AscendTech

Technologies Inc.

Archelon ROV 2016 - 2017
AscendTech 4-H Robotics Club
Monmouth County, New Jersey, USA

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I. Introduction

A. Abstract

Archelon is AscendTech Technologies Inc.'s first Remotely-Operated Vehicle (ROV), and is designed with the purpose of streamlining commerce as well as benefiting the health and safety of the general public. *Archelon* features powerful, advanced image-processing software as well as a robust, modular, economical design. As a lightweight and compact vehicle, the *Archelon* ROV is perfect for operating in precarious conditions to address the issues on our sea ports and water fronts.

AscendTech Technologies is an independent robotics technology firm founded in August 2016 after the disbandment of the FuryTech company of High Technology High School. This technical report describes the development process and design details that make *Archelon* the optimal ROV to fully meet the requirements specified in the Port of Long Beach Request for Proposals (RFP).

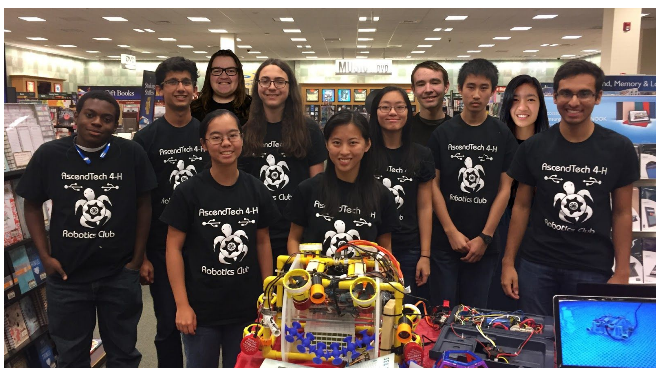


Figure 1: Company photo of AscendTech Technologies Inc.

II. Design Rationale

A. Structure (Frame)

In order to provide structure and support for the thrusters, ½" polyvinyl chloride (PVC) tubing is utilized to construct a frame for the ROV. The water-resistant, lightweight, and readily-accessible properties of PVC make this material a perfect choice. The safety yellow piping is designed to secure structural integrity without sacrificing weight, with the pipes and connectors dimensioned to ensure a proper fit between each piece of tubing. The holes also allow for easy draining of the piping and eliminates the difficulty of ensuring watertight seals in the PVC tubes.

To improve the movement of the robot, two polypropylene wings are attached to the PVC frame. These wings are manufactured with 0.9525 centimeter thick polypropylene sheets cut into a rectangular shape with a semi-circle edges on one side and tear-shaped edges on the other. Two "D" shaped holes, one 12.7 centimeter hole in the center for the electronics tube, four 0.635 centimeter holes for the threaded rods securing the electronics tube, and four 1.27 centimeter (½") holes for the PVC tubing are cut in each tube. The hydrodynamic shape of the wings allow the movement of the robot to be streamlined.

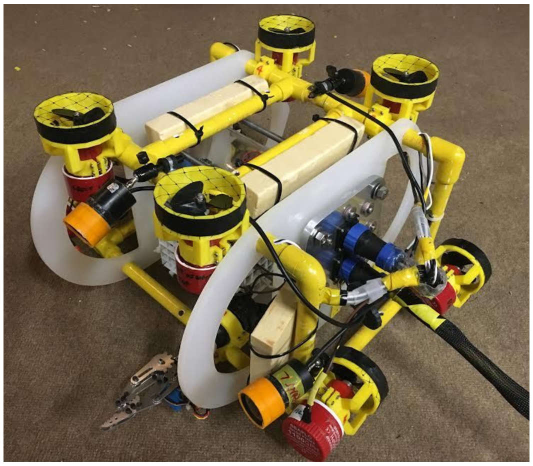


Figure 2: Frame with motors and claw attached

The tubing is fed through the 1.27 cm holes, extending 7 cm from the wings on both sides. The pipes perpendicular to each other are all connected by PVC connectors, and are sealed with PVC cement to ensure a rigid bond on all the connections.

B. Bottomside Electronics Tube

Archelon's bottomside electronics are housed in a 12.7 cm diameter acrylic tube sealed with custom-CNC-machined aluminum endcap plates. The aluminum end cap plates consist of a multiple layers of aluminum and rubber, compressed and secured tightly by 8 screws evenly spaced apart.

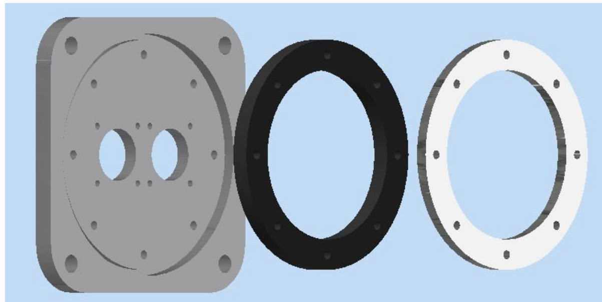
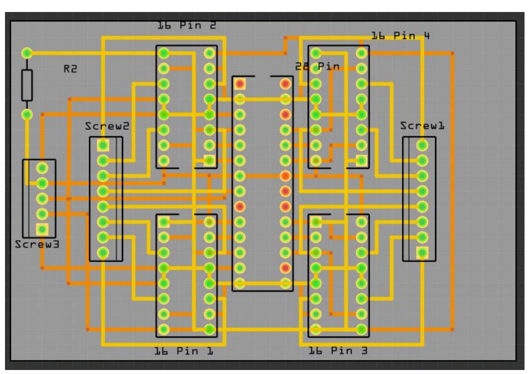


Figure 3: Exploded view of custom-made aluminum endcap plate

Acrylic is chosen because its transparency allows the bottomside electronics to be easily seen, and has nearly-neutral buoyancy properties. The tube's cylindrical shape also adds hydrodynamacy to the overall ROV. The tube's cylindrical shape is selected to reduce drag underwater while maintaining a simple, pressure-resistant geometry.

The endcap plates have IP68-rated, military-grade waterproof connector penetrations, which allow for power supply as well as communication between the Odroid XU4 SoC and the Teensy USB-microcontroller board through the CAN Bus communication protocol.

The bottom side electronics tube is comprised of two distinct control boards, separated into the motor driver and sensor control boards. All integrated circuits (ICs) and microcontrollers have corresponding IC sockets soldered into the boards, so that the electronics are easily replaceable.



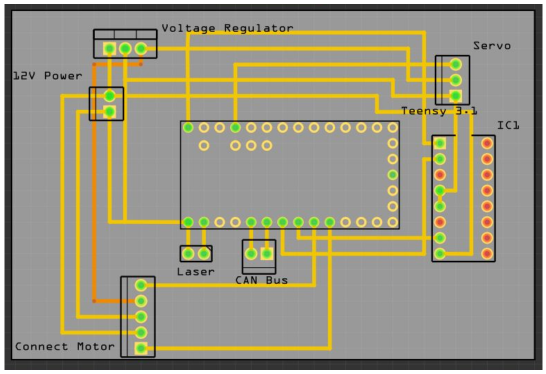


Figure 4: PCB Diagram of Motor Driver Board **Figure 5**: PCB Diagram of Main Control Board

C. Propulsion (Motors)

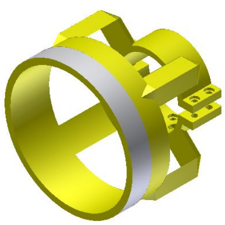


Figure 6: Motor Shield

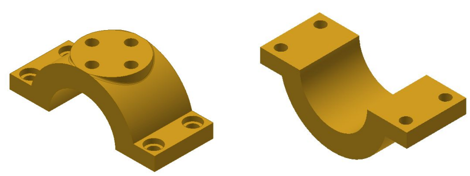


Figure 7: CAD Drawing of PVC Attachment

To ensure that the motors used are completely waterproof, modified bilge pumps are implemented for the ROV. Bilge pumps were chosen because they are brushless and therefore inherently waterproof. The Rule 800 GPH bilge pumpers were chosen after many trials to determine the bilge pump with the most efficient thrust-per-amperage-drawn. The casing for the bilge pump motors were removed along with the impeller. After testing propellers with varying amounts of blades and blade sizes,the three-blade 60 mm diameter plastic model boat propellers were chosen for maximum thrust. These were then installed on all 8 drive bilge pump motors on the ROV with a bilge shaft adapter. The adapter also contains a screw that runs through the center of the propeller, which is then secured with a washer and nut.

The motors are mounted to the ROV using 3D printed housing and attachment pieces that were designed in Autodesk Inventor by two company members. The housing design consists of two semi-circles that clamp around the motor and are tightened with screws and nuts on the side. The PVC attachment design features four holes that align with the four holes on the housing design and clamp down on the PVC similar to how the housing pieces clamp down on the motor. This two piece system for attaching motors is effectively modular, and allows the company to be able to position the motors at precise, desireable locations, giving the motor placement excellent symmetry and the ROV greater stability in the water. The bright yellow color, protective housing, and chicken mesh (placed in front of the propellers) all serve to make the motor safer when it is spinning and to prevent debris from interrupting the movement of the motors.

D. Control System

The control system is designed in a modular fashion for easy maintenance. The thrusters of the ROV are controlled by an ATtiny88 AVR microcontroller, which is connected to a Teensy 3.2 development board through serial communication. The Teensy 3.2 manages the claw and servo, and maintains a connection with the topside control system. There are also 3 cameras underwater which have their own dedicated data wires.

Above water, camera data cables are fed into 3 USB capture cards. These capture cards, as well as an MCP2515 CAN Bus adapter for communication, are connected to an Odroid XU4, which in turn connected wirelessly to 2 computers via a WiFi hotspot. One computer has a program managing the pilot interface, and one has a program managing the copilot interface.

Both programs host a website on localhost and maintain a websocket connection once the user goes to the site on a web browser. The pilot interface has controls for the claw, laser, and movement. It also includes a 2 frames-per-second view from the main camera. The copilot interface has no controls but has images from all 3 cameras so image analysis may be performed.

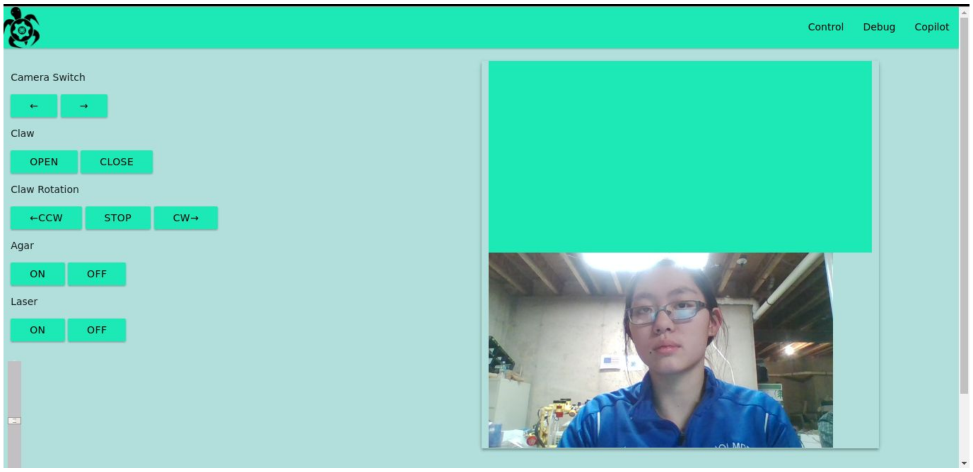


Figure 8: Pilot control interface

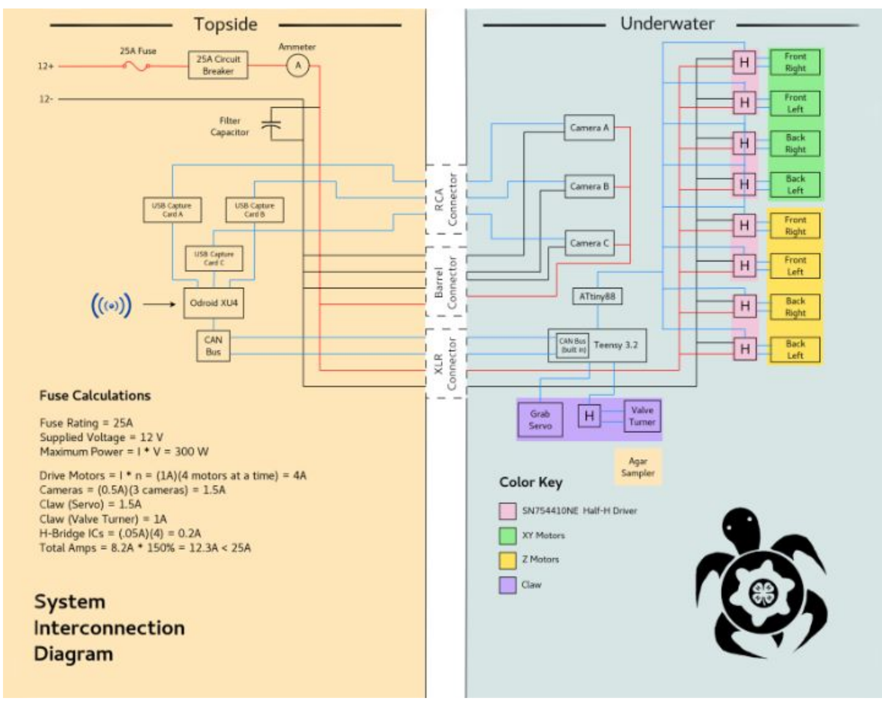


Figure 9: System Interconnection Diagram

E. Ballast System

One of the most significant aspects of ROV operation is maintaining relatively neutral buoyancy. When the ROV is underwater, the forces of gravity and buoyancy simultaneously act on the ROV; keeping the correct balance between the two is crucial in order to allow the robot to remain stable and stationary without having to engage its propulsion system continuously. Neutral buoyancy on the ROV is achieved through a combination of different ballasts and counterweights. The largest ballast is the electronics tube itself; the acrylic tube is sealed with rubber O-rings and aluminum end caps, allowing it to function as a large, airtight ballast. Blocks of closed cell foam are mounted to the top of the ROV in order to make the top more buoyant than the bottom; this is beneficial because it ensures that in the event that the ROV is tilted on its side, buoyant forces will allow it to right itself without operator intervention. Also, holes are drilled into the PVC to allow water to easily enter and exit the frame. Allowing water to enter the frame ensures that the ROV frame does not remain airtight, which would have been difficult to maintain and would have made the ROV far too buoyant. By carefully positioning these ballast components, the company was able to ensure that the ROV would have an overall neutral buoyancy. The ballasts are positioned away from the center of the ROV in order to allow the buoyant forces to exert greater torque, allowing the ROV to right itself more quickly in the event of being tipped over.

F. Camera Sensors

In order to facilitate the operation of the ROV, there are three dual-purpose camera sensors that allow the operator to view the underwater environment as the ROV completes its tasks. The company uses Security Labs SLC-137C cameras and sheaths from previous years but chose to remove the fisheye lenses due to issues with waterproofing. The camera signals are sent to the two poolside laptop monitors for the pilot and copilot.

Figure 10: Camera with orange sheath

The cameras are used not only to give the operators an underwater view but also to determine distances between objects underwater. The two front-facing cameras are constrained to lie in the same plane at a fixed distance from each other. Because the distance between the two cameras is known, the distance from the ROV to an object in both camera's field of view can be calculated by finding the offset between the locations of the object in pictures taken by both cameras. Two images taken by the adjacent cameras are analyzed using ImageJ software, a low-cost photographic image analysis solution. Then, a formula is applied:

$$D = \frac{Bx_0}{2\tan\left(\frac{\phi_0}{2}\right)(x_L - x_D)}$$

where *B* is the distance between the two cameras, x_0 is the number of horizontal pixels in the image, ϕ_0 is the camera's horizontal angle of view, $(x_L - x_D)$ is the offset, in pixels, of the horizontal location of the target object in the two images taken by the different cameras, and *D* is the distance from the cameras to the object (Mrovlje and Vrancic 2).

One difficulty in this calculation is the refraction of light under water. Even if the angle of view ϕ_0 can be determined to a high degree of accuracy in air, water at different temperatures may refract the light, completely throwing off the calculations. This drawback is overcome by using a point on the claw at a known distance in the water to calibrate the cameras each time a measurement is taken, and thus accurately determine ϕ_0 in any circumstances.

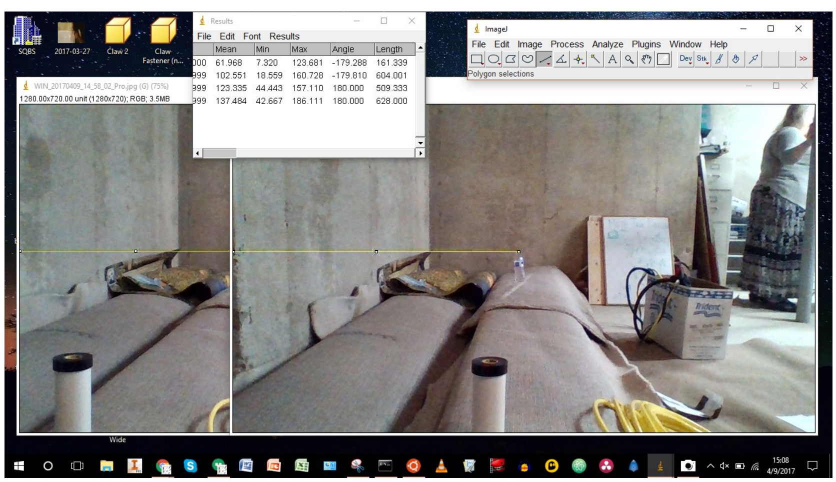


Figure 11: Analysis of two images using the ImageJ software

G. Payload Tools

A. LED Light

The LED indicator light is mounted on the inside of the transparent acrylic bottomside electronics tube. Placing the light inside the tube resolved any difficulties with waterproofing while still allowing it to simulate a Raman spectrometer. The light is powered through the MATE surface power supply and is switched on and off through the surface control monitor.

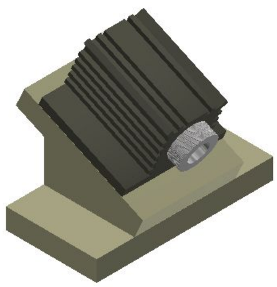


Figure 12: CAD model of Laser and Laser Mount

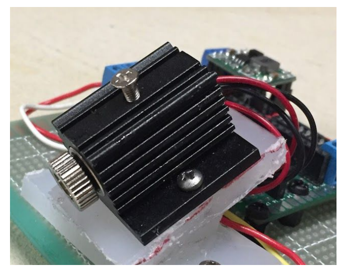


Figure 13: The laser, mounted to the main electronics board

B. Claw

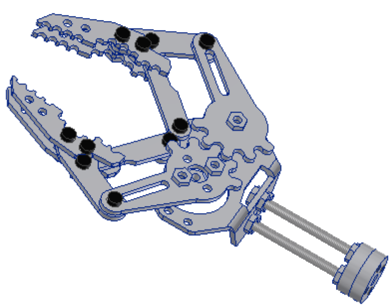


Figure 14: CAD drawing of claw

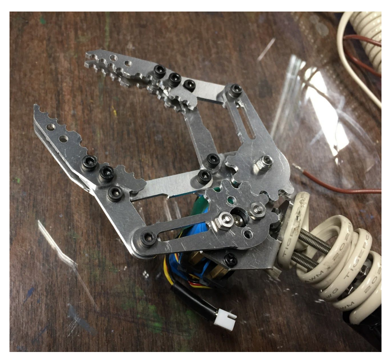


Figure 15: Commercial claw

This year, the company has decided to utilize a commercial claw rather than retain the self-made claw from last year. Last year's claw was bulky and unstable; such a claw would be unsuitable for this year's tasks, which involve navigating inside structures and moving valves by precise amounts. Using a commercial claw ensured that the ROV would be able to maintain excellent performance without sacrificing agility or robustness. In keeping with the ROV's overall theme of compact, efficient performance, the company chose this claw due to its solid build and small size. The claw is controlled by two motors: one 500 GPH bilge pump that rotates the wrist and one servo motor that opens and closes the claw grip.

C. Agar Sampler

Figure 16: CAD drawing of agar sampler

Figure 17: Agar sampler

Our company calculated the volume of agar needed for the mission, and handpicked a 1 ½ inch diameter PVC tube as the container. After conducting research, the company decided to place a one-way valve on top of the PVC tube to create a suction that would help keep the agar in place. After many trials, the company placed an additional valve at the bottom of sampler, so that the agar's weight pushes down on the valve flap, thereby preventing any agar from falling out. The company's agar sampler features durable polyester string at the bottom of the agar sampler to cut the agar into smaller chunks for effortless sampling. The agar sampler also features a PVC ring on the top valve to create a place where the claw is able to grasp the sampler.

H. Troubleshooting

Figure 18: The combination of props built for MATE Ranger 2017 testing

The construction of the ROV required many trials and improvements, from debugging on-board software to stabilizing the robot's movements in the water. The company approached this process of trial-and-error by creating several tools to aid in the troubleshooting process. For instance, the company developed a program to run each motor individually in a loop in order to assess the functionality of each motor and H-bridge. After the airtight seal of the acrylic tube and the proper operation of the motors were determined, the company wrote the necessary software, refined the payload tools, and practiced maneuvering the ROV underwater. In order to give the pilot valuable driving experience and identify issues that may not have been immediately evident during the development phase, the company created props to simulate the actual competition tasks. Unlike last year's props, this year's props were designed to reflect as accurately as possible the dimensions, materials, and structures that would be encountered during the competition in order to simulate more precisely the movements that the ROV would be required to perform.

III. Safety Features and Evaluation

A. Safety Evaluation

As aspiring future engineers, the company members fully recognize the importance of incorporating safety features into all of its projects. The philosophy of AscendTech Technologies is that safety is of the utmost importance, and under no circumstances should any member neglect to follow the rigorous safety procedures in place. Each component of the *Archelon* ROV is designed to be fully functional while being mindful of all safety regulations.

The *Archelon* ROV's design incorporates several safety features, including black indicator tape surrounding the modified bilge pump motors, prominent power connectors to prevent accidental use with household electrical outlets, fully secured wires, and motors that are mounted to the interior of the frame to prevent injury.

Furthermore, the company's officers work hard to highlight the importance of safety during the design process and especially during construction times. All members also agree to abide by all safety rules as stated in the AscendTech 4-H Safety Guidelines, such as wearing safety goggles and appropriate clothing at all times. In this way, the company is able to maintain a safe and efficient environment.

B. Safety Features

Frame:

- Bright yellow coloring for easy visibility underwater
- No loose components
- No sharp edges

Motors:

- 3D printed in yellow for high visibility
- Netting made out of chicken-wire fencing to prevent debris of free floating objects from getting caught

Tether:

- Weatherproof cable for data and power
- Audio connector plugs that clip on so that they don't come out by accident
- All ports are labeled
- Tether is bundled inside a cable organizer so that it becomes one manageable cable
- Tether is permanently secured to bottomside tube using epoxy resin to seal
- Power and ground are run through two cables instead of one:
  - Double the gauging on cable to handle more current
  - Cables can be twisted so there's no magnetic interference

Topside Electronics:

- 25A 12V fuse less than 3 inches from power supply, and a 25A 12V fuse inside box
- Circuit breaker after fuse
- Ammeter that measures current draw
- Digital voltmeter that allows for easy voltage monitoring
- Large filtration capacitor to control any spikes
- Electronics box can be closed for testing in the rain or other damp environments
- Silica gel desiccant inside the box to absorb moisture
- All wiring is properly gauged to handle the proper current draw, and zip tied for organization
- All connectors going to/from topside are all disconnectable yet also very secure

Bottomside:

- All components are soldered or screwed securely with no loose components
- Wiring gauge is maintained so that the right power draw can be handled
- All components that could possibly heat up have heatsinks on them
- Silica gel desiccant inside tube to absorb moisture

- LED lights from modules are intentionally faced outward so the company can check status through the clear tube. A clear tube was chosen so the internal activity can be monitored.
- One side of the tube is permanently sealed with aquarium sealant
- Other side is a removable compression seal with an o-ring and nuts to compress the tube
- Silicon grease added each time the tube is closed to supplement the o-ring

C. Safety Checklists

Company Safety Checklist:

- All members behave appropriately: no horseplay, no running with tools, no hitting
- All members wear safety goggles, closed-toed shoes, and long pants
- All members with long hair wear their hair tied back and secured
- All members fully informed about emergency procedures
- There is always at least one parent in the room
- First-aid kit within reach, in case of injury
- Any member who requires use a tool warns the other members to steer clear of the member's work area

Physical Safety Checklist:

- All sharp edges and objects covered to prevent injury to hands of any operators or transporters of the ROV
- PVC frame firmly secured
- Black indicator tape secure around modified bilge pump motors
- Motors are mounted to the interior of the frame to prevent injury
- ROV transport carried out by at last 2 club members for safe handling

Electrical Safety Checklist:

- 25 Amp fuse present
- No cracks in electronic casing
- Nonstandard power connectors to prevent use with household electrical outlets
- All wires secured, sealed, and not exposed in any way
- Underwater wire connections sealed with solid epoxy

Pre/During/Post Operation Checklist:

- Environment is safe for operation: weather acceptable, launch platform stable and dry, no other hazards present

- Motor dry run
- End effector testing (cameras, claw)

IV. Logistics

A. Teamwork Evaluation and Task Spreadsheet

The company is pleased with the environment of collaboration throughout the process as all members supported one another in achieving this goal. The officers assign the members to work on the frame, propulsion, each payload tool, etc. The members are expected to complete their task in a specific timeframe and report on their progress at every work meeting. Hangout chats and email chains are made which serve as a forum for updates in task progress and schedules.

To stay on schedule and work as efficiently as possible, the company chose to utilize a spreadsheet to keep track of all the tasks to be completed. The company then consulted this spreadsheet and modified it throughout the duration of the project dependent upon progress and other occurrences. Whenever a task was completed, the member would report for an officer about the completion and the officer would edit the spreadsheet with a "Y" for yes next to the member's respective task and assign a new task if possible.

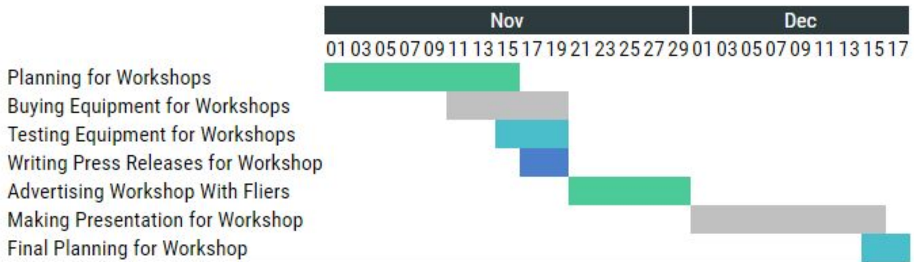
	A	B	C	D	E	F	G	H
1		DO NOT DELETE ANY TASKS FROM THIS LIST						
2		PLEASE ADD A COMMENT OR SEND AN EMAIL TO ASCENDTECH.ROBOTICS@GMAIL.COM WHEN YOUR TASK IS COMPLETE						
3		Project					Finished	
4	COMPLETE	Category	Task	Person	Due Date	Complete Date	On Time (Y/blank)	NOTES:
5	X	Workshops	Testing Kit	Alice & Arihant	11/20/16	11/20/16	Y	
6	X	Workshops	Contact about fliers - Asbury Park Library	Kaishawn	11/19/16	11/19/16	Y	
7	X	Website	Updating	Sam	11/22/16	11/22/16	Y	
8	X	Workshops	Write Press Release for Workshop & send to Rosalie, Alissa & Jaden to review	Alice	11/16/16	11/15/16	Y	
9	X	Workshops	After approved by Rosalie, Send Press Release to HHS, HMS & The Patch	Alice	11/19/16	11/17/16	Y	
10	X	Website	Home Page draft	Alisa L	11/13/16	11/13/16	y	
11	X	Admin	TY - CalPoly & Ulric	Alissa T	11/13/16	11/13/16	Y	
12	X	Admin	TY - Google	Eric	11/16/16	11/15/16	Y	
13	X	Website	Revise Workshop Page	Jaden	11/13/16	11/13/16	Y	
14	X	Website	@ascendtech4H.org	Jaden	11/13/16	11/13/16	Y	
15	X	Workshops	Contact about fliers/announcement - New School of MC	Jaden	11/19/16	11/20/16	Y	
16	X	Workshops	Contact about fliers - Hazlet Library	Jaden	11/19/16	11/19/16	Y	
17	X	Admin	Transcribing brianstorming lists	Kaishawn	11/19/16	11/19/16	Y	
18	X	Admin	Write email for Skip Carter from 4-H Rutgers to see about use of equipment	Rishi	11/16/16	11/12/16	Y	
19	X	Workshops	Contact about fliers/announcement - Sri Guruvaayoorappan Temple	Rishi	11/19/16	11/19/16	Y	
20	X	Website	Amazon - text link?	Rosalie	11/12/16	11/12/16	Y	

Figure 19: Screenshot of spreadsheet used to coordinate tasks and deadlines

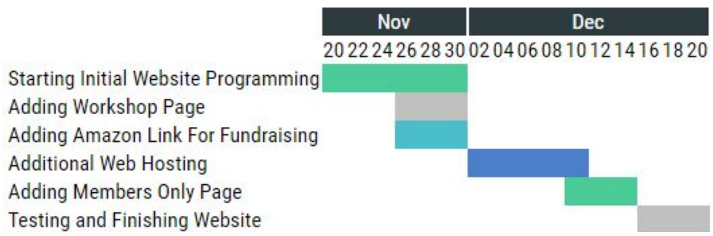
B. Gantt Charts

We used Gantt charts to plan out all of our work so that we could complete all of the tasks on time. Sometimes, tasks would overlap so we had to assign tasks to different groups

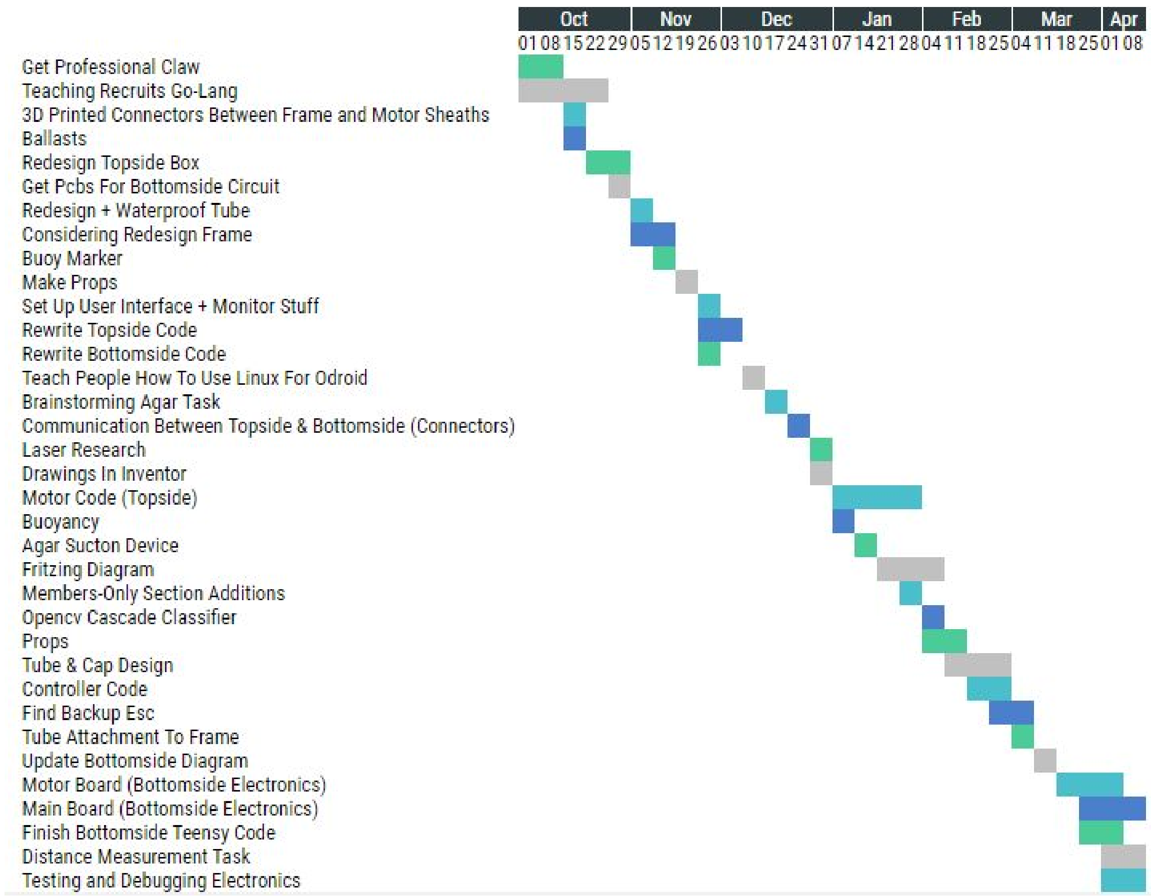
Workshops



Website



Robot



C. Budget and Expense Sheet

AscendTech fundraised using a variety of methods to purchase all necessary parts and materials for construction of the robot. The list below reflects all of the items purchased during the 2016-2017 school year. The company would like to thank Monmouth University and the Weiss family for donating their services by providing a pool for testing of the robot.

We would also like to thank our generous donors who made this competition year possible

Table 1: Donation Sources

Donor	Amount
Ellen Weiss	$75
Gary Weiss & Rosalie DiSimone-Weiss	$100
Helen Lam & Richard Wang	$500

Chengmao Tsai & Yun-chu Ku	$200
Yunghui Lai & Lichuan Sun	$300
Rajendrakumar & Neelam Salwi	$200

Table 2: Equipment Donations

Donor	Item	Cost	Notes
Iain Galloway from NXP Semiconductors	4 Teensy 3.1, a Teensy 3.2, a Teensy LC and 2 Prop Shields	$140.20	Used in bottomside electronics
Rosalie DiSimone-Weiss	Waterproof Sealant with BioS	$4.84	Used in waterproofing endcap plates
Chengmao Tsai	O-Ring, Dash 248 Buna 0.13 in	$6.90	Used in waterproofing endcap plates
Chengmao Tsai	Arduino-Compatible Nano	$8.99	Old topside electronics
Chengmao Tsai	Mega 2560 (Arduino Compatible)	$17.50	Used in bottomside electronics
Chengmao Tsai	Female Header Pins (row of 40)	$1.49	Used in general electronics
Chengmao Tsai	Max485 Module for Arduino: TTL to RS-485	$5.25	Old bottomside electronics
Ulric Gordon-Lewis	⅜″ Aluminum 6″ x 6″ Sheet	$16.08	Machined to create end caps
Ulric Gordon-Lewis	⅛″ Rubber Sheet 12″ x 12″ Sheet	$15.01	Machined to create 2nd layer of end caps
Ulric Gordon-Lewis	¼″ Aluminum 6″ x 6″ Sheet	$14.15	Machined to create 3rd layer of end caps

Table 3: ROV Components Bought During 2016-2017 Season

ROV Component	Cost	Notes
Odroid XU4 SoC	$96.18	Single-Board computer for ROV system
Teensy 3.2	$24.45	Arduino development board
FotoFo Wifi Adapter	$5.99	Used to connect the board wirelessly
Teensy 3.2	$24.45	Arduino development board
50 Pcs 3 Way 3 Pin PCB Screw	$21.57	Used to connect wires to circuit

Cast Acrylic Hollow Tube	$44.52	Used to house electronics underwater
Uxcell SD28 28mm 7 Pin Square Waterproof Aviation Connector Socket Waterproof IP68	$14.52	Bottomside electronics tube penetration connectors
Waterproof Sealant	$14.02	Waterproofing
6 ft Threaded Stainless Steel Rod	$6.42	Used for structure
3 ft Threaded Rod	$2.14	Used for structure
SD28 28mm 24 Pin Square Waterproof Aviation Connector Plug Socket IP68 X 2	$38.62	Bottomside electronics tube penetration connectors
Focusable 650nm 5mW 35V Red Laser "Line" Module Diode w/ driver Plastic Lens (2 Pack)	$1.33	Laser payload tool
AixiZ aluminum mount and heat sink for 12mm modules	$3.50	Mount for laser
30-pin and 12-pin Header Sockets X 3	$12.70	Used to house ICs
6 pcs MP1584EN DC-DC 3A Power Step-Down Adjustable Module Buck Converter HCXM	$3.31	Used to step down 12 volts to 5 volts
Half Bridge (4) Driver DC Motors X 5	$12.15	Used to control the direction of motors
IC Socket 16 Position Tin X 6	$1.50	Used to house ICs
IC Socket 28 Position Tin X 2	$0.66	Used to house ICs
Connector 8 Position 90 Degree 5mm X 3	$4.35	Used to house ICs
Mechanical Claw	$42.70	Used to pick up objects
Pololu Universal Aluminum Mounting Hub	$11.44	Adapter between mechanical claw and 500 GPH Johnson Pump

Table 4: Parts Reused from 2015-16 Year

Item	Cost	Notes
Polypropylene (PP) Sheet, Opaque White, Standard Tolerance, ASTM	$37.42	Used for structure

D4101-0112(⅜”)		
Polypropylene (PP) Sheet, Opaque White, Standard Tolerance, ASTM D4101-0112 (¼”)	$31.08	Used for structure
½ in x 10ft PVC Pipe	$5.79	Used for structure
½ in Furniture Grade PVC Tee in White (10-Pack)	$29.97	Used for structure
½ in Furniture Grade PVC 90 Degree Elbow in White (10-Pack)	$18.00	Used for structure
Ancor 764998 Marine Grade Electrical Wire Seal 18-10 Gauge ⅜ inch	$10.99	Used to waterproof wires
Ancor 765004 Marine Grade Electrical Wire Seal (Round Cable, 1 to 3/0-Gauge ¾ inch)	$29.76	Used to waterproof wires
Epoxy Resin	$10.32	Used for adhesive

Table 5: Miscellaneous Costs

Item	Cost
T-Shirts	$233.59
Costco Food for Workshop	$57.78
ShopRite Food for Workshop	$4.98
Hershey Chocolate Fundraiser Costs	$264

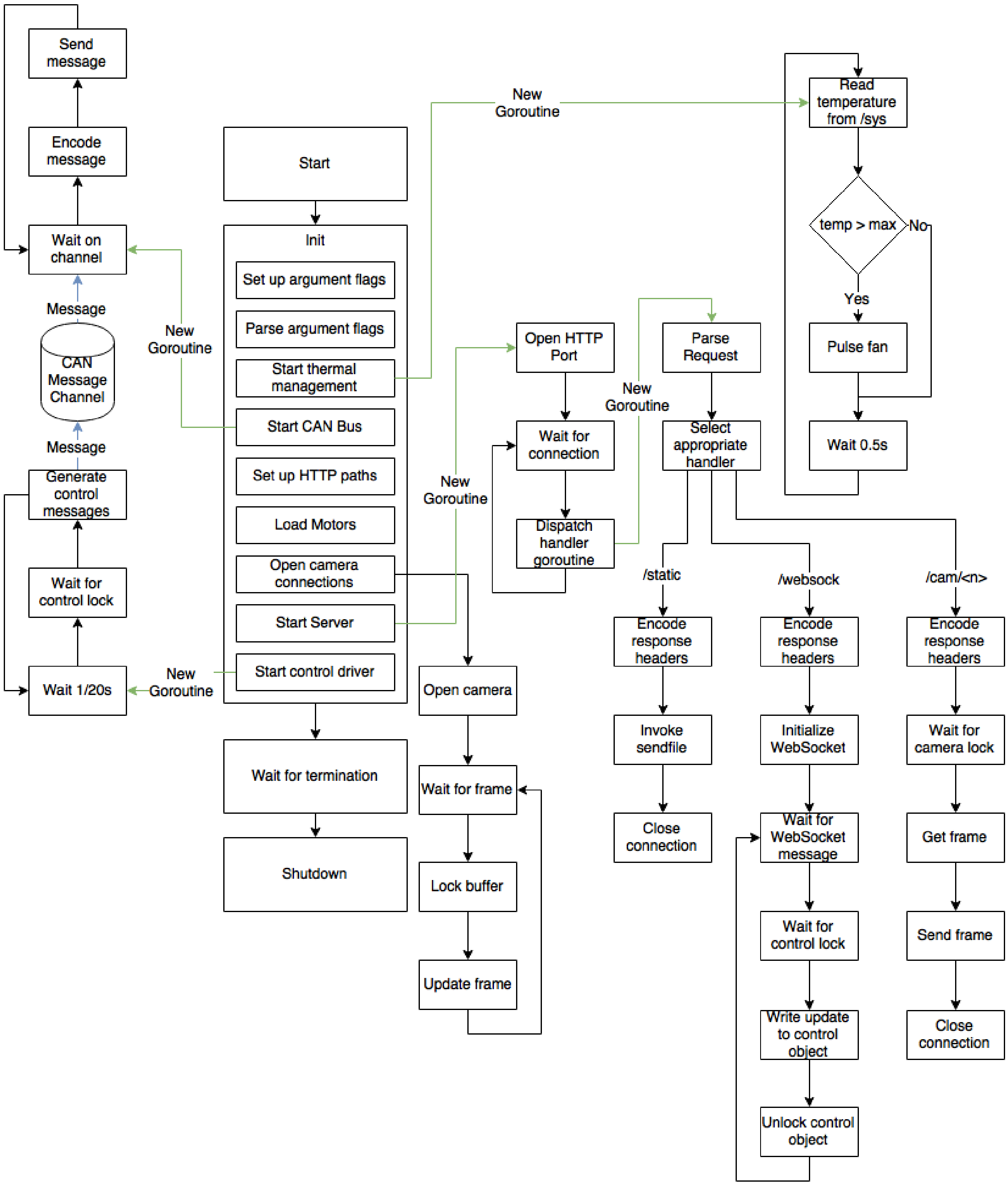
Table 6: Estimated Travel Costs

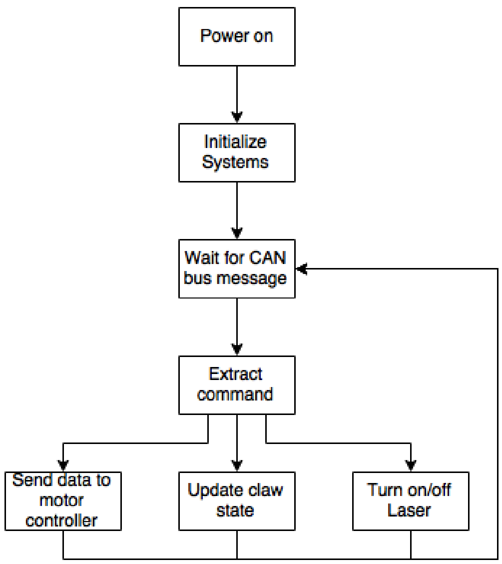
Hotel/Flight Costs	$5435.36

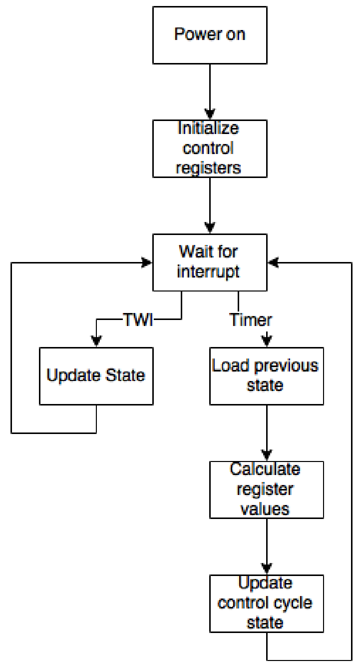
Table 7: Sources of Income

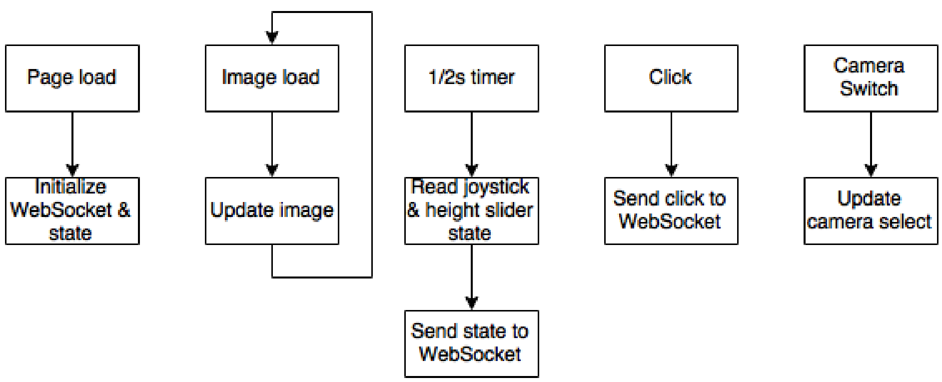
Source	Revenue
Hershey Chocolate Fundraiser	$315.00
Gift Wrapping Fundraiser	$123.45

V. Block Diagram/Flow Charts









VI. Community Outreach

A. Maker Faire

Our company presented at the World Maker Faire in New York. We were able to demo our robot and display our work to interested attendees. It was a great experience, and we received positive feedback about our ROV. In addition, our members were able to learn from other Makers who were presenting at the Faire.

B. Library Workshop

One of the goals of our company, is to get younger kids interested in STEM. To do this, we held a free workshop at our local library to teach circuitry and coding. The participants only had to pay for equipment. The 30 kids and adults had a lot of fun learn ing how to program an Arduino Microprocessor to make a light blink, display words on a display, and make a clock. We plan to do another workshop for more advanced students after the MATE competition.

C. Mini Maker Faire

Barnes and Nobles held a Mini Maker Faire to demo new technology to children and teenagers. We volunteered to present the new technology and our robot. We demoed technology such as a 3D writing pen, 3D printers, and drones. The kids learned a lot about robotics and technology from our presentation and we were very excited about getting children interested in STEM.

VII. Conclusion

A. Challenges

The primary challenge faced by the company was efficient communication. Coordinating each member's schedule in order to optimize the process and keep everybody up to date was challenging as company members ranged in schedule availability and geographical location. The company approached this challenge by sending out frequent emails and holding weekly meetings to provide thorough updates on the company's progress and introduce next steps. Sending Doodle surveys for the members to fill out allowed the officers to choose a time to schedule meetings when most, if not all, the members could attend. It was also fairly common for messages to be sent through group chats, which allowed members to help each other solve their respective problems and update members about schedule changes. For geographical location, the company tried to meet at a member's house for which the location was favorable for everyone's travel time.

Creating a robot that can navigate underwater and accomplish tasks came with a lot of problems. One of the biggest challenges was waterproofing all the technology. We used an aluminum end cap, waterproof connectors, and waterproof sealant to accomplish this task. When connecting wires that were going underwater, we had to solder the wires, hot glue the connection, and then heat shrink the wires. Another significant challenge was getting optimal parts for our goals. Sometimes parts were faulty, couldn't handle the current, or weren't appropriate for our circuit. In this case, we had to either buy new parts or redesign our circuit. In the end, after troubleshooting and months of hard work we had finished our project.

B. Lessons Learned and Skills Gained

One of the most important lessons the company learned was in the optimization and management of resources. As the company had limited funds to buy materials with, the members were hard pressed to find ways to reduce the cost of assembling the robot. At other times, the company found that some people had certain skill sets that were instrumental to the building of the project but were not always able to meet with the company. This year presented a particularly difficult challenge in coordination, since it was the first year of the AscendTech organization. However, by overcoming these obstacles with gantt charts and detailed schedules, the company learned to how to best utilize the members' talents to produce a high-quality final product. The company developed collaboration and time management skills and further improved upon the ability to delegate tasks, all of which contributed to the overall success.

C. Future Improvements

Though the company was able to achieve their objectives, the company also believes in constant innovation as there is always room for more improvement. The AscendTech Robotics company is currently planning several improvements to the ROV design. Currently, part of the electronics system is topside and part is underwater. Though having part of the electronics system within the ROV frame leads to less power loss through the tether, it adds to the overall bulk of the ROV. By using lighter components, especially in the protective casing, the ROV could become lighter and more agile. In addition, investing in a professional printed circuit board would significantly reduce wiring errors and disconnections, improving overall efficiency. This solution could feasibly eliminate the need for the clunky physical referencer. Improvements to payload tools include making the agar device more compact and easier to use. Currently, it is awkward in size and weight, causing the ROV to tilt dangerously when the claw holds the agar device. By using a smaller check valve, such as that on a bicycle pump or a scuba mask, the company could eliminate part of the size. Reducing the width of the PVC tubes' edges would also eliminate unnecessary weight.

D. Reflections / Experiences

Underclassman

"I observed the senior members of the team and through observation learned many new things: the design process, how to write a technical report, and some of the issues

that arise when constructing an ROV. It was amazing that even though it was the first year this club existed, the members worked dedicatedly to build the robot and raise money to fund the club. I helped write the technical report and created props to test the robot with. The time that I have spent in this club is something that I could never have experienced in the classroom or in the clubs at school. I can't wait to discover what kind of knowledge and skills I will acquire participating in this club next year."
~Katrina Florendo, Freshman

Upperclassman

"Participating in MATE competitions was a major factor that fueled my interest in STEM. Attending a STEM high school and getting involved in robotics has opened my eyes to the paucity of females in STEM fields, and I'm proud to help break down this barrier. MATE helped me realize my interests lie greatly in science and technology and I am excited to continue research, science, and robotics in college. I will never forget the integral part MATE has played in my high school career!"
~Alissa Tsai, Senior

E. Acknowledgements

The AscendTech Robotics Club would like to take the time to thank everyone who helped with the development of the ROV, be it technical or moral support. The company would first like to thank MATE and MATE Pennsylvania for making the competition possible and for the resources and support made available to all of its competitors. The company would also like to thank the club's parent advisors for their patience and advising of this club.

The company would like to thank the Weiss family, Tsai family, Lai family, Salwi family, Helen Lam and Richard Wang for their financial donation to the club. Additionally, the company would like to acknowledge Mrs. Weiss, Mr. Tsai and Iain Galloway from NXP Semiconductors for equipment donations and the parents of all members of the club for their support and assistance with transportation.

The club would like to thank Professor Jim Nickels of the Urban Coast Institute at Monmouth University for letting the company use the pool and water tank facilities for testing. The club would like to thank Mr. Ulric Gordon-Lewis for his machine shop and 3D printer accessibility. The club would also like to thank Ms. Jill Zande for serving as MATE Competition Coordinator.

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