Long Beach City College

EIR Club – Long Beach, CA

VX Industries

2017 MATE International ROV Competition

Port Cities of the Future: Commerce, Entertainment, Health, and Safety

Explorer Class

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Chief Engineering Officer: Edward Gonzalez
Software Engineer: Jorge Ceja
Fabrication Director: Michael Schubert
Foreman: Jonathan Turner
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I. Abstract:

Whether it be ensuring the safety of those in close proximity to the ports, installations to enhance trade procedures, or guaranteeing unhinged entertainment, Erik the RED's (Research, Entertainment, Development) capabilities are seemingly endless and can be incorporated into several industries if need be.

Revolutionary in comparison to its predecessors, Erik branches away from the norm. He foregoes the standard acrylic tube housing and implements "pucks," allowing main components to be isolated from one another. This provides an ease of access in the case of maintenance, and mitigates water leaks and transportation damage. The newly integrated thrusters are nearly half the weight of the previous, and double the power. Utilizing four thrusters provides us with just as much propulsion, all while cutting down on cost, weight, and size. Through calculations, the thruster arrangement provides maximum control and thrust, thus allowing us to retain the agility VX Industries is known for. With Erik's small size, maneuvering through and around obstacles is a breeze. The highlight of Erik is his fully enclosed three axis manipulator, capable of lifting extensive loads.

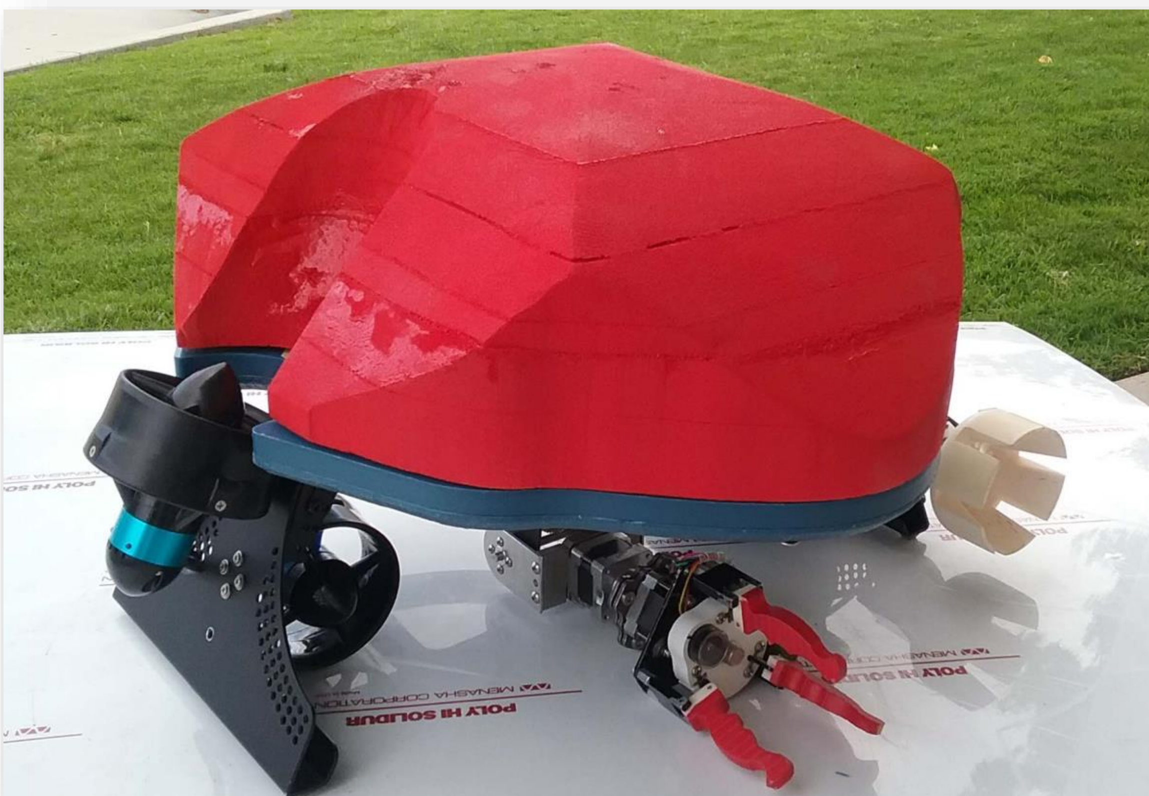


Figure 1. ERIK the RED Full Photo Before Beauty Treatment

II. Design Rationale:

Main Circuit Boards

Figure 2: Main Port and Starboard Circuit Boards

Developing a waterproof circuit board system both reduced weight and more importantly, increased ROV reliability. The number of penetrations into the electronics space was reduced from 22 to four. In addition, each of the four pucks provide a measure of redundancy, each with one sealed opening for signals. Each puck connects to the board via 32 pin connectors protruding through an aluminum heatsink. Beneath the heat sink are two circuit boards that replace cables that may otherwise increase leak hazards. The two boards are then potted in a watertight thermal epoxy that regulates the heat. By using a single circuit board, only one tether connection is needed for all communication and power between the surface and the ROV.

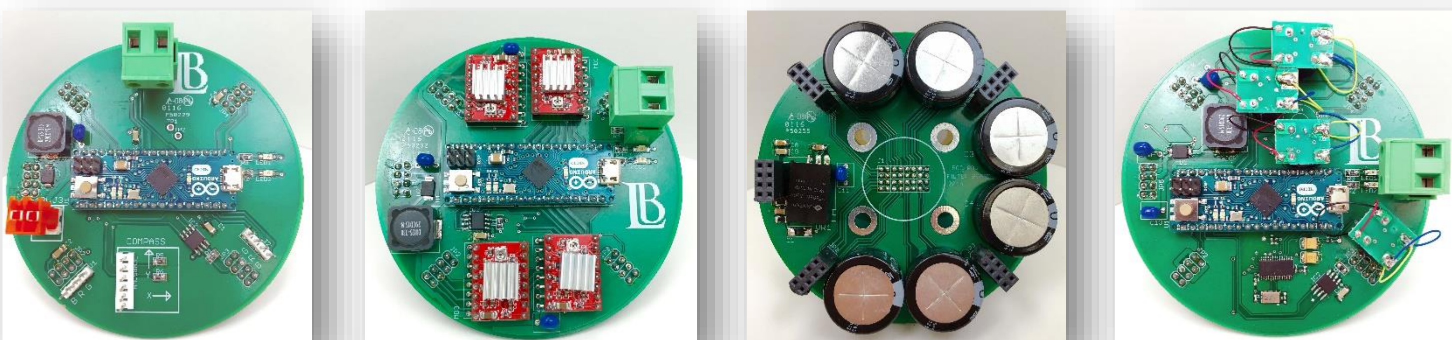


Figure 3: From Left to Right: Thruster Puck, Manipulator Puck, Filter Board, and Video Puck

Circuit Boards Pucks

Prior to the task release, we began developing a smarter circuit board system. Our goal was to access the boards without fussing with the O-ring seals common in the typical acrylic cylinder housing. We found the exact mechanism to do so in the form of a simple stainless steel container. A pressure test was conduct on the container consisting of 50PSI simulating the container submersed at a depth of about 34 meters. The container proved more than adequate, and so we tailored our circuit boards to fit within the dimensions of these containers.

Our circuit board "puck" design provided the freedom to develop the basics and essentials and later adjust them to fit within the requirements provided for the competition.

Three types of pucks were developed:

The Thruster Control Puck consists of Arduino microprocessors and pressure sensors. Each puck has the capability of controlling four thrusters -- for redundancy and safety measures, only two thrusters are controlled resulting in two separate pucks each controlling two thrusters.

The Manipulator Puck houses four stepper drivers, three are used to control the three stepper motors the current manipulator is equipped with. The fourth driver is used to control the Valve Motor.

The Display Puck controls the four camera BALUNS and LED lighting.

Each puck has a high capacity filter board able to filter the incoming power and provide the Arduino processors with an electrically "clean" environment without pulses and glitches present in many previous systems. A water sensor that notifies the surface control for manual shut down, limiting damage and programming glitches that may shut down the ROV is also included.

Mechanical Design

The physical characteristics of ERIK have undergone several major changes. The first conception mimicked a more traditional ROV that allowed for easy manufacturing development and weight reduction. However, that design didn't meet the size or weight requirement, and balance issues were introduced once the manipulator was added.

When designing, a quick assembly process, simple components, and straight forward programming were kept in mind to maximize time spent on wet runs and piloting practices.

Over six months were spent on designing ERIK. Each revision would strip away excess weight and size, and simplify the manufacturing process.

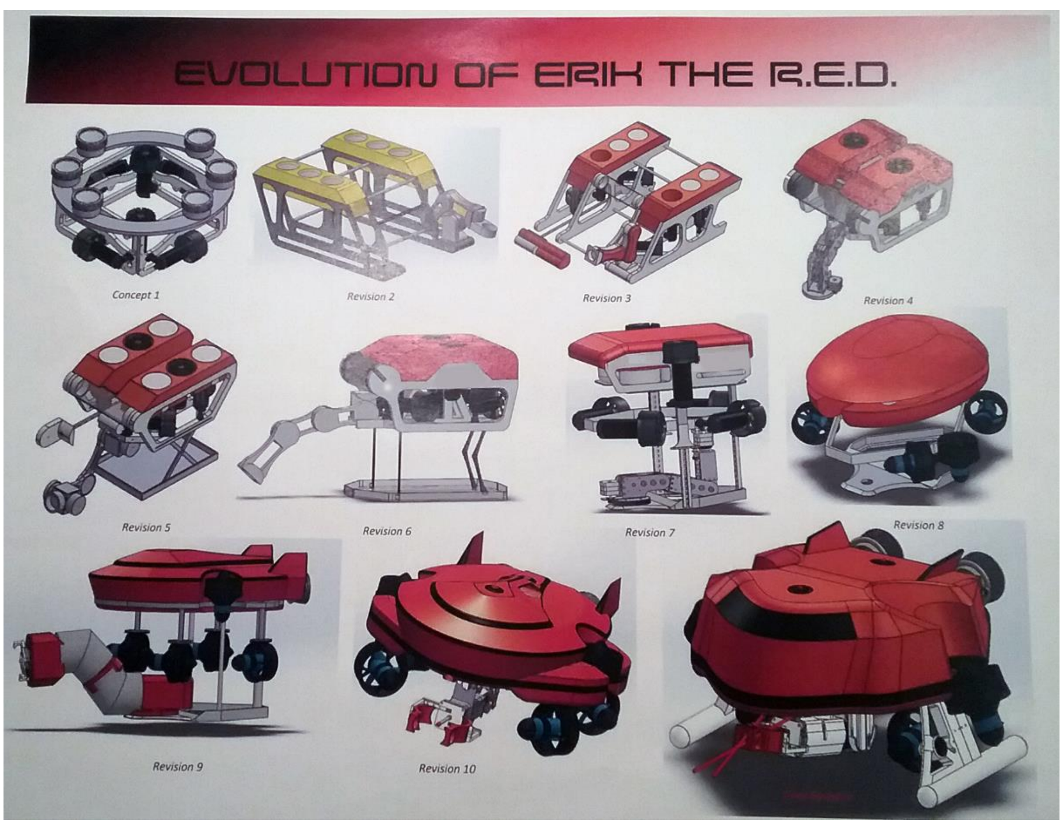


Figure 4: Evolution of ERIK the RED

The first radical modification began with the manipulator placed on a pseudo elevator/carrying shelf that allowed the manipulator to store samples and transfer mission specific equipment. We explored several variations of this design, only to realize a more simplistic design would provide what we needed.

Thrusters

Replacing the Seabotix thrusters with Blue Robotics' T-200 provided us the edge needed. The newly integrated thrusters were half the weight, a fraction of the cost, and nearly double the power.

This then played into our final drastic change. At our school's annual science fair, our robotics team set up a presentation using the MATE Triggerfish and our older ROV the Delta Explorer. While the six-thruster configuration helped the Delta Explorer maneuver beautifully, the Triggerfish's four thrusters were more than adequate to pilot with. By removing two thrusters, we could allocate more weight towards mission specific components and the body of the ROV.

Figure 5: Blue Robotics T-200 Thruster

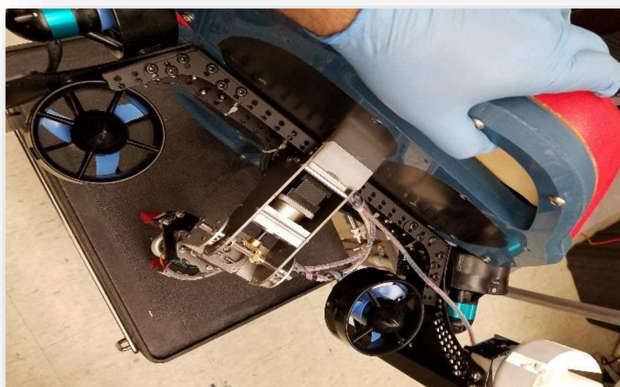


Figure 6: Thruster Configuration mounted on Legs

Float

Our float is of an original design, created from varying layers of high density polyurethane foam boards glued together. By using the profile of our mounting frame as a starting point to make certain that our float would correspondingly bond to that frame, we then expanded upon that profile in our CAD software (SOLIDWORKS). Taking in to account our exiting ROV's parameters such as size, weight, spacing of electronics and wires, and center of mass, we then created a corresponding solid model in SOLIDWORKS that functionally fit our needs as dictated by the ROV, took hydrodynamics in to account, and was still aesthetically pleasing. From there, we imported the SOLIDWORKS file it to Fusion 360 software which is compatible with our Haas VF-1 CNC milling machine.

We glued the foam boards into two separate blocks beforehand with a combined minimum height of six inches. Dividing our foam blocks initially into two allowed us to create a cavity to house our electronics by simply cutting out the required shape out of the bottom layer and then capping it with the top layer. By doing the layers separately and combining them after their shapes were cut out of the CNC mill, this eliminated the need to maintain an exact positioning when flipping over the single foam block to when transferring from the outside profile cut to the internal electrical cavity cut.

After each block's shape was roughly cut out using the mill, the shapes were further refined and smoothed by hand, using various shaped rasps and sanding implements. During this post processing, the individual doing the work made sure to work in a well-ventilated room, while wearing a particulate respirator and eye protection seeing as the particulate from the foam is easily arbore and hazardous. Next, the two foam halves were glued and fitted together create our final shape.

Figure 7: Blocks of Polyurethane Foam Boards glued together

Figure 8: Bottom Float Prior to Sanding

Figure 9: Finished Float Prior to Resin Coating

Tether & Management

An equally light tether was a necessity. We used two shielded Cat5 cables and a 16 AWG twisted pair for power to minimize the weight as much as possible. Though one Cat5 only uses two twisted pair, the cost and weighted associated with purchasing that type of cable negated the benefit, and removing the sheathing would be disrupted by the 16AWG power cables' EMF. We performed multiple size vs voltage drop calculations and determined that a single pair of 16AWG wires would provide us with a minimum voltage of 36 volts at the ROV while drawing maximum current of 30 amps.

Figure 10: Tether Connector with Strain Relief

Figure 11: Outside the Tether Box

Figure 12: Inside the Tether Box

We went through numerous tether placement configurations with the various design changes. Ultimately positioning it at the rear provided the best placement as well as a robust tether strain relief. Our design team fabricated a special aluminum housing that allowed the tether connector to screw right into the back, giving us one connection for all the tether wires. The aluminum housing started as a solid block and was precisely milled to 100th of a millimeter.

The tether is easily withdrawn and retracted from its housing box. Located on the rear of the box are video, power, and LED connections between it and the cart. The gears within were created in house along with the crank and crank shaft. This decreases the time necessary to clean up. Additionally, a winch was attached to the front of the box to allow the tether to be pulled without catching on any sharp edges, and stop the tether from being reeled in completely. By utilizing the cart and tether box, we can isolate the alternating current from the direct. When powered, flashing orange lights located within the box and on top of the cart notify that voltage is being applied.

Control Station Cart

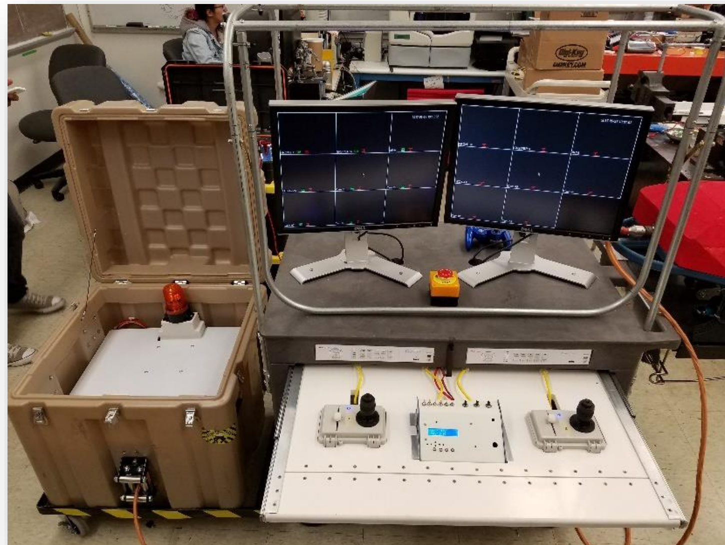


Figure 13: Control Station Cart with Power

The tether box is then attached to the cart, which also acts as the control station. The pull out table holds the surface control box and two joysticks. Incorporating these features allows pilots to "plug and play," drastically decreasing the time required to set up. As a safety measure, having two stations guarantees each pilot focuses on the task at hand, whether that be maneuvering the ROV of operating the manipulator. A nearby emergency button located directly in front of both pilots cuts all power to the ROV if needed. The four cameras connected to the ROV relay video to the monitors via DVR connections. To maintain consistent visibility of the monitors, a folding canopy with black out curtains was developed, blocking out light. A laptop stand was added for the topographer to create the survey map.

3 Axis Manipulator

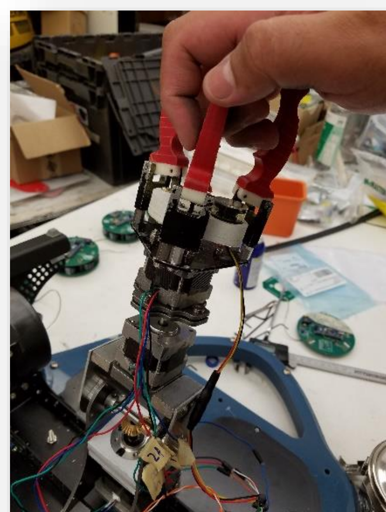


Figure 14: Complete 3 Axis Manipulator

ERIK's 3 axis manipulator provides the capability to complete a multitude of tasks. Armed (pun intended) with 3 stepper motors, it lifts loads of up to 2kg. Attached to the uppermost motor is a 27- 1 gear box, which delivers enough torque to lift the rest of the arm and any loads the ROV must carry throughout its missions. The original design contained 3 gear sets, which we found to not hold the load in place. By removing the gear sets and integrating a planetary gear box on the stepper motor, we reduced the number of mechanical components interacting with one another, which may have led to gear slips. The next motor acts as a wrist and rotates the gripper. The third motor operates the gripper, it rotates the shaft, the screw pushes and pulls the plate connected to the fingers, causing them to open and close. The curvature of the gripper finger allows for inside and outside gripping of various sized objects. Outside gripping ensures that the mission specific tooling such as that agar sampler and marker buoy are grasped well, while inside gripping by opening the fingers ensures objects collected such as the clams or positioning beacons will not fall during the transportation to the basket.

Figure 16: Basket with all the items needed to be transported to the surface

Mission Specific Tooling

Agar Sampler for Task 3 Health: Returning Sediment Sample

The tapered cylinder and jagged edges allows the ROV to use minimal force to insert the sampler, and the inner spiraled edge safeguards the material is stabilized and will not spill. The cap was designed with the gripper finger's indentations, which ensures the sampler does not slip or fall while in use. The opening centered on the cap was created to allow for water flow. By doing so, the sampler is guaranteed to retrieve at least 350 milliliters of sediment.

Figure 15: Agar Sampler and Buoy Marker

Buoy Marker for Task 4 Safety: Attaching a Buoy Marker to the High Risk Container

The first issue of creating the buoy marker was finding a way to first attach a component to the U-Bolt on a container. Our first attempt required a spring based button to open and close a clip like mechanism, but figured too much maneuvering would be needed. Our next idea was based on the idea of carabiners, still a spring based devise but much simpler to handle. Rather than including a spring, tension held metal pieces provided just enough strength for the task. We then created a two-component housing for the piece, connected the two by string, and made it so the upper half of it was detachable. These pieces were 3D printed from ABS, a positively buoyant material and also have the same finger indentations as the agar sampler cap to provide a better gripping surface. Magnets hold the upper and lower pieces of the marker buoy together, and only a small force is required to pull the two apart. Once separated, the upper portion floats to the surface.

Basket for Task 1 Commerce: Retrieving 3 Positioning Beacons, Task 2 Entertainment: Returning Fountain, Task 3: Clam Collection & Agar Sample Retrieval

The basket acts as an elevator and a makeshift toolbox. It fits perfectly under the ROV, and has an easy handle for the ROV to grip onto. Our original idea was to split the basket into positive and negatively buoyant components. When deployed, the two would've been sandwiches as one and expand once released. The issue with this was that we had no way of knowing how the basket would expand, and figured a rigid body would provide us the structure and assurance. The top of the basket contains slots for the Agar Sampler and Buoy Marker, and a large slot is left to drop other materials such as the clams and the positioning beacons. All the elements that must be returned to the surface of the pool will then be together and taken up at once, rather than having the ROV bring each individually.

Valve Motor for Task 2 Entertainment: Stopping and Restoring Water Flow

Figure 17: Valve Motor

While the manipulator has the capability of turning the valve to stop water flow as requested in Task 2, the spare fourth driver provided a simpler means of doing so. Rather than having the manipulator consistently reposition, the stepper motor placed on the leg of the ROV can quickly and easily open and close the valve. Tailoring a mount specifically to the curves of the valve reduces the need to shift and adjust. As the stepper motor begins to rotate, the mount locks onto the valve while the indicator arrow notes the number of turns.

IC Measure for Task 4 Safety: Determining Distance between Containers & Survey Mapping

The topographer will utilize a simple and efficient program called IC Measure to map the containers in task Safety: Risk Management. The process begins with placing a reference marker attached to a basket near the containers. The pilot will then maneuver the ROV directly above the containers and take a snapshot using the camera on the ROV arm aimed down. The topographer will upload the image to IC Measure. Then the reference marker will be assigned on the image in IC Measure, thus calibrating scale and distances. The topographer then can simply layout the distances between containers which is automatically calculated by IC Measure based on the calibration and reference marker.

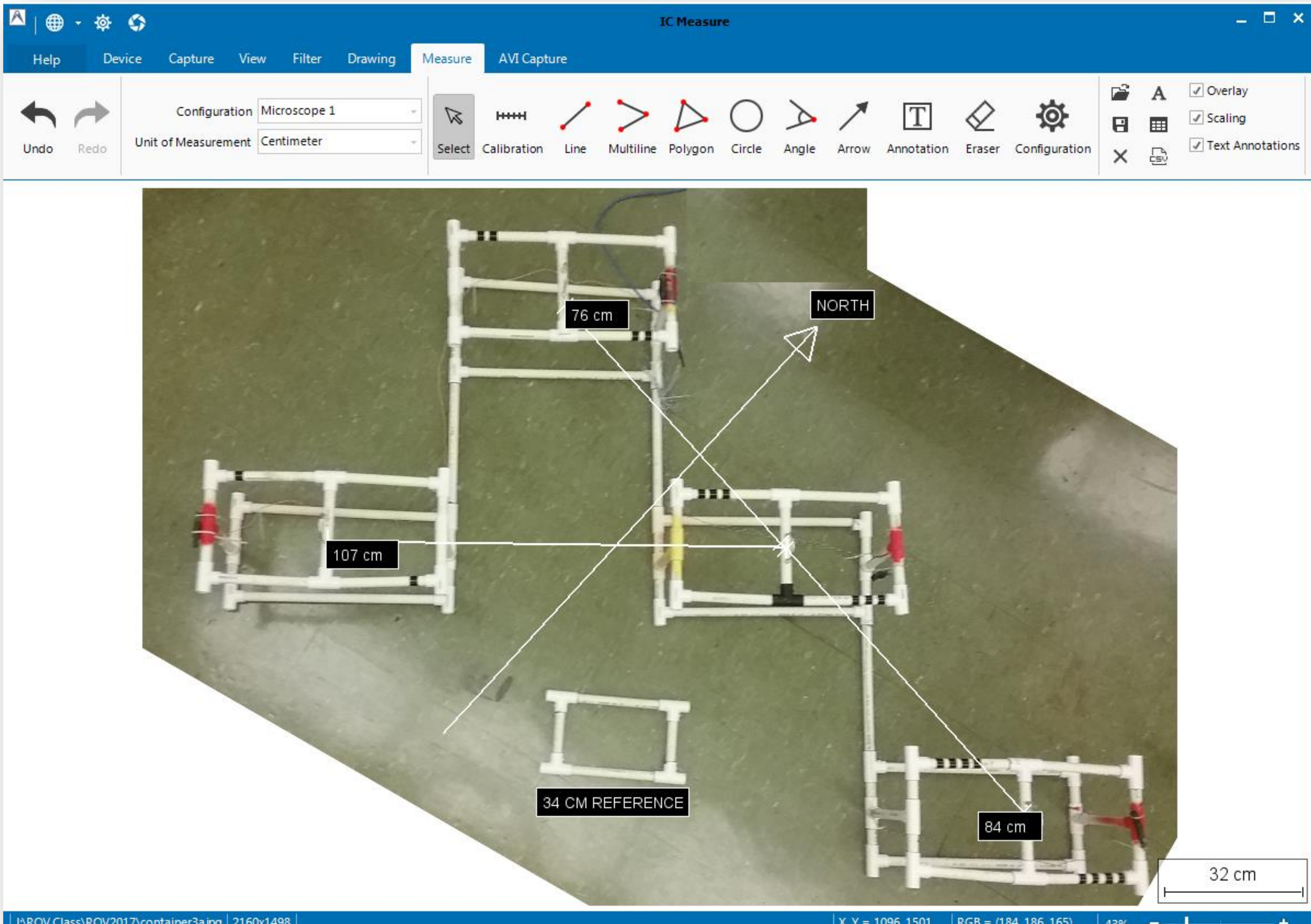


Figure 18: IC Measure Program with Example Configuration and Mapping

RFID Finger for Task 3 Health: Determining Contamination, Task 4 Safety: Obtaining Bluetooth Data

The first concept for the Bluetooth/RFID sensor was to put in into the gripper as one of the fingers. This added 8 additional wires that needed to go across the rotating gripper joint. It was decided that the Bluetooth/RFID sensor would be fixed and the ROV navigated to align with the light sensor and RFID data. This allows us to simply control the light and connect to the RFID (Bluetooth) device. The acquired data is placed into the status packet and sent to the surface controller for display on the controller LCD display.

Figure 19: RFID Finger with LED

III. Safety

Our Dedication to Safety

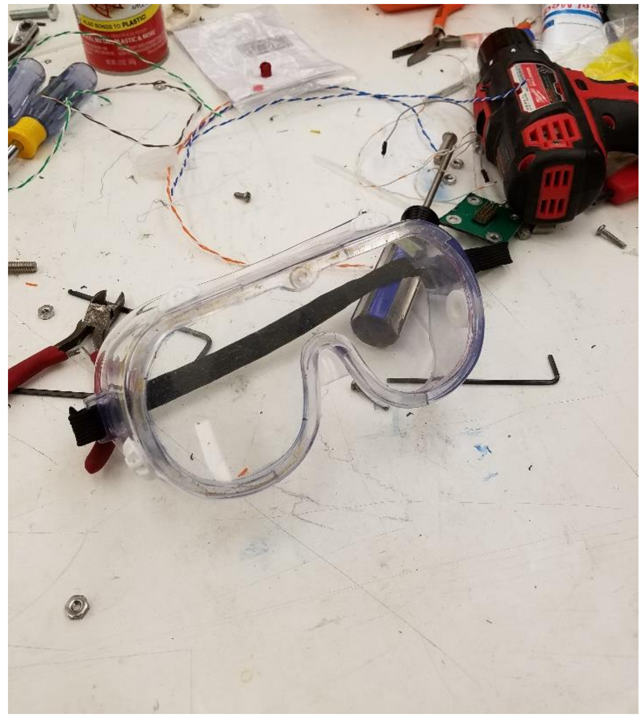


Figure 20: Lab Safety Equipment

Safety has a negative connotation of slowing work down, frustrating employees and provides mountains of tedious paperwork. VX Industries doesn't care. If you work for us, you follow our guidelines or you're out, it's that simple. We deal with hazardous materials, high voltage, and dangerous working conditions all the time. Our people handle the same problems our products do, and like our products, their impacts have global effects. So we've adapted the "Slow is smooth, and smooth is fast" philosophy. Our methodical process and aggressive supervisors, systematically mitigate any possible safety hazards that are known and not known. Yet, we cannot wrap everything in bubble wrap, and most incidents are human neglect therefor if any employee regardless of position, conducts unsafe acts—they're fired.

The same applies to our manufacturing process and the products themselves. No short cuts or cheap quality material is used throughout our manufacturing process. Every design is scrutinized for possible safety hazards to the operators, in product maintenance and the environment the product works in. Every sharp corner, unless specifically designed for an indented purpose, is rounded off. The tools that have jagged edges are clearly marked and designed to mitigate worst case scenarios. VX Industries wants to help preserve all life and planet Earth. We take every precaution using numerous checklists and strict adherence to company policy. No excuse qualifies for work related incidents or death.

ROV Safety

At VX Industries, safety is of the upmost importance. Not only do we expect the highest standard of safety for our workers, but also for our products.

The Anderson Power pole connectors provide a platform which eliminates the possibility of incorrectly connecting the system and potentially frying the system.

Strain relief is present on all wires potentially under tension or stress, thus protecting the equipment from accidental disconnects which could result in damage to connectors or even shorting from exposed wires.

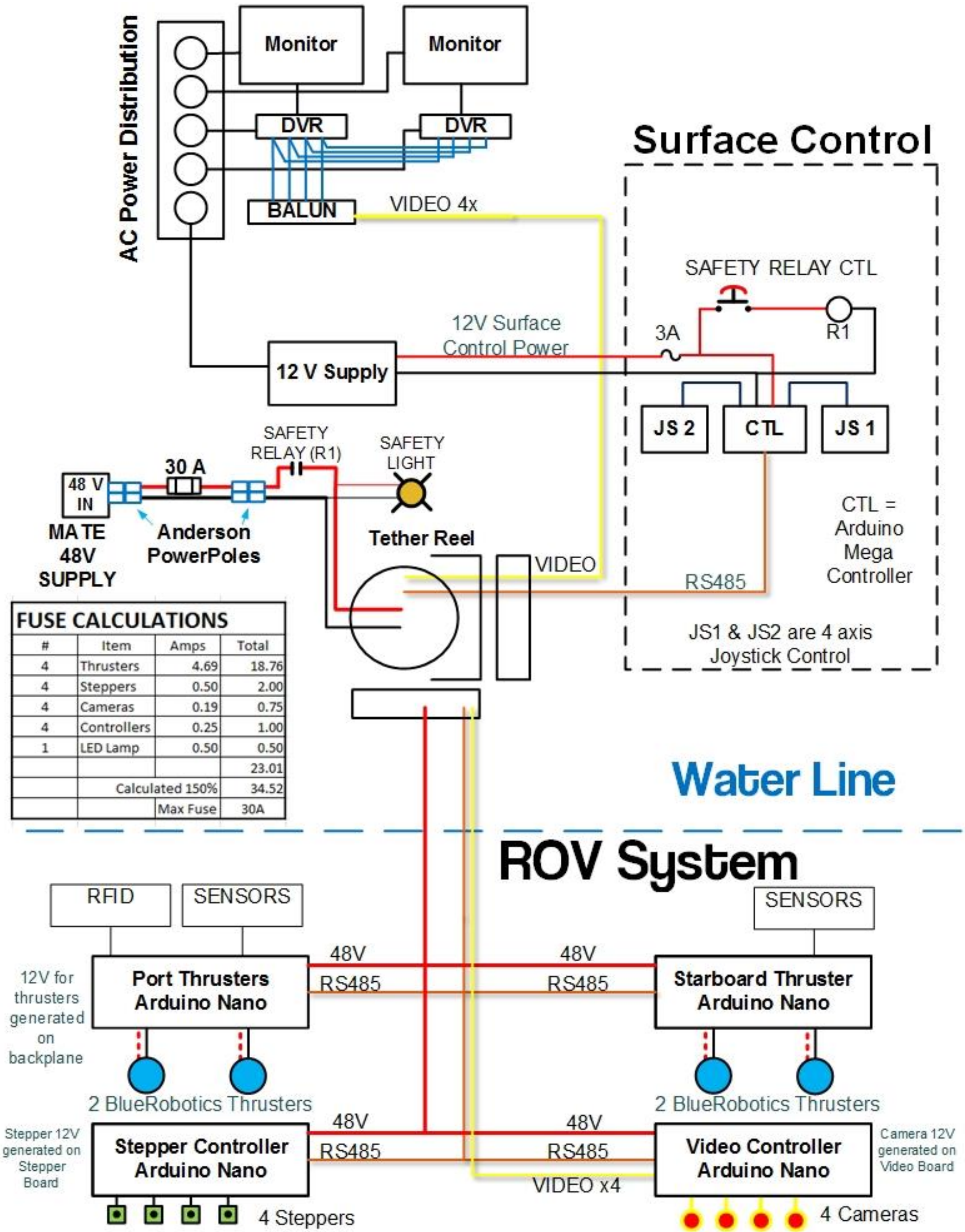
With water as a potential hazard it is important to have a fuse to provide protection; the 30 Amp fuse provides such short circuit protection along with overcurrent protection from faulty power sources. Also, each puck has a water sensor, in the case of any leaks notice will be sent to the surface control. By isolating the ROV into four systems (thruster control, stepper motors for the manipulator, and video) the ROV can be directed back to the surface for maintenance.

To ensure safety of persons nearby while launching the ROV, two bright amber hazard beacons are installed on the cart control station and activate automatically when the master switch is triggered and power is established.

A potential hazard present to all ROV teams is the long tether which can become tangled and a serious danger to persons working waterside. To safely manage the tether, an in house manufactured crank and storage container provides quick and efficient deployment and retrieval. The connection for this tether box is protected by a cover to prevent damage to connections or accidental contact by persons managing the tether while power is on.

An emergency shutoff button is installed directly in front of the main controls on the cart control station to enable pilot or arm operator quick disabling of power going to tether and ROV. As well the button must be rotated in order to establish power, preventing accidental activation if pushed. This provides an easy and efficient answer to any emergency situations with the ROV becoming uncontrollable, shorting, or other unforeseen situations.

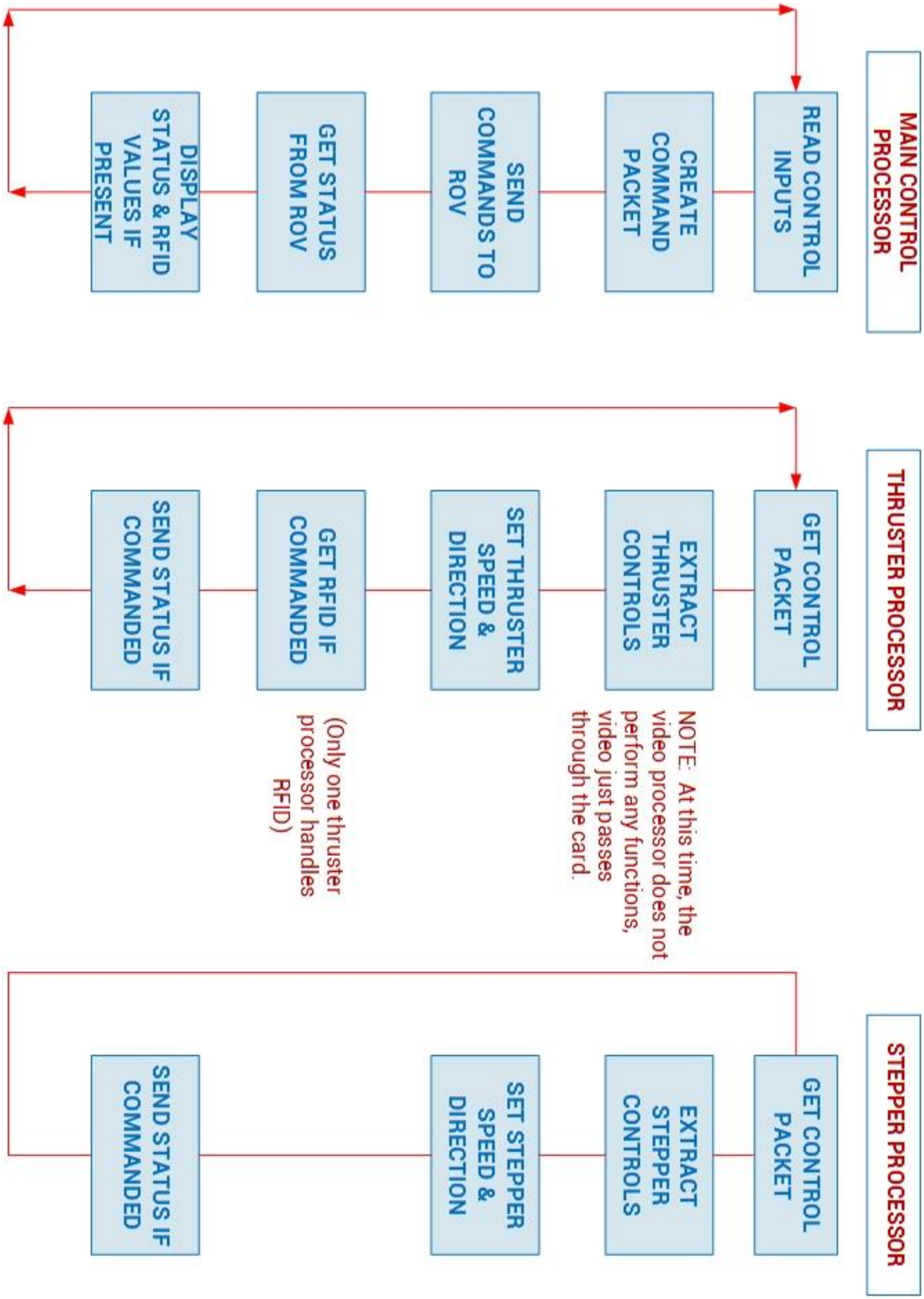
IV. System Integration Diagram



FUSE CALCULATIONS

#	Item	Amps	Total
4	Thrusters	4.69	18.76
4	Steppers	0.50	2.00
4	Cameras	0.19	0.75
4	Controllers	0.25	1.00
1	LED Lamp	0.50	0.50
			23.01
	Calculated 150%		34.52
		Max Fuse	30A

V. Software Flow Chart



VI. Financial Report

ERIK the RED Project Cost

Item	Quantity	Cost	Total Cost
Purchased Parts			
Aluminum Container	4	$ 21.95	$ 87.80
iSmart DVR	2	$ 66.32	$ 132.64
Aluminum Plate	1	$ 60.00	$ 60.00
Blue Robotics Thrusters	4	$ 249.00	$ 996.00
CMOS Camera Module	4	$ 31.95	$ 127.80
Electronic Components for Circuit Boards	Many	$ 834.76	$ 834.76
Bare Circuit Boards	10	$ 20.00	$ 200.00
Pressure Sensor	2	$ 14.95	$ 29.90
Hardware, screws, nuts, etc	Many	$ 352.45	$ 352.45
Utility Cart	1	$ 119.00	$ 119.00
Easy Drivers	4	$ 14.95	$ 59.80
Connectors	Many	$ 845.95	$ 845.95
Slider Potentiometers	2	$ 12.53	$ 12.53
Mini 3 Axis Joystick with Button	2	$ 197.50	$ 395.00
SainSmart 1602 LCD Shield Module Display	1	$ 14.99	$ 14.99
Joystick Control Cases	2	$ 15.39	$ 30.78
Aluminum Case for Mega	1	$ 34.01	$ 34.01
Mega Protoshield for Arduino	1	$ 14.95	$ 14.95
Arduino Mega	1	$ 49.95	$ 49.95
Arduino Nano	4	$ 4.00	$ 16.00
NEMA 16 Bipolar Stepper Motor	2	$ 10.00	$ 20.00
NEMA 17 Stepper Motor with Planetary Gear B	2	$ 27.64	$ 55.28
Thermal Epoxy	4	$46.47	$ 185.88
Marine Epoxy	4	4.99	19.96
		Subtotal	$ 4,695.43
Donated Parts			
Miscellanious (Surface Mount, LEDS, Screws,	1	$100	$100
High Density Foam, 4.5kg Sheet	1	$ 547.76	$ 547.76
Rapid Prototype ABS Plastic	4	$ 25.00	$ 100.00
Connector for Tether	1	$ 350.00	$ 350.00
Aluminum Block	1	$ 11.60	$ 11.60
Polypropylene Sheet	1	$ 58.50	$ 58.50
Aluminum Legs	2	$ 30.00	$ 60.00
Plastic for Pull Out Table	1	$ 25.00	$ 25.00
		Subtotal	$1,253
Reused Parts			
Dell Monitor	2	$ 50.00	$ 100.00
		Subtotal	$ 100.00
		Project Total	$ 6,048.29

Budget

Working Capital		
EIR Club*	$	2,700.00
Scholarship	$	10,000.00
Crowd Source	$	8,500.00
TOTAL	**$**	**21,200.00**
Expenses		
Project	$	8,600.00
Shipping	$	-
Travel	$	-
Meals	$	-
TOTAL	**$**	**8,600.00**
NET	**$**	**12,600.00**

** VX Industries fundraises through the EIR Club*

VII. Company Information

Bottreypich Chap | Chief Executive Officer, 2nd Year Mechanical Engineering Student

"My face says it all."

Myia Dickens | Chief Finance Officer, 2nd Year Mechanical Engineering Student

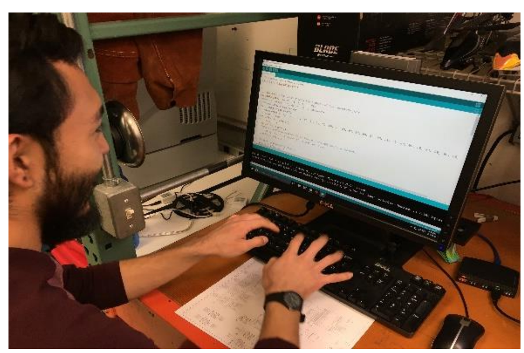
As a mechanical engineering major, who plans to have a career in the robotics field, VX Industries has helped me learn how to integrate the different skills (i.e. programming and electrical) needed to build a fully functioning robot. My time at VX Industries has allowed me to gain hands-on experience and the practical skills needed to work in the industry. Some of these skills include: learning how to solder, the names and use of tools in the workshop (i.e. floor drill press and screw sizes), and taking a thought or concept and making it into a reality (constructing the hand-crank for the tether), among many other things. My goals for next year include learning more about the initial design process of designing an ROV, in addition to strengthening the skills that I have obtained.

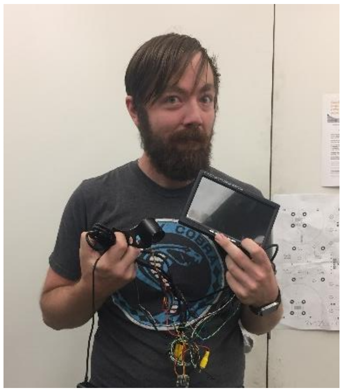
Edward Gonzalez | Chief Engineering Officer & Pilot, 2nd Year Drafting Student

Win some, lose some. Looking back this has definitely been a positive experience…ordeal. It both stretched and grew me as a student and person. Working on the ROV is something I definitely enjoyed. However, I wasn't aware of the level of commitment it would require of me. I certainly expected it to require effort and time, but the degree necessary for us to finish was unexpected. I feel that because I enjoyed the process of design and general iterative problem solving (of which there was tons) so much, I didn't mind the focus required, but I think other areas of my life had to give way, if I we were to complete the ROV. Whether it was worth the effort, I'd like to think so; but only time will tell… I at least will take these experiences and wisdom I have gained

Jorge Ceja | Software Engineer, 3rd Year Electrical Engineering Student

Through the robotics program, I have been able to apply the knowledge I have gained from my engineering courses. The practical approach of the program has opened opportunities in the engineering field and has open the door to network many likeminded individuals. Being able to build software and hardware from concept to reality in a team environment has given the entire team the skills necessary to succeed in their respective fields.



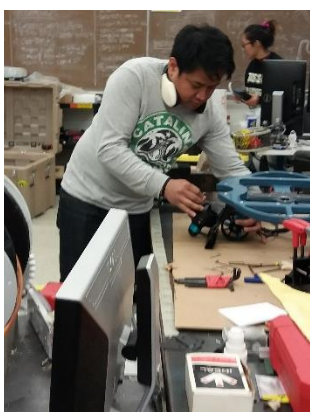


Michael Shubert | Fabrication Director, 2nd Year Drafting Student

"When I started with the team I was already familiar with work in a shop environment, (i.e. tools, fasteners, precision, etc.), as I am a woodworker and maker. As well, I had a surface level understanding of the various parts and components of an underwater ROV. Through working with the team on our ROV, I have increased my experience with the practical execution of design, manufacturing, physics, and programming. As well, deepen my understanding with many times of media, such as foam, plastics, and metals. I usually work alone on work projects, so I enjoyed being able to work with a team to build something quite complex and unique. Currently I am enrolled in a Drafting and Engineering Certification Program; this experience has brought me to a point where I would like to reach a higher degree in Engineering to perhaps develop even more unique and beautiful systems like our ROV."

Jonathan Turner | Foreman & Pilot, 1st Year Electrical Technologies Student

"My goal when building our ROV was building skills for my future career and teamwork. It turns out it was a far more personal growth experience. I learned that I'm far more insecure about what others thought of me. I previously thought I didn't care what others thought when in reality I just never had people I cared about to worry what they thought of me. but through all this I have discovered that the people I like are just as flawed as I am and learned to relax around them. An important note was that this was the first group where my team was just as invested in doing well as I was so I got experience working with competent and enthusiastic people. So in total I learned about workplace interactions and how to conduct myself in a workplace environment and to communicate as a team. In the future I will attempt to have a more concrete long term plan for the project and be more involved in the planning from the beginning. "



Kerwin Fredeluces | Foreman, 1st Year Electrical Technologies Student

Since I got into the robotics class, the first thing Professor introduced us to was the capabilities of what we could do with the right set of skills. He told us by learning the software tools as foundation through this class like Solidworks, we could build anything we could ever imagine, such as the ROV. And this got me interested in joining the competition. Everyone participating and apart of the team had the benefit of learning and gaining hands on experience doing great things. Being a part of the team, everyone was motivated to do their part just to reach the goal of finishing the project to the best of our abilities. I'm thankful to have had the opportunity of being on this team and learned to be cooperative and listen to constructive criticism all while working well with great friends. Beyond that there's an amazing great instructor, he trusted us students to do the work, which gave us opportunity feel the experience of being creative person.

Teamwork

One of the most useful tools implemented this year was a simplified Kanban Board, which allowed us to communicate status, progress, and issues throughout each step of the project. Separating the board into three sections: to-do, in progress, and done, provided a guide for deadlines and insight into how much time had to be allocated outside of our own schedules to be completed. By providing a list of possible projects, members could choose which skills they wished to work on depending on the type of work needed. This also allowed each member to hold themselves accountable for the projects that they signed up for, ensuring a steady workflow and constant state of progress. The board had been incorporated into our organizational and planning processes half way into the competition building stage. The difference in productivity and vision can be attributed to it.

The biggest resource each member lacked seemed to be time. Aside from school and for some, work, finding a day or even a few hours to meet each week was difficult. Saturdays or late night after class sessions were the best time for us students to collaborate. As each member began to hone in their skills, we were able to begin taking on solo projects, and spent those few hours we were available collaborating with the advisor and other members to further develop and revise. Constantly keeping each other up to date with the status of the subproject ensured that if at any point a member could not complete a project, another member could finish it for them. This was essential in keeping a flexible and stress free environment.

As we began to understand what was required of us to complete each mission, the vast components of the ROV allowed for us to explore different skills. Having the freedom to choose and explore helped us develop our abilities in CAD, programming, and ultimately transforming ideas into reality. This also gave us a sense of self accountability in which our growth was based on the amount of effort and work put in.

Challenges

As a company, organization is the largest sector we would like to see improvement in the years to come. Though subprojects allowed individuals to work to their schedule, there seemed to be a bit of a lack of coordination within our processes. When together, we all managed to work with cohesion and meet our daily goals. In contrast, if a member headed a project and was unable to make it to a work session, productivity was hindered and the rest of the group would have to delay their processes. This only became an issue due to the lack of company members. As a club at a community college, the majority of the students are full time students and full time workers, and are unable to dedicate the hours they would like to.

Whether it be to decrease costs, weight, or better a process, we consistently would improve and revise each design even when a working model was created. This would prevent us from moving on to other tasks that called for our attention, and as deadlines approached we found ourselves rushing to complete what was left on our to-do lists.

Future Improvements

Though working with a smaller company has its advantages, recruiting more members that are passionate about marine technology and robotics will provide us with a greater number of minds. The transition phase between company management from year to year is the most difficult stage to overcome, and the most insightful. To ease this process, recruiting in the fall and spring semesters are essential. A set recruitment period will allow for the past members to gradually work with the oncoming members and provide them with the necessary information to advance in their endeavors. Also, during this stage we would have member orientation to provide new members with insight as to the type of commitment and work they are getting themselves into by joining us. As membership increases, we will gradually implement subproject lead positions and weekly meetings to discuss the progress of each division. By creating this ladder of expertise, members can continue to grow under the supervision of experienced members and alongside similar minded team members.

VIII. References & Acknowledgements

References

Cover Photo: Photo by Port of Long Beach
Figure 5: Photo by Blue Robotics
Other Figures: Photos by Bottreypich Chap, Edward Gonzalez, Jonathan Turner, & Scott Precop

Acknowledgements

Scott Fraser, Mentor and Advisor: For your continued support and dedication to our education. As well as the countless times we made you stay out late to let us continue working.
MATE: Giving us a medium in which we can learn and develop what we love to do. For helping some of us find our calling in life.
EIR Club: Their continued financial support and manpower that you have provided to our team.
Long Beach City College foundation and donors: Without your generous donations we would have never made it to this competition, thank you for the chance to let us "Change the industry standard."
NOAA and The Aquarium of the Pacific: Without your request to have us at NOAA Day in November, we would not be as far as we are today. Thank you for giving us something to work towards early on.
Significant others and Family: Thank you for your support over the past year and allowing us to dedicate our time away from you to accomplish something great.

Other Acknowledgements

Marine Technology Society
Long Beach City College Electrical Program
Students of ELECT 230

Additional Company Employees Not in Management

Nate Ashby
Tina Aguierre
Orlando Aguilera
Krissi Munn

Company Employees Who Have Taken Employment Elsewhere

Scott Precop
Raymond Thompson
Guillermo Olarte
Mario Bermudez
Anthony Rasca
Julio Arujo