



2026 Technical Documentation

POMONA SUBSEA INITIATIVE

AT CAL POLY POMONA

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ABSTRACT

Pomona Subsea Initiative is an undergraduate student-led company from Cal Poly Pomona specializing in the design, construction, and operation of underwater ROVs. In its inaugural year competing in the 2026 MATE ROV Competition, the team presents *Barreleye*, developed in response to MATE's theme of the UN Decade of Action for Cryospheric Sciences and the exploration of Earth's frozen regions.

This global initiative emphasizes research, collaboration, and awareness surrounding Earth's frozen regions including polar ice sheets, glaciers, sea ice, snowpacks, and permafrost. These regions store nearly 70% of the world's fresh water and play a critical role in global climate systems.

The design and construction of the ROV and its tooling followed a philosophy centered on operational efficiency and modularity. Using SolidWorks, additive manufacturing, and iterative pool testing, the team developed specialized tools and attachments intended to reduce pilot strain and improve task completion efficiency during competition missions. While the manipulator remains a versatile system for object acquisition and interaction, certain mission elements benefit from dedicated tools designed for specific operations. These tools may be mounted directly to the ROV or deployed independently to function separately from the vehicle.

The competition reflects real-world subsea engineering challenges, where modular tooling and specialized manipulator end-effectors are commonly used to improve precision, efficiency, and safety in underwater operations. Similar systems are applied in scientific exploration, infrastructure inspection, environmental monitoring, and delicate handling tasks such as coral research and recovery operations.



Figure 1: Team Photo

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TEAMWORK AND COMPANY PROFILE

Pomona Subsea Initiative (PSI) is an interconnected team of 15 members that is affiliated with the California State University, Pomona. We have focused on working and innovating new technology to contribute to advancing the ROV industry to address marine preservation and climate change, especially in colder regions of the Earth.

COMPANY ORGANIZATION

The organization of PSI consists of a CEO, COO, CIO, CTO, and CFO, making up the highest positions of the company that oversee most of the operations

spanning financial, information, logistics, and technical work. Under these roles are the engineering leads (including mechanical, electrical/software, and safety) who are responsible for teaching and guiding the interdisciplinary engineers in the company. Due to its smaller size, PSI, at its core, operates as an interdisciplinary project-based company, where being involved in all aspects of the project is highly encouraged. Engineering leads are expected to aid every member of the company, and PSI members then are fitted into their niche while still possessing the understanding and knowledge of other subsystems in the overall system.

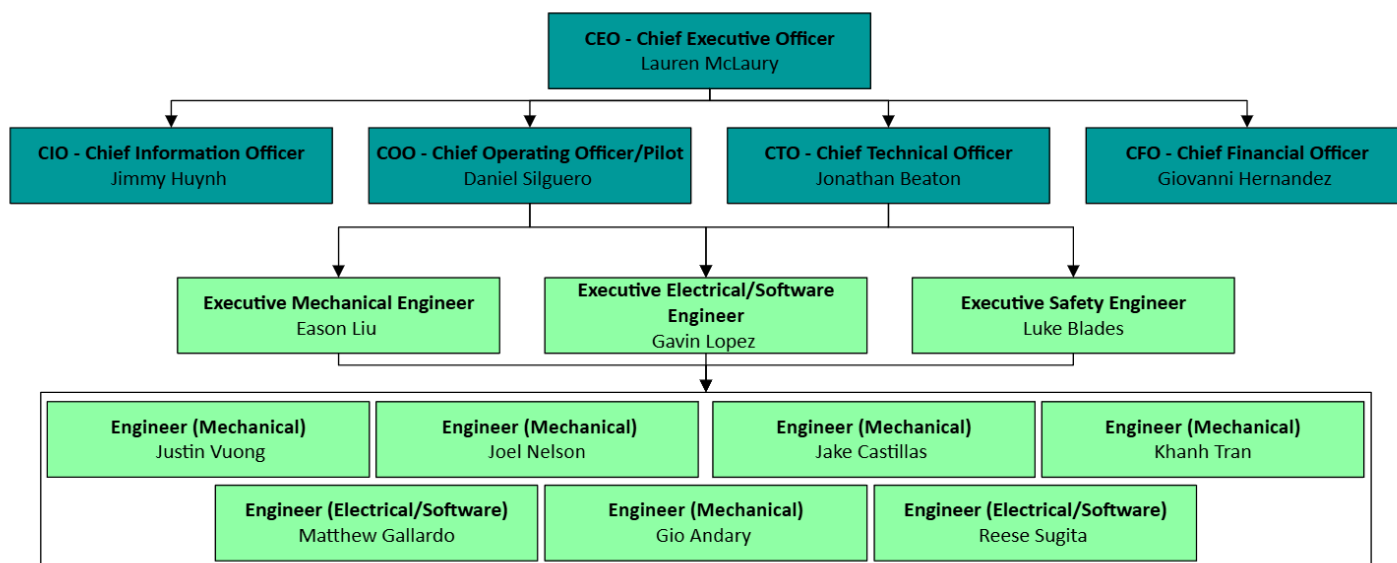


Figure 2: PSI Organizational Chart

COMPANY SCHEDULE

PSI was first established in late August 2025 and spent the month of September recruiting and seeking talent to join the company. Individuals were recruited onto the company via word of mouth, where their technical prowess and behavioral qualities were assessed by the CEO and COO. The initial ideation phase began with weekly meetings where all company members would gather and discuss possible design considerations and/or iterations. Time spent between meetings is used to research and create

rough prototyping. During these meetings, a timeline was also created with the hopes of a working product being in the water by early February, allowing ample time for further improvements to comfortably prepare for the product demonstration video mid-May deadline. These initial meetings spanned until late November. The schedule for the building phase shifted meetings to a more dynamic system where weekly company meetings still occurred; however, smaller and more specialized meetings amongst different members also took place. The deadline for a working water-suitable ROV was met, and testing

occurred in February where PSI identified overlooked flaws or possible improvements that could be made. This is when the iteration phase began. Smaller groups of company employees took on different parts of the ROV to refine and specialize in while other teams took on the task of developing different supporting tools and payloads. Finally, there

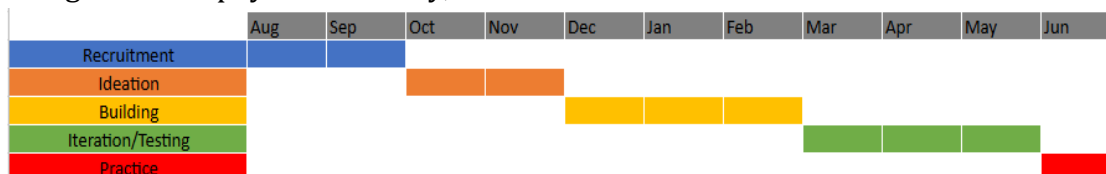


Fig. 3: PSI's year-round schedule.

COMPANY RESOURCES

With small, specialized meetings and tasks being distributed with asynchronous progress in mind, PSI used tools such as Google Drive and Discord in order to provide progress updates and receive feedback. Files that were shared for all employees included both software code and CAD models, allowing everyone access to the most up-to-date version of the project. Other communication avenues, such as Outlook, were used to communicate with sponsors and mentors. As for logistics, programs such as Excel and Google Sheets were used for record-keeping. These communication resources were the backbone of allowing for a cohesive day-to-day project, where employees were able to make progress and ensure everyone was kept in the loop, avoiding confusion. This allowed for proper progress tracking while encouraging an involved and fluid work environment where employees were able to join and contribute to any part of the project. Having none of the subsystems' progress kept in the dark, supplements the interdisciplinary structure under which the company was built. These updates are reflected in the associated project pages, which serve as the primary day-to-day form of documentation that tracks project progress, plans, links, pictures, and project metadata.

was dedicated time to practice and rehearse prior to the final product demonstration. Members were given time to acclimate to their respective poolside responsibilities, final testing for the ROV would be completed, and final tweaks such as buoyancy and ballast adjustments could be made.

ROV OVERVIEW

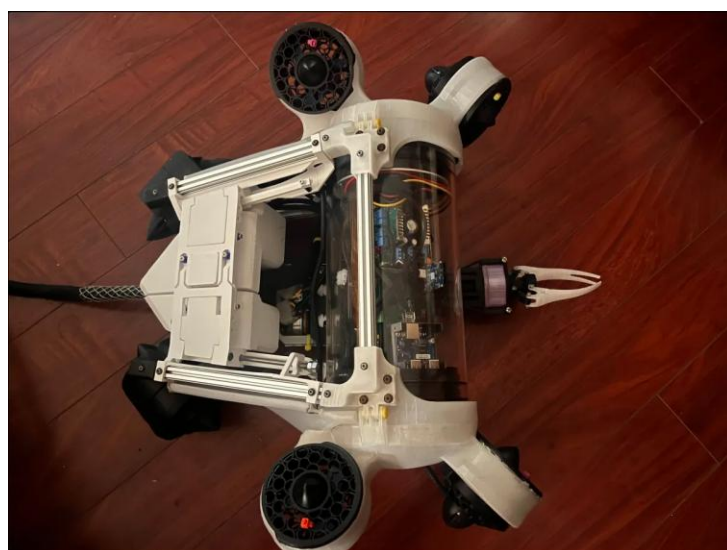


Figure 4: Top view of *Barreleye*.

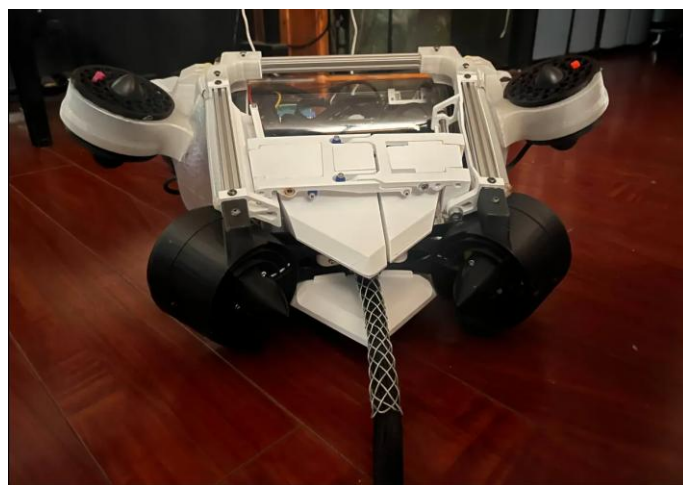


Figure 5: Back view of *Barreleye*.

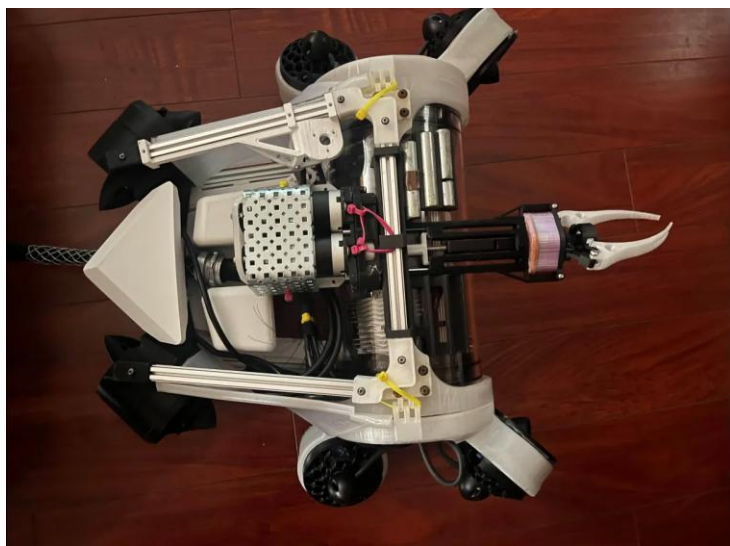


Figure 6: Bottom view of *Barreleye*.



Figure 7: Front view of *Barreleye*.



Figure 8: Side View of *Barreleye*.

DESIGN RATIONALE

PLANNING AND DESIGN PROCESS

As a first-time participant in MATE ROV Competition, PSI was tasked with developing reliable systems that allow for competitive performance during the competition while also creating a strong foundation for future iterations of PSI's ROV. In order to start

from scratch and develop a functioning ROV, PSI utilized a process that considered the lifespan of all components throughout the duration of development. The design process used by PSI includes:

Identification of Problem: Problems are oftentimes created due to constraints stated in the request for proposals. Being aware of specified constraints allowed PSI to gain and understand a problem and actively create a solution within the constraints to resolve the issue. Problems are also discovered through testing and its results. Feedback from testing allows for corrective action and improvement.

Brainstorm Solutions: After discovering and analyzing the problem, PSI brainstorms possible solutions to the problem as a group. The brainstormed solutions are then re-evaluated based on performance, reliability, and maintainability. Based on this evaluation criteria, a solution is selected for the product.

Design and Prototype: After the best solution is selected through the brainstorming process, the design along with prototypes of the design are created and evaluated. Prototypes include variations of the original design that emphasize or target aspects of a component that may create an advantage. Designs and prototypes are evaluated based on factors such as cost, performance, and ease of manufacturing.

Testing: Prototypes are tested, and the data from testing informs the design and further iteration of the part.

Push to Market: Once the design has been sufficiently tested, ensuring quality, it is pushed to the final vehicle.

PSI's planning process prioritizes problems that are presented in the mission rules, relate to vehicle reliability and performance, and are beneficial to building the skills of team members.

SYSTEMS APPROACH

Barreleye's system approach is based on the idea of breaking the vehicle into subsystems, finding problems regarding those subsystems, making improvements, and integrating said improvements into the final design. Mechanical, electrical, and software subsystems are then combined to create a functional ROV capable of completing the tasks presented in the request for proposals. Trade-offs between subsystems are also evaluated in order to produce the greatest overall performance.

All physical/mechanical components are designed using CAD and allow for interactions between said components to be simulated. This allows PSI to model and understand how a mechanical component will perform before it is applied to the ROV. This process also allows for prototyping and testing without wasting material and for more efficient refinement of the system being evaluated.

VEHICLE STRUCTURE

The frame of *Barreleye* is predominately made of aluminum extrusions with 3D printed connectors. This material choice balances cost, weight, and size.

PSI designed the vehicle around the idea of using aluminum extrusions because they were existing materials and available at no cost. Additionally, aluminum extrusions are sufficiently strong while being light weight, helping to keep the vehicle weight low and maintaining structural integrity. PSI cut the extrusions to specific sizes to create a visually appealing profile in a compact intentional footprint.

The combination of 3D printed connectors and components with the aluminum extrusions further expands the customizability of the vehicle. All 3D prints were done in PLA, an affordable, lightweight, safe, and easy to use filament. With the ease of 3D printing any model PSI could make, the vehicle could be designed and contrasted to fit the desired footprint.

VEHICLE SYSTEMS

COMPONENT SELECTION

The tasks presented in the 2026 request for proposals demand a vast range of ROV capabilities. With that in mind, PSI selected components and materials for *Barreleye* that provided a cost-effective way to rapidly develop solutions to the tasks through 3D printing.

In-house 3D printing allowed the company to design and create iterations of several task specific tools in a short period of time at a low cost. PSI developed a robust manipulator that can open and close with limitless rotation. This manipulator consists of 3D printed components along with stainless steel gearboxes to ensure sufficient power, strength, and reliability. This manipulator allows *Barreleye* to complete most mission tasks that involved grabbing and manipulating infrastructure such as the valve and samples such as servicing the Holyrood subsea observatory, testing whale safe fishing gear, powering an oil platform from a wind turbine, and collecting coral samples. However, there are four specific tasks that this manipulator falls short in .

The lobster pot` recovery requires a large amount of lifting capability that *barreleye* cannot reliably supply with putting excessive stress on the system. To accomplish this task, PSI used an industry grade lift bag combined with a custom 3D printed PLA quick attach mechanism.

Recovering the buoy anchor requires attachment of a recovery line to anchor and returning the line to the surface. To accomplish this, PSI designed, printed, and assembled a custom PLA rapid recovery clamp that can be attached and left while staying tethered to the surface.

An additional task is to collect two basket stars, but with the manipulator alone, this would take a large amount of time due to the complete occupation of the claw. To combat this, PSI designed a PLA detachable

spear-like tool to collect both basket stars at once while keeping the manipulator free for other tasks. Lastly, to survey the iceberg, the keel depth must be measured accurately, which *Barreleye* cannot do with mechanical systems. PSI chose to implement a pressure sensor to measure the pressure differential between the top of the iceberg and the bottom. When used in combination with a pressure to depth conversion for water, the length of the keel can easily be determined. To use this sensor properly, PSI designed an attachment from aluminum rod to extend the sensor out of the way of *Barreleye's* movement. Aluminum rod was selected for the strength it provides, extending the longevity of the tool that is in a high stress position.

DESIGN EVOLUTION

From the beginning stages of preliminary design, PSI kept in mind the mission environment. A large portion of the tasks must be completed in the current. Rather than fight the current, PSI designed *Barreleye* to glide through it. The position and orientation of the watertight enclosure that houses the main camera and all electronic components running the ROV is one PSI's most unique design choices. As seen in Fig 5 the acrylic tub has been oriented along the width of the vehicle rather than front to back, and it is positioned in the front of the vehicles footprint. This combined with the custom designed dome end cap covers that round off the flat ends of the tube, create a hydrodynamic profile. Thanks to this profile, during operation, *Barreleye* can position itself facing the direction of flow to maintain a low and uniform drag across the vehicle. Additionally, the back of the ROV is comprised of tapered aluminum extrusions encapsulated with form fitting plastic skins, helping to direct the water around and away from the vehicle as seen in Fig 6. With the large range of tasks outlined in the request for proposal as mentioned previously, PSI started *Barreleye's* design as a robust platform with basic structural components and room for modular tools to be added. Figure 9 and 10 shows the base design of *Barreleye* prior to any additional

components. As time went on and PSI decided to attempt more tasks with the vehicle, new attachments as specified above could be designed and attached with ease *Barreleye's* frame using the space open on the aluminum bars as seen in Figure 6.

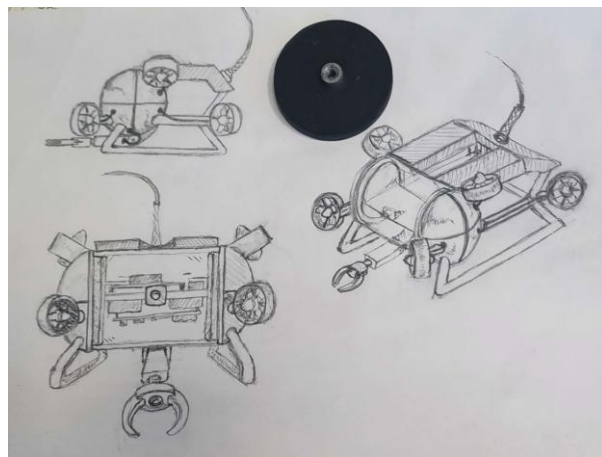


Figure 9: Preliminary Design Sketches.

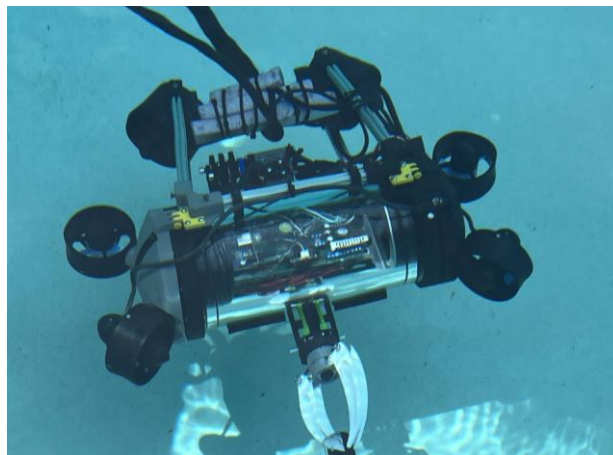


Figure 10: Barreleye base design.

CONTROL SYSTEM

Barreleye communicates with the surface computer through an ethernet cable connecting an Arduino Mega 2650 and the surface station computer. The surface station runs off a ASUS ROG Zephyrus laptop that sends packaged python code through USB. The code runs through an ethernet converter because of simplicity of design and smooth communication. The signal reaches the ROV through the tether and is converted to USB. This hub sends signals to the Arduino and sends and receives signal from the RH-SDI1600DK camera. The camera offers high

resolution and compatibility with underwater functionality. The signal received from the Arduino is directly used to activate the motors. Pulse Width Modulation (PWM) signals are sent to motors as needed. The human input on the PS4 controller is packaged in the code and sent as a PWM value between 1100 and 1900 microseconds to initiate thrusters, the manipulator or adjust buoyancy of the ROV.

SOFTWARE LAYOUT

Figure 13 displays the layout of the software. There are 3 divisions of operation, the surface station, the electrical housing and the motion and feedback. The surface receives all feedback and sends all inputs. The electrical housing receives and sends PWM signals to the motors and stores data from sensors. The motion and feedback translate and rotate the ROV as well as collect data required for individual MATE tasks.

SURFACE STATION

The Pilot and co-Pilot are responsible for any human input signals. This translates to the motion of any thrusters and manipulators. Using a PS4 controller and a DX6e 6-channel DSMX controller as the operator allows ease of use and simplicity of code. The joysticks of the DX6e controller directly correlate with the direction of motion. Magnitude and angles are processed in python and converted to a local coordinate system information that can be understood by the Arduino. Conversion of the coordinate system introduces the simplicity of controlling the movement of the ROV. Motion of all non-thruster motors and movement of cameras are operated by the Co-Pilot using the PS4 controller as seen below. The layout of the DX6e controller does not allow for control of the ROV's roll. This is for overall simplicity; the manipulator itself can rotate for any task that calls for a rotation about the y-axis and adding two methods for accomplishing one objective is unnecessary. However, as stated under the Propulsion section, the thruster layout allows for

roll if the thrusters are fired in a certain way. If needed this feature could be added to the horizontal movement of the left joystick of the PS4 controller.



Figure 11: Diagram of Human Input Manipulator Controller.



Figure 12: Diagram of Human-Input ROV Controller.

PHOTOGRAMMETRY

The CTO is responsible for receiving all data from the Arduino and processing it. This includes all readings as well as 3D rendering using 3DFLOW program. This program allows direct video processing to generate 3D models. The cons to this alternative are lower overall resolution and blur from non-constant velocity. This means faster acquisition of data and overlapping in frames when compared to photo-imaging. The cons to this alternative are lower overall resolution and blur from non-constant velocity.

ELECTRICAL HOUSING

The Arduino is the most important component of the ROV. It operates as the brain of the ROV by connecting the surface station to the actuators. The Arduino is a cheaper and lower power option for running the ROV. PSI as an organization also has great experience with using Arduinos. A Raspberry Pi as an alternative is more heavy duty which means it processes faster and is better for multitasking and specific software applications. However, it also is much more expensive and consumes more power than an Arduino. For this specific application using a Raspberry Pi would be overengineering and more costly to the project.

ACTUATORS

All the motors take processed data from the Arduino in microseconds. They operate on a scale of 1100 microseconds, which is full reverse, to 1900 microseconds, full forward. This is important for the design of the thrusters because the value they receive dictates the direction of translation and motion that occurs. Similarly, the manipulator receives a signal that allows it to grab and release as well as rotate the claw. The manipulator was designed to sit directly at the bottom of the electrical housing and keep motors and gears in the empty space behind the housing which keeps the overall footprint of the ROV smaller. The ballast receives input from a motor that rotates a bevel gear and translates the buoyancy modules. The modules were modified to fit up and down the ROV without any conflicting space with the motors for the manipulator.

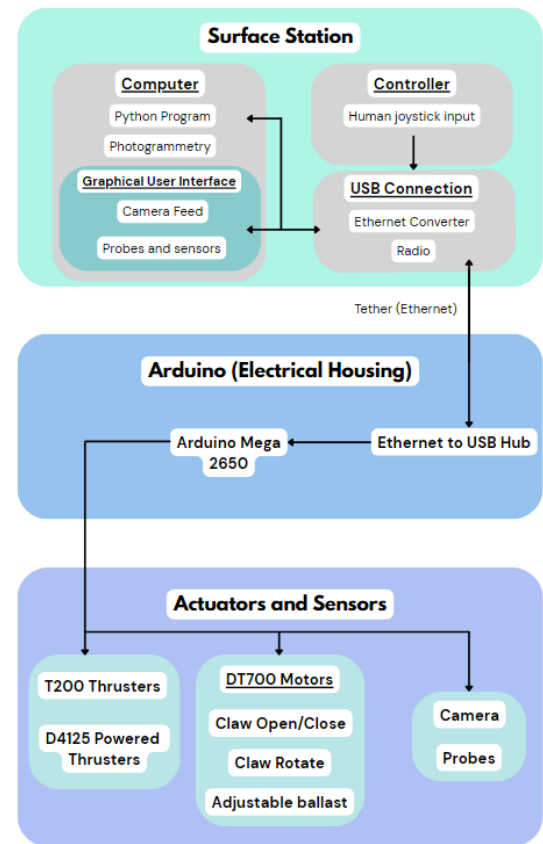


Figure 13: Electronic System Overview Diagram.

ELECTRICAL SYSTEM

Barreleye is run off a 48 V power supply with an amperage of 30. The power connector is connected to a fuse of less than 30 cm, and all power is run down a 12-gauge low voltage wire which powers all capabilities of *Barreleye*. This design is simple and efficient, allowing full power to be transferred to the ROV and effectively controlling the voltage. The power cable is run through two different buck converters. The first is a step

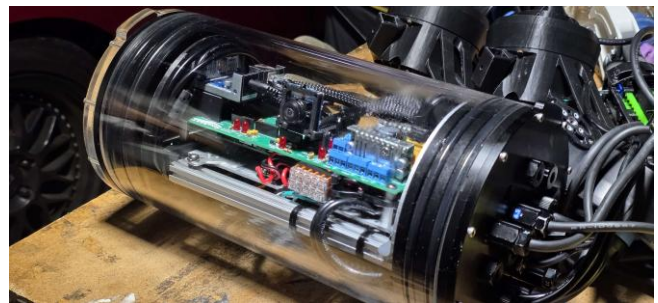


Figure 14: Internal Electrical Components.

down to 5 V. This voltage is consumed in the ethernet hub, which is a vital source of information and sends

all inputs for motors as well as processes imaging from the three cameras. The other buck converter is a step down to 12 V. This voltage is used to power the Arduino Mega 2650 and the 9 different ESC. The Arduino works in sync with the buck converter to run all 9 different motors. Six are Blue Robotics ESC, which run the thrusters, and three operate the manipulator and adjustable ballast.

TETHER CONSTRUCTION

The tether supplies all power and signal for *Barreleye* to operate. The tether must be flexible and neutrally buoyant, so it does not affect the operation of the ROV. Power comes from a twelve-gauge low-voltage landscape lighting wire connected to the power supply. This effectively delivers power and has high durability and flexibility. Along with the power cable is an ethernet cable. The ethernet cable translates USB information on both the surface station and ROV. All the functions of *Barreleye* come from this cable. A high quality ethernet cable was selected to effectively block electromagnetic turbulence from the ROV. To ensure neutral buoyancy, 1.27 cm foam runs along the tether to provide buoyancy and ensure smooth operation of the ROV. Every foot and a half of the power cord, ethernet cable and foam are wrapped with electrical tape. This ensures the cables do not get tangled during operation. Lastly, sheathing covers the 3 cables as another measure to create smooth operation and prevent any tangling of the tether.

PSI determined the length of the tether using the Mate depth requirement of 5 meters and an assumption that the max distance a task would be from the poolside is 15 meters. This requires a conservative length of 17 m of the tether that would be in the water. Choosing a tether length of 22.89 m allows 5 m of flexibility on the surface station.

TETHER MANAGEMENT PROTOCOL

Before operation one member is designated to oversee tether management and will verify that the tether is uncoiled in a consistent pattern such as

circular around a spool. The member will verify the tether is clear of debris and firmly connected to the surface station and the ROV. During operation of the ROV, the tether should not provide excess or lack of slack which would obstruct the motion of the ROV. As the tether is pulled back in, it shall remain in its consistent pattern. After operation the tether is disconnected from both the power station and the ROV.

PROPULSION

Barreleye utilizes a six-thruster footprint to effectively provide five DOF to the ROV. The sixth DOF is adjusted using the buoyancy manipulator. Four of the thrusters are Blue Robotics T200 thrusters, and two were manufactured around a 2.3kg 650kV brushless motor to save on cost. The T200 thrusters run off 12 V, are lightweight, and operate most efficiently at low throttles. For the two thrusters manufactured in-house, the casing was designed to maximize current draw and limit energy loss by creating a smooth hydrodynamic case while enforcing safety from contact with the propeller blades. These two thrusters also show much higher power outputs but at much lower efficiency. However, this is an accepted substitution due to the save on cost. All thrusters operate between a PWM of 1100 μ s, as full reverse, and 1900 μ s, as full forward, through signals from a Blue Robotics ESC.

The thruster layout ensures that the throttle for each thruster can be kept low while not compromising the velocity of the ROV. Four of the six thrusters are oriented to maximize translation across the X and Y as well as rotation about the Z. These will be the most routine directions of motion. Figure 15 shows the arrangement of thrusters for each translation and rotation. The red arrow represents the resulting thrust from the opposing movement of water through the thruster. The angles of the thrusters are all 90 degrees apart. This allows each to negate components of thrust to focus on translation into one direction. For example, in the Y-translation, each thruster is angled to provide equal X and Y

components of thrust. All Y components are positive, while the X components alternate between positive and negative directions.

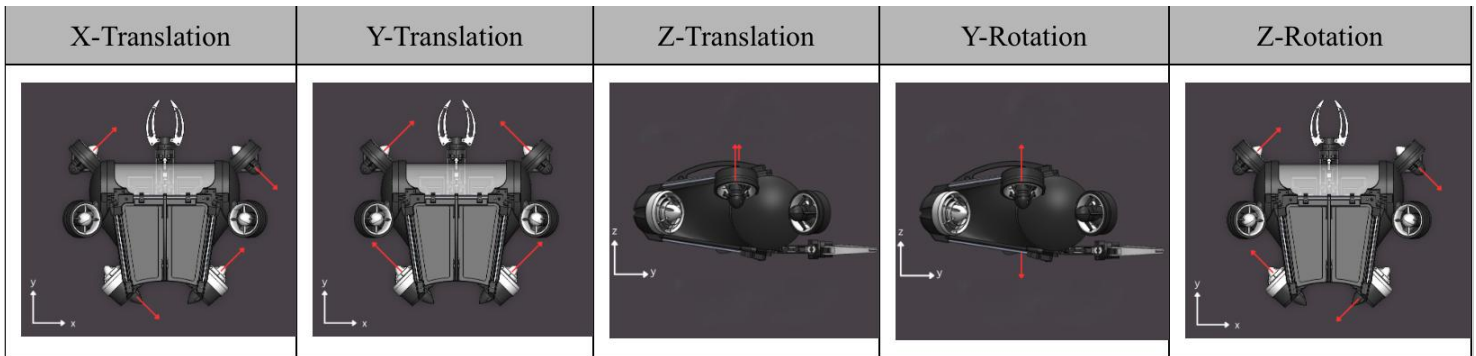


Figure 15: Thrust characterization data.

The two custom made thrusters were manufactured with safety in mind. Each are built with gaps that do not exceed 1 cm but still provide a smooth hydrodynamic opening to minimize drag. The four T200 thrusters had to use custom safety guards to protect from hazardous contact with the propeller. These were 3D printed with PLA and use a circular pattern to minimize area that blocks the oncoming current.

BUOYANCY AND BALLAST

Ease of piloting is necessary for overall ROV efficiency and general safety of its surrounding environment through mitigating unanticipated movement and imbalance. To achieve neutral ROV (and manipulator) angle-of-attack, we established buoyant equilibrium through the addition of hollow, 3-D printed, PLA modules to produce upwards force.

The vehicle uses flotation modules that move bow to stern to automatically adjust the buoyancy. This is set using a system of bevel gears powered by a DC motor. The motor powers a vertically supported shaft going from the bottom to the top of the ROV with a 10-tooth gear sitting horizontally on the top. The two gears have a 3.6:1 gear ratio for a slower speed and higher torque output motion. Torque translates through a 36-tooth gear connected to a threaded shaft, which moves a sliding apparatus with roller supports. Flotation modules can be added and removed from

the apparatus depending on need and can be sized accordingly. Moving the flotation modules closer to the stern also shifts the center of buoyancy to be in line with the ROV's center of gravity.

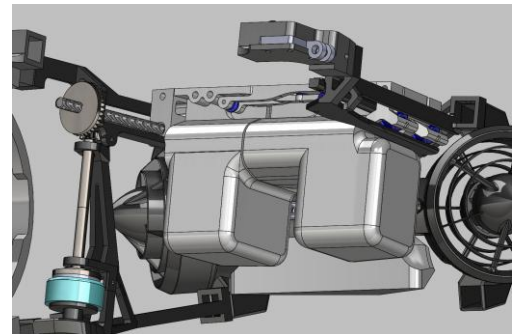


Figure 16: Front view of the buoyancy and slider mechanism.

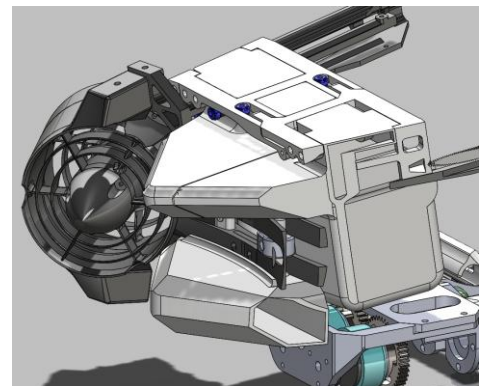


Figure 17: Back and section view of the buoyancy.

In combination with position-specific buoyancy placement, the ROV incorporates a modular ballast frame located beneath the water-tight tube to encourage stability. For weight, we chose 0.62" steel

rods cut into bundles of 3" lengths. These 3" pieces are snapped into the frame's C-shaped cups. The modularity allows for easy application and removal and customization in both the left/right & front/back directions to precisely adjust the center of weight. This frame also helps center the manipulator.



Figure 18: The ballast frame and C-shaped cups.

PAYLOAD AND TOOLS

CAMERAS & SENSORS

Barreleye uses a three-camera configuration. All cameras are IMX323 image sensors with different lenses dedicated to their purpose. The primary camera has a fisheye-lens and is mounted centrally on the vehicle. The wide-angle field of view provided by the fisheye lens gives the pilot an expanded visual during task operations, minimizing blind spots when navigating the mission task arena and grabbing objects with the manipulator. The central position of the camera takes full advantage of the wide-angle lens.

The remaining two cameras are fitted with low-distortion, low-light lenses. These are dedicated to the photogrammetry pipeline used in **Task 1.2**, where the team must autonomously generate a scaled 3D model of the coral garden. To automatically scale the 3D model we create, we use stereo vision. Stereo vision requires two cameras at a known, fixed baseline distance; the two ArduCam modules are mounted at opposite ends inside the 6-inch acrylic electronics housing, providing the widest achievable separation to maximize depth estimation accuracy.

The photogrammetry dedicated cameras operate independently from the piloting camera and are only activated when needed. This separation is intentional, as streaming from all three cameras consistently would introduce a bandwidth bottleneck originating from the internal USB hub, creating visible latency on the pilot camera feed. Limiting concurrent streaming to the pilot camera during normal operations reduces USB bandwidth consumption, reserving full throughput for the stereo pair during the brief photogrammetry capture window.

Phantom sole sensing element is a Blue Robotics Bar02 Pressure Sensor, communicating with the onboard Arduino Nano over I2C protocol. The sensor was selected for its $\pm 0.16\text{mm}$ depth resolution accuracy, which is critical given the float's reliance on pressure-derived depth as its only feedback variable. Depth measurements are sampled continuously and used to compute the float's instantaneous velocity via computing position delta. This velocity estimate feeds directly into the bang-bang control loop that governs the buoyancy engine, making sensor accuracy an influential driver of control loop performance. The MS5837 also provides an on-board temperature reading, which can be used to correct for water density variations during depth conversion. A second Bar02 Sensor is mounted on *Barreleye* and is dedicated to the iceberg keel depth measurement in Task 2.2. The sensor measures hydrostatic pressure at the keel, from which depth is derived using the standard relationship between pressure, fluid density, and depth. This measurement must be accurate to within 5 cm of the true keel depth to receive full points, so we once again went for the high-accuracy Bar02 variation of the BlueRobotics pressure sensor.

TOOLS AND ATTACHMENTS

Several tools were created to aid in performing tasks the team identified as difficult to accomplish with just the vehicle's manipulator, or to be more time efficient. One of these tools would be a lift bag, which would

attach to the manipulator and be attached to a heavy object that would otherwise be too difficult for the ROV to pull up to the surface. This tool was created with missions such as recovering the lobster pot in mind, as attaching a lift bag and inflating it to the surface would be very time-efficient. Due to the vehicle being free to perform other mission tasks while the lobster pot floats to the surface, waiting to be pushed back to shore. Another tool that was created with a mission task in mind would be a manipulator attachment that would allow for an easier attachment of the recovery line to the buoy anchor. This tool was designed with ease of use in mind, including a big “mouth” that allows for the ROV to easily attach the recovery line to the buoy anchor, saving precious time. Finally, a harpoon-like tool was created as an attachment to the vehicle itself, with the idea of being able to collect basket star coral. It would work by having the ROV insert the tool into the basket star coral, leaving the manipulator free to perform other tasks, being much more efficient with not only time but also the number of tasks that can be completed by resurfacing.

MANIPULATOR DESIGN

Barreleye is equipped with a two-axis manipulator arm shown in Figure 19. This tool can open and close with infinite rotation. It specializes in broad tasks that require gripping and/or rotating objects. Specific tasks include servicing the Holyrood subsea observatory, testing whale safe fishing gear, powering an oil platform from a wind turbine, and collecting coral samples. Having infinite rotation along with the gripping motion allows the claw to complete critical tasks with ease.

The manipulator is constructed from a combination of 3D printed and metal components. There are two systems within the manipulator: the linear actuator assembly for open and close, and the rotation driver. Both of these systems are powered by identical 600KV brushless motors attached to a 10:1 metal planetary gearbox. From the gearbox, the linear actuator motor spins a threaded rod that drives a

shaft forward and backwards to open and close the manipulator. The rotation driver motor transmits power through two parallel steel axels to the end of the manipulator where a series of bearings and gears allow the jaws to rotate freely around the center actuating shaft.

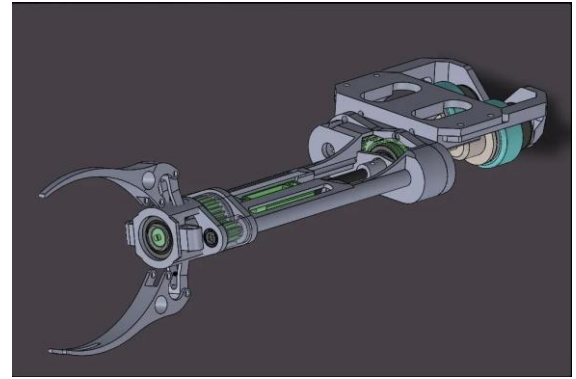


Figure 19: 2 Axis Manipulator.

FLOAT DESIGN RATIONALE

Our vertical profiling float, *Phantom*, was designed for the depth control and remote data transmission that **Task 4: MATE Floats** requires. It prioritizes simplicity and affordability, with most internals 3D-printed and readily available electronics. The design allows for rapid disassembly, inspection, and repair between runs.

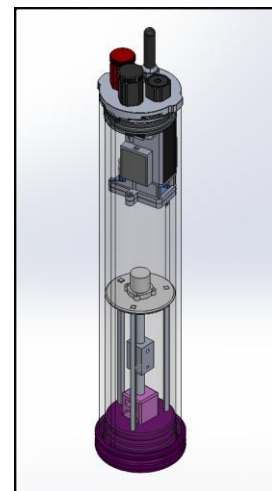


Figure 20: *Phantom* Cad Model.

Phantom's buoyancy engine consists of a linear actuator driving a piston within the float. A 3D-printed endcap seals the bottom of the acrylic tube,

fitted with an elastomer membrane for waterproofing. As the actuator extends the piston, the membrane deforms outward. This increases the float's displaced volume and reduces its net density, causing it to ascend, and vice versa. Minimal piston movement is required, as the 2" diameter, 12" long tube selected provides a small yet capable form factor. The actuator motor is driven by a VEX motor controller receiving a PWM signal from an Arduino Nano.

Communication

Phantom uses an APC220 RF transceiver module connected to the Arduino Nano for all wireless communication. Upon deployment, the float continuously transmits data packets at half-a-second intervals until contact is established with the shore-side receiver connected to a laptop at the mission station, and is on standby until the deployment signal is received. Once the float completes its vertical profiles and is recovered, it wirelessly transmits the full depth-over-time data packets to the surface

laptop. Each packet contains the required company number, timestamp, and pressure/depth data. This data is then processed through a MATLAB script, which generates the final depth-versus-time graph for judging. The float also tracks its own velocity by computing the rate of change of depth from sequential pressure sensor readings, enabling autonomous depth control using a bang-bang (on/off) control scheme.

Power Distribution

Phantom is powered by a single 9V battery. This perfectly fits the form factor of our 2" diameter tube that houses *Phantom's* electronics. A measured FLA of 169 mA dictated the selection of a 200 mA fuse. A 9V-to-6/5V voltage regulator steps down the battery voltage before powering the Arduino Nano and APC220 radio module, as thermal analysis showed that routing 9V through the Arduino's onboard regulator at expected current load would heat it beyond operating temperatures.

BUILD VS. BUY, NEW VS. USED

This section lays out the reasoning for new and used components. The decisions to purchase components were made mainly out of either the inability to build said components on our own, or fear of unreliability. Many components were also provided to us with the MTS Eagle Ray kit grant.

Component	Build vs Buy & New vs Reuse	Justification
ROV		
Manipulator Gear Box	Buy + New	Why Buy?: 3D printing gear box was attempted but was not reliable. Why New?: A gearbox at the size we needed was not readily available, so we bought new.
ROV Thrusters 6x	Reuse + New 4x Buy/Build + New 2x (Motor=Buy) (Thruster Shroud = Build)	Why Reuse? 4x: These were received in an MTS grant. Why New? 4x: These were received from MTS Why Build? 2x: Cheaper than purchasing Blue Robotics thrusters at \$230 each. Why New? 2x: New thruster motors provided confidence in the reliability of their performance.

<u>3D Printed Components:</u> Manipulator, end caps, rear thruster frames, buoyancy mechanism, misc., hinges and frame connectors	Build + New	Why Build?: Original design was required for the needs of the ROV structure. Why New?: New 3D prints gave ample design freedom around the ROV frame.
Frame Aluminum extrusion skeleton	Build + Reuse	Why Build + Reuse?: Aluminum extrusions were readily available in our workshop.
<u>Electrical Components in Acrylic Tube:</u> Acrylic Tube, Arduino MEGA	Build + Reuse	Why Reuse?: Provided by an MTS grant
Camera 3x	Buy + New	Why Buy?: The ROV required multiple cameras for angles necessary for the tasks of the competition. Why New?: Readily available cameras were not available.
Tether	Build + Reuse	Why Build + Reuse?: Materials readily available.
Float		
<u>Electrical Components:</u> 5v buck converter , brushed motor drivers, endcap/penetrators, brushed DC motor	Build + Reuse	Why Reuse?: Provided by an MTS grant
<u>Electrical Components:</u> Pressure sensor, Arduino Nano, Receiver and Transmitter	Buy + New	Why Buy?: Accurate and well-made components were not feasible with PSI's manufacturing capabilities. Why New?: New components provide reliable results which are crucial for the tasks of the float.
Control Station		
Power box	Build + Reuse	Why Build + Reuse?: Provided by an MTS grant
ROV Controller	Reuse	Why Reuse?: RC controller readily available and fit to needs of ROV.
Manipulator Controller	Reuse	Why Reuse?: PS4 controller readily available and fit to needs of ROV.
Laptop	Reuse	Why Reuse?: Laptop readily available and fit to needs of ROV.

Table 1: Build vs Buy, New vs Used Component Overview.

SYSTEM INTEGRATION DIAGRAMS (SIDS)

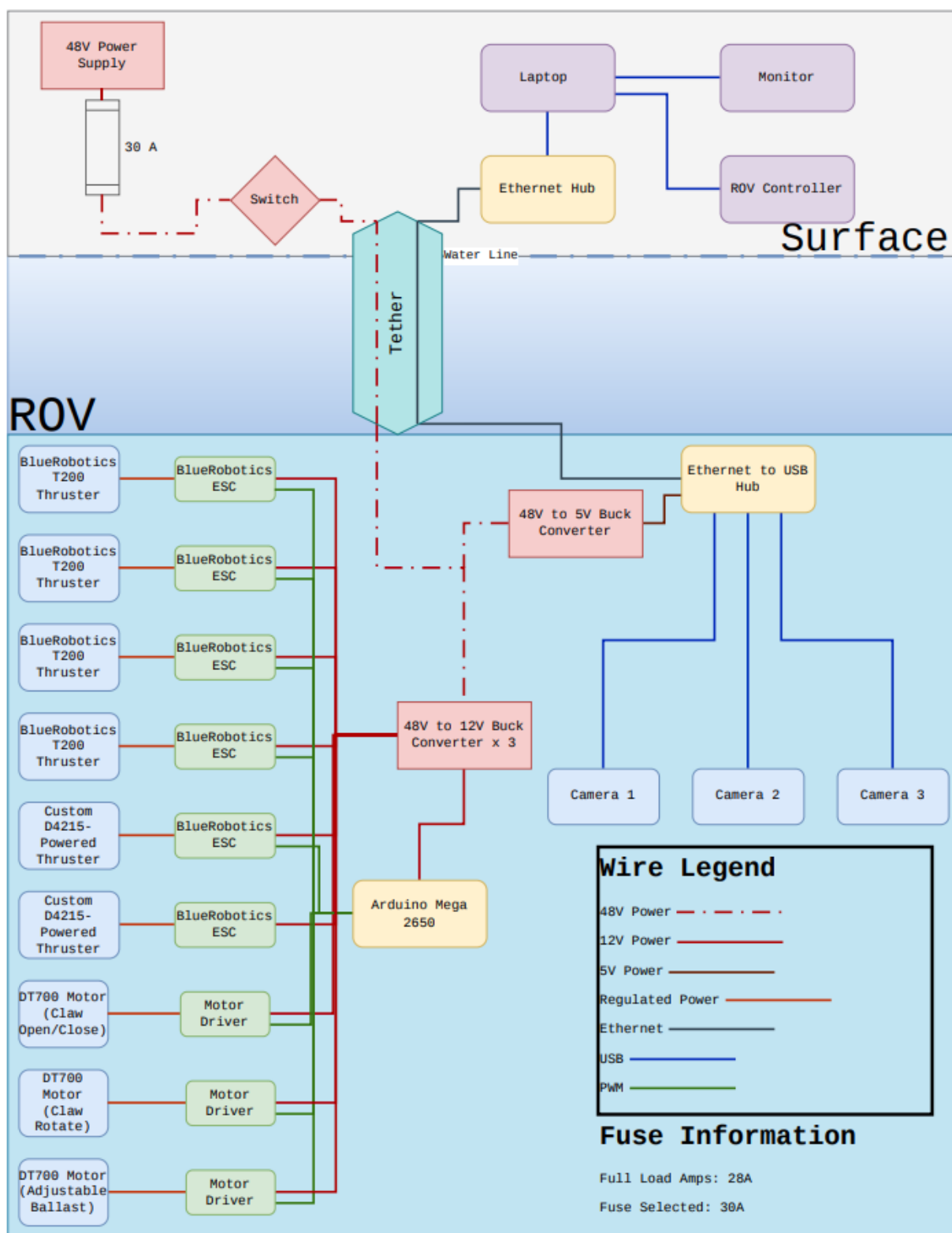


Figure 21: Main ROV SID.

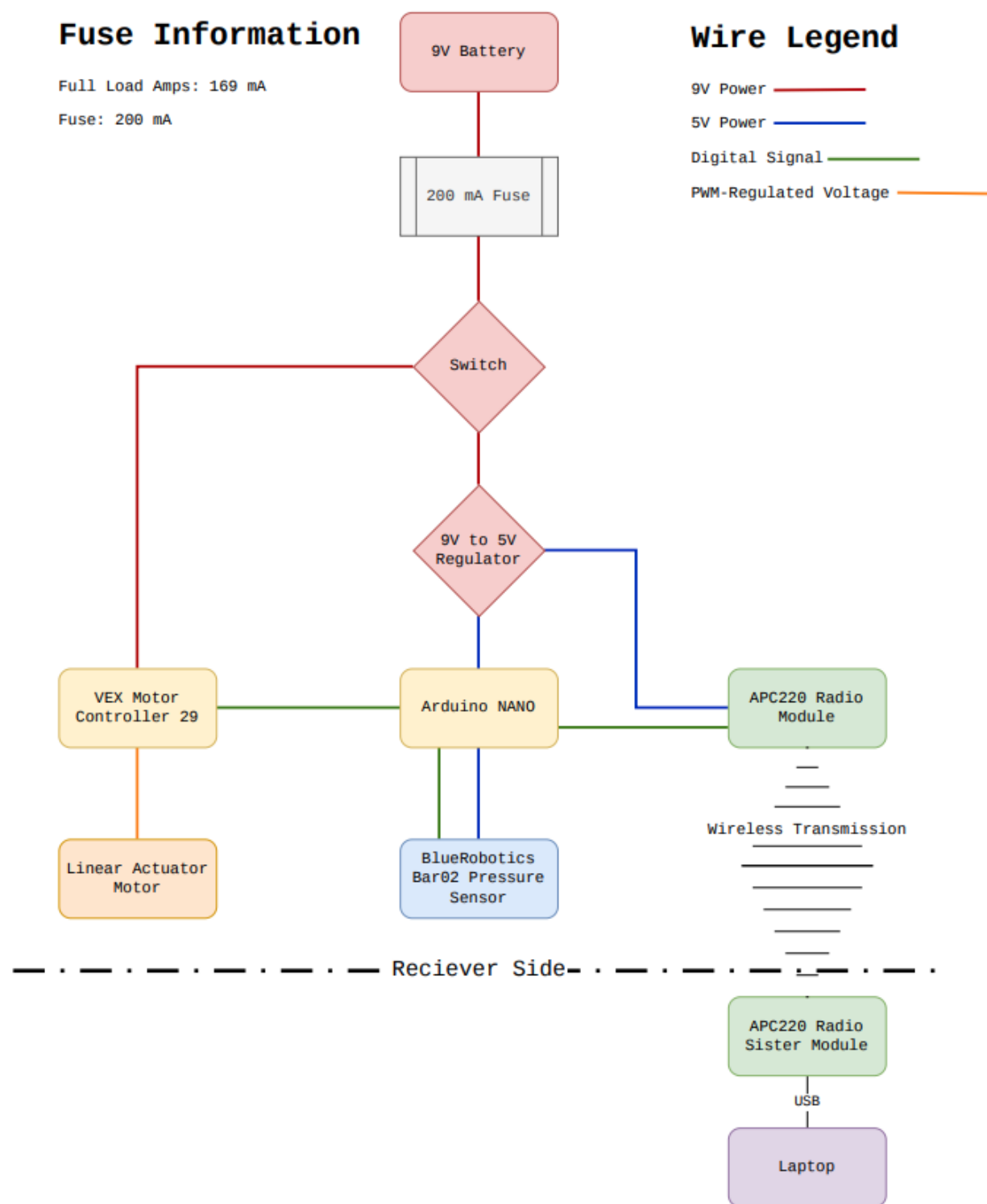


Figure 22: Float SID.

SAFETY

There is nothing more vital to the operation of PSI than the safety of the individual. Design, transportation, and operation can all pose hazards to members and to the ROV itself. PSI enforces strict safety guidelines in the shop and during operation of the ROV, to keep all people and materials unharmed. All aspects of this organization are inspected by no less than 3 members to create an environment of understanding and security. PSI strives to understand risks and enact measures to prevent any future hazards from occurring. Following many of the safety guidelines established in Appendix B.

PERSONNEL SAFETY

Personnel safety is at the forefront of priorities in the design, development, assembly, and testing of PSI's ROV. To create a comfortable and efficient work environment for all PSI members while working in an environment full of possibly dangerous equipment, certain personal protective equipment (PPE) is required. PPE used in the workspace includes safety glasses, closed-toed shoes, gloves, and a ventilation hood when soldering. In addition to utilizing PPE, each team member underwent training on how to properly use the previously mentioned equipment. This allowed for all PSI members to be confident in utilizing tools around the workspace while being safe.

An aspect of personnel safety that is especially important to PSI is communication. Before a tool such as a power tool or soldering iron is used, all company members should be notified of such usage to stay clear of the workspace. If a team member spots anything that could raise the possibility of danger such as the misuse of a tool, spill of a liquid, sharp edges, or exposed wiring, it should be communicated to the team, and corrective action should be taken. All mentioned personnel safety precautions are necessary to create a safe environment allowing for

the highest level of productivity for PSI and all of its members. exam where the member demonstrates proficiency.

EQUIPMENT SAFETY

Safety involving equipment is also a main aspect of PSI's ROV development and operation. Protection of the ROV and its support equipment is key to producing a vehicle capable of completing the necessary tasks while maintaining safety for PSI members. A procedure that all PSI members follow involves organization of the workspace. Company members are expected to return tools and components back to their designated location while keeping the workspace clean in order to avoid losing or damaging important components.

Electrical components of PSI's ROV are crucial to its performance, and precautions are taken in order to protect said components. Wired connections are all soldered to create strong connections and wrapped in electrical tape to prevent electrical burns and short circuiting. Groups of wires within the capsule are also bundled together using zip ties to avoid tangling of wires that may disrupt ROV operation. All zip ties used are trimmed short and filed to remove all sharp edges. In regard to the tether, a protective cable sleeve, strain relief, and a safety fuse are used to prevent damage to both the ROV and the surface equipment. To further protect the electrical components within the capsule, the capsule is properly sealed to avoid any water leakage into the capsule, and any wiring fed through the walls of the capsule were also sealed using epoxy.

Mechanical components of the ROV are just as important to performance and are protected just as the electrical components are. All thrusters and motors of PSI's ROV were waterproofed and fitted with guards that both prevent debris from getting lodged within them and prevent any team members

from getting injured by accidental contact. All mechanical connections such as fasteners and bolts were checked for looseness, and the entirety of the ROV was checked for wear or damage. All procedures mentioned are crucial to equipment safety and allow for excellent protection of PSI's ROV and its components.

OPERATIONAL SAFETY

PSI trained all members how to properly handle *Barreleye* and ensured overall design provided no safety hazards during operation. Appendix A shows the checklist used by PSI to ensure that steps were taken before operation to safely perform underwater tasks. An important part of these steps is keeping the inner cylinder dry and free from debris. Before operation the cylinder is thoroughly inspected to ensure it is clean and that wires run smoothly from the PCB to the designated port on the end caps. Then the O-rings are lubricated, and the end caps are firmly set in place. All gears and motors are guarded to prevent accidental injury, and the outside of the ROV is inspected to verify lack of any damage.

Before operation at least 3 team members must be present, and the water must be clear of any debris that could damage the ROV. The tether must be properly laid out without any tangling, and the power supply must be dry and away from water. When all members are ready, operation may begin.

SAFETY PROCEDURES

PSI has outlined safety procedures that are required to be followed when handling the ROV, leading up to actual deployment, during the mission run, and after deployment. These procedures are meant to keep all individuals of the team safe, and ensure that the ROV is not a hazard and poses no risk to the environment

Appendix A

CRITICAL ANALYSIS

At PSI, products are tested rigorously until flaws and weak points are revealed. When failure occurs, it is asked, "How can this be fixed?" To answer this question, one of two options is chosen; the first choice is always simplifying the design, but if that is not possible or practical, redundancies can be implemented.

TROUBLESHOOTING PROCESS

To simplify the troubleshooting process, PSI identifies as many causes as possible for failure. These causes are then categorized and sorted from simplest to most complicated. Starting from the simplest reason for failure, solutions are discussed and tested. If the solution fixes the failure, PSI assesses how to prevent the same problem from occurring in the future. If it does not fix the issue, the solution process moves to the next simplest cause of failure. Trouble shooting in this way ensures that the simplest solution is always implemented first. This is the most time and cost-efficient strategy that ensures results.

EVALUTING DESIGN OPTIONS

CUSTOM THRUSTERS

PSI designed, tested, and manufactured custom rear thrusters with the goals of low cost and improved performance. This was done through three development stages: research, prototype, and improvement. Starting with research, PSI dove deep into the world of small marine thrusters, gathering information on what works, what doesn't work, and what hasn't been tried. From there, a design was conceived with careful consideration given to the certainties of tried-and-true designs balanced with the potential benefits and risks associated with uncharted territory. A prototype was developed digitally and ran through flow simulations seen in

Figure 23, allowing virtual optimization before manufacturing began. Using the simulation, it was evaluated if the thruster was ready for physical prototyping or if the design needed to be adjusted. Lastly, the physical product was made and rigorously tested both on and off the ROV to make final tweaks before manufacturing additional units.

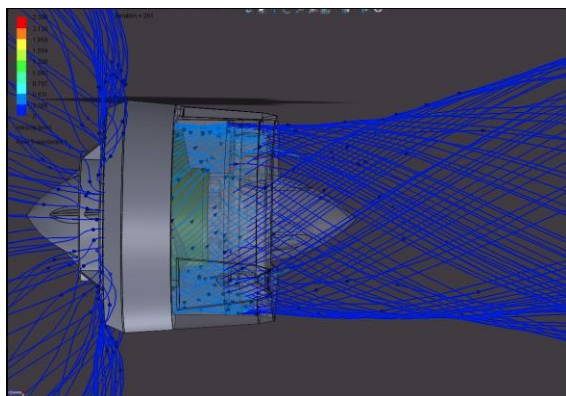


Figure 23: CFD Simulation of prototype Thrusters.

MANIPULATOR

The two-axis manipulator detailed above went through several iterations both digitally and physically before becoming the final optimized product. While a similar design strategy as the thrusters was followed, the development process proved to be much more challenging because flaws in the design tended to show themselves in the physical prototype testing phase. When an issue was found in the manipulator prototype, a troubleshooting process was followed to minimize the failure and continue the testing process of the manipulator as a whole. This led to the discovery of critical design flaws that required complete overhaul and major design changes. After several iterations of the prototyping process, a design was chosen to simplify the components of failure; materials were selected to maximize strength, and the final product was manufactured.

ACCOUNTING

BUDGET

PSI's budgeting strategy for this year's competition revolved around cost-efficient decision making. This was necessary because as a team competing in this competition for the first time, we did not have established relationships with sponsors when the team was created. This forced us to use funds out of our own pockets for the initial stage of design, prototyping, and component purchasing and manufacturing. We believed that purchasing components was, most of the time, more expensive than reusing old components or 3D printing components. PSI was fortunate enough to receive an Eagle Ray kit from the Marine Technology Society (MTS) through a grant supporting the creation of first year university companies. This kit, along with the additional tools and materials provided from the grant, were free of cost for the company and considered reused components. Appendix C displays the decision-making process we went through to either buy, 3D print or recycle components readily available to us. This strategy allowed us to efficiently spend on the ROV, float, and control station. After reaching out to potential sponsors during our prototyping and designing stage, we were able to obtain funds and reimburse our expenditures during the time we had no sponsors. For more details on expenditures and funding, refer to Tables 2 and 3.

Travel Estimate						
Category	Description	Cost (USD)	Qt.	Subtotal		
Airfare	Plane tickets from LAX to YYT	~1100	11	~12200		
Lodging/Food	Housing and Food for the team for 5 days	~75/day	11	4,125		
					Total	\$16,325

Table 2: Costing for championship travel.

Purchased and Manufactured Components				
Budget Category	Type	Item(s)	Quantity	Est. Cost (USD)
3D printed Parts - Cost estimated by weight - Cost includes prototyping iterations	ROV	Manipulator Assembly	1	\$10.52
		End caps	2	\$30.12
		Misc (assembly connectors, hardware, etc.)	-	\$50.90
		Buoyancy Mechanism	1	\$9.83
	Float	Inner Skeleton	1	\$20.32
Total 3D Printing Cost:				\$120.69
Manipulator	ROV	Manipulator Gearbox	2	\$50
Thrusters		Thruster Motors	2	\$62
Bouyancy		Steel Ballast rods	3	\$19
Electronics	ROV	Cameras	3	\$120
	Float	Receiver	1	\$40
		Transmitter	1	\$40
		Pressure Sensor	1	\$80
		Arduino Nano	1	\$5
Float Shell	Float	Acrylic tube	1	\$38
Total				\$575.69

Table 3: Total budget allocation.

ACKNOWLEDGEMENTS

Pomona Subsea Initiative would like to thank all organizations and individuals who helped make this project possible. Through financial contributions, logistical assistance, and moral support, their efforts have played an important role in this team's success.

- MATE for logistical support
- Marine Technology Society for ROV supplies and tools
- Samuel & Sons Co. for financial support
- South Gate Engineering for financial support
- Dr. Paul Nissenson for logistical and administrative support
- Dr. Henry Xue for logistical and administrative support
- The Family and Friends of PSI for their moral support.

REFERENCES

Blue Robotics. "T200 Thruster for ROVs, AUVs, and Marine Robotics." *Blue Robotics*, bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-thruster-r2-rp/.

"D4215 Brushless DC Motor." *Flash Hobby Technology Co., Limited*, 2020, www.flashhobby.com/d4215-brushless-dc-motor.html. Accessed 22 May 2026.

Laboratory Safety Guidelines. <https://www.cpp.edu/engineering/me/documents/labsafety.pdf>

UNESCO. "When the Cryosphere Changes, Everything Does." *Un-Cryosphere.org*, 2025, www.un-cryosphere.org/en.

United Nations. "The 17 Sustainable Development Goals." *United Nations*, 2015, sdgs.un.org/goals.

APPENDIX A: SAFETY CHECKLISTS

Use this appendix to that the ROV is handled safely inside and outside of the water, serving as a checklist for job site hazards, ensuring all electronics and devices are working properly, and the vehicle is free of any damages, and safety of all individuals, perform checklist in a procedural manner.

ROV CONSTRUCTION

Disassembly:

[] Ensure the outside of the vehicle is dry and clean, including debris, equipment, liquids, etc.

Assembly (Before Closing)

[] Make sure no wires are exposed, hanging, or loose.

[] Check that electrical components are free from liquid, and no parts are being pinched or flexed.

- ☐ Clean and inspect O-rings and grooves to ensure no damage, no debris, and proper lubrication.
- ☐ Inspect tube and endcaps for damage check cable connectors for proper connection and waterproofing.
- ☐ Make sure the pressure vent plug is removed so pressure doesn't build up.

Assembly (Closing)

- ☐ Align the endcaps to create the proper fit with the main cylinder and properly twisted on
- ☐ Check to make sure the tether coming out of the back is free from the back compartment and the strain relief is attached to the rigid ROV frame.
- ☐ Verify that screws and pins holding T-bars and end caps are fully secured and tightened
- ☐ Screw on and verify the pressure vent plug
- ☐ Ensure electrical components are still correctly connected, and O-rings are sealing the main cylinder.

ROV OPERATION

- ☐ Make sure members responsible for the basic operation of the ROV are present (pilot, tether manager, software lead, and safety engineer).
- ☐ Ensure features like thruster shrouds, buoyancy modules, ballasts, and manipulators are secure.
- ☐ Check that the tether is not tangled and properly laid out for ease of use and avoid being hazardous.
- ☐ Set up electrical components such as power supply and operation devices (laptops and controllers) away from the water and ensure they are dry.
- ☐ Verify the connection of all station devices, such as laptops, controllers, ROV, and power supply, ensuring they are free of being a tripping hazard, with no liquids nearby.
- ☐ Have recovery equipment present (e.g., net).
- ☐ Place in water and check for leaks and/or flooding of the main electrical pressure hold.
- ☐ Neatly organize and check that all ROV payloads are present and ready to be exchanged.
- ☐ Make sure all poolside assistants are wearing proper safety equipment, such as closed-toed shoes, gloves, and safety glasses.
- ☐ Pilot announces, "READY FOR ACTIVATION".
- ☐ Handler announces "DEPLOYMENT READY" with the ROV over the deployment area
- ☐ Pilot announces "DEPLOYMENT INITIATION" after double-checking controllers, and the ROV is stabilized
- ☐ Handler announces "DEPLOYMENT COMPLETED" after releasing the ROV.
- ☐ The safety engineer is responsible for enforcing no running and that the job site stays free from hazards.
- ☐ Make sure communication and conversations are clear and only contain important, relevant information between the poolside assistants, operator, and safety engineer.

ROV RESURFACING

- ☐ Once ROV resurfaces, the operator announces RETRIEVAL INITIATION.
- ☐ Handler picks up the ROV by the rigid frame or tether strain relief and announces RETRIEVAL COMPLETED.
- ☐ Dry the ROV of water and ensure all parts are present and still properly secured onto the vehicle.

APPENDIX B: LAB SAFETY (REPURPOSED CAL POLY POMONA'S LAB SAFETY GUIDELINES)

These guidelines and rules must be followed with parts most rules being directly outlined by Cal Poly Pomona, and other rules being added and repurposed for the specific projects laboratory setting.

1. Coming to the laboratory
 - a. Do not wear any loose or baggy clothing, unbuttoned coats or unbuttoned sweaters. Wear sensible clothing to the laboratory that provides some protection for the majority of your body
 - b. Footwear that completely covers the foot is required, and no necklaces or loose jewelry
 - c. Confine or tie hair that reaches the shoulders. Remember hair is very flammable and is easily caught in rotating machinery
2. Before beginning work on project
 - a. Locate all safety equipment including fire extinguishers, fire blankets, eye wash facilities, first aid kits and the lab phone, and exits.
 - b. Take care of any hazards identified in equipment, ensuring the workspaces are clean of clutter.
3. While working and using laboratory equipment
 - a. Keep alert for any developing safety hazards as exhibited by unusual noise, unusual vibration, unusual high or low temperature areas on the equipment, unusual data trends, smoke etc.
 - b. When you have completed your laboratory work, shut down the equipment, clean up your work area, and leave it in a safe condition for the next users.
4. In the event of a fire, follow these instructions
 - a. If the fire is minor and you are not endangering your personal safety, shut down the equipment
Use the nearest fire extinguisher to extinguish the fire. Or pull the fire alarm in big fire cases
5. Use of safety glasses
 - a. Safety glasses may be required to be worn by group members.
6. In the event of an injury
 - a. Contact emergency personnel by calling 911

APPENDIX C: COST ACCOUNTING

Available Funds			
Category	Name	Amount (USD)	
Sponsorship		Samuel Son & Co.	\$3,500
Sponsorship		Southgate Engineering	\$1,000
Sponsorship		Schmidt Ocean Coalition	4,500 + Travel Grant
Total		4,500 + Travel Grant	
Financial Summary			
Funds:		Total Expenditures	
\$4500 + Travel Stipend		\$16,900.69	
Balance		- \$12,400.69 + Travel Stipend	