East Tennessee State University Buccaneers Underwater Robotics

2025 Technical Document

East Tennessee State University

Johnson City, Tennessee, United States

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Luke Seal, Software
Noah Shelton, Float
Matthew Smith, Safety

ETSU Underwater Robotics

Contents

Company Organization

Pearson Mills

- **CEO**
- **Documentation Lead**
- **Finance**

Quinn Bentley

- **Electrical Engineer**
- **Laser Cutting**
- **CAD**

Samuel Deaton

- **COO / Pilot**
- **Software Engineer**
- **Electrical Engineer**

Luke Seal

- **Software Engineer**
- **Float Software**
- **Frontend Software**

Noah Shelton

- **Electrical Engineer**
- **Float Hardware**
- **Backend Software**

Matthew Smith

- **Safety Officer**
- **Tether Manager**
- **Waterproofing Lead**

Patrick Lanham

- **Mechanical Engineer**
- **Frame Design**
- **CAD**

Abstract

The Buccaneers, or Bucs, are an underwater robotics company based out of Johnson City, Tennessee, and are affiliated with East Tennessee State University. Consisting of seven members and situated in a region known for its extraordinary freshwater biodiversity and close proximity to hydroelectric infrastructure, the Buccaneers are uniquely positioned to engage with real-world aquatic challenges, from ecosystem monitoring to sustainable energy initiatives. Additionally, the nearby Erwin National Fish Hatchery and TVA-operated dams serve as further inspiration for the company's mission of engineering innovation in order to achieve environmental preservation.

Founded in 2020, the Buccaneers have built a strong foundation in underwater robotics, spreading messages of sustainability and ingenuity. With backgrounds spanning biology, computer science, engineering technologies, and environmental health, the company brings an interdisciplinary approach to the design and deployment of marine technology.

In response to this year's request for proposals, the Buccaneers proudly present *Halcyon*, a versatile and high-performance Remotely Operated Vehicle (ROV) engineered to address the challenges of climate change, invasive species, and marine renewable energy. *Halcyon* features a custom 3D-printed frame designed for modularity and strength, an eight-thruster vectored configuration for omnidirectional control, and a newly developed topside control system to enhance pilot feedback and mission efficiency. Each subsystem was the result of iterative design, extensive testing, and a focus on reliability and serviceability.

This document details the Buccaneers' development process—from initial research and system integration to final deployment—while showcasing the company's commitment to innovation, safety, and sustainability.

Figure 1: Image of company members at ETSU Valleybrook. Credit: Matthew Smith.

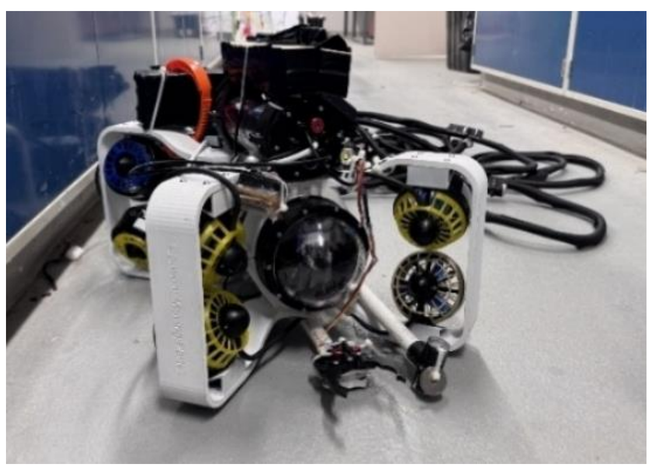


Figure 2: Image of Halcyon, the Buccaneer's newest ROV. Credit: Samuel Deaton.

Project Management

Task	Start	Goal Finish	Actual Finish
Recruitment	Aug 26, 2024	Sep 30, 2024	Sep 16, 2024
ROV Design	Sep 2, 2024	Nov 30, 2024	Nov 21, 2024
Float Design	Sept 16, 2024	Nov 30, 2024	Dec 3, 2024
ROV Prototype	Jan 1, 2025	Mar 31, 2025	Apr 16, 2025
ROV Construction	April 1, 2025	April 30, 2025	May 7, 2025
ROV Testing and Troubleshooting	Apr 15, 2025	June 1, 2025	Ongoing

Figure 3: Schedule developed by company to ensure proper pace throughout year.

Scheduling

To ensure optimal company efficiency, the Buccaneers implemented a predetermined schedule at the beginning of each semester. To determine the best meeting dates and times, a survey was distributed where members selected available times. As the season progressed, meeting frequency increased to ensure completion of the project.

As shown in Figure 3, the season began with recruiting new members and researching and developing the general design of *Halcyon*. Once MATE mission specifications were released, further development began to ensure that *Halcyon* would be fully capable of completing every mission with success. Upon fabrication of the ROV, in-water testing began.

Teamwork and Company Description

The East Tennessee State University Buccaneers are a highly experienced underwater robotics company dedicated to the efficient completion of the design and construction of *Halcyon*. The company is comprised of seven undergraduate students with a combined 30 years of experience in MATE. Each member has a unique skillset, which leads to the natural delegation of tasks to each member. This logical organization guided new members to their department. The company's departments include mechanical, electrical, software, and float. With such a small company, members often overlapped between departments, leading to a well-rounded knowledge of the project for all members.

The company is led by two positions. The first is the Chief Executive Officer (CEO), which manages the finances and coordinates with sponsors and the University. The Chief Operations Officer (COO) oversees the development of the ROV and its systems.

Figure 4: Table showing company members and information.

Name	Position	Year	MATE Exp.	Field of Study
Pearson Mills	CEO	Jr.	7	Biology
Samuel Deaton	COO/Pilot	So.	7	Computing
Quinn Bentley	Electrical	Jr.	7	Psychology
Patrick Lanham	Mechanical	Fr.	1	Engineering Technologies
Luke Seal	Software	So.	1	Computing
Matthew Smith	Safety	So.	6	Environmental Health
Noah Shelton	Float	Jr.	1	Computing

Resources, Procedures, and Protocols

In the day-to-day operations of the company, the Buccaneers employed various methods to ensure their success. To determine the design of the ROV for the year, company members would meet and brainstorm ideas. Cost-benefit analyses were conducted for multiple components and members would discuss what would be best for the design.

The Buccaneers meet at East Tennessee State University's Valleybrook campus. The company has a designated workspace and access to tools and materials. The workspace is available to company members whenever they need it for their projects. The Valleybrook campus also houses a small indoor above-ground pool used for thruster and control system testing.

To communicate online, Discord was used. Discord was selected for the instant sharing of ideas, pictures, and meeting plans. If any member was unable to attend, a rough update of progress would be shared. Also used was Microsoft OneDrive for technical documentation and file storage. Autodesk Fusion was used as computer-aided design (CAD) software.

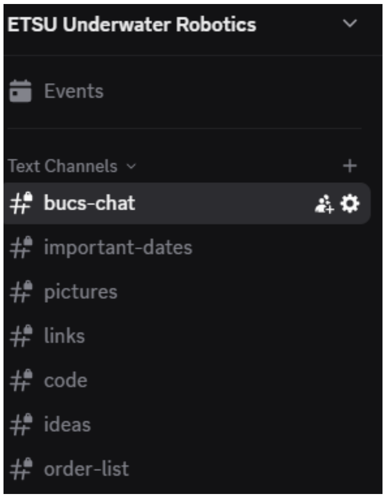


Figure 5: Image showing communication channels on Discord.

Design Rationale

Innovation

The Buccaneers are focused on a balance between innovation and not reinventing the wheel. Countless methods in the realm of underwater robotics are now tried and true. However, the Bucs believe there is always room for innovation and improvement. The Bucs' *Halcyon* features several design elements that are not too common in the MATE ROV Competition. This year, the structure is fully original and 3D-printed, reducing the overall cost compared to past frame materials. The past thruster configuration has been improved from the previous year, with optimized thruster angles. Also new is the piloting controls, coupled with new sensors, allowing the ROV to move in any direction. These innovative features, outlined below, mark *Halcyon* as the Buccaneers' most advanced ROV yet.

Frame & Structure

Halcyon boasts a unique structure: one made completely out of carbon fiber filament. Past ROVs have featured extruded aluminum beams connecting the front and back of the vehicle. Compared to these rigid and relatively heavy components, *Halcyon* utilizes the watertight enclosure to attach the front and rear components, reducing unnecessary mass and simplifying construction, since the enclosure itself now functions as a structural element. The structure of the ROV is mounted to the enclosure by 3D-printed enclosure mounts. After referencing the Safety Data Sheet, it was clear that the Polymaker PETG-rCF08 was sustainable and non-toxic. This frame design was chosen because of its hydrodynamic symmetry and easy mounting angles for vectored thrusters.

The aluminum frame did have increased strength, but the weight reduction allowed by using 3D-printed parts far outweighs the minimal strength benefit. The 3D-printed parts also allow for smaller parts, as the overall frame can be customized to enhance strength at stress points, instead of requiring long metal beams across the entire ROV. According to Mark3D UK, a 3D-printed frame would be stronger than an aluminum frame.

The 3D-printed structure is made of Fiberon™ PETG-rCF08 from Polymaker. This filament has a density of 1.3 g/cm^3 – less than half of the density of the previous aluminum frame. Using a more lightweight material eases the process of achieving neutral buoyancy and reduces thrust demands. Fiberon™ PETG-rCF08 is produced reinforced with carbon fiber, strengthening the final product. The result is a structure featuring high dimensional stability, with exceptional tensile and flexural moduli.

Figure 6: Final frame print following prototyping. Credit: Samuel Deaton.

Before construction, the printed parts were painted white for visibility in darker waters. In construction, only stainless-steel fasteners were used, meaning that the screws, nuts, and bolts would not rust or corrode after prolonged exposure to water. A standardized size, M3, was chosen for all fasteners as it allows for lower cost and easier maintenance.

Designing and printing the frame allows for the full customization of the ROV's design. Unlike extruded aluminum, which relies on fixed profiles and mounting brackets, 3D printing allows for any geometry, enabling integrated mounts and weight optimization. If the ROV needs to be adapted for certain uses, the design can be quickly modified and reprinted. Additionally, printing the structure promotes modularity of components, as mounting holes can be placed anywhere during the design phase, rather than being limited by fixed rail spacing or brackets. The increased utilization of 3D printed components not only allows for increased modification and customizability but also ensures easy installation and replacement if parts are damaged.

ROV (Year)	Material	Density (g/cm^3)	Ease of Use	Cost	Customizability
Kraken (2023)	HDPE	0.95	Moderate	Low	High
Calypso (2024)	Extruded Aluminum	2.71	Moderate	High	Moderate
Halcyon (2025)	PETG with Carbon Fiber	1.30	High	Low	High

Figure 7: Comparison of frame of Halcyon and previous ROVs of the Buccaneers.

Thrusters

Halcyon is propelled by eight Blue Robotics T200 thrusters. As with previous ROVs, T200 thrusters were selected for their reliability, strong thrust capability, and compatibility with the control system. Additionally, they have their own electronic speed controllers designed specifically for their operation, from Blue Robotics. Each thruster is located in a corner of the ROV's structure, mounted at a 45° angle. This angle provides omnidirectional movement yet allows for a stronger up and down thrust. Mounting the thrusters within the frame of the ROV protects the thrusters from being bumped during operation and transportation. Moreover, locating the thrusters closer to the ROV's center of mass naturally reduces the necessary torque for rotating, allowing for more precise control in piloting.

The front and rear thrusters are both directed towards a point behind and in front of the ROV, respectively. This configuration allows for high maneuverability and thrust efficiency. When moving in any direction, every thruster can contribute to the propulsion of the ROV. Distributing the power between eight thrusters also allows for operation at the most optimal range on the efficiency graph (Figure 8). For example, if only two thrusters were used to ascend or descend, their power usage would be less efficient. When power is distributed among eight thrusters, power can be used at its maximum efficiency.

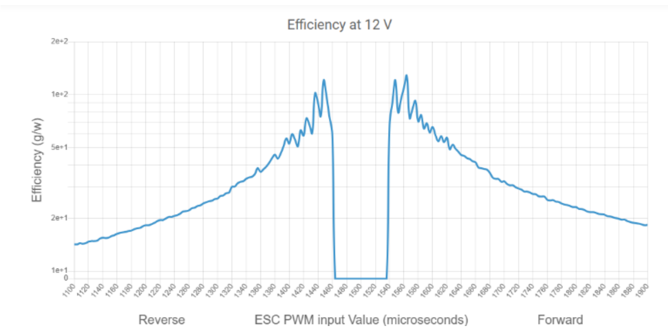


Figure 8: Graph showing power efficiency of T200 Thruster at 12 Volts. Credit: Blue Robotics.

Furthermore, if a thruster fails, the remaining thrusters can compensate for it, a feature not as strong in a six-thruster configuration. When carrying a heavy load, power can be increased to the front thrusters, allowing the ROV to stay level as it is piloted. Each thruster is fitted with 3D-printed thruster guards to ensure the safety of operators and to prevent outside interference with the propellers (Figure 9). The guards meet IP-20 standards, keeping objects greater than 12.5 mm from reaching the propellers.

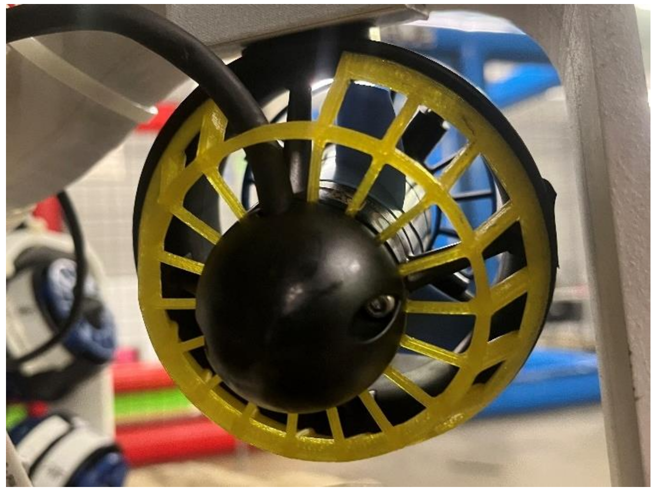


Figure 9: Image showing thruster equipped with propeller guards. Credit: Matthew Smith.

Vision

Figure 10: exploreHD 3.0 underwater camera in mount. Credit: DeepWater Exploration.

Halcyon is outfitted with four Arducam cameras, an exploreHD 3.0 camera, and an RCA camera. The Arducam cameras were selected for their low cost and high quality. The exploreHD camera is from Deep Water Exploration and was chosen for its crystal-clear video, light weight, and industry-level reliability. The RCA camera was used for its robust design and proven reliability with previous ROVs. Digital cameras were selected over the RCA cameras to be the primary video source for their higher quality imaging and lack of a need for video conversion.

Every camera is positioned to allow for maximum functionality in completing the MATE mission tasks. For example, one camera is facing the manipulator for the many tasks that require use of the manipulator. One camera is located on a foldable arm that when extended gives the camera a third person view of the ROV in the water. This allows the pilot(s) to gain a more complete view of where *Halcyon* is in the water. The six camera streams are available for viewing on the Calypso Control Station during operation. *Halcyon* also has two Lumen Subsea Lights – dimmable LED lights capable of outputting up to 1500 lumens of light. The lights enhance the ability of *Halcyon* to perform in low-light conditions.

Buoyancy

Through measurements, calculations, and testing, *Halcyon* has achieved near-neutral buoyancy. Throughout the design process, buoyancy was considered and influenced the design. The ROV was constructed in a way that it would be significantly symmetrical, in both shape, size, and mass.

To calculate the needed upward buoyant force to counteract the weight of *Halcyon*, the weight of the ROV was measured in air and in water. Using these measurements, the volume and density of the ROV were figured. With these values and the known density of water, the Archimedes' Principle equation was employed to calculate the buoyant force of *Halcyon*.

This calculation informed the selection and placement of Subsea R-3312 syntactic buoyancy foam, a closed-cell foam specifically designed for underwater applications. The foam was added strategically to achieve near-neutral buoyancy and to balance the ROV in all axes.

In addition to buoyancy, the locations of thrusters, watertight enclosures, and internal electronics were carefully planned to maintain both vertical and horizontal stability. The result is an ROV that remains balanced in water, requires minimal pilot compensation, and performs reliably in all mission scenarios.

Calypso Control System

Halcyon is designed for easy piloting with several beginner friendly features. This is accomplished through a simple, yet advanced, graphical user interface (GUI). The top half of the GUI is housed in the lid of the topside control system and displays five cameras simultaneously, with one in an expanded view. The top GUI also shows the status of sensors onboard the ROV, including the depth and pressure sensor, temperature sensor, and leak sensor (Figure 11). Additionally, the current piloting mode of the ROV can be viewed (i.e., precision, turbo, tilt). *Halcyon* can be piloted with the use of one or two controllers, depending on pilot availability and needed agility.

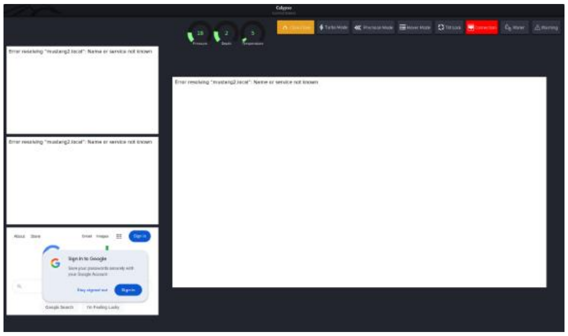


Figure 11: GUI without camera feeds connected.

Sensors

Halcyon is fitted with six unique sensors that enhance its operation and performance. Housed within each watertight enclosure are SOS Leak Sensors. Each leak sensor is plugged directly into the Raspberry Pi Pico. If either sensor detects water, a signal is sent to the topside control system and the pilot's controller vibrates.

The ROV's second sensor is a Bar02 sensor, capable of measuring depth, pressure, and temperature. The Bar02 measures depth to a precision of 0.16 mm, allowing the pilot(s) to gain further knowledge of where the ROV is in the water. This sensor grants the pilot(s) the ability to accurately see how far the ROV is from the floor or surface. The reading from the depth sensor can hold *Halcyon* at a certain depth when the pilot(s) enables Hover mode. The Bar02 sensor is located in the rear flange of the main watertight enclosure.

There is a Celsius temperature sensor in the rear flange of the main watertight enclosure. It is also connected to the Pico and relays the surrounding temperature to the surface with a precision of ±1˚C, with a response time constant of up to two seconds.

To assist in determining the pH of a saline solution in Task 1.3, *Halcyon* is fitted with an onboard pH sensor. This sensor is connected to the electronics enclosure and sends pH readings to the topside control system. The pH probe is capable of penetrating the wrap of the water sample and detecting the pH value of the sample.

For ensuring current limits with our electrical system, a current sensor is used. If this sensor detects a current value higher than the threshold, the thrusters and other electronics will be limited. This ensures that *Halcyon* does not use more current than allowed.

Lastly, there is a gyroscope and accelerometer within the enclosure. The gyroscope and accelerometer enable the pilot(s) to know the position of the ROV, with knowledge of both rotational and linear motion. The gyroscope can be used to tilt the ROV forward, which is useful in creating a 360˚ photosphere or connecting the pCO2 sensor to the subsurface Smart buoy.

Payload and Tools

In order to complete missions, the Buccaneers have implemented custom tooling designed to effectively accomplish various tasks. For most tasks, such as Task 1.2 (Replace a damaged thermistor) and Task 2.2 (Place a hydrophone), a general-purpose manipulator is used. This manipulator has been specifically designed with multiple targets in mind. Different targets not only have different weights, but different shapes and orientations as well. Having a manipulator that can effectively retrieve multiple targets reduces time spent switching tools.

Tasks such as Task 2.2 (Place a Hydrophone) require specialized tooling to efficiently complete the mission. In order to retract the metal pin in the hydrophone, a magnet attached to the front of the ROV is used, resulting in less precision required to pull the pin, thus increasing performance. For Task 2.2 (Collect life stages of Jellyfish) a specialized basket is used to safely retrieve the Medusa Jelly. This basket is designed to reduce drag yet provides the jellyfish with enough water for a safe retrieval. Using specialized equipment reduces the time it takes to complete missions. The Buccaneers have created many prototypes to create the most optimized and efficient tools.

Full capabilities of *Halcyon* can be found in Appendix F.

Watertight Enclosures

The electronics of *Halcyon* are housed within two Blue Robotics watertight enclosures. The larger enclosure is aluminum, has a diameter of 13 cm, and a length of 30 cm. The enclosure's durable aluminum body allows the electronics to stay cool by quickly adjusting to the water's temperature. This means that the enclosure serves as a heat sink, transferring the heat created by the electronics to the water.

The wires enter and exit the enclosure through a rear end cap that features 26 M10 penetrator holes. This high-capacity end cap was selected for its ability to accept a large number of wires, which is vital for the use of eight thrusters and six cameras. Furthermore, more components can easily be added to the ROV's design in the future, such as additional cameras or manipulators.

The secondary enclosure is made of acrylic and measures 7.5 cm in diameter and 24 cm in length. It was added to house additional electronics that could not be integrated into the main aluminum capsule due to space constraints. While it does not offer the same thermal conductivity or pressure resistance as aluminum, it is suitable for housing lower-power components and provides visibility into the enclosure's interior for monitoring.

Both caps can lock to the enclosure tube via a locking cord, further enhancing the enclosure's ability to remain watertight. The locking component also prevents the electronics from rotating, reducing the likelihood of any internal damage. A benefit of separating electronics into multiple enclosures comes in leak protection. If a leak begins in one enclosure, only a portion of electronics are at risk. This can be likened to watertight bulkheads in ships, preventing water from spreading throughout the base of the ship. Both enclosures house desiccant gel packs that absorb any moisture that may seep in.

Topside Control System

The primary electronics of *Halcyon* are housed onboard, leading to a streamlined topside control system with minimal components. The lid of the topside control system contains a 39.6-cm monitor, displaying the camera feeds and sensor outputs. The monitor in the base of the system displays a three-dimensional model of *Halcyon* with real-time gyroscopic updates. The topside control system features strain relief and abrasion protection for the camera, power, and communication wires entering the control system, ensuring stable power and communication from the surface to the ROV. Additionally, a USB-C power brick powers both monitors and a Raspberry Pi 5. The Pi 5 manages the GUI and controller inputs.

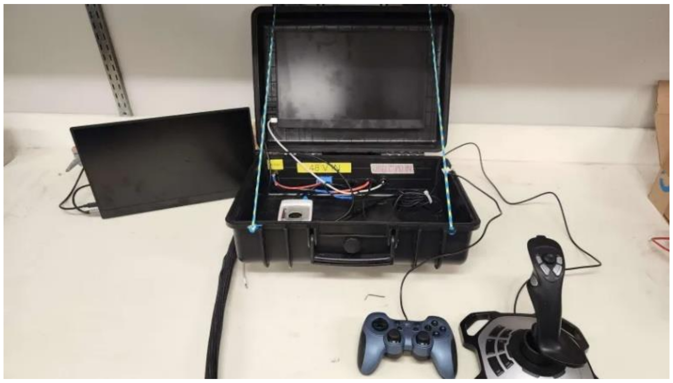


Figure 12: Topside Control System with ROV Controllers. Credit: Pearson Mills.

Power

Power enters the system at the tether as 48 volts after passing through a 30-amp fuse then enters the watertight enclosure. From there, a 48-volt-to-12-volt converter converts the voltage to 12 volts. This power is distributed through Blue Robotics ESCs to the T200 thrusters, and to the cameras, and a 12-volt-to-5-volt converter. This converter sends 5 volts to the Raspberry Pi Pico, Raspberry Pi 3B+, and to the servos for the manipulator.

Software

To control the movement of *Halcyon*, the pilot(s) uses both a Logitech Rumblepad 2 and a Logitech G Extreme 3D Pro. This allows for precise control of the omnidirectional movement that is possible with the thruster positions.

The Raspberry Pi 5 on the surface utilizes custom code written in C#, C++, and Assembly to optimize the controller inputs. The custom GUI, known as Calypso Control System, uses C# to handle the visual elements. It then uses C++ to handle controller inputs as well as modes and sensors. Assembly is used for calculating thruster vectors. The inputs reach the ROV in less than 32 milliseconds, allowing for near instantaneous control time. This is paramount when piloting the ROV with limited time as well as allowing for quick corrections in the event of changing conditions.

The propulsion system takes the joystick inputs and calculates the percentage of movement. This is then used in combination with precalculated vectors to provide data for the thrusters. Using precalculated vectors reduces the time it takes to calculate vectors every time, which helps to achieve a quick response time. Because each input is a separate vector, they can be added together for multiple movements. Having the additional buttons and joysticks on the Logitech G Extreme 3D Pro allows for individual buttons for starting missions as well as full tilt controls with the joystick. There is also a sensitivity dial that controls the vectors even further than the driver assist modes allow. For very accurate movements, precision mode can be activated. This limits the thrusters' movements significantly. To traverse at high speed or lift heavy objects, turbo mode can be used. This mode will raise the limiter, and in combination with the sensitivity dial can remove the limiter entirely for extreme situations. For staying at a certain depth, hover mode can be engaged. This is not only helpful for completing a depth hold, but also for carrying heavy objects. The thrusters will automatically compensate for the heavier load and adjust accordingly. For holding at a certain angle, tilt lock is used. Tilt lock checks the MPU6050 gyroscope and accelerometer and adjusts the thrusters based on the result. When the poolside technician is handling the ROV, safe mode can be initiated to ensure employee safety. This mode prevents any inputs from reaching the ROV, resulting in a fully shutdown robot.

Build vs. Buy, New vs. Used

This year, the design of *Halcyon* incorporates a combination of new, commercially available components, custom-designed and 3D printed pieces, and reused components from previous ROVs. The new components were purchased based on comparison with previous components. The 3D-printed mounts were selected for their customizability and affordability. The reused parts were chosen for their known reliability and no cost to use.

Component	Reasoning
T200 Thrusters	All eight thrusters featured on the previous ROV were deemed to be in ideal shape and were reused. The reuse of eight thrusters allowed the company to not spend over $2000 on new thrusters (See Appendix D).
Main Watertight Enclosure	The enclosure and its caps were reused due to a similar functionality required this year.
Certain Electrical Components	*Halcyon* reused a Raspberry Pi 3B+, buck converters, and one Lumen Subsea

	light. The tether was also reused.

Figure 13: Table explaining reused components.

Component	Reasoning
Digital Camera	New cameras were purchased as higher quality was sought.
M200 motors	Past servos were unreliable and difficult to waterproof, justifying the purchase of new, stock-waterproof motors.
Secondary Watertight Enclosure	Additional buck converters were added to the main enclosure, requiring a second enclosure to fit the remainder of the electronics.

Figure 14: Table with examples of purchased, new components on Halcyon.

Component	Reasoning
PETG-rCF08 Structure	The previous extruded aluminum frame lacked much customizability. Printing the frame allowed for full customization of every aspect of the frame.
Enclosure Mounts	The mounts for both enclosures were printed. They are very rigid and only cost a few dollars to print versus manufactured mounts costing upwards of $80 USD.
Thruster Mounts	Custom mounts for the T200 thrusters were printed. This allows the thrusters to be mounted at a 45˚

	angle and easily attached.

Figure 15: Table showing company-constructed components with reasoning.

Buoyancy Engine

Our buoyancy engine, *Luna*, has been specifically designed to complete tasks efficiently and safely. *Luna* is comprised of a Raspberry Pi Pico, a Servo, a Bluetooth module, and a Bar02 sensor. It uses the Bluetooth module to transmit data from the float to a control station on the surface. A Bluetooth module was used based on previous years' experience, as they worked well with low power requirements. Once the Pico gets the signal to begin the mission, the servo actuates a syringe, changing the buoyancy dynamically to either float or sink. With this specialized hardware, *Luna* can complete Task 3.1 (Design and construct an operational vertical profiling float).

Problem Solving and Brainstorming

When the fall semester began, company members would meet to discuss and brainstorm ideas for the upcoming year's ROV. This involved weekly meetings for three months for ideation. Design ideas were drawn on a whiteboard then in Autodesk Fusion. This process was heavily seen in the design of the frame, thruster location, manipulator, and mounts.

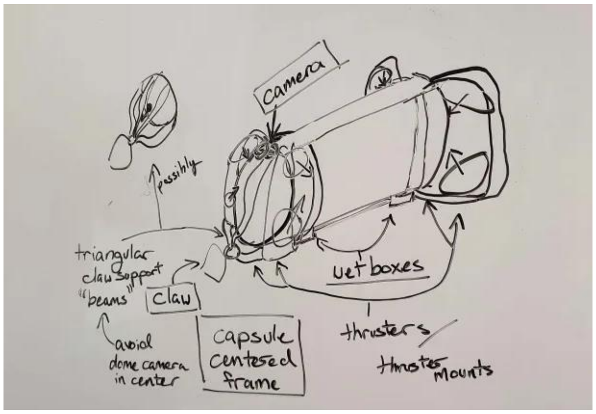


Figure 16: Whiteboard drawing from September 2024 of potential design of ROV. Credit: Julianne Barteck.

Members would comment on said design and the design would be modified as necessary. For example, an original manipulator design was printed. It was shared with company members and tested. However, the design did not function as intended, leading to improvements in its design.

Testing and Troubleshooting

During construction and upon completion of *Halcyon*, all components underwent thorough testing. In initial water testing, one manipulator design did not meet the company's standards as it was unable to function properly with the MATE missions. It was modified during testing and became a custom tool.

Another instance of testing came with the use of a vacuum pump with the watertight enclosures. The pump would be attached to a vent plug or pressure relief valve and a vacuum would be created. If the gauge maintained its reading for fifteen minutes, the enclosure would be ready for in-water operation. If the pressure significantly decreased, all penetrators and O-rings would be inspected. This troubleshooting process was repeated until the enclosures were fully sealed.

Safety

Philosophy

The Buccaneers uphold strict safety standards throughout the ROV development and deployment. Maintaining a safe environment for both company members and marine life is a priority. As such, company members work to maintain a professional and safe environment at all times. All company members undergo safety training of potential hazards and are informed of emergency situations. By adhering to strict safety standards, the Buccaneers not only prevent injuries, but create a safe working environment for company members and users.

Company Safety Measures

During the operation of *Halcyon*, the Buccaneers adhere to a strict set of protocols to ensure the safe handling of the vehicle. For example, whenever *Halcyon* is deployed, the team follows a "Pre-Flight Checklist." This checklist consists of multiple steps including a fuse check, thruster test, a thorough enclosure test, tether check, visuals check, and basic ROV operation safety protocols (Appendix E). The Buccaneers observe operational safety measures that are outlined in the Jobsite Safety and Environment Analysis. These measures ensure avoidance of the risk of injury and damage to individuals or the ROV.

While constructing the ROV, all company members are required to wear safety glasses as part of their Personal Protective Equipment (PPE). Additionally, it is mandatory to wear closed-toed shoes and remove any jewelry when in an active workspace. Team members with long hair are required to tie it back to prevent it from getting caught in any machinery. Multiple company members completed OSHA certifications to ensure workplace safety. The COO has an MSSC-CPT 4.0 certifcation.

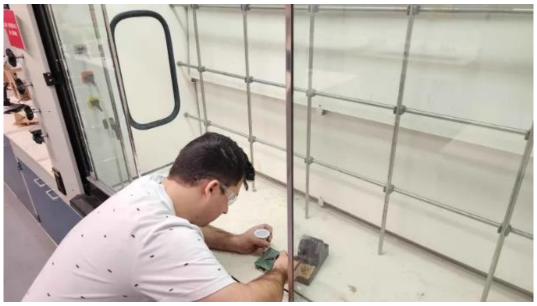


Figure 17: Image showing company member wearing eye protection and soldering under fume hood. Credit: Pearson Mills.

ROV Safety Features

Apart from the operational safety procedures that the Buccaneers employ, there are also many safety features built into the ROV. These various features range from electrical and mechanical to software safety measures, which ensure the lowest chance of personal harm or machine damage.

In terms of electrical safety, *Halcyon* utilizes a 30-amp fuse to prevent unsafe shorts that could harm the electrical components or members of the team. This is an inline fuse that is housed within 30 centimeters of the Anderson power pole connectors. The surface-side control box contains a kill-switch so that in the case of a short, fire, or any other electrical issue that may damage electronics, a team member is able to instantly prevent power from reaching the ROV. With the idea of electrical workmanship in mind, this also serves as a safety feature, wherein wires are not contributing to any other safety risks such as loose wires, bad jumpers, or improper wire gauge size. Mechanical safety includes the reduction of sharp edges, securing the frame, utilizing tether thimbles and strain/abrasion protection at key places of possible movement. The motors are equipped with 3D-printed motor shrouds that prevent any undesired contact with the propellers.

On the software side of safety, there are several features that have been included to ensure *Halcyon* and the Buccaneers can always run at the fullest potential. Leak sensors allow the company to identify when a possible short could arise due to water leakage. When the sensor identifies a leak, the Raspberry Pi Pico will notify the Raspberry Pi 5 and return the signal to the surface to be viewed via a custom GUI. In order to prevent unnecessary damage, the power output by the thrusters is reduced by a code multiplier in the PWM output signals. Because of the eight-thruster configuration of *Halcyon*, the power can be greatly reduced; otherwise, it is too powerful to use safely.

Accounting

To organize the funding of the construction of *Halcyon*, the Buccaneers established a detailed budget at the beginning of the season. This proactive approach ensured that the company could make informed financial decisions throughout the development stage and remain focused on engineering and innovation in the later stages.

Working within the financial guidelines of the University, the Buccaneers compiled a comprehensive list of projected expenditures to request. This included registration fees, travel and lodging, and ROV components. Through this process, the company received substantial support from the University's Student Government Association, which served as the company's primary internal funding source. In addition to university funding, the company secured three external sponsorships. These partnerships allowed the Buccaneers more room for innovation and helped form partnerships with industry professionals.

From the beginning, the company emphasized cost-effectiveness. Early budgeting and ongoing accounting allowed the company to track purchases carefully, reuse components from past projects where feasible, and prioritize spending on essential upgrades. This strategy helped avoid unnecessary expenses and provided financial flexibility for unexpected needs.

View the full budget and project costing in Appendices C and D.

Acknowledgements

The Buccaneers would not be where they are today without the support of key sponsors and University supporters. The Bucs would like to thank Natasha Gardner for the administrative support, Betsy Cunningham for being our mentor as well as the contact for ETSU Research Corporation, Julianne Barteck for mechanical engineering expertise, and Natalie Nottingham for the assistance with documentation. We would also like to thank the MATE ROV Competition Judges and Volunteers for making all this possible. The Bucs would also like to thank the following organizations for helping them every step of the way!

STUDENT GOVERNMENT ASSOCIATION
EAST TENNESSEE STATE UNIVERSITY

ETSU Research CORPORATION

polymaker

TMT Tennessee Machine Tool Inc.

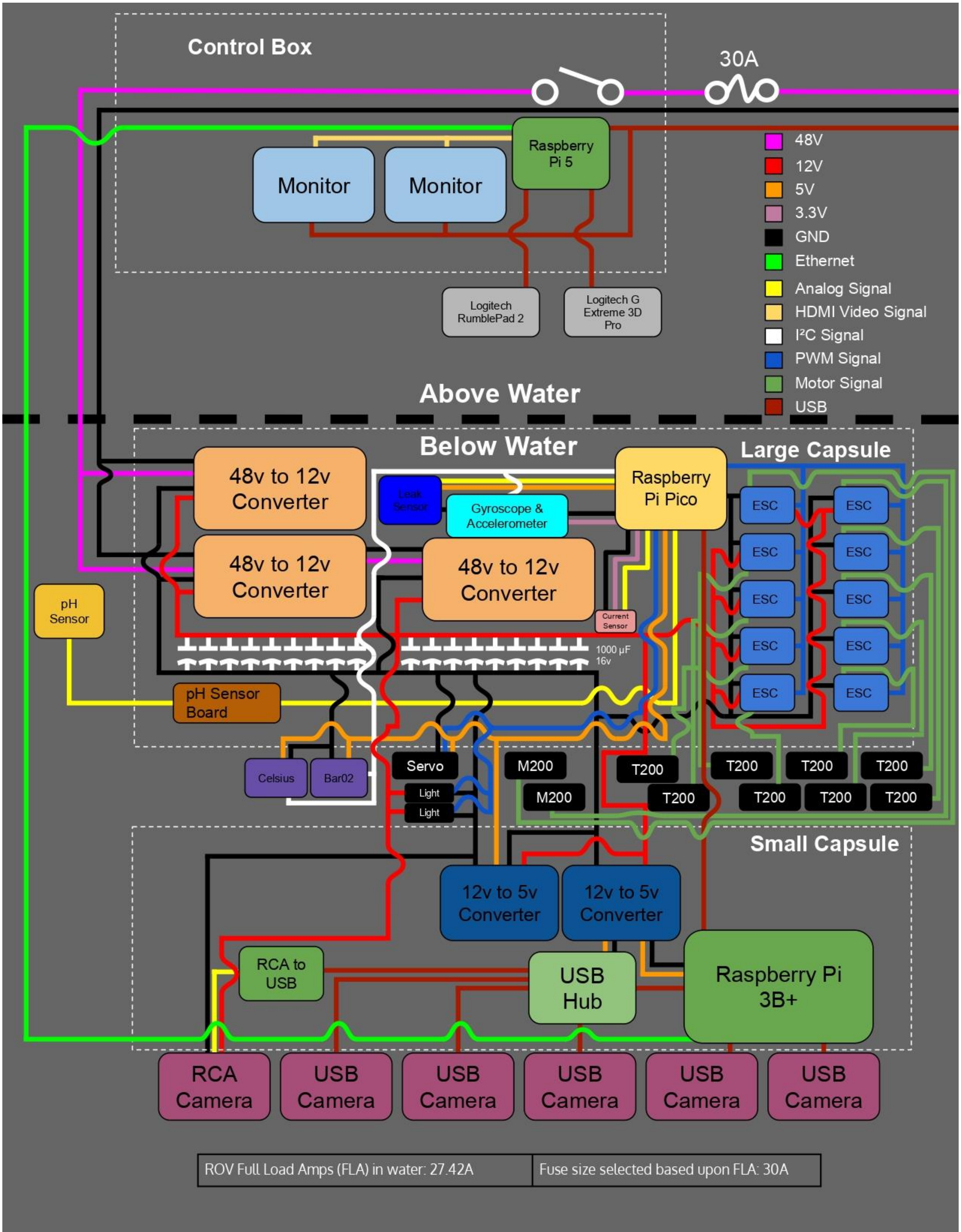
MATE ROV COMPETITION

JOHNSON CITY Ford

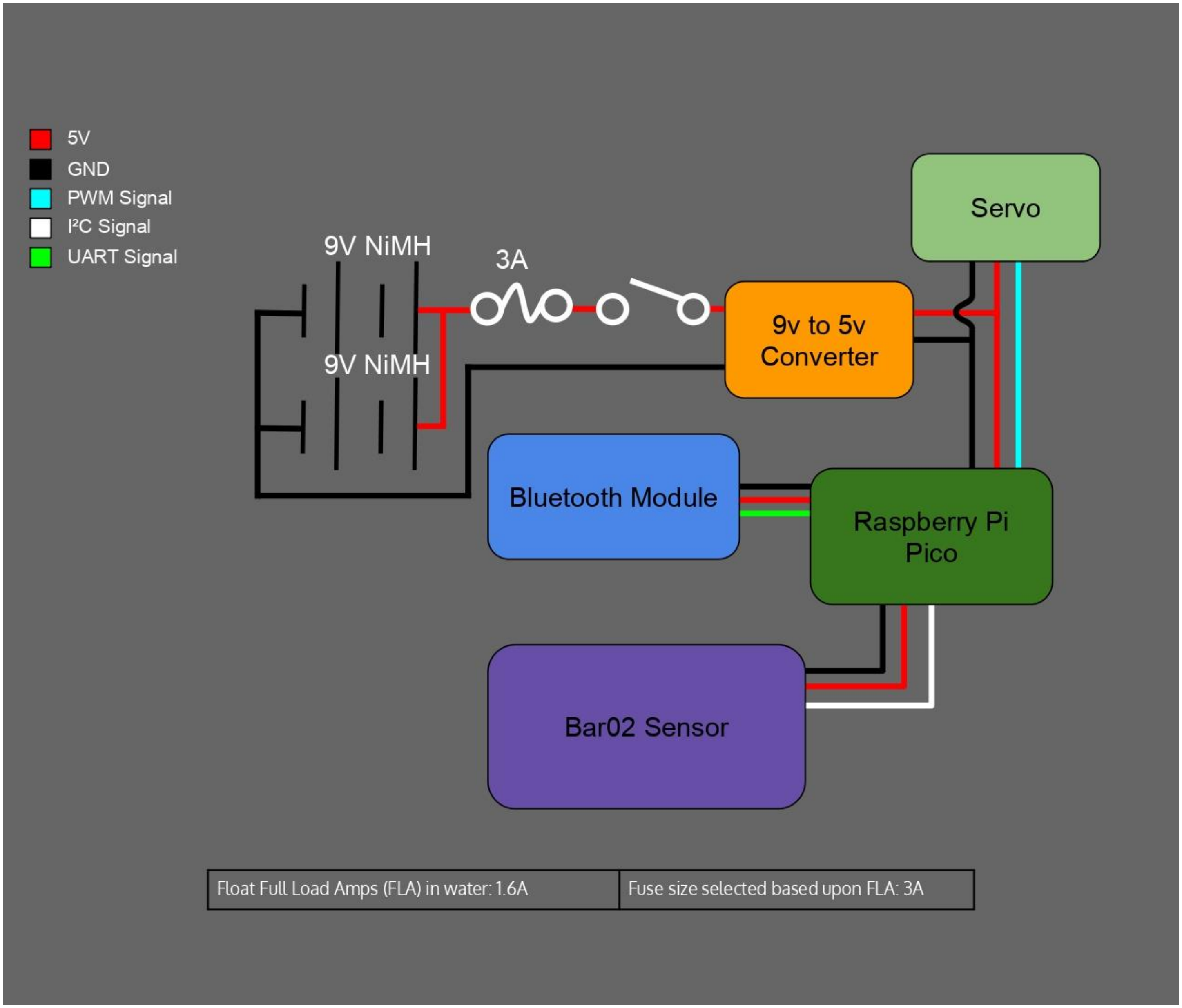
STREAMWORKS

Appendices

Appendix A: Main ROV SID



Appendix B: Float SID



Appendix C: Budget for the 2025 season.

Budget

School Name: East Tennessee State University

Reporting Period
From: 26 Aug 2024
To: 23 Jun 2025

Income Source	Amount	
Student Government Fund	$	7,390.00
Tennessee Machine Tool	$	250.00
Johnson City Ford	$	250.00
ETSU Research Corp	$	1,000.00

Expense	Category	Description/Examples	Projected Cost		Budgeted Value	
Hardware	Purchased	Enclosure, fasteners	$	800.00	$	800.00
Hardware	Re-used	Enclosure, thrusters	$	2,500.00		-
Hardware	Donation	Polymaker filament	$	300.00		-
Electronics	Purchased	Pico, cameras, buck convertors, ESCs	$	800.00	$	800.00
Electronics	Re-used	Controller, Pi 3B+, Light	$	1,000.00		-
Sensors	Purchased	Bar02, Celsius, pH	$	200.00	$	200.00
Travel	Purchased	Lodging, rental car to MI	$	5,300.00	$	5,300.00
General	Purchased	Team Shirts	$	400.00	$	400.00
			Total Income		$	8,890.00
			Total Expenses		$	7,500.00
			Total Expenses (with re-used/donations)		$	11,300.00
			Remaining Amount		$	1,390.00

Appendix D: 2025 Project Costing Sheet.

Category	Type	Expense	Amount	
Frame	Donated	Frame filament	$	70.00
Thrusters	Reused	T200 Thrusters	$	2,064.00
Tether	Reused	Tether	$	60.00
Enclosure	Reused	Aluminum watertight enclosure	$	634.00
Enclousure	Purchased	Acrylic enclosure	$	304.00
Tools	Purchased	pH, manipulator, magnet	$	400.00
Raspberry Pi	Purchased	Picos	$	10.00
Raspberry Pi	Reused	Pi 3B+, Pi 5	$	168.00
Cameras	Purchased	exploreHD, Arducam	$	430.00
Lights	Purchased	Lumen Subsea	$	170.00
Lights	Reused	Lumen Subsea	$	170.00
Monitors	Purchased	Topside monitors	$	120.32
Controllers	Reused	Logitech Rumblepad 2	$	30.00
Controllers	Purchased	Logitech Extreme 3D Pro	$	40.00
ESCs	Purchased	Blue Robotics ESCs	$	380.00
Buoyancy	Reused	Subsea R-3312	$	48.00
		Total (ROV)	$	5,098.32
Travel				
Hotel Lodging	Purchased	5 nights, 2 rooms	$	3,060.00
Rental Car	Purchased	1 vehicle, 7 days	$	395.87
MATE ROV Registration	Purchased	EXPLORER registration	$	650.00
		Travel Total	$	4,105.87
		Grand Total	$	9,204.19

EAST TENNESSEE STATE
UNIVERSITY

Preflight Prep

1. Connect to power
2. Notify team members power has been connected
3. Flip on power
4. Pilot call out "Power on"
5. Team member place ROV in water
6. Team member calls out "hands-off"
7. Initiate Motor test
8. Pilot drive Forward
9. Pilot Turn Right
10. Pilot Turn Left
11. Pilot Lift Down
12. Pilot Lift Up
13. Pilot Drive Back
14. Pilot call out "Motor Test Complete"
15. Visual systems Check
16. CEO asks teammates if systems are ready to go
17. When all confirmed, CEO says "mission launch"

Appendix E: Pre-operation Checklist for the Buccaneers.

Appendix F: ROV Capabilities. The Buccaneers took the MATE missions into account in every step of the design and construction of Halcyon. The chart below shows how Halcyon was designed to complete every mission task set forth by MATE.

Task 1.1: Determine type of ship.	*Halcyon* has multiple cameras that are able to distinguish the various types of ships.
Task 1.1: Determine length of ship.	*Halcyon* can take a picture of the shipwreck, then compare the known length of the hull to the rest of the ship. This results in knowing the total length.
Task 1.1: Determine the cargo that the ship carried.	The primary manipulator and front cameras can be used to remove and replace the lid, while viewing the cargo inside. The manipulator can be rotated to its horizontal or vertical orientation to remove and replace the cover with ease.
Task 1.1: Create a 360° photosphere image.	The pilot of *Halcyon* can initiate the use of PTGui, a software made for creating spherical panoramas. With the use of a camera on the ROV, all seven targets will be shown in the image. The pilot can tilt the ROV in any direction to view every target.
Task 1.2: Replace a damaged thermistor.	*Halcyon* can remove the damaged thermistor with the manipulator. The pilot can engage in precision mode to assist in lining up the new thermistor with the connection points.
Task 1.2: Install pCO2 sensor.	*Halcyon* can carry the pCO2 sensor in the manipulator then connect it using tilt controls and precision mode if necessary.
Task 1.3: Determine the pH of the water sample.	A pH sensor probe is mounted to *Halcyon*. The pilot can line the probe up with the sample using precision mode and a dedicated camera. The probe is able to penetrate the plastic wrap and detect the pH.
Task 1.3: Measure the dissolved CO2 levels.	*Halcyon* can deploy a syringe and pull the plunger. This fills the syringe with the water and is returned to the surface for testing.

Task 2.1: Connect a floating solar panel array.	The manipulator of *Halcyon* can be used to remove the port cover, then retrieve and install the power connector. Precision mode can be activated to line up the connector and hub.
Task 2.1: Replace sacrificial anode.	The manipulator, along with depth hold and precision mode, can be used to rotate the sacrificial anodes as needed. The front cameras allow the pilot(s) to see where the anodes need to be rotated to. The manipulator can be rotated if the pilot needs to reposition.
Task 2.1: Mitigate corrosion.	Any camera on *Halcyon* can be used to inspect the base structure. The manipulator can be used to apply the epoxy patch.
Task 2.2: Collect life stages of jellyfish.	To collect polyp stage jellies, *Halcyon* can tilt back, making the manipulator face towards the surface of the water. This allows the manipulator to grab polyps located near the water's surface. To collect the medusa jelly, a custom container is mounted to *Halcyon*. This container collects the jelly in its water without significant drag or putting pressure on the jelly.
Task 2.2: Collect fish species underneath the solar panel array.	Like the polyp stage jellies, *Halcyon* will till back and grab the fish species with the manipulator. The ROV can drive back to the side of the pool with its manipulator above water to return the fish species.
Task 2.2: Place a hydrophone.	The manipulator can grasp the hydrophone by its grab loop or base then place it in its designated location. *Halcyon* has a magnet within a camera's view to pull the pin and release the hydrophone from its base.

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