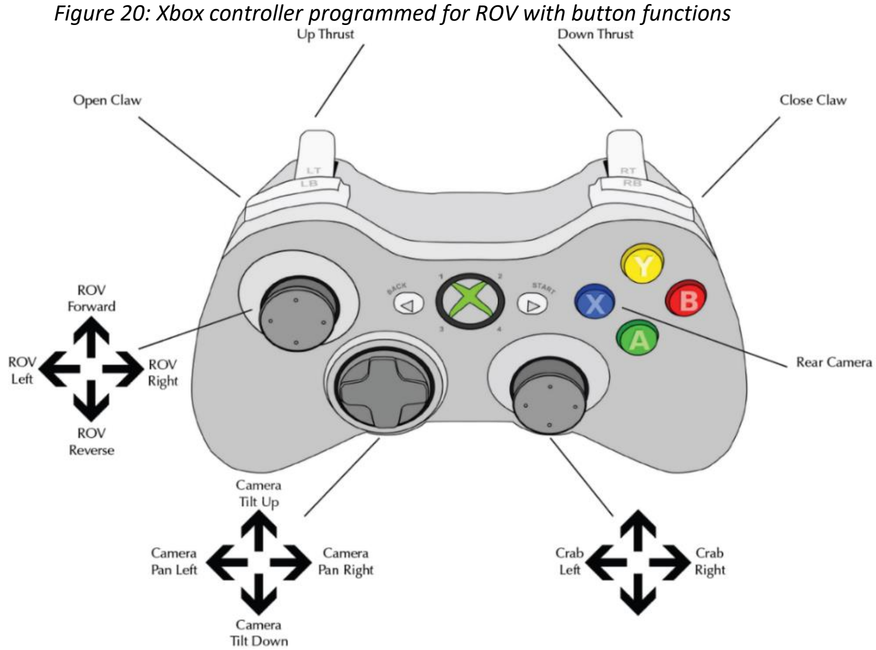
IX. Software

At the heart of the control system is a Microsoft Windows 7 laptop running National Instrument's LabVIEW 2017. LabVIEW's Graphical User Interface (GUI) is straightforward and allows commands to be easily employed but is still complex enough to handle the control inputs of our electronic systems. LabVIEW allows the laptop computer to conduct the bulk of data processing, which is preferable to putting the stress on the onboard ROV microcontroller. The LabVIEW software controls our thrusters, cameras, tooling, and the manipulator via an XBOX controller. The Razr IMU (inertial measurement unit) provides ROV positioning feedback to pilot via a horizon indicator in LabVIEW. This IMU includes a triple-axis gyro, a triple-axis accelerometer, and a triple-axis magnetometer.

Other indicators and controls found in the LabVIEW GUI are thruster power output settings, which allow for finely tuned movements, temperature meters, a depth gauge, actuator controls, and speed controls for the tooling. Additionally, there is an auto hover function using the pressure sensor. The sensor is a Bar30 which can measure up to 300 m and has a depth measurement resolution of 2 mm. This allows for a highly accurate auto depth management.

Based on input from the XBOX controller (*Figure 20*) and the GUI, LabVIEW determines what action the ROV needs to perform. LabVIEW then issues commands via the tether to the ROV's on-board microcontroller ChipKit Max 32. The Max32 then responds accordingly by directing all of the ROV's components to complete the necessary action. A second laptop is used for image recognition and control of a mini-ROV. This laptop uses Python to identify organisms and measure objects.

Figure 20: Xbox controller programmed for ROV with button functions



X. Logistics

A. Company Organization

S.U.R.E has four sub-teams. These four teams are responsible for design, programming, electrical, and public relations, respectively. Company members are placed in each sub-team based on their experience and interests. Having mini teams within the company allows the members to focus and specialize on certain parts of the construction and documentation of the ROV.

B. Project Management

S.U.R.E Robotics created a schedule at the first of the year for the team to follow to make sure all deadlines were met well before their due dates. The schedule was written on a board in the meeting room where all members could see it clearly and refer to it easily. The team met twice a week for three hours throughout the 2018-2019 year, during which they designed, manufactured, and constructed *Seawolf VIII*. The creation of the ROV happened in three phases: design, manufacturing, and assembly.

During the first phase, the company began to develop a plan for building the robot. A schedule and budget were created and S.U.R.E. decided on what materials to use for the new ROV, keeping in mind the conditions and tasks the robot would encounter as it preformed the missions required of it. With these aspects in mind, the design team formulated a blueprint for the ROV and created a model using SolidWorks. Through much trial and error, they designed a compact and sleek ROV with the maneuverability and versatility specified by the Eastman RFP .

After the initial design process, the electrical team used the blueprints of the ROV as a guide while creating the circuit boards and other components. The programming team began to create the program needed for *Seawolf VIII*, as well as the controller. The end caps of *Seawolf VIII* were milled and the acrylic tubing obtained.

The last phase of the construction of *Seawolf VIII* was probably the most challenging. The programming, design, and electrical teams worked closely together, combining their work. Once the bottom plate was completed, the company assembled the ROV and began testing it. Many factors had to be maintained and refined as the company created an ROV to meet Eastman's standards.

C. Finances

S.U.R.E. Robotics created a budget for the construction of *Seawolf VIII* by comparing budgets from years past and predicting likely expenses for the new ROV. This budget includes all expenses for the creation of the ROV as well as travel expenses for all company members and food costs for when the company works extra hours during meal times. The budget also considers the amount of money made during fundraisers and the money donated to the cause. The company started with a balance of twelve thousand dollars, which had rolled over from previous years.

D. Public Outreach

S.U.R.E. Robotics participated in many community outreach events during the 2018-2019 school year. Our first outreach event was in September of 2018, when we hosted a F.I.R.S.T. robotics camp on campus. Youth (ages 10-15) in the surrounding areas came and participated in a robotics class. The team served lunch and provided snacks for our visitors. In October of 2018, our school had its annual homecoming. The company set up a pool and showed the *Seawolf VII* from the previous year. Visitors could come up and drive the robot in the pool. In November of 2018, members of the company went to the Children's Science Museum in Jackson. The museum was hosting an event, and the team went to show the *Seawolf VII* to everyone and to talk about the construction of it. Also, in November, for two separate stations, a few members of the company went to a local radio station and did an interview about the company. The Seawolves talked about the building of our ROV and the company as a whole, including our outreach events. In March of 2019, the company hosted a karate competition on our campus. At the competition, the company served food and snacks to everyone. Also in March, our school hosted a junior high math competition. The company showed off some of the previous ROV's and allowed the students to drive the robot. Another outreach event was when members of the Seawolves attended an underwater intervention conference in New Orleans, Louisiana. This summer, the company will be hosting an ROV camp for our local high schools.

E. Budget:

S.U.R.E. 2018-2019 Budget		
Cash Income		
Contributions	Amount	Dates
Georgia Pacific	$5,000	5-Oct-18
Karate Spring Fundraiser	$752.30	30-Mar-19
Fall FTC Fundraiser	$1,694.94	8-Sep-18
Total Money Raised	$7,447.24	
Expenditures		
Supplies		Cost
3-D Printing		$564.82
PVC		$38.32
PVC		$34.64
Gripper		$329.00
T100 thrusters		$714.00
speed controllers		$150.00
pressure sensor		$88.00
Fiber Optics		$99.30
Router		$42.67
Electronics		$430.76
Registration		$300.00
Travel		$960.00
Hotels		$2,240.00
T-Shirts		$168.00
Acrylic Tube		$89.20
Rack		$40.00
Domes		$69.00
Total		$6,357.71

XI. Conclusion

A. Testing and Troubleshooting

During the construction of *Seawolf VIII*, each working part was tested before being connected to the ROV. After the robot was complete, the company began to run tests to check all working parts. Thrusters, cameras, tooling, and waterproofing were tested before the submersion of the ROV in SolidWorks to a depth of 20m. The first test in water was done in a large vat. One company member held the robot in place underwater while another controlled the ROV. Thruster capability was tested as well as waterproof seals. After the ROV was determined fit for deeper water, it was taken to a local pool and tested to a depth of 3m. During this time, the company perfected the set up and take down of *Seawolf VIII*, learning how to work together seamlessly while the ROV was in operation. The team created a safety checklist (Appendix A) as they worked through complications to ensure a safe ROV mission each time.

B. Challenges

S.U.R.E. Robotics experienced several challenges in the making of *Seawolf VIII*, which forced the team to work overtime and correct these mistakes. One of the problems was with the design of the robot. Halfway through the building of the robot, we had to find a new designer for the robot. This was a challenge because the new designer had to work on the design in a small time slot to get it completed, and he had to complete a design that someone else had started. This forced the team to move quickly with the construction of the ROV. One problem the team encountered was that the temperature of the robot was exceeding the shutdown temperature of the electronics. The company placed a small fan to circulate air in the electronics housing which brought the temperature to approximately 100 degrees Celsius. Another issue occurred during one of the tests of the ROV. While testing the ROV, the team noticed that the ROV was shutting down while in the water. After taking the ROV out and examining the ROV, a company technician noticed that water had gotten into the base of the ROV. The Seawolves went to work to figure out what was wrong. Members of the company who had constructed the ROV found that one of the end cap penetrators was not tightened all of the way. The Seawolves made sure that all of the electrical components were still working properly and put the ROV back in the water. While this was a relatively quick fix, everyone was reminded that one small mistake can cost the team huge amounts of time.

C. Lessons Learned

S.U.R.E. is made up of members from all different backgrounds with different experiences. Having a diverse company allowed for each member to learn about things they had never done before. Engineers were required to learn how to program using LabView, Python and to effectively use other software such as SolidWorks, PowerPoint, and Excel. Members learned how to work as a group to be more efficient, leaving less room for errors. The company had to problem solve constantly, which was great experience for S.U.R.E. members. Through community outreach the company-built relationships with the people around them and demonstrated how important robotics and engineering skills can be.

D. Future Improvements

One of the biggest issues this year for the company was poor time management. Because of this, the company was forced to work overtime during the last two weeks to ensure that everything was finished on time. To avoid this problem in the future, measures will be put into place to ensure each member is held accountable for completing the tasks required of them.

Another improvement that would greatly enhance the quality of the ROV would be to have easier access to the circuit boards. The way the robot was designed places all the main electrical components in one center acrylic tube. This created a unique and sophisticated look, but hindered accessibility to the circuit boards. The circuit board set-up could be enhanced by having quick release adapter that holds the PCBs in place.

E. Reflections

Jenner McInnis (CEO): "As the lead designer and president for this year's company, I had a lot of fun designing the ROV in Solid Works. Although I was required to work long hours, it was neat to see how the robot came together. I will be able to use things I learned in my future job."

Andrew Tanksley: "My main job this year was to construct the ROV. I had a lot of fun putting the ROV together and testing it in the water. I will be able to use many of the things I learned this year to help me in my future job."

Austin Coleman: "As a team member who worked closely on the building of the robot, I thoroughly enjoyed being a member of the team this year. I was required to work long hours, but learned a lot during the construction of the ROV that will help me in my future schooling and jobs."

Payton Davis: "As the technical report writer for this year, I really enjoyed working with the team to design and build a robot. I have learned a lot, and I can't wait to see how the robot does at competition."

Trey Dorsey: "I was the public relations director for this year's robot. I enjoyed working with the team to advertise the robot and put community outreach events together."

XII. Appendix

A. Safety Checklist

Set Up Procedure:

1. Check that all company members are wearing safety glasses and closed-toed shoes
2. Check work environment and ROV for any hazards (sharp edges, untidy cables, et/slippery area)
3. Check that power supply is off
4. Inspect electrical components and connections for water proofing
5. Connect surface computer to router
6. Connect coder to router
7. Connect tether to router
8. Connect tether to power supply
9. Connect tether to ROV
10. Connect power strip containing surface laptop, TV, router, power supply to external power supply

Initial Power Up:

1. Co-pilot powers on TV, router, and surface laptop
2. Co-pilot announces "power is on" as 48V power supply is turned on
3. Tether manager affirms electronic status lights are correct and alerts pilot and co-pilot
4. Launch team places ROV in water and keep it immobile
5. Launch team checks for leaks in the ROV (If leaking, refer to "Failed Leak Test")

Launch:

1. Launch team releases ROV as co-pilot starts timer
2. Tether manager calls out "ready"
3. Pilot takes control of ROV and begins mission tasks
4. If communication with ROV is interrupted, refer to "Communication Issues"

Retrieval:

1. Pilot steers ROV to pool side for launch team to retrieve.
2. Co-pilot calls "Ready to remove ROV"
3. Launch team removes ROV from water and tether manager calls "ROV is out of pool"
4. Co-pilot stops timer

Shut down:

1. Co-pilot calls "shutting down" before powering off ROV.
2. Co-pilot shuts down surface laptop, router, TV and power supply
3. Tether manager disconnects tether from ROV.
4. Team packs all gear

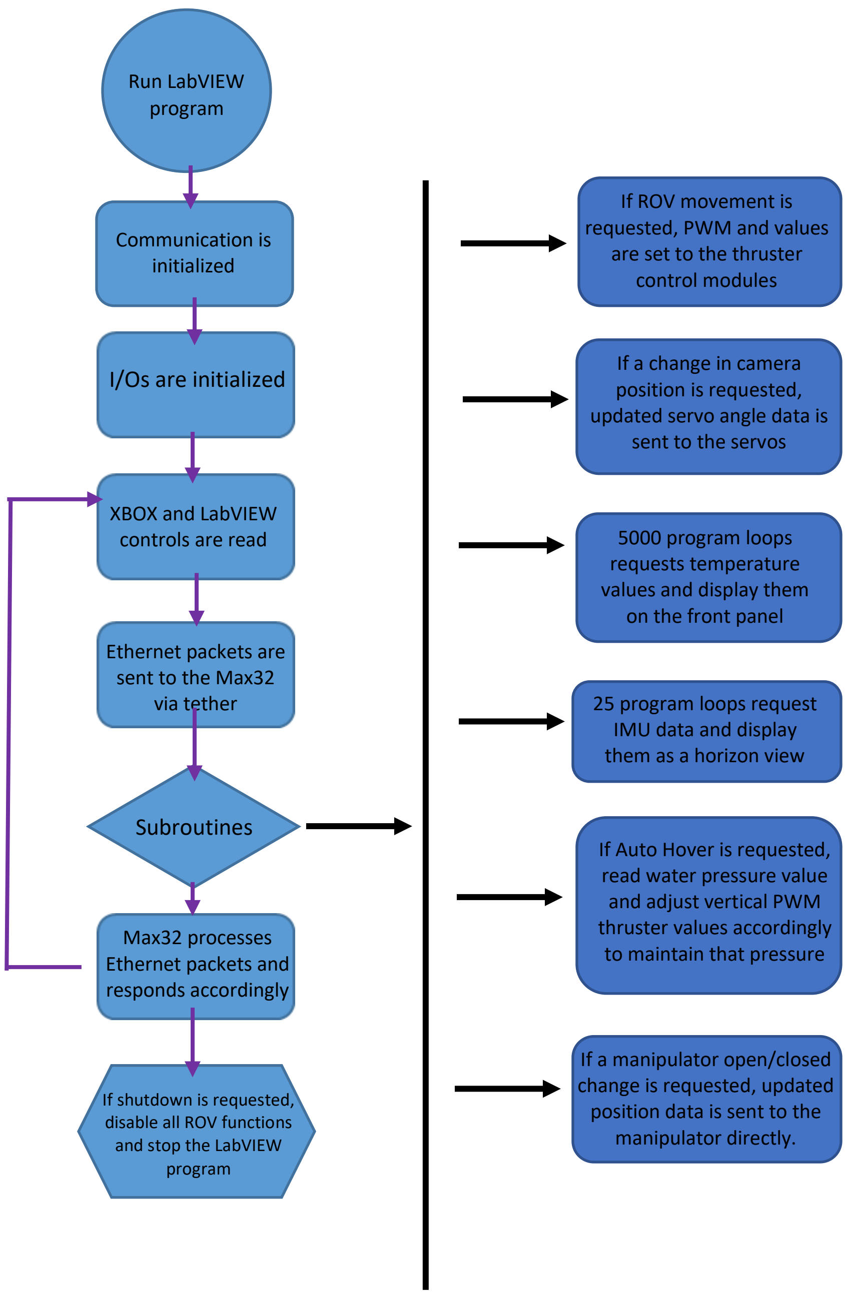
Failed Leak Test:

1. Pilot brings ROV to pool side
2. Co-pilot calls "shutting down" and powers off ROV
3. Launch team retrieves ROV and begins troubleshooting
4. If problem is solved, begin process again with "Initial Power Up"

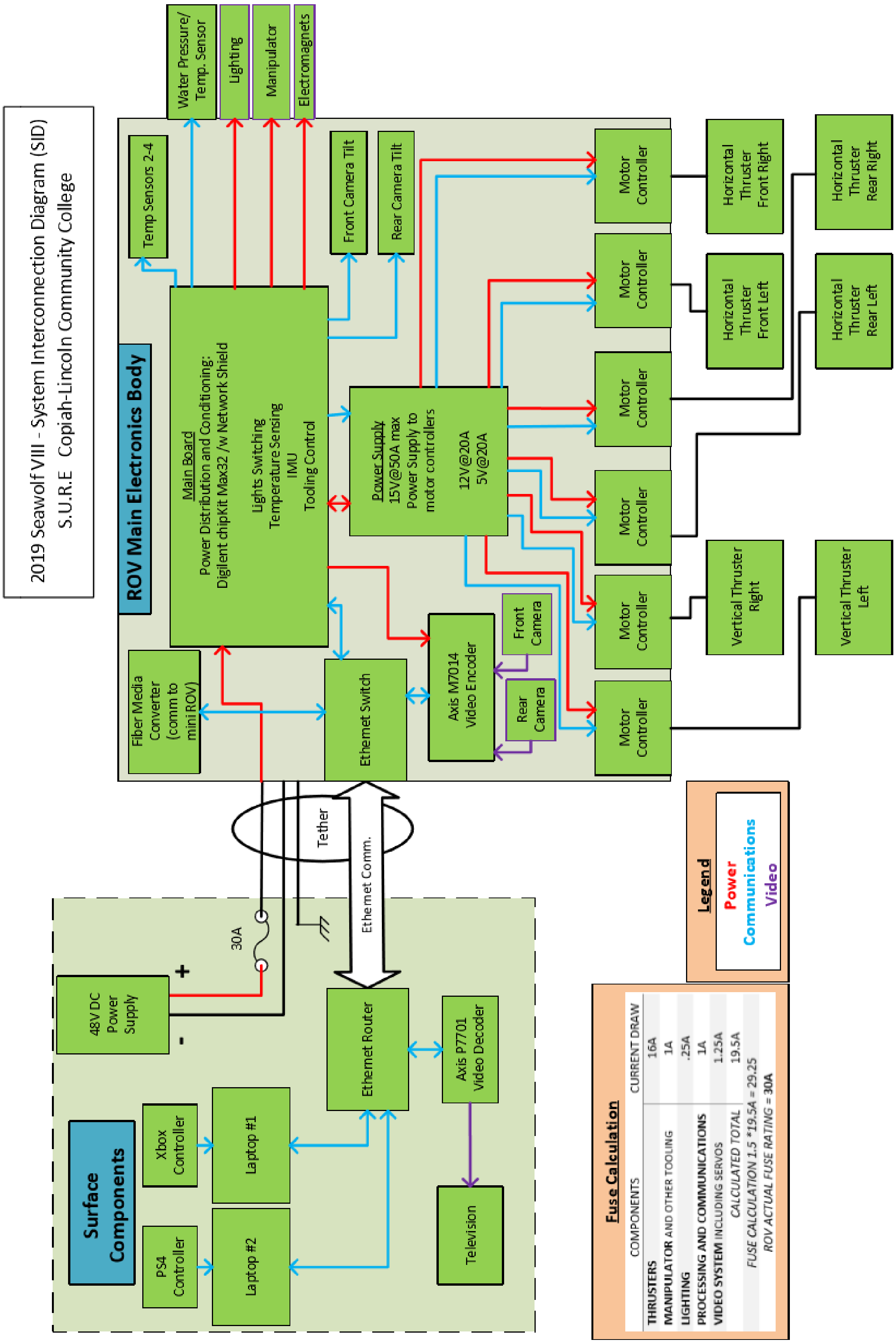
Communication Issues:

1. Co-pilot checks surface computer program for communication issues
2. Co-pilot checks serial connection to ROV
3. Co-Pilot checks if programs are running correctly
4. Pilot checks power supply
5. Tether manager checks tether for imperfections and connections

B. Software Flowchart



C. System Interconnection Diagram (SID)



D. Acknowledgements

Figure 21: Doug Hoy, director of Georgia-Pacific Monticello LLC Public Affairs/Communications, presents a donation of $5,000 to the Seawolf Robotics Team on behalf of the Georgia Pacific Foundation. Pictured from left: Dezirae Katt, Doug Hoy, and Joseph Crouse.

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MATE

Georgia-Pacific

COPIAH LINCOLN COMMUNITY COLLEGE

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