SEAOWLS

FAU HIGH SCHOOL

Boca Raton, FL

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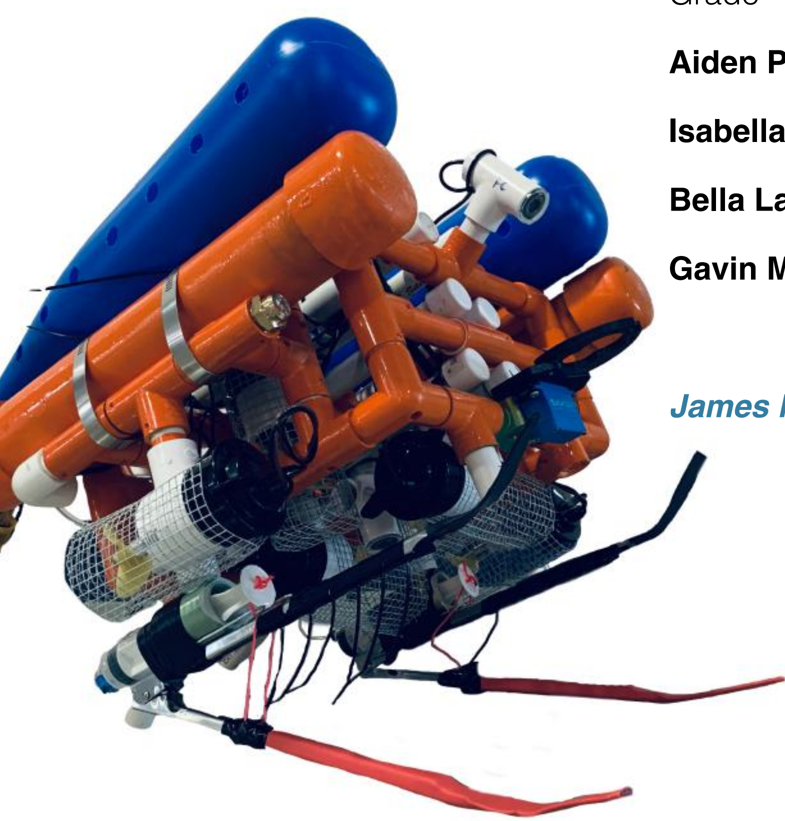

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ABSTRACT

This technical design report is an overview of the engineering thought processes that were used to create the most effective and efficient craft capable of completing the tasks that are in our strategically ordered flight plan. Our company name is the SeaOwls and our mission is to create the most sustainable ROV using recycled materials, being creative with everyday items, and making our robot unique. The tools equipped with the craft are a hook which is designed specifically to replicate the action that happens similarly in an animal, multiple hydraulic systems, and three cameras—one used for a third view perspective, this will be used to have the optimal amount of clarity in the water. The second camera was faced directly at the servo and the hook, and lastly, the third camera was used to look down at the floor to complete the tasks on the floor of the pool. The hook is used to pick up objects and bring them to other places, the net is used to catch on objects and potentially pull them, and the camera is used to monitor what we are doing underwater. This hydraulic system is unique and uses two plastic baseball bats with flotation inside to push water in and out of the system bringing the robot up and down through the water. With these tools, our robot can perform some of the competition tasks which relate back to real-world tasks that involve taking care of our environment and producing clean energy.

DESIGN RATIONALE

MECHANICAL

The Big Duck 225 costs 1,839 dollars. It is 18x14x10 and weighs 19.6 Lb on land.

The frame consists of PVC pipes with elbows and T's that are reused to have a lightweight and sustainable craft. We chose the PVC for the overall design of the robot because it is durable, strong, and inexpensive. The PVC allows for the robot to have easily adaptable and interchangeable pieces.

We designed Big Duck 225 without internal electronics in order to improve mobility and reduce the chances of leaks. While this small and simplistic robot works well for our design, it can become difficult when trying to leverage weight to achieve some of the tasks on our flight plan. The smaller and lightweight frame benefits our team by allowing the pilot to maneuver the craft in a more manageable manner, it also allows for our team to move faster through the tasks without any drag or buoyancy issues.

Many of the tasks involved required removing objects and inserting them into new areas around the course. To achieve this, we designed the Big Duck 225 with six different cameras to enable us to accurately survey the ROV and course while collecting these pins and lifting objects. The ROV is also equipped with two hooks and two claws. The first hook is attached to the robot in the front through a connecting PVC pipe linked to the rest of the craft and a servo, this servo has a 3-D printed mechanical hook. The second hook is specially made for specific tasks and is unique to any other. This second hook is made with eco flex 50, a liquid silicone making the “Soft claw”. This soft claw was created by first CADing the molds to decide the shape of the claw, then 3-D printing it and laying down the resin for it to dry. We then used air pockets to reach onto the items of choice. These two hooks are used for separate parts of the course, but each one can be adapted in case of an emergency. The second source of collecting items is our claws, they are positioned on the bottom of our robot. These are used to collect items, like the fish, underneath the robot and on the floor of the pool.

The ROV was adapted significantly from our initial design. We competed in the Regional Competition with our initial design and mission of keeping our robot mostly sustainable with reusable items. Although we have adapted our robot, we still do have many efforts to continue to be as successful in reusing and reducing our mark in the issue of plastics.

PROPULSION

Our ROV uses six Johnson SPX Bilge Pump motors that allow the craft to efficiently and swiftly move through the water. Each motor runs off of a 12- volt current that allows the robot to propel itself through the water. These motors are pre-built and waterproofed which is why these specific motors were chosen for our robot. This eliminates many issues that could occur in the future through malfunctions of doing the improper steps to waterproof motors. The thrusters are positioned carefully on the robot giving it the ability to move up, down, turn, and most importantly allow it to strafe.

Strafing is the movement of moving from side to side without having to turn. Strafing is a useful feature that we decided to incorporate into the setup of our robot mobility under the water. Being able to strafe allows us to make subtle adjustments while trying to perform tasks that require high precision and patience. Strafing gives us an advantage by allowing us to complete tasks faster by not having to spend as much time trying to adjust the craft when doing difficult tasks. In addition to the strafing, we also positioned our up and down motors in the same direction facing down as opposed to another orientation in order to go down fast.

The reason why we do not need to go up as fast is because of the pneumatic buoyancy that is attached to the craft which allows us to float up to the surface very easily and also sink to the bottom if necessary.

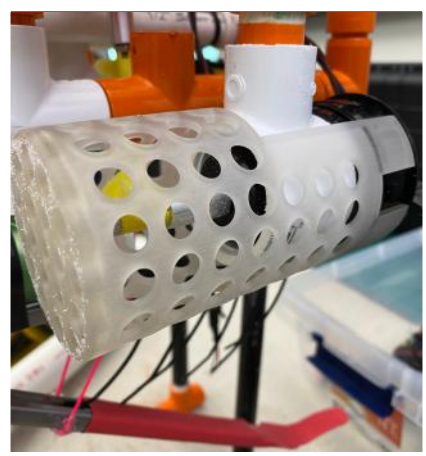


*Image 1: Pasti Dip drying onto Chicken Wire to cover the sharp edges

*Image 2: Chicken Wire placed on the waterproofed motor

*Image 3: 3-D Printed Resin motor cover

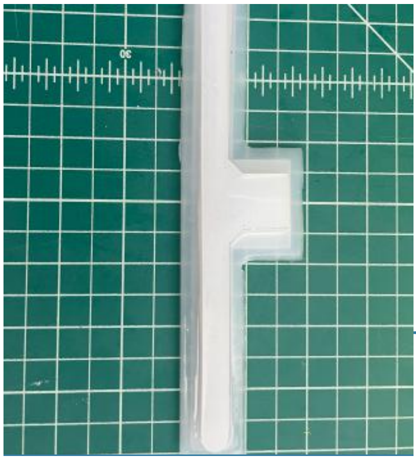
MANIPULATORS

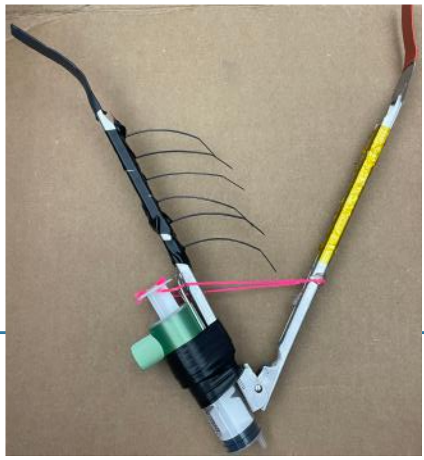
The craft consists of four manipulators that allow the robot to complete the tasks that require it to pick up and pull out different objects. There is one mechanical claw, one soft claw, and two claws that run off of propulsion. The mechanical claw is attached to the front of the robot and is operated with a simple servo. This claw is simple and not overly complicated so it can complete tasks that are not as complex as delivering the hydrophone. The Hook itself is made out of Delrin and it is attached to the craft by a 3D printed piece that connects to the PVC frame.

The soft claw is made out of liquid silicone EcoFlex 00-50. In order to make the soft claw, we had to create a 3D printed mold for the silicone to go into it. We mixed up the silicone and poured it into the mold and let it cure for 3 hours. To allow for air to pass through the claw we created two separate pieces that were then put together with additional silicone. One side had an indent so when the two pieces were put together there would be a gap to allow for the air to travel through the claw effectively. This claw would be primarily used to pull out the pin that releases the net since the soft claw would less likely get caught on the net compared to the mechanical claw.

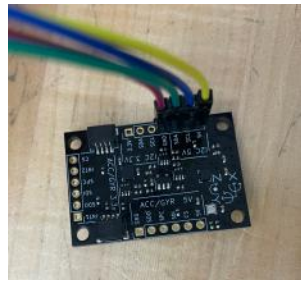
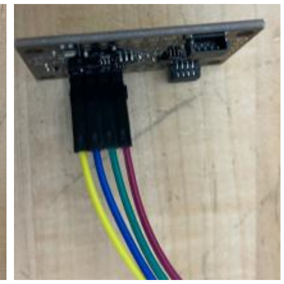
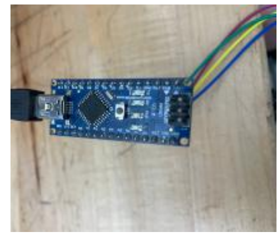
The last two manipulators are identical to each other and are both mounted at the base of the robot. These claws are controlled by airflow which travels through the tether and into a syringe that causes the claw to open and close. When the syringe becomes filled with air the claw opens and when air is removed the claw closes. Using airflow allows us to easily operate the claws without the need for wires and programming which can become complicated. These two claws' main functions are to pick up and replace the pipe and also grab the fish and put it into the bucket. The claw is made out of a syringe, string, and reused tongs which go with our main theme of rescuing old parts. The claws get attached to the base of the craft with a 3D printed part that can connect to the PVC frame.

Out of the 3 manipulator designs that are on our robot, the most unique would be the soft claw. The soft claw is made up of a very intricate design that allows it to function and bend when air is pushed in and out of it. The design and function are much more complex and unique in comparison to the other two designs that are on the craft.





SENSORS

On our craft, there is a 3-axis gyro, 3-axis accelerometer, 3-axis magnetometer, pressure sensor, and temperature sensor. The first sensor, the gyro sensor, is used for measuring angles in the pool and how we can remove items from the course in the most optimal way. The gyro sensor has been placed in the center of the robot, it is placed here in order to effectively see the bottom of the course and to make accurate measurements. The second sensor that we have on our craft is an acceleration sensor that is being used to understand the speed and direction that our craft is moving while our pilot is facing away from the pool. The magnetometer is also in the center of our craft and it is being used to, find which direction we are moving similar to a compass.

The last sensor that is being actively used on our craft is the pressure sensor, this sensor is being used to measure the altitude at which the craft will be positioned. All of these sensors are vital for completing our mission and tasks across the course, these sensors allow us to better understand the monitors that are facing away from the pool.

BUOYANCY AND BALLAST

On the robot, there are two 2-inch PVC pipes that are mounted on each side of the robot. These pipes are slightly negatively buoyant since we also have pneumatic buoyancy that is installed on the robot. This air-controlled buoyancy allows the robot to float up to the surface at a fast rate and also sink to the bottom of the pool depending on how much air is going in and out of the system. Air is filtered into the tube by an air pump that would be on the ship. The pneumatic buoyancy is constructed out of reused baseball bats and rescued floats. The end of the baseball bat was cut off and the float was placed inside. An air tube that comes through the tether then connects to the float that inflates and deflates it. This air is pumped into the flotation from an air pump that we constructed out of PVC and a custom 3D printed part that compresses the air through an air tube.

TETHER

Our tether is made up of many cables that run through to power the motors, and camera, and bring air to the pneumatic devices on our craft. There are six cameras on the craft that have their wires attached next to the main tether just in case one of the cameras goes out, we can easily replace it. There are also four air tubes that run through the tether to bring air to the pneumatic buoyancy, both pneumatic claws, and one for the soft claw. The four air tubes make the tether positively buoyant so that the tether does not weigh our robot down in the water.

There are also two cables that include 8 wires enclosed within the cables each. One of these eight wired cables is dedicated to giving power to our motors, while the other is used for the Arduino communication and servo communication. We chose this cable as it had enough wires to allow us to have leads for all of our electronics. Our team decided on using a snakeskin enclosure on our tether as it is able to fit the cables inside the tether neatly and keep them safe. The snakeskin cover is lightweight so it does not affect the buoyancy of our craft. 12 volts of power are going to all the electronics and cameras onboard the ROV with the exception of the Arduino, receiving 9 volts. The tether is folded in a circle to maximize efficiency in the water, having no kinks in the tether, resulting in the tether being able to reach its maximum length. After every time the tether is used, our company makes sure to fold the tether neatly and checks that no wires are loose, resulting in a good, intact, and well-working tether.

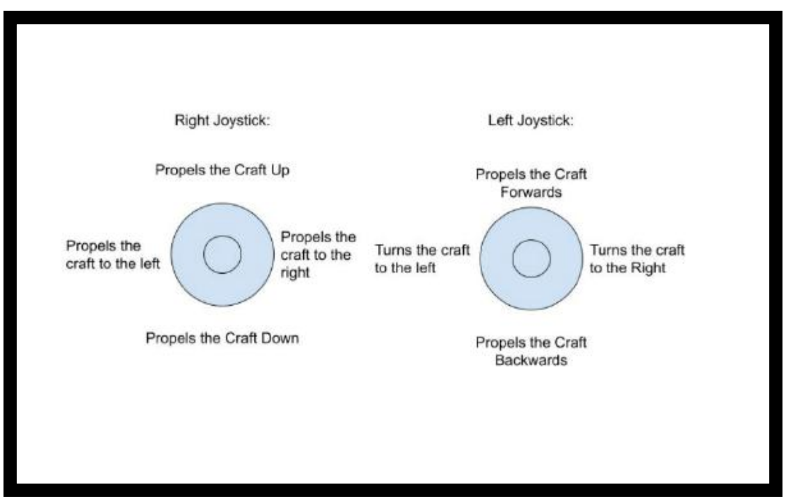
* Tether with tape to understand how much has been release into the water

ONBOARD ELECTRONICS

Our onboard electronics includes an Arduino Mini, attached to a pressure sensor and an IMU sensor. The IMU and Arduino Mini are confined in a small 3d-printed box in the middle of the craft, that is filled with resin, allowing for no water to enter. The Pressure sensor connects to the Arduino Mini through a hole in the box. The Arduino Mini then sends the information given by the pressure sensor and the IMU to an Arduino Uno on our control box. Combined, the Arduino Mini sends data which includes information from the IMU and the pressure sensor. The IMU has sensors such as a temperature sensor, gyroscopic sensor, and a magnetometer. We then convert the barometric data into a measure of how deep we are in the water. We use the magnetometer and gyroscope to communicate the precise location of our robot to our driver. And we use the temperature sensor to determine the temperature of the electronics to ensure they are not overheating.

MOTORS AND CONTROLLERS

Our motors are grouped into four different categories: Strafing Motors, Up/Down Motors, Left Motor, and Right Motor. The left joystick controls the Strafing Motors and the Up/Down Motors. Moving the left joystick up spins the Up/Down Motors, forcing the craft to move up, and moving the left joystick down spins the Up/Down Motors in reverse, forcing the craft to move down. Moving the left joystick to the right spins the Strafing Motors, propelling the craft to the right, and moving the left joystick to the left spins the Strafing Motors in reverse, propelling the craft to the left. Our right joystick controls the Left and Right Motors. Moving the right joystick forward will spin both the Left and Right Motors, moving the robot forward. Moving the right joystick to the right will cause the Right Motor to spin in reverse and the Left Motor to spin normally, causing a change in yaw towards the right. Moving the right joystick to the left will cause the Right Motor to spin normally and the Left Motor to spin in reverse, causing a change in yaw towards the left. Moving the right joystick down will cause the Left and Right Motors to spin in reverse, propelling the robot backwards.



*Graph of the controls on the Control box

CONTROL SOFTWARE

The software is split up between code on the robot, code on the control box, and code on the computer. These three programs communicate with each other over a serial interface. The code on the robot is written in C++ and is designed to be as simple as possible. It sends IMU data and pressure data to the other components. Simple is the goal for this component as this microcontroller will be covered in epoxy. The control box code is written in C++ and controls the robot's motors. It can communicate with the computer and forwards data over the USB interface. This system is controlled from a program written in Rust running on a laptop. This program is built using the bevy game engine it displays camera feeds, sensor data, and a 3d model of the robot. It uses this information along with user input from a gamepad to send commands to the control box and control the motors.

The electrical systems of our craft are based originally on the barracuda box. This box operates by using Sabertooth motor controllers to control the motors. It also has a built-in system to take in the camera input however we opted to use a multiplexer We used this because we upgraded to 6 cameras in order to provide our driver with the best view possible to operate the craft. Inside the craft, there is also an Arduino which can be used to implement code such as to use the mosaic. Due to our 6 motors and 6 cameras we needed to use 35A of fuses to keep our robot safe. For more information about the dynamic of our electronics can be found on the electrical SID on appendix A where the components are described.

PHOTOMOSAIC

The photomosaic of the designated seafloor area is completed by having the code embedded into the control box monitors. This application that is used is being done through the images that are captured from the Big Duck's cameras and then sewing them together.

FISH DETECTION

We are completing the task of collecting the fish by using the manipulators that are on the bottom of the craft. These manipulators are created in order to replicate the function of python teeth. Python teeth have the function of being able to collect items but not allow them to be released. We are currently using the manipulator to create the same function as the python when collecting the fish. We created this manipulator to be on different sides of the craft in order to release on side into the bucket of choice and then release the other claw to make sure that the fish stays in the bucket.

SEA GLIDER

The buoyancy engine that was engineered is an autonomous profiling device that travels from the top of the pool to the bottom and back. This profiling device consists of an Arduino Pro Mini, 9v Alkaline battery, a 100ml Syringe, 3-D printed cylinder and weights. All of these items come together and the cylinder creates a pump that is filled with different levels of water in order to allow it to go up and down. By having this syringe hooked up to a motor and the Arduino it allows the buoyancy engine to move with one remote.

COMMAND AND CONTROL BOX

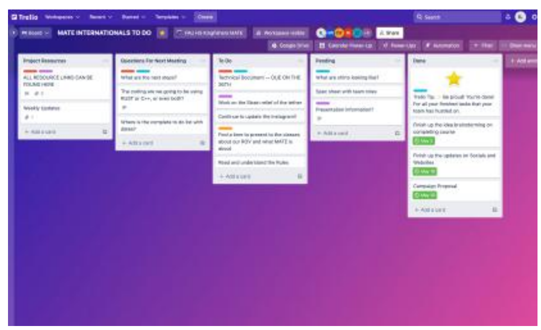
The Big Duck 225's control box contains a water proof casing that protects all of the monitors and electronics that can be seen in the image. This is vital to the workings of the robot because if any water would to get in it would destroy the controls. We also implemented a laser cut top of the electronics area for extra protection.

In addition to the laptops, the control box contains one large monitor that has been reused from previous project. This display has the camera feeding in six different sections of camera areas that are vital for the pilot. Some of the cameras that are displayed on the screen are predominantly used for the pilot and other parts of the display are being used to complete the image processing. Although most of the work is done through the monitors, most of the information is transferred to a separate computer.

BUILD VS BUY, NEW VS USED

The main theme of our robot was reusing old parts that we already had in the STEM lab we were working in. The ROV is made up of reused PVC and motors from previous years and pneumatics are made up of old syringe that we had from other projects and ideas. We tried hard to really reuse instead of having to buy new parts for things. However, unfortunately we didn't have everything we needed just in the lab we were working in, so we decided to purchase a barracuda box for electronics and wiring which is what is being used to control and operate the craft. This box is crucial to the operation of the craft and this is something that we could not make out of the parts that we currently had. Despite this, the majority of the robot is still made of materials and parts that are from older creations. When it came to having to make a purchase we first decided as a team if there was anything that we had already that could be made into what we were looking for. For example, the pneumatic operated manipulators ended up being constructed of a reused syringe, string, and tongs as opposed to buying new parts to create a similar gripper. The benefit of reusing allows us to cut down on costs, be sustainable, and help the environment by not buying and wasting more than we need to.

PROJECT MANAGEMENT



The SeaOwls designed our team in the attempt to be productive and efficient every time we meet. With each member having different skills, and the urge to learn more skills we tried to take into consideration everyones interests with their knowledge. Most of the roles that are seen above are simply the labels of what the teammate does best, but not all that they contributed to. Each team member had a different background and different passions and by exploring different aspects of the company everyone on the team was able to have unique experiences. Each "division" of work as the team named it was lead by the chief officer who was elected in the beginning of our companies creation.

With busy schedules and different priorities the schedule that we created was different week, but meetings were mandatory on Thursdays in order to come back to base with the team and discuss what progress was done and what needs to be done. Whenever teammates could come to the STEM Lab they did, and the first thing that was looked at was the Trello board that listed all of the things that were in need of doing. When the team could not all make it or had to contact each other our team communicated through our Discord server.

MEDIA OUTREACH

Our team used the resources that were available to us as well as the promotion of word of mouth to bring support to our team. We created an Instagram that currently has 14 posts of our progress in building our robot and competing in competitions. We also have our website that can be accessed through this link: https://sites.google.com/fau.edu/fau-high-seaowls/home?authuser=1

The Instagram username can be found by: fauhighseaowls

INNOVATION AND PROBLEM SOLVING

Issues that we came across are the following, preparing for the issues that occur such as not planning for soldering. Soldering takes time and technique, the team had multiple instances that occurred where soldering had to be redone due to lack of planning—therefore creating control box malfunctions. The time restrictions between the building of our robot and the new construction of our school created limitations on when we could go in and work on our robot. Many of the beginning iterations of the design for the ROV became too complicated, but as a team we decided to keep it simple and working it well. We did want to some unique aspects that would be helpful for completing the tasks. Most of the designs were changed but the base and frame of the robot continued to stay similar. Most of the edits that were done throughout the robot happened as an added part to complete more tasks.

CRITICAL ANALYSIS

When we went to compete at our regional competition in order to qualify for worlds, we discovered that our tether was too short. This meant that at the competition we could not get to all of the obstacles and get as many points as we may have hoped. We then had to go through the process of lengthening our tether by finding a new tether and then retiring our craft to use this new tether. The difficulties that occurred with the tether continued on making it harder to have the pneumatics in place was well as the wiring for all 6 of the cameras. We also had issues with the prop guards. We had to go through many iterations of the prop guards. First we used the regular chicken wire that can be found at Home Depot, then we used 3d printed resin prop guards but they were falling off our craft. Then we went to a chicken wire design but it was too sharp and would fail the safety test. Then we coated the chicken wire in Plasti dip in order to make it not sharp and safe.

ACKNOWLEDGMENTS

We would like to thank our amazing mentors, Mr.Nance and Mr.Phipps for helping us throughout the process of building our robot. Thank you Motorola for the materials for the Buoyancy Engine, thank you OURI for the Barracuda Box, and thank you to CCTC Camera Pros for the Multiplexer.

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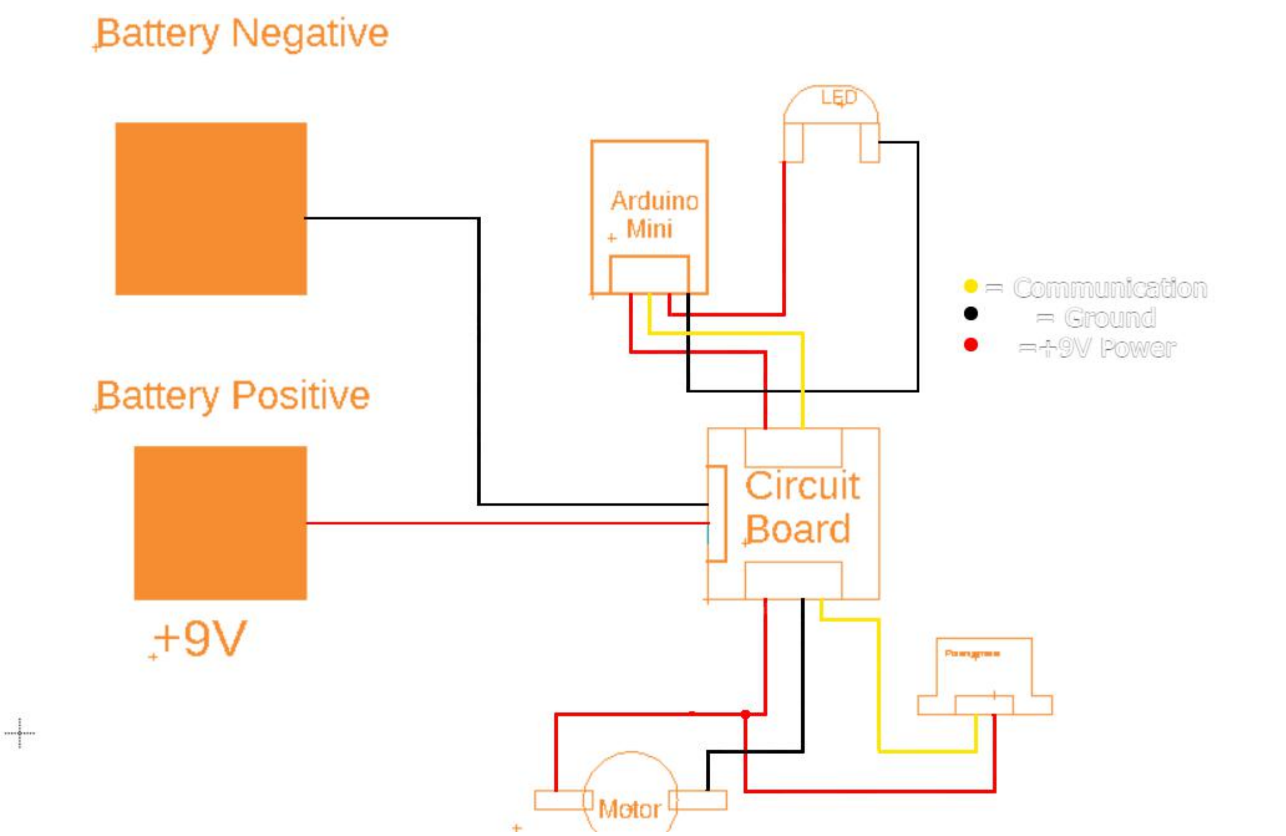
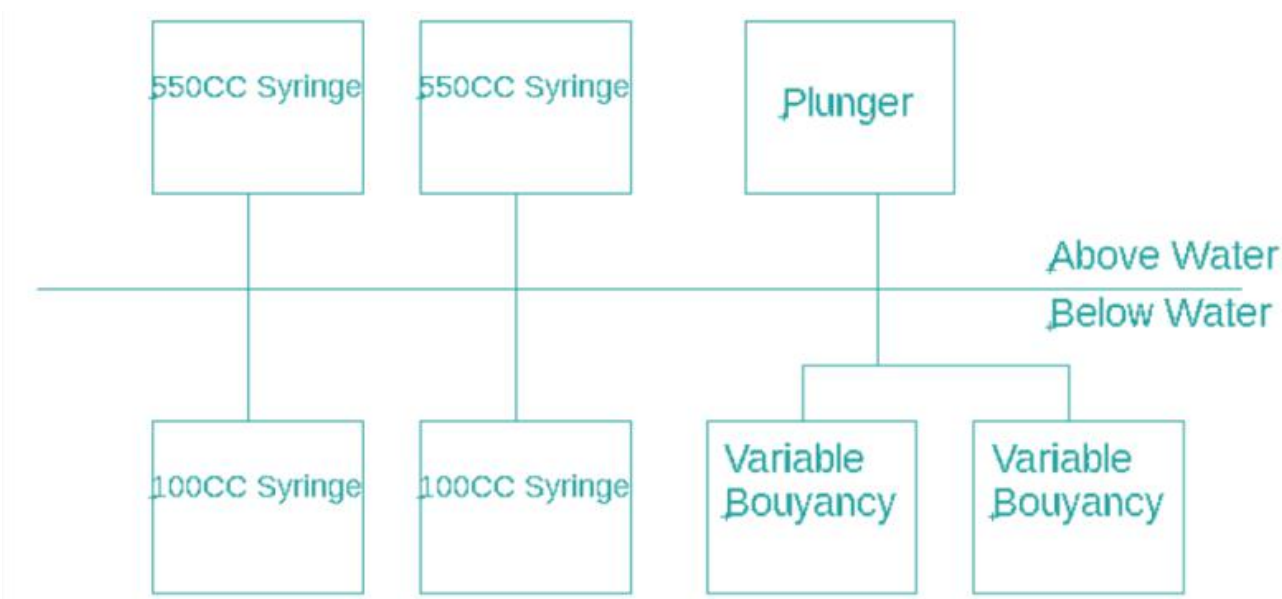
APPENDICES

APPENDIX A (SID, PNEUMATICS, NON-ROV)

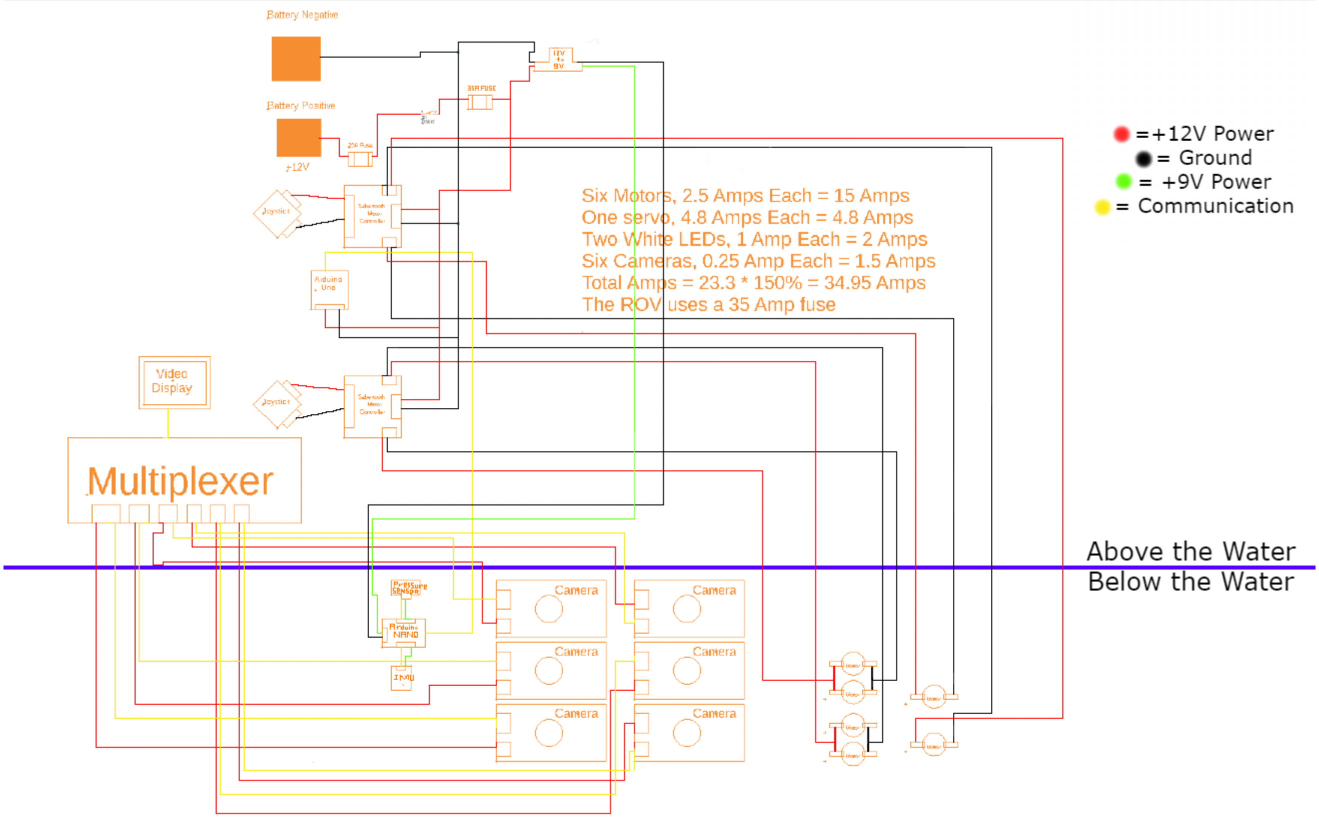


*Non-ROV SID

*All Pneumatics



* SID Diagram


Battery Negative
Battery Positive
+12V
Six Motors, 2.5 Amps Each = 15 Amps
One servo, 4.8 Amps Each = 4.8 Amps
Two White LEDs, 1 Amp Each = 2 Amps
Six Cameras, 0.25 Amp Each = 1.5 Amps
Total Amps = 23.3 * 150% = 34.95 Amps
The ROV uses a 35 Amp fuse
=+12V Power
= Ground
= +9V Power
= Communication
Video Display
Multiplexer
Above the Water
Below the Water
Camera
Camera
Camera
Camera
Camera
Camera
Joystick
Joystick
Arduino Uno
Pressure Sensor
Arduino NANO
IMU

APPENDIX B (PROJECT COSTING AND BUDGET)

Description	Quantity	Unit Price	Cost
10' PVC Pipe	1	$4	$4
T Connectors	33	$1	$26
Elbow Connectors	1	$0	$0
3-way Corner Connector	8	$2	$16
5-way Corner Connector	1	$3	$3
Cross connectors	5	$1	$5
4-way T connector	1	$2	$2
Motors	6	$18	$107
Buoyancy Engine Pack	1	$65	$65
Barracuda Box	1	$900	$900
Silicone for Soft Claw	1	$43	$43
Camera	6	$18	$108
Capture Card	3	$19	$60
Buoyancy PVC Pipe	2	$14	$27
Pressure Sensor	1	$17	$17
IMU	1	$38	$38
Arduino Nano	1	$12	$12
Syringes (pack of 30)	1	$20	$20
Floaties	1	$1	$1
Multiplexer (Camera System)	1	$350	$350
Arduino Mega	1	$35	$35
Total			**$1,839**