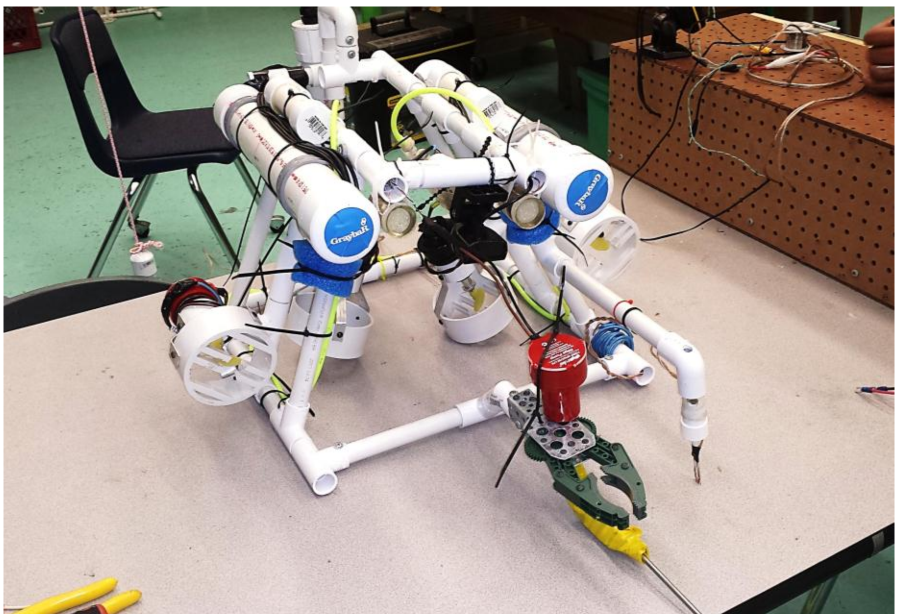
Foy H. Moody High School

Corpus Christi, Texas

Hydrotech Robotics

Our latest product “The Gyarados”



The Completed Gyarados

Hydrotech Staff Members

Top Row Left to Right:
Nishan Sabbagh- CEO 1st year
Ben Galicia- Pilot 1st year
Catalina Gonzalez- Safety 1st year
Robert Gonzalez- Co-designer 1st year
Blaze Cruce- CFO 1st year

Bottom Row Left to Right:
Karla Gonzalez- Co-reporter 1st year
Ariel Saldaña- Co-reporter 1st year
Carlos Vasques- Co-designer 1st year

Mentors:
Leo Gonzalez-Coach

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Abstract

Hydro-Tech Robotics specializes in producing underwater ROVs (Remotely Operated Vehicles) designed to meet the standards of our customers. Our latest project is the "Gyarados", a ROV designed to maneuver in and around shipwrecks providing multiple purposes with historical, environmental, and scientific research. The team members involved in this build is Nishan Sabbagh, Blaze Cruce, Ben Galicia, Robert Gonzalez, Catalina Gonzalez, Karla Gonzalez, Carlos Vasquez, and Ariel Saldaña. Each member played a crucial role in completing this project in a timely fashion in order for it to be a complete success.

The Gyarados comes equipped with basic functions such as four motors for propulsion, air tanks and inflatable bags for buoyancy, and a claw for general handling of underwater objects.For the current tasks required by our current client at the Thunder Bay National Marine Sanctuary, our team has included a conductivity sensor for finding possible underwater sink holes, scoop for removal of trash and other debris, color camera providing nearly 180º of vision, 180º claw for easier pickup of flat debris, and a pump for the extraction of any unwanted liquids or possible biohazards.

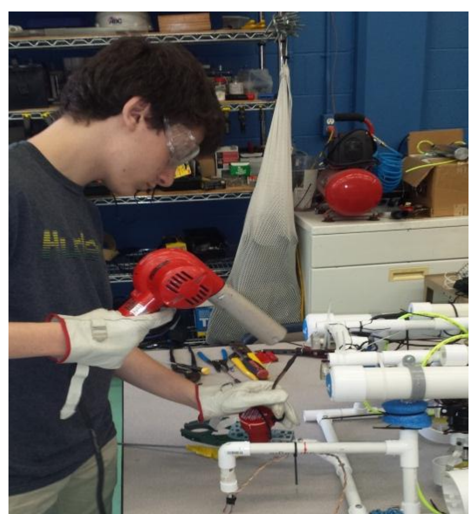
With our final product the Gyarados, Hydrotech will serve our client and mission by completely and efficiently completing any and all tasks necessary in this year's shipwreck theme.

Theme

ROVs are a major contributor in exploring shipwrecks and giving detailed information to identify the type of ship such as the Titanic, which was unable to be found until the technology of ROV's had been improved. Over the years ROV's have become more complex and given abilities that humans could only dream of having. ROV's are especially useful in any dangerous location of the ocean such as depths that are inhabitable by humans and are much safer, cheaper, and easier to send down compared to manned submarines, which are the only other option for extreme depths. At the Thunder Bay National Marine Sanctuary (TBNMS), ROV's are used for uncovering the secrets of undiscovered shipwrecks along with maintaining quality of the ships for years to come. Specialty ROVs can be used for determining the type of ships by looking at the characteristics of the ship and by recovering cargo on the ships. Other robots can be designed for maintaining the quality of the ship and the surroundings by removing trash such as bottles or they can be designed to keep track of the biological life around the ship and even replace sonar beacons to keep track of where the ships are.

Safety

Our company HyrdroTech strives to maintain a professional standard of safety for employees, clients, and operating environment. Our safety philosophy is to maintain an ROV that provides no hazard to anything or anybody. To do this we have designed our ROV to be safe in several different aspects. In building the ROV we have designed propeller housing out of a PVC cap, thus providing barrier between the hazardous propellers and anything in the outside environment such as fish or plant life. All



Gloves and Safety Glasses are always required when dealing with extreme heat.

electrical connections covered with hot glue and heat shrink leaving no exposed wire so none of the electrical current will conduct throughout the water. With both the hot glue and heat shrink there is an assured waterproof connection. As well we have made sure that no sharp edges are present on the robot, if something is encountered that does possess a sharp edge it is proceeded to be sanded down or cover it in hot glue. Also a 15-amp fuse is attached to our tether lead in our control box preventing any possible electrical accidents to our staff or ROV.

While operated or working with our ROV safety precautions are always followed to maintain our safety philosophy. When working all company staff always has hair tied back, is wearing closed toed shoes, and is wearing safety glasses. When operating the Gyarados we follow policy that all members are not touching the while any motors or systems are running. Also our pneumatics system's psi is checked before being run to ensure that nothing is hazardous.

- See appendix for safety checklist

Cost Analysis

Category	Parts Description	Estimated Cost	Acquisition Cost
Frame materials	PVC pipe PVC tees	$17.00 $11.00	$30.00 $14.00
Onboard Electrical systems	25 ft CAT-5 wire	$11.00	$12.00
Claw Manipulator	VEX Claw Underwater Servos	$25.00 $110.00	$20.00 Donated
Control board	VEX Cortex FRC Motor Controllers FRC power distribution Board VEX controller Peg board	$200.00 $480.00 $175.00 $30.00 $35.00	Reused Reused Reused Reused Donated
Propulsion	1000GPH Bilge Pump cartridge Motor propellers Thruster mounts	$160.00 $16.00 $25.00	$140.00 $12.00 $18.00
Pneumatics	Air Tubing Handheld pump Saline bags	$65.00 $7.00 $4.00	Donated Reused Donated

Buoyancy	PVC Pipe PVC caps	$8.00 $1.50	$7.50 $6.00
Tether	100ft CAT-5 Nylon rope	$25.00 $10.00	$28.00 $22.00
Key Features	Camera Swivel servos Conductivity wires Tubing Surface pump 12 V Lights	$35.00 $110.00 $10.00 $12.00 $125.00 $20.00	$30.00 Donated $15.00 Reused Reused Reused
Total:		$1727.50	$354.50

Design Rationale: Key Features

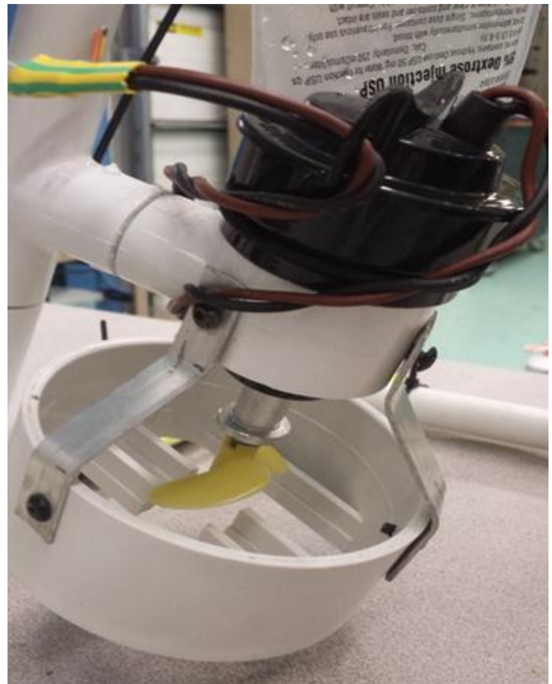
Frame

The Gyarados's frame was inspired around a previous design seen after at competition the year before. We found that the dimensions of the Gyarados were proper to fit inside the hole of the shipwreck. The outer dimensions of the Gyarados measure 75*62*34cm. The frame is constructed out of ½ inch PVC because of its relative low cost and ease to work with. With the PVC it was very easy to mount things such the motors and claw. Also because of the hollow PVC used we were able to run wire through it. Because of the triangular frame used were able to symmetrically mount air tanks on each side making our robot stable in the water.

Propulsion:

Overall, settling on a design solution for our propulsion was one of the easiest jobs we faced as a company. With some of our members having experience in this competition from previous years, none of them had ever seen anything other than motors (or bilge pumps) with propellers on them to control the movement of the ROV. Because of that, we felt it was much

easier and straightforward to use 500 GPH motors (which we later upgraded to 1000 GPH) to control the movement of our robot rather than try to reinvent the wheel when it seemed unnecessary. In our final design our ROV has four motors which will provide the ROV all necessary degrees of movement up, down, left, right, clockwise, and counter-clockwise. However with our motors there became a conflict with our company's safety philosophy in that the spinning propellers provided a dangerous safety hazard. To solve our company has designed a simple motor guard that would offer protection. With the motor guards the hazardous spinning propellers are shielded so subsequently the outside environment such as aquatic life is safe.



Motor with propeller housing

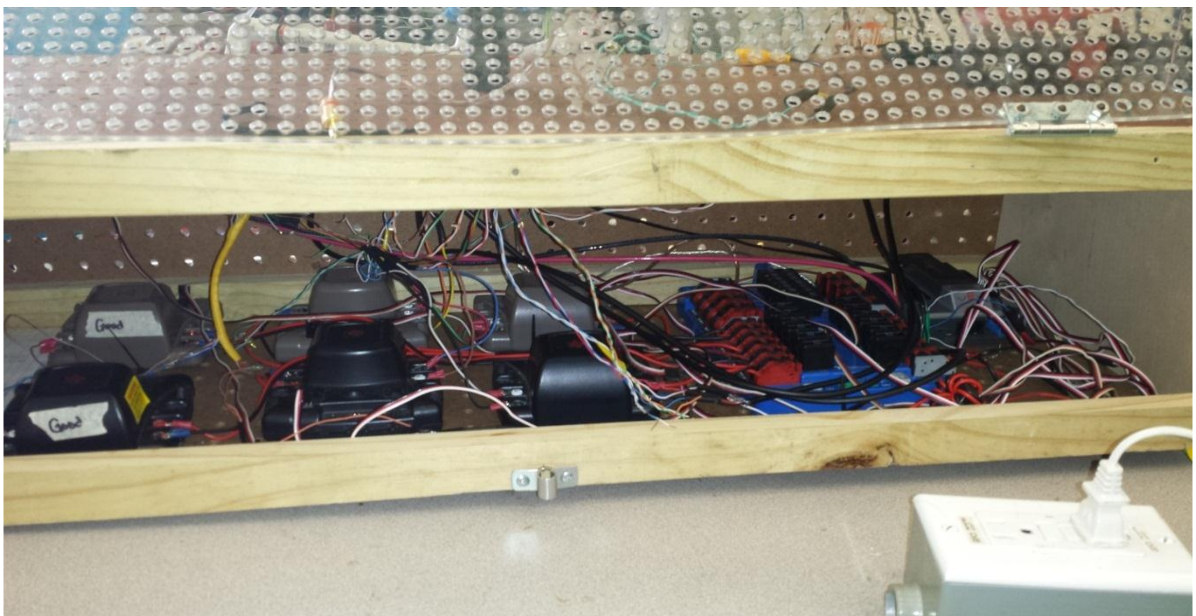
Camera

While building our "practice" ROV we had created our own waterproof cameras that provided a wide viewing radius. When we began construction of the Gyarados, we found this type of camera to be quite bulky and unprofessional, so we decided to take a different approach. We used a smaller camera, but at the time, sacrificed the wide viewing radius. We combated this by attaching a servo motor to the mount that the camera is on in order to allow us to adjust its position. This not only looked more professional, but also came at the same cost of our original camera.

Camera on adjustable mount

Control System

When we built our "practice" ROV at the beginning of the school year, we had a very simple means of controlling it from the surface by using toggle switches. While this was very easy to wire and was helpful with explaining the concepts of creating an ROV to our new members, we found it a very difficult means of controlling the ROV because you would normally have to activate multiple switches at once in order to maneuver the robot as you wished. Because it was a strain on the hands and did not look professional enough, we brainstormed many different ways of controlling our ROV, and all the ideas centered on using a programmable VEX or XBOX controller.



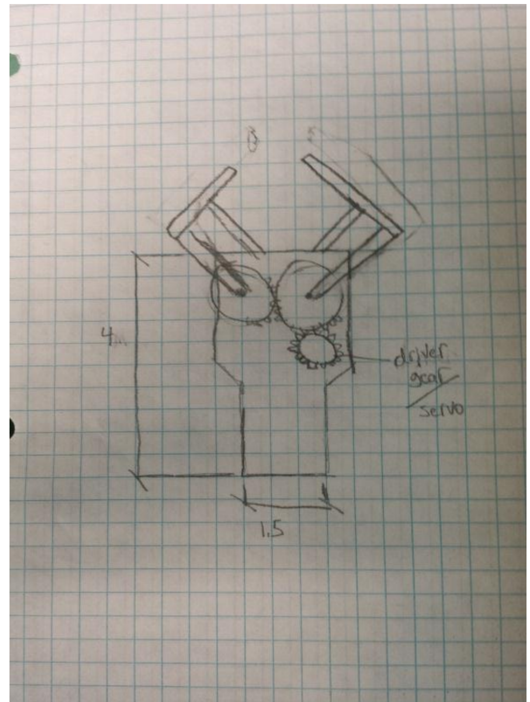
Control Panel for the ROV

Because our school has competed in many different competitions in the past, we had the available resources in order to make using a VEX controller very easy. As an extra safety feature, we powered everything on our robot through an FRC Power Distribution Board, reused from last year, which not only allowed the very organized layout of the wiring in our control panel, but also contained amp fuses to prevent the power from shorting out throughout our robot.

Design Rationale:

Competition Tools

Claw manipulator



Sketch of original claw design

To successfully accomplish the tasks present this year our company knew that a claw would be necessary on the ROV. To recover many of the objects in and around the shipwreck our claw would let us recover and deploy many things from the surface and underwater. These are things such as the bottle, plate, sensor string, etc. In designing our claw it was determined that the Gyarados needed a claw that contains high torque, high grip strength, durability, and relative low cost. When designing our claw we considered using a hydraulic syringe that would open and close based on the force we applied at the surface with another syringe. We concluded that this idea was inefficient due to how slow it was and the inefficiency of running a separate tube from the surface. We later designed a new claw manipulator using a VEX Claw powered by a high strength servo. With our design complete the claw was planned to be now faster, stronger, and much more versatile. Simply put, our claw works with a high torque servo that turns a gear connected it shaft. That gear then turns another gear that will then manipulate our claw either opening or closing it .We acquired these through Citgo, one of our best sponsors. In designing our claw we discovered with our high torque motor and gear ratio operating the claw it could be both high speed and high torque. To build our claw our team had to learn how to incorporate an underwater servo to a claw that was intended for use with land robotics we learned about how to do things like this and use the gears to our advantage from our engineering classes in school.

- ❖ See appendix for wiring diagram

Agar Extractor

Agar Extractor with conductivity wires at tip

While brainstorming an idea for how to extract the agar, we realized that an on-board pump was not only ineffective, but was also bulky and unprofessional. We decided to use a pump on the surface that plugged directly into the outlets supplied by MATE. This conserved energy while also allowing more creativity throughout the ROV allowing us more space to experiment with other ideas. Because we were using a pump on the surface, we had to run tubing down along with the tether and put a nozzle somewhere on the robot.

We created an arm that the nozzle is mounted on and positioned it on the front of the robot so that no additional cameras would have to be mounted in order to view it. The pumping mechanism works by using a switch on the pump and sucking air (or water/agar) through the nozzle and to the surface. The agar can either be collected directly from the bag or piped into the bag. The arm and nozzle later became a key feature on our robot because of its ability to penetrate the plastic wrap covering the cups.

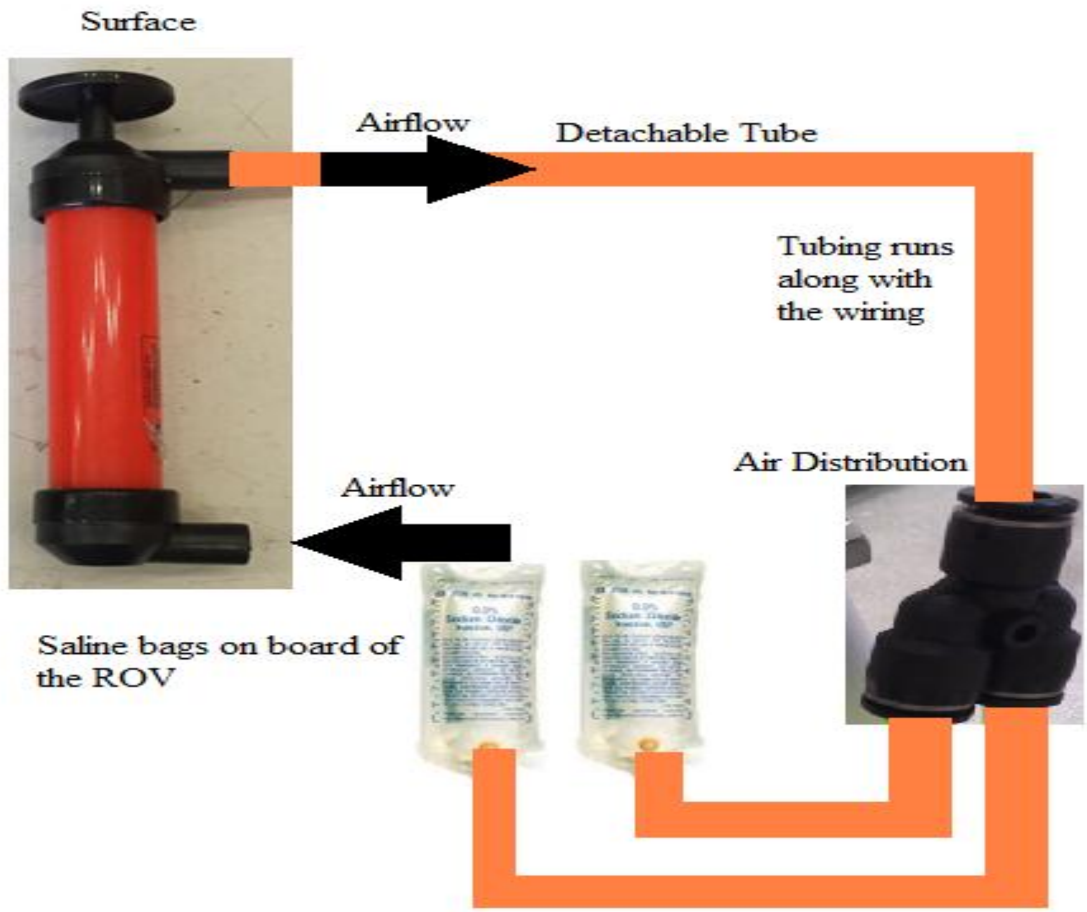
Conductivity

Our group had originally felt that measuring conductivity would be one of the most difficult tasks to accomplish, but after a small amount of research and brainstorming we came up with a very simple and effective solution. In our research we learned that conductivity is measured in milliamps, and that you can measure it by creating a simple circuit that uses saltwater (which is ionized) as a means of transferring electricity from two wires that probe into the area of concentration. After discovering that, we experimented with different ideas that mainly included attaching two wires, one of which carried energy and another that did not, to some sort metal rod. In actuality, these designs proved to be very bulky and looked quite unprofessional until we had the idea of simply attaching the two wires to the nozzle that penetrated into the sample of Agar. This design worked exactly as planned and executed flawlessly, while maintaining minimal uses of resources along with the general theme throughout the ROV of professionalism.

Active buoyancy control

In order to lift the sensor string and make all ascents easier and faster our group decided that we would need some sort of buoyancy system. To solve this our team has built an active buoyancy control system using an electric air pump and saline bags attached to our ROV. At the surface when the electric air pump is turned on air will be pumped down to the surface of our ROV inflating the saline bags giving our ROV positive buoyancy making it float up with whatever it is carrying. Whenever we want the ROV back at standard neutral buoyancy we will simply have the air pump suck air out of the back bringing it back to its normal state. Our company decided that the electrical pump would work best because it would be simpler and safer than using an air compressor. Also we chose saline bags because they were readily available in our school and they seemed that they would serve its purpose the best. We learned how we could use an air system to provide positive buoyancy from our experience taking Principles of Engineering at our school.

Buoyancy Control Air pouches



Pneumatics Diagram for active buoyancy system

Future Improvements

The Gyarados is a prototype ROV that will be improved upon through: neatness, cost, and weight. Most of the wires running to the surface are hidden within the nylon rope, although having a minimum timing on multiple of things that are added is leading to more and more exposed wire. In the future ROVs all lines will be added to the robot and through the tether before any parts are fully secured. Cost was not one of the biggest issues, yet the price of the robot could easily be lowered by making 3D models of the propeller blades which could have modified to be larger and more efficient. Also by using an eight conductor wire rather than 2 four conductor wires we would improve on the overall look of the robot. Weight was a huge factor accepting the fact that the ROV wanted to sink immediately after being set into the water. Overall though through this we have learned many lessons to be even more successful at next year's competition.

Troubleshooting

Throughout the process of building the ROV there has been countless times where things have gone wrong with our ROV and its systems. To solve this problem we had to develop troubleshooting techniques to actually identify the problem present that needs to be fixed. The technique we developed was to identify the problem and use the design process to come up with a solution. For example when our claw was not operating we determined that the problem was a spring present in the VEX claw that gave too much resistance. To solve this we went through the design process and determined that the simplest and easiest way to solve this problem was to just simply disassemble the claw and remove the spring. Overall this troubleshooting technique has worked very so far and solves the problem whenever there is some malfunction on our ROV.

Company Evaluation

Over the course of building the Gyarados, our company has had a reasonable number of successes and failures, although overall Hydrotech has been successful in manufacturing a working ROV that meets the demands of our client and operates well in a shipwreck scenario.

Hydrotech as a company has a multitude of strengths, the greatest probably being its innovative design team in which each member has their own specialized field to contribute such as electronics, wiring, or safely constructing the actual ROV. Hydrotech focuses solely on building a quality product that serves its purpose by being efficient and reasonably priced. Our latest product, the Gyarados, reflects our cohesiveness as a company while also displaying the ROV's key strengths, such as its maneuverability and neutral buoyancy. Combined these two features allow the ROV to travel quickly and efficiently underwater, being able to transport objects if necessary while also being able to move any direction wanted: up, down, left, right, or diagonally.

Areas needing improvement on the ROV would have to be its propulsion and camera. The propulsion (motors) could have had a higher GPH, giving the ROV more thrust and power moving through the water. Also in order to keep down on cost and weight we used a smaller, less expensive camera that sacrificed the optimal focus and viewing radius that we were looking for.

What our team would do differently next time would be to use slightly larger PVC in the frame of the ROV so that it is much easier to run wire through the inside of the robot. Also to make the ROV neater we could design it with a bigger ballast tank so no additional positive buoyancy such as foam would need to be added.

Overall though the most rewarding experience of building the ROV would have to be learning the dynamics of working together as a team to achieve a goal. Just learning how to work together despite our differences and contradicting ideas was a large challenge, but over time working on the Gyarados we each learned our own strengths and weaknesses as team.

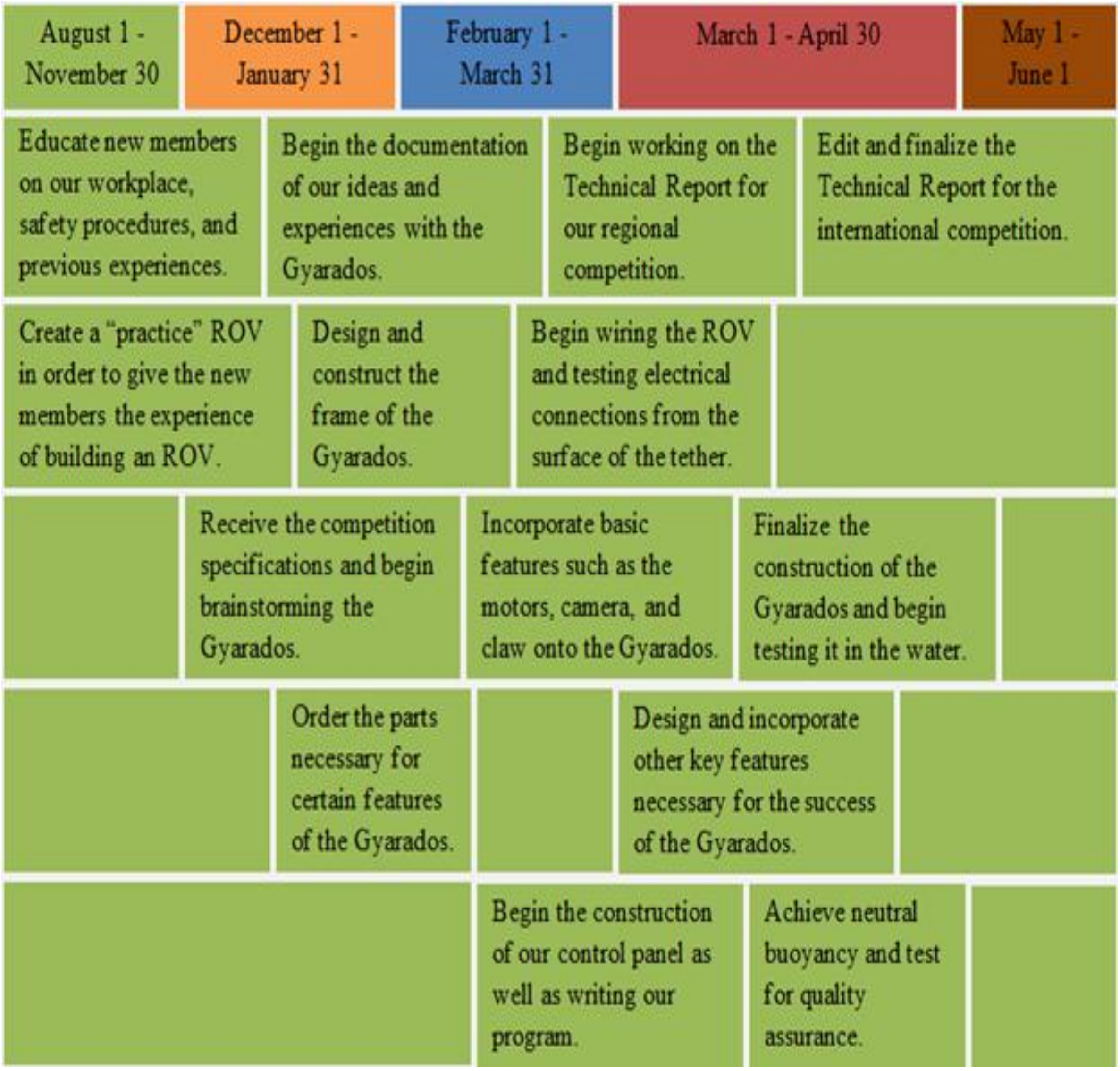
Acknowledgements

- MATE Center-for giving us the opportunity to compete at an event like this
- The staff of the Corpus Christi Natatorium-for allowing us to work on our ROV in their pool working under the water pressure in the deeper end of their pool.
- Leo Gonzalez-for providing transportation, guidance, and mentoring our underwater robotics class.
- Citgo-for sponsoring our underwater robotics class and paying for everything else needed for the robot such as the camera, motors, the claw, and wiring.
- The Galicia family-for allowing us to test our prototype in their pool achieving neutral buoyancy on our robot.

Appendix A: Safety Checklist

- Ensure all members are wearing safety glasses and have no hazardous clothing (open toed shoes, loose sleeves, etc.)
- Check all electrical connections are covered, no exposed wire
- Check for any possible sharp edges on robot
- Make sure all electronic equipment is not near water or wet
- Ensure all connections are correct on control board
- Before turning board on ensure connected properly to power source
- Before running any motors ensure all members are not in way of propellers

Appendix B: Development Schedule



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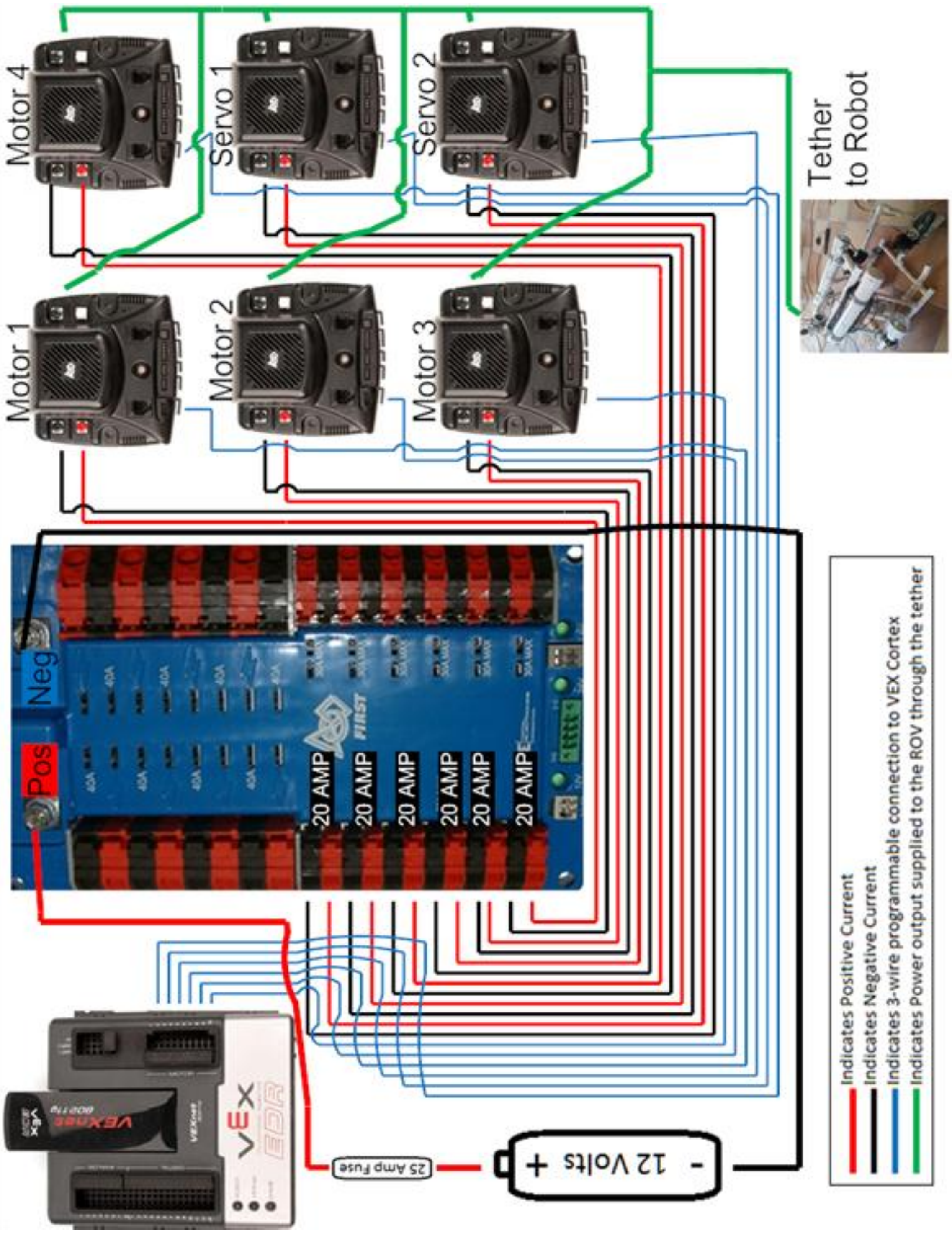
Appendix C: Wiring Diagram



Wiring Diagram created using SmartDraw© Software