LANDSTOWN HIGH SCHOOL

DEEP SEA TACTICS

Landstown High School

Virginia Beach, Virginia, United States

TADD III
Technical Documentation
MATE 2023 Competition

Chief Executive Officer
Daniel Tomov

Chief Design Engineer
Carter Eliott

Chief Fabrication Engineer
Carter Elliott

Chief Software Engineer
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Robert Vasquez

Mentor
Tyler Swartz

Design
Dylan Sison

Electrical
Dylan Sison
Nathan Long

Software
Dylan Sison
Dylan Myers
Evelyn Freck
William Faircloth

Fabrication
Tara Bell
Ruby Neice
Dylan Sison
Nathan Long
Christian Munoz

Marketing
Aiden Donovan
Robert Taliaferro
Alex Nesbitt
Labib Khan

ABSTRACT

Deep Sea Tactics is made up of five specialized groups that all contribute to the success of our design. These teams consist of Electrical, Marketing, Modeling, Design, and Coding, all of which have a key role in the ROV. Each team overcame their own challenges, along with working together to tackle larger ones. Our teams collectively strive to succeed and have put in strong effort throughout the entire school year to the broad aspects of maintaining a company. Deep Sea Tactics uses 3D modeling software to visualize the ROV and how different parts fit together. Laser cutting was used to make the main body and larger parts, whilst the rest was 3D printed with PLA. To complete part of the product demonstration, Deep Sea Tactics created an arm to complete tasks such as picking up items and delivering them to the objective. One part of the arm was the claw, being custom designed to fit all our needs, along with being very cost efficient.

The tasks this year are designed to highlight the United Nations Decade of Ocean Science for Sustainable Development and inspire the global community.

The Deep Sea Tactics team taking a group photo on the school stairs.

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TEAMWORK

Project Management

Our team is made up of five specialized divisions, with each division consistently finishing the tasks and completing the product. The five groups and their aims consist of:

- **Engineering:** Build the physical final product of our robot
- **Design:** Create a model/design that will be later used to make the actual robot
- **Coding:** Plan, design, and execute the code and software
- **Electrical:** Wire and design the electronics for the robot and the float

Each member of the team comes from a different area of engineering, coding, or marketing that helped build our team to where it has come today

- Daniel Tomov – Senior, CEO, Chief Electrical Engineer, and software developer
- Carter Elliott – Senior, Chief Design, Fabrication, Modeling and Safety Manager
- Christian Munoz – Senior, worked on the GO-BGC Float.
- Tristan Figueroa-Reid – Junior, Chief Software Engineer, Software Developer
- Dylan Sison – Sophomore, procedural 3D model generation, and coding
- Tara Bell – Sophomore, helped in 3D printing, building, tether, design the arm
- Dom Varner – Sophomore, Design the body of the robot and helped with tether
- Labib Khan – Junior and part of marketing team
- Robert Vasquez – Junior, Head of Marketing
- Robert Taliaferro – Freshman and co-head of the marketing strand
- Connor Sauers – Senior, electronics team assistant
- Alexander Nesbitt – Freshman, aids with fundraising and letters/documentation
- Ruby Neice – Sophomore, designed arm, body, and did background research
- Dylan Myers – Junior, web designer and software engineer. Head of UI / UX.
- Nathan Long – Senior, worked on the GO-BGC float and designed custom PCB for ROV
- Toby Hay – Senior, assembled props for testing.
- Evelyn Freck – Sophomore, worked on procedural 3D model generation
- William Faircloth – Junior, coding member, web designer and software developer
- Aiden Donovan – Senior and marketing member, helps with fundraising
- EJ Baybay – Freshman and electrical member, aids with assembly and planning
- Lou Brown – Freshman, helped in 3D printing, building, tether, design the arm
- Alex Zhao – Freshman, Marketing Team Member

The team meets every Tuesday from 2:00 PM to 4:30 PM to work on our robot. During this time, the team works on any Marketing, Engineering, Design, Coding, or electrical tasks that needs to be completed. Members are incentivized to work for the team at home due to necessary extensive research surrounding our product.

DESIGN RATIONALE

Engineering Rationale

Our engineering design rationale for the underwater ROV system is the result of a thorough and thoughtful design process that focused on creating a vehicle that meets the needs of the tasks at hand. We started by defining the specific requirements of the ROV system, such as its compact and maneuverable design, frontal claw system, and advanced control and imaging systems.

To achieve these requirements, we made several important design decisions, such as choosing HDPE materials for the frame and a square shape for best water dynamics and maneuverability. We also selected six high-performance T-200 Blue Robotics motors, as well as a frontal claw system with variable rotation for maximum precision and versatility.

Throughout the design process, we faced several key trade-offs and challenges. One of the biggest challenges we faced was striking a balance between size and functionality. On the one hand, we needed a compact vehicle that could navigate through tight spaces, but on the other hand, we required enough space to accommodate all the necessary sensors, cameras, and other equipment.

To address this challenge, we chose a square shape for the vehicle, which allowed us to optimize water dynamics while still providing enough space for all the necessary equipment. We also carefully integrated all the sensors, cameras, and other equipment into the vehicle's structure to ensure maximum performance and efficiency.

Another challenge we faced was balancing durability and weight. We needed a vehicle that could withstand the harsh conditions of underwater environments, but we also needed it to be lightweight and easy to transport and deploy. Ultimately, we chose HDPE materials for the frame, which provided exceptional durability and corrosion resistance while remaining lightweight.

Innovation

Our underwater ROV system is a revolutionary design that incorporates several innovative features, including the use of high-density polyethylene (HDPE) material, a smaller and more compact design, and an increased axis of propulsion. This design was inspired by the failures we experienced last year when our earlier ROV system was too large and heavy, lacked tractor control propulsion, and was difficult to maneuver in confined spaces.

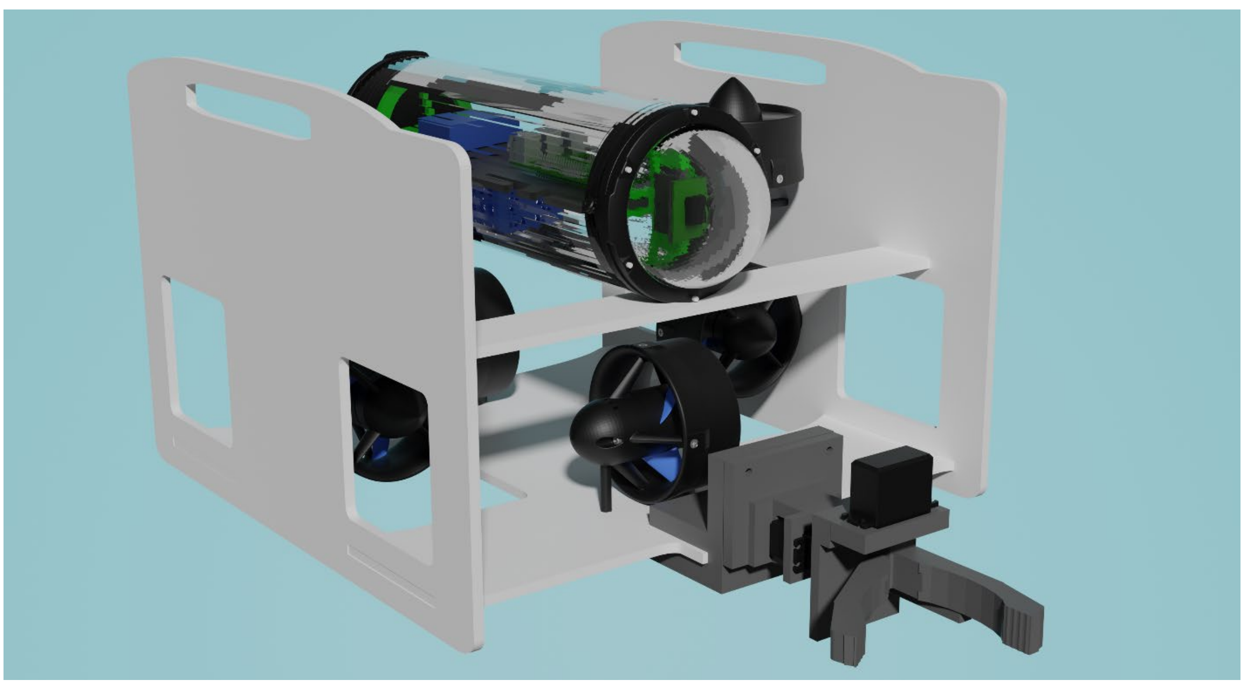
To address these issues, we turned to HDPE, a lightweight yet durable material that is ideal for underwater applications. By using HDPE, we were able to create a smaller and more compact ROV that is easier to control and maneuver in tight spaces. In addition, the increased axis of propulsion allows our ROV to move more efficiently and quickly, giving us greater control and precision during underwater operations.

Our design process began with a thorough analysis of the failures we experienced with our earlier ROV system. We found the need for a lighter and more compact design that would be easier to transport and deploy in the field. We also recognized the importance of having better control over the ROV's movements, especially in challenging underwater environments.

With these insights in mind, we developed a new ROV system that uses the latest advancements in materials science and propulsion technology. The result is a highly capable and efficient underwater ROV system that meets the needs of a wide range of underwater applications, from scientific research to industrial inspections and more.

Systems Approach

Our systems approach involves a holistic view of the underwater ROV system, considering all components and subsystems in relation to one another and their role in achieving the overall objectives of the system. We consider not only the technical aspects of the vehicle, but also the human factors involved in its operation and maintenance. By taking a systems approach, we ensure that all components work together seamlessly, optimizing performance and functionality while minimizing risk and maximizing safety. Our approach also allows for greater flexibility and adaptability in response to changing requirements or unexpected challenges, ensuring that the ROV system remains effective and efficient in all operating conditions.



Model of TADD III by Dylan Sison

Vehicle Structure/Systems

Optimized for efficient water dynamics and allows for maximum maneuverability in the water. The ROV is powered by six high-performance T-200 Blue Robotics motors that provide exceptional propulsion in all directions, many of which were reused from previous years. These motors and our sleek design allow this ROV to make tighter more precise movements in navigation this year's tasks. These motors are controlled by our central control system, which is housed in a durable acrylic tube.

Vehicle Structure/Systems(continued)

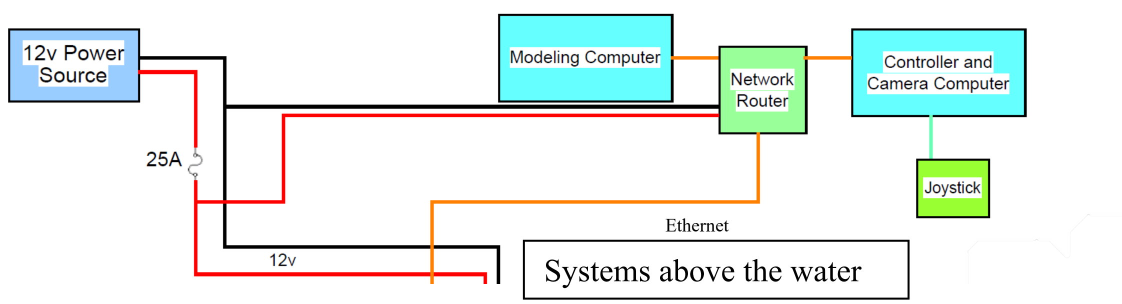
In addition to its advanced propulsion systems, our ROV system also features a frontal claw system that is capable of grabbing and manipulating objects underwater. This claw system has variable rotation, allowing us to control the angle and orientation of the claw for maximum precision and versatility in completing the given tasks.

The square shape of the vehicle is optimized for water dynamics, with a streamlined design that reduces drag and improves maneuverability. The compact size of the vehicle also makes it easier to transport and deploy in the field, while still providing ample space for all the necessary sensors, cameras, and other equipment. The vehicle's frame is constructed using high-quality materials, including HDPE, which provide exceptional strength and durability while remaining lightweight, cheap, and resistant to corrosion and other forms of damage.

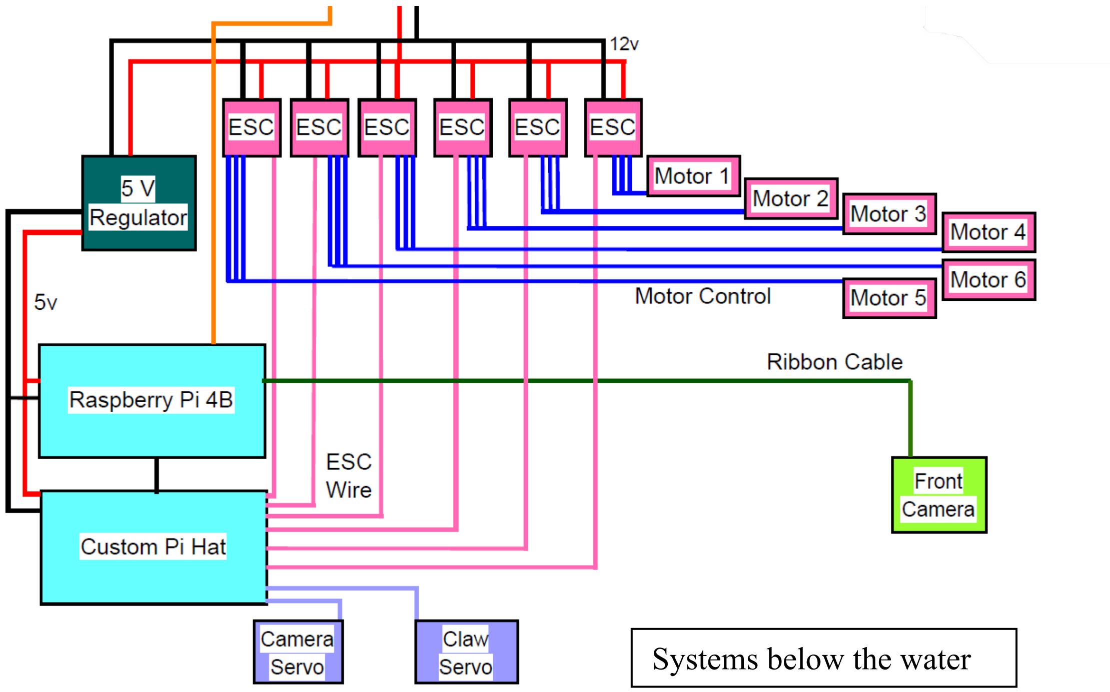
Overall, the cost of our ROV was manually labor and time. The main components of the System were hand made in AutoCAD and Adobe Inventor, where we could CNC and laser cut our materials to make a functioning system.

Control/Electrical Systems

The electrical system originates at the water's surface control box. This box is equipped with a router that establishes a network between the remotely operated vehicle (ROV) and any computers intending to communicate with it. By utilizing a router to configure the network, there is no longer a need for team members to manually configure IP addresses. Conveniently, the router is affixed to the control box using Velcro, which makes repairs or replacements effortless, if required. Because the control box is mostly empty, it is used to keep spare parts which may be used in a typical underwater robot launch. Items such as extra fuses or an air pump to test for leaks are examples. Additionally, a laptop stationed at the surface uses a Logitech G Extreme 3D Pro Joystick and a custom web interface to transmit commands to the robot.



These commands travel through an ethernet cable and into the ROV, where they are interpreted by a Raspberry Pi. Then, the commands are sent to the individual motors and servos, allowing for precise control of the ROV.



Systems below the water

Propulsion

The ROV's frame was designed to accommodate six BlueRobotics T200 Thrusters. These thrusters were selected based on their exceptional performance-to-amperage ratio and affordability. To account for the budget, the team opted to reuse four motors and purchase two additional thrusters. The additional two thrusters allow the robot to move sideways, a function which was not available on previous designs. The additional motors have increased the software team's responsibilities, as they must implement more control functions from the joystick, such as manage rotation. When the joystick is moved to the left, the sideways motors will move the robot left. Rotating the handle will cause the forward and sideways motors to work together, enabling steering. The vertical motors are conveniently bound to a slider located at the bottom of the controller, allowing for precise and straightforward maneuvering with both hands.

This approach effectively boosts the ROV's maneuvering capabilities while keeping expenses within the project's budget.

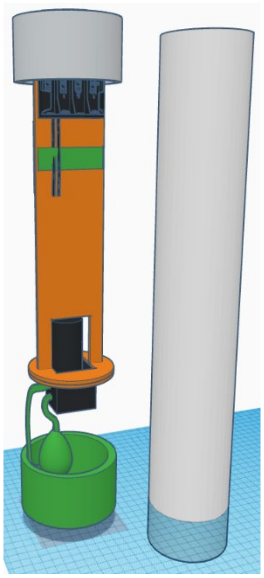
GO-BGC Vertical Profiling Float

Physical Design

This year's GO-BGC vertical profiling float uses a buoyancy engine primarily based around a 12V gear pump that allows it to transport water from an internal balloon, also known as a bladder, to an external bladder and vice versa to alter the volume of the float. As the volume increases, the density will decrease, causing the float to float once the density of the float is less than the density of water. This design does not use a solenoid valve, instead using careful timing to counteract the pressure that both the outside environment and the bladders put on the system. The physical design involves a 3-inch diameter PVC tube, along with two flexible rubber end caps, with one fastened and one not fastened (see section labeled "Safety").

Electrical Design

The entire float runs on eight AA batteries, creating a 12V primary electrical system. This 12V is fed directly to a LM298N DC motor controller, allowing for easy control for both the speed and direction of the water pump. It is also fed to the main PCB, which contains a dual 5/3.3V regulator, a DS3231 real-time clock, and an Adafruit Pro Trinket microcontroller. The 5V section of the regulator powers the DS3231 RTC and the microcontroller. The 3.3V section of the regulator powers the XBee Series 1 Full Duplex transceiver, used for bidirectional RF communication between the base station and the float. Finally, within 5cm of the AA battery bank, there is a five amp fuse.

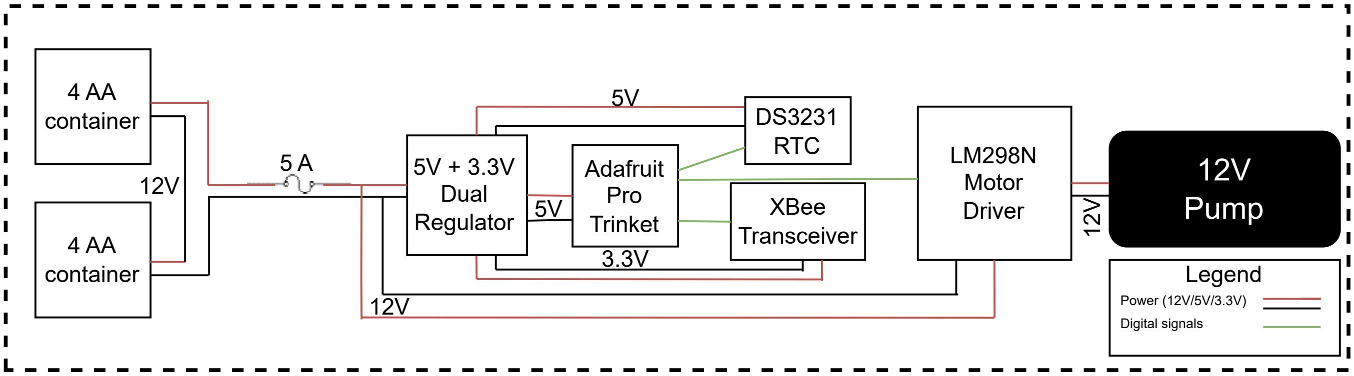


Model of the Float by Christian Munoz

Safety

The primary concern for safety of the vertical profiling float involves the potential for an unsafe amount of pressure building up within the float housing, which could prove to be dangerous. At the same time, proper construction and sealing of the housing is necessary to prevent water intrusion. Therefore, we decided on using the bottom rubber end cap as a pressure release plug, as it easily pops off the float when the pressure in the housing is too high. This was assessed by inflating the bladder on the inside excessively, which resulted in the end cap popping off the float when the displaced air significantly increased the internal pressure. In practice, before deploying the float, the internal bladder is filled with the end cap off, the end cap is then placed and secured without a fastener, and then the bladder is drained in order to create a slight internal vacuum, which ensures that when the bladder is filled to its normal level, there is not positive pressure built up in the float. Should the bladder fill excessively however, the end cap pops off to relieve the pressure. Finally, in terms of electrical safety, a five amp fuse was chosen to protect the electrical system from potential damage and hazardous situations, as the short-circuit current of the battery bank exceeds five amps.

Non-ROV Device System Interconnection Diagram



Fuse Calculations

Pump: 0.6 amps
XBee: 0.2 amps
Adafruit Pro Trinket: 0.2 amps
Real Time Clock: 0.2 amps
Total: 1.2 amps
1.2 *150% = 1.8 amps
The Vertical Profiling Float uses a 5 **Amp Fuse**.

SAFETY

Safety Procedures

1.) Any Individual working with tools that have the potential to cause harm must have the following: OSHA- safety glasses, respirator/filtered mask if harmful pollutants are being presented, Gloves suited for the given task.
2.) When managing the ROV or other tools all individuals are present with another individual in case of liability or complications.
3.) Before the ROV is presented in its environment all seals must be checked.
4.) Locking cords must be placed and ensured.
5.) Seals must be evaluated via air pump to ensure that all seals hold and function.
6.) Main connections to ROV to power, control station, and motors checked for clearance, strain relief, and no issues.
7.) Tether checked for any abnormalities or issues with all flotation secured and tether tied to a ground feature in place.
8.) Main power fuse checked and evaluated.
9.) All connections connected to the tether connected and check for proper functionality.
10.) Outside of water testing: functionality control of all servos, motors, and cameras.
11.) ROV gently placed in water and checked for any further issues if missed.

Procedure	Check Mark
Pre-Power Checks	
All crewmembers are wearing safety gear	
Power is disconnected before conducting a safety check	
Check the fuse is not blown	
All mechanical structures fastened securely	
Motor guards are fastened securely and clear of obstructions	
All sharp edges covered, and cap nuts installed	
Shafts and manipulators clear of obstructions	
Video gear clear of obstructions	
Cables tied down and electrical connections are waterproofed	
Check all seals are installed correctly	
Check electronics enclosure end caps are fastened correctly	
Check operating environment is clear of obstacles	
Call out "Safe"	

Pre-Water Checks	
Connect the tether to the control station and power the system	
Check the video system	
Check motor and sensor systems	
One crewmember and the tether man lower the ROV in the water	
Call out “In Water”	
In-Water Checks	
Call out “Pilot in Command”	
Recovery Checks	
Check ROV is at the surface, facing away from the pool wall	
Power down the system and call out “Crew in Command”	
Two crewmembers and the tether man lift the ROV from the water onto land.	

The Landstown Deep Sea Tactics Safety Manager is responsible for reviewing this safety checklist with the rest of the team before workshop or pool competition activities. This checklist is an effective reminder to the entire team. By reviewing this safety checklist before each activity, the importance of safety always is established and reinforced.

Safety Features

Safety Feature	Description
Black and yellow hazard tape	The black and yellow hazard labels are taped around thrusters, providing a safe way to warn that there is danger and to avoid unnecessary injuries.
Fast-blown fuse	With the fast-blown fuse, the electrical current in the circuit is cut off to avoid electrical overload. It also avoids electrical shock caused by the exposure of wires to the conductive properties of water, avoiding full system failure.
Motor Guards	All holes are less than 10mm and there are no sharp edges. They are also securely mounted in a way in which they will not interfere with the operation of the motors.
Trigger Button	Button 1 on the controller determines if the thrust motors will turn on. If it is not pressed, the ROV will not move.

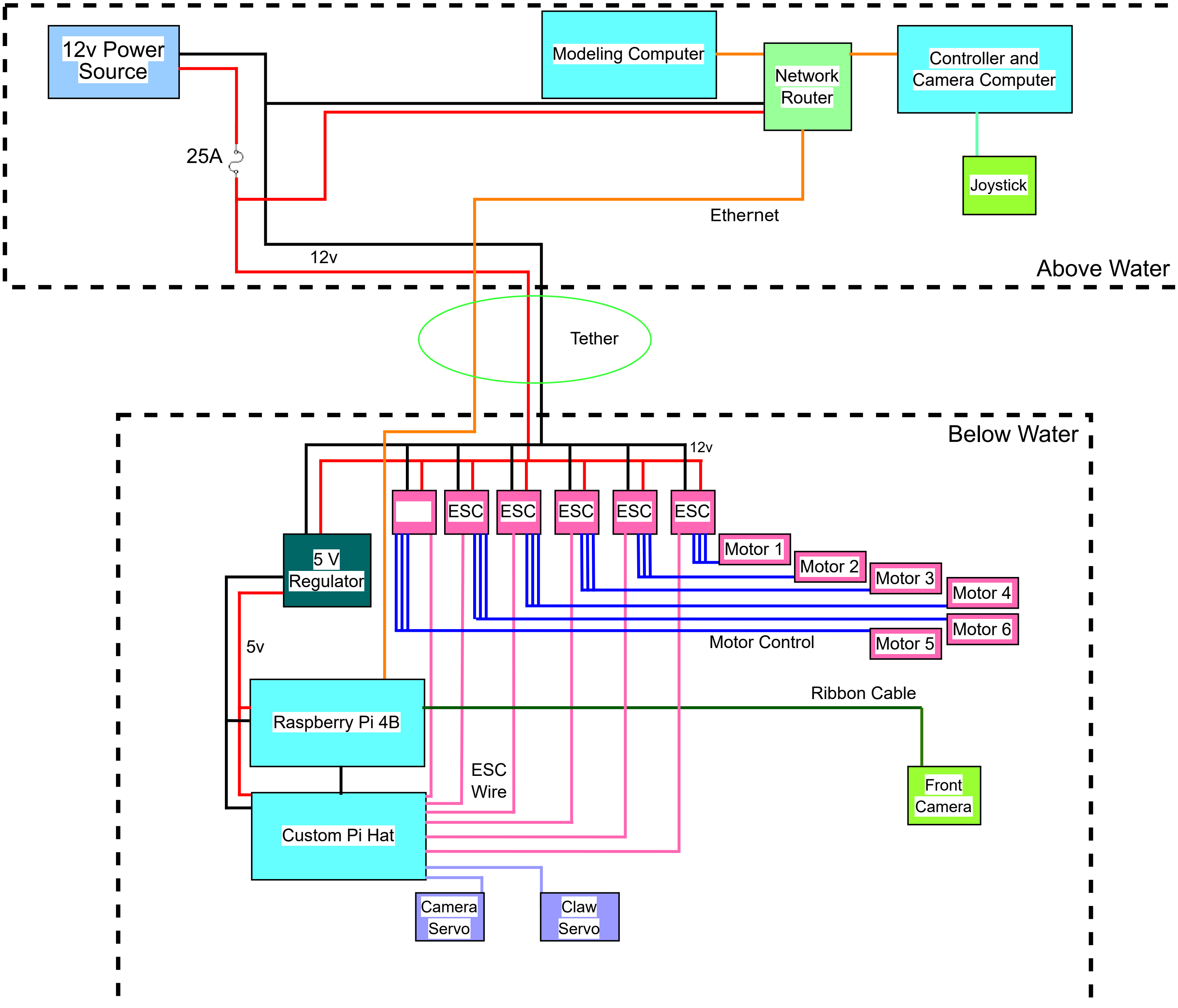
CRITICAL ANALYSIS

Testing/Troubleshooting

Initial testing occurred above water with the securing all seals and devices making sure each input and output was waterproof. Then main testing occurred in a controlled pool environment. The system issue that prevailed was discerptions in buoyancy as the frontal claw mass PLA was not as dense as calculated due to a change in filament type causing an imbalance in the ROV system. To fix this issue, we attached pool noodles in given places near the rear of the ROV to adjust for the dominant trailing edge mass. Another problem occurred with the camera view. The camera view was inversed so, as an operator, the visuals were disorientating leading to more difficulty in control while underwater.

For the buoyancy module, testing was initially conducted without the external PVC shell. The data transmission and pump systems were evaluated using a bucket of water that would function as the water surrounding the float in the pool. Upon evaluating these systems, multiple design flaws were discovered including the likes of unnecessary gases in the system, small leaks, and vacuums within the bladders. The unnecessary gases were removed through taking away one of the bladders and creating an open system. Any leaks were solved by tightening junctions and replacing bladders. The system was originally designed with a two-bladder system where water was pumped between an internal and external bladder. However, this led to the bladders getting caught in the hoses. This problem was also solved by removing the external bladder. After placing the electronics into the external PVC shell, it was discovered that the system’s density was too low leading to a positive buoyancy after activating the pump. This problem was solved by adding ballast to increase the mass.

ROV System Interconnection Diagram



Fuse Calculations

Motors at 100%: 3.8*4 = 15.2 amps
Motors at 50%: 2*1.8 = 3.6 amps
Raspberry Pi: 0.5 amps
Router: 0.3 amps
Servos: 2*0.15 = 0.3 amps
Total: 19.9 amps
19.9 *150% = 29.85 amps
TADD III uses a **25 Amp Fuse**.

Legend

Ethernet
2 Conductor ESC Wire
Power (both 5v and 12v)
3 Conductor Servo Wire
3 Conductor Motor Wire
Raspberry Pi Camera Ribbon Cable

ACCOUNTING

Budget

We started the year with a budget of $3,300, which we did not expect to use entirely. The team thought most parts such as electronics and motors would be reused from last year, since they function. There were things the team expected to buy, such as two more motors and HDPE to build the frame out of. On the other hand, the team did not expect to need to buy new equipment to build the ROV. A new laser lens and endmill bits had to bought so the team can cut the ROV and GO-BGC Float parts.

Travel Expense Estimates

We will be traveling to Longmont, Colorado, which is around 40 miles north of Denver. We are planning to take a flight into Denver International Airport (DEN) with Delta and American Airlines. Once we arrive, we will be renting a van capable of transporting the robot, the computer with the controls, and any other electronics needed to maintain the robot. From there, we will drive to our hotel in Longmont and unload the equipment. We will be booking four hotel rooms, three hotel rooms will be for the students, who will be grouped in pairs. The fourth hotel room will be for the teacher and the equipment, along with any other adults that come with the team. To get around Longmont or get to the event venue, we will be using a combination of the van we rented and services such as Uber or Lyft.

Cost Accounting

Item Quantity	Item description	Unit Cost	Item Total	Running Total
4	DHDPE Smooth 1/4" 24"x18"	$23.85	$95.40	$95.40
2	T200 Thruster with Penetrator (BlueROV2 Spare)	$210.00	$420.00	$515.40
5	Potted Cable Penetrator	$6.00	$30.00	$545.40
1	End Cap - Aluminum 18xM10 – 950mm	$52.00	$52.00	$597.40
1	5V 6A Power Supply	$25.00	$25.00	$622.40
1	100ft- 1/2" PET Expandable Braided Sleeving	$15.99	$15.99	$638.39
1	GearIT 14/2 Marine Wire 14AWG Gage - Tinned	$99.99	$99.99	$738.38
1	FTVOGUE 12V ZC-A250 Mini Self-priming Pump	$17.79	$17.79	$756.17
1	Dernord PVC Tubing ¼”IDx3/8” OD Flexible Clear	$6.89	$6.89	$763.06
1	Runch 100pcs Latex Balloons, 12 inch multicolor	$12.49	$12.49	$775.55
1	Yosoo 6mm DC 12V Small Solenoid Valve	$11.35	$11.35	$786.90

Purchased and Reused

Purchased	Reused
HDPE Smooth 1/4" 24"x18"	Metal Brackets
Potted Cable Penetrator	T200 Motors
End Cap - Aluminum 18xM10 – 950mm	Raspberry Pi
5V 6A Power Supply	Electronic Speed Controllers
100ft- 1/2" PET Expandable Braided Sleeving	Watertight Enclosure
GearIT 14/2 Marine Wire 14AWG Gage - Tinned	Dome
FTVOGUE 12V ZC-A250 Mini Self-priming Pump	Flanges
Dernord PVC Tubing ¼"IDx3/8" OD Flexible Clear	Polycarbonate
Runch 100pcs Latex Balloons, 12 inch multicolor	---
Yosoo 6mm DC 12V Small Solenoid Valve	---

Income Sources

We earned income from support through fundraisers and donations. In total, we earned $1,508.53.

Event/Source	Amount
Landstown Highschool Winterfest (Fundraiser)	$156.00
Mooyah (Fundraiser)	$67.73
Krispy Kreme (Fundraiser)	$506.00
Donations from Parents	$778.80
Total	$1,508.53

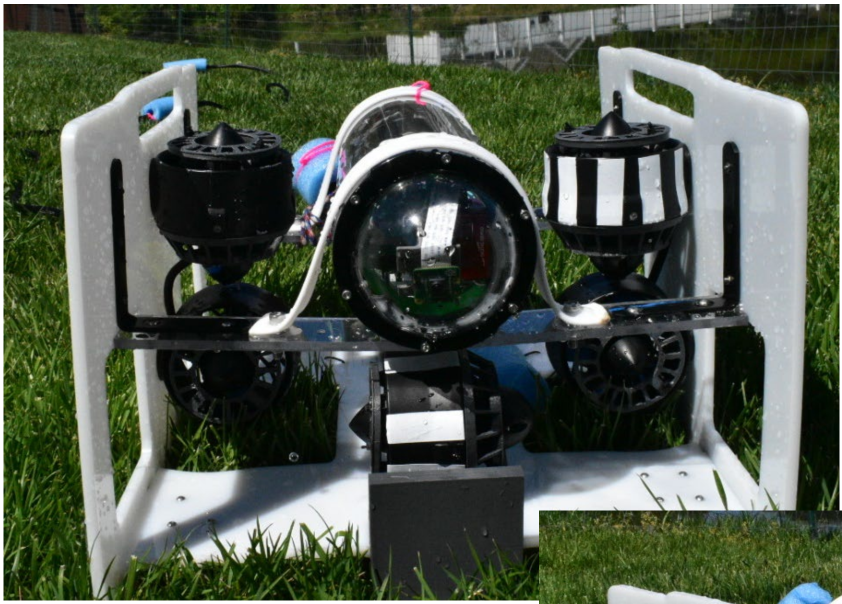
ACKNOWLEDGEMENTS

Ty Swartz – For supplying $700 as a budget for the build.

Landstown High School – For letting Deep Sea Tactics borrow money

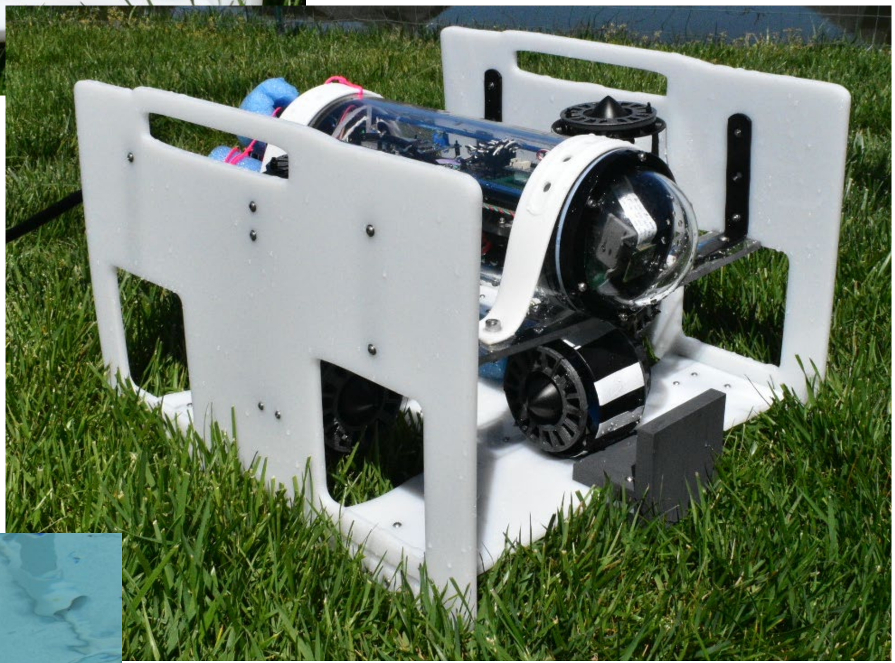
- Dr. Johnson – Principal LHS
- Rachel White – Coordinator of the Technology Academy @ LHS
- Dr. Lockett – Director of Tech + Career Education
    - Department of Technology + Learning
- Dr. Hurd – Coordinator of Engineering/Technology Department
- Michael Turney Jr – Technology Education Teacher – Advanced Technology Center
- Tom Siler – CTE Teacher @ LHS

Photos of TADD III



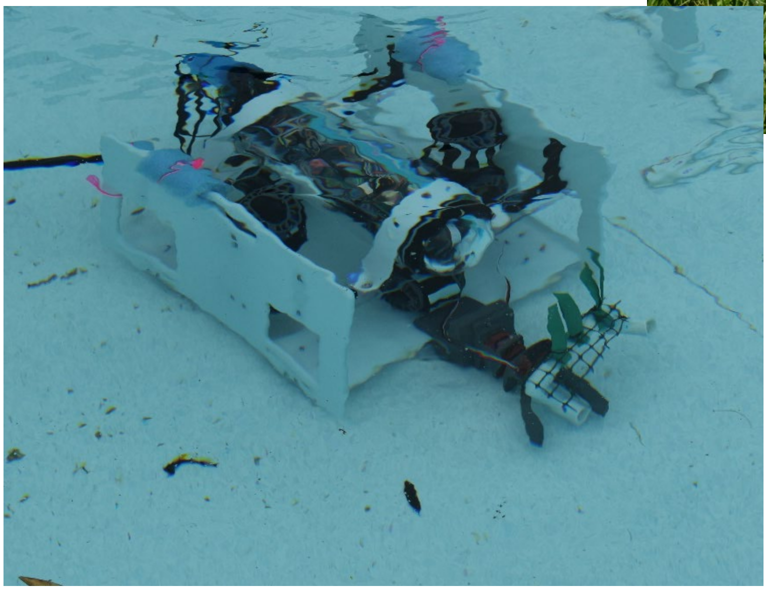
Front view of TADD III

Photo by Daniel Tomov



Side view of TADD III

Photo by Daniel Tomov



TADD III grabbing algae from the bottom of a pool

Photo by Daniel Tomov