



## The Deep Dive Project

### Company Members

### Positions

#### **First bottom row**

Santiago Mendez (Left)

Research and Development

Nicolas Leos (Middle)

CEO

Rosario Moreno (Right)

Safety Officer

#### **Back row**

Justice Cortez

Main Engineer

Alyssa Vega

PR

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Safety Assistant

Kevin Acevedo

CFO

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Pilot

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Co-Pilot

### Mentor

Romeo Valdez

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

The Deep Dive Project is an organization that specializes in space exploration and is one of the most innovative companies in the world. We have had major successes in the past and our newest goal is the complete exploration of one of Jupiter's most dangerous moons, Europa. Many other multinational corporations share the same goal as us. However, with our technical expertise and highly innovative engineering team, we will surpass them in their goals without much difficulty. With our current production rate, our ROV, Europa Explorer will soon be completed and be functional at optimal capacity. Our company will not only provide one of the fastest and lightest products on the market, but Europa Explorer will easily make history by becoming Europa's first navigator.

Europa Explorer is designed to measure the temperature of the water coming from the vent through the use of a temperature sounder, to determine the thickness of the ice covering the moon, and to determine the depth of the ocean with a depth sounder. We added a robotic arm to the ROV to transport equipment and to collect samples of oil from the sea floor. We also installed a waterproofed camera in order to see while exploring the depths of The Gulf of Mexico. With the camera we will be able to photograph the coral colonies to determine their health. The frame is made of PVC piping, a durable and waterproof material. The wires for the cameras and the four propellers run through the piping.

## Design Rationale

### Frame

For our ROV's frame our company used about 1.5 meters (m) of ½" PVC piping. The reason we used this material is because of how affordable and easy it is to work with. We chose this design because for its ease of mobility and its compact size. With this specific of PVC piping, we minimized the size of the ROV so that we fit into the 48 centimeter (cm) size limit. We got our inspiration for this design from studying other designs and improving upon those to make our own the very best in the industry.

Our design is called El Cubo (The Cube). Most of the attachments we added were constructed from PVC. For the design of our claw we used 2 tee connectors 4-7.62cm cut ½" PVC piping, and 1-5.1cm ½" PVC. Overall, we used a total of 16-90° connectors (elbows), 27 3-way connector (tees), 2 PVC couplers, and a total of about 150 cm of ½" PVC piping. We came to consensus with this decision using a decision matrix during the winter before we started building. As soon as we all came to agreement with the design, we started building. Our engineer and software designers put in many hours of extensive work to assure we had the best operational and most efficient ROV.

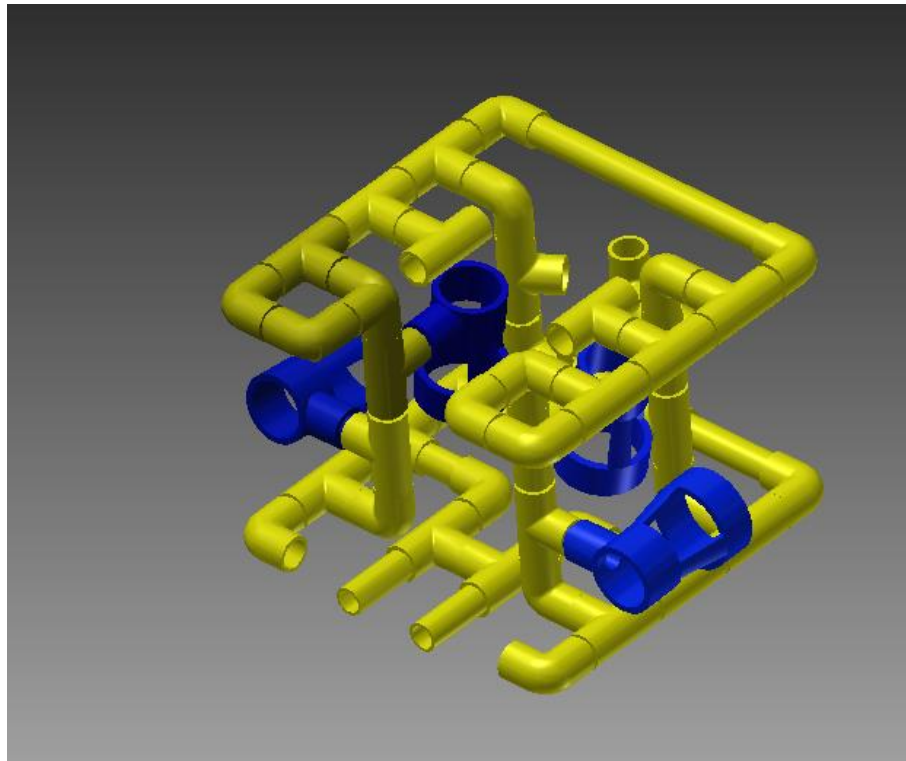


Figure 1: Our new frame design named "El Cubo".

## Ballast System

For our company's ROV ballast system, we used 2 pieces of PVC pipe, 43.8 cm in length and 2" in diameter. These specific pieces of PVC have a negative buoyancy of -18.581 g/cm. We were able to get these numbers and calculations from a worksheet on "Mate Summer Institute 2014" website. To calculate the buoyancy of the ROV we used the formula  $F_b = M/18.581$ .  $F_b$  is the amount of positive buoyancy the ROV needs to float just under the surface of the water but not sink to the bottom.  $M$  is the mass of the ROV. Our ROV weights approximately 6.803 kilograms. The amount of buoyancy that our ROV produces is -18.581 which is when until we put the air into the floating devices. This formula helps us calculate how much air we need to put into the ballasts to make the ROV neutrally buoyant. Neutrally buoyant means that that the object will stay just below the surface of the water. In the Appendix A it shows the worksheet we used.

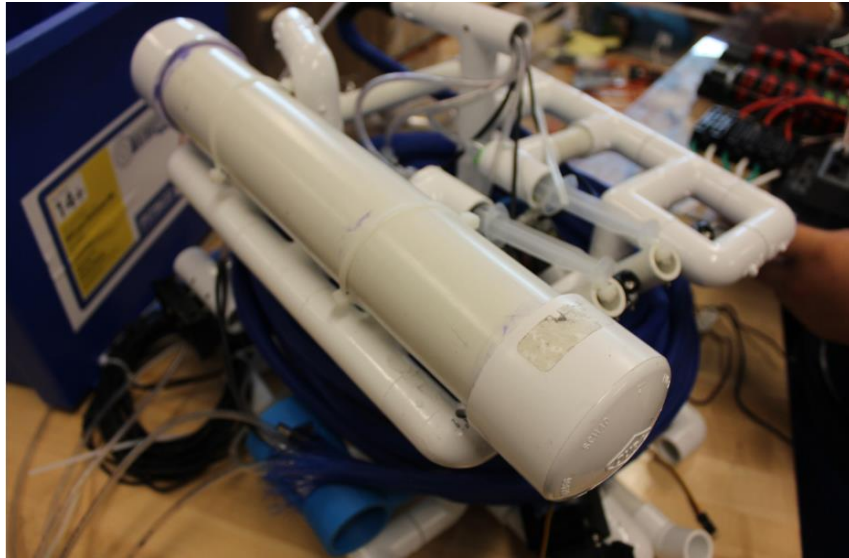


Figure 2: Buoyancy tanks on our ROV.

## Motors

For the International Mate Competition we ordered 4 brand new motors which are now 1250 ghp, which will help us go up and down the water at a faster rate. Before installing the motors we discussed where to place the motors and propellers when building our new design for our ROV. After we discussed where to put the propellers and motors, we decided to place them on the inside and outside of the ROV so it can move in all directions efficiently. We had our propellers shrouded, which were 3-D printed in order to follow safety precautions and so we can pass the safety inspection. The angles that we set for our propellers aids the ROV's movement through the water when we do our tasks. We conserved the amount of motors because we wanted to add other equipment, like the depth and temperature sensor.

The motor configuration is the same as in last year's model. In using vector configuration, the ROV is able to move in all directions. We drilled a hole for the wires so we can have a better wire efficiency, which makes the motors respond better because the wires won't be loose. We installed the propellers by screwing them onto the motor with screws that came standard with the equipment. Propellers are crucial to the operation of the ROV because they help the ROV move through the water and perform the tasks we need it to do.



Figure 3: One of the four motors we used.

## Control System

The Europa Explorer has the state of the art hydraulics inside and outside of the ROV. The hydraulics are located near the claw and the thermometer. We use 4 syringes that are attached together with a clear vinyl small tube with water inside of it. The hydraulics are on the top of the control box that is used to power the ROV. The control box is made out of Lexan glass that has been used in a past project. The wiring inside the box has been completed by our main engineer. We had to solder the electronic component on a circuit board along with the wiring. The monitors had to be double-stacked on top of each other with a metal plate that contains Velcro and the temperature gauge on the side.

We used a VEX control box, which has proven reliable when used in past projects because it was easy to program. The box consists of a VEX power distributor board, voltage regulator to power up current devices that are running on low power, and 6 Victor motor controllers. The control box also has a wireless VEX microcontroller paired with the VEX net keys, which helped our pilot feel comfortable using this type of control box to complete our tasks.

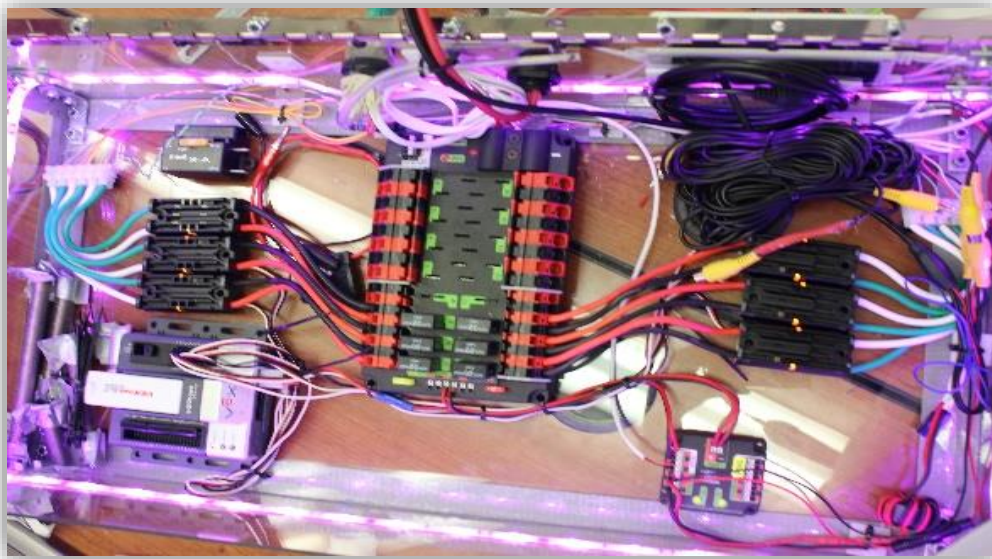


Figure 4: Our company's new control system.

# Subsystems & Attachments

## Cameras

For the MATE competition, the cameras are used to help complete the tasks required by the challenges. The cameras help us to see underwater. Without the cameras our ROV would not be able to function correctly. Our company's ROV has our cameras located on the top and middle of the ROV. We placed the cameras in certain places for specific reasons. The camera on the top enables us to see the claws and the sensors while the middle camera gives us a first person point of view for the ROV. The cameras are equipped with range finders so it is easier for the driver to figure out the distance between the ROV and the target object. After we put the cameras on, we waterproofed them so they will be able to work underwater while we do our tasks.

We decided to waterproof the cameras in the same manner as we did on our previous model. The product we used to waterproof them is EnviroTex Lite. The EnviroTex Lite provides a thick coat of liquid that prevents the camera from getting wet, enabling us to complete our tasks in a timely and efficient manner.



Figure 5: Our waterproofed cameras.



## Collection Device

On Europa, the collection device will collect two oil samples and return them to the surface to be analyzed. The collection device is a claw located directly in the center of our ROV. It is connected to 2 ¾" PVC T-connectors with 1 in the middle of the claw to limit how far the claw can go down. This extension branches off the bottom back part of the ROV frame. Between the 2 T-connectors there is a 4½" piece of PVC and on the outside of the T-connector is another 4½" piece of PVC which connects at a 90° angle. Under the main claw, there are 2 pieces of PVC that are built to stop the claw and hold the oil sample in place as we bring it to the surface for collection. The claw winds up and down by a hydraulic line filled with blue-colored water for easy identification. This helps the company distinguish between the hydraulic lines and the other systems on the ROV.

## Tether

The tether serves as the lifeline for the entire ROV. All power and data are transferred from the control box to the ROV through the wires encased in the tether. The tether has a nominal weight of 1.308 kilograms and measures 30.48 meters in length. It is ejected from the back of our ROV. To insure that the tether will hold and that none of the connections on the ROV are damaged, a mesh-like sheathing is used to hold all the cables together. The tether is one of the most important features of an ROV because it is the communication link between topside and onboard the ROV. The tether acts as one solid wire with a long body holding in other cables rather than multiple wires held together exposed to the water. This cohesion helps gather the wires more effectively without pulling one out. Our tether is from the Pipeman's Installation Solution Company.

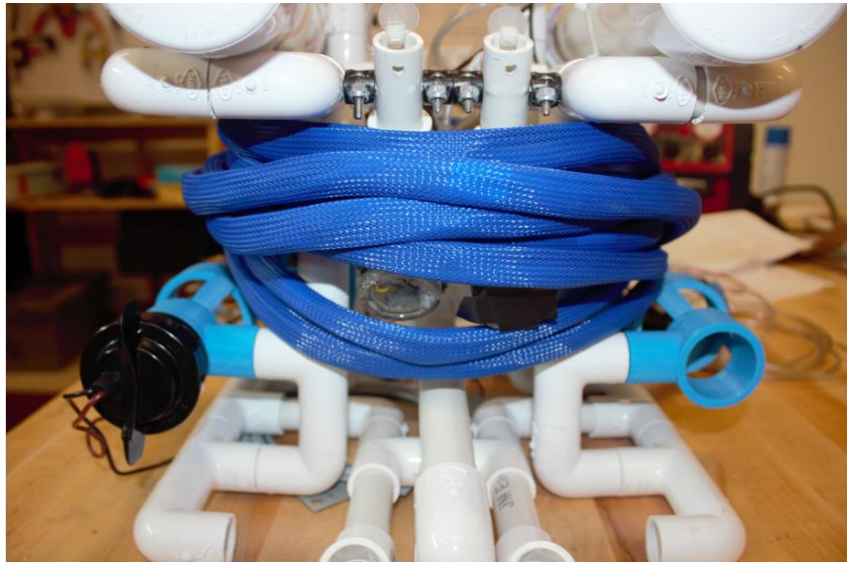


Figure 6: Tether wrapped around our ROV.

## Temperature Probe

The sensor that we used on the robot is a Vernier Temperature Probe that connects to a LabQuest. Since the temperature probe wire was significantly shorter than the wires in the tether, we had to extend them. An important feature of the probe is that it can measure temperatures ranging from  $-40^{\circ}\text{C}$  to  $135^{\circ}\text{C}$ . The entire length of the Probe is 15.5 cm long and is located on the inside of the back right of the ROV. It is enclosed in the PVC pipe direct between the tether and the claw. This PVC pipe is connected to a hydraulic line that functions to lower the probe into the right location to gather calculations. The hydraulic line is joined to a syringe that lowers the temperature probe and raises it back up. This specific component of the ROV has green-colored fluid to be easily identified. On Europa, the temperature probe will be used to measure the temperature of the water coming out of the vent.

# Safety

## Rules and Procedures

Safety is our top priority here at The Deep Dive Corporation. We make sure that all members follow protocol to ensure that the company adheres rules and regulations. Our company has a safety officer who supervises the team and ensures that they are following the safety protocol in the work area. Our safety protocol contains basic human safety tips. The following safety tips include:

- Wearing pants, closed toed shoes, and short-sleeve shirts in workplace.
- Tying back long hair to keep it from getting caught in power tools.
- Wearing gloves and goggles when working with power tools and sharp objects.

Our company's lives are of the utmost importance to every official in the corporation, and everyone is treated with a high level of respect. Rules are clearly communicated and reinforced in order to retain the maximum level of efficiency and safety. Any guests of the workplace are met with professionalism and cleanliness. Not only does the safety of our employees matter but so does the safety of our products. The ROV was designed and built with the following safety features: We eliminated all sharp edges and securely fastened all connections. Further, the propellers were covered by specially made motor housing. Propellers were manufactured in-house by using a 3D printer and designed in Inventor.

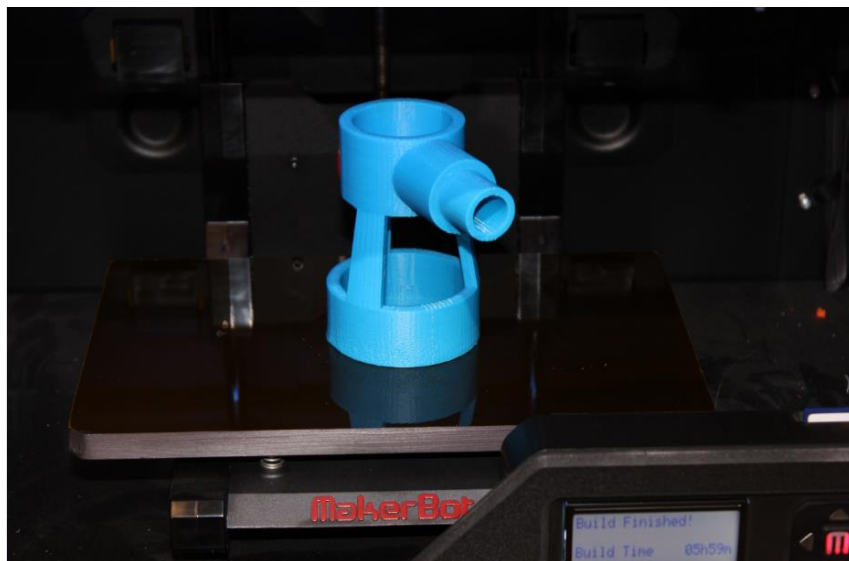


Figure 7: Motor housings were made with the 3-D printer.

## Reflections

### Experience

At our first regional competition we came in with two teams, our company The Deep Dive Project and our sister company, The C.O.R.P.S. After the product demonstration, we totaled 165 points. We were able to find the thickness of the ice, depth of the sea, collect 2 oil samples, analyze the chromatograph of the both, identify 4 CubeSea serial numbers, take them to the elevator, take still picture of a coral colonies, and collect only one coral samples. With this score added to the technical report and the presentation, we got a total score of 244.3 which let us advance to Internationals.



Figure 8: Our Company advancing to The International Mate Competition.

## **Lessons Learned and Skills Gained**

During our design and building process, we learned many different things. A majority of our team were rookies so almost everything we experienced during this building process was new to us. We learned how to make waterproofed cameras. We thought it was a challenging process, but in the end we saw that the work was detail oriented but important. We also manufactured our motor housings in house, which was also very time consuming but helped us learn the 3D printing process. Our main engineer, Justice Cortez, stated that one of the main things he learned was how to make the ROV pieces more compact. We wanted our ROV to be as small as it can be while still being able to hold all of its components needed for the mission. The more compact it is, the less expensive the ROV will be which benefit the company and the client.

## Description of Challenges

Our main technical challenge that shaped the entire design of the ROV was finding a way to mount all of the attachment and subsystems to the product, while still meeting in the size limit. The frame was constructed in a unique shape that allowed for all of the components to be included in the design without overpowering each other. Another issue encountered was buoyancy. When the ballast tanks were too large, we expanded the pipe's diameter and shortened its length. This ensured the ROV wouldn't lose its buoyancy and would still remain within the size range. Lastly, the entire company had trouble with constructing the tether. In general, our design was changed numerous times throughout the construction, but its ingenious design protected the wires and therefore the control of the ROV. Thus, it truly was our durable lifeline.

This year our company managed to work extremely well together, even amid occasional disagreements. A significant obstacle that we as individuals face when working with others towards one goal is communication. When we first started working together, not everyone was completing the assignments on the same time table and some had a trouble staying focused. In response to the problems, we all developed a system to keep each other on track. We would often ask each other, "What are you working on now?" then would hold each other accountable based on the responses, and if help was needed by any company member, there was someone who was made available to assist. These tweaks made for a successful system and now we communicate effectively.

# Improvements Made

## New Design

After winning regionals and advancing to The International Mate Competition, we are creating a similar design for our ROV. Our main engineer brainstormed various ideas for a new frame for the ROV. One the ideas produced was to make the robot more compact. In doing this we can create a faster and lighter robot to ensure easier navigation for our driver. We also want to improve the depth sounder because it was not able to get into cone view. The last improvement we want to make is to expand our control box to ensure that our wires are organized and easily seen.

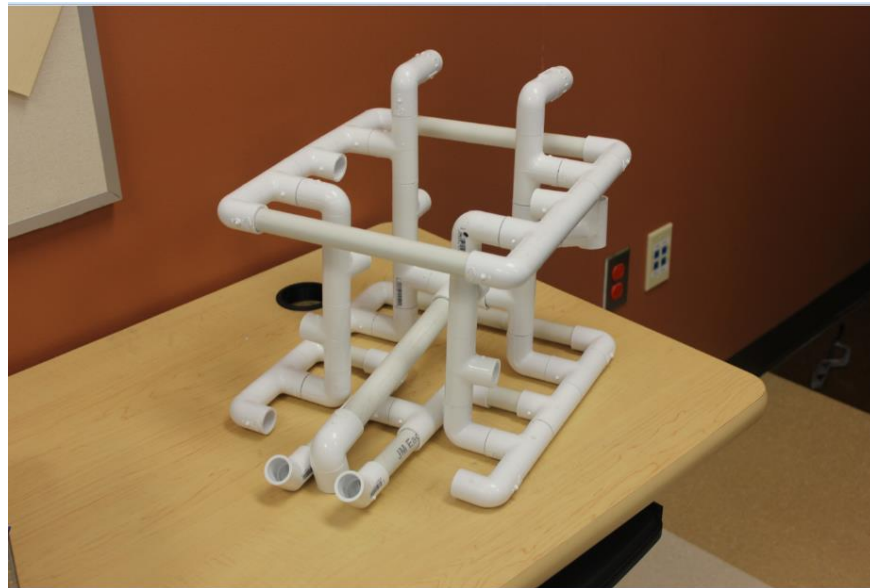


Figure 9: New design for our ROV.



## Depth Sounder

The optimal point for the depth sounder is right in the center of the cone view. If the depth sounder is on the edge of the cone view, the view won't be accurate enough. In our case, it needs to be as flat as possible. Therefore, the ROV needs to be flat to get the best reading on a flat surface. Any objects making the surface uneven may interfere with the signal. Models moving at trolling speeds increase the "Ping Speed" which in turn results in receiving more information. This increases the accuracy.

The transducer should be mounted in a position where clean, turbulence-free water passes under its face. Turbulence will break the signal. The position needs to be ideal. It can't be behind a tracker skid or roller or behind a strake or half-strake. These can disrupt the signal, so it would be better if the ROV moves while taking the reading.

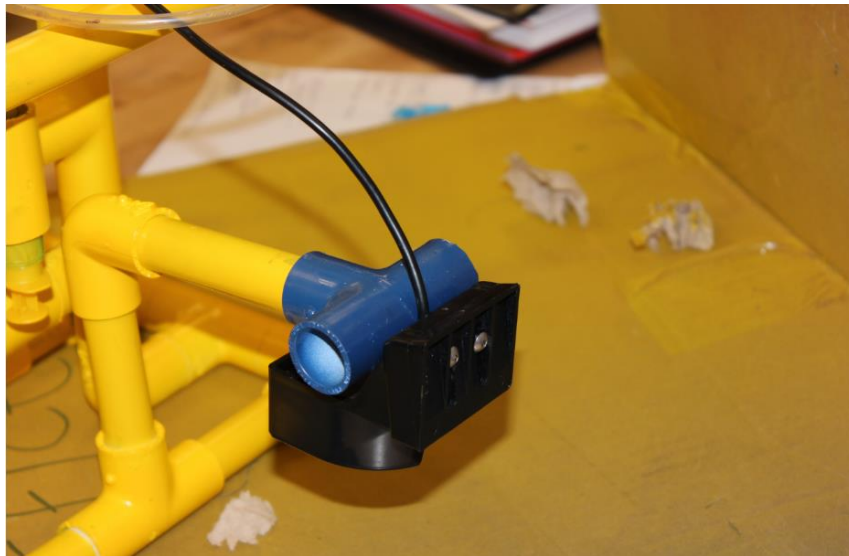


Figure 10: Depth Sounder that will help us determine the depth of the ocean.

## Rotatable Robotic Arm

The robotic arm collects oil samples, coral samples, and flips over the crates to see the serial numbers. After advancing from regionals, our company came up with a new design for the claw. The new robotic arm that we attached to our ROV is also rotatable. This new addition to our ROV will benefit us in many ways and will help us complete our tasks at a faster rate. The arm collects the coral colonies, oil samples, and carries crates with the correct serial numbers to the elevator. The arm can also rotate which helps the ROV rotate the CubeSeas to see if we collected the CubeSeas with the right serial numbers. The rotatable arm can also pick up the CubeSeas as well.

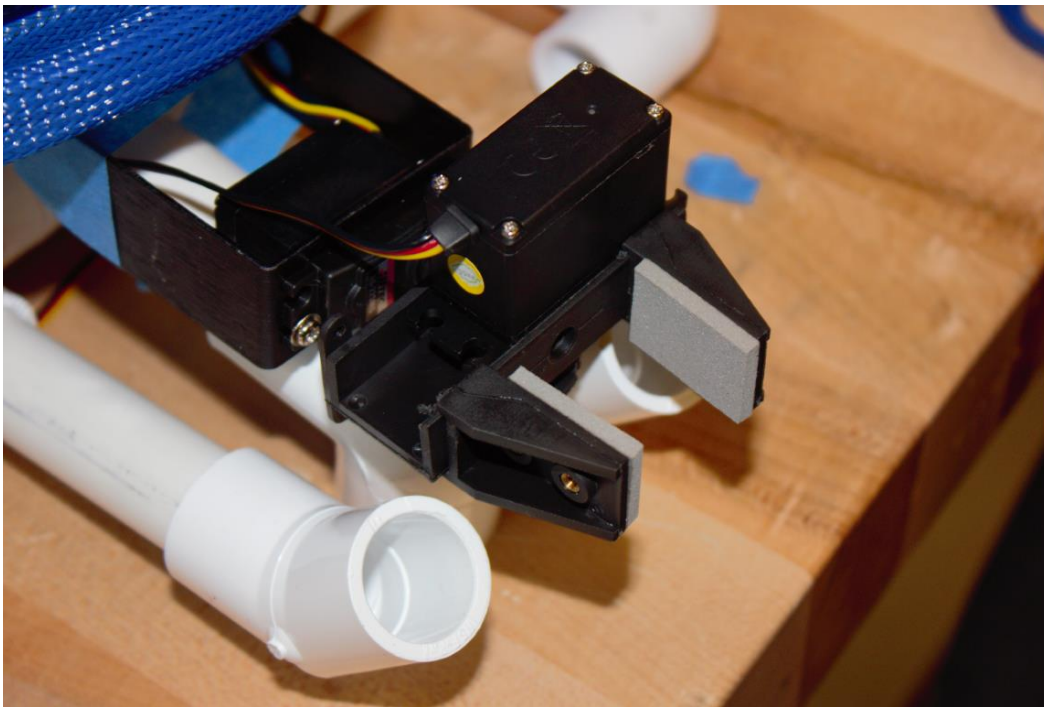


Figure 10: Robotic arm we are using to collect coral, and oil samples.

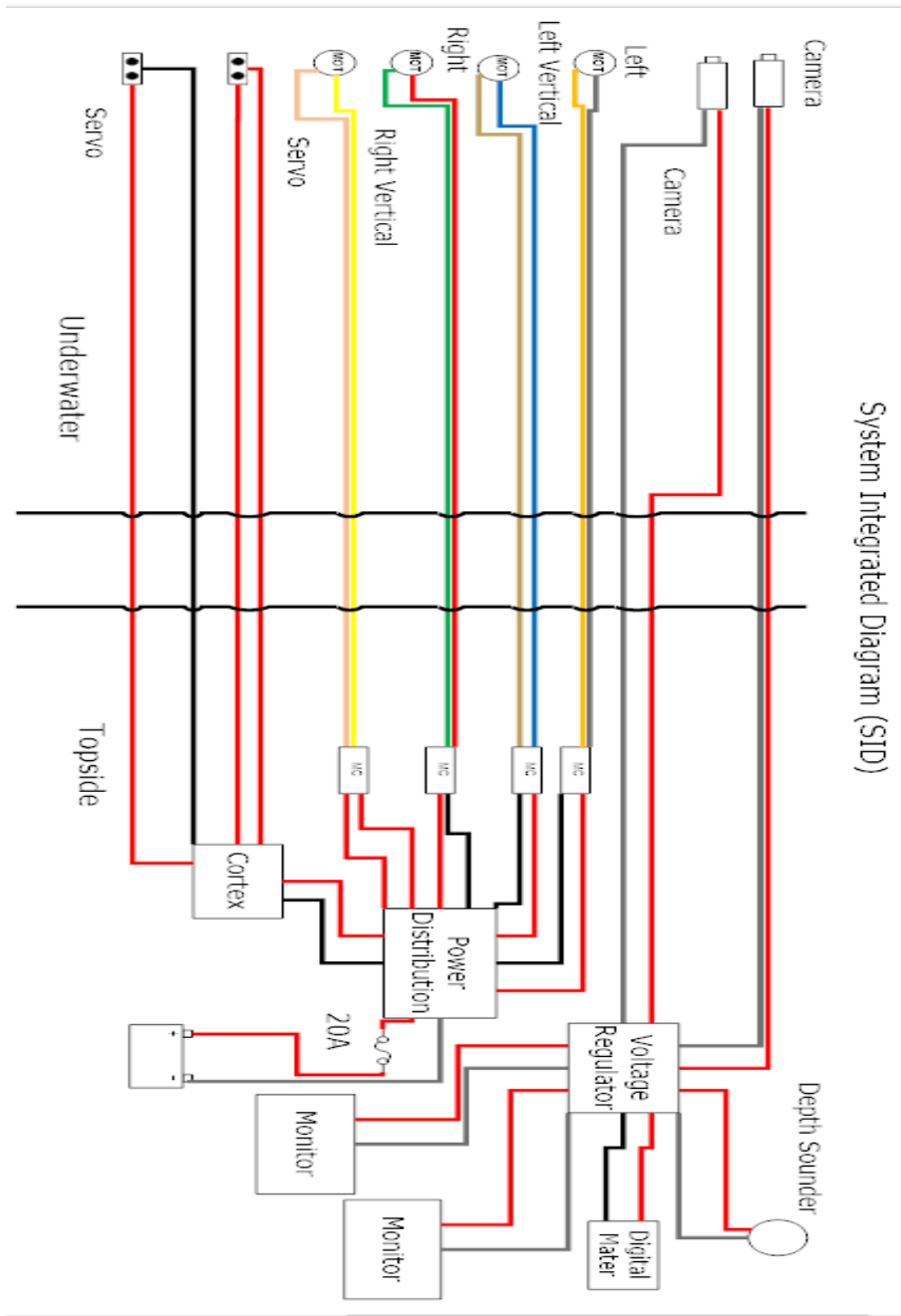
## Deep Dive Project Budget

|   | Description                                 | Amount          |
|---|---|-----------------|
| 1 | Start-up funding provided by STEM ECHS      |                 |
|   | Funds allocated Robotic Activity Account    | \$7,500.00      |
| 2 | Start-up funding provided by Harlandale ISD |                 |
|   | Funds used as a Home Depot Expense Account  | \$1,500         |
|   | <b>Total Funds Available</b>                | <b>\$9,000</b>  |
|   | Description for Internationals              |                 |
| 1 | Start-up funding provided by STEM ECHS      |                 |
|   | Funds allocated Robotic Activity Account    | \$10,500        |
| 2 | Start-up funding provided by Harlandale ISD |                 |
|   | Funds used as a Home Depot Expense Account  | \$1,500         |
|   | <b>Total Funds Available</b>                | <b>\$12,000</b> |

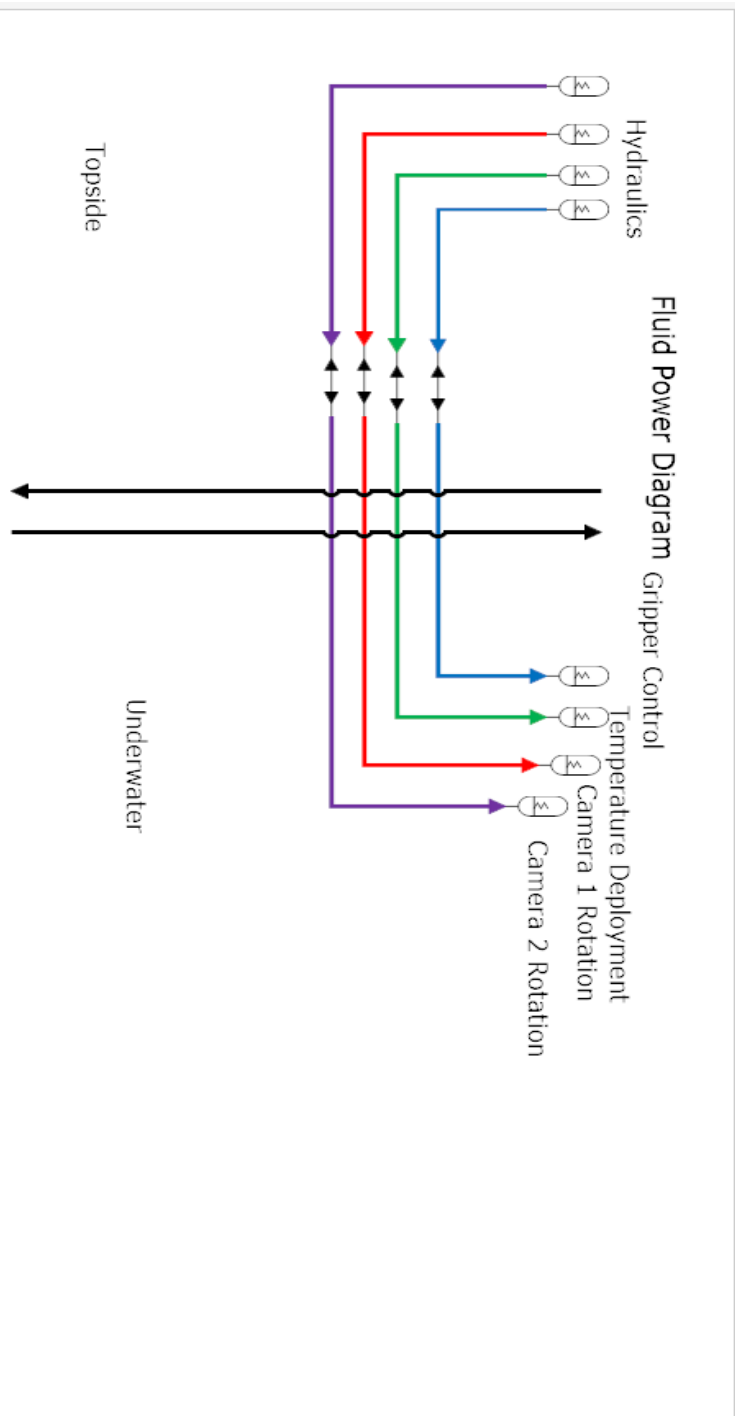
| Expenditures for Regionals |  |                      |
|----------------------------|--|----------------------|
| Item                       | Description  | Cost                 |
| 1                          | Mate Kit   | (\$635.00)           |
| 2                          | Mate ROV Registration Fee  | (\$135.00)           |
| 3                          | Amazon – Waterproofing Materials                                 | (\$39.98)            |
| 4                          | Home Depot- PVC and Miscellaneous Items                          | (\$103.57)           |
| 5                          | Electronics- Labquest 2 etc.                                     | (\$377.52)           |
| 6                          | Costs of Meals   | (\$1,500)            |
| 7                          | Lodging-8 rooms for 2 Nights                                     | (\$1,032)            |
| 8                          | Transportation   | (\$28.00)            |
| 9                          | <b>Total Expenditures for Regionals</b>                          | <b>(\$3,851.07)</b>  |
|                            | Expenditures for Internationals                                  |                      |
| Item                       | Description  | Cost                 |
| 1                          | Mate ROV Registration Fee  | (\$135.00)           |
| 2                          | Amazon- Waterproofing Materials                                  | (\$39.98)            |
| 3                          | Home Depot- PVC and Miscellaneous                                | (\$277.75)           |
| 4                          | Electronics- Labquest 2 etc.                                     | (\$377.52)           |
| 5                          | Costs of Meals   | (\$1,809)            |
| 6                          | Lodging-8 Rooms for 4 Nights                                     | (\$3,612)            |
| 7                          | Transportation- District Van                                     | (\$400.00)           |
| 8                          | <b>Total Expenditures(Including Expenditures from Regionals)</b> | <b>(\$10,502.32)</b> |

| Final Accounting                    |                    |               |
|-------------------------------------|--------------------|---------------|
| 1                                   | Total Revenue      | (\$9,000)     |
| 2                                   | Total Expenditures | (\$3,851.07)  |
| 3                                   | Net Balance        | (\$5,148.93)  |
| Final Accounting for Internationals |                    |               |
| 4                                   | Total Revenue      | (\$12,000)    |
| 5                                   | Total Expenditures | (\$10,502.32) |
| 6                                   | Net Balance        | (\$1,402.32)  |

# System Integrated Diagram



# Fluid Power System



# Appendix A

## Worksheet for our ROV's buoyancy.

MATE Summer Institute 2014



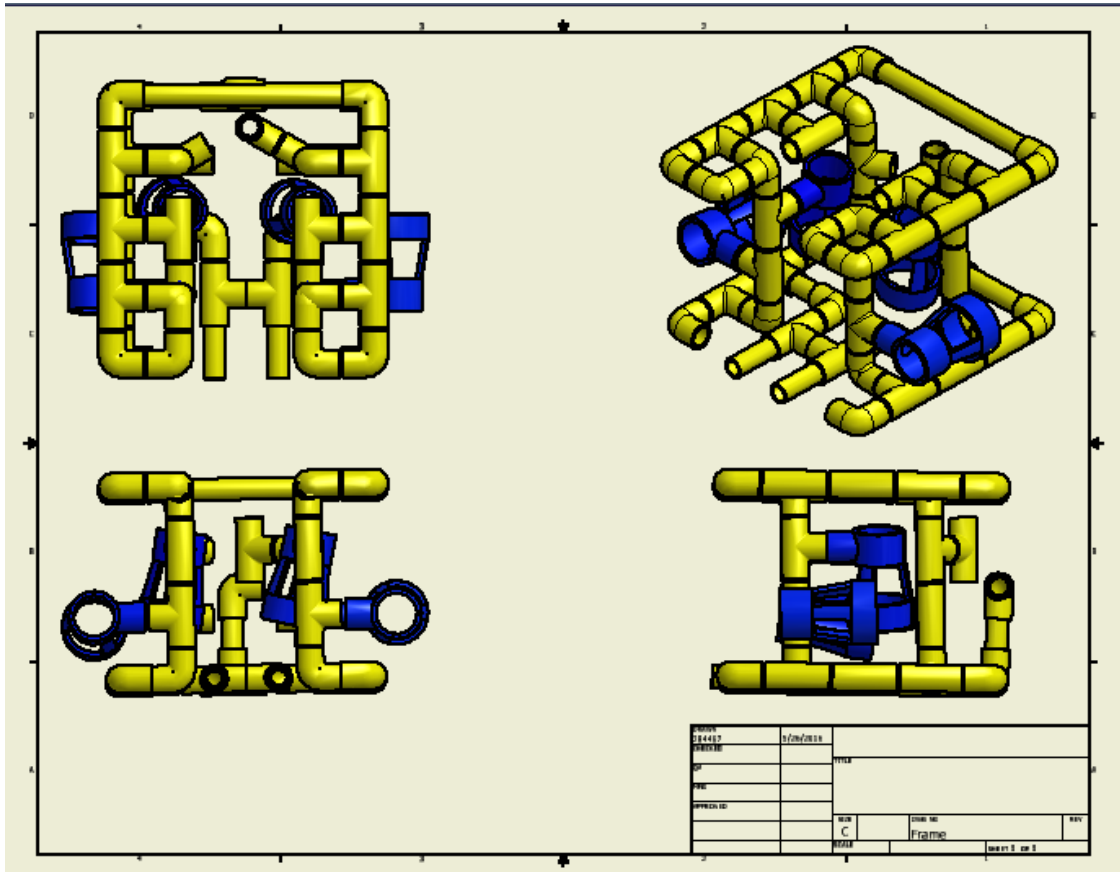
Team #: \_\_\_\_\_

| PVC Pipe Specifications                                    | 1" PVC | 1 1/2" PVC | 1 3/4" PVC | 2" PVC  |
|--|--------|------------|------------|---------|
| Diameter (cm)  | 3.340  | 4.216      | 4.826      | 6.033   |
| Weight in Air (g/cm)                                       | 2.532  | 6.357      | 7.174      | 10.000  |
| Volume per cm (cc)   | 8.762  | 13.960     | 18.292     | 28.581  |
| Net Buoyancy (g/cm) [weight in air per cm - Volume per cm] | -6.230 | -7.603     | -11.118    | -18.581 |

1. Dry weight of ROV with everything installed = \_\_\_\_\_ g  
*(This value is for comparison with value recorded in step two below and not used in calculations.)*
2.  $F_{net}$  or apparent (wet) weight of ROV = \_\_\_\_\_ g
3.  $F_{net}$  required from two Buoyancy Tubes to achieve neutral buoyancy = \_\_\_\_\_ g
4. Total tube length required to achieve neutral buoyancy  
*(Complete the table below for each pipe size.)*

|  | 1" PVC | 1 1/2" PVC | 1 3/4" PVC | 2" PVC |
|--|--------|------------|------------|--------|
| Total Length Required                            |        |            |            |        |
| Length per Tube [Total length / number of tubes] |        |            |            |        |

# Appendix B



IDW of our frame design.