2024-2025

TECHNICAL REPORT

RovRunners

Linn-Benton Community College

Albany, OR - USA

Frame	Tavie Brown, Sara Leathers, Sarah Mortenson
Controls	Eric Anderson (COO), Samantha Miles
Technical Writers	Cooper Madison-Dawson
Electrical	Jason Fanger (CEO), Connor Rud, Julian Whitton, Carson Emmert
Manipulator	Wade Johnson, Azreal Switzer
Vertical Profiler	Dwayne Wallace, Hunter Niedens, Noah Nielson
Mentors	Greg Mulder, Heather Hill, Kathy Austin

Introduction

Figure 1. Linn-Benton ROVrunners Team Members

Abstract

Cory is an efficiently designed underwater vehicle initially built for the 2024 competition. This year we developed a plethora of new attachments and features to assist in completing a variety of differing tasks.

To maintain Cory's aquatic supremacy, we've upgraded the mobility via two more vertical thrusters and an expanded codebase. We've also been working hard on a brand new housing, made to slim down our profile, granting access to tighter spaces. To allow for higher dexterity and manipulation control, we have replaced the two-year-old claw design with a new humanoid robot hand. With the new upgrades, Cory continues to move forward in its ability to tackle real-world challenges that impact our aquatic ecosystems.

A fifteen-member team (Figure 1) have spent the last year developing this ROV, making sure it follows safety standards to the letter. We've spent this time well to create a truly versatile ROV, ready to complete any challenges that are presented to us.

In this document, we hope to share Cory's journey of development and innovations, and show its ability to meet the obstacles and requirements it may face in both the competition and the real world. The ways in which we've changed and improved both the physical ROV and the ways we use the ROV will display our desire to advance this field and its applications.

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Teamwork

Company Profile

We are the ROVrunners, based at Linn-Benton Community College in Albany, Oregon. One of the challenges of a community college team is constantly trading old members for new ones as veteran team members move on to higher education.

To combat this issue, we make sure to form lasting bonds with our fellow team members, bonds that continue even after leaving. We work on homework together, personal projects, as well as, of course, portions of the ROV. Through this process, we disperse knowledge and training surrounding different styles and techniques involved in STEM fields. Through these group projects, new members can find their passions and where they can fit their past skills and grow new ones.

This strategy ensures that we can grow a collection of old and new members who know how to work in the real world to achieve their own and their future employer's goals.

Figure 2. ROVrunners Technical Writing Group

Personnel

Name	Responsibilities
Dwayne Wallace	Pool Side Support, Vertical Profiler
Eric Anderson	COO, Pilot, Coding, Cameras, Computer Systems
Cooper Madison-Dawson	Technical Writer, Poolside Assistance
Azreal Switzer	Copilot, Claw, 3D Designer, Frame, Cameras
Jason Fanger	CEO, Pilot, Coding, Cameras, Computer Systems
Wade Johnson	Benji, 3D design, Copilot, Poolside Assistance, Technical Writer, Chef
Sarah Mortenson	Vertical Profiler, Frame, Sous Chef
Sara Leathers	3D Designer, Frame, Thrusters
Samantha Miles	CFO, Pneumatics System, Accounting
Noah Niesen	Vertical Profiler
Hunter Niedens	Vertical Profiler, Frame
Tavie Brown	Frame, Poolside Assisance
Carson Emmert	Electrical System, Cameras
Connor Rud	Electrical System
Casey Bianco-Davis	Machining

Table 1. Members and Responsibilities

Resource Management

Since it worked so well last year, the team has been keeping track of all files and documents on a shared Google Drive. The shared drive worked as a library for both current and past files, including technical documentation, 3D designs, procedures, and photographic documentation.

Fast back and forth communication was facilitated via a team Discord server, which we have been using for over four years to great effect.

In person meetings were held in our personal lab space where we worked on the main ROV, and where we held the majority of our tools and resources.

Figure 3. Saturday Pool Tests

Planning and Scheduling

The ROVrunners met twice weekly during the school term on Tuesdays (Figure 4) and Saturdays. The Tuesday meeting, organized by head mentor Greg Mulder, served to review what was completed the previous week as well as organize what will get done in the coming week. Round robin style, individuals or sub-teams would take turns explaining their plan, progress, and/or the hurdles they faced. If any assistance or collaboration with another sub-team was needed, it would be discussed at this time.

The Saturday meeting served as an in-person collaborative workday, and/or a day for testing, often at a local pool (Figure 3). These meetings would always end with a Tuesday-style group discussion of what had gone well, what hadn't gone well, and what direction to go next. Sub-teams and individuals often planned their own meetings and workdays during the week in addition to those shared by the whole team in order to accomplish goals more quickly.

Figure 4. Tuesday Meeting

Design Rationale

Design Philosophy

The main idea of our design philosophy this year was improving upon the past designs. We focused on improving a variety of simple fixes for quality of operation, as well as a few large fixes which we hope will improve both the current and future function.

For practicality purposes, we always maintained a functional ROV ready for testing and practice. By doing this, we could take more time developing ideas and implementations of our many improvements, some of which took multiple months to finalize. Every time we would finish an upgrade, we would take a final evaluation of its practicality and decide when the installation would take place. This way, everyone would be aware of when the ROV was usable and when it was not.

Using the backlog of improvements from last year, along with new members and their ideas, we never run out of new ways to improve the ROV.

At the start of the year, we took a list of all things that we wanted to improve upon and made a ranking of importance. We used both the knowledge and experience of members from years prior and the information we had on tasks for this competition year. After formulating a list, we began working on the major improvements. We especially focused on the improvements that could potentially take the longest time to develop. We all split into sub-teams to tackle each design problem, and spent the first term in early development, while also making sure to test the ROV often so we could identify further upgrade ideas. Through this methodology, we've been able to create a superior Cory than the one that preceded it (Figure 5).

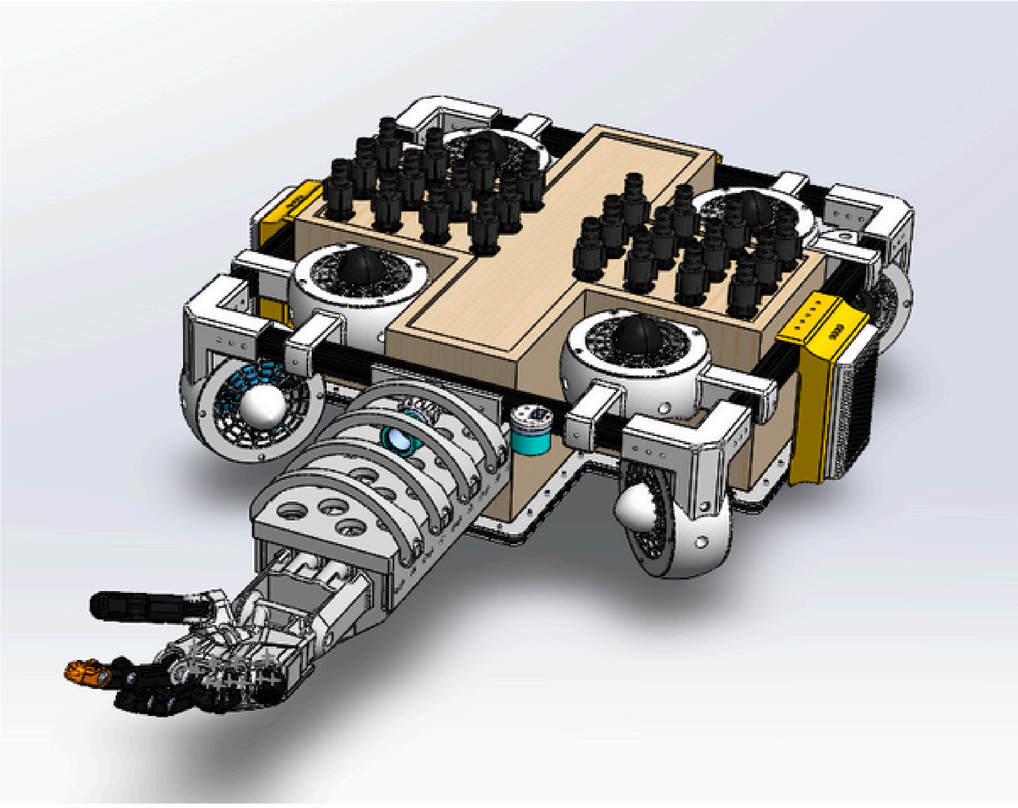

Figure 5. Cory

Hardware

Frame and Structure

Cory features an anodized extruded aluminum frame (Figure 5), measuring 0.48 m × 0.48 m × 0.15 m. The frame incorporates 3D-printed corner brackets that serve as thruster mounts and cover all sharp edges, while the anodization of the aluminum prevents oxidation. This robust yet lightweight aluminum structure ensures ample strength and allows for modular expansion with additional components as needed.

The frame is designed to accommodate three power converters and a cylindrical electronics housing, all centrally mounted along the vehicle's axis. This arrangement provides a low and centralized center of mass, maximizing stability during operation. Likewise, R-3312 polyurethane foam from BlueRobotics is arranged on the corners and below the electronics housing to achieve neutral buoyancy, with the center of buoyancy only slightly above the center of mass to provide increased maneuverability (Figure 6).

While the bulk of the frame is aluminum, true to the company's design philosophy, 3D printed brackets hold the aluminum frame together. These brackets were iteratively designed to provide the necessary strength without hindering the function or design intentions of the frame itself. In contrast to previous frame designs by the ROVRunners, Cory's "single layer" flat frame uses significantly less aluminum, creating a lighter, more affordable, and hydrodynamic basis upon which the rest of the vehicle can be built.

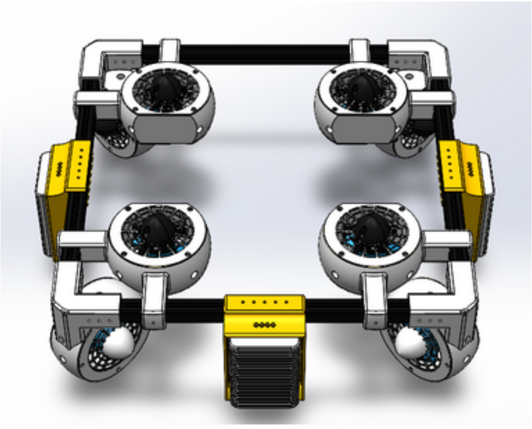

Figure 5. Cory's frame

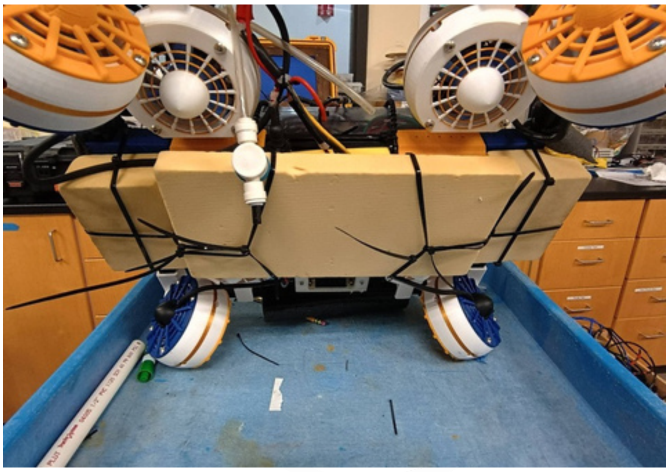

Figure 6. Cory's buoyancy foam on the frame

Propulsion System

Cory uses 8 BlueRobotics T200 thrusters for navigation. These thrusters, an upgrade from previous ROVRunner builds, were selected for their enhanced thrust capabilities and the brand's proven reliability. Four thrusters are mounted at a 90° offset from one another at each corner, providing primary directional movement. The 4 vertical thrusters are mounted at each corner to add roll, pitch, and yaw motility to Cory's capabilities. (Figure 7).

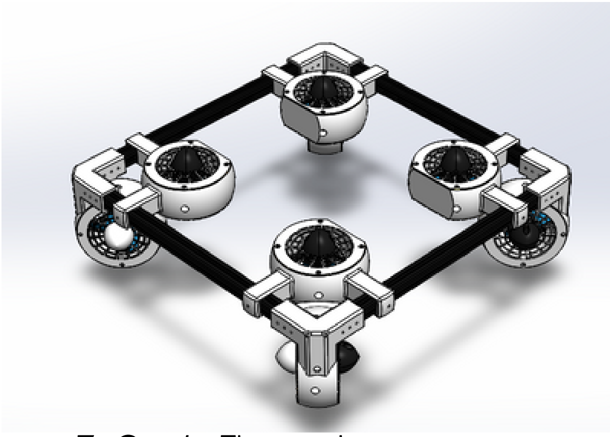

Figure 7. Cory's Thruster Layout

The main directional movement is achieved using vector geometry. This arrangement reduces movement power because half of each thruster's output is countered by another when moving linearly. However, this approach allows for precise yaw movements to change the ROV's direction without sacrificing stability or requiring additional thrusters.

The T200 thrusters are housed in custom-made 3D printed cases, with IP-20-compliant shrouds protecting the propellers for safety (Figure 8).

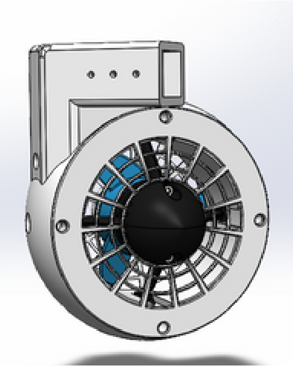

Figure 8. Cory's Thruster Shrouds

Electronics Housing

At the center of Cory lies our custom waterproof housing. Born out of the need to waterproof a control component that didn't end up getting used, the team broke away from their long-held tradition and designed a completely custom waterproof container. The housing cuts costs that you would find for a prefab housing. Using a length of clear PVC that we already had and an inexpensive 1/2 inch poly barb male adapter as ports designed to be connected to 1/2 inch swivel adapters.

In order to ensure that the housing's seal is robust and that there are no leaks, a handheld vacuum pump (Figure 9) has been modified with compatible connectors for easy and portable testing. A similarly modified bike pump (Figure 9) is used to determine the nature of any leaks detected by pressurizing the housing to ~3.5 kpa and applying soapy water to any seals.

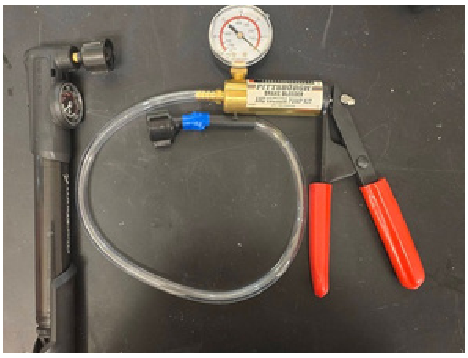

Figure 9. leak test tools

Due to the difficulty involved in removing and re-installing the electronics in the tube, a new housing is being tested that is larger and has an access point with an area wide enough for a hand to fit into for ease of maintenance (Figure 10).

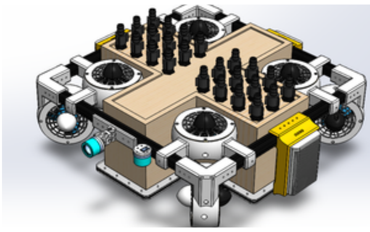

Figure 10. Redesigned electronics housing

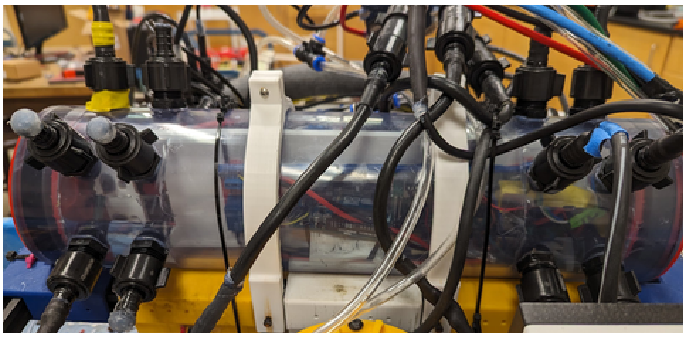

Figure 11. Final housing design with electronics components inside.

Manipulators

Cory is equipped with a pneumatic claw (Figure 11) designed specifically for the 2025 competition challenges. The 3D-printed claw is engineered with high precision and is built to be very durable, making it ideal for underwater operations. It features two concave fingers that automatically center objects, ensuring a secure hold on various shapes, especially round ones like PVC pipes. Each finger is powered by three couplings and a single pneumatic piston, allowing for smooth opening and closing with a simple switch. The pneumatic system is affordable and easy to install.

One major flaw we've noticed in past years is the claw base's tendency to break under tension. To solve this, we've spent time researching different materials, from the more durable filament PETG, to reinforced epoxy, but eventually we settled on milling an aluminum piece to work as the claw's base.

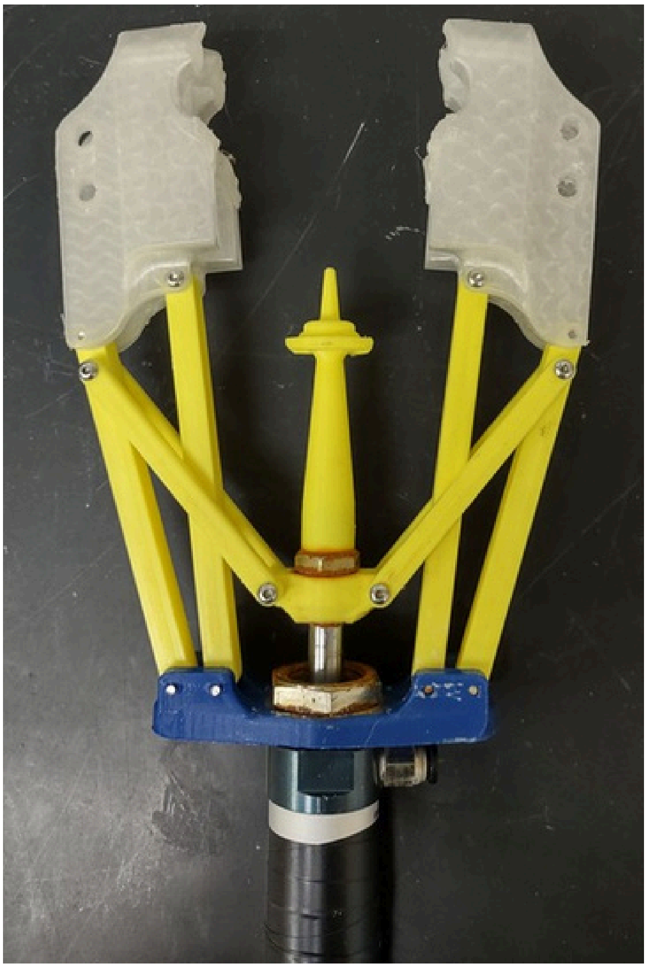

Figure 11. Cory's Manipulator

This year, we wanted to attempt to create a more dexterous and variable manipulator. In an attempt to achieve this, we've been working on a humanoid robot hand. This took twelve long months to get working from inception to the final functional product. We started with the most complex part of the hand: the fingers. In total, we went through more than fifteen different versions of a functional finger as we attempted to reach a level of strength and movement control that suited our needs. Once we had a hang of fingers, we pivoted to the actual "muscles" of the hand. After comparing pneumatic and electrical control, we opted to use electric because of its precision. Between linear actuators and disked servos, we decided to use the latter due to the density in which we could pack them together. We started with smaller 2kg per centimeter servos, then once we realized the strength limitations, we switched to 20kg per centimeter servos.

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Figure 12. Benji the robot hand.

Analog Cameras

The cameras use 22AWG UL2464 Power Cable with red, black, and yellow tinned copper conductors, ensuring reliable power delivery and signal transmission. Each camera connection features a SharkBite 1/2 Inch Poly Crimp Swivel Adapter, making the cables waterproof and durable for underwater conditions. The central hub (Figure 13) has six connections in total—four for the cameras, one for the 12V power input, and one for the video feed output. This setup enables efficient power distribution to the cameras and seamless video feed transmission to the topside DVR. This year, a smaller DVR, the Eversecu 4ch Mini CCTV Video Recorder, was selected to save space, resulting in a cleaner setup and more efficient data management.

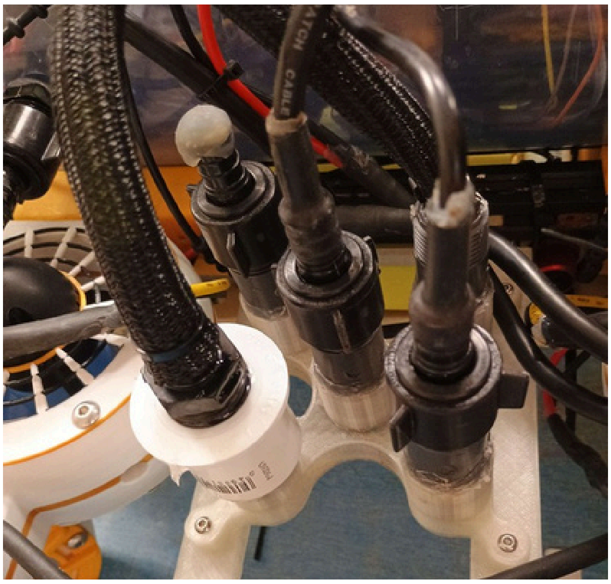

Figure 13. Analog Camera Hub

The 2025 ROV analog camera system is a linear progression of the previous year's design. We focused on maintaining the same general functionality and design for backwards compatibility and maintained modularity while reshaping it to fit our new mounting requirements. The system currently uses two (up to four) cameras mounted above and to the side of the claw for maximum visibility of the manipulator, each in custom resin casings for the best protection and performance. These cameras were picked because they are small and perform well. Their small size and custom 3D-printed mounting solutions mean they can be placed in more spots without getting in the way, making maintenance and troubleshooting easier. A faulty camera can be swapped out in a matter of minutes, ensuring minimal downtime and maximum efficiency. The custom resin housing (Figure 14) protects the cameras from water damage and other risks while keeping a clear view, making the camera system very robust.

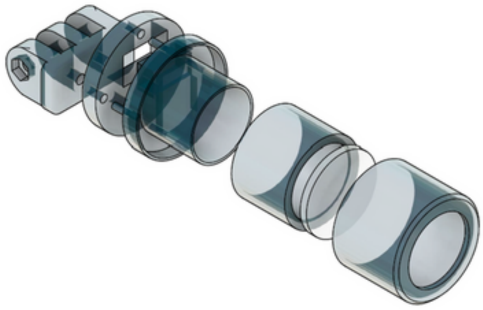

Figure 14. Exploded View of Camera Housing

Electric/Controls System

Tether

We designed Cory's tether (Figure 15) to be flexible and detachable. The tether is 15 meters long for ease of manipulability and portability while maintaining the ability to reach the furthest corners of the pool. It's composed of two 48 VDC power wires, two Cat8 cables for Ethernet connectivity and interference shielding, and two air hoses for our pneumatics systems, all of which are contained in a tough but flexible sheathing and affixed by strain-relief loops on either side.

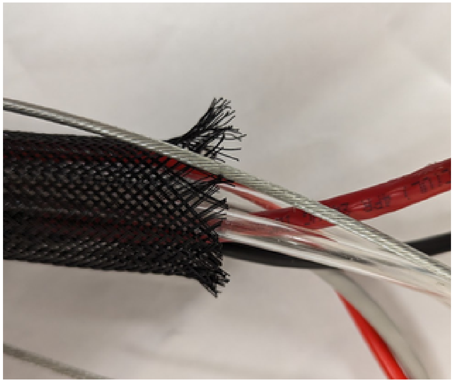

Figure 15. Tether

Wires contained in the sheathing are:

- Shielded Cat8 for clear analog camera signal.
- Shielded Cat8 for the Ethernet-based control signal communication system.
- Two 10-gauge power wires for 48 VDC power.
- Two pneumatic air hoses with a 1020 kpa (148-psi) rating for the claw.

At the topside of the tether, there is a closed-mesh, single-eye strain relief that connects to a plastic clamp on the control station. Coming from the strain relief, we have a communications Cat8 which connects to the control station computer, a second Cat8 which connects to the analog video display system, and two power wires which connect to our fused power supply box. There are also two air hoses coming from the strain relief, which connect to the pneumatic outputs of the control station.

On the ROV-side of the tether, there is a closed-mesh, single-eye strain relief that connects to a cable which wraps around the ROV frame, and is rated for 100 kg. The connections from the tether wires come from the strain and connect to their specified ports. The two 10-gauge wires are divided into three 48 VDC power lines, which connect to the three onboard power converters through custom waterproof connector couplings. One Cat8 connects to the analog camera system, and the communications Cat8 enters the electronics housing to connect to the onboard Raspberry Pi. The two air hoses connect to the pneumatic claw, such that pressure can be alternated to actuate the claw.

Connectors

The waterproof connectors are designed to be affordable, allow for modularity, and be simple to produce. All connectors (Figure 16) are made using standard plumbing components, which keeps costs down, costing only six dollars per connector, which is substantially less than the SubConn connectors that we were previously using.

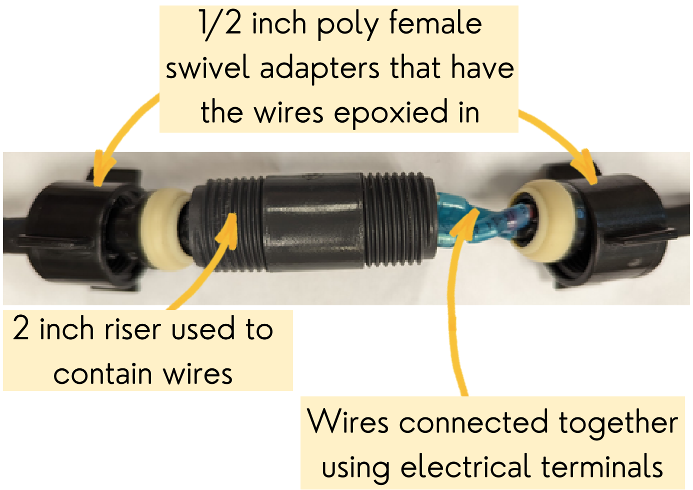

Figure 16. Custom connectors

These connectors are used to attach the tether to the 48 to 12 VDC converters. Single connectors are also used to connect to the electronics in the waterproof housing and used for the analog cameras.

Converters

Cory hosts three onboard power converters (Figure 17), which convert the provided 48 VDC to the more commonly used 12 VDC. As with all of the ROV's components, the power converters were designed with modularity in mind. Each converter is an independent unit that can be removed or replaced as needed to accommodate different functions. During last year's competition, one of these modular power converters failed, allowing an on-the-fly replacement to be done.

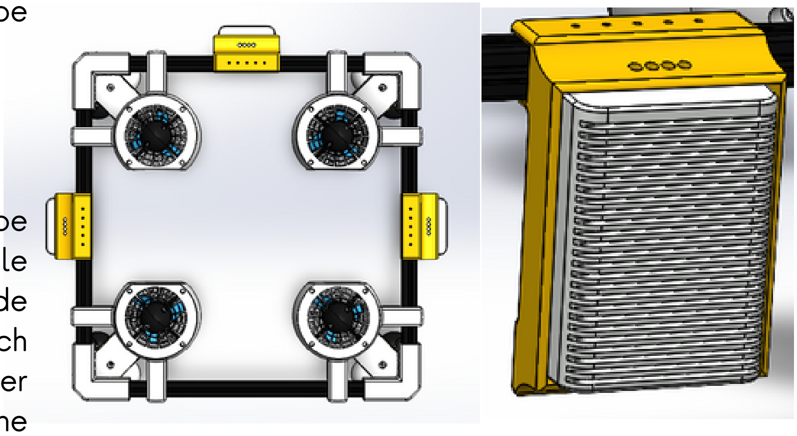

Figure 17. Mounted 48 to 12 Volt Converters

Inside the custom waterproof housing, there are two 12 VDC to 5 VDC converters running in parallel to supply power to the Raspberry Pi.

Controls

Cory is controlled via a Logitech USB controller (Figure 18) connected to a surface Intel NUC via USB.

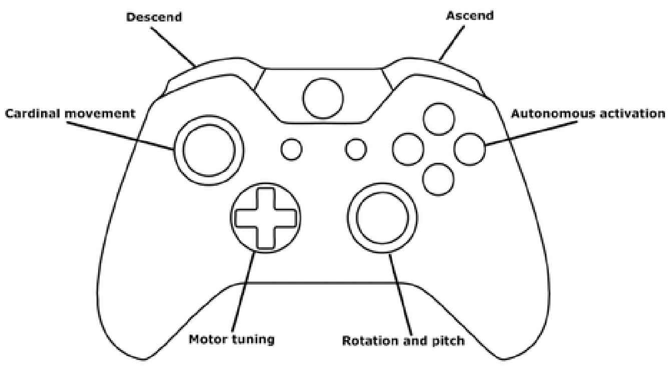

Figure 18. Controller Layout

The Intel NUC, located in our topside control box (Figure 19), converts controller inputs, sensor data, and pre-programmed commands into PWM values for the electronic speed controllers (ESCs). It then sends these values and other commands through an MQTT broker hosted on the PC. The onboard Raspberry Pi, which is located in the electronics housing on the ROV (Figure 20), receives the values and through pigpio outputs the PWM values from the built-in pins via. software PWM to the thrusters and any other attachments we choose to integrate. Meanwhile, the Pi also sends back the sensor data from our Pixhawk 6c and Blue Robotics depth sensor.

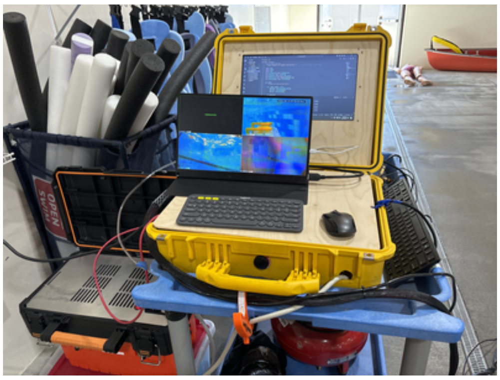

Figure 19. Topside Control Box

Initially, the control system used a Pixhawk 6c and Raspberry Pi 4B, housed in a custom electronics casing. Having deferred Pixhawk development from last year, we have connected it along with a Blue Robotics depth sensor to the Raspberry Pi to use as a sensor array for our control systems on the surface.

The motion programming has been overhauled since last year, being generalized such that it can work on an ROV with any thruster configuration, sensor loadout, or other relay, PWM, or i2c-controlled devices. The code allows fine-tuning of thruster output to account for asymmetrical drag, optimizing vehicle stability and movement, PID-controlled yaw, pitch, roll, and depth, camera-based AI control, multiple control modes, and easy and powerful customization of controls.

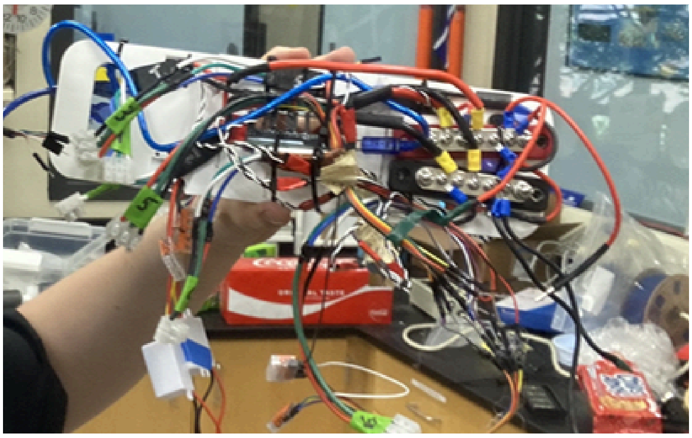

Figure 20. Electronics components on tray before placed in waterproof housing

The ROV's secondary control system is for its pneumatic tools. In the control interface (Figure 21) pneumatics are controlled through the use of a switch on the surface, which toggles a 5/2 solenoid. The solenoid is connected to a pair of pneumatic tubes that run down the tether to the ROV to operate our claw and any other pneumatic devices and accessories we may choose to employ in the future.

Figure 21. Pneumatics Control Interface

Vertical Profiler

Our vertical profiler, D.A.V.E. (Deep Aqua Vertical Explorer), is an independent device capable of completing many profiles while collecting essential environmental data. It is housed in a recycled 3" by 11" Blue Robotics. Reusing this tube conserved resources and matched our design requirements effectively. This past year, we began using custom PCBs, which allowed us to create robust connections between small electronics while being extremely inexpensive. We used a custom PCB on the float due to the restricted space.

We have reliably and consistently used the power and flexibility of 3D printing. This allowed us to create finely tuned, low-cost components tailored to our needs. The profiler includes 3D-printed legs to protect the penetrators from damage and includes an integrated handle to simplify deployment via our ROV. The legs also incorporate a fixed ballast, contributing to both form and function. Additionally, we created several 3D-printed tools to support easier maintenance and usability of our ROV systems.

For power, D.A.V.E. uses an onboard battery system that consists of two nine-volt nickel-metal hydride (NiMH) batteries connected in parallel. This configuration provides enough battery capacity to last several hours. Using a NiMH battery allows for high current draw with minimal voltage sag and allows us to recharge the batteries, further reducing operational costs.

To gather the necessary data, D.A.V.E integrates a DS18B20 temperature sensor, a Sparkfun Micro Pressure Sensor, and a real-time clock (RTC). All components are connected by a custom-designed PCB along with the SAMD 21 Pro RF-LoRa and other components. This PCB ensures a solid mechanical and electrical connection between all of our fragile components. It also allows us to cram the boards in a tighter space, freeing up room for other things.

D.A.V.E. has a buoyancy engine that is powered by an Actuonix linear actuator controlled by a SparkFun SAMD 21 Pro RF-LoRa, which is also used for radio communication with the base station. This actuator is a robust and effective solution for fine-tuning buoyancy control during profiling operations.

The profiler's behavior is managed by a custom-designed software program based on a state machine with four distinct states: Idle, Descending, Holding Depth, and Ascending. This provides clear, functional state transitions and keeps the main program loop clean and easy to manage.

Figure 22. Vertical Profiler

System Integration Diagrams (SIDs)

Electrical SID

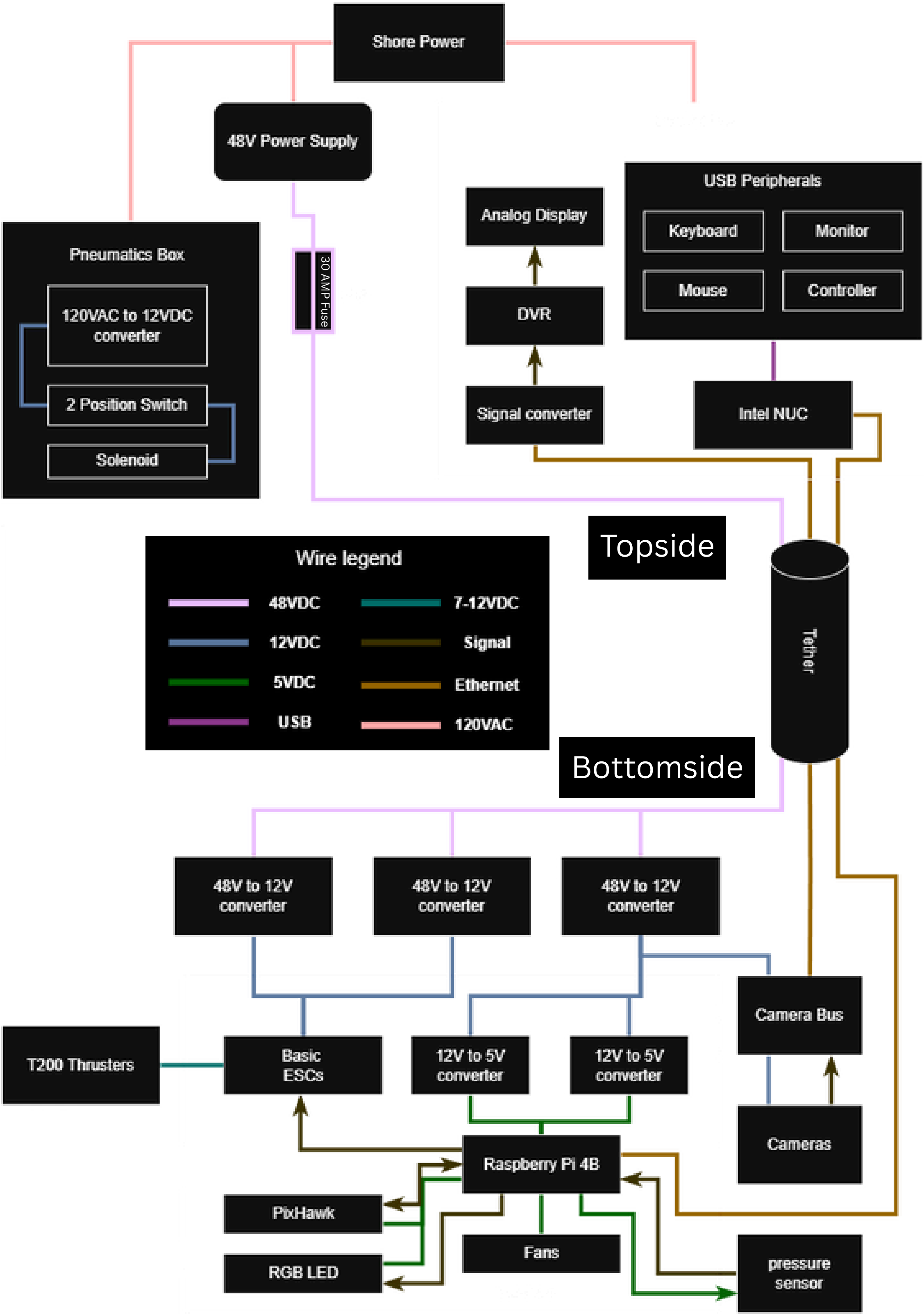

Figure 23. Electrical SID for Cory

Vertical Profiler SID

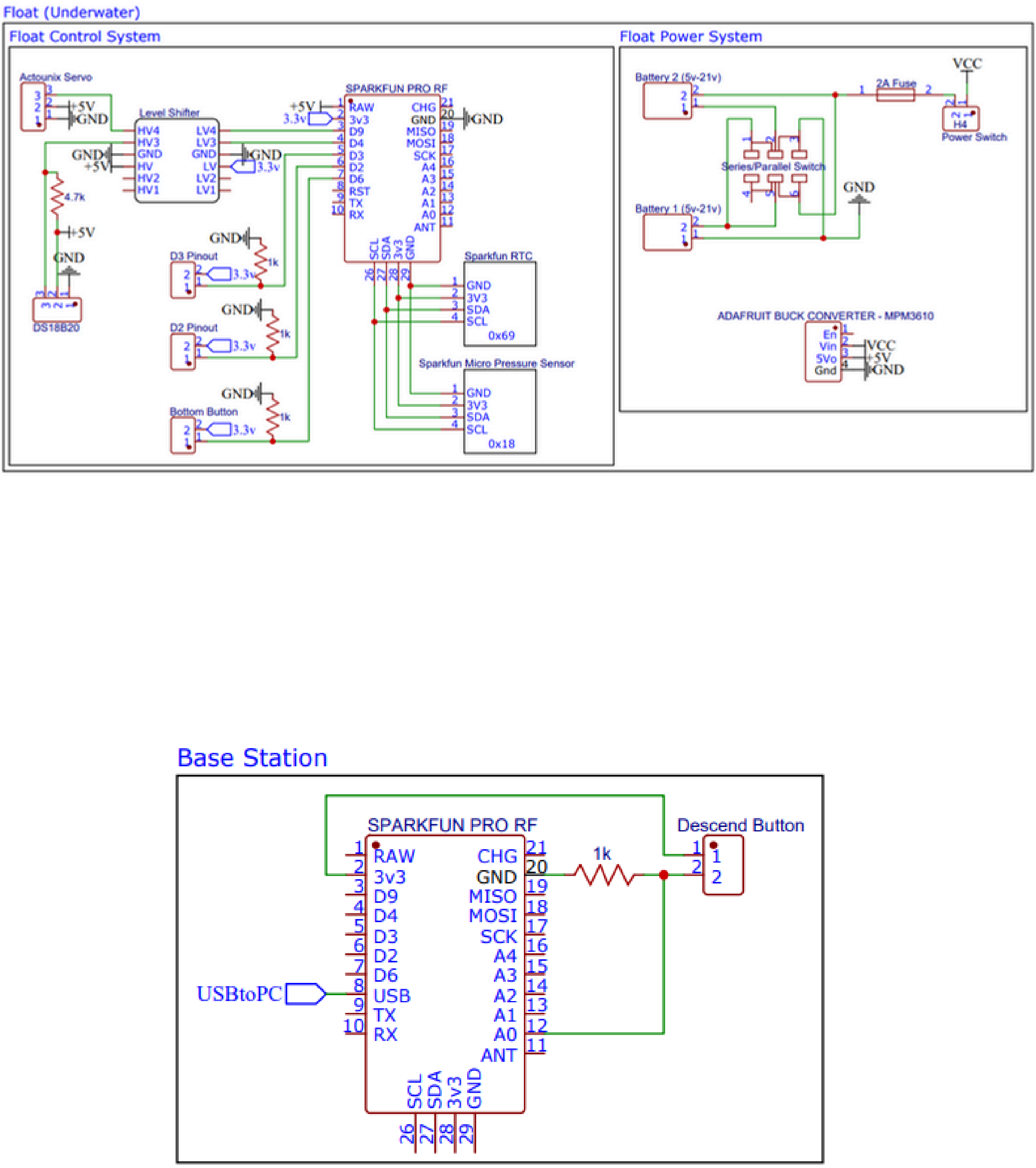

Figure 25. Vertical Profiler Diagram

Pneumatic SID

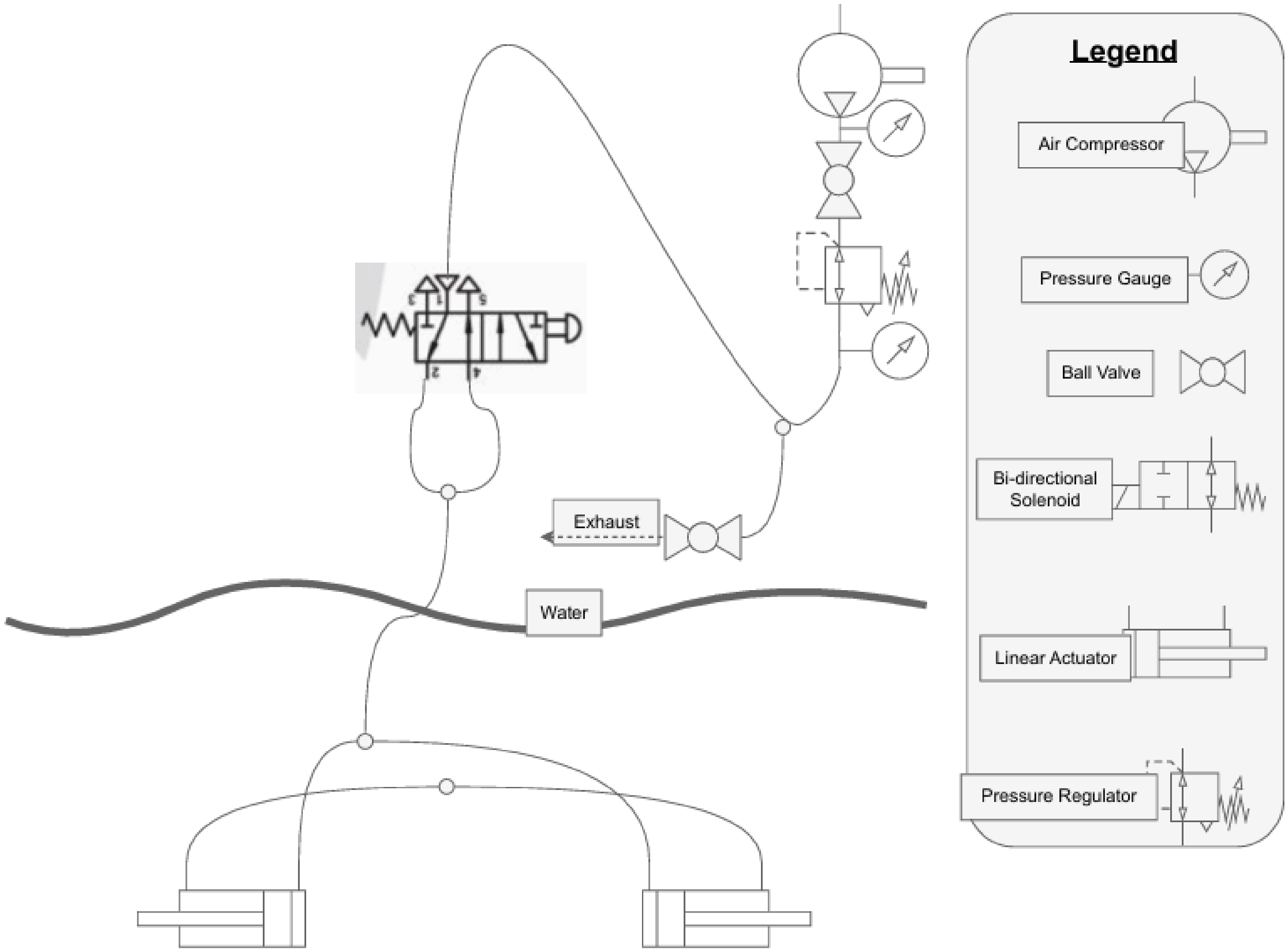

Figure 24. Pneumatic System Integration Diagram

Safety

Safety Philosophy

Employee safety is the company's top priority. All team members are dedicated to strictly following the safety guidelines and procedures established by MATE.

Before participating in any poolside operations,, ROVrunner members are required to complete a comprehensive training course focused on safety protocols and potential hazards. During all relevant activities, proper PPE is required to prevent injuries.

Company Safety Protocols

Safety protocols are strictly enforced, with all members having a designated job to ensure the safety of the group and machinery. For example:

- Eric and Sara are designated to perform vehicle safety checks during setup for operation. The vehicle may not enter or be near water prior to completing the safety checks. In performing this inspection while keeping the vehicle away from the water, we reduce the risk of electrocution and harm to personnel, in addition to reducing the risk of shortages and damage to both the control station and the ROV.
- Jason is responsible for control station checks, including assuring that all wires are properly connected and protected. This procedure is performed prior to events as well as during setup.

Additionally, the ROVrunners enforce the following lab protocols:

- Two people are required in the lab at all times.
- Safety glasses must be worn if using power tools or performing activities which create dust or debris.
- Closed-toed shoes must be worn at all times.
- While using knives or razors, team members maintain a minimum arms length distance from other members.
- During hot-work team members are encouraged to remove synthetic materials.
- Any questions about how to safely perform a task are directed to experienced teammates.
- An organized workspace is the best way to prevent accidents. Cleaning is done often.

The setup and operational plans can be seen in the Appendix.

Vehicle Safety Features

Just as the company's personnel are held to strict safety standards, the company's vehicles are designed and built with safety as the ultimate goal.

When building the ROV, the company paid special attention to the following safety features:

- Smooth edges
- Shrouded propellers
- Securely waterproofed components
- Properly rated waterproof connections between components
- Fused power converters
- Tether is fused at point of connection to the power supply

Additionally, the vehicle's power supply features a single switch for the quick disconnect of the power in case of an emergency.

Critical Analysis

Testing & Troubleshooting

As aforementioned, pool tests were very frequent; we used these times to both train our pilots and learn our poolside roles, but also to find things that could be upgraded. During the design processes of many of the upgrades, we made sure to rigorously test each component, making sure they fit our needs.

As a company, we implemented many ambitious new designs. We successfully introduced an improved thruster mount style, both vertical and horizontal. We modified our pneumatic claw and created a more spacious electronics housing for our important electrical components to be stored on the vehicle. Each time we successfully finished and installed our upgrades, we then tested them in the pool and figured out how practical they truly were. Sometimes upgrades didn't work, and sometimes they did; that was the way of things. Each time an upgrade would work, we'd find other ways of improving upon the design, and we'd pursue that until we could decide whether or not it was truly viable or not.

This year, we wanted to introduce a truly ambitious new manipulator, Benji the robot hand. We realized that one of the biggest things we could upgrade was the ROV's ability to interact with the world around it, so to achieve this, we spent almost a year developing the hand. The first thing we did was figure out our strategy for the fingers, and this question became the most turbulent on the project, resulting in well over fifteen finger variations, with eight distinct styles (Figure 26).

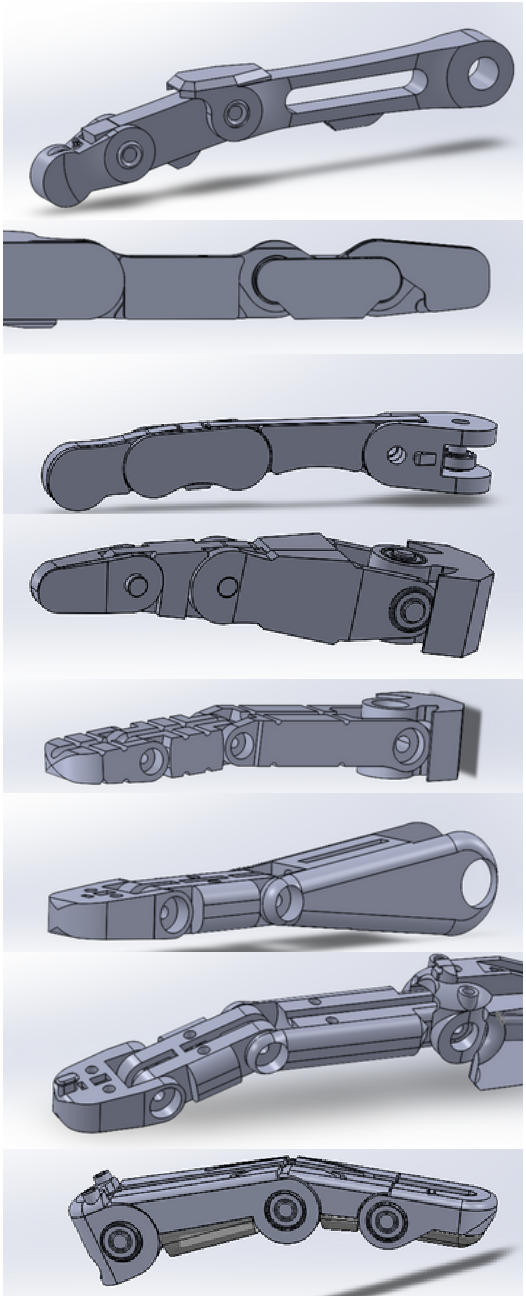

Figure 26. Benji finger types 1-8 going from top to bottom.

Accounting

Budget

The budget for the 2024 - 2025 competition year was structured around an $15,000 grant awarded by the LBCC Student Life and Leadership and a $10,000 grant from MATE for travel. Initial estimates were for $3,000 to be allocated to the project build. The remainder would be allotted to competition travel expenses. The completion of a travel expense projection came out to $21,500 showing we had a surplus of $500. This surplus was used as a buffer allowing us to expend more in R&D and saving for the next year.

Further partitioning of build expenses was achieved through team estimates. A contingency fund was established for budget overages. Multiple checks and balances were implemented to ensure appropriate spending. Expenses would be submitted by teams to a shared Google Sheets document. These requests were to be approved by faculty advisor Greg Mulder. For Cost Accounting see Appendix C.

School: Linn Benton Community College			
Mentor: Greg Mulder			
Income			
Source			**Amount**
MATE ROV			10,000
Linn Benton Student Life and Leadership			14,500
Expenses			
Category	**Description/Examples**	**Projected Cost**	Budgeted Cost
Hardware	Aluminum, Filament, etc.	1000	1000
Electronics	Arduinos, Rasberry Pi, etc	2000	2000
Travel	Airplane tickets, Housing etc.	20,100	20,000
		Total Funds:	24,500
		Total Expenses:	24,100

Table 5. ROVrunners 2025 budget

Conclusion

Acknowledgements

The ROVrunners would like to acknowledge the countless contributors that allowed the company to thrive in the MATE competition.

Members of the ROV team would like to personally thank our mentors, including Greg Mulder, Kathy Austin, and Heather Hill, for their immense efforts towards leading and guiding the efforts of the team for the greater success of our ROV.

We would also like to thank Oregon Space Grant, LBCC Sutdent Life and Leadership, and MATE for providing the funds to allow the team to come together and participate in a truly amazing learning and professional experience. From their contributions, we were able to design, build, and operate an ROV of our own.

We must also thank the Willamette-Valley Family YMCA for graciously allowing our team to use their pools each week for crucial testing of ROV piloting and tasks at no cost. Through their help, we have been able to greatly improve nearly all aspects of the ROV, allowing us to achieve many more of our company goals.

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- "Polyurethane Subsea Buoyancy Foam." General Plastics, https://www.generalplastics.com/products/r-3300
- "T200 Thruster." BlueRobotics, https://bluerobotics.com/learn/t100-thrusterusage/

Appendix A

Setup Plan

ROV Setup (topside and ROV-side happening in parallel):

- Topside (2-3 people):
  - Air tank:
    - Ensure the air compressor drain valve is closed.
    - Charge air compressor.
    - **Ensure the external regulator valve is closed before connecting.**
    - Plug the air supply tube and external regulator into the output port.
    - Ensure the proper pressure is being output by twisting the dial and venting air until it shows 40 psi.
  - Ensure tether is securely connected to the control station.
  - Set up power supply:
    - Ensure both power supply switches are in the 'off' position.
    - Plug the grey power cord into the power supply input.
    - Plug the grey power cord into shore power (use extension cord if needed)
    - Connect tether power into the Anderson port.
    - **Wait for the all-clear from the teammates working on the ROV.**
    - Flip the main power switch next to the grey cable.
    - Wait 5 seconds for the power supply to spool up.
    - Flip the ROV power switch.
    - Listen for the "happy noises" to confirm it booted up correctly.
    - **Stand by in case of emergency shutoff request from ROV team.**
  - Set up monitor box:
    - Plug in the box to shore power using the cable extended out of the box.
    - Set up internals:
    - Open and remove the cover.
      - Extract the controller, keyboard, mouse, and secondary monitor (without disconnecting them)
      - Turn on the PC by pressing the power button.
      - Connect the communications Cat8 to the PC.
      - Connect the camera Cat8 to the signal converter.
      - Replace the cover.
    - Assemble the display, mouse, keyboard, and controller on top of the cover.
    - **After the ROV has been connected and powered up:**
      - On the PC, open the command prompt and VSCode.
      - In the command prompt, type the following commands:
        - ssh rovrunners@192.168.2.2
        - cd Desktop/SpikeBottomSide/bottomside_rp_python/bottomside
        - ./gpio_start.sh
        - ./py_start.sh
      - In VSCode:
        - Navigate to the __main__.py file.
        - **Make sure someone is ready to kill power to the ROV in case of software malfunction.**
        - Hit run.
  - Pneumatics box:
    - Open the box.
    - Plug the power cable into shore power.
    - Plug the tether pneumatics tubes into their respective blue and purple ports.
    - **Call teammates clear of the claw for safety.**
    - Plug the air supply tube into the red port.
- ROV-side (At least two people):
  - Ensure strain relief is properly connected and secure.
  - Ensure all power and data plugs are connected and tight.
  - Ensure all necessary dummy plugs are installed and tight.
  - Ensure the endcaps are installed, tightened, and appear to be maintaining a good seal.
  - Ensure there are no exposed wires, broken parts, unsealed cables, or otherwise compromised components.
  - Electrical:
    - **Step back and call all clear of the ROV.**
    - Tell the teammate manning the power box that they can initialize the ROV.
    - Watch for shorts or other power failures.
    - **If there are any such failures, immediately warn the power box operator to kill all power to the ROV.**
    - If not, inform the operator of such and continue.
  - Pneumatics:
    - Ensure the pneumatics lines are plugged into the claw piston properly.
    - **Step back and call all clear of the ROV.**
    - Tell the teammate manning the pneumatics box to apply pressure.
    - Watch and listen carefully for any leaks.
    - **If there are any leaks, immediately tell the pneumatics operator to shut off pressure.**
    - If there are no leaks, wait a few more seconds, inform the operator of such, then continue.
  - Check the seal:
    - Remove one dummy plug.
    - Take the vacuum pump and attach it in the plug's place.
    - Reduce the internal pressure down to -300 mmHg (we would use SI units, but that's what our vacuum pump has)
    - Wait 10-15 seconds to see if the pressure drops.
    - **If the pressure drops, do *not* let it in the water until the issue has been fixed and verified as such.**
    - If the pressure is maintained, release the pressure and re-install the dummy plug.
  - **Wait for the all-clear from all teammates.**
  - Inform the judge that setup is complete.
  - When allowed, two people will assist each other in deploying the ROV.

Figure 27. Set Up Plan

Appendix B

Construction Plan

Construction:

- The Core:
  - Take the electronics board and slide it into the tube, verifying that the camera
  - Wires:
    - Plug all of the ESC wires into their labeled mates through whichever port is most conveniently placed, matching wire colors.
    - Plug all of the power cables into an external port. Yellow-marked connectors are paired with their external equivalents.
    - Feed the Cat8 connector through the nearest port above the Pi and connect the ends, matching colors again.
    - Feed in the depth sensor wire and plug it into its matching cable.
    - Attach dummy plugs to any unused ports.
  - Take the endcaps and check them for damage and debris.
  - Insert one, making sure the flange is flush with the end of the tube.
  - Hold it steady while a second person tightens it down.
  - Verify the seal wraps all the way around the tube and no air bubbles or debris worked its way in.
  - Emplace the tube brackets and screw them in.
- The Frame:
  - Take each thruster and place it in its labeled location.
  - Insert the loose extruded aluminum pieces into the side thruster pairs.
  - Slide the t-nuts into position and, while holding the thrusters as far on as they will go, screw them in.
  - Slide the assembled pairs onto the core piece's aluminum ends and repeat the process.

Figure 28. Construction Plan

Appendix C Cost Accounting

Budget Category	Budgeted Amount	Source(s)
ROV (Total)	$3,000	LBCC Student Life and Leadership ($3000), Oregon Space Grant Consortium ($3,000, 2023-2024)
Vertical Profiler		
Travel	$21,500	MATE ($10,000), LBCC Student Life and Leadership ($11,500)

General	Qty	Cost of Single Item	Total Cost of Items	Shipping
Screwdriver set	1	23.99	23.99	$0.00
Solder	2	$7.91	$15.82	$0.00
Hot glue sticks	1	$35.99	$35.99	$0.00
T nuts 150pcs	1	$7.95	$7.95	$0.00
zip ties 100pcs	3	$3.79	$11.37	$0.00
metric bolts	1	$20.59	$20.59	$0.00
M5x10mm bolts 100pcs	1	$11.49	$11.49	$0.00
M8 Bolts	2	$11.39	$22.78	$0.00
M8 Nuts	1	$6.89	$6.89	$0.00
M8 Washers	1	$4.00	$4.00	$0.00
M8-1.25 Bolts	1	$12.49	$12.49	$0.00
M8-1.25 Nuts	1	$9.99	$9.99	$0.00
PETG White	2	$15.82	$31.64	$0.00
Replacement socket wrench	1	$13.49	$13.49	$0.00
File set	1	$19.89	$19.89	$0.00
Pliers set	1	$24.98	$24.98	$0.00
T-nuts	1	$15.39	$15.39	$0.00
O-Ring gaskets	2	$11.11	$22.22	$0.00
Clear Acrylic Sheet	1	$12.73	$12.73	$0.00
M3 Bolts	2	$8.99	$17.98	$0.00
Cowboy hat restock	1	$47.99	$47.99	$0.00
1 Gallon Crystal Clear Epoxy Resin	1	$49.49	$49.49	$0.00
10ft, USB 2.0 Printer Cable USB-A to USB-B	1	$8.98	$8.98	$0.00
Heat Gun	1	$28.99	$28.99	$0.00
paper towels	1	$14.31	$14.31	$0.00
GH1.25 Connectors & Cables	1	$18.99	$18.99	$0.00
PETG Filament - 1 kg White	2	$20.99	$41.98	$0.00
		Total + Shipping:	$552.40	
Frame	**Qty**	**Cost of Single Item**	**Total Cost of Items**	**Shipping**
Extruded Aluminum (reused)	1	$30.99	$30.99	$0.00
PETG Filament - 1 kg White	2	$18.99	$37.98	$0.00
Subsea Buoyancy Foam (reused)	1	$35.00	$35.00	$6.50
Sliding M3 T Nuts, 100-pk	1	$4.99	$4.99	$0.00
Spring Loaded T Nut M3, 100-pk (reused)	1	$16.68	$16.68	$0.00
200pc 5MX5mm knurled brass heatsets	1	$9.99	$9.99	$0.00
M5 Screws	1	$9.99	$9.99	$0.00
		Total + Shipping:	$152.12	
Tether	**Qty**	**Cost of Single Item**	**Total Cost of Items**	**Shipping**
10 Gauge wire 100ft 2 pack (reused)	1	$34.99	$34.99	$0.00
14 Gauge Electrical Wire, 50FT (reused)	1	$37.98	$37.98	$0.00
8 cat ethernet 100 ft shielded (reused)	1	$39.99	$39.99	$0.00
Tether Strains (reused)	2	$23.82	$47.64	$0.00
Tether Sheathing - Black, 1" 100 ft (reused)	1	$22.99	$22.99	$0.00
Pneumatic Tubing Pipe 1/4" OD 98 ft (reused)	1	$20.99	$20.99	$0.00
		Total + Shipping:	$204.58	
Connectors	**Qty**	**Cost of Single Item**	**Total Cost of Items**	**Shipping**
DTP Connectors Size 12, 20 pk (reused)	1	$28.99	$28.99	$0.00
Deutsch Crimp Tool (16 AWG) (reused)	1	$22.99	$22.99	$0.00
Deutsch Crimp Tool (12 AWG) (reused)	1	$25.99	$25.99	$0.00
Anderson Connectors (reused)	1	$17.50	$17.50	$0.00
(5 pack) 1/2 in. Plastic PEX-B Barb x Female Swivel Adapter (reused)	1	$10.24	$10.24	$0.00
(5 Pack) 1/2 Inch x 2 Inch PVC Sprinkler Riser (reused)	1	$6.99	$6.99	$0.00
10-Pack Pex-A 1/2" X1/2" Male NPT Adapter Fitting (reused)	1	$19.99	$19.99	$0.00
SharkBite 1/2 Inch Poly Crimp Swivel Adapter, Pack of 25 (reused)	2	$24.15	$48.30	$0.00
(20 Pack) 1/2 Inch x 2 Inch PVC Sprinkler Riser (reused)	2	$15.96	$31.92	$0.00

Table 6. Cost Accounting

Appendix C Cost Accounting

Spade connectors 100pcs 14-16 Gauge (reused)	1	$12.99	$12.99	$0.00
Spade connectors 100pcs 16-22 Gauge (reused)	1	$11.99	$11.99	$0.00
		Total + Shipping:	**$237.89**	
On-Board Controls & Power	**Qty**	**Cost of Single Item**	**Total Cost of Items**	**Shipping**
Raspberry Pi 3b (reused)	1	$35.00	$35.00	$5.01
Pixhawk 6C Flight Controller (reused)	1	$233.99	$233.99	$29.16
MicroSD card set	1	$16.49	$16.49	$0.00
Water sensor	1	$6.99	$6.99	$0.00
12V to 5V Power Converters (reused)	3	$6.89	$20.67	$0.00
30v10a variable power supply	1	$59.39	$59.39	$0.00
Logitech Controller	2	$17.33	$34.66	$0.00
indicating moisture absorbing silica gel	1	$16.99	$16.99	$0.00
Green wire	1	$18.88	$18.88	$0.00
Single Terminal Busbar Pair (reused)	2	$14.99	$29.98	$0.00
Seven Terminal Busbar Pair (reused)	1	$18.99	$18.99	$0.00
Oatey 33403 4-in. End of Pipe Gripper Mechanical Plug (reused)	2	$8.95	$17.90	$0.00
30A 360W 48V Step Down to 12V DC Buck Converter (reused)	3	$32.99	$98.97	$0.00
		Total + Shipping:	**$643.07**	
Cameras	**Qty**	**Cost of Single Item**	**Total Cost of Items**	**Shipping**
FPV Camera (reused)	5	$18.90	$94.50	$0.00
Raspberry Pi Digital Camera	1	$36.99	$36.99	$0.00
USB Camera for Raspberry Pi	2	$9.69	$19.38	$0.00
		Total + Shipping:	**$150.87**	
Pneumatic Claw	**Qty**	**Cost of Single Item**	**Total Cost of Items**	**Shipping**
PNEUMATIC 1/4"NPT 5-Way Solenoid Valve	1	$16.99	$16.99	$0.00
Braided Fishing Wire (547YDS/100LBS)	1	$12.99	$12.99	$0.00
Pneumatic fittings (1/4 Inch Tube OD x 1/4 Inch NPT, 12-pack) (reused)	1	$12.99	$12.99	$0.00
1/4 Inch od Push to Connect Fittings (set of 40) (reused)	1	$13.99	$13.99	$0.00
1/4" pneumatic tubing 100 ft (reused)	1	$22.99	$22.99	$0.00
Pnumatic Solenoid 12V 2 Position 5 Way 4 (reused)	1	$39.69	$39.69	$0.00
Pneumatic Nylon Tubes 1/4 inch (black)	1	$14.69	$14.69	$0.00
Pneumatic Connect Fitting	1	$13.69	$13.69	$0.00
		Total + Shipping:	**$148.02**	
Benji	**Qty**	**Cost of Single Item**	**Total Cost of Items**	**Shipping**
20KG Servos	3	$13.59	$40.77	$0.00
Elastic Bands	2	$6.59	$13.18	$0.00
Bearings 11mm	2	$9.98	$19.96	$0.00
Bearings 8mm	4	$9.99	$39.96	$0.00
Filement	2	$15.98	$31.96	$0.00
Regulus rings	1	$10.96	$10.96	$0.00
Slide Potentiometers	30	$1.42	$42.60	$11.23
White PLA	4	$16.99	$67.96	$0.00
20kg servos	12	$13.99	$167.88	$0.00
		Total + Shipping:	**$446.46**	
Control Station	**Qty**	**Cost of Single Item**	**Total Cost of Items**	**Shipping**
10 Inch Small Monitor Screen (reused)	1	$71.99	$71.99	$0.00
Mini DVR (reused)	1	$59.99	$59.99	$0.00
pvc pipe couplers (reused)	1	$11.69	$11.69	$0.00
Display Driver (reused)	1	23.99	23.99	$0.00
Display Driver (reused)	1	26.99	26.99	$0.00
		Total + Shipping:	**$194.65**	
		ROV Total:	**$2,730.06**	

Vertical Profiler	Qty	Cost of Single Item	Total Cost of Items	Shipping
Silicone diaphragm (reused)	2	$5.99	$11.98	$0.00
Solderable Breadboards (reused)	1	$8.99	$8.99	$0.00
Adafruit Feather 32u4 Bluefruit LE with Headers (reused)	1	$31.95	$31.95	$10.81
Micro Metal Gear Motor with Extended Threaded Shaft (reused)	1	$2.02	$2.02	$2.27
Silicone air bladder (reused)	1	$5.99	$5.99	$0.00
Linear Actuator 2in Stroke (reused)	1	$25.19	$25.19	$0.00
		VP Total:	**$99.20**	

Travel	Total Cost
Van from OSU for Oregon Regional	$150
MATE 2025 Registration	$650
Flight to Alpena	$8,100
Lodging in Alpena	$8,000
Van Rental in Alpena	$1,200
Food in Alpena	$2,000 (estimate)
Total Travel Costs:	**$20,100.00**

Table 7. Cost Accounting Cont.

ROVrunners

For the ROVs who say "Beep Beep!"

6500 Pacific Blvd SW
Albany, OR 97321

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Linn-Benton Community College

MATE ROV COMPETITION 2025