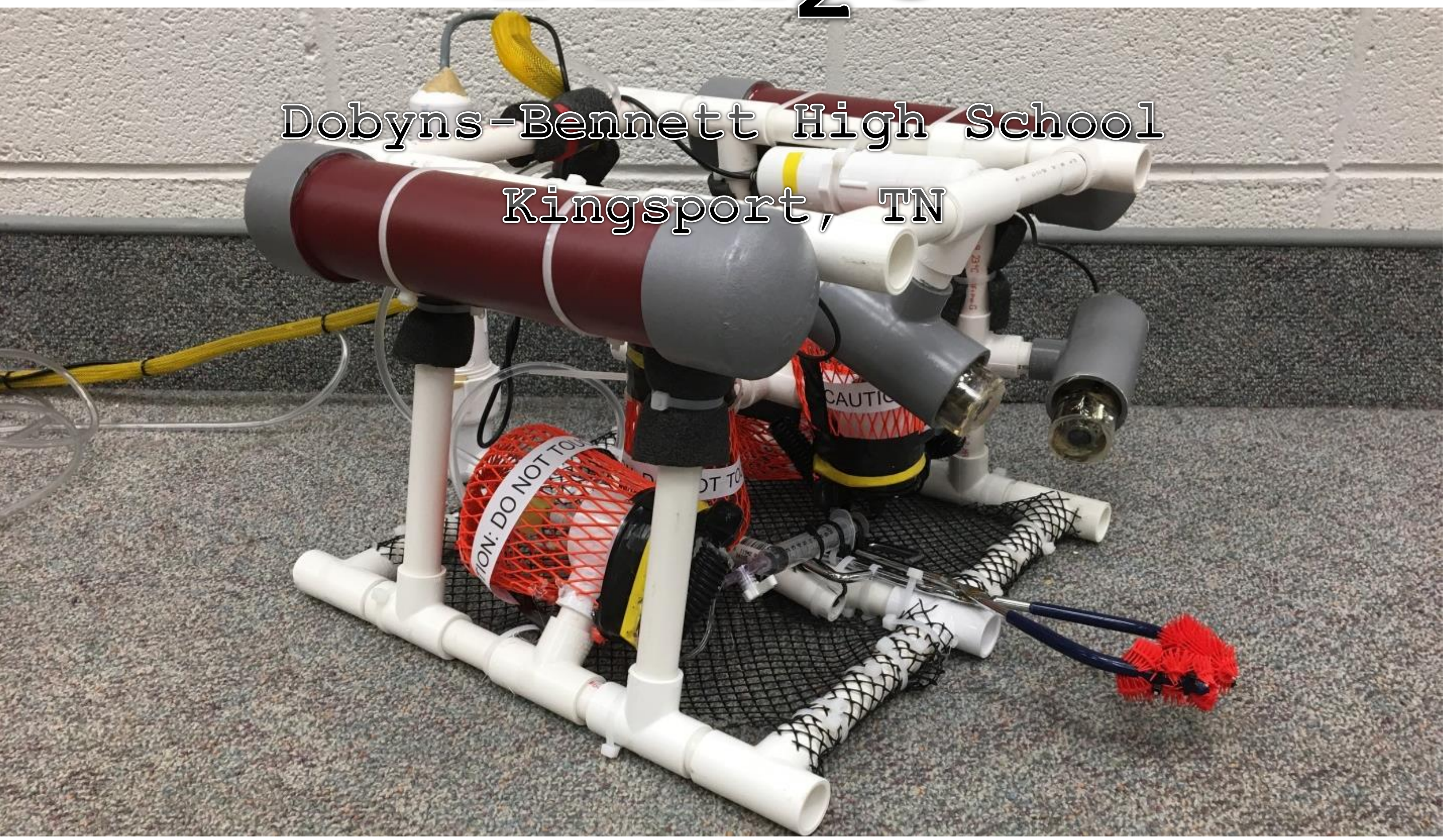
DBH_2O



Dobyns-Bennett High School

Kingsport, TN

Company Crew:

Alexander Long, CEO
Chase Bishop, COO
Makaila Freeman, CFO
Hayden Hufford, Chief Engineer
Tiffany Fish, Safety Manager/Driver
Savannah Miller, Safety Manager
Ellie Salyer, Mission Specialist 1
Gabe Tipton, Mission Specialist 2
Ryan Barganier, Mission Specialist 3

Advisory Board Members:

Mr. Lucas Douthat
Mrs. Amanda Blackburn
Dr. Michael Long

Our Quote:

It all started with a PVC pipe and a Dream

Table of Contents:

Abstract:

Dobyns-Bennett Underwater Robotics has perfected the engineering design process to produce DB-1. DB-1 is a remotely operated vehicle (ROV) designed to complete a variety of tasks. Some of the many tasks our ROV can perform include , (1)remove and identify debris from an aircraft using a lift bag, (2) deliver a seismometer to the surface for the reading of data, (3) properly installing an Adaptable Monitoring Package (I-AMP) to monitor the area as well as transporting it. Our company has worked tirelessly to efficiently produce DB-1 in a short period of time. In addition, the team heavily focused on not only making a ROV that can perform and surpass the tasks required, but also meets the safety requirements. We have thoroughly evaluated our ROV to effectively adress any safety issue that could emerge. Our team has implemented all aspects of engineering, from the basics of the frame to all of our software and programing. Our control system is very practical and sufficient as the system is able to maneuver our device in any direction possible. Lastly, Dobyns-Bennett Underwater Robotics has tested and improved our ROV to fix any issues. As a result, the ROV is now in perfect working condition and is ready to take on any task or challenge presented. The following technical documentation reveals the architectural design, functionality, and handling behind the production of DB-1.

Safety:

Safety Philosophy

At DBH_2O our main priority is maintaining a safe environment that keeps our peers safe and unharmed at all times. Safety was maintained throughout construction by following all safety guidelines and ensuring that all company members are properly trained in all aspects of construction. In conclusion, safety is our company's top priority. We will always adhere to this non-negotiable viewpoint.

Safety Guidelines

DBH_2O introduced many safety guidelines to keep our members safe throughout the building of the ROV. Some of our company safety guidelines include:

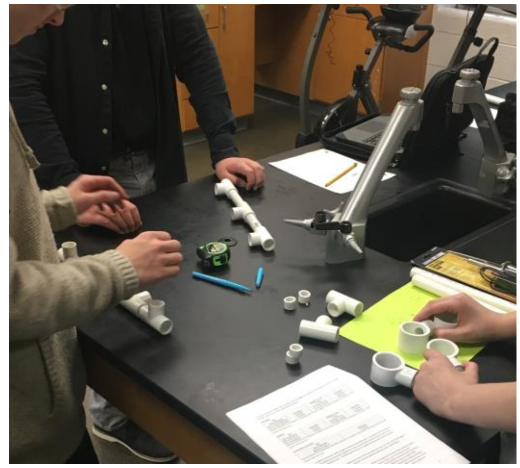
- Wearing Safety Glasses at all times around all construction equipment
- Wearing appropriate clothing and closed toed shoes
- Being aware of your surroundings (this includes people)
- Proper training for all aspects of the construction
- Adhering to all pool safety guidelines set forth by our Safety Specialists (Tiffany Fish & Savannah Miller)
- All tools and equipment are properly inventoried and stored
- Propellers are protected by shrouds at all times
- All components of the control box are properly wired and secured. No wiring is exposed and all electrical components to be submerged in water are properly protected by waterproofing materials.
- Tether is neatly wrapped to avoid knots
- Labels such as "Caution: Do not touch" and "Caution: Do not Submerge".

Safety Features

DB-1 was created with safety as its highest priority. Throughout the development, DB-I went through many safety checks in order to assure the safety of all employees and consumers before the product was in water.
All company members participated in a general safety lecture and a fluid power quiz. Proper attire such as goggles and closed toe shoes were worn throughout the construction and testing phases of DB-1.

Design Rationale:

Mechanical Design Rationale: Frame

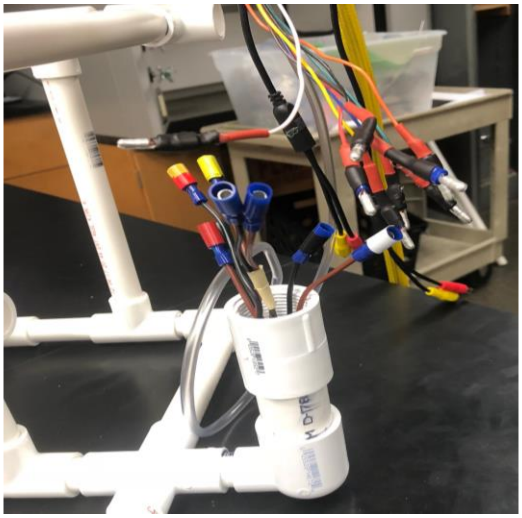


During the early process of building our frame, we made false conversions from inches to centimeters resulting in our ROV being half the size of our current ROV (DB-I) Our ROV now resembles a rectangular prism with a height of 11 ⅛”, a width of 13 ¾ “, and a depth of 16 ¾”. Our power port has been mounted to the side of the frame. It is 3 ½” from the base and 5 ¼” in height. On the corners of the ROV you can find openings where water is able to flow through. This gives the ROV weight so it travels through the water instead of floating on the top of the water. The main material used to create the frame is Polyvinyl Chloride (PVC) pipes that have been measured, cut, and joined together by connectors. We chose to use this material as it is hollow, easy to manipulate, and durable.

Electronics: Control Box

- Triggerfish 3.0 controller circuit board
- Sabertooth microcontrollers set up in an analogue fashion
- 12 volt system
- Integrated camera filter, capacitors, and diodes
- Integrated fuses
- Integrated multimeter voltage meter that measures voltage and amperage continuously
- All twelve volt connection are made via Anderson power pole fittings
- Mate triggerfish control board- bottom portion
- 7” multi signal lcd twelve volt monitor
- 12 volt E-sky:
- Image device: High sensitivity CCD
- TV system: PAL/ NTSC
- Effective pixels: 658*588 pixels
- Resolution- 480 TV lines
- Lens angle: 170 degree
- Power supply: DC12V

Electronics-Power Port:

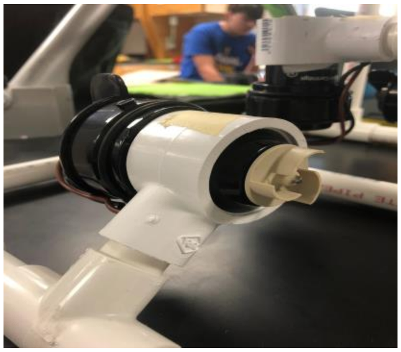


The power port is the piece on our ROV that unites the wires threaded throughout our ROV with the wires contained in the tether system connecting the ROV to our power source. For organizational purposes, the team decided to color code the wires. As a result, we can easily differentiate each of the wires avoiding confusion. In addition, each of the wires includes connectors at the areas where the wires adhere to each other, which makes the attaching process easier.

Tether System:

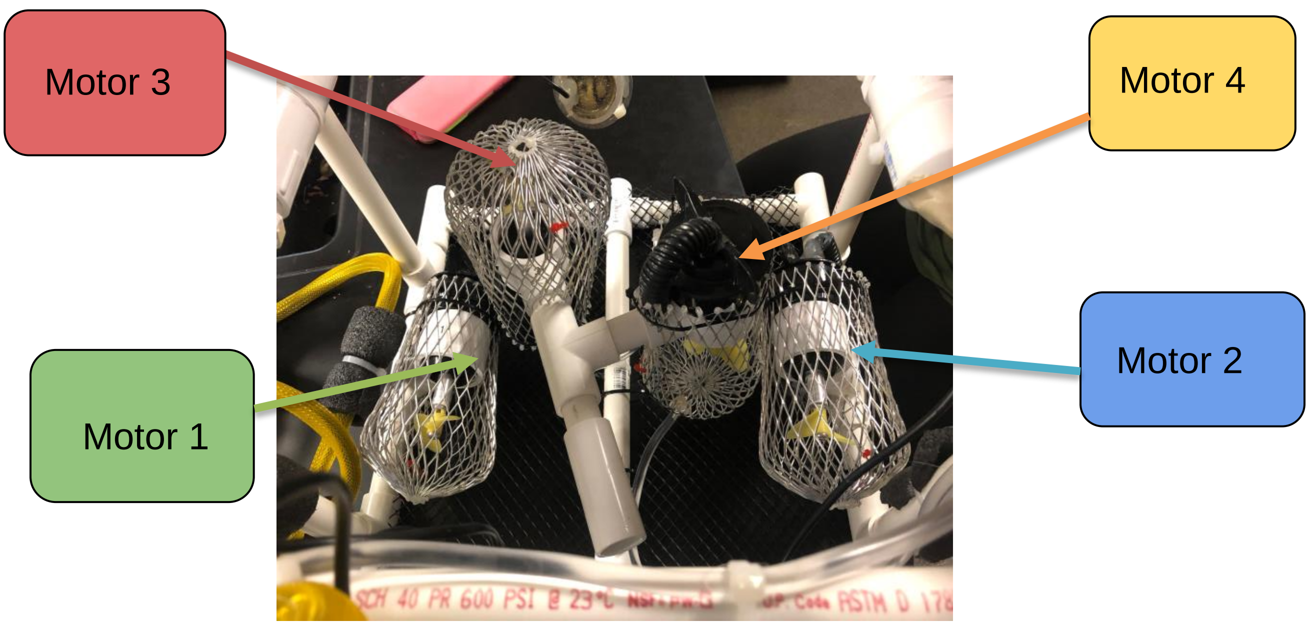
The tether system bundles our hydraulic wiring, power wiring, and camera cords. The bundle was threaded through a yellow mesh that stretches and compresses. Our power cord is attached to a power port that attaches to the frame. We attached our power cord to the port using epoxy that undergoes an exothermic reaction. To create the tether we threaded the wires all the way through the yellow mesh. However, when our team decided to power our arm by hydraulics we had to start the tether over by adding the hydraulic tube. All of the cords being in a similar area make it easier to secure and differentiate between the different wires and their uses. After our first testing of our ROV, we decided to zip tie pieces of foam that will help keep our product neutrally buoyant.

Thrusters:



The thrusters included on our ROV are placed in specific positions resulting in the ROV’s ability to move in any direction desirable. The thrusters are mounted by motor mounts that are then connected to a "T" connector by 1 ½ inch piece of PVC pipe. The "T" connector is the piece that connects the thruster to the frame.

Each position determines the direction the ROV will move. The motor with the thrusters facing up (motor 3) allows the ROV to move downward and upward which acts as a vertical thruster. This gives the ROV the ability to maneuver through the deepest depths of the pool. The two motors located on the lower portion of the frame (motors 1 and 2); create a forward and backward motion if the driver moves the joysticks in the same direction. However, if the driver moves the joysticks in opposite directions this allows the ROV to turn left and right. Lastly, (Motor 4) faces downward that spins counter clockwise while motor 3 spins clockwise. Together the two thrusters work together to move up and down.



Shrouds:
Originally, our company opted to 3D print the shrouds for DB-1, but that did not go so good as it was a millimeter too small. Fortunately, during a trip to Lowes, the team found an item that we now use to act as shrouds. Previously, the metal shrouds were meant to be used in gutters as leaf guards; however, the team has found a new purpose that has been very beneficial in the

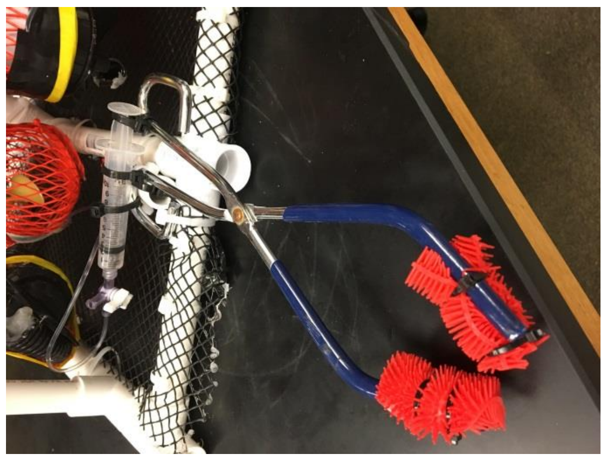
safety of our ROV. In order to secure the shrouds to the propellers, we found the swiftest way to do this was to zip- tie the pieces together. In addition, our company took the precautions to remove any safety hazard as we hot glued the sharp edges of the shrouds. Therefore, after the hot glue dries the sharp edges have now become smooth-rounded points.

Buoyancy:

In order to create neutral buoyancy throughout our ROV we added flotation devices to the top of our ROV. The floatation system is made up of 2 PVC pipes with a length of 11” and has a diameter of 2 ⅜” with two end caps on both ends of each pipe. After both end caps were secured to the ends of the PVC pipe, the team attached the flotation device to the top of the ROV with zip ties. With these tubes full of air at the top of our ROV and our open tubing in the frame that allows water to go through the duo results in successfully integrated neutral buoyancy. The open tubing provides the weight needed to travel swiftly through the water while the floatation devices allow our ROV to float. Additional netting was added to the underside of the ROV so additional weight could be added if needed to maintain neutral buoyancy. This feature would be critical for clients who intend to use the ROV in water with high salinity levels.

Hydraulic Arm

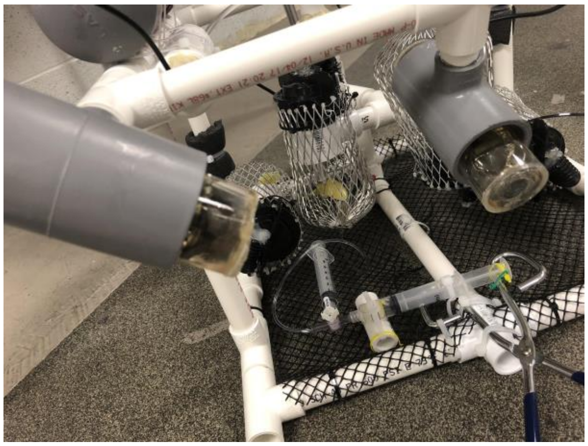
One can see from the name that the Hydraulic arm is powered by water. In order to save time and energy, the team made the executive decision to make the hydraulic arm as simple and efficient as possible. Our first hydraulic arm was designed and printed using a 3D printer; however, when we tested the device in the water it failed to do justice. Fortunately, the team found beaker tongs that made a sturdy and competent arm. In order to power the arm, our team created a three syringe apparatus. One syringe (syringe 1) is attached on one end of the hydraulic tube while the other (syringe 2) is attached to the opposite side with the beaker tongs. Syringe 1 is filled with water as well as the tube. When one pushes the plunger of the syringe, the water is being forced into syringe two thus opening the arm. When the plunger of syringe 1 is pulled back, it



results in closing the arm. In order to secure the apparatus, we zip-tied the tongs and syringe 2, to the PVC pipes located on the side of the ROV.

Vision System

The cords used to power the camera run through the tether. Because we had excess wiring, we decided to store the excess wiring in two mini power ports that can be found on the upper right and left sides of the ROV. We molded clay on the sides of the mini power ports to prevent water from seeping through. Other efforts of water proofing include putting the cameras in plastic cylinders to avoid water damage. We decided to position one camera above the hydraulic arm, so we are able to see what objects are in front of us and so the team can easily determine what actions the hydraulic arm is performing. The side-view camera also helps us see a better view of our hydraulic arm as the ROV will be performing many tasks in the competition.



Troubleshooting:

Test 1:
During our first testing session the team really wanted to try and evaluate how our ROV performed in the water. Our first test was to check if the ROV can move in a back and forth motion and to see if the ROV can float. These two tests were a success. However, the ROV was too buoyant. We tried adding weights to the bottom of the ROV and resulted in the ROV sinking. In addition, as we observed air bubbles surfacing at the top of the water we realized that air was escaping from the floatation devices. This could have contributed to the product sinking, as water was entering the device while air was coming out. We are also planning on doing a better job of securing the floatation devices as the zip ties came loose. When the ROV started tilting to one side we realized there may be too much weight on one side. This is an easy fix, as we can just add some more weight on to the other side. Lastly, we blew a fuse in our control box. This may have resulted in the right motor continually spining. We will replace the fuse and solve our glitch problem in our control box to evolve our product.

Test 2:
Company crew met for our second round of testing. To begin we set up the protocol for ROV deployment. This protocol included motor testing, during this time it was noticed that motor 4 was continually moving without joystick prompting. It was decided to continue with the slight movement and see if the issue would self-correct. Driver and tether manager ran through the ROV start protocol and cautiously deployed the ROV. Once underwater the ROV vision was tested by trying to identify the tail identification numbers. Drivers tested this skill at varying distances. Once the vision was honed in we working on testing the manipulating hydraulic arm. The weight of the wind turbine seemed to overpower the strength of the hydraulic 3D printed arm. The company chooses to press on with this arm and see how much it can handle, when time to remove the ROV from the water motor 4 was no longer running unprompted.

Test 3:
During testing it was documented that the ROV was struggling with vertical thrust. It was at this time the company was to determine a change to the ROV that would support the need for additional thrust.

Test 4:
The company began testing at the pool with mission specialist testing their hand at piloting the ROV. Mission specialist 1 attempted his mission and found that piloting missions will take some time. At this time the company made the decision to make a change to the motor positioning for motor 4 by rotating it from horizontal to vertical. The company also made a change to the sabertooth motor by changing the mode to allow that motors 3 and 4 could turn opposite directions. Also it was during this time it was noted again that the hydraulic arm was struggling and a new solution may be on the horizon.

Test 5:
The 3D printed arm met its demise, when the weight of the debris overpowered the weight of the arm resulting in a fracture of the 3D printed material. Company members returned to the workspace

for a brainstorming round for possible solutions to rebuild/replace the manipulator arm.

Challenges:

Lessons Learned

Throughout our first product build season we have had many real world experiences that we have learned from. This build season has taught us the importance of collaboration, assigning roles, prioritization, time management, and commitment. In order to be a successful company, we have learned that each member must demonstrate these characteristics. Additionally, our company has learned the importance of troubleshooting and problem solving. We quickly learned that it is very rare that things go smoothly on the first attempt. As a result, we have learned that successful companies must work tirelessly to continuously devise new approaches and strategies to improve DB-1 in order to fully maximize its’ potential.

Future Improvements

In the future, this company will work to produce a hydraulic arm that is more robust, build all ROV appendages inside a smaller frame, and cut down on weight. The company will also work towards transitioning towards an Arduino platform. In addition, we will start the constructing the ROV earlier so we don’t feel as if the process is rushed.

Reflections

In the future, DBH_2O will use Arduino, an open source computer hardware and software company, in order to help us in the process of designing, building, and using more technically advanced ROVs. With this equipment our future ROVs will be able to operate even better than before.

Management:

Company organization:

CEO: Alexander Long
In charge of company. Assigns tasks for other company members in the pursuit of company excellence.

COO: Chase Bishop
Director of operations. Oversees ongoing operations within DBH_2O.

CFO: Makaila Freeman
Oversees financial transactions, maintains the budget documents, and chief coordinator of the technical report.

Chief Engineer: Hayden Hufford
Chief Engineer supervises operations, maintenance, and repair of ROV equipment.

Safety Managers: Tiffany Fish and Savannah Miller
Manager is responsible for preventing any accidents within the company. Manager oversees all aspects of build, shares safety expectations to all members of company as well as visitors to company site.

Mission specialist 1: Ellie Salyer
Oversees the aircraft mission, must know ins and outs of mission including task, props, expectations and execution of mission

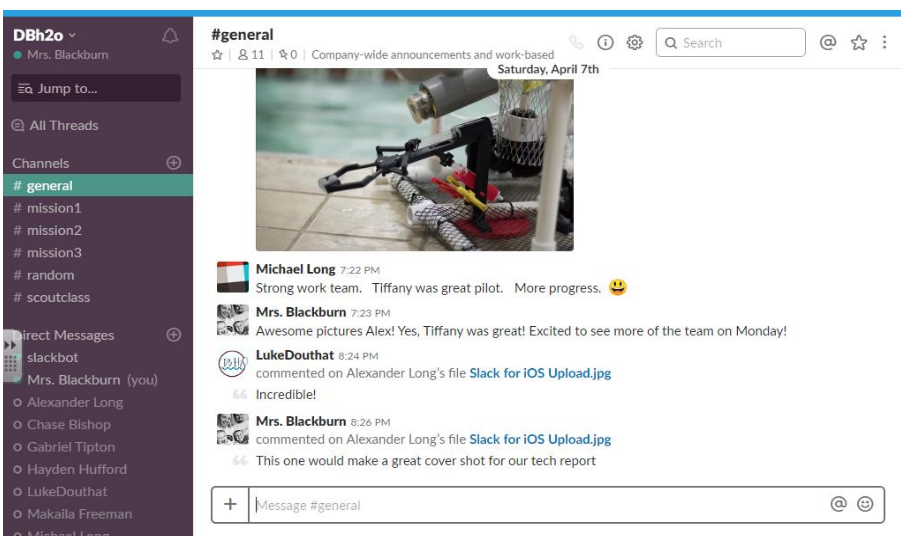
Mission specialist 2: Gabe Tipton
Oversees the earthquake mission, must know ins and outs of mission including task, props, expectations and execution of mission

Mission specialist 3: Ryan Barganier
Oversees the energy mission, must know ins and outs of mission including task, props, expectations and execution of mission

Project Management:

The CEO manages the group by splitting our team into 3 subgroups and assigning everyone a specific job to do for the competition. For example, one person could be working on math equations for another task if the CEO needs them to start doing so. He also provides us with a company briefing before every day we work on the ROV. He checks with in with the mission specialists to see how far we have come with each task. He also checks in with the CFO and COO on budget and track of deadlines. Finally, he organizes the team and gives team members tasks to get the most out of our time.

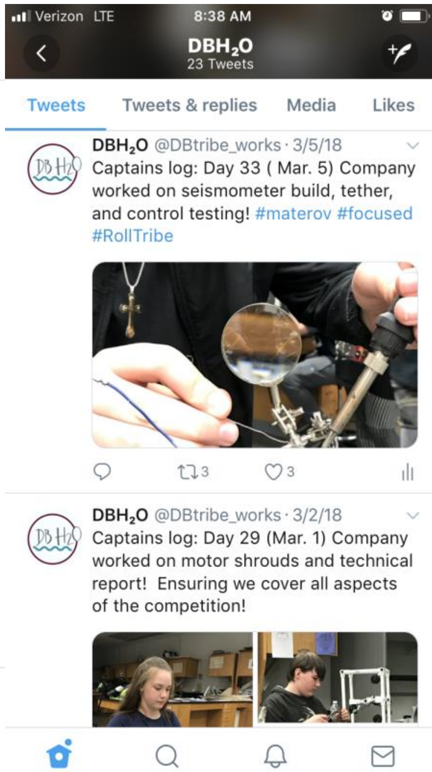
One tool to help streamline communication and daily expectations, is our company's use of the workflow platform Slack. Slack allows open communication for discussion of goals, deadlines, and meeting times.



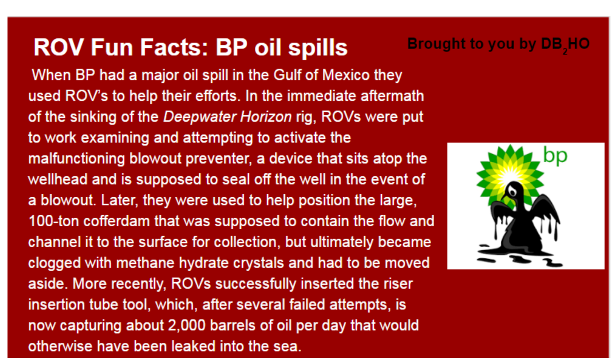
Community Communications:

Our Twitter Page (DBH2O@dbtribe_works) keeps up to date on information regarding company progress and highlights the work being done by company members within our community. Much of our school district's information is shared through social media. As a result, we have been able to share our progress with approximately 14,000 followers of our district through Twitter and Facebook. For marketing purposes the company chooses to log all twitter entries with the caption "Captains Log:" and the

Date. This continuity helped our followers know what to expect when they see a post from us, allowing for progress monitoring, and was a unique feature that helped our post stand out. We often think of our company as a crew that is helping to guide our ship. This being our inaugural year for our company we are trying to find our way much like that of the crew of a ship.



We also created a PowerPoint presentation to help inform our school about the many various uses of ROVs. This presentation was put onto the television screens across all of the different rooms to help inform the school. The slides include information about how ROVs are/were involved with the navy, scientific research, the gas and oil industry, the BP oil spill, and plastic contamination.

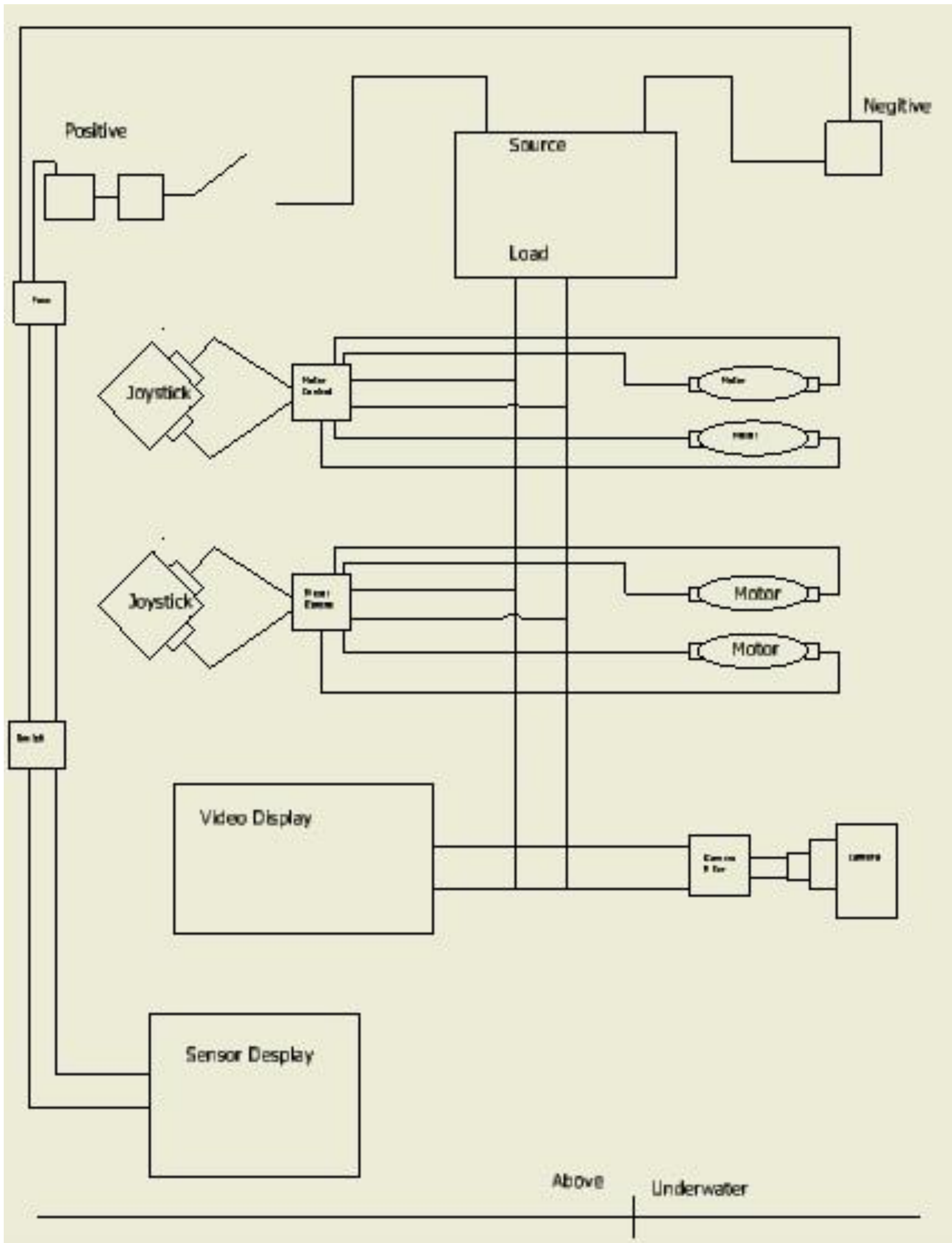


Budget & Project Costs

DBH_2O started this year’s build with $1,000.00. The first purchase made by our company was the Triggerfish Kit which cost $700.00. Additionally, our company was required to allocate $250.00 towards registration costs for regional and international competitions. These necessary items capped out original starting budget, which required our company to begin fundraising efforts. Our company divided these responsibilities into three categories in order to reach the most community stakeholders in the timeliest manner. The first group collected names and addresses of potential community partners. The second company group constructed a letter explaining the company as well as the company’s goals and objectives. The third company group created a video showing all team members as well as DB-1. This video was shared with all potential community partners with the goal of increasing interest and engagement in regards to our company. Fortunately, many local stakeholders have expressed a strong belief in the company and made the decision partner with the company by providing financial contributions.

Appendices

System Interconnected Diagram



By: Ellie Sayler

OBS DESIGN DOCUMENT

Mission two involves retrieving an ocean bottom seismometer (OBS) and finding a way to communicate with the prop to release it without making contact. The objective of the task is to move the OBS to a custom built craft to propel it to the surface for the gathering of data. Once the prop is built, our assigned mission specialist researched wireless ways of communication. After several days of research the company finally settled on the idea of magnetism and the use of a reed switch. The reed switch is a plastic shell with two oppositely turning metal prongs that, when near a magnet come together and complete a circuit(Diagram 1). While the OBS sits on the ocean floor (bottom of pool), DB-1 retrieves the OBS from its data collection container and attaches the OBS with velcro. DB-1 then approaches with a magnet and activates the reed switch. Once the switch is active, a current runs from the surface to a motor attached to the base and pulls the pin holding the transportation device to the base. In the event that the reed switch fails, the robot can still pull the pin manually ensuring the data can always be retrieved.

Diagram 1

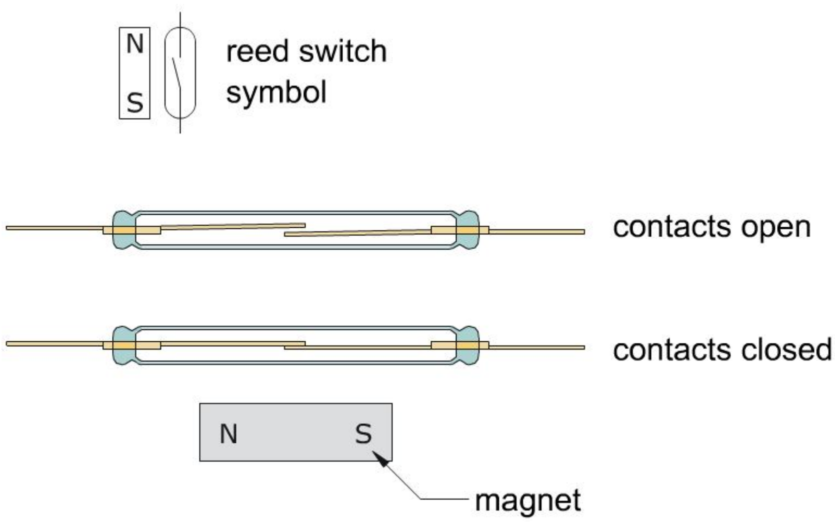
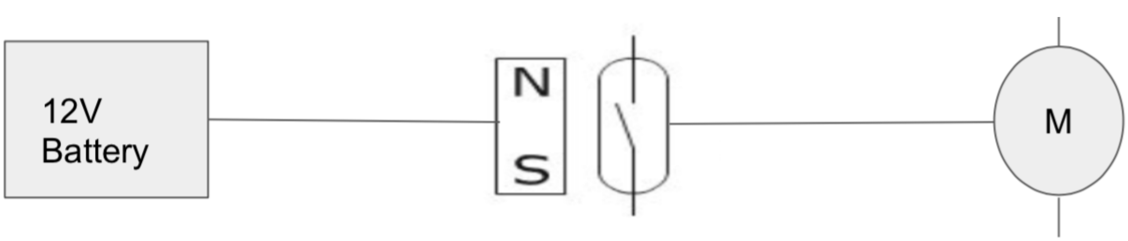


Image citation
Ahmed, Azhar. “A Reed Switch !” *IamTechnical.com*, 3 Nov. 2016, w
ww.iamtechnical.com/reed-switch-0.

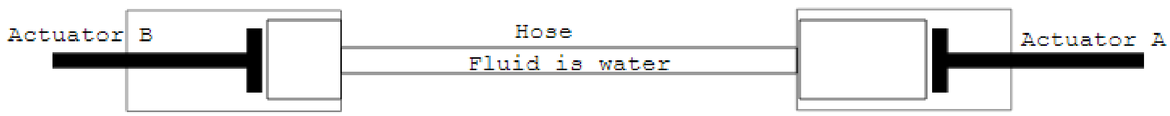
OBS SID



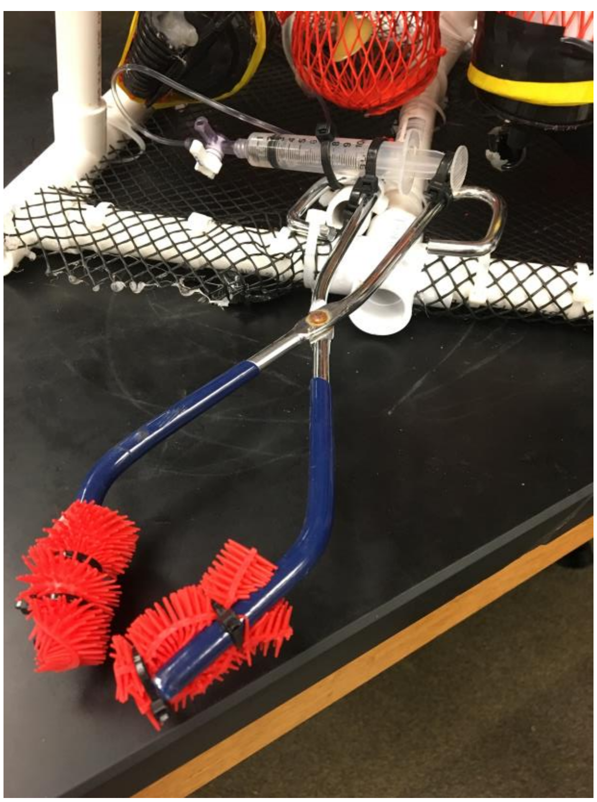
By: Hayden Hufford

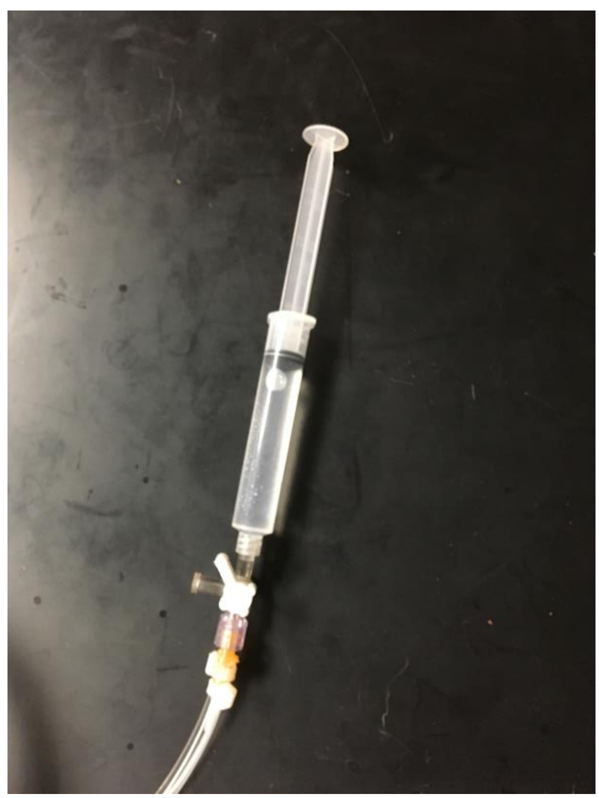
Hydraulic Fluid Power SID

Hydraulic Fluid Power SID



Actuator A is engaged manually. When engaged actuator B will open manipulator arm. When actuator A is withdrawn, actuator B will close manipulator arm.





Budget Sheet

Trigger Fish Kit	700.00
PVC Pipe	
½″ 2- 8′ Piece	4.40
1″ 1- 8′ Piece	3.96
2″ 1- 8′ Piece	8.43
PVC Attachments	
22- T's	2.82*2= 5.64
2- Cross	1.44*2= 2.88
Batteries	
12 Volt	20.00
6 Volt	12.29
Battery Case	23.66
Tether	
Video Cable	6.99
Hydraulic Tubing	22.74
Motor Protection	
4- Leaf strainers	2.62*4= 10.48
Mission Accessories	
5cc Syringes	5.99
Oxygen Tubing	12.83
4- Breathing Bags	8.69*4= 34.76
Reed Switch	2.19
Cameras/ Screen	44.98
Foam	4.99
Video System	
Monitor	27.99
2- Cameras	180.00
Camera Waterproofing Kit	20.00
Hydraulic Arm	
Beaker Tongs	40.00
Hand Scrubber	5.99

Total cost: **$1164.24**

Checklists

Safety Checklist

1.Ensure all personnel have hair tied up, jewelry or earphones removed, as they can become entangled in the equipment.

2.Ensure everyone is wearing closed toed shoes.

3.Ensure safety glasses are worn in the lab and on deck.

4.Ensure there are no hazardous objects in the vicinity.

5.Ensure all electronics are located far from the water.

6.Instill proper communication between all team members.

7.Ensure that all power connections are plugged in correctly prior to powering on DB-1

Pre-Test Checklist

1.Check all electrical equipment

2.Complete dry-run

3.Ensure that waterproof seals are secure

4.Check thrusters for full functionality

5.Test hydraulic arm for functionality

Tether Checklist

1.Unroll the tether

2.Plug tether into control box

3.Upon completion of missions, unplug tether from control box

4.Roll tether

Mission Checklist

1.Adhere to all tether protocol

2.Check all connections

3.Power DB-1

4. Test Thrusters

5. Place DB-1 in water

6. Give “ready” signal and launch DB-1

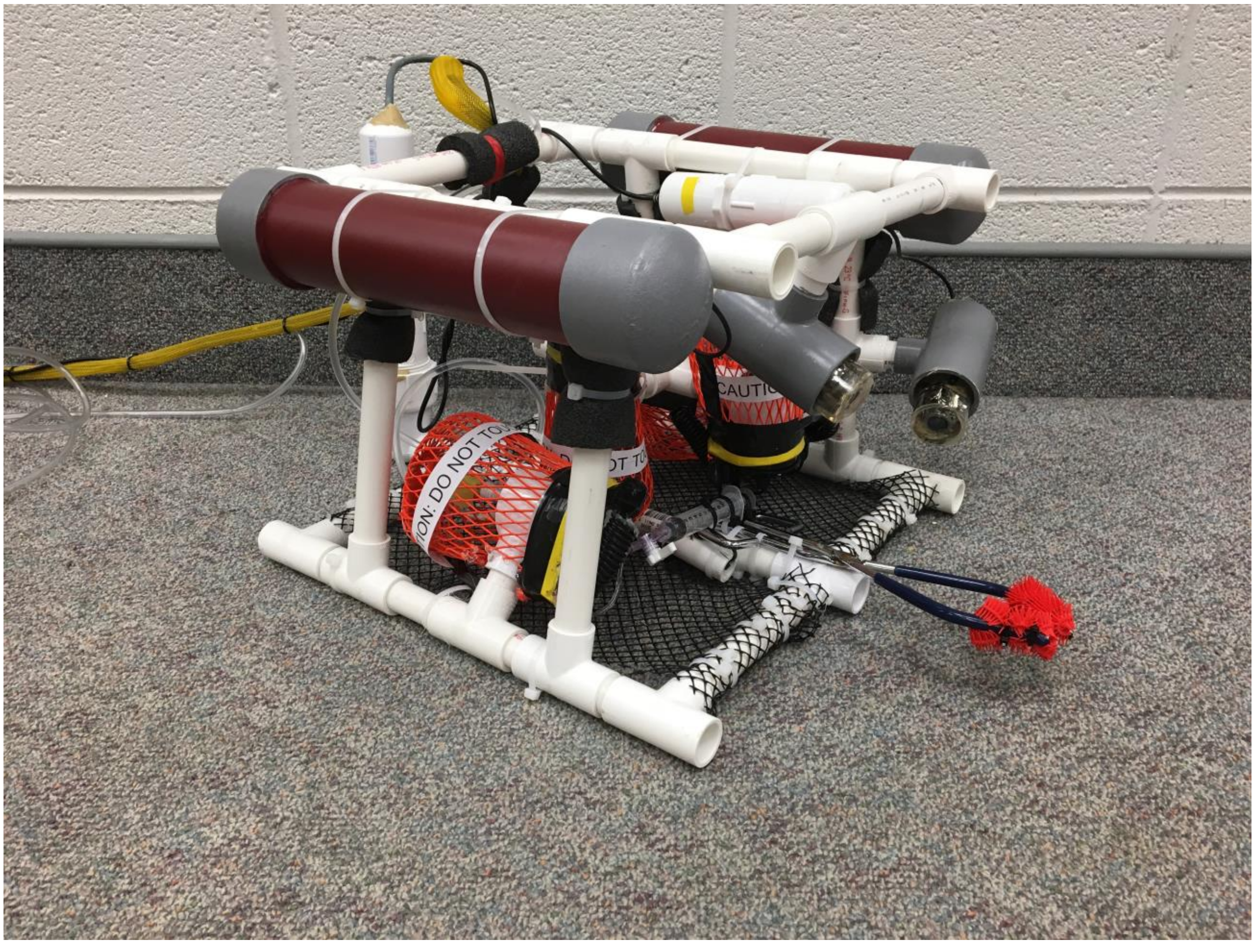
Post-Test Checklist

1. Disconnect Tether

2. Disconnect all power

3. Return DB-1 to safe location

Conclusion:



Dimensions: 48cm X 40cm X 28cm

Weight: 18.2 lbs

Total cost: $1164.24

Acknowledgements

DBH$_2$O would like to give our greatest thanks to:

Mate Center for creating a competition encouraging future leaders to think outside the box to solve real world issues.

Streamworks for hosting the piloted Tennessee Regional and providing companies with funding for their ROV kits and competition registration!

Kingsport City Schools

Walmart #599

OpenBuilds

Friends and Family

Immersed Scuba

Aqueous Solutions

Armstrong Construction

Bristol Anesthesia Services

Dr.Michael Long, You have truly been our biggest fan since the very beginning. You believed in our company and pushed each one of us to think beyond what we already knew. We are incredibly thankful for the time and resource you have provided to help us launch this company.

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