Boulder High School
Robosharks
Technical Report

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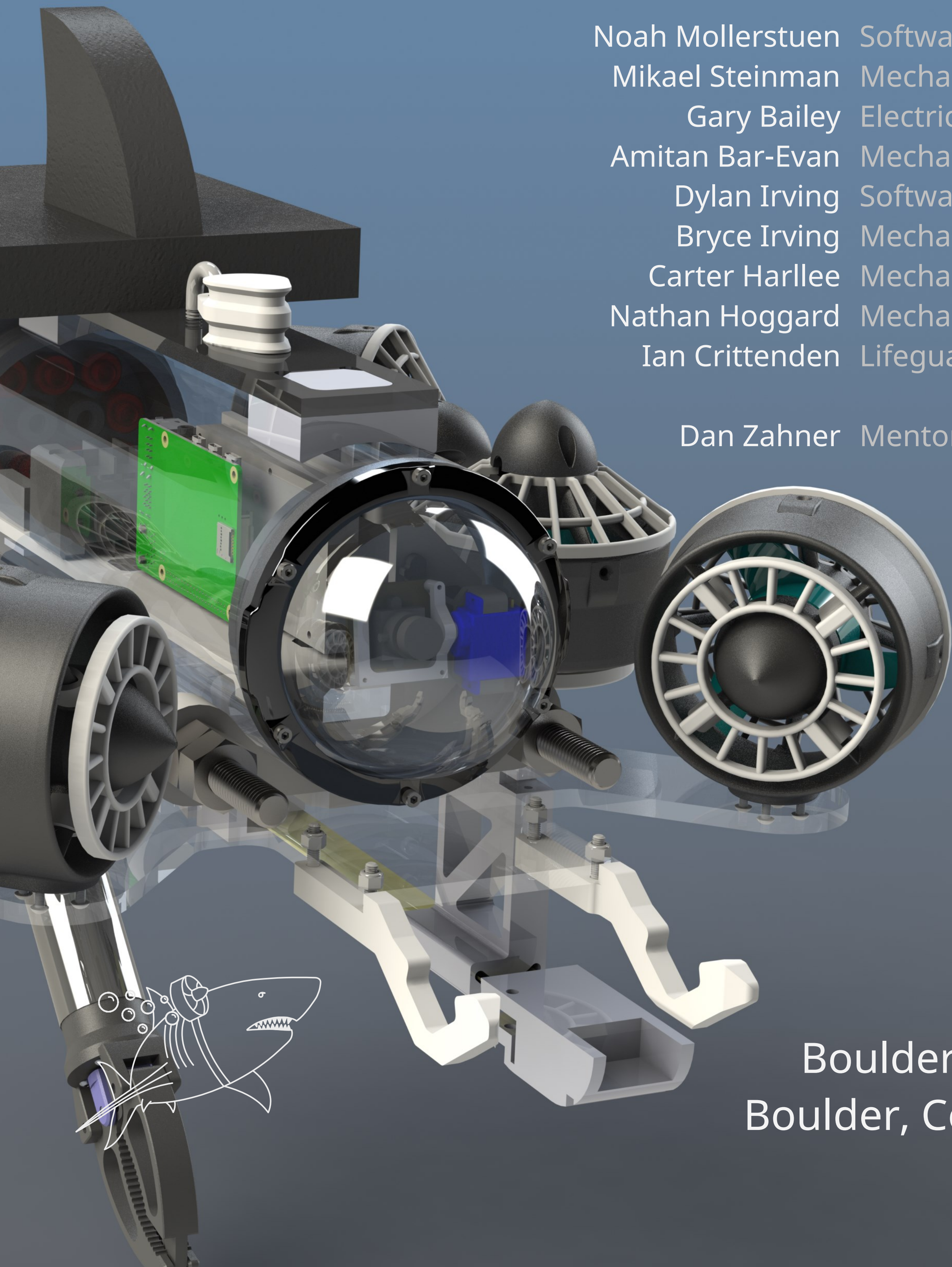

Robosharks
Boulder High School
Boulder, Colorado, USA

The Robosharks Company

Abstract

The Marine Advanced Technology Education (MATE) center released a request for proposals to address a number of crucial issues facing the global community: plastic pollution, the loss of coral reefs, and the contamination of waterways. Based out of Boulder High School in Boulder, Colorado, our company — the Robosharks — seeks to solve these issues. Our flagship product is Hammerhead, a remotely operated vehicle (ROV) equipped to assist in the remediation of these global issues.

Hammerhead is an innovative, simple, reliable, and minimalistic ROV designed to clean up plastic pollution and monitor reef and other marine health. We solved numerous complex problems facing Hammerhead's design, and used pre-existing technologies and commercial off-the-shelf parts to ensure simplicity, reliability, and a short development time.

This document gives an overview of the ROV systems and construction and the design rationale that led to the final product.

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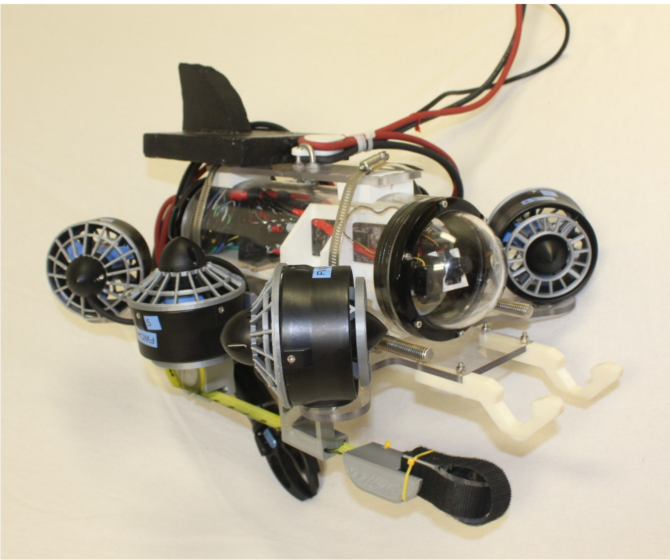
Design Rationale

Mechanical

Hammerhead costs $3,129.70. It is 52.5 x 37.8 x 48.1 cm and weighs 12.47 kg on land.



Hammerhead on land

Its frame consists of a Blue Robotics 4" sealed acrylic tube attached to a polycarbonate plate with hose clamps. We chose polycarbonate for the base plate because it is strong, durable, and transparent. The transparent material allowed us to locate the cameras inside the acrylic tube.

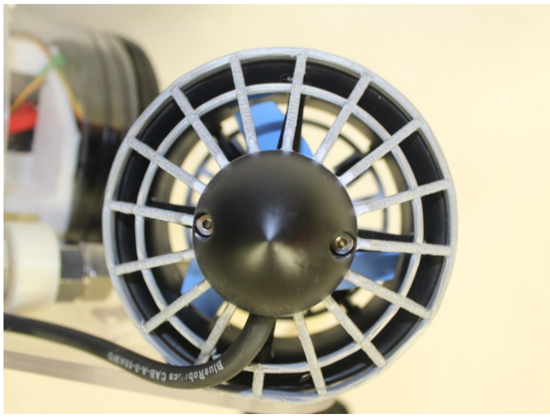
We designed Hammerhead without an external frame, in order to improve mobility and reduce weight, cost, drag, and complexity. While a smaller size does mean our electronics components must fit in a smaller space, we were able to work around this constraint through careful design and efficient cable management. A smaller frame also has the benefit of making the ROV easier to transport and manage.

Many of the requested tasks involve moving props of various kinds to and from the surface. To accomplish this, we designed Hammerhead with three different manipulators: a passive front manipulator for tasks such as the Seabin, an active gripper manipulator for the ghost net and coral, and an extending tool for retrieving the sediment sample.

The ROV changed significantly from the original design. Our first design had two custom active gripper manipulators, but after a faulty seal led to the flooding of one of the motor enclosures, we decided to try having only passive manipulators. Although this worked quite well, we decided to go with a hybrid approach: having one passive and two active manipulators. For our active manipulator, we purchased the Blue Robotics Newton Gripper to go on the bottom and complete the tasks our passive manipulator could not complete. The benefits of passive manipulators are that they are cheaper, lighter, and offer more tolerance of error. The Newton Gripper has the benefits of being more versatile, allowing us to complete more tasks.

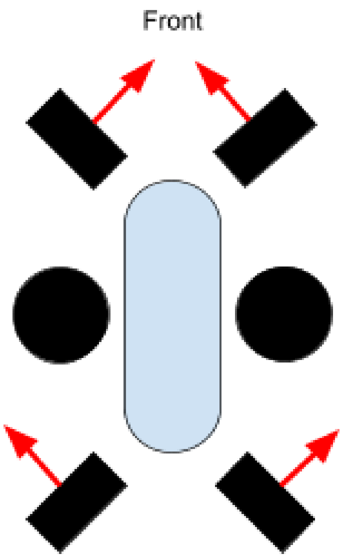
Propulsion

Hammerhead uses six T200 thrusters from Blue Robotics. Four thrusters perpendicular to the center of the body provide translational control in the horizontal plane and responsive yaw control. To increase maximum speed, we arranged the thrusters in an "X" configuration so all thrusters can contribute to lateral and longitudinal movement. Two thrusters to the left and the right of the electronics tube provide vertical axis control. These thrusters can be easily shifted forward and backwards to ensure they are in line with the vehicle's centers of mass and drag, so that the vehicle will not pitch when it moves up or down. The vertical thrusters are also able to provide roll control, but we found that the ROV is stable enough that this was not necessary.

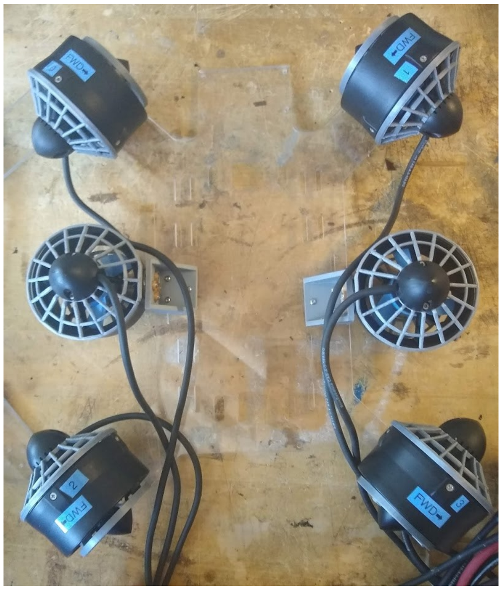


A T200 thruster with guard

These 6 thrusters can draw significantly more than the maximum current of 25 amps when used together. However, we were able to overcome this issue by dynamically calculating the current and throttling down the thrusters to be within limitations. The biggest limitation with our thruster arrangement is the lack of pitch control, but we found this not to be necessary due to our buoyancy system.



Thruster forces while accelerating forward

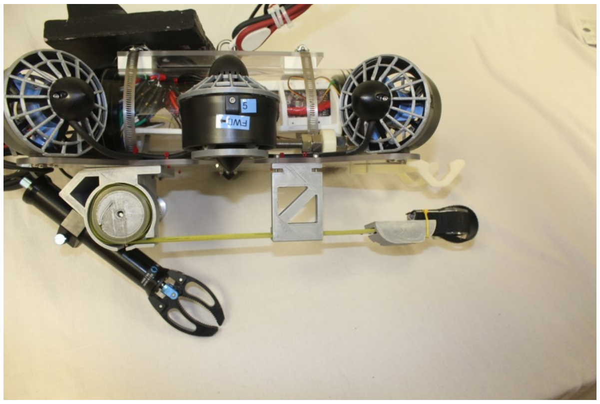


Hammerhead thruster layout

Manipulators

Profile of the front manipulator

Hammerhead has three different manipulators, each designed to complete a different set of tasks. Hammerhead's front manipulator consists of a pair of hooks, carefully shaped to securely hold lengths of PVC pipe while being able to easily grab and release them. This passive manipulator is well suited for tasks such as deploying and retrieving the Seabin power connector. In addition to the hooks, Hammerhead is equipped with a Blue Robotics Newton Subsea Gripper mounted to the bottom of its main polycarbonate plate. This active manipulator is used for the ghost net pin, propagating the corals onto the reef, and other tasks that are difficult or impossible to complete with a passive manipulator.

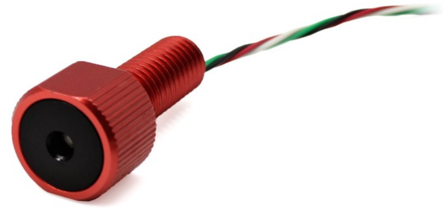


Sediment sample retriever

Hammerhead's final and most unique manipulator is used for retrieving the sediment sample from the drainpipe. It uses a custom built motor enclosure and a 3d-printed spool to extend a tape measure blade to the end of the drainpipe. On the end of the tape measure is a sled, which slides along the bottom of the drainpipe. The sled has two loops of hook tape, which attach to the sediment sample securely enough to easily pull it out of the pipe when the blade is retracted. This system only requires one motor and does not require any electronics or wires to be deployed into the pipe. This makes it reliable, lightweight, and cost effective.

Sensors

Hammerhead is equipped with two USB cameras in its electronics enclosure, each with a clear view of one or more of the manipulators. One camera is in the front of the tube and another is on the bottom of the electronics tray. The front camera is on a servo that can tilt vertically allowing a greater field of view for the pilot.

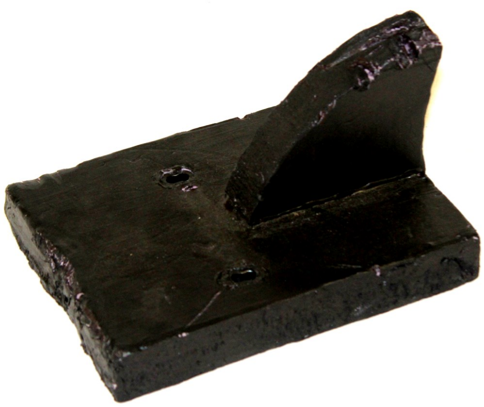


Hammerhead's depth sensor
Image credit: Blue Robotics

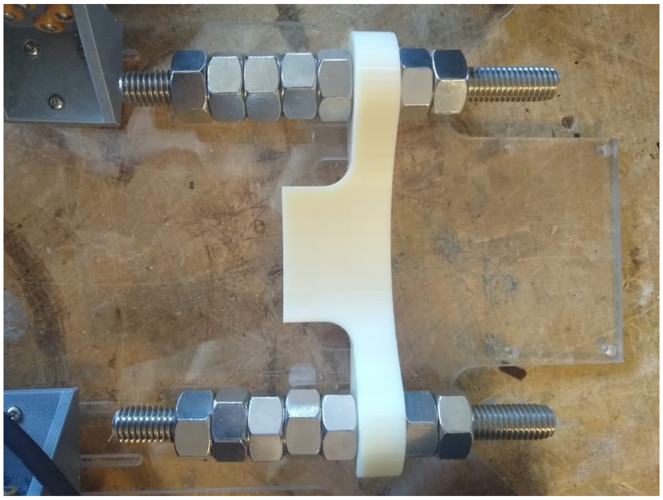
To provide active depth control, Hammerhead is equipped with a depth sensor from Blue Robotics. This simple sensor allows the ROV to remain stable in the case of currents or unexpected forces that push the vehicle away from a stable depth.

Buoyancy and Ballast

While designing Hammerhead, our goal was to make the ROV neutrally buoyant. Mathematically, this means the weight of the ROV must be equal to the buoyant force, which is equal to the weight of the displaced water. To keep the vehicle stable on the pitch and roll axes, the center of mass needs to be well below the center of buoyancy. To achieve this, we used blocks of foam to increase buoyancy at the top of the ROV and used an adjustable system of nuts and threaded rods to increase weight at the bottom of it.



Painted buoyancy foam



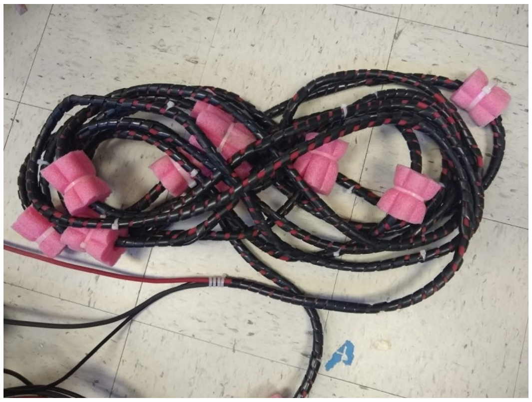
Hammerhead's ballast rods

Electrical

An electrical SID can be found in Appendix A. The components of the electrical system are described below.

Tether

Hammerhead's 20m tether consists of only three cables: two welding cables to supply 12V DC power to the ROV, and an ethernet cable to carry data between the onboard computer and the topside control box. We chose 8 AWG welding cable primarily because it has a low enough resistance while not being too heavy or inflexible. Low resistance is important because, due to Ohm's Law, more resistance in the cable leads to more voltage drop across the cable as more current is drawn, which could lead to brownouts on the ROV side under high loads. Buoyancy foam is attached to several points along the length of the tether to achieve neutral buoyancy.

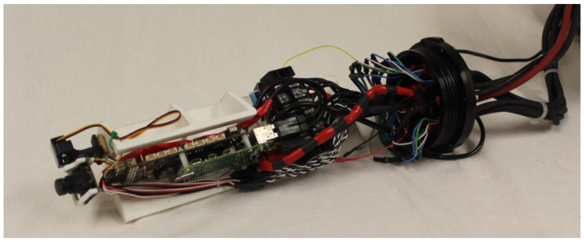


Hammerhead's tether

The tether is wrapped in a figure-eight pattern around two poles on our tether spool, so as to minimize twisting of the cables. During the product demo, the tether manager will control the amount of slack in the tether to ensure that the tether does not obstruct the ROV's path while making sure that the ROV has enough tether to easily maneuver its way through the water.

Onboard Electronics

All of Hammerhead's onboard electronics are contained within a 4" Blue Robotics acrylic tube. They are attached to a custom 3D printed sliding tray that can be easily removed for maintenance. The only onboard computer is a Raspberry Pi 4, with an attached VMX-Pi, a daughterboard designed for robotics applications. This combination was chosen because it provides ample processing power, all the necessary connections for motor controllers, and it allows us to use the WPILib software suite, a robotics control suite we have experience with from the FIRST Robotics Competition.



Removable electronics tray

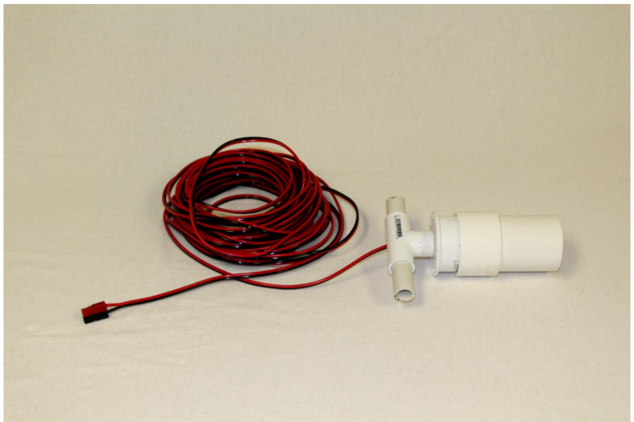
Power is distributed by two terminal blocks near the back of the tray. The terminal blocks stack, but the top one can be easily removed to assist with adding or removing wires to the blocks.

Motors and controllers

The 6 T200 thrusters are controlled by 6 Blue Robotics Basic ESCs, which are connected to the VMX via PWM. In addition, the motor that drives the sediment sample retriever is controlled using a basic H-bridge speed controller, and the Newton Gripper is controlled directly by the VMX over PWM. The wires that connect to the thrusters and manipulators pass through waterproof cable penetrators in order to enter the electronics tube.

Seabin power connector

The power connector to the Seabin consists simply of a 12-volt inductive power transmitter connected to a topside power supply via a long cable.

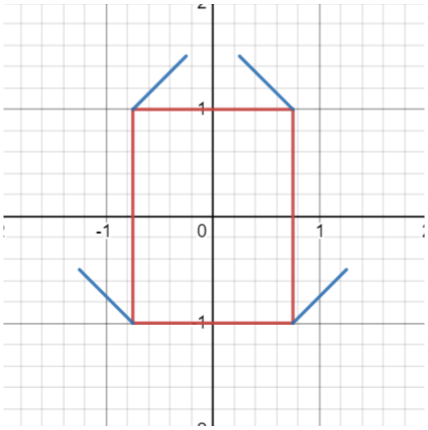


The power connector for the Seabin

Software

Control Software

The majority of Hammerhead's code runs on a single Raspberry Pi 4 in the electronics enclosure. This software was written in the Java programming language making use of the WPILib framework, a robotics programming library usually used for the FIRST Robotics Competition. WPILib provides abstraction that makes it easy to program robots without dealing with low level communications and networking protocols.



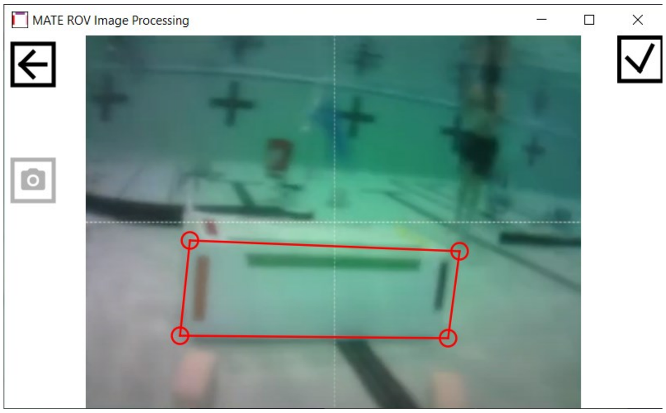
A model of thruster forces
Image credit: Desmos

The main function of the onboard code is to take the pilot inputs from an Xbox controller and translate them into the target output thrust for each thruster. To accomplish this, we created a mathematical model of the forces created by each thruster. By quantifying the amount by which each thruster contributes to the overall motion of the robot on each axis, it is possible, using linear algebra, to work backward to determine the correct thrust for each thruster to achieve the desired movement. Blue Robotics provides public thruster data for their T200 thrusters, so once the correct thrust for each thruster is determined, the code simply looks up the correct PWM value to achieve the target thrust.

In addition to the pilot's inputs, the code also takes into account the depth, yaw angle (measured via IMU), and tether current (calculated from the input voltage to the VMX-pi). Depth and yaw are both actively stabilized, meaning the ROV will use its thrusters to hold its angle and position even in the presence of external forces. All of these features work behind the scenes to make Hammerhead extremely smooth and intuitive to control.

Photomosaic

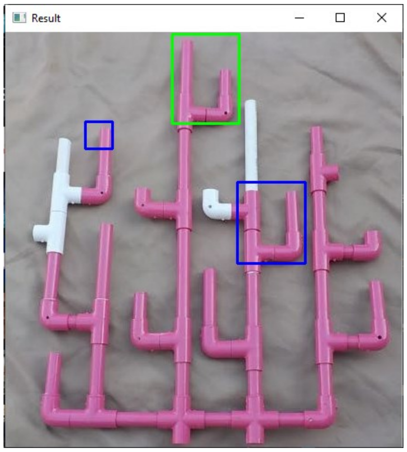
To create a photomosaic of the submerged subway car, the Robosharks developed a desktop application to run on the control box laptop. The primary function of this application is to transform images captured from Hammerhead's cameras and stitch them together. Because the images may not always be captured head-on, the program allows the user to select a quadri-



Robosharks image processing application lateral region from the image and generates a head-on perspective by transforming the image. Then it automatically combines these images into a photomosaic.

Coral Colony Change Detection

In addition to the photomosaic program, the Robosharks developed a second application which runs on the topside laptop. The purpose of this application is to autonomously detect regions of change in the coral colony. The program takes a single frame from the live camera feed and then uses OpenCV to find the pink and white regions of the image (the coral colony). It then applies a modern skeletonization algorithm to simplify the image so it can be represented with a tree data structure. This tree is then compared to the known tree which represents the original coral colony, and any changes are located and displayed to the user.



Coral colony change detection software

Autonomous Transect Flight

To tackle autonomous flight of the transect, the Robosharks developed a program that evaluates the video feed from Hammerhead's bottom camera and adjusts the course of the ROV based on features captured with computer vision. Using the OpenCV Java library, the ROV locates the blue pipes in the image. It then adjusts the ROV's yaw, depth, and horizontal position to keep the ROV headed in the right direction. This program runs on the ROV's onboard computer to minimize latency, which is crucial for a real-time application.

Command and Control Box

Hammerhead's control box is contained within a Condition One waterproof case in order to protect the sensitive electronics inside from splashing or drips from the operating environment. The electronics are mounted to a custom aluminum extrusion frame.

Topside control box

In addition to a laptop, the control box contains two external monitors. One displays the camera feeds and other vital information to the pilot, while the other is used by another team member to simultaneously perform image processing tasks. The central laptop screen contains robot status information, including the remaining time in the product demonstration.

Control box interior

All of the wiring is contained beneath a laser cut table that can be easily raised to provide access. Wires are secured with Velcro and cable ties to keep them from getting tangled and to assist with maintenance. Also in the wiring compartment are two Xbox controllers, which are used to pilot the ROV. Xbox controllers were chosen over joysticks because they are smaller, more intuitive to use, and provide more independent axes than a joystick. Our controllers also have two non-standard buttons on the back side, which are used to increase or decrease the sensitivity of the controls while moving. Because they are on the back, the pilot does not need to remove their thumbs from the thumbsticks to press these buttons.

Pilot's Xbox Controller

Build vs. Buy, New vs. Used

The decision of whether to build or buy parts was mostly determined by how critical and how complex the part was, as well as the cost. Commercially made components can offer more reliability and complexity. On the other hand, custom made parts can be better made to fit our specific needs and are often more cost effective.

Of the items we did buy, some we bought because they were highly critical parts that required the precision and reliability of commercially manufactured items. These items include parts such as the cable penetrators and the main acrylic tube that houses the electronics. The rest of the items we bought included the ROV's active manipulator, thrusters, and all of its electronics, as these parts are too complex for us to manufacture ourselves.

Custom made parts offer the benefit of being the exact part that is needed, as well as generally being more cost effective. Many of the parts we manufactured are relatively simple but perfectly fit to their purpose. We made most of our custom parts via 3D printing and CNC machining. The ROV's main polycarbonate base plate, top plate for strain relief, and buoyancy foam were all cut on a CNC router, while the passive manipulators, sediment sample retriever mounts, support pieces, and electronics tray were all 3D printed.

This was our first year with MATE, so all of the physical components were new. We previously competed in the FIRST Robotics Competition (FRC), but were not able to reuse parts due to vastly different requirements.

Innovation and Problem Solving

Designing and building an ROV in the midst of a pandemic was a significant challenge. At the beginning of the project, we could not meet as a team to design and build our product. In order to move forward, we met virtually once a week via Discord and used Solidworks to design our ideas and share them with the rest of the team.

Many initial designs for each piece of the ROV had to be changed due to time, unconsidered variables, reliability, and durability. We tested Hammerhead in a pool several times throughout construction, and each test exposed new obstacles. We used the same process to resolve every issue: we start by identifying the underlying problem, then move to discussing a solution. After that, we would implement the proposed solution, test it, and if needed, repeat the process until we had a functional and reliable product. Here are specific examples of our team's innovation:

Near the beginning of the project, we spent about a month working with some motor controllers that support CAN bus, a robust data protocol used commonly in the FIRST Robotics Competition. However, this protocol proved to be unnecessarily complicated, and provided little real benefit. Realizing this, we switched to extremely simple and reliable PWM speed controllers.

During Hammerhead's first pool test, on March 13th, we discovered that our buoyancy calculations were off, resulting in the ROV pitching back and sinking. As a temporary fix, we used a shoelace to secure small pieces of pool noodle to the back of the ROV, adding or subtracting pieces of foam until the ROV was neutrally buoyant and level. With each pool test came modifications, which changed the buoyancy, so we attached threaded rods that easily allow us to add or remove nuts as ballast.

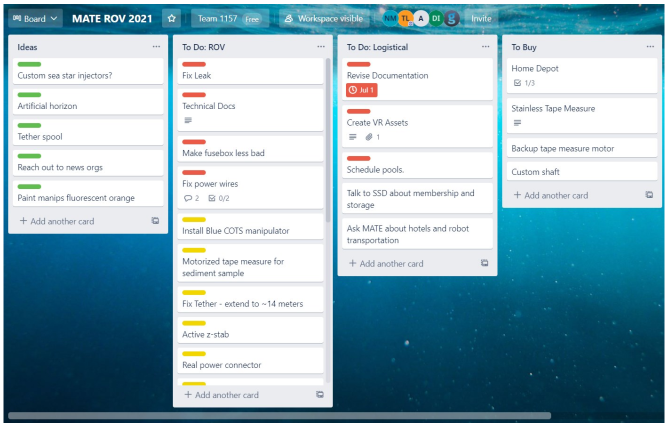
At a later pool test, during which we intended to test Hammerhead's active manipulators, the motor housing for our custom manipulator flooded, rendering the motor and manipulator useless. To continue testing other aspects of the ROV, we zip-tied an Allen key to the front ballast rod to act as a hook. After testing with the Allen key, we realized that in some cases, passive manipulators are perfectly adequate, and are much more reliable than active manipulators. After this, we designed and 3D printed a passive manipulator hook for the front of the ROV. After more testing, we proved that this solution worked better than our custom gripper, so we switched Hammerhead's secondary manipulator to a passive hook as well. While competing at our regional however, we discovered that some tasks are much more difficult with a passive manipulator, so in the end we decided to go for a hybrid solution: a passive hook on the front and the Blue Robotics active gripper on the bottom.

Project management

Our company is structured around individual subteams, with members having overlapping roles. These subteams are generally headed by the most experienced person in that field, but everyone contributes to discussions and has agency in the work they do. For critical roles such as the ROV pilot, we assigned the role by hosting tryouts to allow people to demonstrate their talent, then ran an election to choose the pilot.

Our schedule was centered around dates where we could get access to test facilities, with project goals set for completion by those dates. Between these dates we worked on the ROV every day except Sundays, with team members showing up when they were able. Outside of our meetings, we communicated over Discord to plan and discuss possible changes and issues.

To keep on track during meetings, the company used Trello to keep a prioritized to-do list of tasks.



The Robosharks' Trello board

Safety

Safety is very important to the Robosharks. Hammerhead is equipped with several safety features, including propeller guards and tether strain relief. For more information, please see the attached Job Site Safety Analysis (JSA) and Company Safety Review in Appendices B and C.

To ensure personnel safety during ROV construction we followed operating instructions, required training for certain equipment, and wore safety glasses, hearing protection and other PPE.

Critical Analysis

Our first phase of testing took place in our workshop. When working on wiring and programming, we plugged in the ROV to do stationary testing. This type of testing is efficient because it makes it easy to make changes quickly and allows us to make better use of our limited testing time at the pool.

One Saturday at the pool, we placed the ROV in the pool after some very quick code adjustments. The ROV worked correctly the week before so we were very surprised to see that the control system was wrong: forward was yaw, and up was roll. We took the ROV out of water and ran a simple program that spun each thruster in the correct direction. We discovered the problem to be that 4 of the 6 motor controllers were connected to the wrong thrusters. After trying unsuccessfully to correct this in the programming, we dried the ROV off and swapped some of the wiring on the inside. This fixed our problem.

Another time during development, Hammerhead could make coarse movements underwater, but when we tried to make fine adjustments, it would rotate uncontrollably around the yaw axis. We determined this problem came from the weight of the tether and it was almost impossible to do some of the tasks within the time limit. To solve this problem, the team researched the PID algorithm, which allowed us to correct for errors in position. We included a proportional yaw error correction in the code, and it solved the problem.

References

MATE Competition Website

WPILib Control System

T200 Public Thruster Data

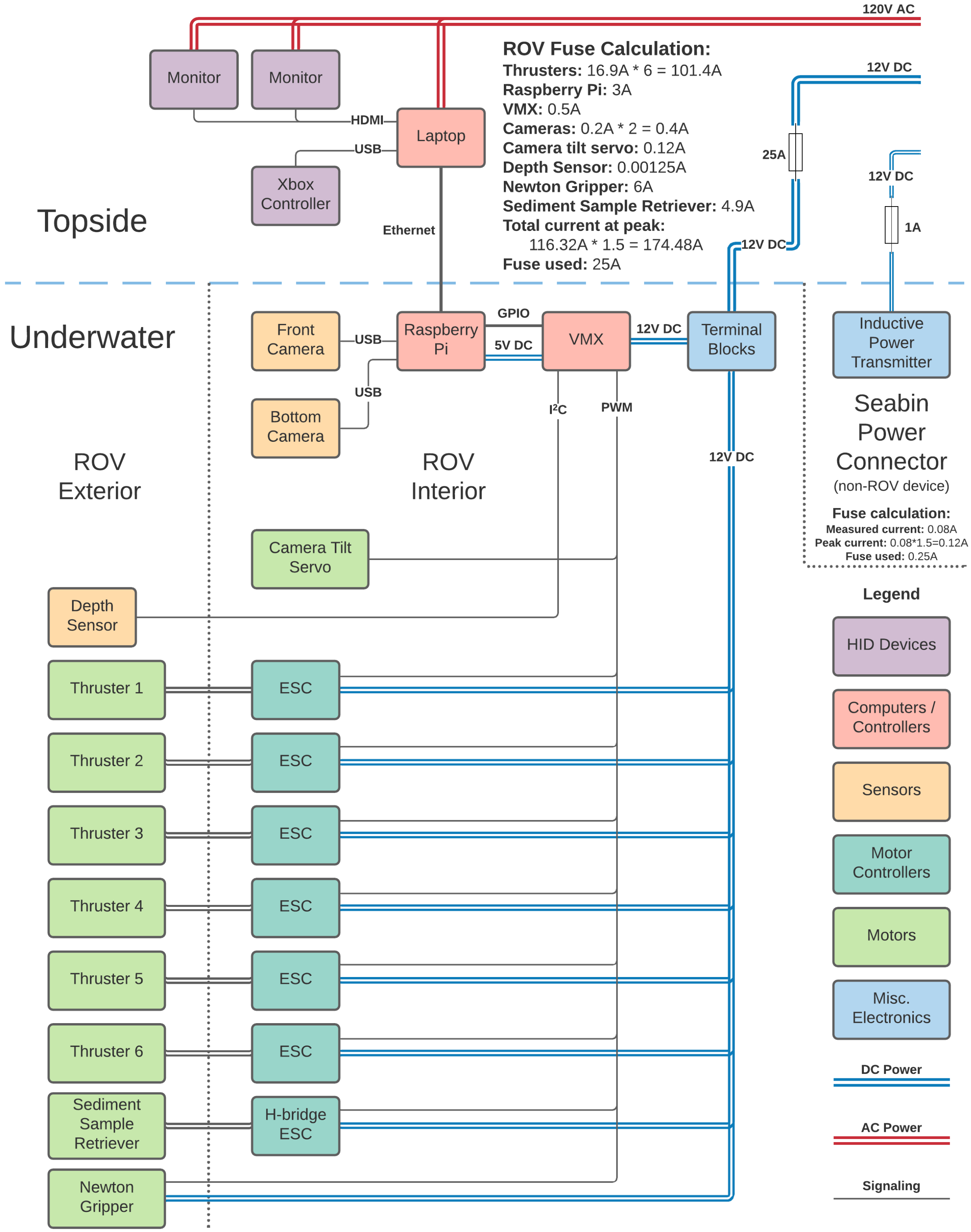
Acknowledgements

We would like to thank the following people and groups:

- Jim and Dede Bartlett Foundation
- Solid State Depot
- Ocean First
- Boulder Elks
- Boulder Parks and Recreation
- MATE

Appendices

Appendix A: Electronics SID (including non-ROV device)



Appendix B: Job Site Safety Analysis

Job Task	Potential Hazards	Control Measures
Entering/exiting the pool area	Slipping on pool deck	Be aware of surroundings Walk, don't run
	Dropping equipment	Secure all equipment in appropriate containers
	Lifting injuries	Ask for help lifting heavy objects
System setup	Getting water on equipment	Don't place equipment on floor Keep cables away from water
	Tripping over wires	Pay attention to where the tether is Keep wires flat on the ground
	Environmental factors	Do not operate ROV in electrical storms
Power-up checks	Voltage spikes	Turn off power supply before plugging in ROV
	Electric shocks	Check for loose wires Keep cables away from water
Poolside operations	Falling in pool	Do not reach far over edge of pool to retrieve props Have a lifeguard present
	Injury from ROV	Wait until all ROV motors have stopped before reaching into water
Clean-up	Falling in pool	Do not reach too far out into pool to retrieve ROV
	Injury from lifting ROV	Ask for help lifting heavy objects

Appendix C: Company Safety Review

Main Fuse

The main fuse is a 25A slow-blow positioned within a foot from the power source. Here is the calculation:

Thrusters: 16.9A * 6 = 101.4A
Raspberry Pi: 3A
VMX: 0.5A
Cameras: 0.2A * 2 = 0.4A
Camera tilt servo: 0.12A
Depth Sensor: 0.00125A
Newton Gripper: 6A
Sediment Sample Retriever: 4.9A
Total current at peak: 116.32A * 1.5 = 174.48A
Fuse used: 25A

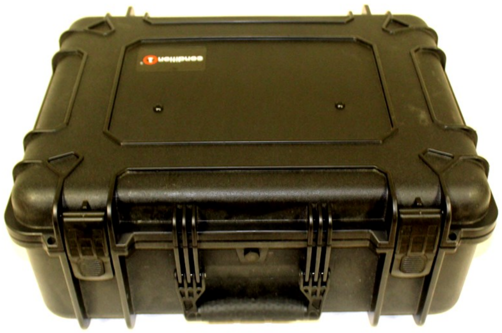
Power Connector Fuse

There is a second 0.25A fuse specifically for the Seabin power connector. Here is the calculation:

Measured current: 0.08A
Peak current: 0.08A * 1.5 = 0.12A
Fuse used: 0.25A

Control Box

All of the topside electronics with the exception of the power supply are in a water resistant carrying case. The structure supporting the laptop and monitors are made out of 8020 aluminum. The wires are secured in bundles using zip ties and are secured to the box with tape.



Water-resistant case

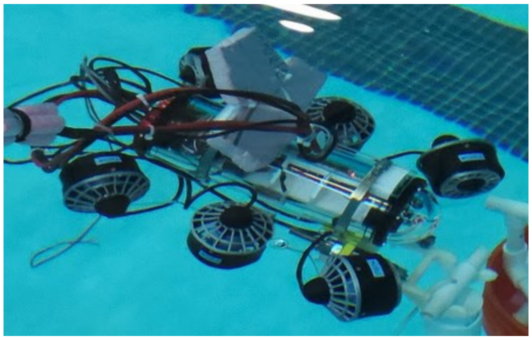
Tether Strain Relief

Before going to the end cap, the tether loops tightly through a hook secured to the robot's main body, so that the end cap is under no tension.

Tether strain relief

Electronics Housing

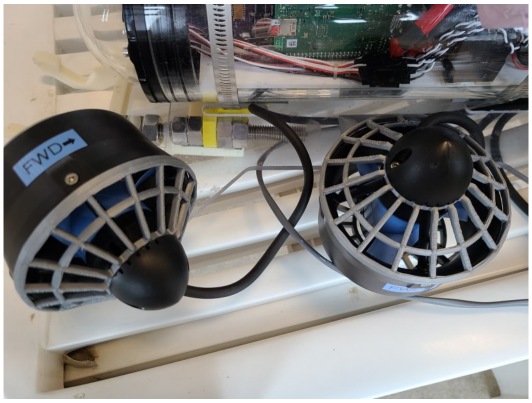
The housing is a Blue Robotics 4 inch acrylic tube and can withstand pressure of up to 100 meters according to company data.



Waterproof electronics tube

Propellor Guards

The propeller guards are 3D printed parts made for the specific model of thruster in use on Hammerhead. They are rated and tested at IP-20.



Propellor guards

Fluid Power

Fluid power is not used on the ROV.

Powered Non-ROV Device

The only powered non-ROV device in use is the Seabin power connector. Care was taken to ensure that the connector is waterproof and fully compatible with the Seabin's power input.

Dangerous Parts

There are no sharp or dangerous parts on the ROV.

Appendix D: Bill of Materials

ROV Materials	Cost ($)
6 Blue Robotics T-200 thrusters	$1,200.00
6 Thruster Speed Controllers	$120.00
4" Acrylic Enclosure	$90.00
Dome End Cap	$39.00
2 O-ring Flanges	$58.00
Aluminum End Cap (14 holes)	$28.00
Penetrator Vent	$9.00
Penetrator Blank	$4.00
9 Aluminum Cable Penetrators	$45.00
Blue Robotics Depth Sensor	$70.00
Blue Robotics Newton Gripper	$439.00
Blue Robotics Camera Tilt System	$39.00
Custom Machined Motor Shaft	$187.98
ServoCity 280 RPM Gearmotor	$29.99
Stainless Steel Tape Measure	$15.99
200ft Welding Cable	$149.96
75ft Ethernet Cable	$15.99
1.5 x 1 ft Polycarbonate sheet	$35.00
30 in^3 of ABS Filament	$30.00
VMX Robotics Controller	$399.00
2 Spinel Electronics USB Cameras	$108.00
Wide Angle Lens	$11.79
2 Terminal Blocks	$5.00
5 25A Fuses	$11.43
Fuse Holder	$13.49
Miscellaneous Nuts & Bolts	$40.00
Total	**$3,129.70**

Appendix E: Project Costing and Budget

						Reporting Period	
School Name				Boulder High School		From:	10/1/2020
Insttuctor/Sponsor				Daniel Zahner		To:	8/8/2021
Funds							
Date	**Type**	**Category**	**Expense**	**Description**	**Sources/Notes**	**Amount**	**Running Balance**
10/1/2020	Re-used	Electronics	Laptop	Dell Latitude E7470	Used in control box	$ (369.69)	$ (369.69)
10/1/2020	Donated	General		Donation from the Jim and Dede Bartlett Foundation	Used for vehicle construction	$ 5,000.00	$ 4,630.31
11/25/2020	Re-used	Hardware	Polycarbonate sheet	12" x 18" x 1/4" Polycarbonate sheet	Used as the ROV baseplate	$ (35.00)	$ 4,595.31
11/25/2020	Purchased	Hardware	Misc ROV Parts	Bolts, Ballast, Hose Clamps	Used in ROV construction	$ (91.36)	$ 4,503.95
11/26/2020	Purchased	Electronics	Terminal Blocks	2 Eight circuit terminal blocks	Only used in prototype	$ (40.10)	$ 4,463.85
12/1/2020	Purchased	Electronics	Crimps	Ring-terminal crimps, Butt splices	Used in electronics tray	$ (55.18)	$ 4,408.67
12/9/2020	Purchased	Electronics	ROV Sensors	Depth sensor, Camera tilt system	Used in the ROV	$ (163.68)	$ 4,244.99
1/11/2021	Purchased	Electronics	Terminal Block Jumpers	16 Jumpers	Only used in prototype	$ (11.34)	$ 4,233.65
1/27/2021	Purchased	Hardware	Motor enclosure parts	Various material for a custom motor enclosure	Used in ROV construction	$ (200.49)	$ 4,033.16
4/5/2021	Purchased	Hardware	Misc ROV Parts	Bolts, Fuses, Gears	Used in ROV construction	$ (239.15)	$ 3,794.01
5/7/2021	Purchased	Food	Pizza	Pizza for regional party		$ (120.94)	$ 3,673.07
5/8/2021	Purchased	Electronics	Cameras	2 Spinel Electronics USB cameras	Used in ROV construction	$ (78.86)	$ 3,594.21
6/21/2021	Purchased	Electronics	Inductive Charger	2 TinySine inductive charger	Used for power connector	$ (38.80)	$ 3,555.41
6/22/2021	Purchased	Hardware	New Endcap	Blue Robotics endcap, Penetrator blanks	Used in ROV construction	$ (50.00)	$ 3,505.41
6/25/2021	Purchased	Hardware	Fuse holder	Splashdown inline fuse holder	Used in ROV construction	$ (22.31)	$ 3,483.10
					Total Raised	$ 5,000.00	
					Total Spent	$ (1,516.90)	
					Final Balance	$ 3,483.10	

					Reporting Period	
School Name			Boulder High School		From:	10/1/2020
Instructor/Sponsor			Daniel Zahner		To:	8/8/2021
Income						
Source				**Amount:**		
Jim and Dede Bartlett				$ 5,000.00		
Expenses						
Category	**Type**	**Description/examples**	**Projected cost**	**Budgeted value**		
Electronics	Purchased	Pi, ESCs, Motors, etc.	$ 1,000.00	$ 1,000.00		
Hardware	Purchased	Acrylic pipe, 8020, Polycarb, etc.	$ 1,000.00	$ 1,000.00		
Props	Donated	MATE competition props	$ 400.00	-		
Food	Purchased	Pizza or Chipotle ordered at meetings	$ 500.00	$ 1,000.00		
Travel	Purchased	Airfare, Food, and Room for World Championship	$ 10,000.00	$ 10,000.00		
			Total income	$ 5,000.00		
			Total expenses	$ 12,900.00		
			Total expenses reuse/	$ 12,500.00		
			Total fundraising	$ 7,500.00