

TECHNICAL DOCUMENTATION REPORT

RoseVG Robotics
For Rose-Hulman Institute of Technology
Terre Haute, IN, USA

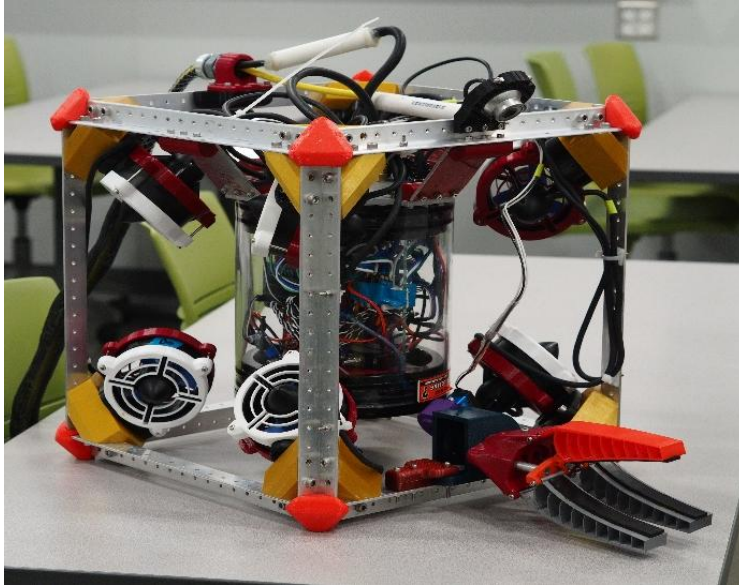


FIGURE 1: CUBERT IN A CLASSROOM SETTING.

Members and Roles:

26' Kevin Cotelleso | CEO | Mechanical
28' Lenore Barczewski | CIO | Mechanical
27' Kayla Kissoondial | CFO | Mechanical
29' Santiago Lema | Mechanical
29' Claire Slusser | Mechanical
29' Alexander Drumright-Frost | Mechanical
26' Connor Luce | Mechanical
26' Steven Reese | Electrical
28' Kyra Zhou | Software
28' Alex Miranda | Float
27' Hadley Jessop | Frame
28' Benjamin Sutton | Float
28' Samuel Geelhood | Float
28' Amelia Jaracez | Float
29' Tristian Schartman | Float
26' Peter Fields | Float

Mentor: Dr. Nathan Brooks

Abstract

We are RoseVG Robotics, a team of 14 students from Rose-Hulman Institute of Technology. We are excited to present our most recent remotely operated vehicle (ROV), Cubert. Cubert is small, highly maneuverable, and capable of completing a wide variety of subsea tasks with minimal outside equipment. Cubert was completely designed and manufactured in the past academic year, and reflects the hard work, technical expertise, and dedication of our team. In addition, this year we've brought a float to competition with Cubert for the first time. We're excited to showcase the culmination of our work this year at the 2026 MATE ROV World Championship Competition.

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Teamwork

Company Overview

RoseVG Robotics is an undergraduate student team that is part of the Robotics organization at Rose-Hulman Institute of Technology. This organization is overseen by a workspace committee, which serves as an executive board overseeing the organization and resource allocation of all of the robotics teams at Rose-Hulman. RoseVG Robotics consists of 14 team members divided into 5 task forces: Frame, Manipulator, Electrical, Software, and Float. RoseVG is led by a CEO who sets the company's priorities, ensures that each task force has defined goals, and manages the company per the team charter. Each of the subteams has its own leader that works with the CEO to set priorities and meet deadlines. Other officers on the team include the team's treasurer and secretary, overseeing the team's budget and documentation respectively. Officers are required to attend weekly officer meetings to report on their progress and to oversee the team as a whole.

Project Management

RoseVG Robotics follows a weekly development cycle. The cycle starts on Monday during the officer- advisor meeting held with the team advisor. During these meetings, the officers go over progress made in the previous week, assess the remaining tasks, add tasks that need to be completed and by what time, assign tasks to the teams, and discuss how our timeline needs to be revised according to the progress that was made. After the officer meeting, the all-team meetings are held on Wednesday and Saturday where the team leads organize their employees to work on the tasks designated to them during the officer meeting. The employees spend the meeting working to carry out the tasks assigned to them by the team leads. The week concludes on Saturday after the all-team meeting, and the development cycle starts again at the officer meeting on Monday.

RoseVG robotics uses Discord for general communications among its employees and its officers, with different channels to divide different subteams and tasks. Notion is used as our corporate wiki and knowledgebase, doubling as a task tracking system. Notion's built-in AI can use our

documentation as a source when answering questions, making it easy for new members to find relevant, consistent information. Github is used for file-sharing and software version control.

Project Schedule

Our team made extensive use of kanban boards to keep track of tasks and a gantt chart to plan out our season schedule. By using Notion for this, we ensured that all members of our team could see and contribute to our plan.

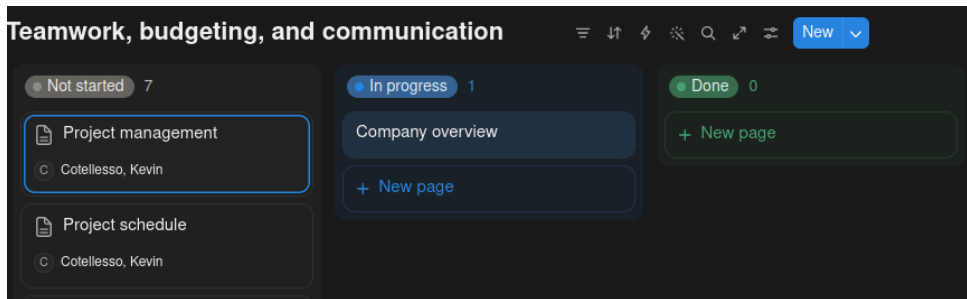


FIGURE 2: A NOTION KANBAN BOARD USED TO ASSIGN AND ORGANIZE TASKS

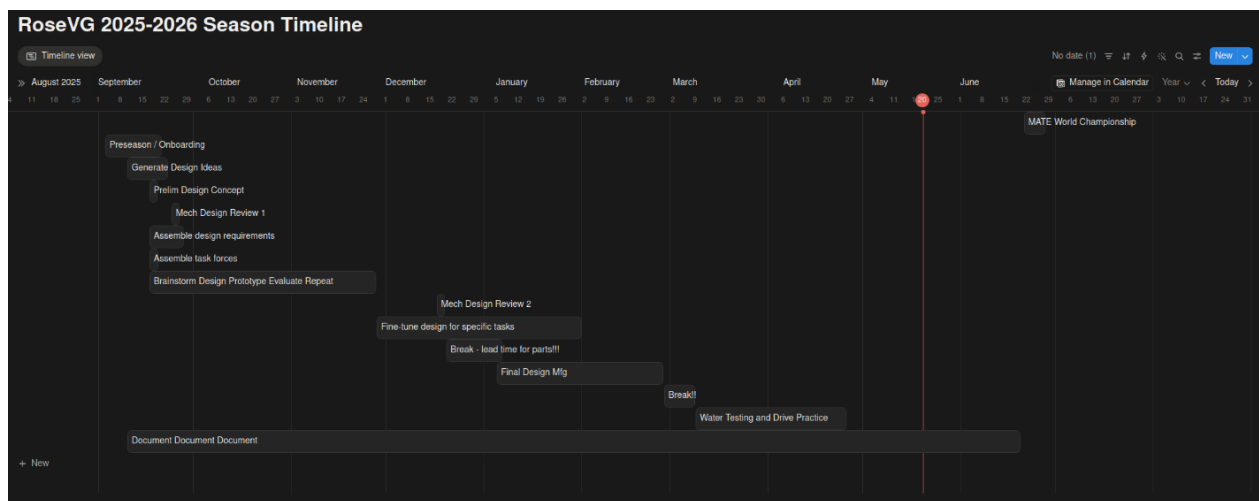


FIGURE 3: A NOTION GANTT CHART USED TO BACK-PLAN THE SEASON

Design Rationale

Cubert was designed in accordance with RoseVG Robotics' design principles and the requirements of the 2025 MATE ROV Competition missions. This section will outline our design principles and how they led to the design requirements for Cubert. It will discuss the overall design of Cubert, then go into detail on each subsystem.

RoseVG Robotics Design Principles

RoseVG Robotics has six main design principles, which are as follows:

DP1 - Smaller is better. Smaller, less bulky ROVs and ROV components are safer and easier to handle by personnel and perform better in tight subsea spaces.

DP2 - Simplicity is better. All else equal, simpler architectures and mechanisms are superior to more complex ones; they are more reliable and easier to service (DP5). DP2 may be violated in cases where a more complex system provides significantly higher performance or reliability or enhanced learning opportunities for students.

DP3 - Solve problems physically first. Solutions that are more physically complex are acceptable if they reduce programming complexity a proportional amount. Do not wantonly increase programming complexity by making physical design changes.

DP4 - Prioritize versatility while remaining competitive in required tasks. Designs that are performant at many tasks are preferable to designs that are performant in one task only; subsea operations can throw unanticipated situations, and higher versatility is a higher likelihood of managing those situations.

DP5 - Ease of service and assembly is better. Mistakes will happen, and technicians are imperfect. The less steps there are to service and assemble components, the faster and easier it will be to assemble and repair the product.

DP6 - Easier to source is better. Easily procurable components are preferable to more niche, esoteric ones.

In cases where two design principles are at odds, a holistic decision making process should be utilized to determine the principle that should receive higher priority. These design principles, along with the requirements of the MATE ROV Competition and lessons we learned from our previous products guided the specific design requirements for the development of Cubert.

Cubert Design Requirements

The initial design requirements laid out for Cubert are as follows:

DR1 - Small enough for 1-person to carry. Cubert should be small and light enough to be carried by one person. This requirement directly follows from DP1 and from our experiences developing Duck, a large ROV that could not be carried by one person.

DR2 – Omnidirectional capabilities underwater. Cubert should be capable of moving in all 6 DoF of physical motion: 3 dimensions of translation (surge, sway and depth) and 3 dimensions of rotation (roll, pitch and yaw). This will allow Cubert to complete a wide variety of tasks at different angles, increasing its versatility (DP4).

DR3 - Symmetry. As much as possible, Cubert shall be designed with physical symmetry in mind. This includes symmetry across all three base planes, as well as radial symmetry. A symmetric ROV naturally will be able to rotate to any orientation (DR2), and will have symmetric hardware, making it easier to repair since there are fewer unique parts (DP5). Finally, symmetric shapes have centers of drag and centers of mass very close to the center of the shape, meaning that there will be less moments applied to the shape as it moves through the water. This will simplify the control of Cubert (DP2).

DR3.1: Symmetric thruster kinematics. In keeping with DR3, Cubert shall use a thruster configuration that is symmetric about all planes as much as possible.

DR3.2 - Center of buoyancy very close to center of mass. Placing the center of buoyancy (CoB; the point in the ROV that the buoyant force acts on) very close to the center of mass (CoM; the point

on the ROV that gravity acts on) will minimize extraneous moments on Cubert, minimizing effort for dynamic leveling control systems (DP3). Cubert may have to tilt itself for some games (DP4), a task that is more difficult the farther apart the CoB and CoM are.

DR3.3 - Center of thrust near center of drag. Placing the center of thrust near the center of drag will allow Cubert to move in a straight line in any direction without drag forces causing the ROV to tilt up or down. This minimizes effort from control systems (DP2, DP4)

DR4 – Highly Configurable Thrust Angles. Cubert’s thruster angles shall be fixed, but easily configurable. This will allow for easy experimentation with alternate thruster configurations (DP2).

DR5 - Slightly Positively Buoyant. Cubert shall be slightly positively buoyant. Cubert should be just buoyant enough to naturally float to the surface if power is lost, while requiring minimal power to keep itself at a certain depth.

Manipulators allow Cubert to do useful subsea tasks by grabbing and manipulating objects beneath the water. Several design requirements were laid out for Cubert’s manipulators:

DRM6 - Manipulators should be modular. Manipulators should be able to be switched on and off of Cubert easily. This will increase field repairability (DP5), versatility (DP4), and simplicity of individual manipulators (DP2).

DRM7 - Manipulators should be able to securely grip long objects at any orientation and in a range of sizes. Many MATE ROV Competition mission requirements include manipulating PVC pipes of varying sizes and orientation, so Cubert’s manipulator should be able to do this. (DP4)

DRM8 - Manipulators should be durable and robust to impacts, bumps, and knocks. Running into objects when in or out of the water should not damage manipulators.

DRM9 - Manipulators should be forgiving of misalignment and imprecision in ROV motion. Quick and precise motion underwater is challenging, so the manipulator should work from multiple angles and positions. (DP3)

DRM10 - Manipulators should be manufacturable in-house, especially components that are likely to wear out. Manipulators are a high-use and high stress component that is vital to the functionality of Cubert. Therefore, it is vital that components are easy to source and replace per DP6.

Final Design – Cubert

Cubert is a small, light, and reliable ROV capable of performing manipulation and observation tasks in underwater scenarios.

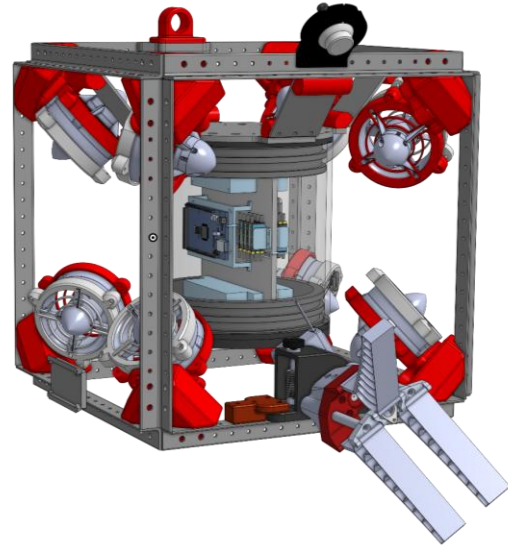
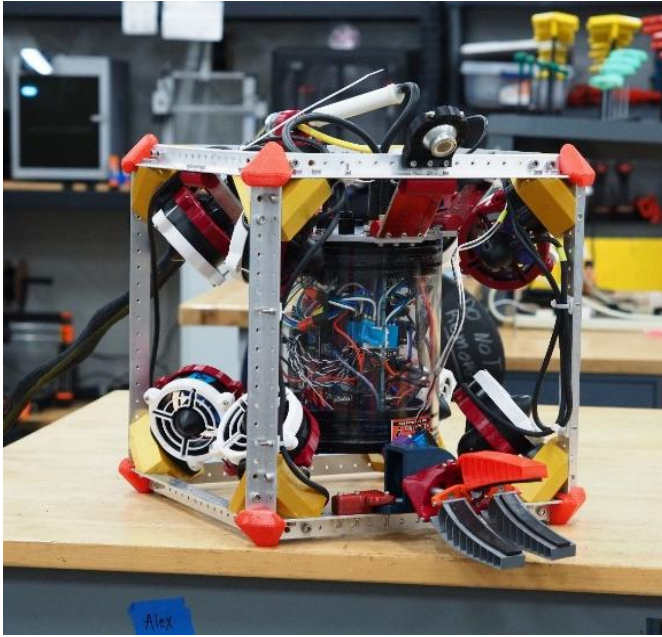


FIGURE 4: PICTURE (LEFT) AND CAD RENDERING (RIGHT) OF ROSEVG'S ROV FOR THE 2026 SEASON:
CUBERT.

Cubert is comprised of three main subsystems: the chassis/drive system, the manipulator system, and the electrical system.

Chassis and Drive System

Cubert's drive system and chassis are what allow it to move underwater. It consists of the outer frame, the thrusters, and drive control systems.

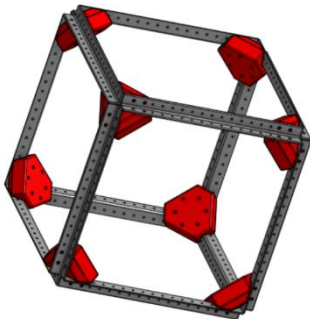


FIGURE 6: CHASSIS

Cubert's drive/chassis system was designed to be light (DR1), rigid, and make Cubert as symmetrical as possible (DR3). The symmetry aspect was a focus for its easy rotational control, and the ability to use any face of the ROV to gain the ability to mount more attachments than possible on one face. To accomplish this, a cube was chosen, with a central cannister and thrusters mounted at the vertices.

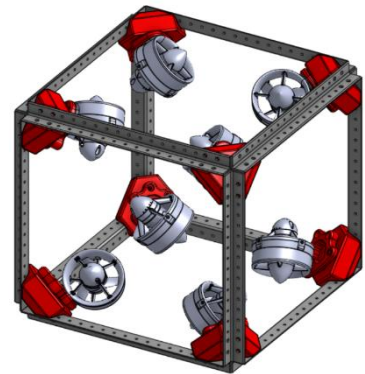


FIGURE 5: THRUSTER LAYOUT

Frame Layout

As mentioned, the frame was laid out to prioritize symmetry. The cube structure is made of intersecting L-Brackets connected by a 3D printed part that also serves the dual purpose of interfacing with the thruster mount. (DP4)

The L-Brackets also contain an m4 hole-pattern to allow for the mounting of the cannister as well as various modular attachments such as the camera and gripper. (DP2)



FIGURE 7: L-BRACKET MOUNTING PATTERN

Thruster Configuration

As can be seen in Figure 6, Cubert uses 8 BlueRobotics T200 thrusters in a symmetric configuration around its center. This configuration meets our design goal for symmetry (DR3) and gives Cubert full control over all six degrees of freedom (surge, sway, heave, roll, pitch, yaw) without biasing one direction too much over the others. This is necessary to enable future advanced control paradigms, such as free rotation to complete tasks. Cubert's 8 thrusters were mounted in the interior each of the frame's vertices using 2 3D printed brackets that serve the dual purpose of ensuring the thrusters are all at the correct angle and connecting to the frame's L-brackets together. These brackets were printed with no top or bottom layers and gyroid infill, allowing water to ingress easily as Cubert leaves the water and keeping buoyancy consistent.

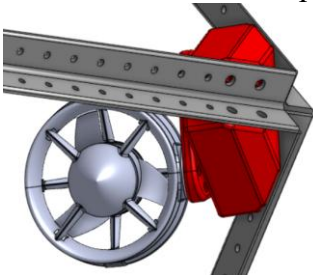


FIGURE 8: THRUSTER
SHIFTED OFF CENTER TO
AVOID THRUST OCCLUSION

This mounting configuration was selected because it maximizes the thrust in each axis of freedom somewhat equally (DP3), and the internal mounting was chosen for the protection it provides for the thrusters. Additionally, the thrusters are shifted slightly to have their faces avoid intersecting the frame of L-brackets to avoid occlusion of thrust.

Cubert represents a different design methodology from our previous robot Scooter. Its symmetric design allows for free rotation around any axis (DR2), unlocking the ability to place sensors and manipulators on any of Cubert's faces.

Orientation Control System

To keep Cubert stable while driving, a custom orientation control system was developed. This system can keep Cubert level while translating, or drive it to desired angles for completion of certain tasks. Cubert's symmetric design ensures that this system does not have to work overly hard, allowing a large performance envelope (DR3).

Cubert features a custom feedback controller that keeps it at a target orientation (roll, pitch, yaw) when in the water. This is done through a cascading Proportional-Integral-Derivative (PID) controller:

- **Inner loop:** A PD controller uses onboard gyroscopes to control angular velocity, and directly controls thruster input to keep the ROV at the target orientation. This inner loop is

very low latency, and stabilizes the robot's motion by instantly resisting any change in Cubert's angle.

- **Outer loop:** A separate PI controller uses accelerometer measurements from the onboard Inertial Measurement Unit (IMU) to detect the angle by measuring the direction of gravity. This controller controls the angular velocity input of the **Inner Loop**, driving Cubert to any desired angle.

While the current iteration of the system keeps Cubert level when driving, future versions will allow for holding other orientations as the mission requires. A code snippet of Cubert's PID controller update function is below. The code was reused from our previous ROV, Scooter, but the inner/outer loop cascading architecture is new.

```
float PID::update(float setpoint, float measured) {
    error = measured - setpoint; // "how far off you are"
    dt = (millis() - lastMillis)/1000.0; // Used for integral and derivative

    // de/dt Derivative term. Acts as a damper by resisting change in error
    d = kd*((error - lastError) / dt);

    // Proportional term. Resists error directly.
    p = kp*error;

    // integral(error, dt) ... Trapezoid rule integral. Look it up
    integral += (((error - lastError)/2) + lastError)*dt;

    // Bound the integral so we don't have windup
    integral = min(integral, maxIntegral);
    integral = max(integral, -maxIntegral);
    i = ki*(integral); // integral

    lastMillis = millis();
    lastError = error;
    return p+i+d;
}
```

FIGURE 9: CUBERT'S PID CONTROL UPDATE FUNCTION, WHICH CALCULATES ERROR IN A SIGNAL, ITS TIME DERIVATIVE, AND ITS TIME INTEGRAL AND USES THEM TO DRIVE THE ROBOT TO A DESIRED STATE.

Control Electronics

Cubert houses a dual-processor setup, with a Raspberry Pi 4B handling higher level tasks and an Arduino Mega 2560 microcontroller handling lower-level tasks. Both processors are easily obtainable (DP6) and easy to use/debug (DP2, DP5), having extensive online documentation for their use.

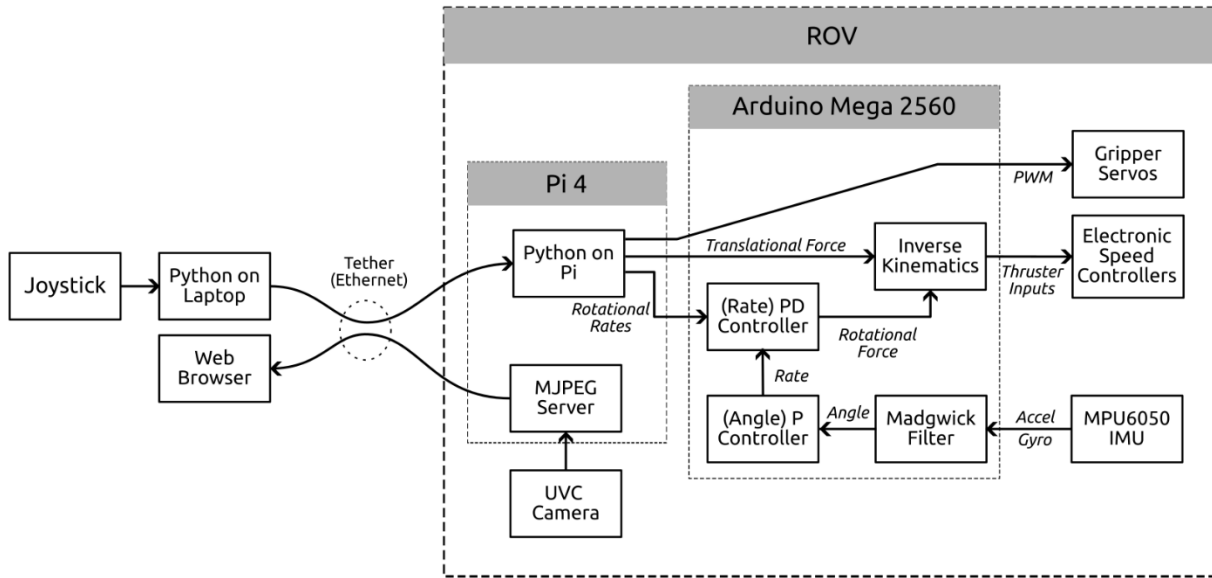


FIGURE 10: HIGH LEVEL DIAGRAM OF CUBERT'S KINEMATIC, COMMUNICATION AND CONTROL SYSTEMS CODE.

Raspberry Pi

Cubert's Raspberry Pi 4B is designed to handle higher level or computationally intensive tasks such as communication topside, computer vision, and autonomous behavior. It constructs a local area network and acts as a DHCP server, assigning an IP address to the drive station connected to it over the Ethernet tether. As can be seen in Figure 10, the primary pieces of software run on the Pi are a Python script that forwards commands from the topside drive station to the Mega, and an MJPEG server (ustreamer) that streams Cubert's camera feeds up to the drive station where they can be accessed using a normal web browser.

Arduino Mega

Cubert's Arduino Mega 2560 handles low-level, low latency, and precise timing tasks, and communicates with the Pi using a USB serial interface. Its main job is to communicate with Cubert's thruster motor controllers using Pulse Width Modulation (PWM), read acceleration data from its inertial measurement unit (IMU) using I2C, and implement a low-latency cascading PID motion control system to keep Cubert level in the water.

Canister Design

Cubert's canister is the home for all onboard electrical components. It keeps water out, transmits heat away from sensitive electronics, and allows wires to exit. Cubert's canister layout is an innovative design that is durable, reliable, and easy to service.



FIGURE 11: PHOTOS OF CUBERT'S CANISTER SYSTEM.

We utilized an 8-in acrylic watertight canister purchased from Blue Robotics for a previous season and cut down to the desired length. This canister was chosen for its reliability and availability (DP6). In determining how we wanted the canister to mount to the rest of the frame, we needed to ensure that it was centered, as the canister is a significant source of buoyancy. Centering it correctly would simplify the control system of the ROV, which is very important to its omnidirectional capabilities (DR3). Thus, we designed and manufactured custom mounts to position the canister in the correct location.



FIGURE 12: DETAIL VIEW OF CUSTOM MOUNT THAT HOLDS ONE END OF THE CANISTER TO CUBERT'S FRAME.

One important aspect of our design is that one of the canister endcaps is mounted to the frame itself. The internal electronics are mounted to this cap, such that the acrylic tube can be removed from the ROV and the electronics stay in place for ease of access (DP5).

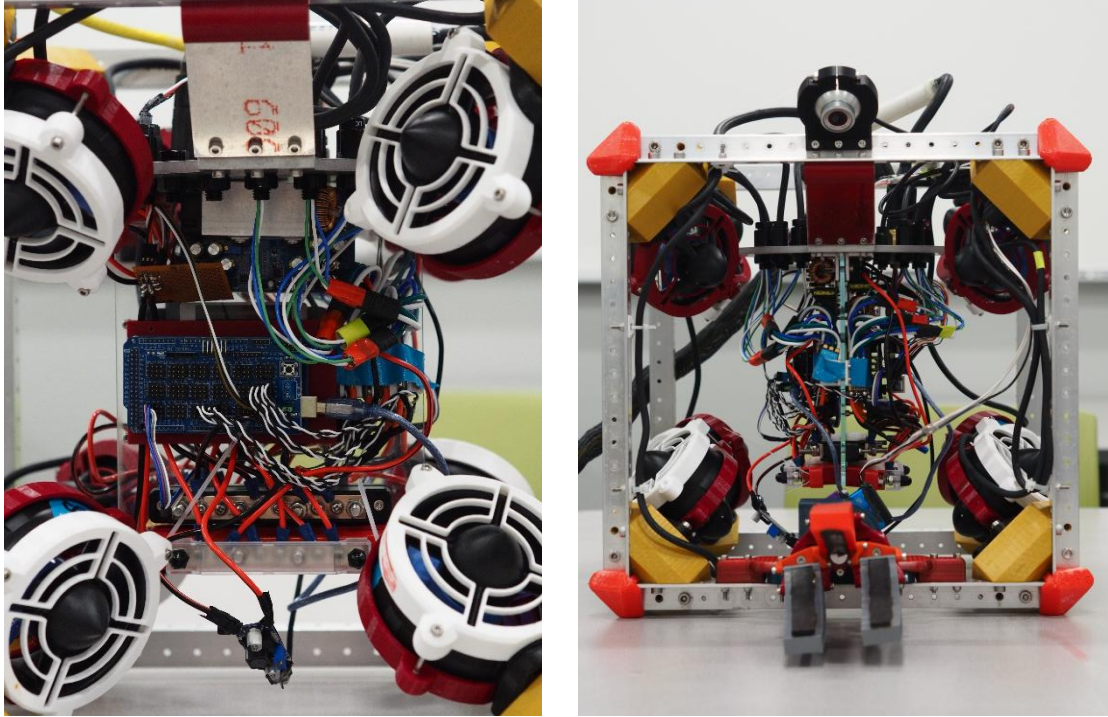


FIGURE 13: SIDE AND FRONT VIEWS OF CUBERT'S ELECTRONICS MOUNT BOARD. WHEN THE ACRYLIC TUBE IS REMOVED, ALL ELECTRONICS REMAIN MOUNTED AND EASILY ACCESSIBLE FOR FAST SERVICE.

An added benefit to mounting the electronics board onto the aluminum endcap is that the electronic components that are most prone to overheating can be positioned such that they are in contact with the endcap, which is thermally conductive and exchanges heat outside the canister. The electronics mount features several shelves so that central components such as the Raspberry Pi and the Arduino Mega are easily interfaced to other components, including the power buses and the Electronic Speed Controllers.

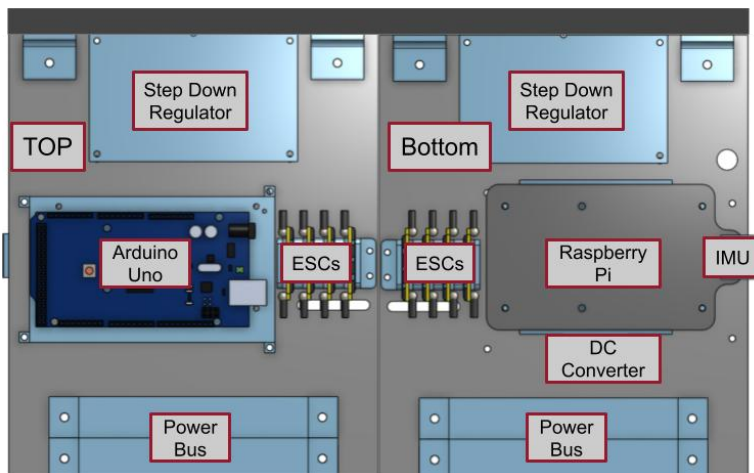


FIGURE 14: VIEW OF BOTH SIDES OF THE ELECTRONICS MOUNTING PLATE.

Buoyancy

In order to estimate Cubert's buoyancy, we estimated its volume from our CAD Assembly in Onshape. Buoyant force is calculated from the volume of displaced water, which we found to be approximately 14158 cm³, as shown in the image above. The Buoyant force is equal to the volume times the density of water, which is approximately 0.001 kg/cm³, times acceleration due to gravity, which is 9.8m/s². Therefore, Cubert's buoyant force was found to be approximately 139 N, or 31.2 lbs. Cubert was weighed to be approximately 30.6 lbs, meaning that it was positively buoyant, which is desirable as this makes it easy to recover should Cubert lose power (DR5).

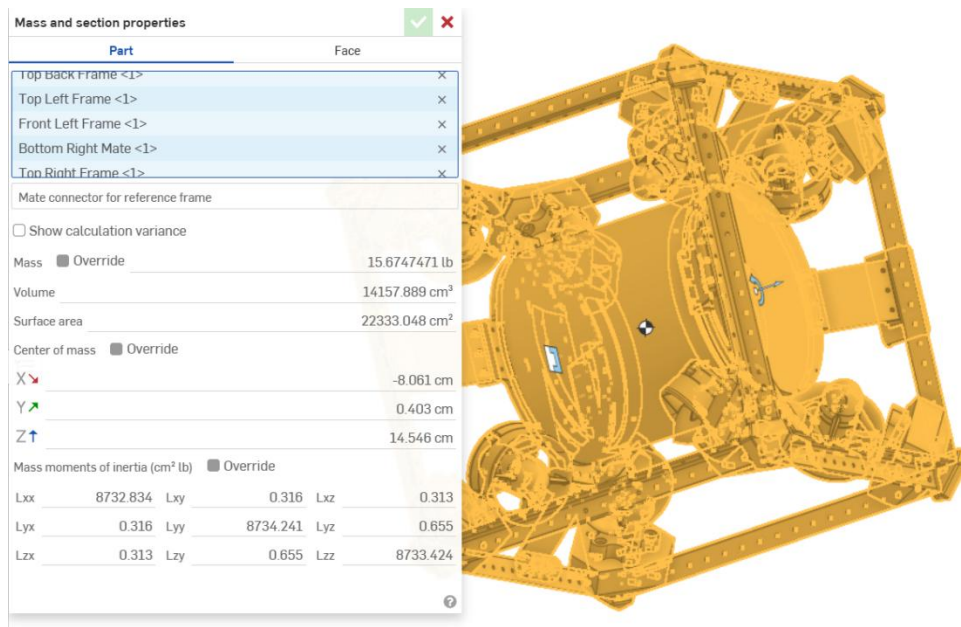


FIGURE 15: ONSHAPE VOLUME PROPERTIES

Beveled Modular Manipulator System

A new manipulator base system was developed for Cubert, consisting of a bevel gear based robotic joint driven by two servos, which connects the manipulator to the ROV body. This modification enables a greater degree of adaptability to our design, not only supporting rotational but vertical as well. Our robotic “wrist” enables Cubert to make more precise adjustments and movements without a need for repositioning, truly making our ROV more “flexible”. The end of this joint is a standardized six-hole interface on which can be attached modular attachments (DRM6).

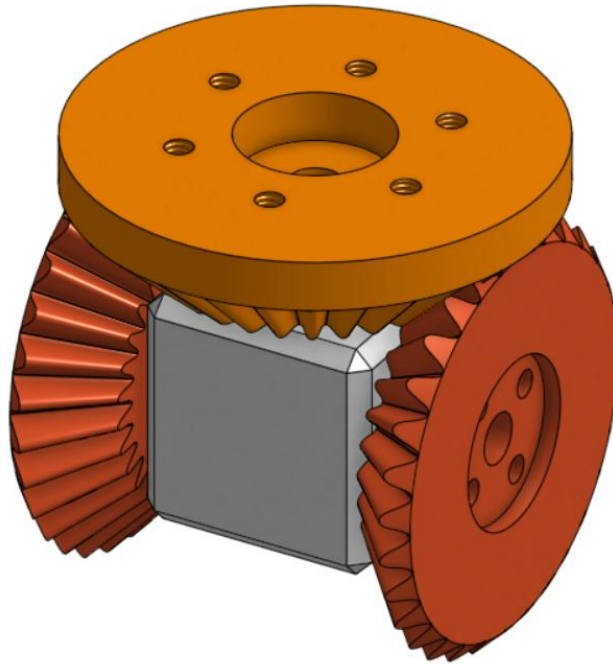


FIGURE 16: THE TWO-SERVO BEVEL GEAR JOINT

In designing this robotic joint we aimed to improve not only our manipulator’s degrees of freedom but also our future adaptations to our claw mechanism. This new design highlights these aspects; it is simple, effective, and features an easily adaptable manipulator mount point, ensuring our feature is more than a one competition gimmick (DRM6). Our design features a set of two servo mounted bevel gears, a central cube for attachment, and a specially modified bevel gear featuring a large flat back and multiple M4 holes for manipulator attachment. Furthermore, all these pieces are 3d printed enabling easy customization for future applications. This simple design and accessible manipulator mounting point is not only a stepping stone for this year but a foundation for the continued evolution of our manipulator design.

Compliant Gripper

RoseVG’s compliant gripper system has been developed over several years to be a high performance and reliable gripper system capable of grasping long objects of varying shapes and sizes, as is required by MATE ROV competition missions and DRM7. It has three compliant fingers that operate on parallel planes and cross each other when closed, allowing for a wide range of objects to be grabbed.

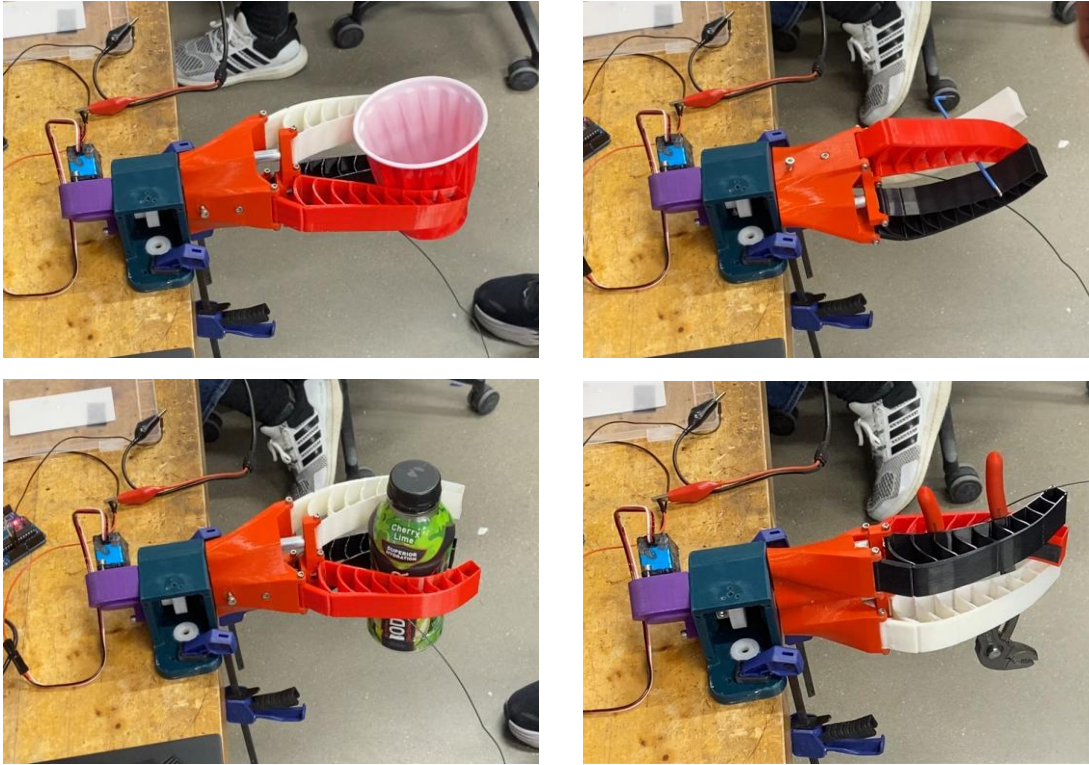


FIGURE 17: ROSEVG'S GRIPPER SYSTEM GRASPING A VARIETY OF OBJECTS.

Using compliant fingers has several advantages over rigid grippers. Firstly, they are more durable than rigid grippers, since harsh impacts will cause the fingers to bend without breakage. Secondly, they are less likely to damage small or delicate objects; excessive grip force will cause the fingers to wrap around the object, increasing the surface area of finger against object and spreading out the grip force.

Electrical System

Cubert's electrical system comprises its onboard microcontroller, its sensors, its power electronics, its camera systems, its waterproofing systems, and its tether. The power electronics are presented diagrammatically in the SID, and this section is a more in depth overview of all systems.

Electrical System Overview

Cubert's electrical system uses a master-slave power distribution architecture engineered to handle the current draw of eight Blue Robotics T200 thrusters while isolating sensitive control electronics. Power originates on the surface from four series-connected batteries delivering 48VDC through Anderson PowerPole connectors. A surface-mounted 30A Littelfuse establishes a strict Full Load Amperage (FLA) baseline, protecting the entire system before power is transmitted down the tether to the ROV's bulkhead penetrators. To mitigate inductive voltage spikes, high-frequency switching noise, and ground loops caused by the thrusters, the incoming 48V line is split into two independent buck converters that downstep the voltage to 12V. These voltages are routed to two entirely separate sets of bus bars, with four thrusters and their Basic ESCs dedicated to each pair. Operating the

thrusters at 12V lowers their individual amperage requirements, keeping the ESCs within safe thermal zones and balancing the mechanical load evenly across both regulators.

Downstream regulation for the control and actuation subsystems is divided between these isolated power planes, leaving a conservative 20% power margin for logic stability. The first 12V bus bar pair feeds a secondary regulator that steps the power down to 5VDC to run the Raspberry Pi 4B. The Pi, in turn, supplies stable USB power to the Arduino Mega, camera, and IMU. The second 12V bus bar pair hosts a separate regulator that drops the voltage to 7.4V to drive the high-torque gripper servos. This physical separation ensures that heavy mechanical loads or sudden stalls on the manipulator servo cannot cause a voltage sag on the Raspberry Pi's power rail, preventing catastrophic mid-mission logic resets.

Surface Power

The power is supplied from the surface with 4 batteries in series, providing 48V to a power switch with Anderson Power pole connectors. After this connector, there is a 30A Littelfuse placed in the line. From there, the tether extends until it reaches the bulkhead penetrators of the ROV.

ROV Power

The 48V power is split into 2 voltage regulators (buck converters), which convert the 48V DC into 12V DC. These two voltages are kept separate from each other on 2 sets of bus bars, to prevent ground loops. One of these 12V bus bar pairs is hooked to a 12V to 5V DC regulator, which is responsible for providing power to the Raspberry Pi 4B. The other pair bus bars are hooked to a 12V to 7.4V DC regulator, which provides power for the servos. The Arduino Mega is powered via USB from the Raspberry Pi. 4 T200 thrusters are powered from each pair of 12V bus bar.

Tether

Cubert's tether supplies power from the surface and enables communication with the drive station. It consists of two sets of two 12 AWG wires to carry 48V power, and one Kevlar-shielded cat5e ethernet cable for communication. It is contained in an expandable sleeving wire loom for protection against abrasion and is strain relieved on Cubert's frame and on the topside drive station. It enters Cubert's canister through a SubConn Circular 4-contact connector (power) and a SubConn Micro Circular 8-contact connector (ethernet).

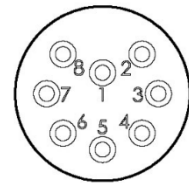


FIGURE 18:
SUBCONN
CONNECTOR

Camera Hardware

Cubert uses a single ExploreHD camera mounted on its front face. The ExploreHD camera is a small, lightweight camera that is simple to install and use (DP5) and delivers high quality relative to its price. Furthermore, it lends itself well to multi-camera streaming, which is an option we are considering for photogrammetry and because of the symmetry in our ROV design. This allows us the flexibility to improve upon the camera setup in the future without needing to worry about changing any existing hardware or software (DP4). We use a custom designed and 3D printed mount to offer flexibility in camera orientation and ease of access of materials. This mount features open top and bottom layers, allowing water to flow through it instead of soaking in over time and changing buoyancy.

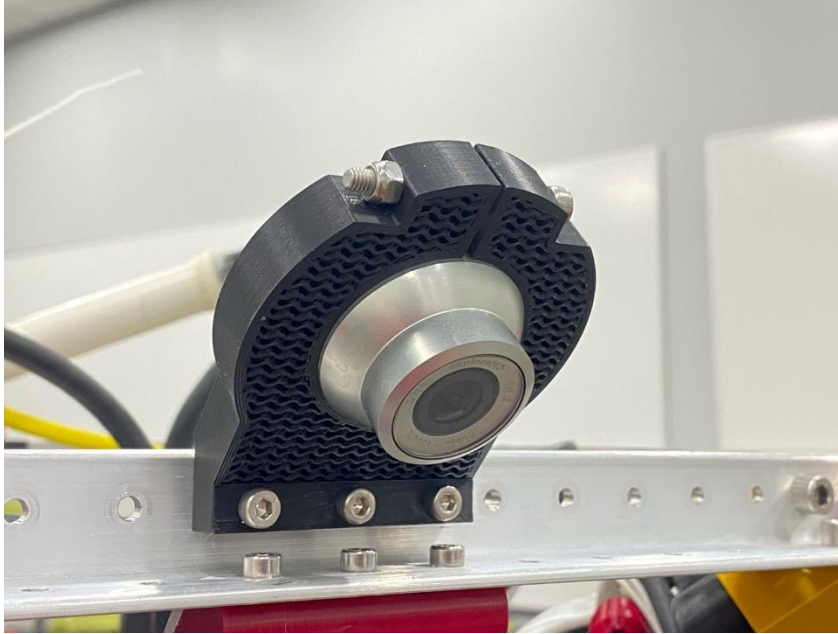


FIGURE 19: CUBERT'S EXPLOREHD CAMERA AND MOUNT. THIS LOCATION ALLOWS CLEAR VISION OF THE GRIPPER AND THE AREA IN FRONT OF CUBERT.

Camera Software

The camera is connected to the Raspberry Pi 4 over USB. The Raspberry Pi hosts a μ Streamer server and streams the camera output as an MJPEG stream over its local area network. The connected computer can access the live output through a web browser. This is a simple way of accessing low latency live video output without sacrificing too much video quality (DP2).

Photogrammetry

This year, the competition requires that the company create a 3-dimensional map of a coral garden. We are electing to use photogrammetry to map this feature, a technology which constructs a 3-dimensional model using a series of images. We used Reality Capture, which is a free photogrammetry application that is capable of processing underwater images. Reality Capture has a built-in scaling feature which is particularly useful in the outlined task. We will be using our onboard ExploreHD camera to record the video for this task, which will then be brought into Reality Capture to create a scaled mesh model of the coral garden.

Electrical Design Process

The power distribution architecture began by managing the massive potential current draw from the eight Blue Robotics T200 thrusters without compromising the stability of our control electronics. By running the thrusters at a lower speed (and at 12V instead of the higher supported voltages), we significantly reduced their individual amperage requirements, allowing us to utilize Blue Robotics Basic ESCs safely within their optimal thermal and electrical operating zones. This constraint enabled us to streamline our main power delivery path down the tether and gave us a predictable Full Load Amperage (FLA) baseline to size our primary safety components, ultimately leading to the selection of a robust 30A Littelfuse on the surface to protect the entire system from catastrophic overcurrent events.

With our maximum current limits established, we focused on isolating our high-current propulsion systems from our sensitive logic components to mitigate electrical noise and ground loops. We addressed this by splitting the incoming 48V surface power into two buck converters that step the voltage down to 12V DC, routing them to two entirely independent sets of bus bars. We dedicated four T200 thrusters and their respective ESCs to each 12V bus bar pair, balancing the mechanical load across both regulators. By physically separating these power planes, we ensured that the massive inductive voltage spikes and high-frequency switching noise generated by the ESCs during sudden thruster maneuvers would not propagate backward and disrupt or reset our primary computing units.

Once the high-wattage propulsion grid was created, we designed the downstream regulation for our control and actuation subsystems, allocating a conservative 20% power margin to accommodate these residual electronics. From the first isolated 12V bus bar, we integrated a smaller 12V to 5V DC regulator dedicated to powering our Raspberry Pi 4B, which subsequently provides clean USB power directly to our Arduino Mega, camera, and IMU. Off the second 12V bus bar, we integrated a separate 12V to 7.4V DC regulator exclusively tasked with driving the high-torque gripper claw servo, ensuring that heavy mechanical loads on the manipulator wouldn't cause a voltage sag on the Raspberry Pi's power rail.

Safety

Safety is first and foremost in RoseVG Robotics's priority regarding our work environment. By ensuring that the personal safety of all our employees is secured and the proper safety features are installed on the ROV, we can minimize the chances of accidents happening. Furthermore, we believe that a safe work environment will improve the morale, productivity, and security of our employees, knowing that they don't have to be overly cautious about every little detail when working on the ROV.

Personal Safety

RoseVG Robotics has safety standards that each employee is required to follow prior to entering the workspace. First, there's a training course that all employees have to complete to gain access to the building where the workspace is. This includes completing a safety module that culminates in a quiz to ensure that each employee is familiar with the material. Safety procedures covered include wearing proper PPE, maintaining a safe and organized workspace, properly disposing of hazardous materials, emergency procedure, and how to operate the equipment at our disposal. After completing this quiz and gaining access to the building, employees are required to complete further training for access to additional workspaces, such as the welding shop, machine shop, and woodworking shop. Anyone found to be in violation of a workspace's safety procedures will lose access to the space and be required to complete the training courses again. Along with our priority of workspace safety, we have an anti-harassment policy that allows the company to kick out any members who are causing trouble during the year. This policy aims to ensure that our employees feel secure at our meetings without the worry that anyone will take away from the experience of working for this company.

ROV Safety

Cubert was designed and constructed with safety and ease of interaction in mind. Starting with its materials, we made sure to have no sharp edges on any part of Cubert by sanding down the materials and filleting or chamfering the corners of any 3d printed or machines parts. On the electrical side, we made sure not to have any exposed wires on any electrical components on Cubert. Any additional component that could be exposed to electricity is covered with electrical tape to ensure it doesn't come into contact with any metal parts. As soon as Cubert was able to run, we ensured that we had secure covers over the thrusters to prevent team members from becoming injured. Whenever operating Cubert, we call out to warn anyone in the vicinity before turning the thrusters on to further ensure that no one is injured by moving parts.

Start Checklist

1. Seal the ROV
 - a) Ensure no wires are caught in between the bulkhead and lid.
 - b) Ensure all O-Rings are in place and lubricated.
 - c) Ensure all thumb screws on both sides are tight.
2. Power the ROV
 - a) Have one worker monitor the ROV while a second flips the power switch.
 - b) If any smoke appears, immediately power off the ROV
3. Dry Systems Test
 - a) Test all 8 motors, the claw, and wrist by moving the joystick.
 - b) Test PID by rolling the ROV.
4. Putting ROV in Water
 - a) Slowly place the ROV in the water while watching for breaches.
 - b) Take it out and inspect for water.
 - c) Repeat for longer amounts of time in the water
5. Waterproof testing
 - a) Leave ROV in water for several minutes while performing typical operations.
 - b) Examine closely for any leaks
6. ROV Operation
 - a) The ROV should be fully operational, proceed with operation.

Critical Analysis

Test Methodology

- Turn on the robot and do a quick check on land to make sure core components (claw, motors, and camera) are in working order.
- Turn off the robot and leave it underwater for around 5 minutes to check for leaks.
- Power the ROV back on and begin testing on an objective of our choosing (one objective at a time).
- Remove the robot from the water while making any necessary changes to the code and uploading through GitHub.

Troubleshooting

When troubleshooting, we use an elimination method. If something isn't working, we isolate the source of the failure by eliminating other possible sources of error. For instance, if the cameras weren't working, we would first determine whether or not the cameras work when plugged directly into the computer. Then we would move on to a cat5e cable, to the tether, and to the USB hub. If the camera stops working at any point through that process, we isolate the problem further from there by checking if any of the wires are corroded, if any of the connections are broken, if the camera requires more power, etcetera. Through this process, we can isolate and solve the error.

Waterproofing

All of Cubert's electronic components must be properly waterproofed to prevent any damage from occurring on the ROV or the team. Most external electronic components are sourced from BlueRobotics or other trustworthy sellers, such as the thrusters and cameras. These components undergo quality control by the manufacturers and are trusted to operate safely underwater. The few external components that aren't already waterproofed, such as the servo motors, are waterproofed following strict processes known to be effective in the past and tested in marine conditions. Our BlueRobotics canister and connectors feature a series of o-rings and tight seals that prevent leaking, and we ensure that we always perform a brief waterproofing test with the electronics powered off before running the ROV.

Accounting

At the beginning of the year, a set amount of budget is set aside for our team. Currently, this team is under an 'umbrella' of other robotics teams that all share one budget. This budget is then distributed accordingly based on documentation and estimated cost for each year. A separate budget for traveling is also given and distributed.

Our team has two main funding sources: Student Government Association (SGA) and the Branam Innovation Center (BIC) funding. This year, the SGA awarded our team \$3312.5, and the BIC awarded us \$1177.50. Our travel funding budget is \$8475. As shown in Table 1, our total funding accounts for as well as money spent throughout the year. Through the utilization of Google Sheets, we can keep track of orders and payments made to each sub team and specifics on what category the item purchased belongs to as shown in Table 2.

MATE	Summary	Budgeted	Ordered Cost	Estimated Budget Remaining	Actual Cost with tax	Actual Budget Remaining
Totals without travel and OTRs	Totals:	\$4,490	\$2,651	\$1,839	\$2,284	\$2,206
	General	\$450	\$134	\$316		
	Mechanical	\$2,070	\$1,344	\$727		
	Electrical	\$960	\$810	\$150		
	Software	\$1,010	\$363	\$647		
Travel Budgeting	Totals:	\$8,475	\$8,271	\$169	\$289	\$8,186
	Flights	\$2,900	\$2,820	\$80		
	Van Rental	\$650	\$620	\$30		
	Gas	\$1,200	\$1,145	\$55		
	Hotel Rooms	\$2,500	\$2,496	\$4		
	Stipends	\$500	\$490	\$10		
	Fees	\$725	\$700	\$25		

TABLE 1: TOTAL FUNDING AWARDED WITH PREDICTED COSTS AND ACTUAL COSTS OF EACH SECTION.

MATE	Budget	Fall	Winter	Spring	Summer	Amt. Budget	Actual Spent
General	Quarterly totals:	\$0	\$0	\$450	\$0	\$450	\$134
	Props	\$0	\$0	\$350	\$0	\$350	\$85
	Organization	\$0	\$0	\$100	\$0	\$100	\$50
Mechanical	Quarterly totals:	\$975	\$827	\$268	\$0	\$2,070	\$1,344
	Raw Stock	\$400	\$200	\$0	\$0	\$600	\$60
	Hardware	\$75	\$80	\$25	\$0	\$180	\$225
	Tools	\$30	\$50	\$0	\$0	\$80	\$26
	3D Printer Filament	\$0	\$0	\$0	\$0	\$0	\$100
	Motors	\$100	\$120	\$0	\$0	\$220	\$116
	Waterjet	\$0	\$0	\$10	\$0	\$10	\$0
	Misc. Parts	\$50	\$50	\$0	\$0	\$100	\$13
	Waterproofing	\$120	\$127	\$183	\$0	\$430	\$575
	Float	\$200	\$200	\$50	\$0	\$450	\$229
Electrical	Quarterly totals:	\$250	\$540	\$170	\$0	\$960	\$810
	Boards	\$100	\$320	\$0	\$0	\$420	\$2
	Components	\$100	\$120	\$50	\$0	\$270	\$441
	Misc. Parts	\$50	\$100	\$120	\$0	\$270	\$80
	Cables	\$150	\$80	\$0	\$0	\$230	\$287
Software	Quarterly totals:	\$250	\$760	\$0	\$0	\$1,010	\$363
	Boards	\$100	\$350	\$0	\$0	\$450	\$38
	Camera	\$100	\$350	\$0	\$0	\$450	\$325
	Misc. Parts	\$50	\$60	\$0	\$0	\$110	\$0
Travel	Quarterly totals:	\$0	\$0	\$0	\$8,450	\$8,450	\$8,396
	Van Rental	\$0	\$0	\$0	\$560	\$560	\$560
	Gas	\$0	\$0	\$0	\$1,150	\$1,150	\$1,150
	Student Rooms	\$0	\$0	\$0	\$1,664	\$1,664	\$1,664
	Advisor Rooms	\$0	\$0	\$0	\$832	\$832	\$832
	Advisor Stippend	\$0	\$0	\$0	\$490	\$490	\$490
	Ferry Fee	\$0	\$0	\$0	\$104	\$104	\$100
	Flight Reimbursement	\$0	\$0	\$0	\$3,000	\$3,000	\$2,950
	Competition Fee	\$0	\$0	\$0	\$650	\$650	\$650

TABLE 2: SPECIFIC CATEGORIES TO BUDGET WAS SPENT ON THIS YEAR

BoM of ROV:	Item	Description	Type	Cost Per	Quantity	Total Cost
Mechanical	BlueRoboticsT200 Thruster	Drive motors to propel ROV	Reused	\$220.00	8	\$1,760.00
	Canister		Reused	\$506.00	1	\$506.00
	Canister Lids	Aluminum flange and bulkhead	New	\$178.00	2	\$356.00
	Camera	ExploreHD 3.0 Camera	Reused	\$325.00	1	\$325.00
	Aluminum Frame	Aluminum of 1/8" x 1" x 96" brackets	New	\$29.93	2	\$59.86
	Servo Motors	Servo motors used for gripper	Reused	\$28.99	1	\$28.99
	General Hardware	Fasteners and other	New	\$180.00	1	\$180.00
	Waterproofing	General waterproofing such as gaskets	New	\$430.00	1	\$430.00
	3D printed materials	TPU and PETG Materials	New	\$100.00	1	\$100.00
Total:						\$3,745.85
Electronics	Arduino Mega		Reused	\$49.65	1	\$49.65
	Blue Robotics ESC	Motor controllers for thrusters	New	\$40.00	8	\$320.00
	48-12V converter	Voltage regulator module for power	New	\$95.99	2	\$191.98
	Bus Bars	Power distribution terminals	New	\$16.99	2	\$33.98
	Raspi 4b		New	\$99.98	1	\$99.98
	Servo/Sensor Board		New	\$7.49	1	\$7.49
	MPU6050 IMU	Inertial measurement unit for balance	Reused	\$6.99	1	\$6.99
	12-7.2V Converter	Voltage regulator module for components	Reused	\$34.80	1	\$34.80
	Ethernet Tether	50 m Ethernet tether to ROV	Reused	\$400.00	1	\$400.00
	Subcon Connector	Waterproof Connector to power	New	\$330.04	1	\$330.04
	Controller	Controller for ROV	Reused	\$34.99	1	\$34.99
	Misc. Connectors		New	\$287.00	1	\$287.00
Total:						\$1,796.90
TOTAL COST:						\$5,543

TABLE 3: BILL OF MATERIALS OF OUR ROV

Acknowledgements

MATE Center and Marine Technology Society – Sponsoring this year’s competition

Memorial University of Newfoundland – Hosting the 2026 MATE competition

Lee Dagle – Her time, guidance, and yearlong support of the company

Tom Rogge – His guidance and technical expertise throughout the year

Branam & Kremer Innovation Center staff – Use of their tools & machines, and their support & advice

Rose-Hulman Student Government Association – Funding and administrative support

Rose-Hulman Sports & Recreation Center – Generous allotment of pool time Rose-Hulman

EIT – Providing software such as CAD software

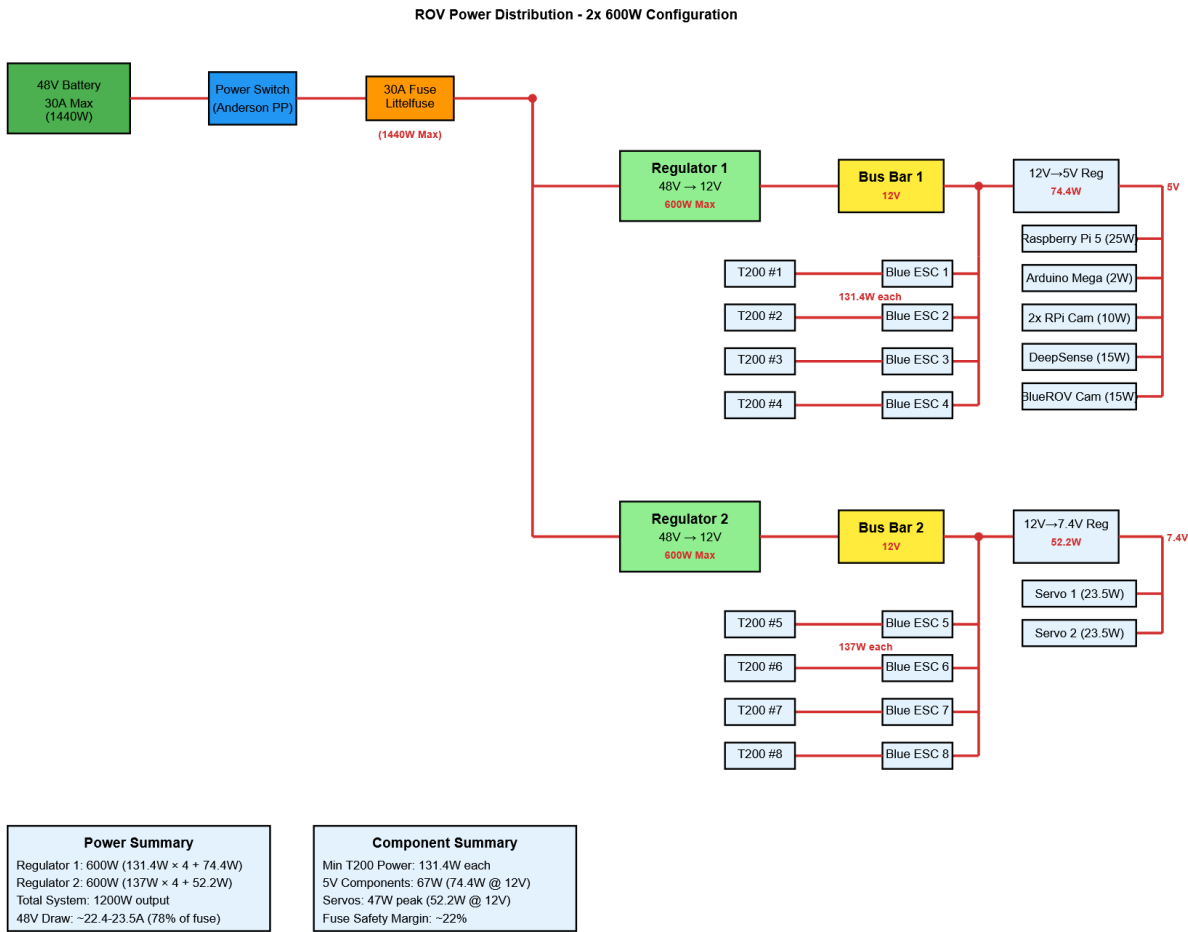
Our families – Their continued support and encouragement

Our advisor Dr. Nathan Brooks – His wisdom and guidance

References

- [1] P. M. Gerhart, A. L. Gerhart and J. I. Hochstein, Munson, Young and Okiishi's Fundamentals of Fluid Mechanics, Hoboken Nj: Wiley, 2021.
- [2] Marine Advanced Technology Education, Underwater Robotics Science, Design, & Fabrication, Monterey, CA, 2010.

Appendix: System Integration Diagram (SID)



Appendix: Bonus Mission