

S.U.R.E.

Seawolf Underwater
Robotics Engineering



SEAWOLF VI

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A. Abstract

The 2017 request for proposal asks for a remotely operated vehicle (ROV) capable of navigating the port of Long Beach, California. Specifically, the ROV must be efficient in design, compact enough to navigate the waters safely, and strong enough to withstand dangerous conditions in the port. A practical ROV is needed for these tasks because of the vast amount of commerce that is connected to Long Beach.

Seawolves Underwater Robotics Engineering (S.U.R.E.) is an education/technology company headquartered in Wesson, Mississippi, United States of America. Our eleven-member company focuses on physics, drafting, precision machining, electronics engineering, mechanical engineering, and business/entrepreneurship in order to deliver superior products and services. S.U.R.E.'s talented company members work rigorously as a team within a safe working environment to further technology and use education as the vehicle to drive progress in the future.

Seawolf VI is S.U.R.E.'s response to the demands of maintaining Long Beach Port, and is equipped to assist with missions such as marine transportation, efficient upkeep of the Fanfare Fountains, sediment recovery, and identification of debris from shipwrecks. The company utilizes technology such as Computer Numerical Control (CNC) milling machines; National Instrument's LabVIEW, AutoCAD, and SolidWorks software; and in-house 3D printing to provide a state-of-the-art ROV. Qualities such as teamwork, leadership, and a strong work ethic allow for an efficient line of products. S.U.R.E. is proud to present Seawolf VI: the best ROV to explore and provide care for Long Beach Port.



Figure 1 S.U.R.E. Company members (l to r) Front: Holly Steen, Dezirae Katt, Virginia Mullins, Kevin McKone (Mentor), Carey Williamson (Mentor), and Colby Phillips. Back: Mary Thornton, Aaron Tate, Timothy Stogner, Charlie Miles, Sam Brister, and Reginald King. Not Pictured: Abigail Hynum Wes Burkett and Celeste Williamson (Mentors).

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B. Design Rationale

1. Overview:

S.U.R.E. worked closely together to complete every phase of the building process. The three major steps of the process were designing, machining, and assembling. Efficient teamwork was crucial to finishing Seawolf VI.

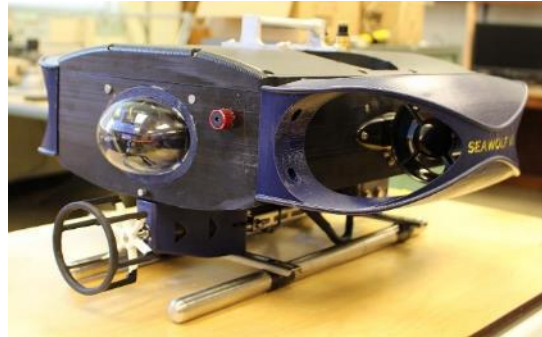


Figure 2 Seawolf VI compact and sleek design allows for simplified navigation of port waters.

2. Design

Thruster capability was an issue that the company needed to address after the *Crust Crawler* thrusters used on Seawolf V performed poorly. At the MATE awards ceremony in Houston, Texas, S.U.R.E. discovered the *Blue Robotics T200 thrusters* which have an elegant design and are very economical. S.U.R.E. built Seawolf VI specifically for these particular thrusters, and decided that two vertical and two horizontal motors would be most efficient for navigating Long Beach Port.



Figure 3 Long Beach Port

Much of the inspiration for Seawolf VI came from S.U.R.E.'s previous ROV model. Seawolf V inspired a design of one electronics housing unit with everything mounted on it to create easy access for electronic repairs and maintenance. Unfortunately, the dome that provided access to the internal equipment was directly bolted in, and the threads from the bolts would become filled with plastic requiring many of the bolts to be cut out. This inefficient design showed the need for an easily accessible ROV. With this in mind, Seawolf VI was built with easy access to the electronics through a lid.

During the body design process, S.U.R.E. decided that having one lid to access all of the internal equipment would be preferable. An O-ring was placed between the lid and the body of the robot to maintain a water-tight seal. This presented the concerns of how to affix the lid to the body of the robot and how to seal the acrylic domes. Initially the lid was to use a latching mechanism; however, the high density polyethylene (HDPE) material of the ROV did not hold much promise of success because the material proved difficult to mount the latches. The company then determined that a bolt solution would be necessary. The idea of bolting the lid down into plastic threads was dismissed due to the heightened possibility of stripping out the

bolts. Finally, the solution was to place stainless rods with threaded holes into the body of the ROV which gave Seawolf VI a secure mounting location for the bolts to pass through the lid.

With a general shape and design, the company needed to affix the electronics and tooling to the machine. In order to secure the electronics, S.U.R.E. designed and 3-D printed stands to secure the four circuit boards. This arrangement put two boards stacked atop one another on each side of the robot. A unique feature of this design includes, strategically placed holes placed into the frame floor instead of bolting the stands into the machine itself. Then the stands were printed to fit securely into the holes allowing both boards (one rack) to be removed easily and swiftly if repairs are needed.

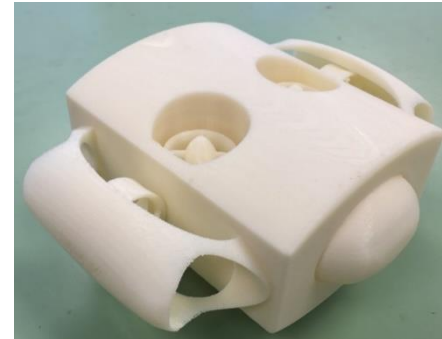


Figure 4 A 3-D acrylonitrile butadiene styrene (ABS) printout of the ROV

Originally, the design for tooling attachment included two rods along the bottom of the robot and printed clamps. However, the more reasonable approach was to mill pockets into the underbelly of Seawolf VI providing ports for the manipulator and valve turning tool. In addition, a hole was drilled into both sides of both ports to allow a pin to be firmly placed to hold the tooling. This unique feature allows for quick and efficient tool changes to customize Seawolf VI for various missions.

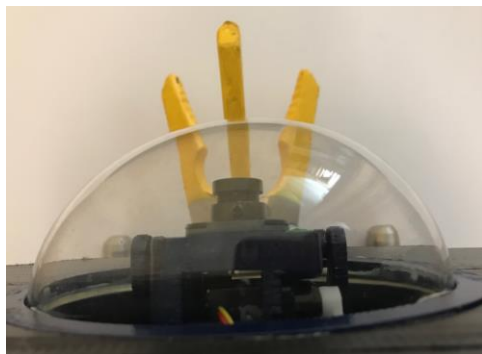


Figure 5 Domes are epoxied in place to provide an air tight seal to protect electronics and clear viewing for the cameras

Acrylic domes measuring 76x127 mm and 12.7 mm flanges were selected to allow full tilting motion for the cameras. Seawolf V was very buoyant, and the large dome was thought to a possible source of unneeded buoyancy. The company chose smaller domes to decrease the buoyancy on Seawolf VI. The electronics are accessible via the lid, allowing the domes to be epoxied in place making them water-tight and secure.

S.U.R.E. wanted to build on its accumulated knowledge from past models and use this to improve this year's model with the challenges of Long Beach Port missions in mind. Seawolf VI's design is sleek and has a low height which is beneficial when navigating tight spaces such as that found when maintaining the fountains in the port. The customized tools for this particular machine can be easily placed and removed to allow quick and efficient easily accessed if repairs are needed, and remains small and lightweight.

3. Machining

Seawolf VI was constructed and milled using both Computer Numerical Control Mill (CNC mill) and MasterCam software. The two primary pieces, which are the body and lid were milled on a

5-axis router. The body and lid had to be completed before the electronics could be fully designed and placed in the robot.

4. 3-D Printing

The board racks, thruster guards, dome rings, tooling mounts, and camera mounts were all 3-D printed using acrylonitrile butadiene styrene (ABS) material. After the electronics were fully designed, the board racks were printed to house them. The thruster guards were made to protect the motors from possible debris. The holes on the ends of the guards were kept close to the diameter of the thrusters to avoid impeding flow. The camera mounts feature a design in two pieces: a bucket for the camera and servo to attach to and a bottom frame for the bucket to rotate in. This is the same feature that the circuit boards use to mount into the machine. The dome rings were designed to provide additional sealing for the domes.

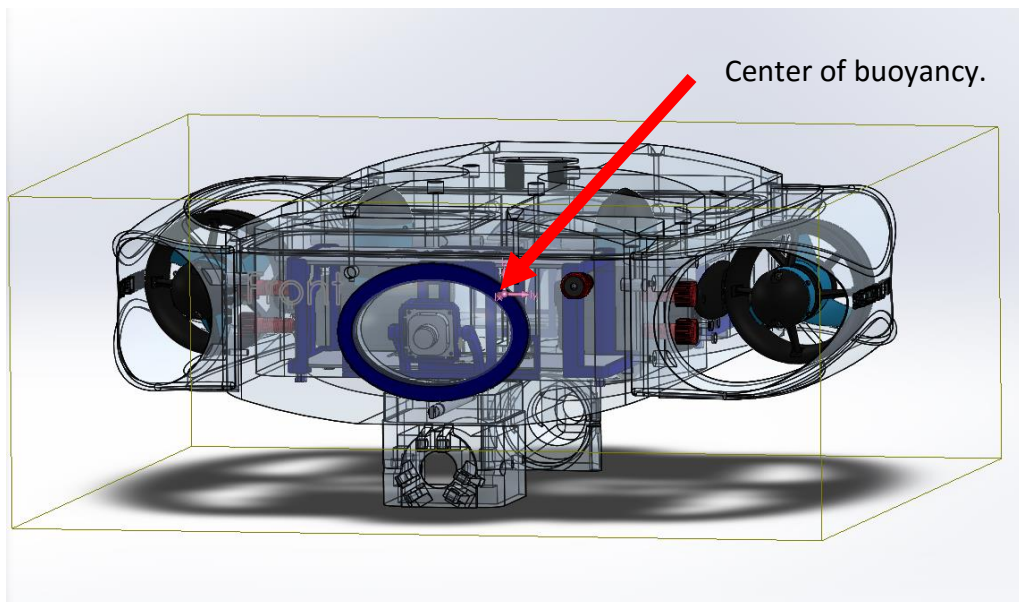


Figure 6 The Seawolf VI body and lid in the machining process

C. Buoyancy

Seawolf VI was designed to be its own source of buoyancy. While the completed design was in SolidWorks, the surrounding material was changed to water to find the center of buoyancy. The material of the robot itself was then changed to HDPE 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 two different pool tests, helped determine that to be neutrally buoyant, Seawolf VI would need to weigh approximately 13.6 kg.

The completed robot with no tooling had a mass 10.5 kg. Tooling will add approximately .9 kg., and more mass will be added to the frame to compensate for the other 1.1 kg.



Once the designers achieved a working design for the Seawolf VI, a preliminary calculation was

Figure 7 After the center of mass was determined, SeaWolf VI was converted to water and the center of buoyancy was found.

performed to determine the center of mass. Past experience has shown that the ROV needs to have a low center of mass to increase the stability of the vehicle. SolidWorks software was used to view the mass properties and determine the location of the center of mass. With the mass properties identified and the understanding that additional tooling would be included later, this information confirmed that this design would be efficient and fit the needs of Long Beach Ports.

D. Thrusters

S.U.R.E. selected Blue Robotics T200 thrusters. This particular model of thrusters was preferable due to increased functionality, reduced finances, self-lubrication, and size. Each motor is run on an individual DC to DC converter due to current limitations. The motors run on 15V which is supplied to them via the converters. Each motor is capable of 25A which is roughly the output per converter. The motor output can be limited to decrease amps, but the lower voltage does have a higher current consumption. 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. These thrusters are also much more economical and user friendly than Seawolf V's Crust Crawler thrusters. T200 thrusters also use water as a lubricant which is cleaner and simpler than using grease as a lubricant. The thrusters are compact and fit into the plan for the size of the robot with one thruster weighing only 1.56 N in water. The ROV has 4 thrusters: 2 horizontal for forward, reverse, and turning, and two vertical for up and down. Each thruster receives input via Blue Robotics penetrators. Previous Seawolf models have used bulkheads, but using penetrators has improved overall performance.



Figure 9 Blue Robotics T200 thrusters

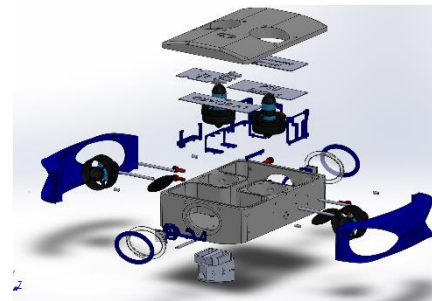


Figure 8 Exploded view including lid, electronics/camera mounts, thrusters, thruster guards, domes, tooling mounts, etc.

E. Tooling

The tooling equipment includes a linear actuator controlled manipulator, a soil sampling tool, a simulated Raman laser, an RFID tool, and a valve turning tool. All of these tools were designed to complete the tasks at hand whilst providing maintenance and care for Long Beach Port.



Figure 10 The manipulator is placed under the camera for easy viewing during missions.



Figure 11 An LED simulates laser needed for soil testing.



Figure 12 The F.A.R.T. 2.0 was modified from the previous model and utilizes a specially cut PVC cap to turn the valve.



Figure 13 The depth/pressure sensor is located on the front of Seawolf VI.



Figure 14 The presence of black shavings intel the milling process of the ROV body from HDPE.

1. The **manipulator** is controlled by a Concess con35 with a load capacity of 2200 N and a 12V DC motor. The manipulator is used for most tasks requiring objects to be moved.

2. The **soil sampling tool** is a simple mechanical device made from 1" PVC used to collect contaminated sediments. The company plans to construct this tool in preparation for the Long Beach Port.

3. The **simulated Raman laser** uses a Blue Robotics Lumen-Light-R1 1500 lm 12V LED to identify contaminants in sediment from the port.

4. The **Radio Frequency Identification (RFID)** tool is a separate off board tool that is designed specifically to acquire the RFID number of sunken containers. This tool is controlled separately by a surface Arduino controlled system. Currently, this tool is being prototyped.

5. The **frictionally assisted rotating tool (F.A.R.T. 2.0)** serves as a valve turning tool and utilizes a 12V DC motor with a custom slotted handle attachment to control water flow to fountains found in the Port of Long Beach.

6. The **depth/pressure sensor** uses a penetrator designed to be water proof.

Tooling is connected to the ROV via wet-mate bulkheads. The actuator uses an 8 pin Seacon bulkhead, and the valve turning tool has a 4 pin Seacon bulkhead. The 4 pin bulkhead is capable of 2 h-bridge outputs, and only one of these is used for the valve turning tool which means that there is a spare in case of malfunction.

F. Material

S.U.R.E. chose HDPE as the material for the ROV frame. The factors in choosing this material included its superior strength, flexibility, and weight. With the hazards found in port environments, HDPE provides a high strength vehicle, and produces a product that is capable of withstanding substantial amounts of stress. While Long Beach has moderate temperatures year round, HDPE is also able to withstand extreme temperatures that could be found in other ports around the

world. This material is also flexible, can be easily milled, is naturally light in weight, and is almost neutrally buoyant which reduces stress on the frame and thrusters.

G. Electronics

Seawolf VI operates with three custom in-house designed circuit boards. These allow Seawolf VI to efficiently work in port environments. Two boards are four layered, and one is a single layer. The four layer boards were manufactured and donated by Advanced Circuits. These two boards include the power supply board and the low voltage control board. The third board, manufactured in-house, is a motor converter board specifically designed to provide power to the thrusters. A fourth board is a purchased video encoder board.

1. Power Supply Board: As stated, this is a four layer board designed in-house and sent away for manufacturing. This board is responsible for receiving the supplied 48V DC and filtering the incoming voltage. It is also responsible for housing two H-Bridges for optional tooling (one to power the valve turning tool), 3 optional 5V switching circuits, 3 optional 12V switching circuits, 5V and 12V DC to DC converter. This board has a 30A fuse holder for incoming voltage and fuses for both the 5V and 12V circuits. A 13 pin header is used to run the signals for the switching circuit from the Low Voltage Control Board.

2. Low Voltage Control Board: Like the power supply board, this board was designed in house and manufactured by Advanced Circuits. This board is powered by the 5V and 12V DC to DC converters found on the power supply board. This board houses the Digilent ChipKit Max32, Ethernet Switch, Razr IMU, Actuator Control Board, connections for 4 temp sensors, two connections for servo outputs, connection for the Blue Robotics temp/pressure sensor, lighting outputs for 2 Blue Robotics lights,

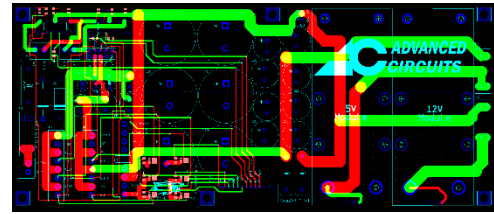


Figure 15 Rendered design of the Power Supply Board in the Ultiboard 1



Figure 16 The power supply board consists of multiple Wurth headers for switching circuits which makes adding new equipment an easy task for tooling expansion.

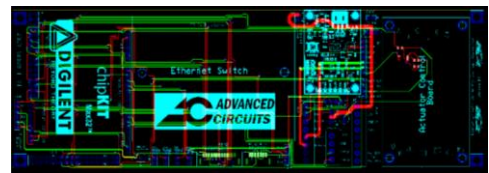


Figure 18 This Low Voltage Control Board takes advantage of all available free space and houses all processing boards with connections to all other



Figure 17 Rendered design of the Low Voltage Control Board pictured in Ultiboard

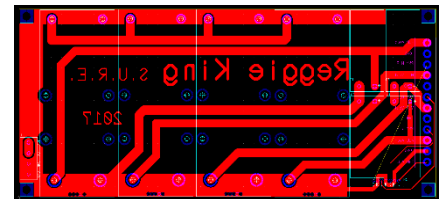


Figure 20 Rendered design of the Motor Converter Board in Ultiboard 14.



Figure 19 Motor converter board is located on top of the rack and should any trouble arise the outputs are effectively located on the side for any troubleshooting needs.

actuator controls, power for the video encoder, and an ambient temperature sensor.

3. Motor Converter Board: This is a single layer board that was designed and manufactured in house. This board sits above the power supply board and is responsible for motor voltages. There are four 15V DC to DC converters located on this board. This board receives 48V directly from the power supply board where it then converted to the 15V that the thruster control modules utilize. This board also houses the outputs for each motor. These include a Vout (15V), GND (ground), and PWM (pulse width modulation). A 7 pin connection to the low voltage board receives the PWM signals and passes them to the output pin for the motor.



Figure 21 Video Encoder includes four-feed capability, should the need arise the SeaWolf VI has room for expansion with ability to house 2 extras cameras.

4. Video Encoder: This board was purchased and removed from its casing to reduce weight and size and is located above the Low Voltage Control Board. It is powered via the Low Voltage control board and two cameras are connected to it. This board also contains a slot for a micro SD card that allows recording and downloading of video footage from the robot. This may prove useful for training purposes and documenting work in LBP.

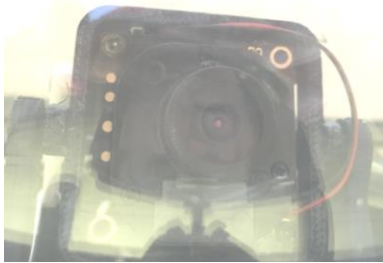


Figure 22 Forward and rear cameras allow Seawolf VI to move efficiently and safely.



Figure 24 This Windows 7 laptop is the heart of the operation and controls SeaWolf VI through LabView programming. Also shown is the Xbox controller used to pilot the vehicle.

5. Cameras: Two standard definition CCTV style 1.2mm cameras are utilized in Seawolf VI. The cameras are on opposite sides of the robot, and one camera receives power and GND from the power supply board while the other receives power and GND from the Low voltage control board. Having a forward and rear camera allows Seawolf VI to move efficiently and safely navigate Long Beach Port.



Figure 23 The Outland's Technology tether is already neutrally buoyant and rugged to last in the Port of Long Beach.

6. Surface controls: The ROV's surface electronics equipment includes an Outland Technologies tether, a video decoder, a TV, a network router, and a laptop PC.

7. Tether: 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

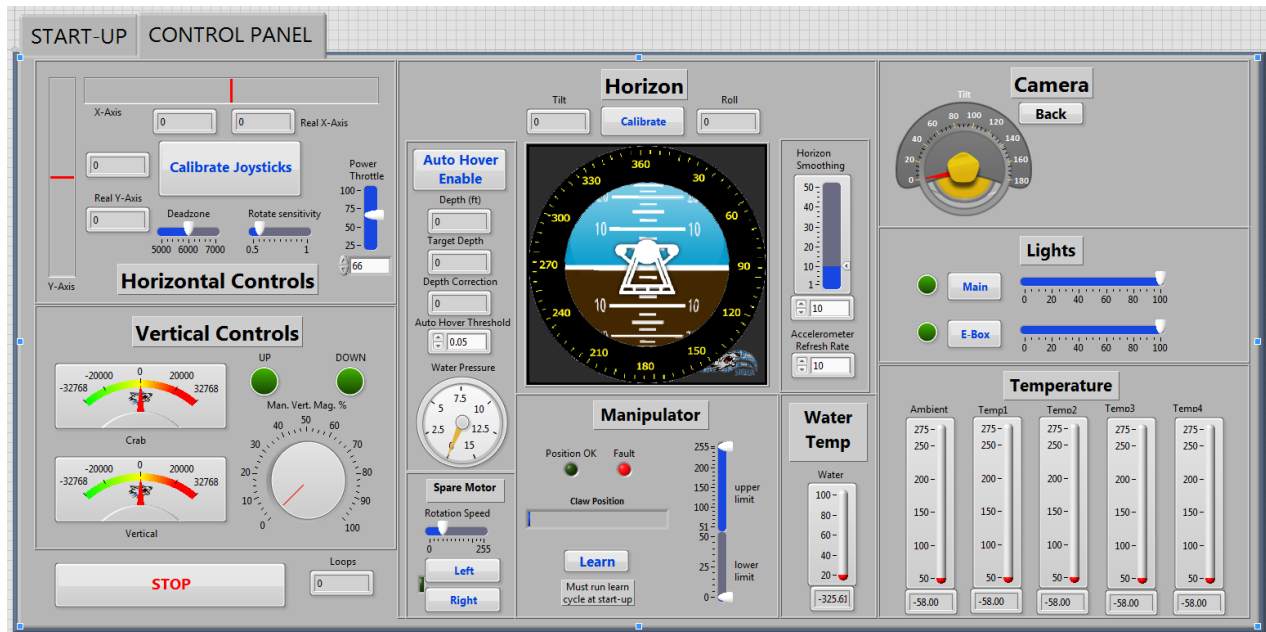


Figure 25 All functions of Seawolf VI may be viewed and controlled through the control panel.

supply. Both ends of the tether have strain relief provided by carabineers secured to Seawolf VI and the control station. The video encoder allows for simple display of the ROV's two cameras. As it is 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. The network router provides standard Ethernet connectivity to all of the main parts of the control system.

H. Software

At the heart of the control system is a Microsoft Windows 7 laptop running National Instrument's LabVIEW 2016. LabVIEW's Graphical User Interface (GUI) is straightforward and allows commands to be easily employed, yet 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 Seawolf VI's 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

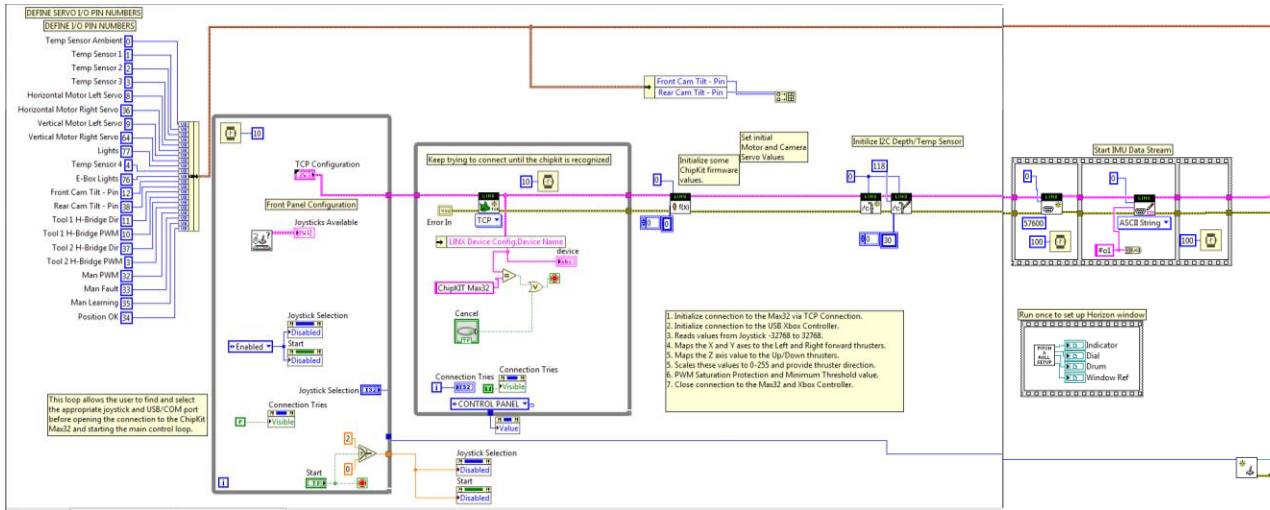


Figure 26 (Above)
Detail of start-up procedures

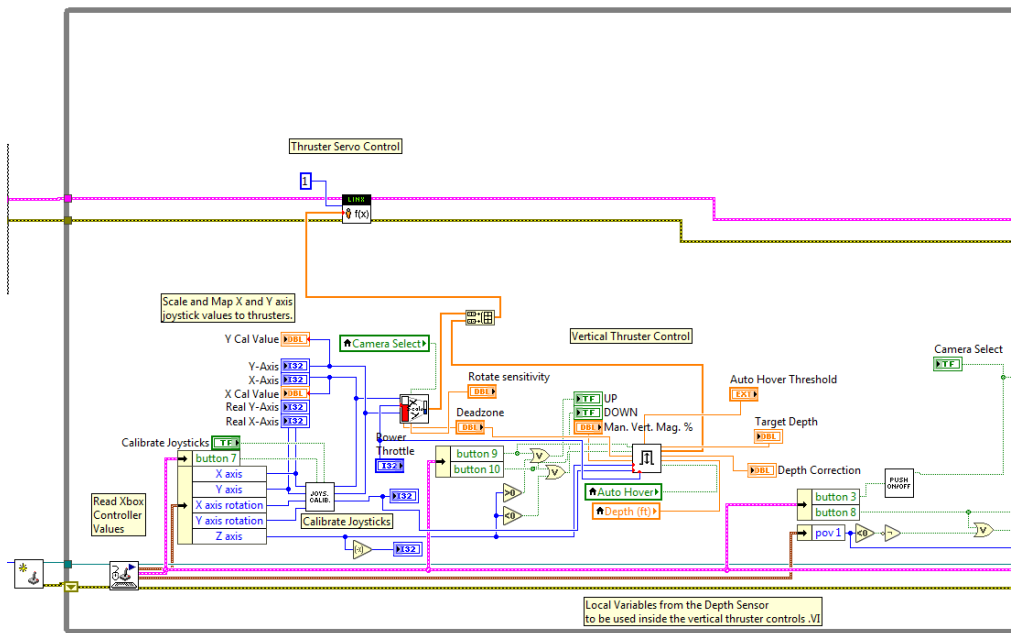


Figure 27 Detail of ROV thruster control in LabVIEW

which allow for finely tuned movements, temperature meters, a depth gauge, actuator output and limit controls, and speed controls for the F.A.R.T. 2.0. 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.

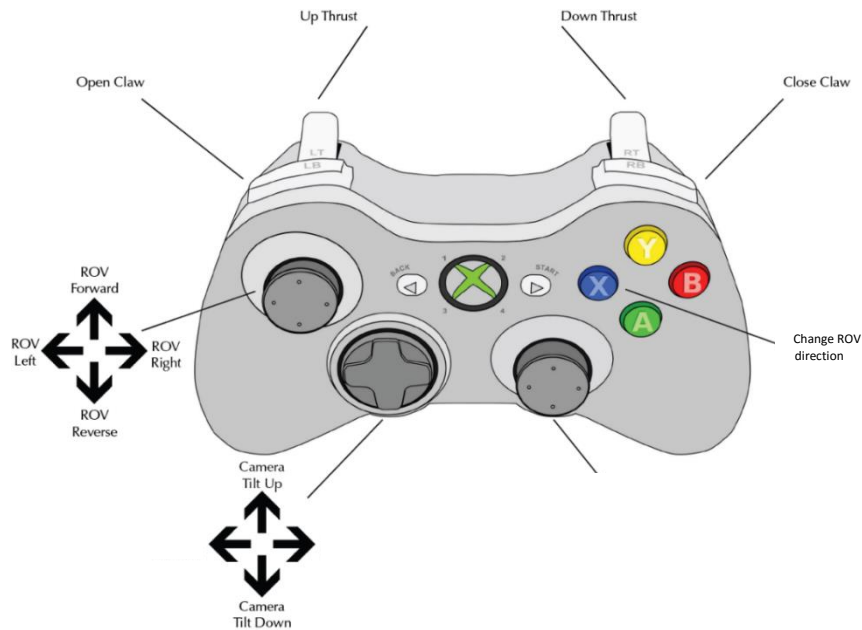


Figure 28 X-box Controller button layout

Based on input from the XBOX controller 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 Max32. The Max32 then responds accordingly by directing all of the ROV's components to complete the necessary action.

I. Community Outreach

Community outreach is a vital part of S.U.R.E. The company believes that its robotics team is a valuable way to cultivate interest in science, math, and engineering for the youth in the area. The Seawolves have participated in various outreach activities, for example, giving tours to high school students; setting up a pool at the Wesson Flea Market to demonstrate ROVs; hosting the First Tech Challenge (FTC) kickoff on-campus; company members speaking at the Dauphine Island Regional MATE Competition; and the CEO speaking about the company at the Nissan Plant in Canton, MS. There are many other outreach activities that the company has hosted, participated, or helped with this year. S.U.R.E. will continue to reach out to its community so that it may better understand the benefits of robotics.

FTC Kickoff: S.U.R.E. hosted the FIRST Tech Challenge Kickoff at Copiah Lincoln Community College in Wesson, MS. This event was the first of many outreach opportunities, and it also served as the first of multiple fundraisers as well. FTC does a kickoff each



Figure 29 A team member explains the ROV hand controls to an interested grade schooler at the Wesson Flea Market

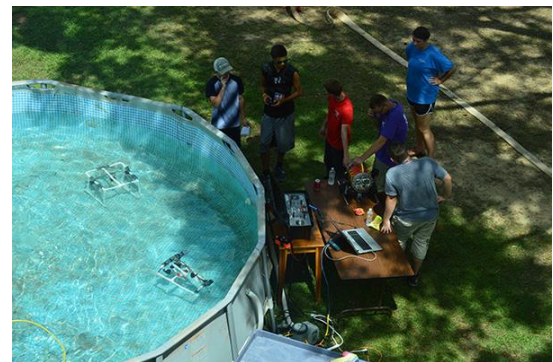


Figure 30 Students attending the First Tech Challenge (FTC) kickoff students were also allowed to test drive Seawolf IV and smaller, simpler PVC machines.



Figure 31 The Seawolves traveled to Alabama to speak at a Dauphin Island Regional MATE Competition. CEO Reggie King and Mentor Dr. Kevin McKone presented. Pictured: Virginia Mullens, Mary Thornton, and Reggie King

year announcing that year’s competition theme and tasks associated with it. During the kickoff, approximately 300 elementary, middle school, and high school students gathered to observe. Seawolves mentor, Dr. Kevin McKone, conducted a seminar emphasizing the MATE program and the robotics industry as a whole. After this seminar, the students toured S.U.R.E.’s work facilities and watched demonstrations using the previously built Seawolf IV.

Regional MATE Competition in Dauphin Island: The S.U.R.E. team attended the regional MATE competition in Dauphin Island to present our ROV to the other teams participating year. The CEO, Reggie King, and mentor, Dr. Kevin McKone, presented S.U.R.E. and machine, and allowed the students to ask questions. The questions pertained to S.U.R.E.’s approach to this year’s request for proposal, the process of building the ROV, etc.



Figure 33 Wesson Cub Scouts learned about robotics at the Wesson Flea Market outreach as part of the requirements for their “cyber chip” recognition.

Underwater Intervention in New Orleans, Louisiana: The S.U.R.E CEO, Reggie King, and mentor, Dr. Kevin McKone, were asked to give a seminar at Underwater Intervention, and explained our program and the importance of STEM and robotics. They also presented the MATE program and the importance of involving youth in the rising robotics industries. The team also learned about many companies that produce state-of-the-art underwater ROVs and their approaches to tasks that are faced to help refine our methods.

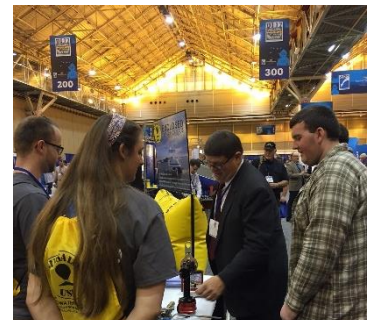


Figure 32 The S.U.R.E team traveled to New Orleans, Louisiana, Underwater Intervention for CEO Reggie King, and Mentor Kevin McKone presented the company. Pictured: Timothy Stogner, Colby Phillips, and Mary Thornton

Wesson Flea Market: The Wesson Flea Market is a local event that takes place each year in the area. The Seawolves set up a booth and viewing/testing pool to involve the surrounding community. The booth had information on our program, demonstrations using Seawolf IV carried out by team members, and Seawolves merchandise such as the Seawolves tumbler.



Figure 34 Students from Warren County, Mississippi schools toured Career-Tech programs and had the opportunity to ask questions about robotics and engineering.



Figure 35 At Nissan CEO Reggie King shared his educational experiences as related to STEM education and what he's gained from his time with S.U.R.E.

S.U.R.E. CEO Reggie King accompanied mentor Dr. Kevin McKone to the Canton, MS Nissan facility. There they spoke by invitation to Mississippi Robotics, an organization that seeks to advance STEM education within the rural communities of Mississippi, utilizing robotics tournaments. Dr. McKone and Mr. King showcased Copiah-Lincoln Community College, S.U.R.E. and how the organizations are reaching out to the community to get children involved in STEM activities.

J. Safety Members of the company underwent several safety-training sessions in the fall of 2016.

Copiah- Lincoln Community College's Workforce Training Specialist, Randy Castilaw, led these sessions which included Slips, Trips, and Falls; Personal Protective equipment; Hand Tool Safety; and Electrical Safety.

Slips, Trips, and Falls training covered how to treat the body in the case of a slip, trip, or fall and how to prevent these accidents. The primary safety precaution to take in preventing accidents is keeping the workplace environment clean and free of safety hazards. This training prepared the Seawolves for the slick surfaces and crowded work areas encountered in the work place.

The Personal Protective Equipment (PPE) colloquium analyzed wearing the proper clothing within the work environment. The PPE vital in preparing for missions includes: reflective vests, gloves, safety glasses, closed-toed/ non-slip shoes, and hard hats. This equipment allows for company members to not only complete their required tasks, but also maintain personal safety while in the field.

The Hand Tool Safety training session emphasized the proper methods of operating basic hand tools, such as: screwdrivers, hammers, power drills, dremels, and different types of pliers. Hand Tool Safety prepared S.U.R.E. to work safely and efficiently during the design and building processes.



Figure 36 Workforce Training Specialist Randy Castilaw discusses personal protective equipment with S.U.R.E. members.

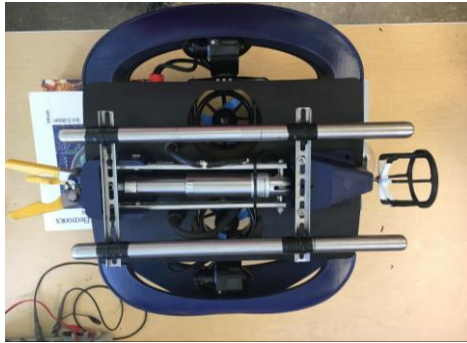


Figure 37 Rods were machined and the mounting brackets were filed removing sharp edges to prevent injuries.



Figure 38 Thruster guards and tooling mounts are 3D printed ABS plastic. The 3D printing process provides a safer and more efficient machine while ensuring personnel safety due to the hands-off nature of production.

The Electrical Safety meeting reviewed proper safety techniques when working with electrical components. Being cautious when working over circuits and live wires, wearing proper personal protective equipment, and being sure that electrical components are powered off before beginning work are a few of the ways that the company enS.U.R.E.s member safety.

From the start of the design process, the Seawolf VI was designed with safety and aesthetics in mind. All parts have been either CNC milled or 3D printed. Each part has been inspected for sharp edges that could either harm personnel or damage equipment/elements of the port that the ROV may encounter.

Some of the safety features of Seawolf VI include the thruster guards covering the external thrusters, the handle located on lid of the ROV, and the skids along the belly of the machine. The guards on the sides of the ROV are 3D-printed ABS plastic and protect the exterior mounted thrusters, deflect foreign debris found in port waters that could cause damage, and prevent injury to handlers of the robot. The handle on top of the lid provides a stable point to take hold of when transporting

Seawolf VI. On the underside of the robot, the skids prevent pressure or impact to the tooling mounts, as well as the linear actuator. They also serve as a stable footing for the machine to sit on the bottom.

1. Safety Checklist

1. All company members put on safety glasses and closed-toed shoes.
2. Check work areas and ROV for any hazards (sharp edges, untidy cables, wet/slippery areas).
3. Inspect ROV's electrical systems and connections for water proofing.
4. Inspect strain relief on tether.
5. Inspect 30A power supply fuse.
6. Connect tether to 48V fused power supply.
7. Power up the laptop, monitor, and ensure the charger is connected to the laptop.
8. Connect XBOX controller.
9. Turn 48V power supply on.
10. Start LabVIEW and open the main program.
11. Designated company member launch ROV into water.
12. Poolside members check for bubbles that indicate leaking.
13. Once procedures are completed, ROV is prepared for mission tasks.

K. Experience Reflections

Colby Phillips: "Being safety manager these past two years has taught me the importance of not only safety in the workplace, but also being able to watch a diverse group of people come together in the end."

Dezirae Katt: "The past year as a graphic designer on the team has shown that, although it is not all about a science or engineering major, and it's possible to help the team by giving a different perspective."

Holly Steen: "I had a lot of fun and learned a lot about how all the little things come together to create the robot. Working with all the different departments, shows that we should always ask for help outside of our majors."

Abigail Hynum: "I never imagined that I would ever be on a robotics team. I thought robotics was nothing but engineering, but it is so much more than that. I have learned so many skills being on this team and made great friends along the way."

Mary Beth Thornton: I participated in FTC Robotics throughout high school, and was so excited to join the team in Wesson. I've learned so much, and made many great friends and mentors that will last a lifetime. Working on the machine itself, and learning about the ever growing robotics industry has been something that I did not think I'd be able to do as a biology major. I would not trade this experience with this group for anything."

Reggie King: With three degrees, being a part of the Seawolves has been nothing short of incredible. Every aspect has required me to use bits and pieces from everything I have learned. I was on the first year's team, last year's, and the current year. It has been incredible to see everyone grow and where we as a team have come in the last six years. I wish the team the best of luck this year and for the future!

L. Issues/Lessons Learned

Early in the production process, the company encountered a milling challenge. Seawolf VI's body design was drawn up in SolidWorks and ready to be milled. However, the amount of time needed to mill the product was a very sizable undertaking, and took more time than expected. The solution was to outsource the milling so the team could move on to the next stage of design.

Once S.U.R.E. began to plan the production of the thruster guards, team members realized an oversight. The large print size of the thruster guards would require S.U.R.E.'s 3D printer to produce the component in two pieces which would require assembly and may mean a loss of quality. In order to keep the thruster guards in one piece, the team decided to have the guards sourced to Primos Hunting who had facilities large enough to print each guard in its entirety.

The tooling process also presented some engineering challenges. The attachment on the F.A.R.T. went through three different stages of modification. First, it started with modified hair brush bristles shaped to stick into the valve and to turn it. Unfortunately, this approach failed and led to the use of a modified PVC end cap cut with a dremel. This design allows the user to visually see the valve turning but it needed refining. Finally, improvements were made by adding a larger end cap to simplify getting the tool on the valve.

During the electronic component planning and testing, the initially purchased DC to DC converters promised high efficiency but proved to dissipate more heat than desired. As the team planned for upcoming missions, it was determined that the Seawolf VI operated in the allotted time frame without overheating. However, long periods of use proved to eventually cause overheating. The company developed plans for water cooling the robot which would be done by installing a water pump and two CPU socket radiators. Then a heat sink and a radiator would be placed on both the bottom two converters and on the top four converters. The cooling system would be an open system where the outside water would act as the coolant.

Plans included BlueRobotics penetrators to allow for an inlet and outlet in which the water would pass. After testing and running this plan, the company decided the water cooling was not necessary at this time.

All teams have their own set of hurdles that mold the organization and how it operates. One hurdle that is unique to S.U.R.E. company is the nature of the community college campus. As a two-year school (on the average) staffing changes drastically each year due to members leaving to pursue their career goals/higher educational goals. This results in the team identifying skilled members and rebuilding every year. A response to the dilemma of the rebuild is for the team to begin identifying students who have experienced robotics or STEM education in the past and recruit them during their freshman year or earlier. As S.U.R.E. continues community outreach annual rebuilding efforts should be less demanding.

In addition, the team as a whole faces the time management challenge. All of the company members and mentors are involved in college life either as a student or as instructors/employees. It was challenging to balance the time it takes to build a functioning, state-of-the-art ROV, college life, jobs, and other club obligations. Communication was managed by group text to keep everyone in the loop and each member dedicated as much time as they could to the perfection of the company rather than being elsewhere.

M. Finances

1. Budget Overview

S.U.R.E. began budgeting for the MATE project in August 2016 with \$8500 in the company's account. With all expected expenses, S.U.R.E. was able to stay financially secure. The largest fundraiser was executed with efficiency due to the team's past experiences.

Initially, due to unclear member information, budgeting travel expenses early on in the planning period was not practical because the company did not yet know how many members it would be sending to the MATE competition. However, that obstacle was overcome with time.

Materials were selected based on efficiency and affordability.

2. Budget Table

Beginning balance		\$8,500.00
HS robotics fundraiser		\$2,000.00
Hardware		-\$90.00
Electronics		-\$350.00
General Expenses		-\$5,700.00
Material		-\$400.00
Uniforms		-\$315.00
Tooling		-\$320.00
School fundraiser		\$2,000.00
Thrusters		-\$680.00

3. Project Costing Table

Type	Source	Item	Amount
Beginning Balance			\$8,500
fundraiser	HS robotics fundraiser	Selling concessions	\$2,500.00
purchase	Amazon.com	Axis communications board	-\$253.51
purchase	bluerobotics.com	Bar30 depth sensor	-\$68.32
purchase	bluerobotics.com	T200 thrusters(4)	-\$685.76
donation	anonymous	cash donation	\$ 10,000.00
purchase	Ace Hardware	misc. hardware	-\$82.00
donation	Georgia Pacific	cash donation	\$5,000.00
purchase	seaconworldwide.com	WET-CON connectors	-\$57.00
fundraiser	School fundraiser	Selling concessions	\$2,500.00
purchase		Company t-shirts	-\$333.00
purchase	Nationwide plastics	material	-\$413.00
donation	Tim Jones	cash donation	\$100.00
parts re-used	Mouser Electronics	chipKIT Max32	\$49.50
parts re-used	Mouser Electronics	chipKIT network shield	\$54.99
purchase	Various sources	misc. tools	-\$800.00
purchase	Various sources	general expenses	-\$3,500.00
purchase	Concens	con35	-\$354.00
purchase	Various sources	fundraising expenses	-\$2,000.00
purchase	Various sources	misc. electronics	-\$1,000.00
purchase	Various sources	Travel expenses	-\$9,000.00
Final amount			\$10,158

4. Conclusion

The Seawolves had a very successful year for finances. The company was very fortunate with donations that were received and the fundraising efforts. An important purchase decision was choosing Blue Robotics T200 as the thrusters. Blue Robotics thrusters were \$250 per thruster as opposed to the Crust Crawler thrusters which were \$600 per thruster. Although travel expenses to the MATE competition were more expensive than the previous year, S.U.R.E. was fortunate to have gained several company representatives throughout this year.

N. Acknowledgements



Figure 39 The Georgia-Pacific Foundation donated \$5,000 to Seawolves Robotics Team. Making the presentation was Doug Hoy, Georgia-Pacific Monticello LLC Public Affairs/Communications. Dr. Jane Hulon, Vice President of Instructional Services; Reggie King S.U.R.E. CEO

Copiah Lincoln Community College - For providing S.U.R.E.'s healthy learning environment and supporting us through innumerable means.

Georgie Pacific, Monticello Division - For taking interest in our local education company and supporting financially and through encouragement.

Marine Advanced Technology Education (MATE) Center—For providing a safe competition medium for students to study marine technologies and in turn help them prepare for the real-world work environment through healthy competition.

I-55 Engineering – For machining the body and the lid for the ROV

Primos Hunting- For 3D printing the thruster safety guards

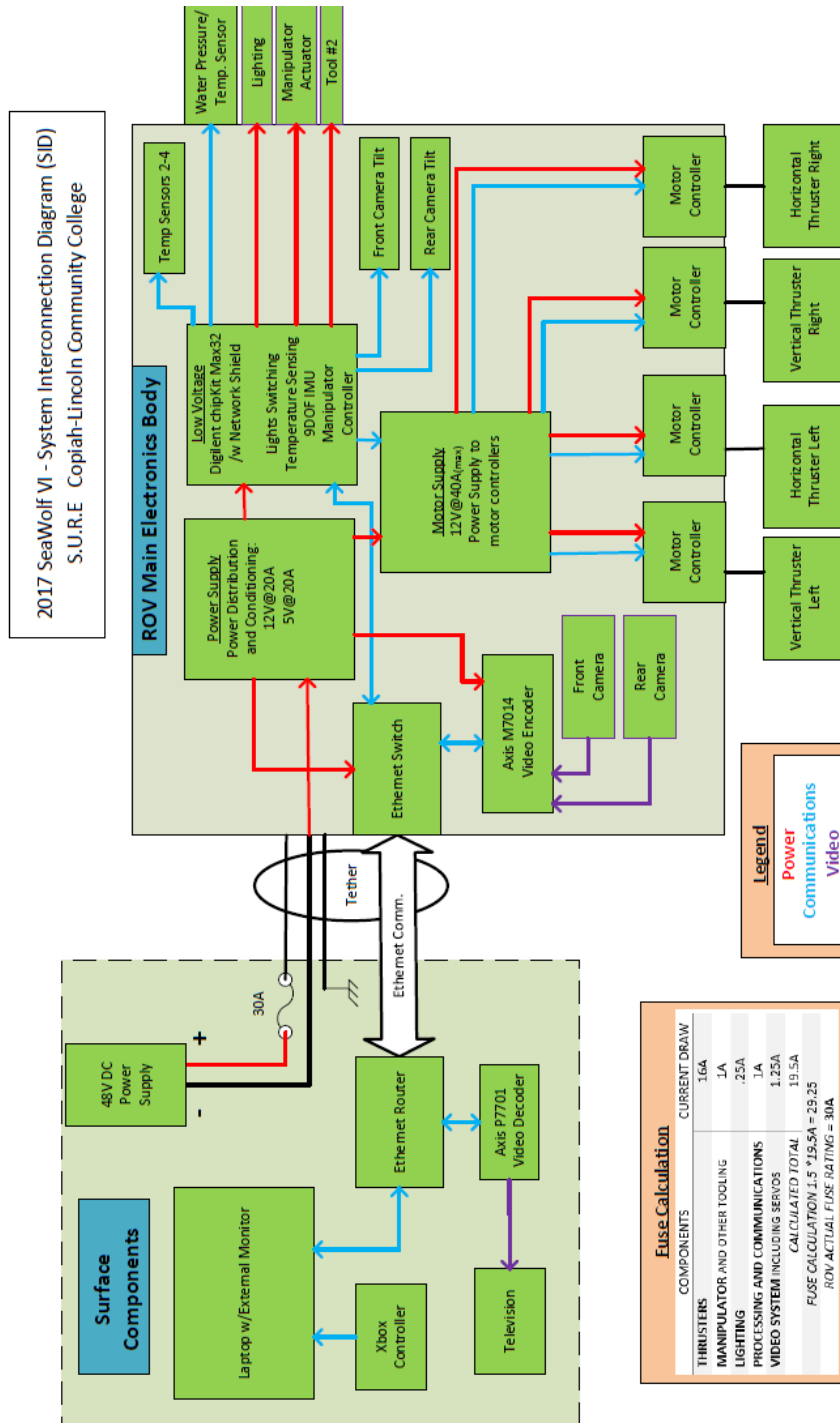
Tim Jones- (former S.U.R.E. tether manager, electronics 2015) for supporting us financially and helping with fundraising during the 2016-2017 year

O. References

- LABVIEW HACKER. (2016) LabVIEW hacker. <http://www.labviewhacker.com/>
- MATE. (2016). Marine Advanced Technology Education. <http://www.marinetech.org/>
- Mississippi Robotics. <http://mississippirobotics.org/about-mississippi-robotics-mechatronics/>
- Port of Long Beach <http://polb.com/about/default.asp>
- Blue Robotics <http://bluerobotics.com/store/electronics/bar30-sensor-r1/>
<http://www.bluerobotics.com/store/thrusters/t200-thruster/>
- Concens <http://www.concens.com/products/actuators/con35>
- Seacon <http://seaconworldwide.com/products/electrical-wet-mate/wet-con/>
- Amazon https://www.amazon.com/Axis-Communications-0415-004-4-Channel-Encoder/dp/B0074ANCMW/ref=sr_1_1?ie=UTF8&qid=1479496315&sr=8-1&keywords=axis+7014

P. Appendices

Appendix 1: Seawolf VI's System Interconnection Diagram (SID).



Appendix 2: Software Flow-Chart

Appendix 3: Troubleshooting Checklist:

1. If program freezes:
 - a. Change windows and end the main program.
 - b. Close LabVIEW.
 - c. Restart Safety Checklist procedure starting with step 11.
2. If ROV fails to communicate:
 - a. Turn off power supply.
 - b. Close LabVIEW.
 - c. Restart Safety Checklist procedures starting with step 9

