



DAM Underwater  
Robotics



**ANGLER**  
ILLUMINATING THE UNKNOWN

## 2026 Technical Documentation Oregon State University, Corvallis, OR, USA

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DAM Underwater Robotics proudly presents Angler, a compact, lightweight remotely operated vehicle (ROV) developed for the 2026 MATE ROV Competition. Designed around modularity, maneuverability, and rapid maintenance, the vehicle utilizes a clip-on rail mounting system that allows components to be quickly attached, removed, and reconfigured while maintaining a compact and hydrodynamic profile.

The vehicle features an eight-thruster propulsion system capable of full six-degree-of-freedom control, enabling precise maneuverability and stability underwater. The control system allows the ROV to maintain position or orientation along selected axes while simultaneously translating along another, improving operational precision during mission tasks and confined underwater environments.

To enhance operator awareness and mission adaptability, Angler incorporates a five-camera feedback system, including a movable camera mount for adjustable viewing angles and improved situational awareness. Active image detection further assists with underwater target recognition, navigation, and mission performance in varying environmental conditions. High-output LED illumination provides broad light coverage, improving visibility and operator awareness in dark or low-visibility underwater environments.

Designed to be small, lightweight, and highly maneuverable, Angler emphasizes reliability, modular engineering, and operational flexibility. This technical report summarizes the vehicle's design process, engineering decisions, system integration, and testing efforts that contributed to the development of a competitive underwater robotics platform.



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## Company Profile:

DAM Underwater Robotics is a student-led subteam of DAM Robotics at Oregon State University's College of Engineering. The team focuses on the design, manufacturing, and operation of remotely operated vehicles (ROVs). DAM Robotics also includes Mars Rover, Combat Robotics, Drone Racing, and Marketing subteams. The Underwater Team is supported by 22 dedicated members, with 12 active undergraduate students ranging from first-year to fourth-year students. Members are organized into Mechanical, Electrical, and Computer Science subteams. DAM Underwater Robotics emphasizes mentorship, technical growth, and hands-on engineering to develop reliable, mission-adaptable, and cost-effective underwater robotic systems.



Fig. 1: Team Photo

## Company Organization:

DAM Underwater Robotics prioritizes marine conservation while continually improving sustainability, reliability, and safety. The team operates through a hierarchical structure based on experience, contribution, and technical involvement. Leadership follows an Officer → Subteam Lead → Team Member structure, with dedicated leads for Mechanical, Electrical, and Programming divisions.

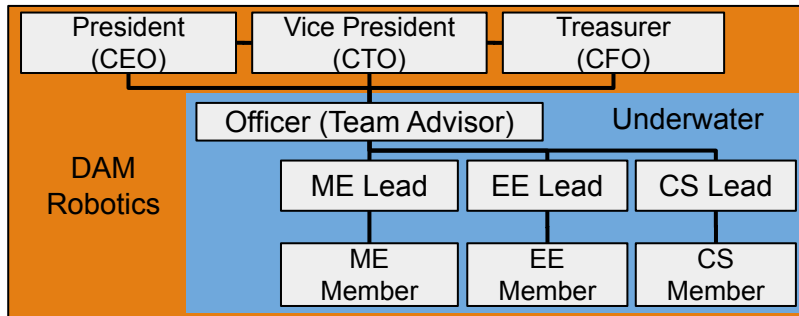


Fig. 2: Leadership Hierarchy

Leadership positions are elected annually and may be reassigned to adapt to project needs. Weekly meetings focus on design, testing, project planning, and operational practice, while workspace and equipment remain available throughout the week for continued development. This structure promotes collaboration, mentorship, and technical growth.

## Company Organization:

Team members are assigned responsibilities based on technical experience, project needs, and individual interests. The Mechanical team focuses on CAD development, structural design, manufacturing, waterproofing, and manipulator systems. The Electrical team develops power distribution, tether systems, lighting, sensors, and electrical reliability. The Programming team focuses on controls, camera integration, communication systems, and image recognition. Leadership and subteam leads coordinate subsystem integration, delegate tasks, and ensure milestones remain aligned with competition objectives.

## Build Schedule

DAM Underwater Robotics managed vehicle development through structured scheduling, interdisciplinary collaboration, and standardized procedures to maintain competition readiness for the 2026 MATE ROV Competition.

Vehicle development followed a four-phase schedule to maintain steady progress while allowing time for troubleshooting and refinement. Phase 1 (Sept. 21 – Nov. 1) focused on onboarding, planning, budgeting, and the transition from ROS 1 to ROS 2. Phase 2 (Nov. 1 – Feb. 1) emphasized proof-of-concept testing, prototyping, electrical schematics, and development of a near-complete ROV CAD model. A winter review checkpoint on Dec. 16 ensured documentation and subsystem progress remained on track during reduced workspace access.

Phase 3 (Feb. 1 – Apr. 30) focused on manufacturing and subsystem integration, with mechanical and electrical fabrication completed by Mar. 15 to allow time for assembly, troubleshooting, and backup preparation. Phase 4 (Apr. 30 – June 22) emphasized pool testing, mission practice, and competition preparation. Major milestones included the regional volunteer event (May 9), video completion (May 15), documentation completion (May 21), and team departure for competition on June 22. Software development continued throughout all phases due to the iterative nature of controls and image recognition systems.

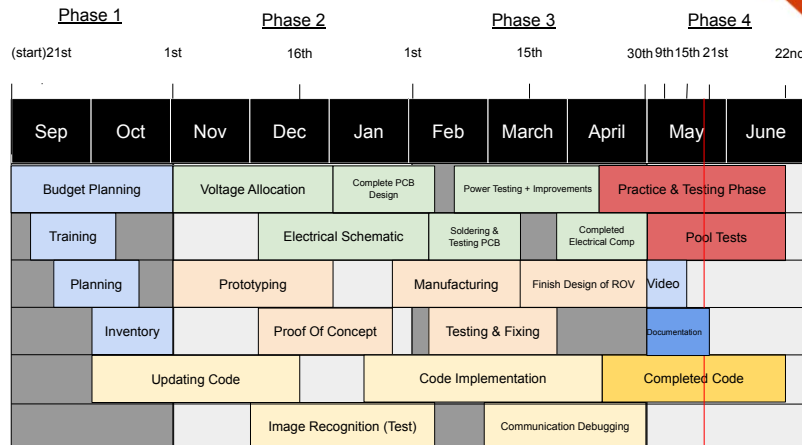


Fig. 3: Build Schedule

## Resource Allocation

Project responsibilities were divided between Mechanical, Electrical, and Computer Science subteams to support parallel subsystem development and integration. The Mechanical team used Fusion 360 for CAD and system design, the Electrical team used Altium for schematics and PCB development, and the Computer Science team used GitHub for collaborative software development and version control. Team progress, documentation, and subsystem updates were tracked through Google Drive, allowing members to cross-reference work and coordinate integration efforts.

Weekly meetings, design reviews, and testing checkpoints were used to monitor progress and resolve operational challenges. Standardized protocols—including waterproofing inspections, electrical continuity checks, tether verification, and subsystem testing—were completed before deployment. Issues discovered during testing were documented and corrected through iterative redesign to improve reliability and reduce mission risk prior to competition.

## Problem Solving

When trying to design a new system we would always start by listing out as many possible solutions to the problem as possible. From this point we could then further filter down ideas to see which ones were the most promising.

The best example of this is the the process behind designing the new clamping frame style after the previous version broke our pressure housing. The rough sketches outline different variations on how we could solve problems we were encountering and these sketches were used to get advice from other Mechanical members.

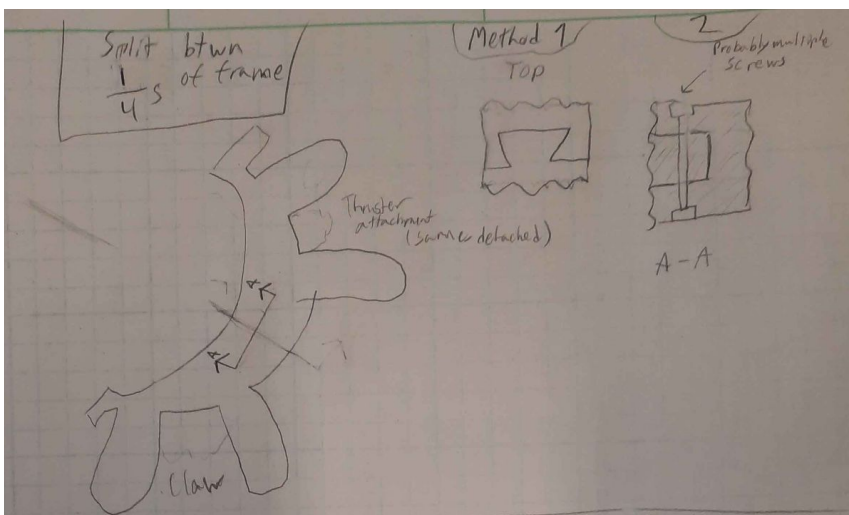


Fig. 4: Rough Sketches of the frame

## Innovation

The main problem with the ROV we started with was that it was very bulky. It was constructed almost entirely out of aluminum beams screwed together. We wanted to do a full frame redesign to make it significantly lighter weight.

We accomplished this by replacing most of that metal frame with 3D printed components and carbon fiber rods. This significantly reduced our weight as well as making us more aerodynamic at the tradeoff of an increased cost.

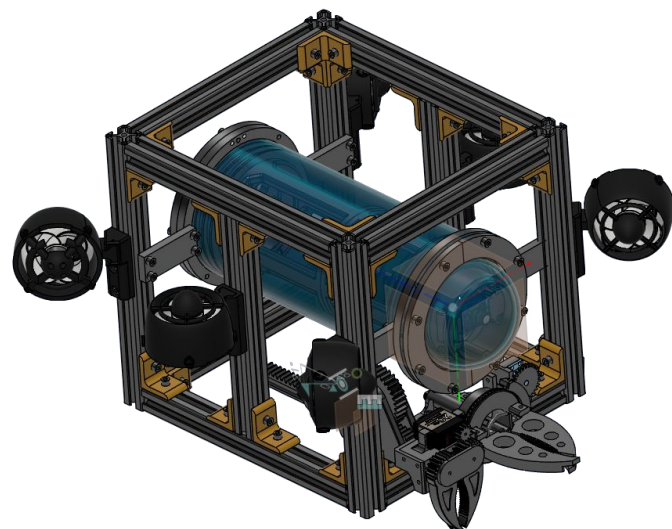


Fig. 5: The old ROV

## Vehicle Structure

The ROV was designed around compactness, maneuverability, and efficiency to improve underwater performance while maintaining full mission capability. Minimizing vehicle size and weight reduced drag, improved hydrodynamic performance, and allowed easier navigation in confined underwater environments. By condensing subsystems into internal pressure housings and modular assemblies, the vehicle maintains a compact footprint while reducing unnecessary external components.

The vehicle utilizes an octagonal frame structure with an eight-thruster configuration, enabling full six-degree-of-freedom (6-DOF) movement, including surge, sway, heave, yaw, pitch, and roll. This layout improves stability and maneuverability, allowing the ROV to maintain position while translating across another axis for precision mission tasks.

Several trade-offs were considered during development. Increased subsystem density improved maneuverability and reduced drag; however, it also increased packaging complexity and cost. Waterproofed motors, custom electronics, and tightly integrated subsystems contributed to an estimated vehicle cost exceeding \$10,000 USD. Despite increased cost, this approach improved reliability, modularity, and long-term mission performance.



Fig. 6: The current ROV

## Systems Approach

DAM Underwater Robotics implemented a balanced systems engineering approach by designing subsystems to function collaboratively rather than independently. Propulsion, sensing, payload tools, buoyancy, recovery systems, and vision systems were intentionally integrated to support multiple mission objectives while maintaining modularity for future upgrades.

As shown in Figure 7, mission tasks rely on overlapping subsystems to improve reliability, adaptability, and operational efficiency. Camera systems, LED lighting, and image recognition support most mission tasks, while the manipulator, recovery line, and variable buoyancy systems provide task-specific interaction and deployment capability. This overlap improves redundancy, mission flexibility, and overall vehicle performance.

To further improve flexibility, the ROV incorporates a clip-on payload interfaces, allowing mission-specific tools and sensors to be rapidly integrated or removed without major vehicle redesign. This overlap between subsystems reduces single-purpose hardware, improves redundancy, and increases mission flexibility.

|                                       | Manipulator | Image Recognition | External Cameras | Digital Dome Camera | Sonar | Variable Float | Recovery Line | LED Ring | External Lights |
|---------------------------------------|-------------|-------------------|------------------|---------------------|-------|----------------|---------------|----------|-----------------|
| Task 1                                |             |                   |                  |                     |       |                |               |          |                 |
| Collect species from the coral garden | ✓           | □                 | ✓                | ✓                   | □     | □              | □             | ✓        | □               |
| Coral garden ridge modeling           | □           | ✓                 | ✓                | ✓                   | □     | □              | □             | ✓        | ✓               |
| Maintain Stable Position in Current   | □           | □                 | ✓                | ✓                   | □     | ✓              | □             | ✓        | □               |
| Task 2                                |             |                   |                  |                     |       |                |               |          |                 |
| Replace eDNA sensor                   | ✓           | □                 | ✓                | ✓                   | □     | □              | □             | ✓        | □               |
| Iceberg visual Survey                 | ✓           | ✓                 | ✓                | ✓                   | ✓     | □              | □             | ✓        | ✓               |
| Recover anchor line                   | ✓           | □                 | ✓                | ✓                   | □     | □              | ✓             | ✓        | □               |
| Task 3                                |             |                   |                  |                     |       |                |               |          |                 |
| Install connector/mission servicing   | ✓           | □                 | ✓                | ✓                   | □     | □              | □             | ✓        | □               |
| Bubble curtain deployment             | ✓           | □                 | ✓                | ✓                   | □     | □              | □             | ✓        | □               |
| Precision maneuvering near structures | □           | □                 | ✓                | ✓                   | ✓     | ✓              | □             | ✓        | □               |
| Task 4                                |             |                   |                  |                     |       |                |               |          |                 |
| Float deployment and operation        | ✓           | □                 | ✓                | ✓                   | □     | ✓              | ✓             | ✓        | □               |
| Sub-zero profiling operation          | □           | □                 | ✓                | ✓                   | □     | ✓              | □             | ✓        | □               |

Fig. 7: Our approach to tasks

## Materials

The ROV is made up of a few different materials. Most 3D printed components are made up of ABS with the exception of the manipulator's TPU gripper. We chose to use ABS as it can easily be made waterproof by putting the parts through an Acetone bath. This dissolves the ABS enough to fill in the gaps left between layers and weld the layers together.

Parts of the pressure housing such as our bulkhead are machined aluminum. Aluminum was chosen as it was cheap and easy to machine. We recently switched many of our steel materials to aluminum as well to better handle the Saltwater that the ROV will encounter at the World competition.

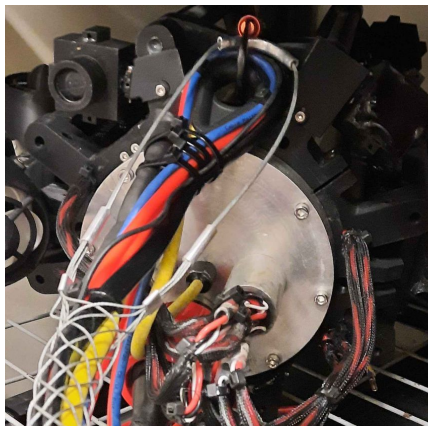


Fig. 8: Aluminum Machined Bulkhead

## Designing for tasks

Another set of components that we changed to better meet the mission specifications were the angles our cameras were at. Visibility is a really important aspect of ROV design and we wanted to ensure that we have all the necessary camera angles to best see what we need to see.

Lastly one of the most important design decisions we made was to make our manipulator able to turn 360°s while holding onto something. This has proved extremely useful for the biofouling observatory task. Being able to rotate our claw without rotating the ROV itself has saved us time and helped ensure that our tether doesn't get tangled as a result of doing multiple rolls in a row.



Fig. 9: Observatory Rotation Task [1]

# Electrical System

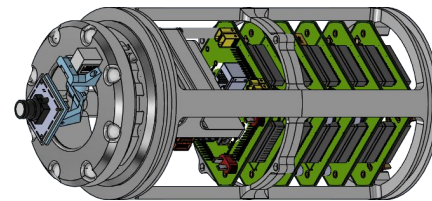


Fig. 10: Internal Electronics

## Control & Electrical Architecture

The ROV utilizes a modular stacked electrical architecture designed to improve maintainability, simplify subsystem integration, and reduce wiring complexity. Internal electronics are organized through a vertically integrated PCB stack housed within a waterproof pressure enclosure, allowing subsystems to be individually serviced or replaced without major redesign.

Power enters the vehicle through the tether at 48V, where dedicated 48V-to-12V regulation boards convert and distribute power throughout the system. Due to the vehicle's approximately 1179W peak power demand, three 600W DC converters were connected in parallel to improve reliability and prevent voltage drop observed during high-load testing. A dedicated 12V-to-5V/3.3V regulation board distributes power to servos, sensors, internal LEDs, and camera systems.

Vehicle control is coordinated through an onboard Jetson Nano and ESP32 control board. Surface controller inputs are transmitted through Ethernet to the Jetson Nano, where commands are processed and translated into outputs for thrusters, servos, manipulators, and mission-specific payload systems. The digital dome camera communicates directly through USB to provide high-resolution operator feedback.

Electrical communication between subsystems is achieved through 5.7A, 300V-rated pin connections, enabling simplified routing of 48V, 12V, 5V, and 3.3V power rails while reducing internal wiring complexity.

## Tether Design and Requirements

The tether was designed to simultaneously provide power, communication, pneumatic control, and operational visibility between the surface station and underwater vehicle. The tether includes:

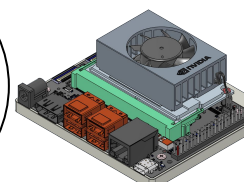
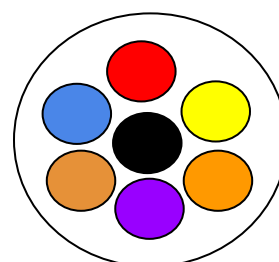
48V positive and negative power lines for underwater power distribution

Two CAT8 communication lines, with one dedicated to Ethernet communication and the second dedicated to analog camera feedback through the onboard ANNKE security system.

Two pneumatic lines, where one supplies approximately 40 psi for manipulator actuation while the second exhausts displaced air back to atmosphere to reduce water intrusion risk

Integrated LED tether indicators distributed throughout the tether to improve visibility and reduce entanglement risk during underwater operation

The tether interfaces directly with the surface control computer and underwater Jetson Nano, enabling high-speed communication while supporting low-latency analog video feedback and mission control.



|              |                         |
|--------------|-------------------------|
| Red          | Power Line 48 V+        |
| Black        | Power Line 48 V-        |
| Yellow       | CAT 8 (Ethernet)        |
| Blue         | CAT 8 (Analog)          |
| Orange       | Pneumatic Line (40 psi) |
| Light Orange | Pneumatic Line (1 atm)  |
| Purple       | LED Tether Indicator    |

Fig. 11: Cross Section of the Tether

## Tether Management Protocol

During operation, tether slack is continuously managed to reduce drag, maintain maneuverability, and minimize snagging hazards around mission structures. Integrated tether lighting improves operator awareness of tether location while assisting nearby personnel during deployment and recovery procedures. This management approach improves operational safety and reduces interference with mission tasks.



Fig. 12: LEDs for tether

## Electrical Design Benefits

The ROV's modular PCB architecture was designed to improve serviceability, reliability, and electrical organization while reducing internal wiring complexity. Rather than relying on point-to-point wiring, dedicated printed circuit boards separate responsibilities between power distribution, voltage regulation, and control systems, simplifying troubleshooting and subsystem replacement. This modular approach improves maintainability while reducing failure points during underwater operation.

The distribution board serves as the primary interface between external penetrators and onboard systems, routing power and

communication throughout the vehicle. Dedicated 48V-to-12V and 12V-to-5V/3.3V regulation boards provide stable power delivery for high-current and low-voltage electronics, while the ESP32 control board coordinates motor and subsystem communication through commands received from the onboard Jetson Nano.

To improve tether visibility and operational safety, integrated LED indicators are distributed throughout the tether. These lights improve visibility in darker environments, allow operators to quickly identify tether location during deployment and recovery, and reduce entanglement risk during mission operation. This feature improves situational awareness for both operators and nearby personnel while helping maintain safer tether routing underwater.

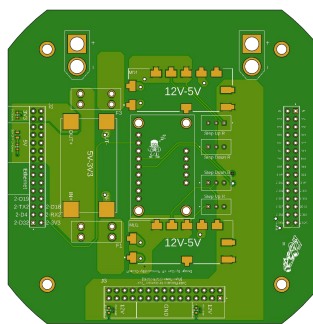


Fig. 13: 12V-5V

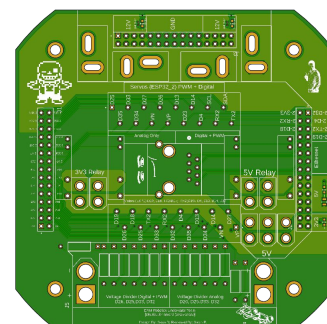


Fig. 15: Power Distribution

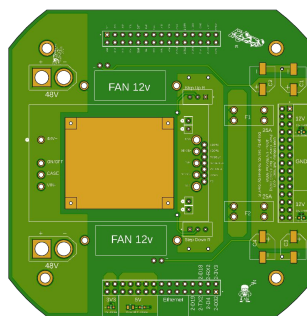


Fig. 14: 48V-12V

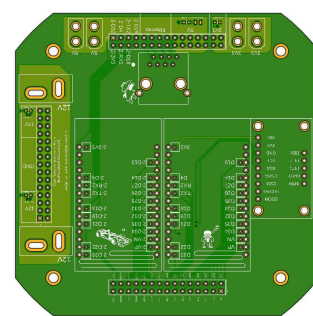


Fig. 16: ESP PCB

## Software Development Process

We use git as a version control system to ensure that progress is tracked and individuals can work on code parallel. Subsystems are generally created as small python files called nodes. Each node is responsible for one or two tasks and the nodes communicate with each in order to accomplish more complex tasks.

## Software Improvements

A variety of software features have been implemented with improved performance in mind. The first is that the video stream from the main camera is compressed before it is sent over ethernet to the ground station, where it is then uncompressed. This optimization decreases latency and improves the ability for the driver.

Another feature of the software is the creation of various different launch files. The launch files allow us to start the ROV in different configurations without needing to edit the source code. This flexibility can allow for more effective testing along with more options in the field.

## Top Level Design

We use ROS2 to communicate between the control box and ROV. To facilitate this, we use two sets of nodes, one set to be run on the control box and another on the ROV. These nodes communicate over ROS topics that are transferred over ethernet.

The nodes on the ground station are responsible for processing the sensor input along with user inputs and giving those to the ROV as instructions. The nodes on the ROV are read out values from sensors and command our motors and servos

This design allows for easy integration of new tasks, as new nodes can be added to the ground station, without needing to change very much of the existing infrastructure. The downside is the increased processing power required. To provide the needed processing power we use a Jetson Nano which is a small computer running Linux with the necessary processing power.

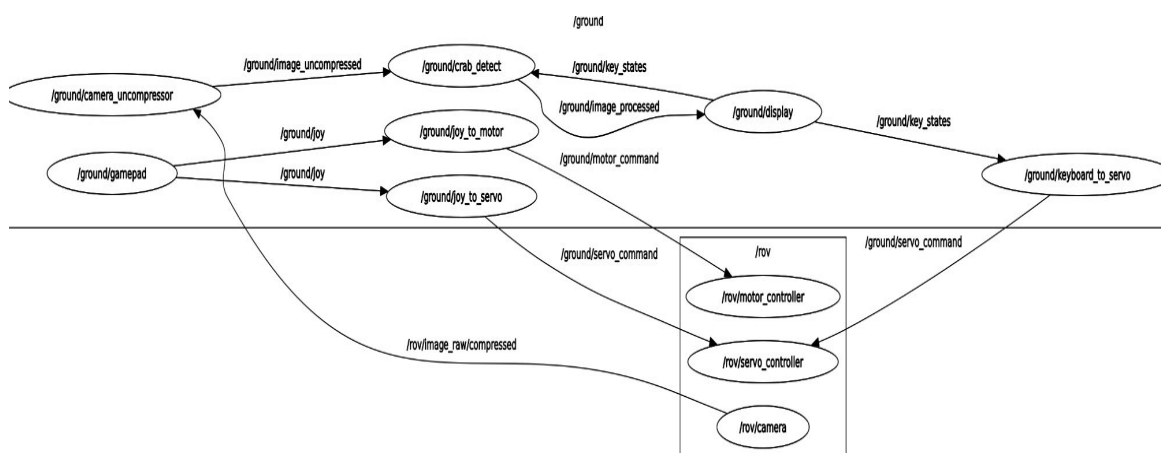


Fig. 17: ROS2 Node Communication Network

This figure shows the various nodes that run in order to operate the ROV. Arrows represent topics where communication occurs. The origin of the arrow represents the publisher for the topic and the end of the arrow represents the subscriber(s) to that topic. The prefix of the node or topic name shows where that

# Design Rationale



## Propulsion System

To maximize maneuverability and mission adaptability, the ROV incorporates an eight-thruster propulsion system designed to provide full six-degree-of-freedom (6-DOF) control, allowing simultaneous translation and stabilization during underwater operations. Thruster placement was selected to improve maneuverability in confined environments while maintaining vehicle stability during manipulator operations and mission-specific tasks. (Refer to ROV SID)

The propulsion system utilizes a combination of ApisQueen 2828 waterproof thrusters and Hobbywater 2838 thrusters, selected based on reliability, cost effectiveness, and prior operational performance. Unlike previous competition years where motors were manually waterproofed and experienced an estimated 25% operational success rate, both selected motors arrive factory waterproofed and epoxy sealed, significantly improving reliability and reducing maintenance requirements. While the upfront cost of commercially waterproofed motors was higher, reduced failure rates, lower replacement frequency, and improved operational consistency resulted in lower long-term system cost and increased mission reliability.

To improve propulsion efficiency and operator safety, the thrusters incorporate toroidal propellers to reduce turbulence and improve flow efficiency. Additionally, custom protective thruster housings were designed to reduce the risk of accidental contact with high-speed rotating components while preventing tether lines, debris, or loose materials from entering the propulsion system during operation.

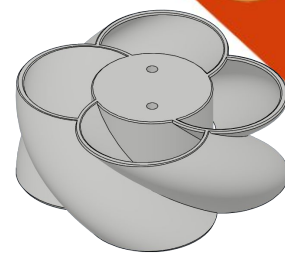


Fig. 18: Thrust housing and toroidal propeller

## Buoyancy System

To improve underwater stability and controllability, the ROV incorporates a modular buoyancy system designed to compensate for subsystem weight, tether loading, and changing mission requirements. The system utilizes clamp-on buoyancy modules filled with urethane expanding foam and internal weighting material, allowing rapid buoyancy adjustment without permanent vehicle modifications.

Buoyancy placement was optimized to counteract rear tether loading by integrating forward-mounted buoyancy elements, improving pitch stability and reducing unwanted vehicle rotation during operation. This configuration improves vehicle balance, maneuverability, and precision during manipulator-based mission tasks.

Initial estimates predicted approximately 1000 g of buoyancy compensation would be required; however, redesign efforts and relocating previously external components into internal housings reduced the requirement to approximately 600 g, improving hydrodynamic efficiency and reducing drag/ thrust demand.

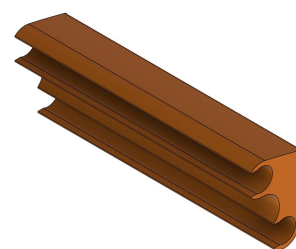


Fig. 19: Buoyancy Holder

## Camera & Illumination System

To maximize operator awareness and mission adaptability, the ROV incorporates a five-camera vision system consisting of four external analog cameras and one internal digital camera. The four external cameras are strategically positioned around the vehicle to reduce blind spots and provide real-time visibility of manipulators, obstacles, and mission-specific tools while minimizing unnecessary vehicle repositioning. These cameras are powered through the ROV's 12V electrical system and integrated with an ANNKE security system, allowing simultaneous low-latency video feedback for improved navigation and task execution.

The fifth camera is an internally mounted digital camera housed inside a waterproof dome enclosure. Unlike the external analog cameras, the digital camera is protected within the dome to allow the use of a non-waterproof, high-resolution imaging system powered through an independent 5V circuit. This camera improves detailed inspections, target identification, mission recording, and image processing performance.

To improve underwater visibility, the dome assembly integrates a custom LED ring illumination system consisting of eight 12V LEDs positioned around the camera dome to provide broad and evenly distributed lighting coverage. Brightness is controlled through a digital potentiometer, allowing operators to optimize illumination while reducing unnecessary power consumption and glare in changing water conditions. The LED ring also

incorporates an integrated servo mounting interface and fixed-angle laser attachment points. The parallel laser configuration allows distance estimation, dimensional scaling, and future underwater modeling by projecting known reference spacing onto target objects

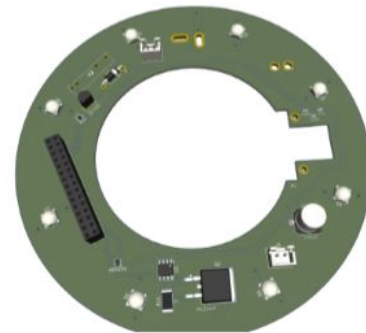


Fig. 20: LED and laser measurement PCB

## Manipulator & Recovery Systems

To meet mission requirements involving object retrieval and manipulation, the ROV incorporates a waterproof manipulator system capable of continuous 360-degree rotation using a waterproof servo motor. This rotational capability allows operators to approach mission objects from multiple orientations while reducing the need for vehicle repositioning during underwater tasks.

To maintain consistent gripping performance, the manipulator utilizes a relay-controlled pneumatic switching system that provides reliable actuation and controlled gripping force for irregular or sensitive objects. Internal relay protection further improves subsystem reliability by isolating power during motor stalls, electrical faults, or abnormal behavior, reducing the risk of hardware damage while maintaining manipulator position stability.

The ROV additionally incorporates a recovery line management system attached to an underwater anchor point. A free-rotating spool

mechanism, enclosed within a protective shell housing, enables controlled unspooling and respooling of the recovery line while minimizing snagging risk and improving deployment reliability.

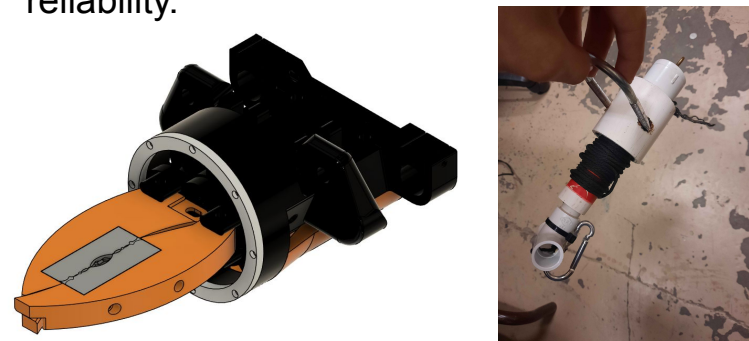


Fig. 21: Manipulator and recovery line device

fuse to reduce the risk of electrical damage. A Blue Robotics pressure enclosure provides additional safety through controlled pressure relief, while adjustable ballast legs allow tuning of descent characteristics and underwater stability based on mission requirements.

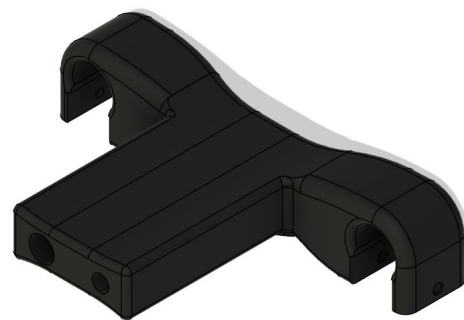


Fig. 22: Sonar Mount

## Modular Sensor and Mission Systems

To improve mission adaptability, the ROV utilizes a modular clip-on rail architecture that enables rapid integration of external payloads without permanent structural modifications. For this year's competition bonus task, a sonar sensor mount was developed using a clip-on attachment system that allows quick installation and removal. To reduce drag and minimize snagging risk, the mount can be repositioned inward when sonar functionality is not required.

The ROV also incorporates a 380 mm variable buoyancy float system designed for sub-zero underwater environments. Constructed from Schedule 40 PVC with aluminum endcaps, the float integrates a four-syringe buoyancy engine actuated by a stepper motor and worm gear transmission to intake or expel water and regulate buoyancy. This configuration enables controlled ascent and descent while resisting back-driving forces caused by increased hydrostatic pressure at depth.

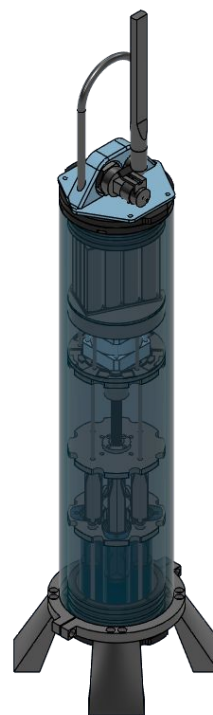


Fig. 23: Float

The float subsystem operates at approximately 1.2 A and is protected through a 2 A cylindrical

## Safety Philosophy

DAM Underwater Robotics prioritizes personnel, equipment, and operational safety through standardized procedures, qualification-based training, and vehicle-specific safeguards. Because the ROV operates using 48V high-power electrical systems in aquatic environments, the team follows strict manufacturing, testing, and deployment procedures to reduce risk to operators, equipment, and wildlife.

All team members are required to follow Oregon State University iLabs safety procedures and complete qualification requirements before operating tools or participating in manufacturing activities. Safety measures are implemented to reduce injury risks, protect equipment from preventable damage, and ensure reliable operation during fabrication, transportation, and deployment.



Fig. 24: Emergency Procedure guidelines

The team maintains a proactive safety culture centered on hazard prevention, operational awareness, and redundancy, ensuring safe operation before, during, and after missions.

## Personnel & Facility Safety

To access iLabs facilities, members are required to wear safety glasses, closed-toe shoes, fitted clothing, and visible identification badges at all times. Loose clothing is prohibited around rotating machinery, and workspace rules are reinforced through posted safety boards located at facility entrances.

Emergency procedures for fire, evacuation, medical response, and hazardous situations are posted throughout iLabs spaces. Additionally, first aid kits are mounted in every building to provide rapid treatment in the event of minor injuries.

All fabrication activities follow the iLabs qualification system, where members must complete required training and authorization before operating manufacturing equipment. The qualification structure ensures proper training in machining, welding, composites, CNC, additive manufacturing, and shop safety, reducing operator risk and preventing misuse of equipment. The qualification progression system is shown in the iLabs Qualification Tree.



Fig. 25: Safety Board in our workspace

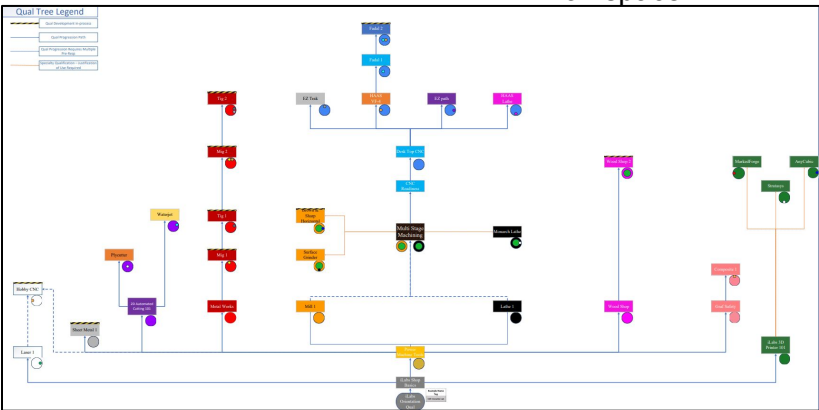


Fig. 26: iLabs Qualification Tree [2]

## Vehicle & Electrical Safety

Because high power and water are a dangerous combination, the ROV incorporates multiple electrical and mechanical safety systems to reduce operational risk.

The 48V tether power system uses a Blue Anderson connector paired with an inline fuse located within 10 cm of the power input, protecting electrical systems from overcurrent conditions and short circuits. Internal and external fuse systems are inspected before operation to ensure safe electrical performance.

To prevent accidental injury and protect wildlife, all thrusters are fitted with protective propeller guards that reduce entanglement risk and prevent accidental contact with moving components. Thrusters are visually inspected before startup to verify no sharp debris or foreign objects are present.



The ROV additionally uses waterproofed electronics housings, strain relief systems, secured tether routing, and pressure-sealed end caps to reduce risks associated with water intrusion and electrical failure.



Fig. 27: Fused power connector and propeller shroud

## Operational Safety Procedures

Due to the hazards associated with operating a 48V underwater robotic platform, the team follows a standardized startup and operational verification process before deployment.

Prior to powering the ROV, an external amp meter is connected to monitor startup current.

Under normal idle conditions, the vehicle operates within an expected range of 1–2 amps at 48V, serving as a key indicator of system health. Abnormal current draw may indicate water intrusion, damaged wiring, electrical shorts, or failing components. If unsafe conditions are detected, power is immediately disconnected and troubleshooting is completed before operation continues.

Before same-day deployment, the vehicle undergoes a 15-minute vacuum leak test to verify pressure housing integrity and confirm O-rings and seals are functioning correctly. During deployment, the ROV is only lifted by the carbon fiber frame members, which are structurally rated for lifting. Operators kneel at the pool edge during deployment to maintain stable handling and reduce accidental drops. Prior to launch, the control team confirms communication, and personnel maintain physical contact with the ROV to prevent unintended drift.

To improve operational awareness during surface handling, the main camera is covered by hand to visually confirm to the pilot that the vehicle remains under physical control and is not safe for operation. If communication or power is lost during operation, the vehicle's slightly positive buoyancy allows it to naturally return to the surface for retrieval, minimizing risk to personnel and equipment.



Fig. 28: Amp-meter

## Design Drivers & Lesson Learned

Throughout the development of Angler, the team prioritized the use of existing inventory and proven components before purchasing new systems. This approach reduced cost, minimized material waste, and leveraged lessons learned from previous ROV platforms to improve reliability. However, one of the largest design influences originated from a critical structural failure during the previous competition season, where the pressure housing cracked during operation. As a result, a major design objective for this year focused on reducing overall vehicle weight while maintaining a similar frame size to improve transportation, storage, deployment, and handling during competitions and outreach activities.

To improve reliability and maintainability, the team emphasized simplicity, modularity, and serviceability throughout the design process. Components were selected based on their ability to be easily attached, removed, repaired, or replaced, reducing maintenance time during testing and competition. Design reviews between mechanical, electrical, and software subteams were regularly conducted to evaluate tradeoffs between manufacturability, cost, reliability, and ease of integration.

The team also adopted a subsystem-based development strategy, where mechanical and electrical systems were validated independently before integration. By separating systems during development, failures could be isolated more efficiently while reducing troubleshooting complexity later in the season.

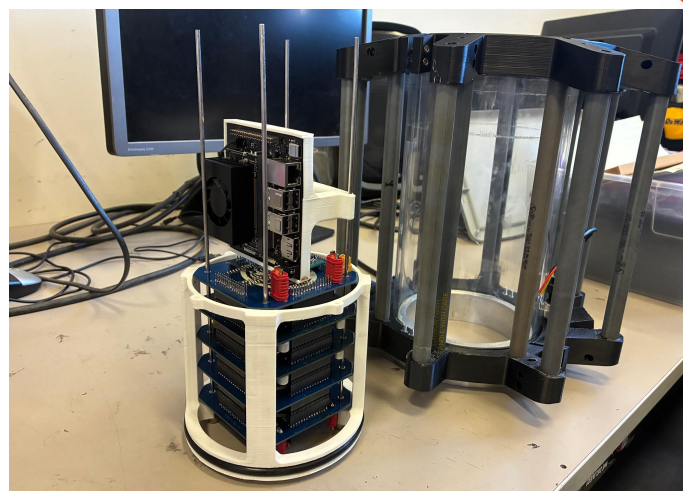


Fig. 29: Testing new frame design

## Prototyping & Manufacturing

To accelerate development and evaluate design options, the team expanded the use of 3D printing for both prototype and final-use components. Additive manufacturing allowed rapid testing of geometry, mounting strategies, and weight reduction while minimizing material waste. Components were frequently modified to remove unnecessary material and optimize structural performance before committing to finalized versions.

Because time constraints and manufacturing failures occasionally occurred, the team evaluated whether imperfect prints remained suitable for testing or required redesign. This process improved scheduling decisions while allowing subsystem testing to continue without waiting for finalized parts.

In addition to mechanical prototyping, the team significantly improved electrical system organization through the implementation of custom printed circuit boards (PCBs). Compared to previous years, PCB integration reduced wiring complexity, improved power distribution efficiency, and simplified

troubleshooting. Team members were trained on PCB fabrication and assembly procedures to reduce accidental damage to expensive electrical components and maximize available testing time.

The team also explored custom modular electrical connectors to replace direct soldered motor connections and improve serviceability. Multiple connector iterations were developed to simplify maintenance and allow faster disassembly while improving motor identification through labeled housings. Although several successful prototypes were created, the design was ultimately discontinued due to budget limitations and manufacturing cost constraints.

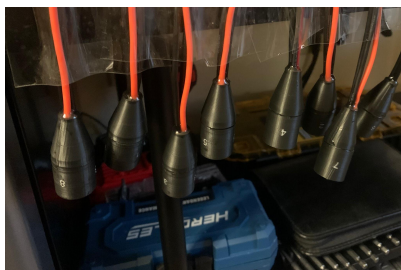
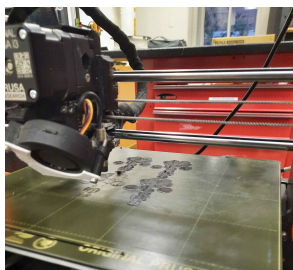


Fig. 30: Example 3D Printing and modular connectors

## Prototyping & Manufacturing

To validate system performance, Angler underwent staged testing procedures consisting of component testing, electrical verification, dry testing, and pool testing.

## Component Testing

Mechanical and electrical subsystems were first tested independently before full integration into the vehicle. Thrusters, cameras, LEDs, pneumatic systems, pressure housings, and electronics were individually verified to confirm

## Electrical Verification

Because the ROV operates using a 48V power system, electrical testing served as a critical safety and performance validation process. Communication through the CAT-8 tether system was verified through continuity and conductivity testing to confirm signal integrity between the surface control system and onboard electronics.

## Troubleshooting

When failures occurred, the team followed a systematic isolation process to identify root causes efficiently. Suspected components were first removed and tested independently to verify functionality. If the component operated correctly, it was reinstalled to determine whether the issue could be replicated at the system level.

If the problem persisted, troubleshooting progressed by verifying conductivity, wiring continuity, and communication between adjacent components to isolate faults within the system. Mechanical failures, such as damaged housings or slipping components, were also evaluated independently before replacement or redesign. This structured troubleshooting process reduced unnecessary component replacement, minimized downtime, and improved overall system reliability during testing and competition preparation.

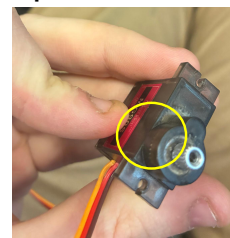


Fig. 31: Ethernet Tester and a damaged housing

## Budget Planning

DAM Underwater Robotics utilized an early allocation budgeting strategy through DAM Robotics to support development of the 2026 MATE ROV Competition vehicle. At the start of the academic year, funding was distributed between subteams based on proposed project plans, anticipated subsystem costs, and projected competition activities. Each subteam presented planned objectives and expected expenditures to justify budget allocation and maintain alignment with competition goals.

Budget projections prioritized mission-critical systems including propulsion, electronics, waterproofing, cameras, PCB manufacturing, and travel expenses to reduce integration risk and maintain subsystem reliability. Reused parts and donated components were incorporated into early planning to maximize financial efficiency and reduce unnecessary expenditures while maintaining vehicle performance.

| Accounting - Proposed Budget         |                      |                       |                                    |                    |                    |
|--------------------------------------|----------------------|-----------------------|------------------------------------|--------------------|--------------------|
| School Name: Oregon State University |                      |                       | From: 09/21/2025<br>To: 05/21/2025 |                    |                    |
| Income (DAM Robotics)                |                      |                       |                                    |                    |                    |
| Source                               | AY Budget (USD)      | Total                 |                                    | Sub-Teams          | Allocated          |
| Roll Over                            | \$ 295.60            | \$ 35,795.60          |                                    | Rover              | \$ 15,750.75       |
| COE                                  | \$ 21,000.00         |                       |                                    | Combat             | \$ 8,589.50        |
| EECS                                 | \$ 12,000.00         |                       |                                    | Underwater         | \$ 4,798.86        |
| MIME                                 | \$ 2,000.00          |                       |                                    | Drone Racing       | \$ 6,156.49        |
| COB                                  | \$ 500.00            |                       |                                    | BOB                | \$ 500.00          |
| Underwater Expenses                  |                      |                       |                                    |                    |                    |
| Description                          | Project              | Category              | Quantity                           | Project Cost (USD) | Budget Value (USD) |
| Plane Tickets                        | Competition          | Travel                | 4                                  | 894.97             | 3,579.88           |
| Hotel Rooms (Competition-Main)       | Competition          | Travel                | 1                                  | 928.14             | 4,508.02           |
| Hotel Rooms (Competition-Travel)     | Competition          | Travel                | 1                                  | 345.67             | 4,853.69           |
| Car Rental                           | Competition          | Travel                | 1                                  | 995.61             | 5,849.30           |
| Long Term Parking (1Week)            | Competition          | Travel                | 1                                  | 148.00             | 5,997.30           |
| MATE Explorer Registration           | Competition          | Registration          | 1                                  | 650.00             | 6,647.30           |
| MATE Fluid Power Quiz                | Competition          | Registration          | 1                                  | 25.00              | 6,672.30           |
| YMCA Pool Rental                     | Competition          | Registration          | 8                                  | 200.00             | 8,272.30           |
| Misc. Prop Materials                 | Competition          | Mechanical Components | 1                                  | 200.00             | 8,472.30           |
| Frame Parts                          | Manipulator + Float  | Materials             | 1                                  | 135.00             | 8,607.30           |
| Mineral Oil                          | Manipulator + Float  | Materials             | 1                                  | 10.00              | 8,617.30           |
| Pneumatic Parts                      | Manipulator + Float  | Mechanical Components | 1                                  | 250.00             | 8,867.30           |
| Servos + Gears                       | Manipulator + Float  | Mechanical Components | 3                                  | 100.00             | 9,167.30           |
| Sensors                              | Frame + Float        | Electrical Components | 5                                  | 20.00              | 9,267.30           |
| Mechanical Parts                     | Frame + Float        | Materials             | 1                                  | 60.00              | 9,327.30           |
| Epoxy                                | Frame + Float        | Materials             | 1                                  | 60.00              | 9,387.30           |
| Acrylic Tubes                        | Frame + Float        | Mechanical Components | 1                                  | 300.00             | 9,687.30           |
| Main Frame                           | Frame + Float        | Mechanical Components | 5                                  | 20.00              | 9,787.30           |
| O-Rings                              | Frame + Float        | Mechanical Components | 1                                  | 80.00              | 9,867.30           |
| Electrical Potting Epoxy             | External Electronics | Materials             | 2                                  | 45.00              | 9,957.30           |
| 3D Resin                             | External Electronics | Materials             | 2                                  | 29.99              | 10,017.28          |
| Chlorine/ Water Cleaner              | External Electronics | Materials             | 1                                  | 100.00             | 10,117.28          |
| Motors                               | External Electronics | Mechanical Components | 1                                  | 50.00              | 10,167.28          |
| Analog Cameras                       | External Electronics | Electrical Components | 6                                  | 20.00              | 10,287.28          |
| HobbyWater Waterproof Motors         | External Electronics | Electrical Components | 8                                  | 39.99              | 10,607.20          |
| ApisQueen Waterproof Motors          | External Electronics | Electrical Components | 4                                  | 29.10              | 10,723.60          |
| Pump                                 | External Electronics | Tools                 | 1                                  | 40.00              | 10,763.60          |
| Soldering Components                 | Dome Camera          | Tools                 | 1                                  | 200.00             | 10,963.60          |
| Electronics                          | Dome Camera          | Materials             | 1                                  | 50.00              | 11,013.60          |
| Clean Dry Resin                      | Dome Camera          | Materials             | 2                                  | 15.00              | 11,043.60          |
| PCB Boards + Components              | PCB                  | Electrical Components | 1                                  | 1,062.49           | 12,106.09          |
| Underwater Inventory + Donations     |                      |                       |                                    |                    |                    |
| Description                          | Project              | Category              | Quantity                           | Project Cost (USD) | Budget Value (USD) |
| Main Acrylic Housing                 | Reused Parts         | Mechanical Components | 2                                  | 150.00             | 300.00             |
| Converters                           | Reused Parts         | Electrical Components | 5                                  | 120.00             | 900.00             |
| Hobbywater Motors                    | Reused Parts         | Electrical Components | 4                                  | 39.99              | 1,059.96           |
| Apis Queen Motors                    | Reused Parts         | Electrical Components | 4                                  | 29.10              | 1,176.36           |
| Pressure Sensors                     | Reused Parts         | Electrical Components | 3                                  | 60.00              | 1,356.36           |
| Jetson Nano                          | Reused Parts         | Electrical Components | 1                                  | 300.00             | 1,656.36           |
| Control System                       | Reused Parts         | Tools                 | 1                                  | 1,000.00           | 2,656.36           |
| Carbon Fiber Tubs                    | Donations            | Mechanical Components | 16                                 | 9.99               | 2,816.20           |
| Blue Robotics LEDS                   | Donations            | Electrical Components | 4                                  | 175.00             | 3,516.20           |
| Blue Robotics Ethernet Cable         | Donations            | Electrical Components | 1                                  | 260.00             | 3,776.20           |

Fig. 32: Proposed Budget

| Projects             | Spent (USD) |
|----------------------|-------------|
| Manipulator + Float  | \$ 695.00   |
| External Electronics | \$ 896.30   |
| Dome Camera          | \$ 280.00   |
| Competition          | \$ 8,472.30 |
| PCBs                 | \$ 1,062.49 |
| Frame + Float        | \$ 700.00   |

| Categories            | Totals (USD) |
|-----------------------|--------------|
| Mechanical Components | \$ 1,280.00  |
| Electrical Components | \$ 1,718.81  |
| Tools                 | \$ 240.00    |
| Materials             | \$ 594.98    |
| Travel                | \$ 5,997.30  |
| Registration          | \$ 2,275.00  |

| Incomes      | Totals (USD) |
|--------------|--------------|
| Requested    | \$ 12,106.09 |
| Reused Parts | \$ 2,656.36  |
| Donations    | \$ 1,119.84  |

| Stats                       | Totals (USD)         |
|-----------------------------|----------------------|
| Total Expense               | \$ 12,106.09         |
| Donations + Reused Parts    | \$ 3,776.20          |
| <b>New Total Expense</b>    | <b>\$ 8,329.89</b>   |
| <b>Allocated</b>            | <b>\$ 4,798.86</b>   |
| <b>Total Funding Needed</b> | <b>\$ (3,531.03)</b> |

## Cost Accounting

Vehicle development emphasized cost-effective engineering through a balance

of purchased, reused, donated, and custom-fabricated components. Purchased components were prioritized when

improvements in reliability, manufacturability, or mission performance justified investment, while reused components from prior ROV generations - including motors, pressure housings, converters, controllers, and structural elements reduced unnecessary costs while maintaining proven reliability. Donated materials and sponsor-supported components further reduced subsystem expenses and improved financial efficiency.

## Build Vs Buy, New vs Used

Strategic build-versus-buy decisions balanced cost, manufacturability, reliability, and mission requirements. Mission-critical-systems, including custom housings, mounting systems, structural components, and power distribution—were developed in-house to improve subsystem integration and meet packaging constraints. Commercial off-the-shelf (COTS) components were

selected when proven reliability, reduced lead time, or cost efficiency outweighed custom manufacturing.

New-versus-reused decisions prioritized funding efficiency by evaluating inherited components for compatibility, performance, and operational reliability. Components meeting this year's requirements were retained, allowing resources to be focused on upgraded systems, testing, and mission-critical improvements.

## Financial Accountability

Team spending was tracked throughout development to compare projected expenses against actual expenditures. This process improved transparency, allowed resource reallocation when necessary, and ensured subsystem priorities remained aligned with available funding and competition objectives.

### Accounting - Project Cost

| School Name: Oregon State University   |                      |                       |          |                  |                       |
|----------------------------------------|----------------------|-----------------------|----------|------------------|-----------------------|
|                                        |                      |                       |          | From: 09/21/2025 |                       |
|                                        |                      |                       |          | To: 05/21/2025   |                       |
| Income (Underwater)                    |                      |                       |          |                  |                       |
| Description                            | Project              | Category              | Quantity | Cost (USD)       | Total (USD)           |
| Annual Allocation                      | Income               | Income                | 1        | 4,798.86         | 4,798.86              |
| T-Shirt Income                         | Income               | Donations             | 5        | 20.00            | 100.00                |
| Donations + Team Members Pool          | Donations            | Donations             | 1        | 654.94           | 654.94                |
| Reallocation                           | Allocation           | Travel                | 1        | 2,175.89         | 2,175.89              |
| Funds                                  |                      |                       |          |                  |                       |
| Description                            | Project              | Category              | Quantity | Cost (USD)       | Running Balance (USD) |
| Wire Heat Shrink Tubing Kit            | External Electronics | Electrical Components | 1        | (9.99)           | 7,719.70              |
| 2mm Bullet Connector                   | External Electronics | Electrical Components | 2        | (8.99)           | 7,701.72              |
| 3.5mm Bullet Connector                 | External Electronics | Electrical Components | 2        | (8.99)           | 7,683.74              |
| Waterproof Brushless Motor             | External Electronics | Electrical Components | 8        | (29.10)          | 7,450.94              |
| USB Male to Bare Wire                  | Dome Camera          | Electrical Components | 1        | (7.09)           | 7,443.85              |
| USB Camera                             | Dome Camera          | Electrical Components | 1        | (41.57)          | 7,402.28              |
| USB ISOLATOR                           | Dome Camera          | Electrical Components | 2        | (18.90)          | 7,364.48              |
| Electrical Boards for Stack in ROV     | PCBs                 | Electrical Components | 1        | (427.14)         | 6,937.34              |
| Electrical Components for Stack in ROV | PCBs                 | Electrical Components | 1        | (647.23)         | 6,290.11              |
| Hardware and Screws                    | Manipulator + Float  | Mechanical Components | 1        | (107.88)         | 6,182.23              |
| Battery Spring                         | Manipulator + Float  | Electrical Components | 1        | (6.99)           | 6,175.24              |
| Digi Key Shipping                      | Manipulator + Float  | Electrical Components | 1        | (6.99)           | 6,168.25              |
| Digi Key Tariff                        | Manipulator + Float  | Electrical Components | 1        | (3.80)           | 6,164.45              |
| VytaFlex 30                            | Manipulator + Float  | Material              | 1        | (29.36)          | 6,135.09              |
| Mold + Housing                         | Manipulator + Float  | Material              | 1        | (69.97)          | 6,065.12              |
| Components and Material                | Frame + Float        | Mechanical Components | 1        | (956.46)         | 5,108.66              |
| Best Western                           | Competition          | Travel                | 1        | (345.67)         | 4,762.99              |
| AirBnb                                 | Competition          | Travel                | 1        | (809.14)         | 3,953.85              |
| Flight Tax + Long Term Parking         | Competition          | Travel                | 1        | (442.85)         | 3,511.00              |
| Flight from YVR to YYT                 | Competition          | Travel                | 4        | (183.77)         | 2,775.92              |
| Flight from YYT to YVR                 | Competition          | Travel                | 4        | (224.01)         | 1,879.88              |
| Carrier Surcharge                      | Competition          | Travel                | 4        | (51.22)          | 1,675.00              |
| Enterprise Car Rental                  | Competition          | Travel                | 1        | (1,071.22)       | 603.78                |
| Fluid Power Quiz                       | Competition          | Registration          | 1        | (25.00)          | 578.78                |
| MATE ROV Competition                   | Competition          | Registration          | 1        | (650.00)         | (71.22)               |

| Projects             | Spent (USD)   |
|----------------------|---------------|
| Manipulator + Float  | \$ (224.99)   |
| External Electronics | \$ (278.75)   |
| Dome Camera          | \$ (86.46)    |
| Competition          | \$ (5,179.88) |
| PCBs                 | \$ (1,074.37) |
| Frame + Float        | \$ (956.46)   |

| Categories            | Totals (USD)  |
|-----------------------|---------------|
| Mechanical Components | \$ (1,064.34) |
| Electrical Components | \$ (1,457.36) |
| Tools                 | \$ -          |
| Materials             | \$ (99.33)    |
| Travel                | \$ (4,504.88) |
| Registration          | \$ (675.00)   |

| Incomes    | Totals (USD) |
|------------|--------------|
| Income     | \$ 4,898.86  |
| Allocation | \$ 2,830.83  |
| Donations  | \$ 654.94    |

| Stats     | Totals (USD)  |
|-----------|---------------|
| Income    | \$ 7,729.69   |
| Projects  | \$ (7,800.91) |
| Remainder | \$ (71.22)    |

Fig. 33: Costs

# Acknowledgements



DAM Underwater Robotics would like to express sincere gratitude to the organizations, sponsors, and individuals whose support contributed to the development of Angler and preparation for the 2026 MATE ROV Competition.

We would like to thank Repeat Robotics, Onshape, Oregon NASA Space Grant Consortium, Protocase, Polymaker, Port Plastics, Altium, and ODrive for their generous support through funding, materials, manufacturing assistance, software access, and technical resources that contributed significantly to vehicle development, subsystem integration, and testing.



Fig. 34: Logos of various companies

Special thanks are extended to Fernando Salazar for generously providing access to a testing facility for underwater vehicle validation. His support significantly reduced operational costs associated with pool rental and enabled repeated testing, troubleshooting, and mission preparation throughout the competition season.

We also thank DAM Robotics, the Oregon State University College of Engineering, mentors, alumni, team members, and families whose continued guidance, technical feedback, and encouragement supported the successful development of the vehicle.

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## References

[1]: [20693798.fs1.hubspotusercontent-na1.net/hubfs/20693798/2026/Supporting%20Documents/EX%20PN%20RN%20Prop%20Building%20Instructions%202026\\_Final.pdf](https://20693798.fs1.hubspotusercontent-na1.net/hubfs/20693798/2026/Supporting%20Documents/EX%20PN%20RN%20Prop%20Building%20Instructions%202026_Final.pdf)

[2]: <https://oregonstate.box.com/s/orblyboag35vvjp7loqidk3awym13vb>

[3]: <https://www.digikey.com/en/products/detail/delta-electronics/Q48SC12050NRDH/6133805?s=N4lgTCBcDalloBYAcBIAwgRjABgKzYDkAIAEQAkQBdAXyA>

## Appendix #: Safety Checklist

