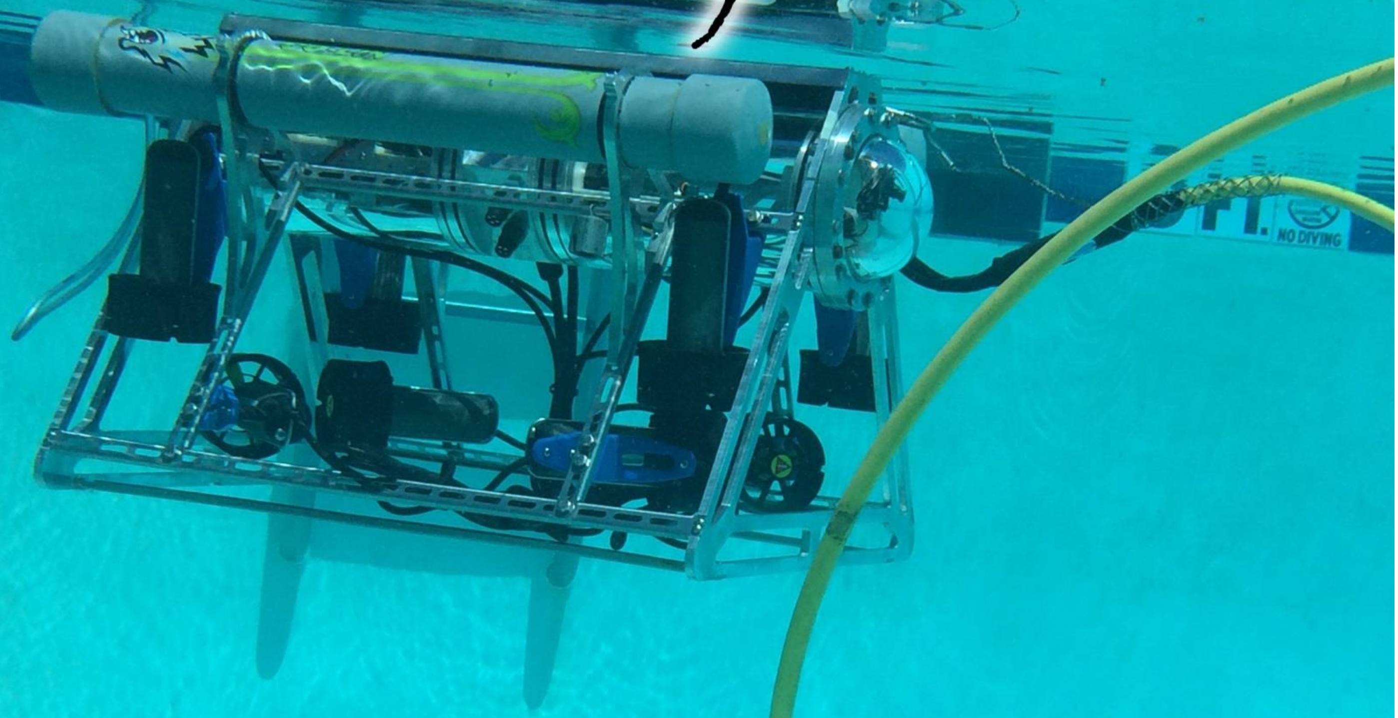
Seawolf III



Seawolves
Copiah-Lincoln Community College
Seawolf Underwater Robotics Engineering

Members: Jonathan Nations (CEO)*
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Josh Hart (Electronics/Secondary Pilot)
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Zach Hite (Engineer)
Jane Bayless (PR/Website Publisher)
Erin Whittington (Technical Report)
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Carey Williamson (Electronics)
Wes Burkett (Drafting)
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1. ABSTRACT

Seawolf III is an observational/working class ROV, designed and built for discovering and retrieving artifacts and debris from historical shipwrecks. *Seawolf III* is also designed to determine the origin and dates of when these ships were in service, and what kind of cargo the ship was carrying when it was decommissioned.

Its design, refinement, and construction are the result of the collective imagination, innovation, and effort of the Seawolf Underwater Robotics Engineering (S.U.R.E.) team members. Drawn in SolidWorks and Inventor 3D CAD software, *Seawolf III* is designed with an eye toward versatility and adaptability. Each *S.U.R.E.* team member participated in brainstorming, designing and building the ROV. Through this process, each member was able to gain technical skills and techniques to build a safe, reliable and easy to use ROV. The total fabrication of *Seawolf III* alone is approximately $8,126.16.

The 2014 Seawolves Robotics Team

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2. DESIGN RATIONALE

2.1 Overview

Seawolf III is comprised of an aluminum and stainless steel frame that creates the rigid structure. There are two acrylic tubes joined together by a milled aluminum block that contain most of the electronics. Below are a hydraulic manipulator and an additional acrylic tube that contains all of the hydraulic components. Movement is controlled by four vectored horizontal thrusters and four vertical thrusters. *Seawolf III* also features LED lighting and a neutrally buoyant tether. *Seawolf III* is piloted by a laptop and an Xbox controller. Many of the components that we are re-using from *Seawolf II* were donated items that were not paid for by the *S.U.R.E.* team. There was much room for improvement on the ROV that the team felt these items should be fine to re-use.

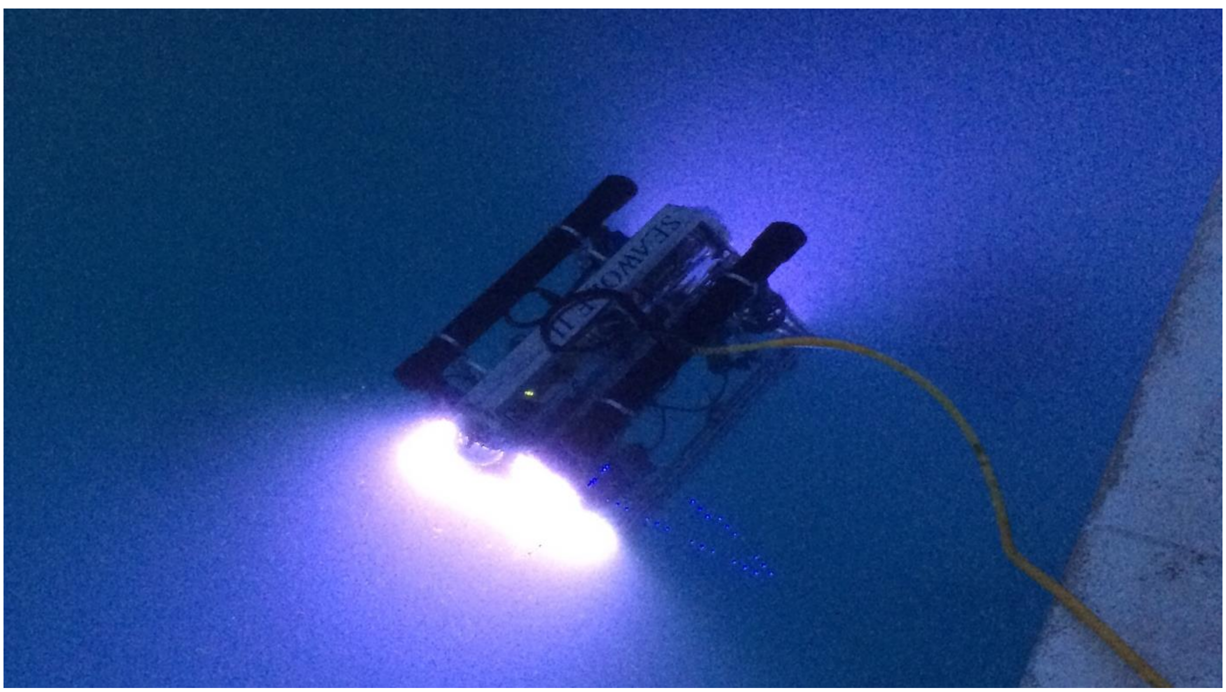


Figure 1: *Seawolf III*

2.2 Frame

The *Seawolves* decided to use last year's frame because of its unique design. The frame was designed and tested in Inventor and SolidWorks 3D CAD software by the drafting and design engineers. The end pieces are constructed from 1cm 6061 aluminum alloy because of its light weight and great resistance to corrosion. The triangle shape frame was chosen because it reduces the amount of upward drag and allows for a more even distribution of weight. The frame also consists of six – stainless steel cross-members which join the two end pieces together and hold the four vertical thrusters, and four – vertical stainless steel struts which join the top and bottom struts together and allow the four horizontal thrusters and outriggers to be mounted.

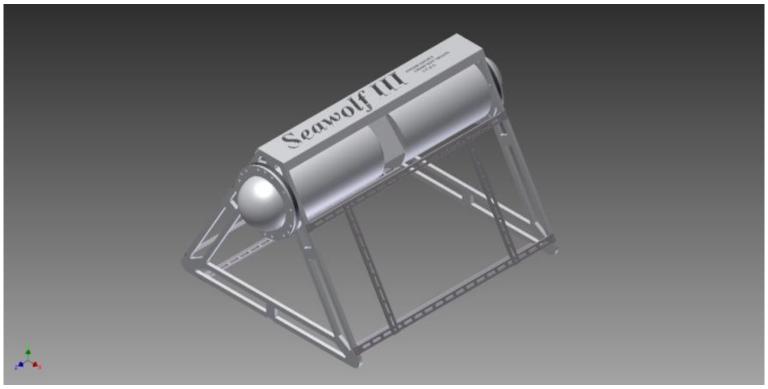


Figure 2: This is a 3D rendering of the frame and main electronics housing minus the outriggers that hold the buoyancy compensating tubes.

The aluminum outrigger mounts hold 2.5” diameter polyvinyl chloride tubes to add buoyancy to the ROV. The top of the ROV is a laser cut piece of stainless steel bearing the *Seawolves*’ name, with a piece of painted syntactic foam underneath for additional buoyancy.

2.3 Electronics and Housing

The electronics are enclosed inside two 15.2cm diameter acrylic tubes, which are joined together by a piece of aluminum stock (milled out by our machinist), and provide a flat surface to mount 7 bulkhead connectors and a pressure relief plug. The plug allows the electronics tube to be taken apart and re-installed with less effort. Both ends of each tube are sealed using two custom made O-rings. On both ends of the tube assembly are aluminum end rings and acrylic domes. The aluminum end rings are a two-piece assembly that bolt together and hold the acrylic domes which are sealed by another O-ring. The purpose of the acrylic domes on each end of the tube assembly is to provide adequate room for the pan and tilt cameras to give the largest possible viewing angle.

Figure 3: Pan and Tilt Camera inside acrylic dome with custom 3D printed mount

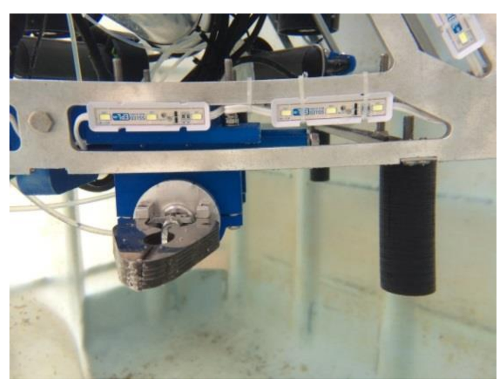


Figure 4: This is the hydraulic manipulator and feet to keep the manipulator off the ground.

Our electronic engineers designed and built a new on-board power supply to convert the supplied 48vDC into filtered 24vDC, 12vDC, 9vDC and 6vDC. This allows us to provide adequately filtered power to all electronics and components on the ROV that require less than 48vDC. This power supply makes use of industry standard 1/8 brick DC-DC converters, commonly found in network equipment. These converters are 94.5% efficient and can operate in a variety of harsh environments. Each converter is fused to prevent over current.

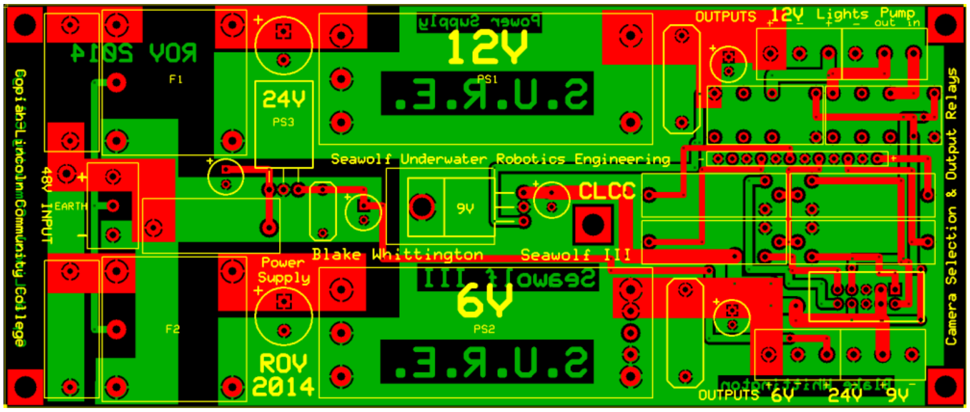


Figure 5: Two sided PCB design of the power supply board drawn by our Electronics Engineer

There is an Ethernet switch inside the electronics tube, which connects the tether to the chipKIT Max32 (see Section 2.4 Microcontroller) Ethernet shield and the AXIS video encoder (see Section 2.7). This allows the control laptop to communicate with each of these components. We decided to change the previous year's communication protocol from RS-485 to Ethernet which provides a more direct communication with the built-in Ethernet interface of the Max32. After the tether connects to the ROV, the signal is connected to an Ethernet switch via RJ45, and from there to the Max32 microcontroller and to the AXIS video encoder. There are two motor controller boards that can control up to four thrusters each. These were also designed and built by our electronic engineers. The power supply board, as well as the motor control board is continually monitored for high temperatures by I2C sensors. In addition to these, an ambient control housing temperature is also displayed on the front panel as shown in Figure 6. This allows high temperatures to be easily seen by the pilot, so the program can be stopped before something is damaged. However, the 1/8 brick DC-DC converters, motor controllers and other components have built-in shutdown thermal protection that protects them from excessive heat.

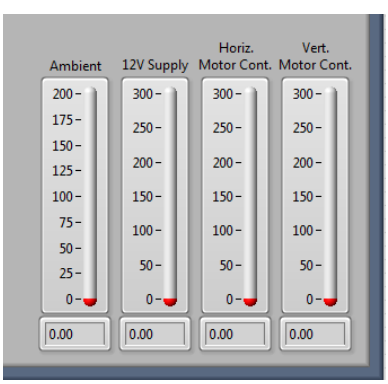


Figure 6: A screenshot of the temperature gauges on the front panel in LabVIEW.

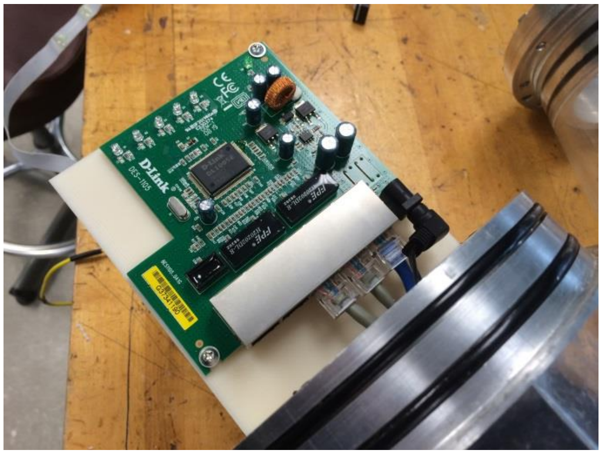


Figure 7: Ethernet switch inside rear main electronics tube

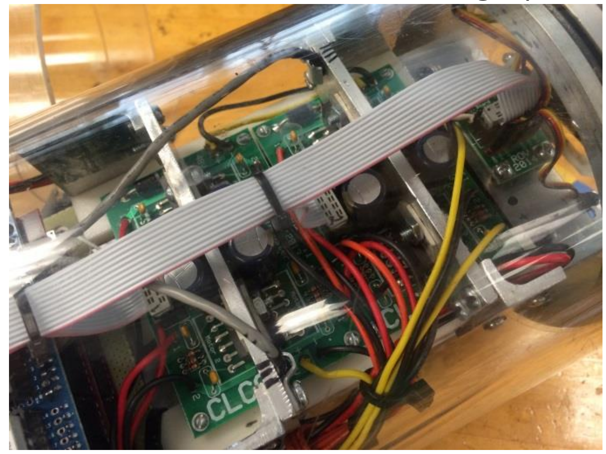


Figure 8: Thruster control boards inside front main electronics tube

We also added an I2C 3-axis accelerometer this year. This allows us to be able to see our pitch and yaw of the ROV as a horizon indicator on the front panel and also use these values in our custom auto level control (see Figure 20).

2.4 Microcontroller

This year, we decided to upgrade our 16 MHz 8-bit Arduino Mega 2560 to an 80 MHz 32-bit chipKIT Max32. That is 5 times the processing speed! The chipKIT Max32 is based on the Arduino open source hardware prototyping platform but adds the performance of the Microchip PIC32 microcontroller. It features a 32-bit MIPS processor core running at 80 MHz, 512K of flash program memory and 128K of SRAM data memory. The previous Arduino Mega 2560's ATMega2560 microcontroller features an 8-bit AVR processor core running at 16 MHz, 256K of flash program memory and 8K of SRAM data memory.

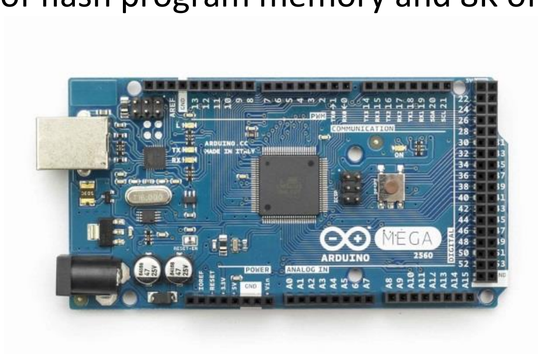


Figure 9: The Arduino Mega microcontroller was used last year for the control system

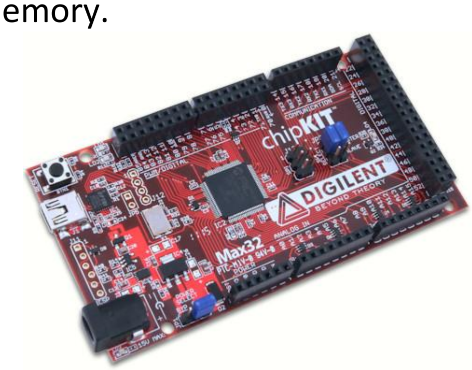


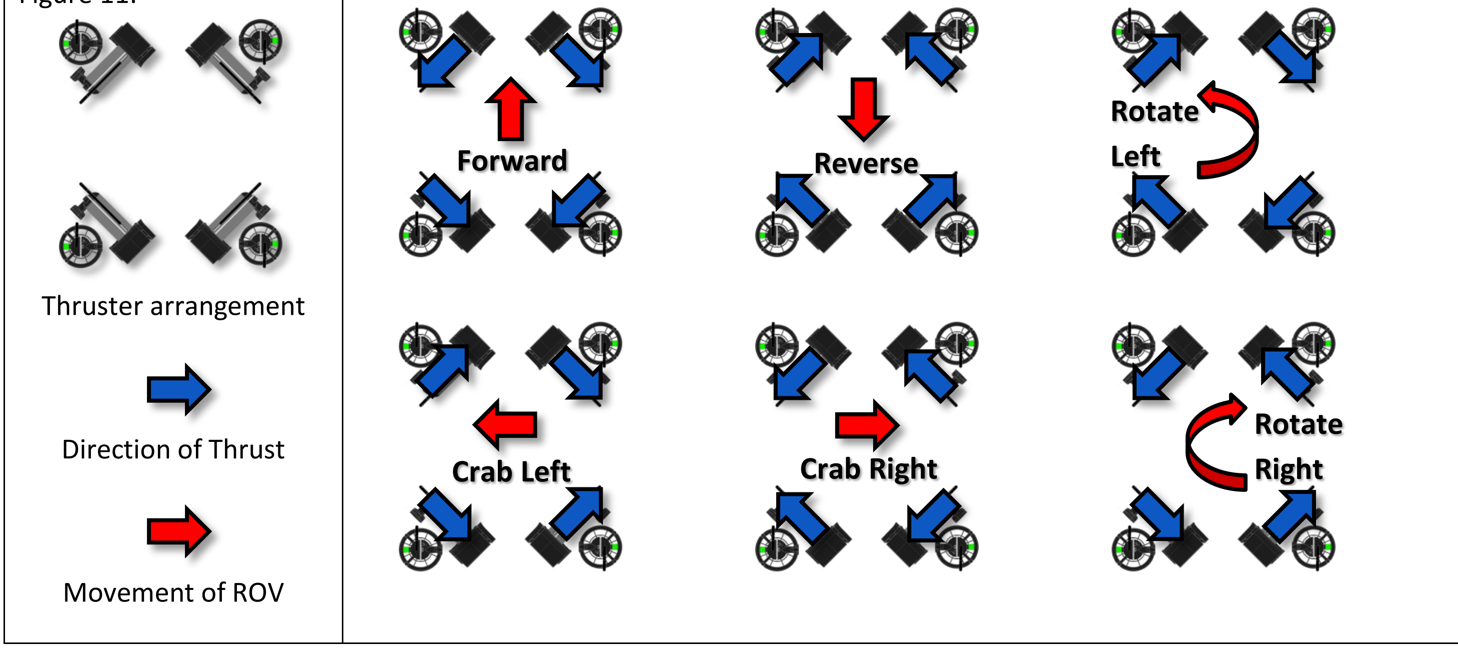
Figure 10: The chipKIT Max32 has the same form factor as the Arduino Mega

The microcontroller runs an in-house customized firmware version of the LINX open source project (www.labviewhacker.com). This firmware accepts Ethernet packets from LabVIEW and translates that into commands to the on-board ROV hardware.

2.5 Thrusters

There are a total of eight Seabotix, 24vDC, 110W maximum, BTD150 standard thrusters with a continual bollard thrust of 2.2kgF on-board *Seawolf III*. The four horizontal thrusters are positioned in a vectored format and the four vertical thrusters are mounted in the corners of the ROV, which allows for excellent movement along multiple axes. Thruster control is shown in Figure 11:

Figure 11:



Although we are re-using six commercial thrusters, we decided to add two more for a stronger thrust in the water column. This also allowed us to design an auto leveling feature (see Figure 18) within our program. The auto leveling and auto hover feature allows us to complete the sonar scanning tasks with little to no effort from the pilot.

2.6 Manipulator

The past *Seawolf* teams have failed at making a functional manipulator, but this year, we were motivated to do so. The simple yet effective manipulator was designed collaboratively by the team. Designs were sketched on paper for weeks, then in CAD software to see a 3D rendering of how well it functioned. 3D prototypes were printed until we were satisfied with the results. The first design was meant for delicate tasks, whereas the final design gave us a better grip pressure. Spectrum Control (Wesson, MS), donated the jaws and machining time, which are made of five layers of stainless steel that were cut out by a laser, then welded together to form two single pieces. The ends of the two jaws are mounted to an aluminum alloy mount (shown in Figure 12) that was machined in-house, and it allows for a pivot point when the jaw opens and closes.

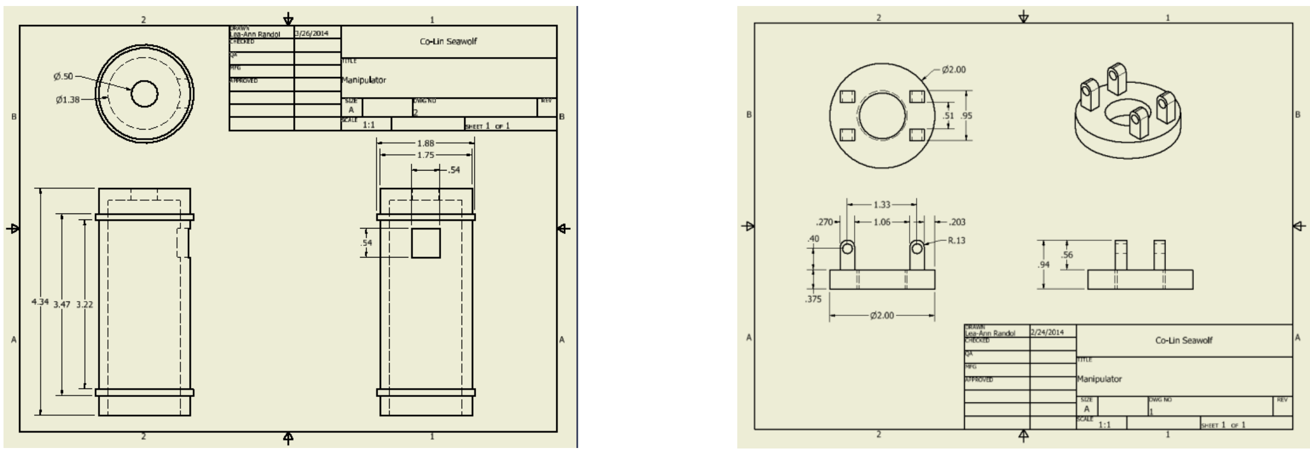


Figure 12: Technical drawings of the manipulators ABS printed actuator housing, and the aluminum alloy mount that the jaws mount on.

The manipulator is operated by micro sized hydraulic components, with all fittings, hoses and components rated at 2,068kPa or more. The hydraulic system is mounted into a 10.16cm diameter by 45.72cm long tube under the main electronics tube. It consists of a pump with a built in reservoir and adjustable bypass, a servo controlled valve block to direct the flow of fluid, two linear actuators, and two pressure sensors. The pressure is set at a maximum of 999.7kPa to keep it under the safety specifications, which states a maximum of 1034kPa.

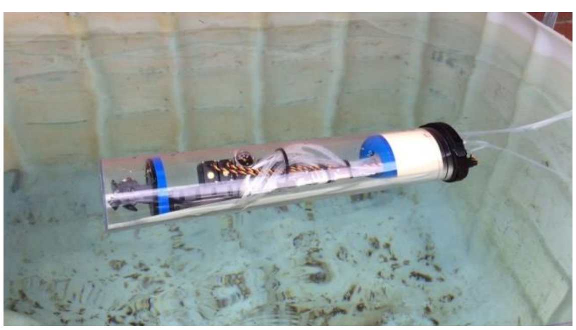


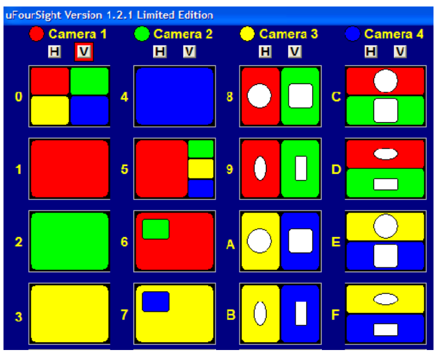
Figure 13: Checking the hydraulics tube for buoyancy, then we submerged to check for leaks

The pump can be turned on and off by the program when needed. Once pressure is built up to the set max, the servos can then be controlled to direct the hydraulic fluid (mineral oil) to the different parts of the actuators, allowing them to move in and out. A 7.62cm stroke hydraulic actuator is utilized in an ABS 3D printed rack and pinion assembly to rotate the manipulator 90 degrees, and a 2.54cm stroke actuator is used for controlling the grasping capabilities of the claw. The manipulator was designed to be used to move debris off the seafloor and to retrieve sensors and a ceramic plate for the competition. There is also a water pressure sensor inside the hydraulics tube that sends an analog signal back to the microcontroller that we convert into a depth level, this is incorporated in our custom hover feature.

2.7 Video System/Lights

There are three cameras on-board *Seawolf III*, with the option to attach a fourth waterproof camera beneath the ROV for special tasks (if needed). The two cameras in the main electronics tube have pan and tilt functionality in order to achieve the best angle of view needed to complete a task. The third camera is stationary inside the hydraulics tube, and is focused on the tip of the manipulator so it is easy to gauge when to close the manipulator on a target. The fourth optional camera can be mounted on one of the horizontal cross-members with two bolts, and plugs into the available wet-mateable 4-pin bulkhead connector on the electronics housing. The camera signals are multiplexed using a four input Ovation Systems video multiplexer. This multiplexer allows the pilot to select individual camera or groups of camera feeds to be transmitted to the surface. The output of this multiplexer is routed to a single input Ethernet video encoder. This video encoder runs a web server which is accessible from the surface computer via the tether's Ethernet cable.

Figure 14: available camera selections and combinations



We incorporated lights onto both sides of the ROV to help with seeing the date and finding the plate inside of the shipwreck. The lights being on both sides prevent us from having to turn the ROV around, inside the shipwreck. The pilot can switch the camera view and easily drive out without any damage to either *Seawolf III* or the shipwreck.

Figure 15: The super bright LED pods are mounted on both sides of the ROV to give enough illumination for all cameras. They operate at a voltage level of 12vDC and have an output power of around 12W, which means they draw a total current of 1A. These lights also make it great to run night operations as seen here.

3. Safety

Safety has been a main priority throughout the process of designing, building and testing of *Seawolf III*. All *S.U.R.E.* members were briefed on operating and programming machinery from the team's mentors. Safety glasses are to be worn at all times when working with any of the tools or machines to ensure everyone's eye safety. All eight Seabotix thrusters were outfitted in the factory with a warning indicator and a protective shroud over the propellers to prevent bodily injury as well as environmental damage (Figure 18). Regarding electronics, members created a custom heat sink dispersing heat from the controller boards through aluminum stock into the central aluminum hub where it then disperses the heat to the surrounding water.

Each DC-DC converter on the power supply board has been outfitted with a slow blow fuse to provide fault and over current protection for the ROVs converters and other equipment. In addition to the required in-line fuse on the tether, the electrical engineers also programmed in a reset switch into the Max32. If for any reason the ROV loses communication during a run, instead of resetting the entire sequence, a button is pressed on the screen bringing controls to the pilot in a matter of seconds rather than minutes. On top of the already provided emergency stop switch, the tether also has a break away release rated at 50A 600V (Figure 16). In case the switch gets jammed in an emergency, the tether can be quickly disconnected to cut off power to the ROV. On either end of the tether is a strain relief hook that must be connected to the power supply and the ROV.

Figure 16: Showing the quick disconnect and in-line 20A fuse holder

Figure 17: Showing one side of the strain relief hooked to the power supply

Sharp edges were removed from *Seawolf III*, in order to protect people and the pool itself. The way *Seawolf III* is designed, it allows for many places to grasp and deploy it into water, but we recommend two team members lifting it near the bottom of the frame to prevent injury. One instance of a near disastrous mistake was during “pool time”, when the housing wasn’t checked thoroughly and the pressure plug was not screwed in. We were about ten seconds away from a water filled electronics tube. That is why we have made a safety checklist to abide by. A copy of our safety checklist can be found in Appendix F.

Figure 18: An image of the BTD150 Seabotix thrusters with the warning indicator and protective shroud

4. Software/Code Examples

For piloting *Seawolf III*, it was decided to use LabVIEW, a National Instruments program. LabVIEW allows us to control our ROV with the laptop where the laptop does most of the processing instead of our microcontroller. This speeds up the communication process, because the laptop's CPU is much more powerful than the microprocessor. LabVIEW has a GUI (Graphical User Interface) that is very user friendly. In the Block Diagram view (as seen in Figure 19), small blocks called "sub .VI's", which are smaller programs inside the main program, allow us to program our microcontroller to do the things that we need it to do.

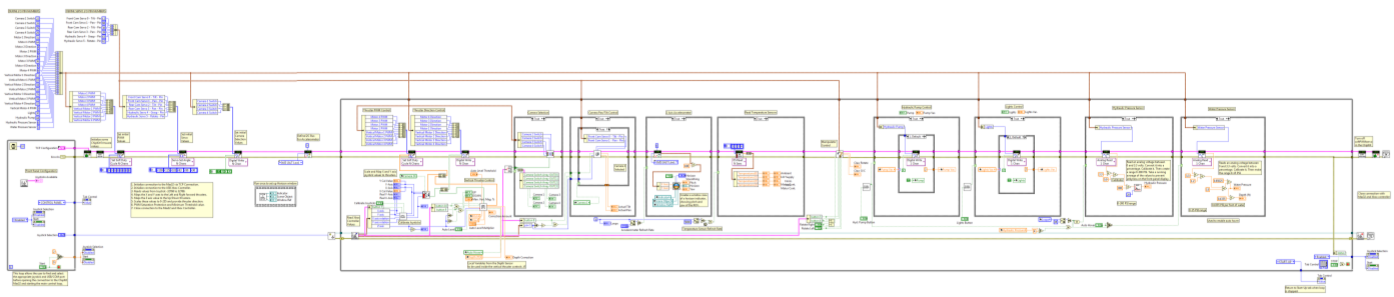


Figure 19: Here is an overview of our LabVIEW program that controls our ROV. Each small sub .VI contains more code like in Figure 20.

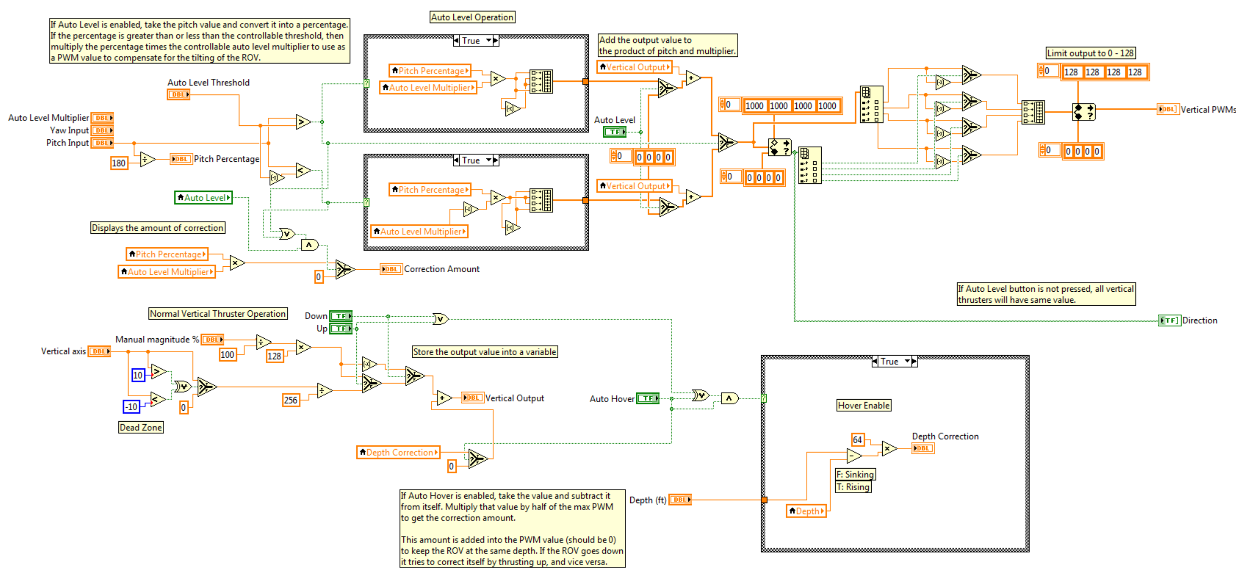


Figure 20: This is one of our sub .VI's that controls our vertical thrusters. It's also the code for our Auto Level and Auto Hover functions. If neither Auto functions are selected, the vertical thrusters are controlled by the Xbox controller and all thrusters rotate at the same speed. If Auto Level is selected, the code above will try to correct for any pitch in the ROV by taking the pitch value and converting it into a percentage so the correcting PWM value will be gradual instead of always fast or always slow. If Auto Hover is selected, it reads in the depth value from the water pressure sensor and tries to hold that value. If the value increases or decreases, the thrusters will thrust accordingly to return *Seawolf III* to the target depth.

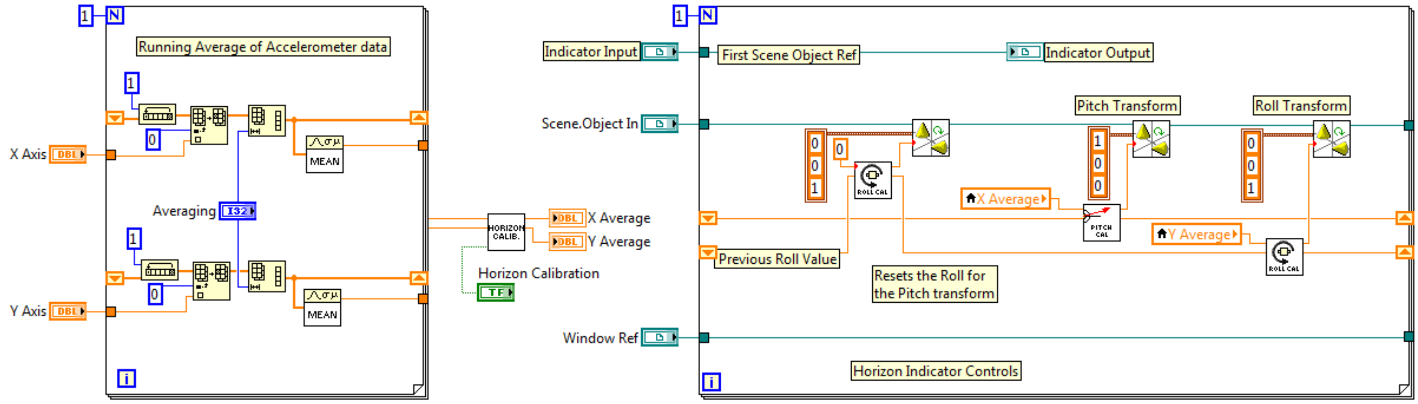


Figure 21: This is the horizon indicator code that takes in values from the 3-axis accelerometer (we're only using the X and Y axes) and creates a running average so the motion of the indicator is a continual fluid movement instead of a jerky movement.

Figure 22a:

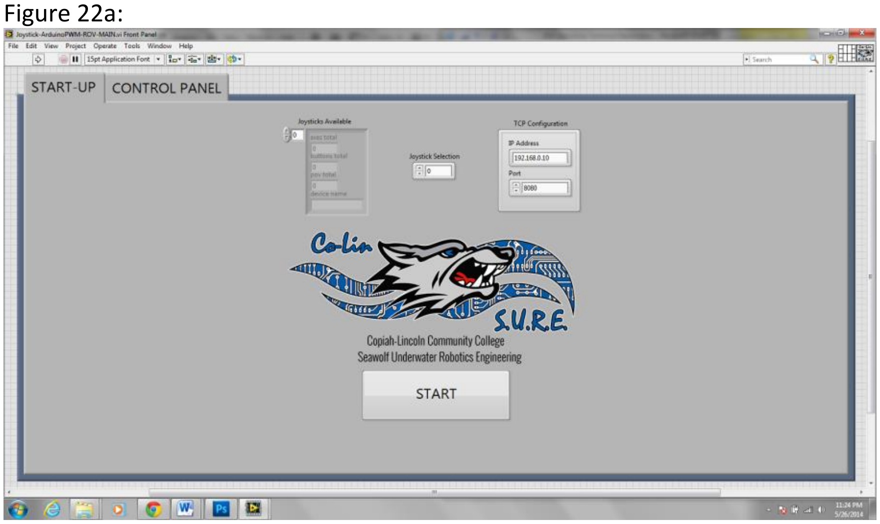


Figure 22a shows our front panel controls on start up. This allows you to select an available controller to drive with, and connects with the IP address that is on the microcontroller.

Figure 22b:

Figure 22b shows the front panel once it has made connection. This gives us controller values for the thrust, camera servo positions, hydraulic pressure, water pressure, water depth, temperatures readings for motor controllers, power supply and ambient temp., and a horizon indicator showing the position of the ROV.

5. CHALLENGES/TROUBLESHOOTING

The *Seawolves* encountered many technical and non-technical challenges throughout the school year that hindered production of the ROV, but this did not stop us from completing the build.

5.1 Technical

With the addition of two more thrusters, our 12vDC power supply would continually reset. Initially this was thought to be because of the noise in the power system. Using oscilloscopes to troubleshoot the system running at full speed (shown in Figure 23); we determined the noise to be around 6vAC. We added a large amount of capacitance (18,800 uF) and TVS (transient voltage suppression) diodes to reduce undesired noise and feedback from the thrusters. We were still having issues with the cut out when all thrusters were being operated 100% at the same time, so we checked the voltage drop across the tether alone. Across the 36.58m tether itself, the drop was in excess of 12vDC. We were able to half that by reducing the tether length to 18.29m. It was decided that 18.29m would be long enough to complete all the tasks necessary at the depth of 5.48m within 17.45m from the edge. With the new filtering and a shorter tether, the total voltage drop in the whole system came down to roughly 6-8vDC. This solution masks the underlying issue, but the limitations of MATE's power allowance will not accommodate a longer tether for our system.

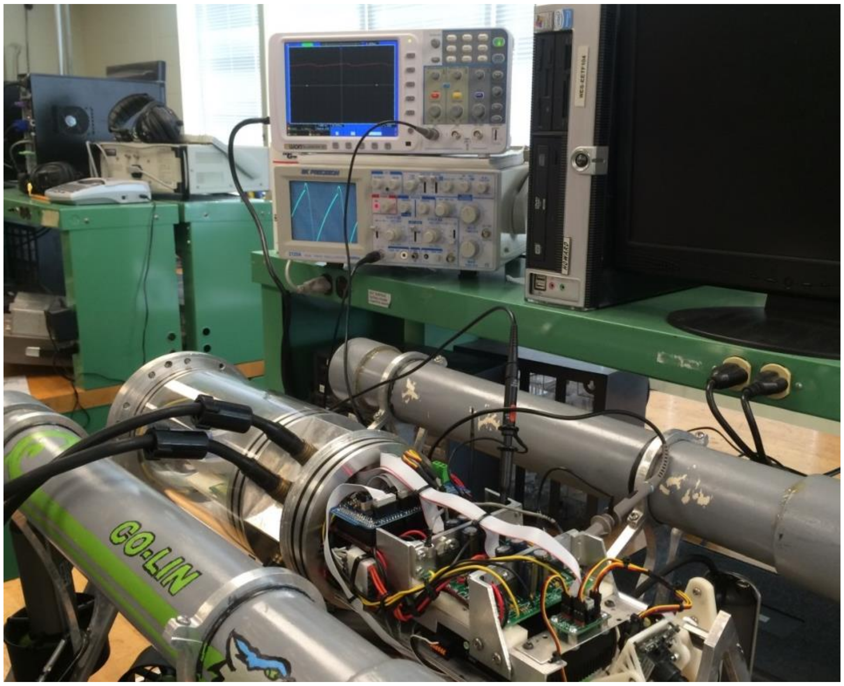


Figure 23: Here, the electronic engineers were troubleshooting the filtering and voltage drop issues using analog and digital oscilloscopes.

5.2 Non-Technical

The team only had one experienced member this year, and because of this he was designated as the CEO of the company to help guide and share his previous experience. With so many new team members who did not have any previous ROV experience, there was a steep learning curve.

At the beginning of the school year, each member got to choose what main systems of the ROV they would like to work on. From there, each group hit the drawing board trying to design each system the way they thought it should work, and then at the next meeting the whole team would discuss every idea until we settled on one. With some members having jobs and/or living far away from campus and/or having kids, it was sometimes difficult to get the whole team to every meeting/pool day. We used internet sources like Google Drive, Canvas, and email to communicate and share files over the weekends and holidays.

6. Skills Gained

The team learned many lessons by working on *Seawolf III*. Perhaps the greatest lesson was learning to do multiple jobs. All of the members took an interest in other components of the design, as well as gaining new insight into their respective fields. The Electronic Engineers honed their skills in designing and producing PCBs, soldering wires and components, and even teaching other team members how to waterproof soldered connections. The CNC Machinists spent many hours in the shop producing what the Drafting and Design Engineers constructed in SolidWorks CAD.

The academic members of the team sat in on work days to learn about the trades that go into constructing an ROV, and eventually got to get their hands dirty and help out. One of the small but very important parts of this process was to build the props that would be used for trial runs in a local pool. This allowed us to practice most of the missions that will be in the International Competition. The most important skill gained, that some team members lacked at the beginning of the year, was communication within the team to help design and manufacture *Seawolf III*.

7. Future Improvements

With the industry of ROVs ever changing, so do the missions. With the design of *Seawolf III*, it allows for many improvements and additions. The manipulator can get the tasks completed this year, but later there may be a need for another manipulator to “lock” the ROV onto the equipment it's working on. This will inhibit the movement of the ROV, and will allow better control with the other manipulator. The stainless steel struts allow for a number of tools to be mounted because of the many mounting holes cut throughout it. That is what makes the structure of *Seawolf III* so great, ease of adding and interchanging components.

8. Reflections

"Being a member of the Seawolf team has made my final year in college a great one. As of right now I don't have much experience in the industry of electronics, but this project has taught me so much more than what I could have learned just by sitting in a classroom setting.

If anyone ever thinks they would enjoy a hands-on experience during college, the best advice I have for them is to do it. You can learn so much more than what your field of study is, which will help you later on in life."

~Blake Whittington (Electronic Engineer, Pilot)

"Joining the Seawolf team has made my last year at Co-Lin one to remember. Even though there were many challenges to overcome and endless nights of writing I wouldn't change a thing. Through this experience, I have learned so much about the industry of electronics and machining.

I would recommend this experience to anyone. You will learn so much more than in a traditional classroom."

~ Erin Whittington (Technical Writer)

"Because of S.U.R.E., I have learned many aspects of CNC programming that I would not have otherwise. It also has shown me many weaknesses in my leadership style.

I believe all of us involved have learned much of product development and collaboration."

~ Jonathan Nations (CEO, Machinist)

9. Budget/Expense Report

Material Expenses				
Item	**Quantity**	**Unit Cost**	**Total Donation***	**Total Purchase**
120ft. Tether - “Seatrepid”	(1)	$500.00	$500.00	
BTD150 SeaBotix Thruster	2,(6)	$578.92		$4,631.36
Custom Power Supply Board	1	$215.00		$215.00
Custom Hydraulics System	1	$1,028.00		$1,028.00
Pan & Tilt Camera with Servos	1,(1)	$80		$160.00
Video Multiplexer board - “Ovation Systems”	1	$800.00	$800.00	
LED Light Pods	1	$17.00		$17.00
Aluminum ROV Frame - “Spectrum Control & Holifield Engineering”	(1)	$200.00	$200.00	
Acrylic Electronics Tube	(1)	$45.00		$45.00
Custom Thruster Control Boards	(2)	$50.00		$100.00
SS Claw for Manipulator - “Spectrum Control”	1	$100.00	$100.00	
8 ft. O-ring material - “Gatlin Corp.”	(1)	$50.00	$50.00	
16-pin Male bulkhead connector	1	$32.30		$32.30
16-pin Female bulkhead connector	1	$34.10		$34.10
16-pin Male/Female whip	1	$46.80		$46.80
8-pin Male whip	1,(1)	$12.80		$25.60
8-pin Female bulkhead connector	1,(1)	$20.50		$41.00
Syntactic Foam - “Seatrepid”	1	$100.00	$100.00	
Syntactic Foam – “Holifield Engineering”	1	$150.00	$150.00	
“New” Material Donation			**$1,150.00**	
Total Material Donation			**$1,900.00**	
“New” Material Expenditure				**$2,644.34**
Total Material Expenditure				**$6,376.16**
Note: () item re-used from last year * total donation price is an estimate **“New”** does not include previous year’s donations or expenses				

Misc. Expenses			
Item	**Quantity**	**Unit Cost**	**Total Purchase**
PVC pipe and fittings	NA	NA	$109.10
Magic of Science Show Fundraiser	1	$1,390.00	$1,390.00
Apparel	50	$8.84	$442.00
Total Misc. Expenditure			**$1,942.10**

Monetary Donations/Fundraising	
Donor	**Donation Amount**
Georgia Pacific	$5,000.00
Magic of Science Show Fundraiser	$125.00
Ole Miss FTC Fundraiser	$500.00
Grand Total	**$5,625.00**

Summary	
Total Material Donation	$1,900.00
Total Cash Revenue	$5,625.00
Total Material Expenditure**	($2,644.34)
Ending Cash Balance for Travel Expenses	**$2,980.66**
Note: ** does not include previous years expenses	
Total Cost of Seawolf III	**$8,126.16**

10. Special Thanks

Dr. Ronald E. Nettles II, President, Copiah-Lincoln Community College
Dr. Jane Hulon, Vice President of Instructional Services, Copiah-Lincoln Community College, Wesson Campus
Miss. Jackie Martin, Dean of Career-Technical Education, Copiah-Lincoln Community College, Wesson Campus
Dr. Jill Logan, Dean of Academic Instruction, Copiah-Lincoln Community College, Wesson Campus

11. Acknowledgements

Brookhill on Natchez – Providing a pool for practicing

Copiah-Lincoln Community College – For registration and travel expenses and for providing a great friendly atmosphere to be in

Georgia-Pacific – Monetary donation

Holifield Engineering – Providing a pool for practicing

MATE center – Providing such a great experience in underwater robotics

Ovation Systems – Donation of 4-video multiplexer board

Seatrepid – Donation of tether, hosting of Regional qualifier, tour of facilities

Spectrum Control – Donation of Manipulator claw material and machining time

12. References

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LABVIEW HACKER. (2014). *LabVIEW Hacker*. http://www.labviewhacker.com/

MATE. (2014). *Marine Advanced Technology Education*. http://www.marinetech.org/

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APPENDIX A: SID

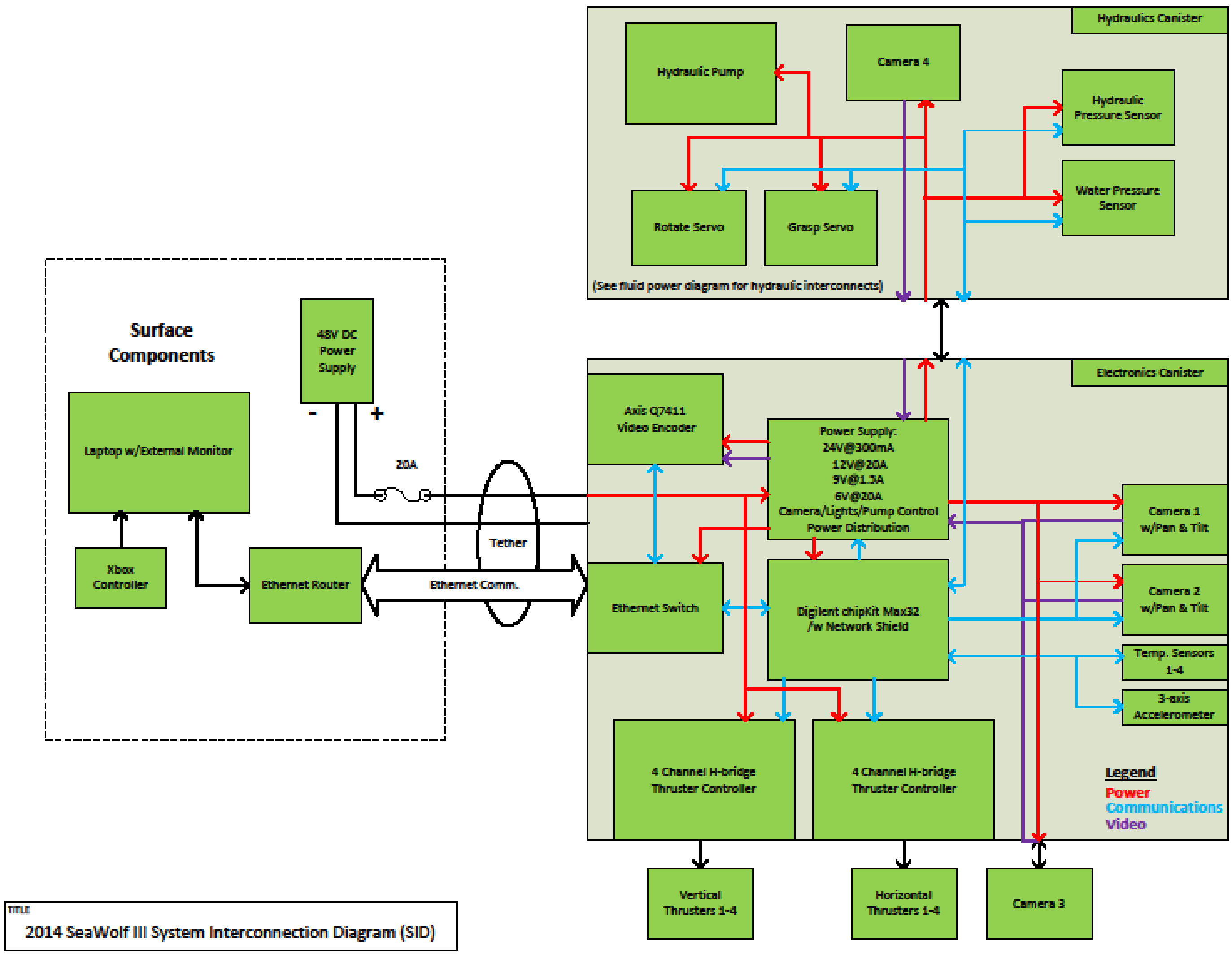


Figure 24: System Interconnection Diagram of Seawolf III, showing the Surface components and controls on the left and on-board components and interconnections on the right. Arrows point in the direction of data/power flow.

APPENDIX B: FID

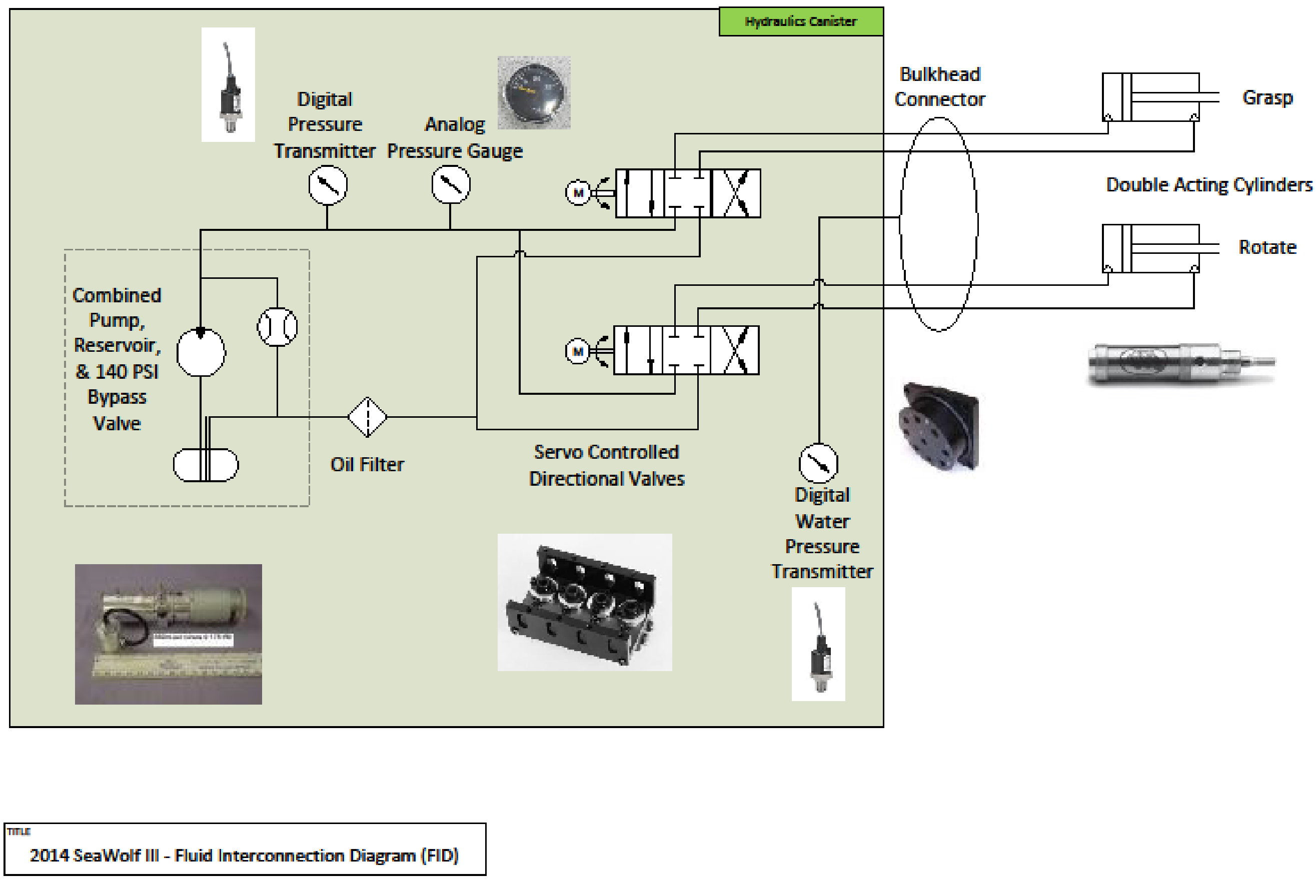
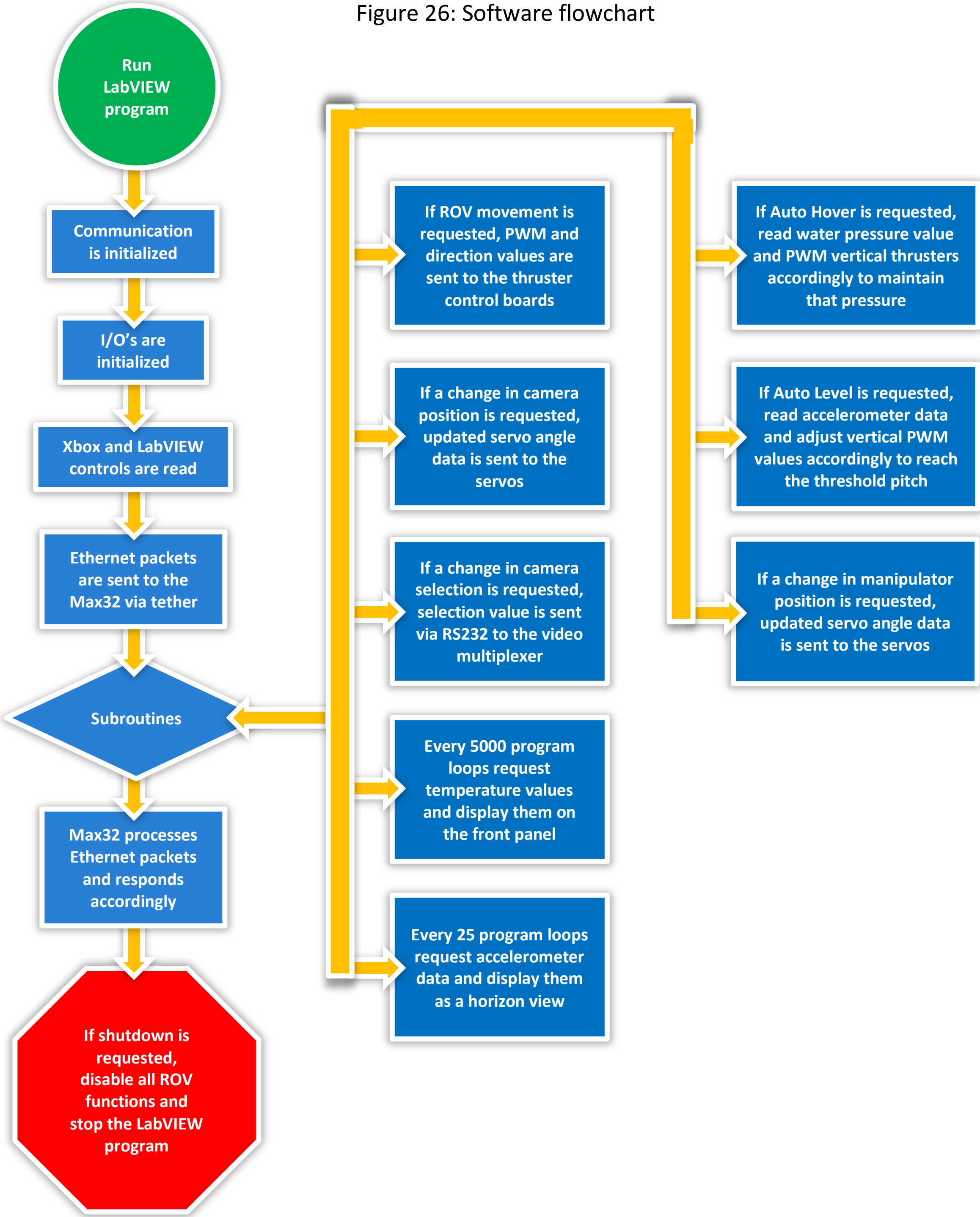


Figure 25: Fluid Interconnection Diagram of Seawolf III, showing all of the hydraulic system components.

APPENDIX C: SOFTWARE FLOWCHART

Figure 26: Software flowchart



APPENDIX D: PILOT CONTROLS

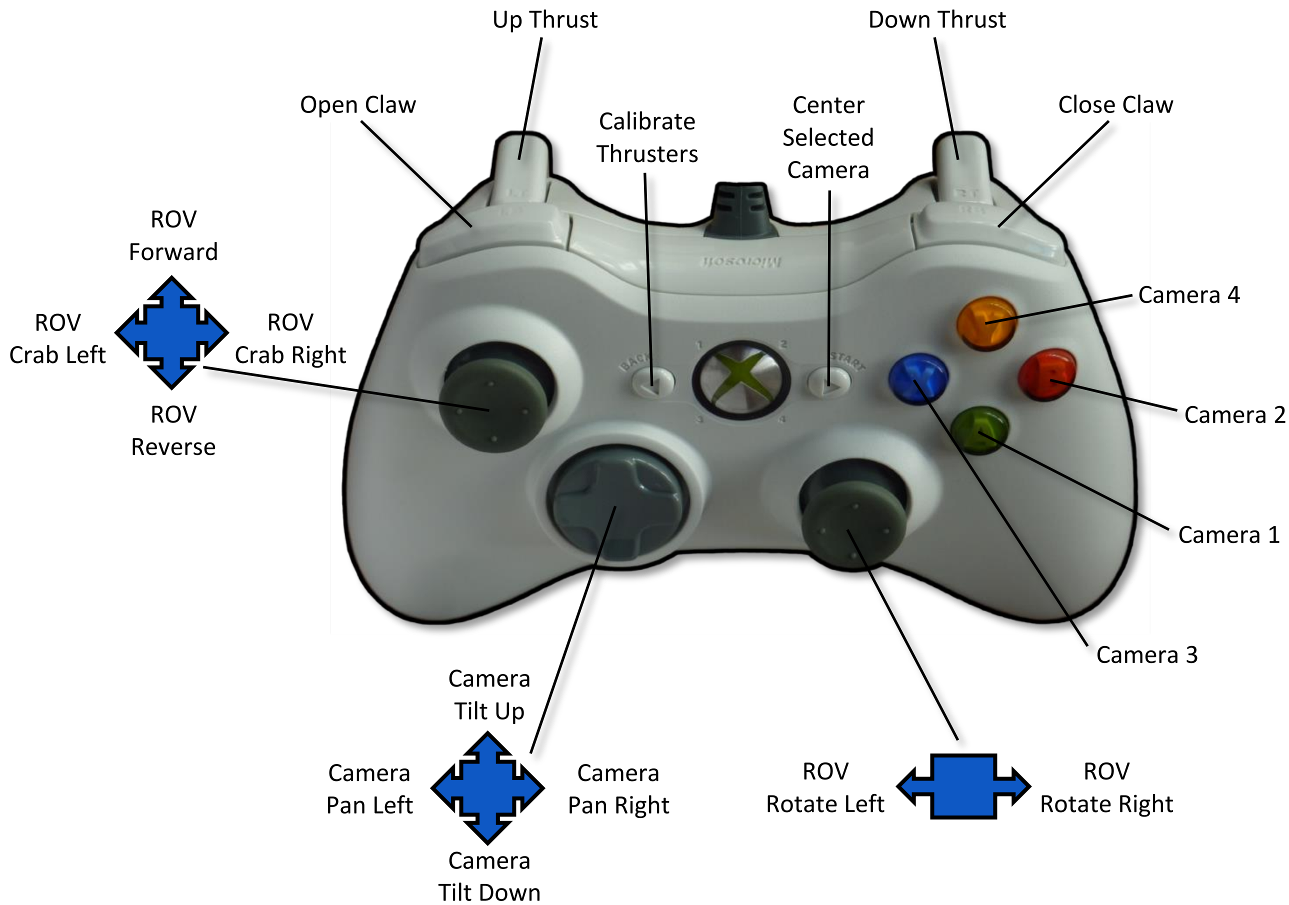


Figure 27: Button layout and controls for *Seawolf III*

Appendix E: Request For Proposals

MATE Center
Monterey Peninsula College
980 Fremont Street
Monterey, CA 93940

Dear Sirs,

Please review the bid for services in response to your Request for Proposals:

An observational class ROV to map and survey the underwater wreck site:

Contract Rate (Greater than 6 months)	$800 per day
Call-Out Rate (Less than 6 months)	$900 per day

A working class ROV to remove hazardous material from the ocean:

Contract Rate (Greater than 6 months)	$5,500 per day
Call-Out Rate (Less than 6 months)	$6,500 per day

Invoices will be delivered weekly and payments are due within at least 20 days. We will have a meeting to discuss the ROV and give a demonstration in Alpena in June 2014. We will construct an ROV that is customized for the specific missions, the actual functioning ROV will be ready 2 months after the contract is awarded.

Please note that any additional assignments encountered will be billed at a rate to be determined based upon the assignment.

Thank you for reviewing our proposal and we look forward to seeing you in June.

Sincerely,

Caleb Smith, CFO

APPENDIX F: SAFETY CHECKLIST

Checklist	Do the following in order
	Put on safety glasses
	Always team lift ROV with two members
	Make sure all plugs and caps are on ROV
	Connect the tether to the ROV and secure with strain relief
	Check that there are no exposed sharp edges
	Make sure all electrical connections outside of ROV are seated
	Check the in-line 20A fuse
	Connect the tether to the 48V power supply and secure with strain relief
	Turn on power to the laptop and monitor and make sure charger is connected
	Connect Xbox controller
	Start LabView and open the main program
	Turn 48V power supply on
	Allow the 3rd LED on internal Ethernet switch to come on
	Start program
	Check that all thrusters, manipulator and lights are working
	Put ROV in water and trim with weights