

The C.O.R.P.S.

The Corporation of Offshore Reconnaissance and Polar Submersion

S.T.E.M. Early College High School

4040 Apollo Street, TX, USA



Company Members

From left to right:

<u>Name</u>	<u>Year</u>	<u>Role/Discipline</u>
Daniel Benavides Jr.	2018	Chief Executive Officer
Penelope Pongpiachan	2020	Chief Administrative Officer
Noah Johnson	2018	Pilot
Emma Garza	2020	Chief Marketing Officer
Carlos Macias	2020	Chief Financial Officer
Omar Arredondo-Martinez	2018	Head Engineer
Roy Amaya	2020	Electrical Engineer
Olivia Garcia	2020	Mechanical Engineer
Epi Flores	2020	Chief Safety Officer
Julia Calderon	2018	Head Engineer

Mentors

Romeo Valdez

Jillian Ozuna

Abstract

The Corporation of Offshore Reconnaissance and Polar Submersion (C.O.R.P.S) is from S.T.E.M. Early College High School located in San Antonio, TX. The C.O.R.P.S. is an innovative and successful company specializing in marine technology solutions. The C.O.R.P.S. has succeeded in many of the past programs provided by MATE and will continue to attend more. There are ten well-rounded and cooperative individuals in the company who have contributed time and energy, both in and out of their role in order to complete the company's final product to successfully meet our clients' needs. The C.O.R.P.S.' latest Remotely Operated Vehicle (ROV), *General* (Figure 1.), was created in order to search for the remains of a vintage airplane and return its engine to the surface. Additionally, *General* will install and recover a seismometer and a tidal turbine to monitor the environment. To complete the Request for Proposal, *General* is equipped with three cameras, six thrusters, two hydraulic manipulators, one distance measuring device, two lift bags, and one magnetic attachment to trigger an OBS. In order to ensure that *General* is as maneuverable as possible, size, weight, and material have been optimized. The control system is entirely encompassed in a Pelican 1560 case, contains a 48.26 cm Insignia TV, and is connected by an 11m tether. Together these attributes create *General* (Shown in Figure 1.), an exemplary ROV that is ready to perform and complete all our clients' tasks.



Figure 1: *General*, The C.O.R.P.S. 2018 ROV

Table of Contents

Title Page	1
Abstract	2
Table of Contents	3
Corporate Profile	4
Scheduling	4
Safety	6
Company Safety Philosophy	6
Vehicle Safety Features	6
Safety Checklist	7
Design Rationale	8
Underwater	8
Frame	8
Propulsion	9
Cameras	10
Buoyancy	11
Tether	11
Tools	12
Hydraulic Manipulator.....	12
Ocean Bottom Seismometer (OBS)	12
Measuring Device	13
Lift Bag	13
Topside	13
Control Box	14
Controls	14
Code	14
Testing	15
Finances	15
Build vs. Buy	15
New vs. Re-Used	16
Reflections	16
Lessons Learned/ Challenges	16
Future Improvements	17
Experience Evaluation	18
Acknowledgements	20
References	20
Appendices	21
Appendix A: System Interconnection Diagram	21
Appendix B: System Interconnection Diagram	22
Appendix C: System Interconnection Diagram	23
Appendix D: Finance Charts	24

Corporate Profile

For the C.O.R.P.S., teamwork is essential to efficient work completion. The C.O.R.P.S.' project team is created by evaluating each individual's strengths, weaknesses, and personal preferences, and using that information to assign jobs. The corporate leaders, the Chief Executive Officer (CEO), Chief Administrative Officer (CAO) and Head Engineer continuously work together to move the project forward by checking in with the other members. Every meeting begins with a brief summary of what has been done, what needs to be done, and how well the company is following the Project Timeline (Figure 2). Next, the members either break off into groups or work on individual assignments. During this time, members are not limited to their assigned role and always have the option to develop their skills in different areas of the project (i.e., the Chief Marketing Officer helping create a 3D model on Inventor). This allows each person to offer new ideas, become a well-rounded company member and add to the overall progression of the ROV. At the end of each meeting, the company members present ideas, changes, and new information as a group. This process ensures that they are collaborating, gives them the opportunity to polish their speaking skills, allows everyone to learn about each other's progress, and lets them know what to expect in the next meeting.

Scheduling

The first schedule (Figure 2) was designed to fit all the phases needed to create a fully functioning ROV. The 9 weeks was divided into three sections: planning, developing, and perfecting. The first two weeks of the project timeline was only for planning. During this time, the C.O.R.P.S. worked together to test prototypes and create the plans and designs needed. These tasks were able to be completed on time because the members were required to attend meetings specifically for creating designs for the product. Eventually, all the designs inputted were combined to make one unique design. The design of the ROV was then tested with the creation of a cardboard prototype. Once testing was completed, the engineers started building the ROV itself. While the engineers worked, the other members began writing the technical documentation. With all the members working on the task, everything was able to be finished on time. After this, the C.O.R.P.S. was able to move onto the next phase, perfecting, which allowed them to practice the product demonstration and maneuvering the ROV.

9 week project timeline

Start Date: 02/26/2018

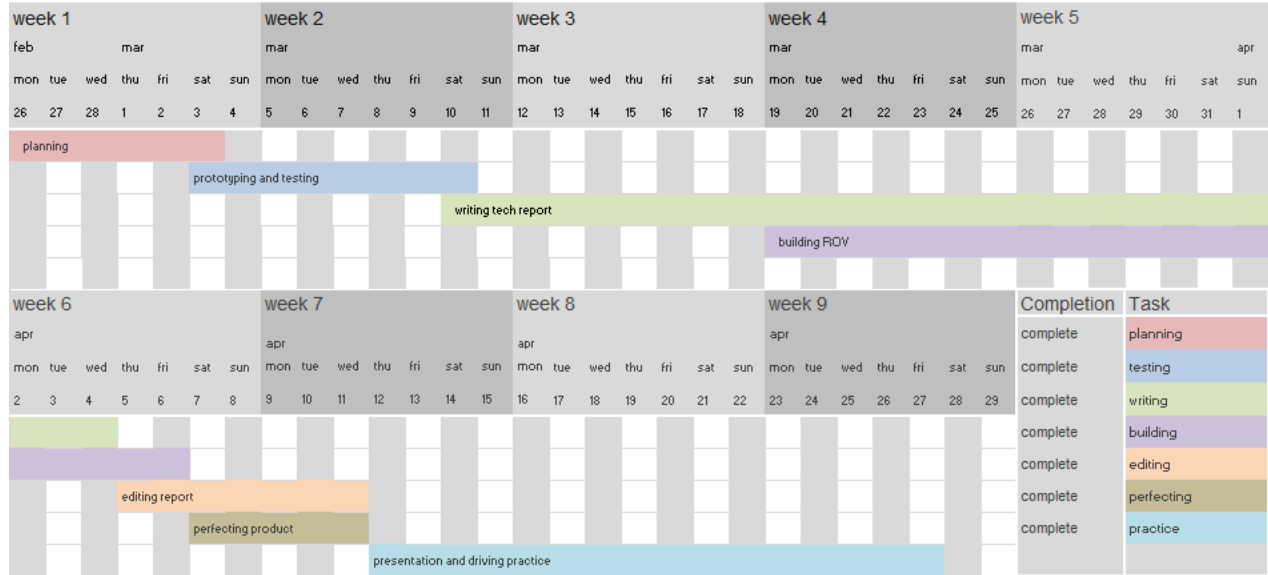


Figure 2: 9 weeks project timeline

After a successful demonstration and presentation of the product at the 2018 Texas Regional Competition, the C.O.R.P.S. created a new schedule (Figure 3.) to further perfect the ROV and technical documentation. They began by dedicating the first week back to making a list on what needed to be improved and worked on. Once that list was created, the members went off to work on separate tasks such as contacting public officials, recreating tether, editing technical documentation, and many other tasks.

international project timeline

Start Date: 04/30/2018

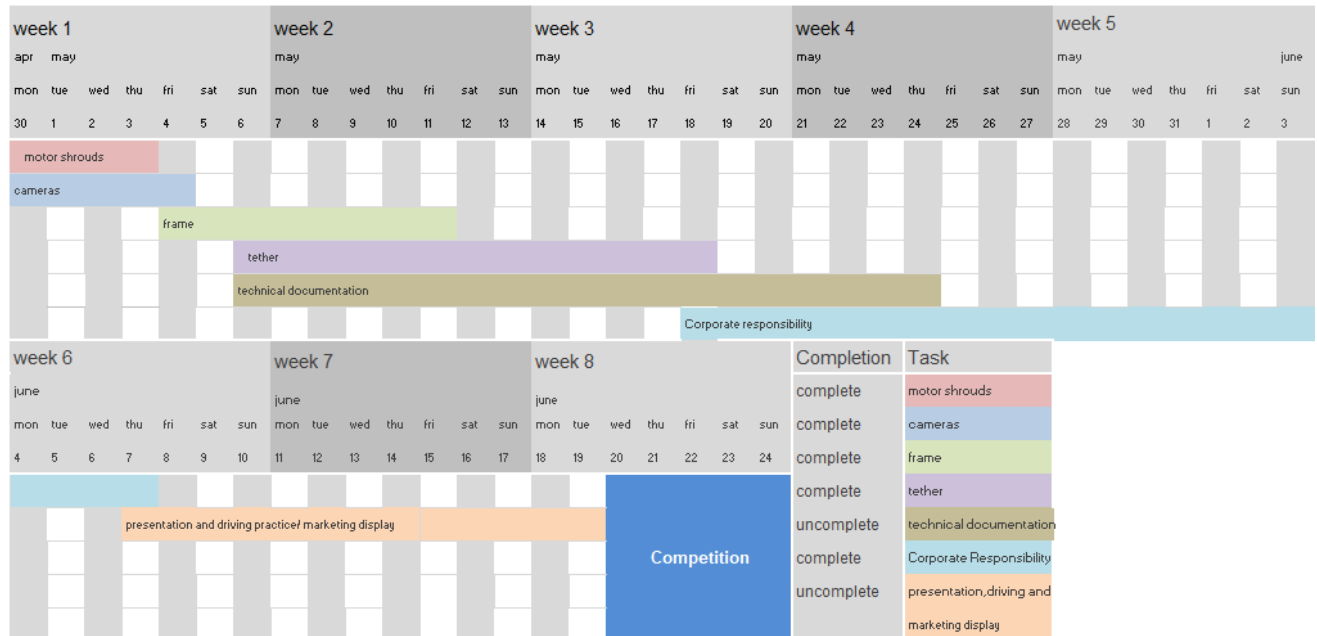


Figure 3: International project timeline

Safety

Company Safety Philosophy

The C.O.R.P.S.' first priority is to promote a safe work environment. Through proper communication, the company was able to successfully construct the ROV while following safety protocol. All employees are required to wear goggles and gloves when dealing with sharp tools. The safety officer ensures all company members follow safety guidelines. Company members are trained to avoid hazards like sharp edges, exposed wires and faulty fluid power systems. The company enforces the safety rules and is prepared to properly handle any safety hazards.

Vehicle Safety Features

The table on the next page (Figure 4.) shows potential safety risks of the ROV and ways to avoid them. The priority of the C.O.R.P.S. is to ensure all electronic connections are waterproof and to prevent any accidents from happening. The C.O.R.P.S. utilizes a severity and accident probability scale to evaluate each risk with 1 being the lowest and 5 being the highest.

Potential Risks	Consequences	Severity	Accident Probability	Prevention
Fingers caught by propellers	Possible laceration to the finger	3	1	Cover up propellers with motor shrouds not big enough for fingers to go through
Water leak into ROV control system	Can cause fire or short circuit the different subsystem wires	4	1	False base created to prevent water from making contact with the electronics
Body part caught inside ROV frame	Injury from multiple subsystems	3	2	Always ensure ROV is off when working
Hydraulic line disconnects from syringe	Hydraulic fluid spills into pool, endangering the environment	4	1	Have the line securely connected to both ends of the syringe
Entangled inside product tether	Can trip/fall if mobility is limited	3	3	Keep tether wrapped in one area and always be aware

Figure 4: *Potential Safety Risk Table*

The C.O.R.P.S. implemented additional measures to reduce risk of injury occurring while operating the ROV. All thrusters are encased in custom 3D printed motor shrouds that prevent fingers from contacting the propellers. Due to an increased amount of shaking, the motor shrouds were changed to be mounted directly in front and on the back side of the bilge pump thrusters to further prevent any chance of injury from the propellers. A false bottom is included within the control box to prevent water from the tether coming into contact with any of the electrical components. All edges of the ROV are rounded off to prevent cuts or scratches. For easier portability, holes are cut into the port and starboard sides of the ROV. Underwater components and wires were triple checked after being waterproofed and stress reliefs were placed both on the ROV and the control box to ensure that wires remain secure.

Safety Checklist

The company members must refer to the Construction Checklist before handling the ROV and any of its components. This lowers the risk of accidents occurring and keeps the workplace clean and neat. Taking these precautions also decreases the chance of any possible malfunction within the ROV components. The Pre-Operational checklist comes into play when it is time for the company to put *General* in the water. Strict adherence to these checklists increases the margin success since it reduces the likelihood of any component malfunctioning.

Construction Checklist Pre-Operational Checklist

- ✓ Safety Glasses worn while using power tools
- ✓ Gloves worn while cutting materials
- ✓ Hair tied back
- ✓ Keep liquids away from electronics
- ✓ Turn off electrical tools when not in use
- ✓ No running or misbehaving in the workroom
- ✓ Teach all members how to use power tools safely
- ✓ Clean up table so that no materials get lost
- ✓ Put tools back in cabinet when done with them
- ✓ Labeled lockers have corrects materials

Pre-Operational Checklist

- ✓ All components properly secured on ROV
- ✓ No exposed wire
- ✓ No damage to hydraulic tubing
- ✓ No compromised material
- ✓ Tether not twisted
- ✓ Stress relieves are in place
- ✓ ROV remains off until all checklist criteria is met

Design Rationale

Underwater

Frame

The C.O.R.P.S.' philosophy is that the frame's material is key to creating a light, maneuverable and effective ROV. With C.O.R.P.S.' previous products, the company primarily used PVC (Poly Vinyl Chloride) and Acrylic to construct the frame; however, this year, the company decided to utilize UHMW (Ultra High Molecular Weight). The company chose to implement a frame (Figure 5.) comprised of

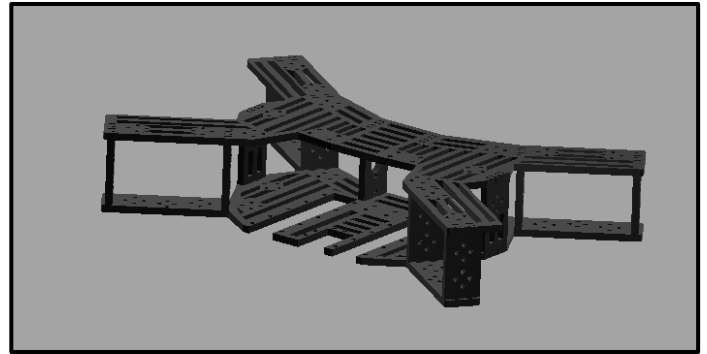


Figure 5: ROV Frame

UHMW because the material itself provided many benefits such as structural ability and buoyant properties. When compared to Acrylic and PVC, UHMW is a material that is highly applicable for an underwater project. *General's* design is a combination of precision, affordability and efficiency. The frame was developed using Inventor software and gave a clear insight on how the ROV would function with its components attached. These Inventor-created models were continuously updated and changed as testing and evaluation dictated. After 3 initial prototypes, *General* was created out of cardboard. The cardboard prototype served as the backbone for the fully developed *General*. Design flaws were continually improved upon. The UHMW was cut and measured in-house. Each incision made into the frame was calculated to be an efficient use of space, while encompassing the various attachments. The thickness of the material is $\frac{1}{4}$ -inch and the frame is adjoined via eight aluminum brackets bolted down by 32 screws and nylon nuts. Wires are efficiently and neatly secured to the frame with numerous zip tie strain reliefs. Every aspect of the frame design and construction was carried out with attention to detail starting from the walls all the way to the corners that need to be rounded off. The shape of the walls, as well as the top and bottom plates are also designed to allow water to pass through the design freely. Each wall was made to allows the thrusters to push and pull the water without any resistance. The walls were also designed to allow the *General* to move freely through the water with minimal resistance on the frame, while also not compromising the structural stability.

Propulsion

The *General's* propulsion system allows ease of navigation throughout the water to efficiently accomplish assigned tasks. This system is composed of six 1250 GPH Bilge pump thrusters mounted on *General's* frame. Two bilge pump thrusters are mounted vertically and are used specifically for ascending and descending in the water. These two thrusters are attached to the center of the port and starboard sides of the frame for an even ascent and descent rate. When mounting these two vertical thrusters the company had to decide whether it would be more efficient to have the thrusters completely vertical, or at an angle relative to the ROV to support strafing movements. The decision was made to mount them vertically because the ascending and descending rates needed to be as fast as possible. The remaining four thrusters are mounted

directly under the four Subsea Buoyancy Foam covers. After testing and rearranging the possible positions and angles of the thrusters, a 25-degree vector proved to be the most effective for each motor. This gave *General* 68% power going forward and backward and 32% power while strafing toward the port and starboard sides. This was implemented because strafing is an important movement to accomplished the tasks given to the company. The positioning of the *General's* thrusters is essential for ROV maneuverability and efficiency. To mount the bilge pump thrusters to the frame, an innovative motor housing was designed and created. The new in-house manufactured motor shrouds were made using Inventor 2017 software on a 3D printer at



Figure 6: *Motor Housing*

S.T.E.M. Early College High School. To fix problems with screw placement, C.O.R.P.S. decided to make housings with screw holes both in the front and the back which go through both the housing and the frame. A nut is located on the outside of the housing. C.O.R.P.S. implemented a push and twist design similar to a previous PVC motor shroud design, which is both simple and efficient. Changing the overall design both decreased the amount of weight on the ROV and lessened the 3D printing production time. After several prototypes were constructed and tested, the company was satisfied with the outcome of the newly developed housings (Figure 6.). The light-weight and efficient design has made mounting the motor shrouds easier to use and increases the number of sites where the motor shrouds can be mounted on the ROV. This innovative design reduces the risk that the top half of the motor housing will break off.

Cameras

General features three 0.635 cm Closed-Circuit Display (CCD) flush mount, waterproof cameras where two are facing the front and the third one is in the center near the claw facing from the front of the ROV. One of the CCD cameras is located in the center of the ROV which is used to gain a strategic view of the surrounding environment during mission use and any obstacles in the ROV's path. The camera wires are positioned around vital sections on the ROV and are connected to the control system through the tether. The first camera will be

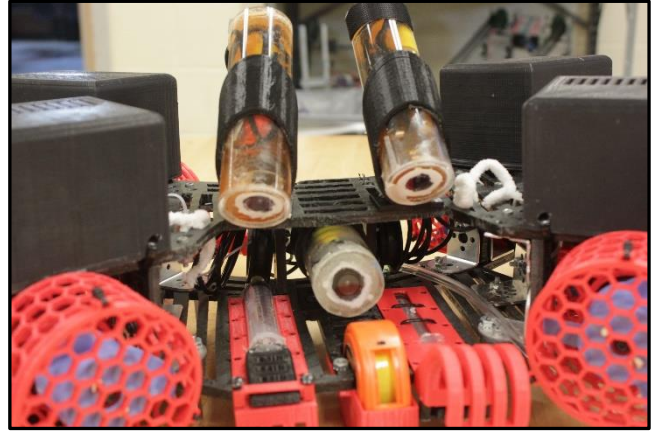


Figure 7: *Cameras*

displayed on the Insignia LED TV on the lid inside the control system, while the second camera will be connected to the supplied secondary display, and the third camera will connect to a tertiary display that is also supplied. This allows for all three cameras (Shown in Figure 7.) to be displayed simultaneously. The first and second CCD cameras allow the General to see its claw and to be able to read the measurements. Being able to use all of the ROV cameras allows the pilot to focus on multiple spots and allows the potential to focus on two tasks at once. With the current configuration, General's field of vision is increased and there is a smaller chance of performance error. The first and second camera are located on the starboard of the ROV and are secured in two in-house manufactured 3D printed parts attached to the frame. The third CCD camera is located in the center of the ROV near the claw and hydraulic manipulator which is also secured in an in-house manufactured 3D part attached to the frame. The company created a 3D printed mount in order to achieve the desired angle which would allow the pilot to see the measuring device and a lift bag. The ideal mount angle was determined through product testing and was created with cost and size efficiency in mind. The mount was manufactured using the least wasteful amount of material and in a design that is unique to General. The camera mount was specifically designed to complement the structure of the ROV by being compact and easy to manipulate. Each of the rear ended CCD cameras are located at the bow of the ROV and are individually attached.

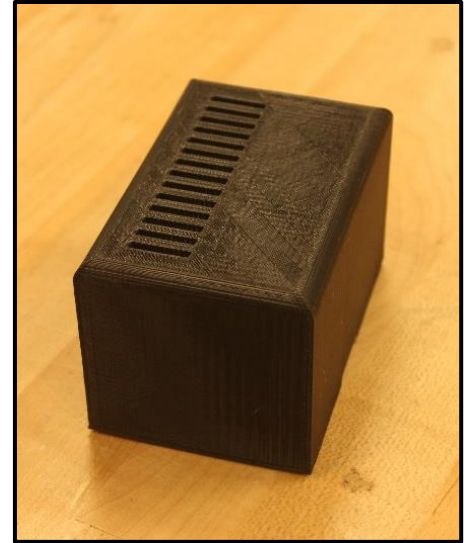
Buoyancy

General's buoyancy system is composed of four rectangular Subsea Buoyancy Foam prisms within in-house manufactured covers. Located at the top corners of the frame, they evenly distribute the ROV's weight underwater. To calculate *General's* buoyancy, the C.O.R.P.S. started

with an equation provided by a robotics organization called Blue Robotics and derived a rational equation from it to use on the ROV. The equation:

$$W/10 \cdot h$$

W is the wet weight of the ROV, 10 is derived from the pre-cut width and length of the seafoam, and h is the unknown variable of height. After wet weight is determined, the C.O.R.P.S. reconfigures the equation to calculate the height of the seafoam. After the seafoam height is calculated, the company manufactures 3D printed covers (Figure 8.) for the seafoam to safely secure them down on to the frame. The seafoam containers are then



rounded for the most hydrodynamic maneuverability and are mounted to the UHMW topside of the ROV with four zip ties to each corner of every cover. Additionally, there are slits on the outside of the design that allow water to pass through the coverings.

Tether

The C.O.R.P.S. decided to use a VEX PRO electrical system to power all the components of the ROV. The power wires run through the approximately 100-ft long tether (braided expandable sheathing). There are three different types of wires within the tether including: camera wires, neutrally buoyant wires, and vinyl tubing. The three camera wires enable the pilot to observe the environment around *General* by sending power from topside control system to the cameras themselves. The neutrally buoyant wires are made to carry power and commands from the control system to the thrusters. They are neutrally buoyant because of their thick coverings as well as buoyant foam within the wire. The company decided to switch from fathom tether to braided expandable sheeting because the original couldn't withstand all the wires and the new one allows for much more leeway for the wires. The tether is 27.5mm in diameter, weighs 3.18 kg, and has a pair of 14-gauge double stranded wire. The vinyl tubing that is encased within the sheathing has the purpose of controlling the hydraulic manipulator located at the bow of *General*. The vinyl tubing has a .21 mm diameter and contains water dyed with food coloring. The dye used complies with regulation for hydraulics as it is non-toxic and is implemented to make the tubing visible underwater and also assist in locating any leaks.

Tools

Hydraulic Manipulator

The Hydraulic Manipulators are designed to fit the U-Bolts on the props, to fit the quarter-inch PVC and to properly place the lift-bags. After the PVC is in the top facing Hydraulic Manipulator, the syringe is pushed from topside to slide the cover piece forward, which blocks off the path for the PVC to escape. This allows for the ROV to maneuver freely while keeping whatever is in its grasp in place. The C.O.R.P.S. placed a second bottom facing manipulator in consideration that this mechanism also works for securing the lift bag by holding it steady to attach and keeping it ready to be released. General's Hydraulic Manipulator (Figure 9.) uses water throughout the reservoir and vinyl tubing since water suffices as a safe alternative to other specialized liquids because it doesn't harm the environment.

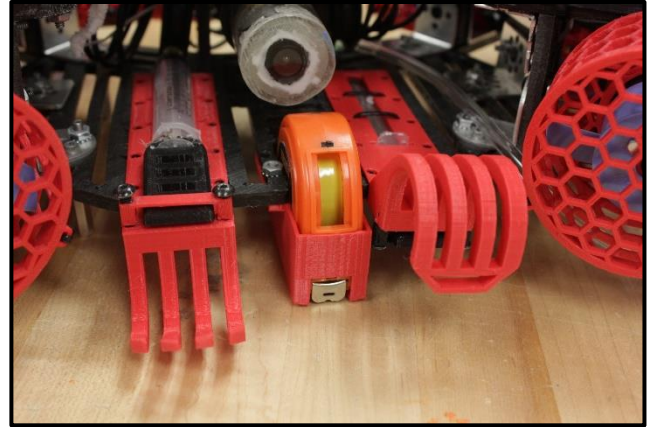


Figure 9: *Hydraulic Manipulators*

Ocean Bottom Seismometer (OBS)

The C.O.R.P.S. OBS (Figure 10.) is primarily comprised of PVC. For the release, *General* uses a magnetic reed switch powered by a nine-volt battery which runs current through a series circuit. This circuit powers a Johnson bilge pump connected to vex winch. The winch is then connected to a VEX high-strength shaft which secures the OBS. The OBS Release is activated by a magnet connected to the outside of the Hydraulic Manipulator. An OBS is comprised of three main sections. These include the anchor, release, and the actual OBS.

The OBS contains the cradle and cable connector. The anchor is constructed using a combination of 1/4in. PVC and 1in. PVC. Attached to the anchor we have is a release mechanism. The reed switch is powered through a series circuit connected to a 9-volt battery and a Johnson bilge pump. A VEX winch attached to the bilge pump is connected by string to a VEX high-strength shaft. When activated, the winch reels in the string. This action pulls out the shaft, which acts as a pin to release the OBS.

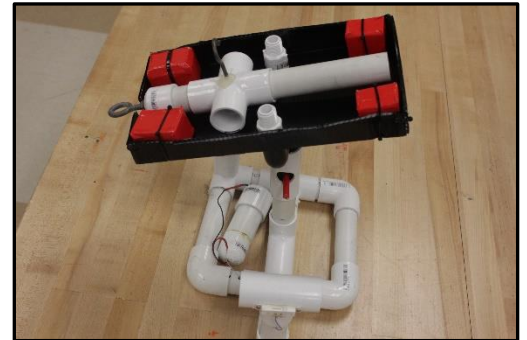


Figure 10: *Ocean Bottom Seismometer*

Distance Measuring Device

During the product demonstration, a mission specific tool was installed for “measuring the given distance from the base of the tidal turbine” and “measuring the given distance from the bottom on the mooring line”. In preparation for these tasks, *General* has been equipped with a 2m measuring tape mounted to the front center of the bottom panel between the two hydraulic manipulators. Attached to the tip of the measuring tape is a hook. This hook is what is used to latch onto the hooks in order to determine the distance in those tasks. To accurately read the tape measure distance relative to the measuring point, 0.05m must be subtracted from the overall number because that is the length of the diameter of the wire. Also, a camera was mounted above the tape measure in order to have a complete view of the attachment.

Lift Bags

General utilizes Carter lift bag that were purchased online at Armon International. They are made of a strong, lightweight nylon coated in urethane. This material allows it to be both durable and lightweight. The bag weighs 0.45 kg and has the capacity to lift 11 kg. Its inflated dimensions are 0.381kg by 0.508 kg, with an open bottom to vent the expanding air as it ascends. The lift bag (Figure 11.) will be used to move debris and an airplane engine from the wreckage. The lift bag will be inflated by an air compressor connected to vinyl tubing running through the tether to the ROV. Using this method of inflation allows the company to regulate the air pressure and to ensure that the air is constantly flowing into the lift bag. The vinyl tubing is attached securely to the interior of the bag with Velcro. To deploy the lift bag, the driver must first attach a hook to the U-bolt, back away, and then begin inflating the bag.



Figure 11: *Lift Bag*

Topside

Control Box

General, along with all of its attachments, are powered through a VEX PRO Power Distribution Panel located within a Pelican 1560 Case (shown in Figure 12.). This durable and lightweight system is divided into three layers, each serving a unique purpose. The first and highest layer of the control system contains a 19” Insignia LED display (Figure 13.) that allows the pilot to traverse the environment around the *General* efficiently, a Watt Meter LCD Display where voltage and current is shown, configurable

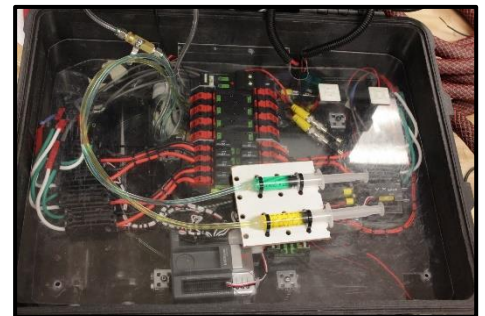


Figure 12: *Control Box*

pressure regulator, and a manual hydraulic control system which leads to the *General's* hydraulic manipulators. The second layer contains a power distribution panel which supplies a safe current to the systems of the ROV, a voltage regulator, seven motor



Figure 14: False Bottom

controllers, a VEX robotics cortex, and nine fuses. The third and final layer (Figure 14.) is similar to a false bottom and serves as a



Figure 13: LED Display and

barrier against water breaching the system and as an added feature, the last layer contains surplus wiring and tubes in case of electrical malfunctions. There is also a compressor and two air reservoirs added for instant inflation.

Controls

The C.O.R.P.S. selected a VEX Robotics Controller in *General's* design. The VEX Controller allows the engineers to adjust the buttons specifically for each pilot. In total, there are twelve buttons for the pilot and two joysticks.

Code

The company's Engineers have been using the Robot C programming language for 4 years and have found this language easy to understand and easily configurable for those who purchase the product. Robot C is a cross between Java and C++, it uses subroutines already developed to easily write code. The head engineer worked on all of the coding with the help of the electrical engineer. The programmer took into account that it was six thruster drive with four thruster used to go in the horizontal plane and two thrusters to go in the vertical plane. For the four horizontal thrusters, the programmer used a mecanum (movement in all directions) code used from competing in land robotics. The code is implemented through a VEX Cortex. On this cortex a program can be modified or have a new one made altogether, this allows the product to fit the needs and wants of any pilot that controls the General.

Testing

Troubleshooting is a vital part of designing an efficient ROV and ensuring that all of the components are utilized to their maximum potential. The C.O.R.P.S. troubleshooting guide contains rules to make the ROV as safe as possible. The Safety Officer worked with the other members of the C.O.R.P.S to create a well-rounded document. The troubleshooting guide is used as a reference anytime adjustments are made to the ROV, especially, when setting up before the product demonstration. Any time the company encounters errors, the troubleshooting guide is consulted to help pinpoint what is malfunctioning. Following this protocol allows the company to properly address and fix problems. The C.O.R.P.S. first started troubleshooting the ROV in the cardboard prototype phase. During this phase, each member came up with multiple unique designs for the ROV, after evaluating each design they took the best features from each and incorporated them into the final product. Using the early design, water flow was calculated and motor placement errors were identified. After the mechanical and electrical engineers finished creating a second cardboard prototype with those errors in mind, the claw weight distribution was calculated along with camera angles and placement. Once the cardboard prototype phased was completed, the full ROV was built. At completion, wiring was tested to ensure the electrical system functioned properly. The safety officer oversaw all processes.

Finances

The C.O.R.P.S. began with a budget of \$1500, including money remaining from last year's Harlandale ISD (HISD) grant. The C.O.R.P.S. needed to fundraise for all the expenses for the major improvements in the ROV. Two fundraisers were held by the Robotics club with one consisting of breakfast items and the other including snacks that earned the corporation \$215. The regional competition made the C.O.R.P.S have to improve on their income by doubling down on fundraising. The C.O.R.P.S held a bake sale that made around \$256 and a barbecue plate sale that grossed a total of \$2,000. HISD would also pay for the C.O.R.P.S travel expenses and housing for the International competition. In total, the C.O.R.P.S was able to raise an income of \$29,471 and kept a final balance of \$3,082.89 with the inclusion of all the expenses.

Build vs. Buy

This season, the C.O.R.P.S. concentrated on buying any materials or parts that were unable to be built. Thus leading to most of the ROV's parts being bought in order to aid in the building of an effective and efficient ROV. The UHMW had to be bought since it is a material that is important to the ROV's frame and hard to manufacture in-house. There were some parts that were not bought but created with the help of a 3D printer that allowed for more accessible builds and molds. The built parts that benefited from being 3D printed were the housings for the cameras, seafoam containers, and propeller housings. The printed housings allowed for a comfortable size for all of the mentioned parts and less money having to be spent for every housing. The C.O.R.P.S.' manufacturing saved the team not only just money but the time and effort needed to buy every single part of the ROV.

New vs. Re-Used

The C.O.R.P.S. prioritized creating a ROV capable of being very effective and cost efficient. The new design enabled the company to re-use available materials and make needed improvements from earlier designs. The goal was to always improve *General's* systems and create a ROV that would meet the criteria of being effective and efficient with the parts being made rather than buying parts that were already built. One of the new materials purchased was the UHMW sheet uses as the material for the base which had to be ordered since it cannot be easily made, but has unique qualities. *General* is mainly composed of new parts (i.e., the 1250 GPH thrusters, the UHMW, the lift bags, and three cameras). Everything else that is not directly connected to the ROV is consisted of both new and reused material and parts. For example, the control box electrical parts are consisted of new parts to ensure the safety of anybody near it while the hardware holding the control box is made of a reused Pelican 150 case that was left in a great condition following last year's competition. While most of the materials were new, the C.O.R.P.S was able to save a total of \$857.98 with the re used parts.

Reflections

Lessons Learned/Challenges

Technical- Our main challenge this year was learning how to work with UHMW. With all of our previous products, we used a combination of PVC pipe and ABS plastic. Although we used more ABS plastic for Commander, one of our past products, we didn't know how the UHMW was going to react to drilling holes for attachments. After numerous trials we were able to construct a unique shape, while remaining inside the 48 cm size limit. Another issue encountered was

buoyancy. Rather than using ballast tanks, we decided to use Subsea Buoyancy foam. Since this was another product that we had never worked with, it took extensive research to successfully calculate, measure, cut and position the foam for *General*. In short, we overcame multiple design challenges this M.A.T.E. season, and have produced the best possible product.

Interpersonal- This year the C.O.R.P.S. was subject to an in-school competition between the three MATE teams at STEM ECHS. This ensured we would have to finish everything even earlier than the past years if we want to go to regional. Naturally, due to the diverse schedules of each of the 10 members, there were issues with communication and attendance. In order to solve this, we created a Project Schedule that contained a chart to monitor productivity. Whenever someone was going to miss a meeting or had an important announcement, they would tell the company and everyone would be aware before the end of each meeting. This system was successful in producing solutions for other problems encountered, as well.

Throughout this entire experience, the C.O.R.P.S. has learned many important lessons.

C.O.R.P.S. should always be prepared for anything- The week of our regional competition last year, our C.E.O. experienced a medical emergency and was unable to attend competition. This unfortunate situation taught the entire company the importance of communication in times of stress. Despite their leader's absence, everyone continued to work hard and, in the end, became stronger as team.

UHMW is a better frame material than acrylic- At our 2017 regional competition, one of our presentation judges approached us and asked why we decided to construct the frame using acrylic. After giving our reasons, he advised us to research a material called Ultra High Molecular Weight Polyethylene (UMHW). We learned that it was, in fact, a much more efficient material and are now using UMHW.

The shape of motor housing affects speed efficiency- The same presentation judge from our 2017 regional competition also spoke to us about improving *General's* motor housings. Originally, we had designed the housings to be angular and concaved along the inside. After our conversation with the judge, we learned that a completely circular housing shape would allow the water to flow through it from all sides. We redesigned all of our housings and, in the end, helped the ROV drive faster and smoother.

Future Improvements

Innovation is a strong priority of The C.O.R.P.S. and its values. As a company, we understand that there is always room for positive change in our product and its performance. After long discussions within the company, we concluded that the following improvements are crucial to our success in the near future:

On board electronics- The majority of the electronics will run inside of the ROV. The tether will be thinner and the control system will be smaller. The ROV would have to be a few inches taller due to having the wires on it but it may be riskier because if the water gets in, it would damage everything.

The propellers on the thrusters- If The C.O.R.P.S. increases the diameter of the propellers and adjusts the shape enough, the overall power and efficiency of the thrusters can increase dramatically. Having propellers with a larger area would be a more cost efficient way of increasing thrust versus searching for more powerful thrusters that would draw more power.

Experience Evaluation

Daniel Benavides, Chief Executive Officer

“I enjoy M.A.T.E. because everyone in the company has something different to offer. MATE has changed my outlook on S.T.E.M. fields. After being in it for three years I know that in the future I will continue into the field of engineering. After the regional competition I know for sure that I can pass the torch to the next generation of The C.O.R.P.S. because they all share the same passion for STEM as me and my fellow seniors.”

Penelope Pongpiachan, Chief Administrative Officer

“My second time participating in the program has helped me gain more experience for me to apply to future MATE competitions. I have gained a greater knowledge with technology, as well as, responsibilities. Additionally, I was given the chance to become closer with my teammates because of the challenges we had to face together.”

Noah Johnson, Pilot

“This is sadly my final year in MATE, however it has been my favorite. This year I feel the team truly grew stronger together. I feel confident in my team and their future. I know they have great leaders, builders, and speakers and hope they continue the C.O.R.P.’s name and winning spirit and record.”

Omar Arredondo, Head Engineer

“It was my goal to make MATE great again, this year was a challenge because I had many things to do besides robotics like the year before, many responsibilities fell on my lap and I had to deal with them, but I overcame them I assumed my responsibilities.”

Emma Garza, Chief Marketing Officer

“This being my second year has allowed be to broaden my knowledge on engineering and entrepreneurship. Although we have had our ups and downs, we have come together to have such an amazing company that will continue into the future MATE competitions.”

Julia Calderon, Research and Development

“This was my first year at M.A.T.E. and the experience in the C.O.R.P.S. company was amazing and it was fun the whole time. It did get a little dull at times, but those were few and far in between. I enjoyed it so much I cannot wait till next year.”

Epi Flores, Safety Officer

“My first year of M.A.T.E. has been a fun and memorable experience. The C.O.R.P.S. was an amazing team that allowed me to experience what being in a company is really about and it prepared me for the future. I’m looking forward to joining M.A.T.E. again next year.”

Olivia Garcia, Mechanical Engineer

“Being a part of C.O.R.P.S. for my first year in M.A.T.E. and seeing how the company worked together was extraordinary. This was an amazing experience in building a ROV especially as someone who is usually a builder, using different material than I’m used to in a different environment than I’m used to really broadened my robotics horizons.”

Roy Amaya, Electrical Engineer

“My first year in the C.O.R.P.S MATE team has been very memorable and I love it. MATE underwater robotics was a wonderful experience for me especially since I’ve been on other robotics teams at my school that are land based. Building the ROV also helped in transitioning myself into the “underwater robotics” part of things, having to calculate for natural obstacles that normally wouldn't be on land. MATE robotics has opened my eyes to a new form of engineering that I had never previously thought of.”

Carlos Macias, Chief Financial Officer

“Working with the C.O.R.P.S has been a really amazing experience even if it is my first year on the team. I had a lot of fun and even more work to do. I hope that I continue to be part of this unit and to do my best for the future.”

Acknowledgements

The C.O.R.P.S. is eternally grateful for all of those who played a role in our success and would like to recognize and thank each of the following organizations and individuals:

S.T.E.M. Early College High School for exposing us to the world of robotics and providing the opportunity for us to compete again.

Mr. Romeo Valdez for your endless support, expertise, and patience. You’re our most cherished teacher, inspiring mentor and fearless leader.

San Jacinto College Maritime Technology & Training Center for hosting all of the MATE companies and the regional competition.

The M.A.T.E. Center for accepting our design and for organizing a competition that creates an environment to thrive in.

10 Bit Works for allowing us to use their facilities and teaching us how to operate the Rabbit Laser System.

The S.A.R.K.S., our outstanding sister company, for supporting us throughout this entire 2018 M.A.T.E. season.

The C.O.R.P.S.’ Families for your continuous sacrifice throughout this project and your willingness to help us in any way possible!

References

S.T.E.M. Early College High School: Mr. Valdez for his advice from years of experience with MATE

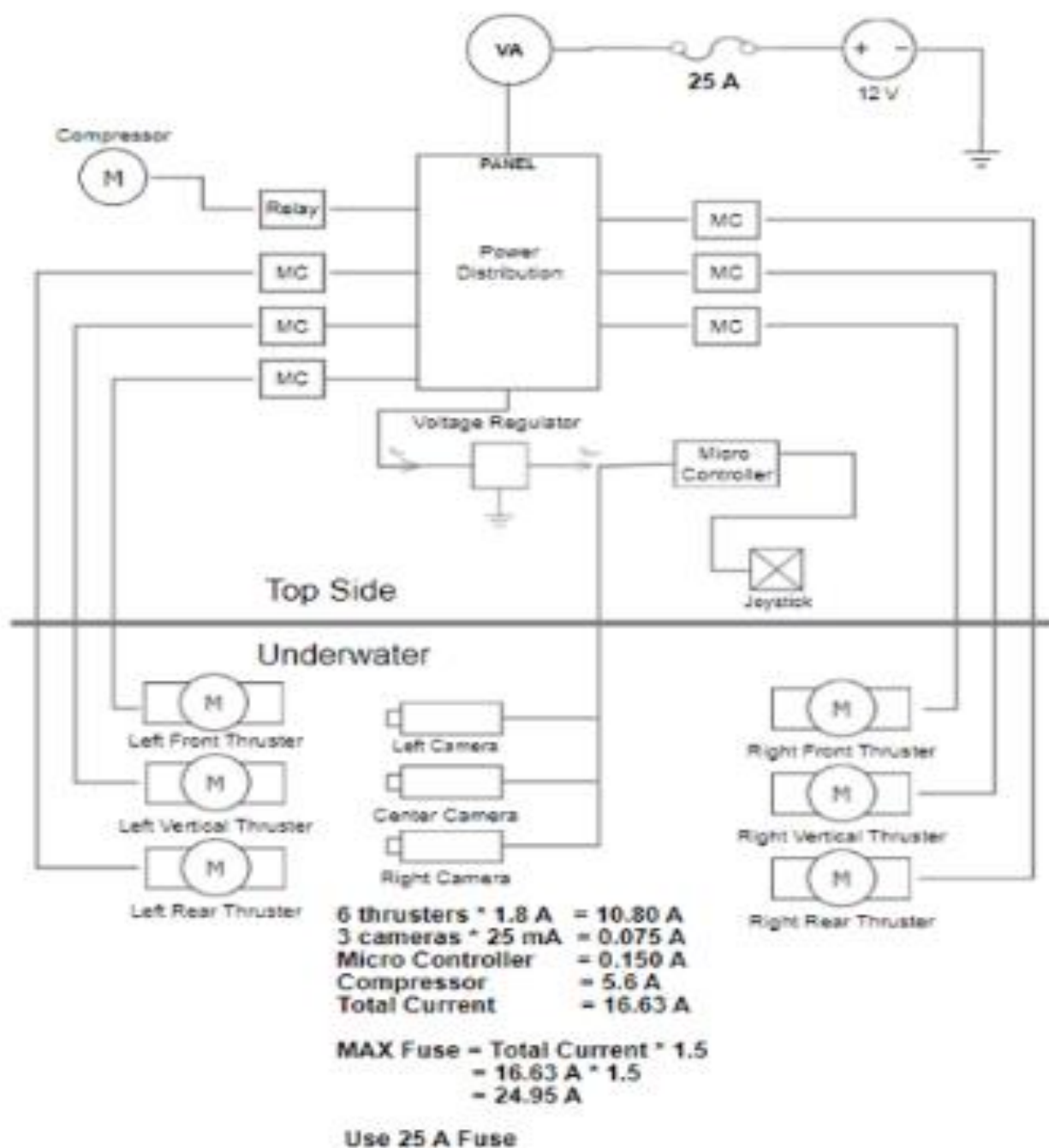
MATE Center: Competition Manual, Forums, Former Tech Reports

Autodesk Inventor 2016: 3-D Modeling Software

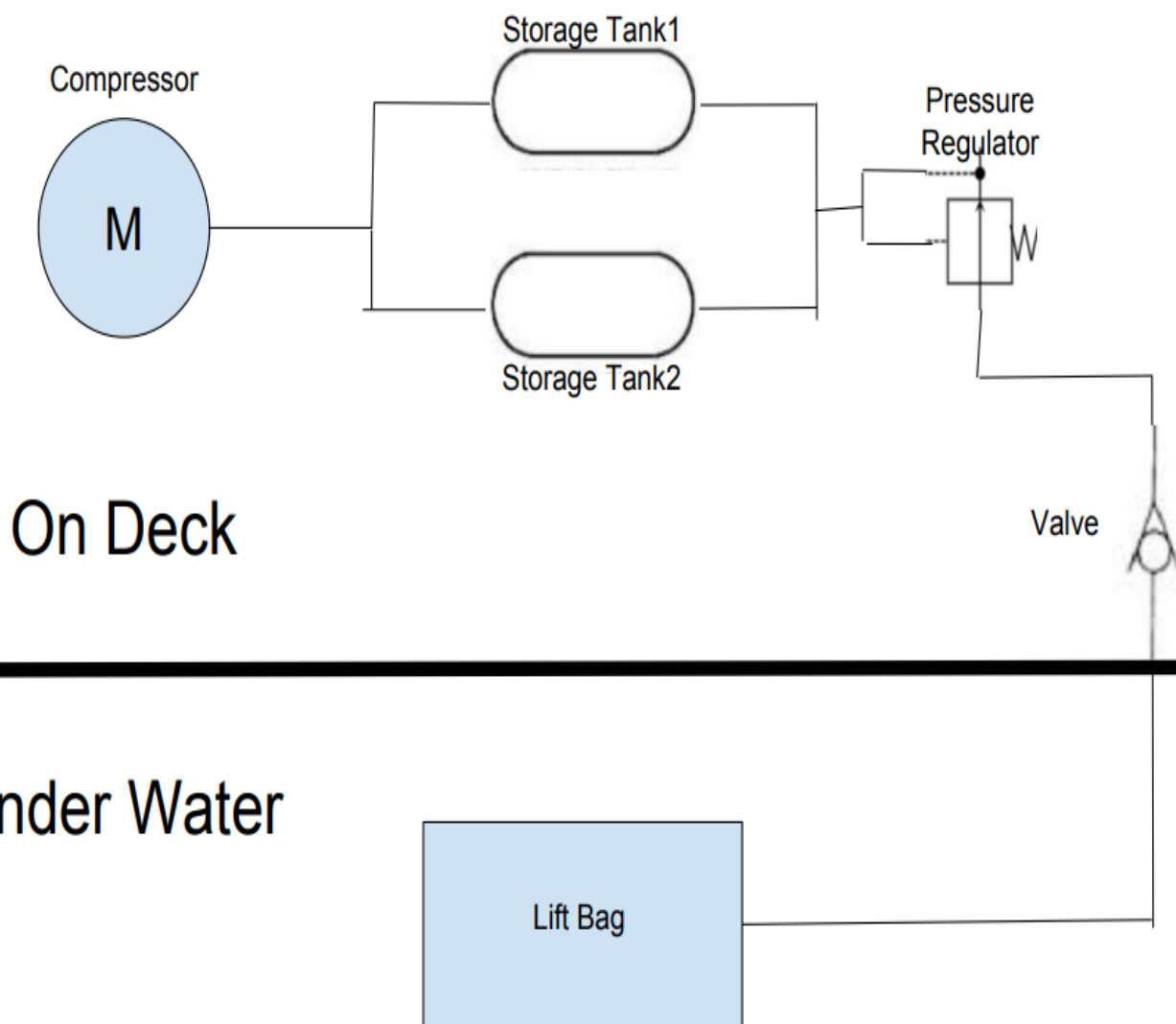
Granger.com: UHMW Specs

Appendices

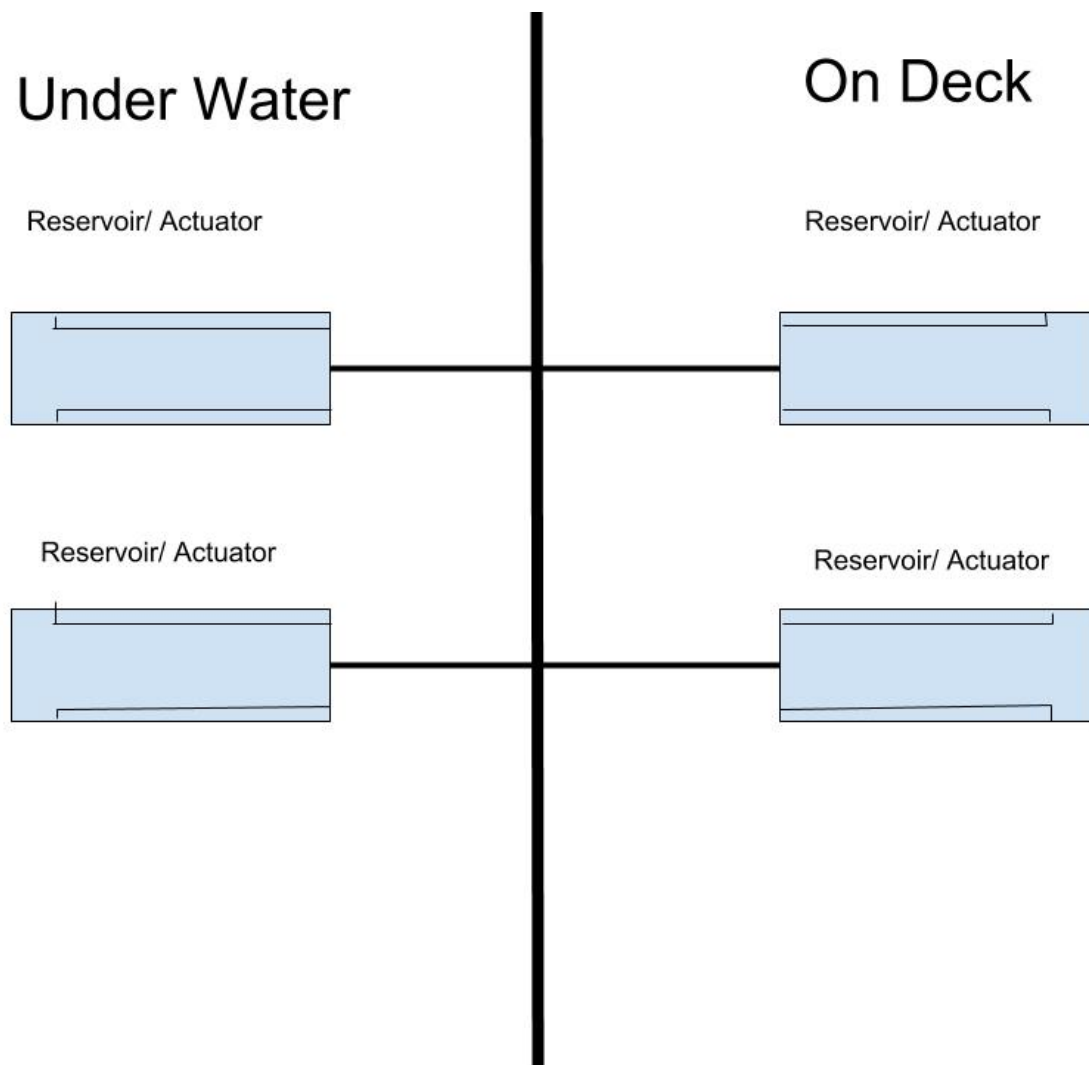
Appendix A- System Interconnection Diagram (SID)



Appendix B- System Interconnection Diagram (Pneumatics)



Appendix C- System Interconnection Diagram (Hydraulics)



Appendix D- Financial Charts

	C	D	E	F	G	H
	Type	Quantity	Expense	Notes	Amount	Running Balance
1	Reused	1	Tool	Used to measure voltage	\$ (9.26)	\$ (9.26)
2	Reused	1	Hydraulics	Implemented as a hydraulic	\$ (4.45)	\$ (13.71)
3	Reused	1	Material	To see the liquid in our hydraulics	\$ (12.50)	\$ (26.21)
4	Reused	2	Sensor	Used to be able to see anything near ROV	\$ (19.52)	\$ (45.73)
5	Reused	4	Electronics	Controls voltage	\$ (19.96)	\$ (65.69)
6	Reused	1	Electronics	Used to control small motors	\$ (34.95)	\$ (100.64)
7	Reused	1	Hardware	Used to cover very long wires	\$ (36.85)	\$ (137.49)
8	Reused	1	Electronics	Used for control of Vex materials	\$ (39.99)	\$ (177.48)
9	Reused	1	Hardware	The case for the control box	\$ (159.37)	\$ (336.85)
10	Reused	1	Hardware	Used to restrict ROV movements	\$ (166.76)	\$ (503.61)
11	Reused	1	Hardware	Distributes power to control box	\$ (204.99)	\$ (708.60)
12	Reused	1	Electronics	Controls voltage output	\$ (359.94)	\$ (1,068.54)
13	Reused	6	Material	Used as the material for the ROV	\$ (142.14)	\$ (1,210.68)
14	Bought	1	Material	Used for 3D printing	\$ (240.00)	\$ (1,450.68)
15	Bought	5	Material	Fill air in the lifts	\$ (162.00)	\$ (1,612.68)
16	Bought	4	Tool	From San Antonio to Houston (Regionals)	\$ (256.45)	\$ (1,869.13)
17	Bought		Travel	A place to stay at for Regionals	\$ (5,000.00)	\$ (6,869.13)
18	Bought		Travel	Used to build OBS frame	\$ (4.00)	\$ (6,873.13)
19	Bought	4	Hardware	To help all the wires by keeping them safe and secure	\$ (15.00)	\$ (6,888.13)
20	Bought		Hardware	Funded by School District	\$ 1,500.00	\$ (5,388.13)
21	Granted	1	Fundraising	STEM Robotics sales for Regionals	\$ 215.00	\$ (5,173.13)
22	Granted	3	Fundraising	The school's district pay for expenses mentioned	\$ 5,500.00	\$ (582.87)
23	Granted		Fundraising	A bake sale where baked goods were sold	\$ 256.00	\$ 2,582.87
24	Granted	1	Fundraising	A barbeque where plates are being sold	\$ 2,000.00	\$ 22,582.87
25	Granted		Fundraising	HISD decided to support the C.O.R.P.s by paying for trip	\$ 20,000.00	\$ 3,438.87
26	Granted		Travel	The entire costs for the C.O.R.P.s at the international competition	\$ (19,144.00)	\$ 3,082.89
27	Bought		Travel	The New TVs that allows the driver to see through the cameras	\$ (355.98)	\$ 29,471.00
28	Bought	2	Electronics	Total Raised	\$ 29,471.00	\$ (26,288.11)
29				Total Spent	\$ 29,471.00	\$ 3,082.89
30				Final Balance	\$ 3,082.89	\$ 3,082.89
31						

1	Income						Amount	Budgeted Costs
2	At Start of Project	Source						
3								
4	HISD (Harlandale Independent School District)						\$ 1,500.00	\$ 4.00
5	Combined Fundraiser						\$ 215.00	\$ 142.14
6	S.T.E.M Travel and Housing						\$ 5,500.00	\$ 240.00
7	Baking Sale						\$ 256.00	-
8	BBO Sale						\$ 2,000.00	-
9	HISD pays for International Travel and Housing						\$ 20,000.00	-
10	Expenses							
11		Category	Type	Description/Examples	Projected Costs			
12		Material	Purchased	PVC Pipes	\$ 5.00		\$ 4.00	
13		Material	Purchased	UHMW for ROV Build	\$ 159.99		\$ 142.14	
14		Material	Purchased	Filament Spool for 3D printing	\$ 240.00		\$ 240.00	
15		Tool	Reused	Wattmeter	\$ 10.99		-	
16		Hardware	Reused	Continuous Hinge	\$ 6.00		-	
17		Hardware	Reused	Pelican 1560	\$ 160.99		-	
18		Electronics	Reused	Circuit Breaker 20 Amp	\$ 20.00		-	
19		Electronics	Reused	Power Distribution Panel	\$ 206.00		-	
20		Electronics	Reused	Spike H Bridge Relay	\$ 35.00		-	
21		Electronics	Reused	VEX Net 2.0	\$ 40.00		-	
22		Electronics	Reused	Victor SP	\$ 359.00		-	
23		Hydraulics	Reused	10 cc/mm Syringe 10-Pack	\$ 5.00		-	
24		Tool	Purchased	Johnson Pump 1250 gph Bilge Pump	\$ 165.00		\$ 162.00	
25		Sensor	Purchased	700 TVL Fishing Camera	\$ 202.00		\$ 199.99	
26		Sensor	Reused	1/4" Rear View Camera	\$ 15.00		-	
27		Transportation	Purchased	Trip to Regional Competition	\$ 300.00		\$ 256.45	
28		Housing	Purchased	Somewhere to stay during Regionals	\$ 5,000.00		\$ 5,000.00	
29		Tether Sheathing	Purchased	Protecting cables in control box	\$ 20.00		\$ 15.00	
30		International Travel and Housing	Purchased	Also includes every expense during competition	\$ 20,000.00		\$ 19,144.00	
31		Insignia 24 LED TV 720p	Purchased	The TV's allow the driver to see cameras from ROV	\$ 400.00		\$ 355.98	
32				Total Income	\$ 29,471.00		\$ 29,471.00	
33				Total Expenses	\$ 25,519.56		\$ 25,519.56	
34				Reused/Donated Expenses	\$ 857.98		\$ 857.98	
35				Total Fundraising Needed	\$ -		\$ -	