Aquabot Technicians

Foy H. Moody High School
Corpus Christi, Texas, USA

Octobot

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Sophomore-Aaron Garcia- Power Supply
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I. Introduction

A. Abstract

Aquabot Technicians specialize in producing custom underwater Remotely Operated Vehicles (ROV) designed to surpass all industry durability and safety standards at a cost effective price. Our company utilizes 17 specialized team members that have technical and engineering experience in all aspects of developing ROVs by diligently applying the “work smarter, not harder” design process. Our newest ROV “Octobot” is a binary craft that can complete tasks in both, inner space (under ocean water) and in outer space (Jupiter's moon Europa). An electronic controlled claw manipulator, filtered camera with a high resolution screen, an accurate temperature sensor, a pressure depth sensor are some of the new innovations that make *Octobot* ideal for critical equipment recovery, exploring ocean reefs, studying deep-water corals, analyzing a gas chromatograph. We realize, and are well aware of the inflated cost to ship any kind of payload to outer space. Our compact and light weight ROV frame and thruster system is ideal for shipping systematically as a payload to outer space for a mission to Europa.

Aquabot Technicians CEO Natasha Sanchez being interviewed after the Regional MATE Competition by local KIII news station on May 9th 2016.

II. Safety

A. Company Philosophy

Throughout the process of constructing *Octobot*, Aquabot Technicians encountered some minor bumps and bruises, but nothing more. Aquabot employees strive to work in a safe environment that is maintained and monitored daily by our safety specialist. Our company's catchphrases are: "Work smarter not harder" and "It's not just safety first, but safety always".

B. Lab Protocols

To insure the utmost safety while operating in the lab and to work on any ROV project, specific safety procedures are implemented. Safety glasses and closed toe shoes must be worn at all times in the shop(seen in *Figure I*). Cords are kept out of aisles and walkways to keep the area neat and prevent tripping. When operating machinery, especially the drill press, where hands could be caught in dangerous rapidly moving parts, team members are prohibited from wearing gloves.

Figure I: Our CO-CEO is giving an example of proper safety attire.

In reference to our employee's safety, each member when going into the shop to work on *Octobot* must:

- Wear safety glasses or goggles while working in the shop.
- Verify work environment is safe before beginning to work.
- Verify tables were neat and clean.
- Verify all tools work without flaw.
- Verify all appliances are turned off at the end of the day.
- Used PPEAs needed.
- Ensured that another employee of the company monitors each member of the company while working with equipment.

C. Training

Aquabot Technicians train through a *"peer-to-peer"* system. New employees are required to spend their first meeting observing experienced members operate machines. Thereafter, they are able to start operating the machines under supervision of senior members who will guide them and assure that they comply with safety procedures. This culmination of observation, training, and practice has proven to be an effective method in teaching new employees proper adherence to safety and to safety protocols.

D. ROV Safety Procedures

With soft skids and smooth edges, Octobot contains numerous safety features designed to keep the crew, ROV, and work environment safe during operation. All sharp edges are rounded off by sanding all protruding corners and miscellaneous burr's. Propellers have shroud covered with mesh netting to ensure we protect wild life and habitats during operation. In addition to ensure electrical protection, any exterior conductors are enclosed.

III. Design Rationale

A. Frame

With new constraints of 49cm total size and 11kg weight we decided to use a mixture of two different frame shapes after trial and error, which began with a basic vector shape, then evolved to a simple Triggerfish shape. We first thought to use a vector shape because it is easier to move and control in the water by our pilots (Seen in *Figure II*). The triggerfish shaped frame has many aspects that help it maneuver through the water efficiently, especially since the main frame is made of 'Polyvinyl Chloride' (PVC) rather than the Aluminum that we had used in the previous year. The PVC frame is constructed to have no sharp edges and to evenly distribute the weight of the motor thrusters, and camera to have a good center point of mass (seen in *Figure III*). The frame took approximately two weeks to completely assemble. The majority of the two weeks was time used to design the frame and not the actual constructing.

Figure II: Image of bare frame

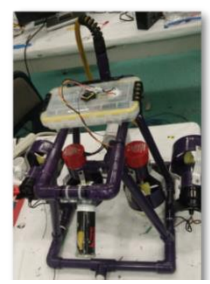


Figure III: Final frame with all components.

B. Claw Manipulator

Figure IV: The "Beak".

The claw manipulator was created to easily accomplish the tasks given. The claw or "beak" was designed to pick up anything from oil caps to samples of corral. We created the beak to be able to maneuver through any obstacle at hand. While being developed, our company came across the decision of whether to build it from scratch or find existing designs that we could possibly modify. We weighed our options and realized that it would be in our best interest to recycle our claw from last year and make small modifications. Through the use of a Servo Motor, the beak (seen in *Figure IV*) is capable of opening and closing to obtain and perform all necessary tasks. Overall, we managed to find a claw that accommodates all of the criteria needed at relatively low cost, and made modifications in its assembly to make it fully functional for all the tasks. Further explanation on the functionality of electrical programming; refer to section F. Programing (page 6).

C. Camera

The camera was implemented to give the pilots a visual of what is taking place underwater such as to identify corals on artificial reefs of decommissioned oil and gas platforms. A task that came along with connecting the camera was being able to properly wire the camera to the ROV and making it waterproof. We used epoxy on the camera rim to connect with the acrylic lens. Then the connecting wires were placed into a casing where acrylic resin was used to fill the casing for waterproofing (seen in *Figure V*). With the seaMATE Triggerfish kit we received a camera that has a lens angle of 170o, resolution (TV lines) of 420, a video output of RCA connector, 1.0 Vp-p,75ohm, a DC 12V±10% power supply, and a power consumption of Max 0.5W.

Figure V: Top view of our waterproofed camera.

D. Temperature Sensor

Figure VI: Temperature Sensor with plumbers tape.

Aquabot Technician employees came together to decide on the options we had for the temperature sensor that would work best under extreme conditions on Jupiter's moon Europa. We decided to use 32184-MP Digital Thermostat. The temperature reading is displayed on a LED screen located at the control box. Its sleek design will secure the temperature probe sensor into a crevice on the seafloor with the use of plumbers tape (seen in *Figure VI*). Installation and the strategic placing of the probe are vital for retrieving the most accurate climate readings while measuring temperature of the venting fluid. The sensor and LED display uses 12 volt power supply and senses temperature from -50C to + 110C.

E. Motor Thrusters

There are two Johnson 500GPH motor cartridge ROV thrusters that are standard equipment with the SeaMate kit. These motor thrusters are used for the horizontal thrust movement of the ROV where there is the least resistance as compared to the vertical heave movement. Two 1000GPM bilge pump motors were added by our team of electricians for the vertical heave movement of the ROV for lifting both coral samples and oil mat samples from the seafloor (seen in *Figure VII*). Since these motor thrusters are more robust than those that came with the SeaMate kit, they are able to withstand the stress that will be applied to the ROV while surfacing any payloads.

Figure VII: One of *Octobot's* Johnson 1000GPH motor

F. Programming

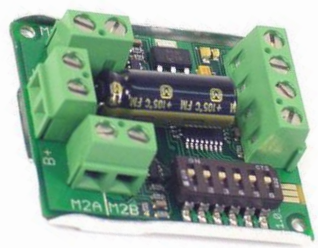


Figure VIII: Sabertooth motor controller used in *Octobot*.

For programming *Octobot* beck claw and temperature sensor, we utilized the Arduino microprocessor, which came with the fail-safe control system from SeaMate. We decided to use the example program called *Knob* (refer to Appendix D). *Knob* utilizes a potentiometer which allows the pilot more precise control of the beck claw. The pilot can decide the entry width and the speed of the closing/opening of the claw with *Knob* potentiometer control.

To control the thrusters on *Octobot* we decided to use analog joysticks. The company found the joysticks allow easy maneuverability, which is crucial for the scenarios that *Octobot* will be put through such as aligning the cable connector into the port on the power and communications hub located on the Environmental Sample Processor (ESP). The joysticks utilize Sabertooth motor controls, which then send regulated voltage (anywhere from 0-12 volts) to the robot's propulsion thrusters (seen in *Figure VIII*).

G. Power supply

The power supply was designed by our design engineers to solve a constant power supply problem we have encountered for a long time. By applying the average power of a wall outlet (GFI 120V AC) through a transformer that rectifies power to 12V DC, we have a continuous stream of constant power to the ROV. In the past years our power supply, a 12 volt battery, would lose power over a short time causing our microprocessor and camera feed to fail while operating the propulsion system. Our new innovative power supply ensures that the ROV has a steady stream of power (seen in *Figure IX*).

Figure IX: Octobot's new innovative power supply.

H. Control box

The *Octobot* comes with a fail-safe control system sold by SeaMate. This control system is engineered with a comprehensive and a systematic installation manual. The process of building the control box took approximately 130 man-hours to fully assemble. The control system consists of several components that include; 25 amp fuse retainer, Kill Switch, two Sabretooth motor controllers, DC to DC converter, camera filter, watt/voltage meter, two joy sticks, motor simulator board and a microprocessor. A durable water resistant case and tether strain relievers come as standard equipment. To enhance the control box and functionality of *Octobot*, AquaBot Technicians electrical team added the temperature sensor display, control knob for the claw, and a RCA video output (seen in *Figure X*).

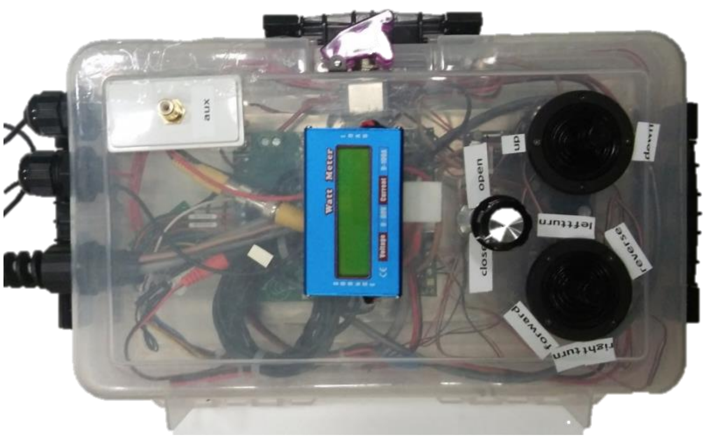


Figure X: Octobot's
SeaMate Control Box Top view

I. Tether

The Tether is made to be narrowed to allow for the ROV to maneuver throughout the underwater missions with minimal drag. Also there is a nylon coating that is placed over all of the conductors to bind them together. There are additional bindings of the wires with electrical tape to make sure that the conductors would not become loose when the nylon coating was applied (seen in *Figure XI*).

Figure XI: Our tether in the processes of being assembled threw the strain reliever.

- The tether is 13.4112 meters long.
- The tether includes 3 wires in total, which include, 8 Conductor wire, CAT 5 wire, and a camera Video and Power wire used to read the feed on our screen from the camera (seen in *Figure XII*).
- Tether strain relievers are placed on the ROV and Control box.

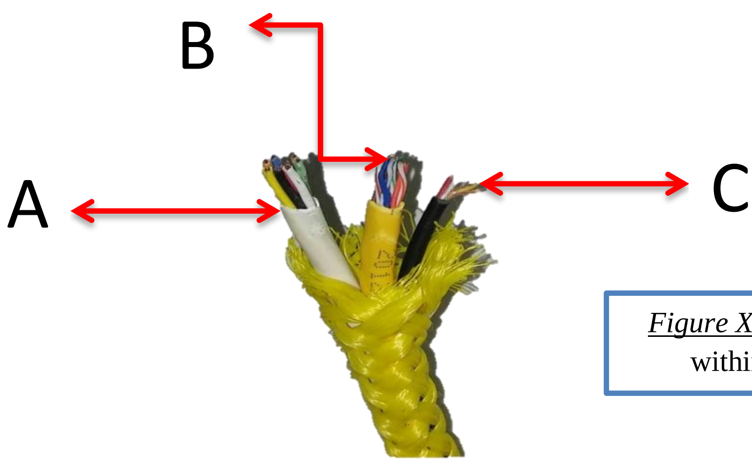


Figure XII: Conductors within the tether.

A. 8 Conductor, 20 gauge stranded, for Thrusters

B. CAT 5, 24 gauge stranded, for sensor and claw

C. Camera Video and Power wires

Figure XIII: Octobot is being tested to calculate bouncy.

D. Buoyancy

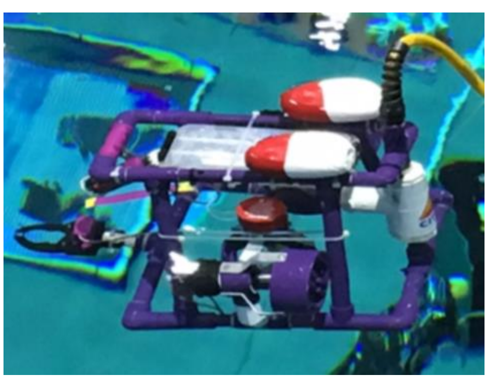
To calculate the buoyancy of our ROV (seen in *Figure XIII) Octobot* we used the formula:

Fb=PghA or Buoyant Force = (density of liquid) (gravitational acceleration) (Volume of liquid) = (density) (gravitational acceleration) (height of liquid) (surface area).

When density of water is 1,000kg/m^3. The gravity acceleration is 9.807m/s^2. The volume of pool is (23.5 million liters). The height of liquid 18.288m, finally the density (.349g/m^3) and surface area (3.188) of the ROV. After doing all the calculations, we added the necessary buoyancy to the ROV to make it stable.

Figure XIV :
PVC 3.81cm x 33cm 2 newton's lift
Bouy 7.5cm x 12cm 4 newton's lift

With the option to use either the PVC bouancy ballast tanks or the buoy ballast we came to a team decition to use the bouys for our final ROV design. We came to this conslusion when we measured the ballast tanks by using a *"newton and dynes"* scale, measuring each ballast tank underwater, and realised that the data proved the bouy to be twice as effective with 4 newtons of lift in the water versus the PVC having 2 newtons. The decision to use the buoy ballasts is most effective because of it's size to lift ratio (As seen in *Figure XIV*).



Octobot in the NBL pool with accurate buoyancy.

IV. Logistics

A. Cost Analysis

The materials selected for our ROV were based upon price and functionality. Our ability to create a cost-effective and high-quality product is one of our company's greatest strengths, and provides us with a constant budget goal while we keep mindful of our clientele. The following charts clearly show that our company budget goals were met. This year's starting budget goals were: $1000 ROV, $2500 Travel, and $500 Miscellaneous

Cost of ROV Parts			
Category	**Parts Description**	**Actual Cost**	**Acquisition**
Structure	Polyvinyl Chloride (PVC) (26) PVC Fittings	~$45.00 ~$48.10 ($1.85 each)	Reused Reused
Motors	(2) Rule 1000 GPH Bilge Pumps (2) Johnson Bilge 500GPH Pumps	~$75.58 ($37.79 each) ~$29.98 ($14.99 each)	Reused ~$29.98
Camera	(1) Car waterproof and Night vision camera	~$9.99	~$9.99
Claw	Homemade Claw	~$14.98	Reused
Electronics and Servos	CAT5 Bulk Wire Premium Digital Servo	~$53.99 ~$33.99	Reused Reused
Bouncy and PVC	(2)Airhead Plastic Float	~ $6.54($3.27 each)	Reused
seaMATE Kit		~$630.00	~$630.00
Total		**~$948.15**	~$670.00

Travel Expenses (Regional and International)		
Category	**Details**	**Cost**
Fuel/Travel	School Bus: 10mpg at 750 miles (65 gallons of gas), & $1.90 per gallon	$285.00 round trip
Meals	3 Days with 14 people 2 meals per day ($7 each)	$588.00
Rooms	3 Days; 4 Rooms at $118 per night	$1416.00
Total	**$2,289 each trip**	

Overall Expenses		
Category	**Details**	**Cost**
Income	Moody High School Instruction Budget Donations: HEB and K&M Real Estate Corpus Christi ISD winners Fund	+$1,500 $1,250 $2,500
Expenses	Expenditures Travel (Both trips)	~-$4,578
	ROV	~-670
Total Pay	$2	

V. Conclusion

A. Company Evaluation

Over the course of building this year's ROV the *Octobot*, our company has come across many failures and achievements, but overall AquaBot Technicians has been successful in manufacturing a working ROV that meets all of the demands of our clients and is capable of operating in marine environments as well as in zero gravity space. This year we decided to use little of the previous year's designs and started from almost scratch instead, mainly due to the new size and weight constraints of these years missions. We evaluated all of our employees' strengths and weaknesses to be as innovative as possible when designing the perfect ROV from the Gulf Stream waters to the exploration of Europa.

B. Challenges

One of the main challenges for this year's Aquabot Technicians team was working cohesively together in a productive manner. Aquabot Technicians consist of 17 employees and works in an open-minded environment. We believe that there is no bad idea, so each person is free to give their thoughts on anything, and knows that he/she will not be judge. With a group as large as ours, it is inevitable for heads to clash and safety might have become an issue, but we were able to get pass this enclosed box in order to produce a new and innovative company. By establishing a Job Site Safety Analysis rubric, we understood what was expected from us to be safe conscience in a small working environment where personalities varied. Furthermore, a second challenge Aquabot Technicians have faced was public speaking. As a company, we practiced in order to announce our company most effectively, but it always has seemed like we can do so much better after we have presented to an audience.

What we learned from each of our challenges was that as a team we accomplished many goals and also at times we failed as a team. All 17 employees would come together and effectively resolve any challenges that came our way. Together we achieved many of our goals, all through collaborating, communication, and patience.

C. Trouble Shooting

Aquabot Technicians, our mission is providing our client with a reliable, high-quality product while remaining as cost-effective as possible. Throughout the process of building *Octobot* there have been countless times where things have gone wrong with *Octobot* and its systems. To solve this, we developed troubleshooting techniques to identify the problem present that needs to be fixed (seen in *Figure XV)* by using the design process to come up with a solution. Overall, this troubleshooting technique has worked very well and solved any problem that arose during our company's projects. Whenever the company needed to troubleshoot any of the electronics, we would use a voltage ohm meter (VOM) to:

Figure XV: Validating prototype of *Octobot*.

- Check the power source
- Test power across all switched
- Test the fuse itself
- Test the conductors at their connection points.

D. Future Improvements

Aquabot Technicians will dedicate time and effort to better ourselves as a company through means of communication and planning. Much like this year with new incoming members, next year Aquabot Technicians will try to expand and elaborate on new ideas because every idea is a good idea. However, as a group, we have seen that working collaboratively is a strong-suit of ours while communication has been lacking. Next year, Aquabot Technicians will change that by making sure that everyone is able to both, work and communicate, effectively and cohesively.

E. References

- MATE Handbook
- Company's technical documentation (last year)
- MATE website : http://www.marinetech.org/
- SeaMATE website : http://seamate.myshopify.com/

F. Acknowledgements

- MATE Center- For giving us the opportunity to compete in this event.
- Corpus Christi Independent School District- For funding the underwater robotics program offered at our high school.
- Foy H. Moody High School- For proving the funds necessary to make this trip possible.
- The staff of the Corpus Christi Natatorium- For allowing us to test our ROV in their pool under realistic operating conditions.
- Citgo- For sponsoring us in-school academy.
- Mario Bayarena- For mentoring our team and teaching the underwater robotics class provided at our school.
- Keisha Charles- For mentoring and giving her time to us whenever necessary.
- Jason James- For offering our company access to assorted VEX parts at our school
- H.E.B- For funding our underwater robotics team with $500.
- K & M- For funding the underwater robotics program with $700
- Greggory Heartsfield- Design Consultant Gulf Coast Robotics
- Noah Berry- Technical Documentation Consultant Gulf Coast Robotics

IV. Appendices

A. Safety Checklist

General:

- ✓ Take inventory of tools and equipment at the beginning and end of every day.
- ✓ Ensure all employees are in proper attire.
- ✓ Goggles are used when operating any tools.
- ✓ When handling extreme heat, use gloves.
- ✓ Log all employee work hours.
- ✓ Before the end of each work day, organize all tools and equipment.
- ✓ Longer hair is tied back.
- ✓ Work spaces are kept clear.

Personal Protective Equipment (PPE):

- ✓ Safety Glasses/Goggles
- ✓ Ear Plugs
- ✓ Dust Mask
- ✓ Work Gloves
- ✓ Covered Shoes
- ✓ Shop Apron or Lab Coat
- ✓ Hair ties
- ✓ Hard Hat
- ✓ Life Jackets
- ✓ First Aid Kit

Electrical:

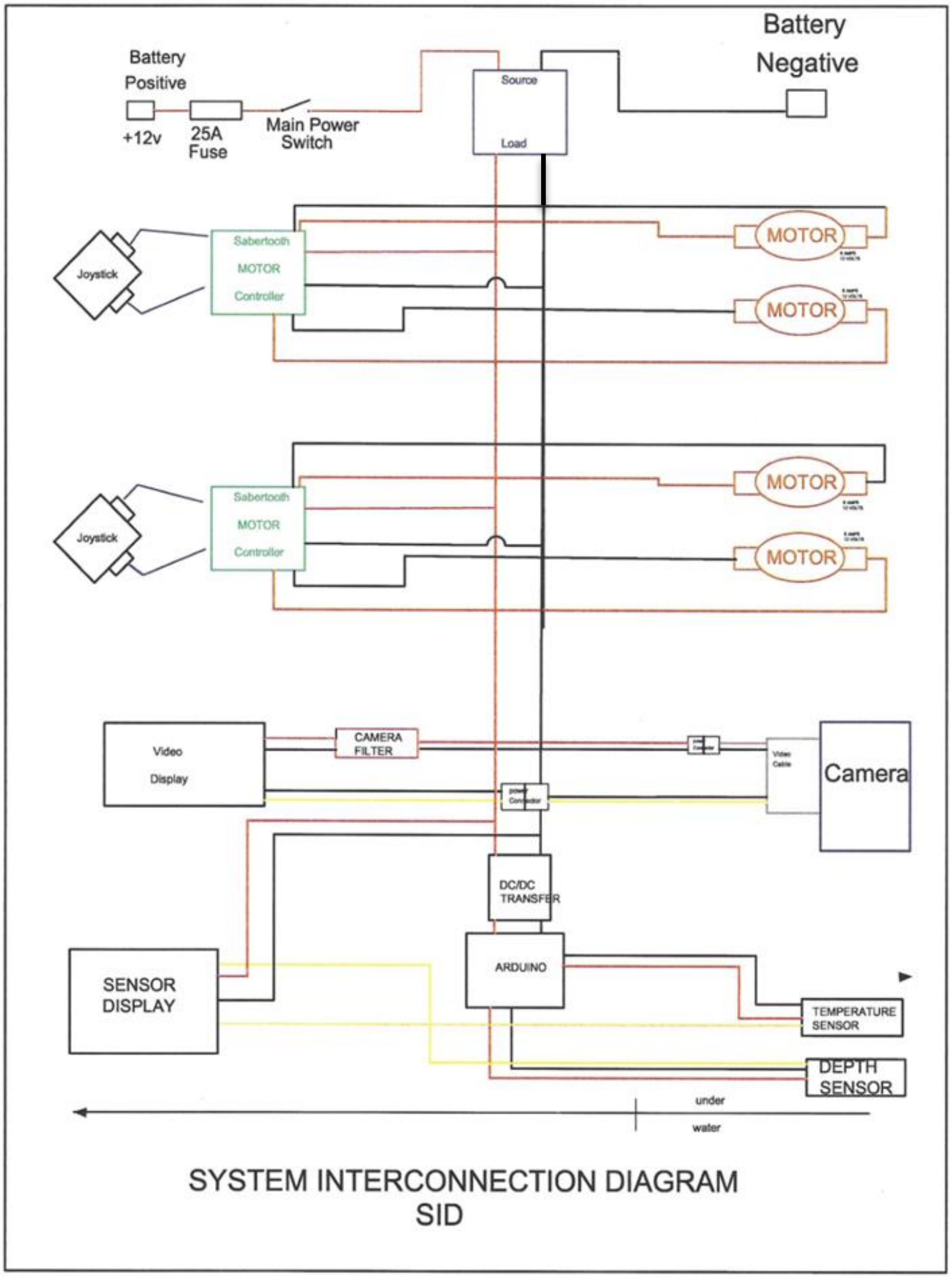
- ✓ Do not work alone while using electrical machines.
- ✓ Disconnect and turn off all power supplies when not in use.
- ✓ Check ROV to ensure that all connections are water proof before getting in water.
- ✓ Don't overheat batteries.

ROV Specifications:

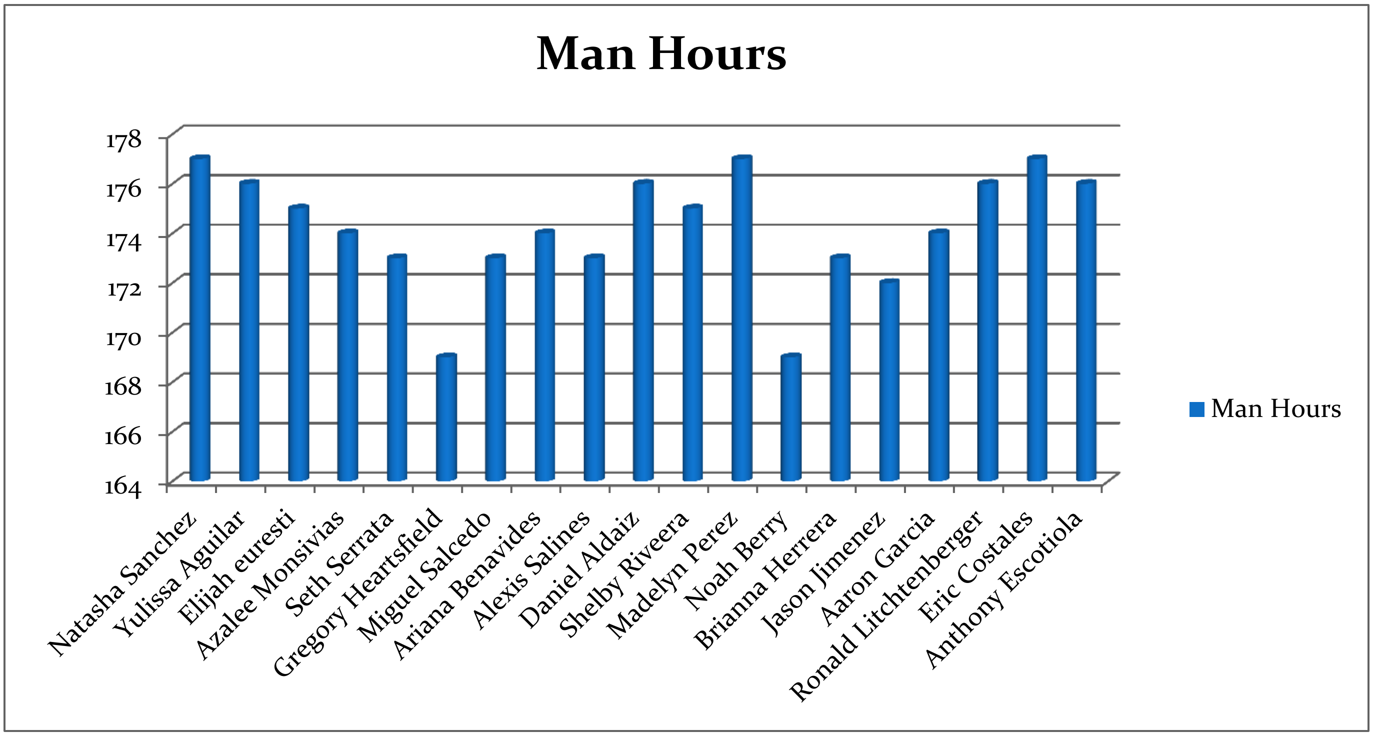
- ✓ Do not pull ROV by tether.
- ✓ Do not put any unnecessary stress on tether.
- ✓ When not in use keep tether coiled.
- ✓ Use precaution when moving ROV.
- ✓ Check ROV for no sharp edges.
- ✓ Wear PPE as needed to operate ROV.

B. Wire Diagram

Corpus Christi, Texas "Octobot" Aquabot Technicians



C. Man Hours



The Aquabot Technicians wanted to create a fully effective ROV and we accomplished this by working on average at least 45 minutes a day Monday through Friday for five months. We all average and achieved a maximum of 175 man hours per staff member and conducted a total of 3,332 hours working on completing *Octobot*.

D. Knob Programing

```
/*
 Controlling a servo position using a potentiometer (variable resistor)
 by Michal Rinott <http://people.interaction-ivrea.it/m.rinott>

 modified on 8 Nov 2013
 by Scott Fitzgerald
 http://www.arduino.cc/en/Tutorial/Knob
*/

#include <Servo.h>

Servo myservo;  // create servo object to control a servo

int potpin = 0;  // analog pin used to connect the potentiometer
int val;    // variable to read the value from the analog pin

void setup() {
  myservo.attach(9);  // attaches the servo on pin 9 to the servo object
}

void loop() {
  val = analogRead(potpin);            // reads the value of the potentiometer (value between 0 and 1023)
  val = map(val, 0, 1023, 0, 180);     // scale it to use it with the servo (value between 0 and 180)
  myservo.write(val);                  // sets the servo position according to the scaled value
  delay(15);                           // waits for the servo to get there
}
```

E. Timeline

	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	6	5	4	3	2	1
	26-Dec	4-Jan	11-Jan	25-Jan	1-Feb	8-Feb	15-Feb	22-Feb	1-Mar	8-Mar	15-Mar	22-Mar	29-Mar	12-Apr	19-Apr	26-Apr	2-May	9-May	16-May	23-May	6-Jun	13-Jun	21-Jun
Milestones										Test 1			ROV Done				Ship						Ship
ROV	Design Procces			Assemble						Full water Test			Validate		Practice		Done	Design Procces for Internatinals	Assemble		Validate		Done
Frame		Design Process		Assemble		Done												Assembleing new Frame	Done				
Electronics				Design Process			Assemble			Full water Test			Done					Design Process	Assemble	Done			
Claw Manipulator								Design Process				Assemble		Done				Design Process	Assemble		Done		
Sensors												Design Process	Assemble	Done				Design Process	Assemble	Done			
Camera											Design Process	Assemble		Done				Design Process	Assemble		Done		
Bouancy										Design Process	Build		Done					Design Process	Build	Done			
Thruster				Design Process		Assemble		Done										Design Process	Assemble		Done		

To insure that *Octobot* was fully prepared for the MATE competition, we created a timeline to ensure we meet all deadlines. The CEO delegated responsibility for the construction of specific components, such as constructing the claw. If parts were not completed on time, company members would work throughout the week to complete the parts. After The Regional Competition we began working on *Octobot*, perfecting all flaws until June 21st when we will depart for International Competition. Our mentors Mr. Bayarena and Mrs. Charles were present for technical guidance along the way, but did not work on the project or any of its components.