



Mana Robotics

2026 Technical Documentation



Figure 1: 'Ōmilu ROV - Photo by Wyatt Schumacher

'Ōmilu — Ranger Class ROV

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Robert McIntosh (11th) — CTO, Pneumatic Engineer

Leia Benioff (11th) — CFO, COO

Lara Blanco Zeini (10th) — Community Outreach, Lead Design Engineer

Santino Tribuiano (11th) — Safety Officer

Leo Kurenbach (11th) — Pilot, Mechanical Engineer

Finlay Mulcahy (11th) — Lead Software Engineer

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Micah McDowell (10th) — Mechanical Engineer

Wyatt Schumacher (10th) — Lead Mechanical Engineer, Design Engineer

Luke Vincent (10th) — Software Engineer

Robyn Brewer — Mentor

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1. Abstract

Mana Robotics is a student-led engineering company based at Hawai'i Preparatory Academy on the Big Island of Hawai'i. The name Mana, a Hawaiian word for spiritual power and authority, reflects the company's deep roots in Hawai'i's relationship with the ocean and its commitment to engineering that serves the natural world. This season, Mana Robotics has designed and built 'Ōmilu and Kulia to meet the 2026 MATE ROV Competition's challenge: deploying technology in harsh, cold-water environments to document fragile ecosystems, monitor ocean health, support sustainable energy infrastructure, and operate autonomously beneath the ice.

'Ōmilu is a compact, agile, and fully field-serviceable remotely operated vehicle engineered for precision manipulation, stable depth hold, and reliable performance in demanding underwater conditions. Its companion system, Kulia, is an autonomous vertical profiling float purpose-built to operate under simulated ice, executing depth profiles and logging oceanographic data without thruster assistance. Both vehicles are original designs, fabricated almost entirely in-house by the student company, and together they represent Mana Robotics' most capable and complete competition system to date.

Mana Robotics is a team of 11 student engineers, now in their second year of competition, bringing expertise across mechanical design, electrical systems, software, and operations, with support from mentor Robyn Brewer. We operate with a strong safety culture, a structured build process, and a commitment to doing the engineering right. This report documents the full story of how 'Ōmilu and Kulia were designed, built, tested, and made ready to compete.



Figure 2: Mana Robotics Team - Photo by Piper McGuire-Turcotte

2. Project Management

2.1 Company Overview

Mana Robotics is a student-founded engineering company operating out of Hawai'i Preparatory Academy. The company designs, builds, and operates remotely operated vehicles that address real-world underwater engineering challenges, while developing the next generation of ocean engineers from the Pacific. The name Mana (a Hawaiian word for spiritual power and authority) reflects the team's grounding in Hawai'i's deep cultural relationship with the ocean and its commitment to purposeful, impactful engineering. In its first season, the company competed at the 2025 MATE ROV World Championship with Ulua, a first-generation vehicle that qualified for Worlds and contested the top Ranger-class teams. That season served as a proving ground; the company had completed the competition with a functioning ROV and a set of hard-won lessons about what it takes to build, document, and operate an underwater system at the World Championship level. The 2026 season has been structured around applying those lessons systematically across vehicle architecture, engineering process, and documentation to produce a second vehicle and a second technical report that reflect the company's full capabilities.

2.2 Team Composition and Roles

Mana Robotics is a student-led engineering company with eleven members, now in its second year of competition. This season's roster consists of six returning engineers and five new members. To foster mentorship while maximizing hands-on experience, returning members took an active instructional role from the start of the season, leading weekly sessions on skills including soldering, power-tool operation, Python programming, electrical wiring, CAD in Autodesk Fusion 360, and engineering safety. This structure created a learning environment in which new members quickly developed real competence, while experienced engineers deepened their understanding by teaching it. The company is organized into sub-teams focusing on mechanical design, electrical engineering, software development, operations, outreach, and documentation. Each sub-team is led by a skilled member who oversees the development of their domain, acts as a technical reference point for newer engineers, and is accountable for delivering their subsystem on schedule.

The CEO oversees company-wide progress by communicating with sub-team leads and mentors, running structured biweekly check-ins to surface blockers and review deadlines, and coordinating fundraising and outreach activities. The CTO leads the overall technical direction of the vehicle, and the CFO/COO manages budget, procurement, and day-to-day operations. Safety protocols and professional conduct, which include but are not limited to maintaining a clean and organized workspace, following the pre-dive checklist, and applying the tools correctly, are expected of every member and enforced consistently across all build, test, and competition activities. Mana Robotics' mentor, Robyn Brewer, provides technical guidance and safety oversight throughout the build and test cycle. All design decisions, fabrication and software development are carried out by student members, and the mentor serves in an advisory and supervisory capacity only.

2.3 Development Schedule

Scheduling and coordination are among the most demanding aspects of running a student engineering company, and Mana Robotics places significant emphasis on both. The company meets at least three to five times per week, in 70-minute or 140-minute sessions, depending on the build phase. Additionally, optional weekend workdays are held throughout the season and consistently draw full or near-full attendance. When a deadline approaches, the company holds evening "crunch sessions" from 6:00 PM to 9:00 PM to absorb the additional work. Scheduling these sessions is a coordinated responsibility, with sub-team leads communicating their availability and workload needs to the COO, who then organizes a mentor or other authorized adult to

supervise the session, which is a requirement under both Mana Robotics' own safety policy and Hawai'i Preparatory Academy's rules governing use of facilities during and after the school day.

Communication between sessions is handled through a shared Slack workspace, with dedicated channels for each sub-team so that mechanical, electrical, software, and operations workstreams can progress in parallel without interference. A shared Google Drive stores all company files, which hold design prototypes, CAD exports, software, photos, budget spreadsheets, safety protocols, and documentation drafts, all organized into sub-team folders and maintained collectively by all members.

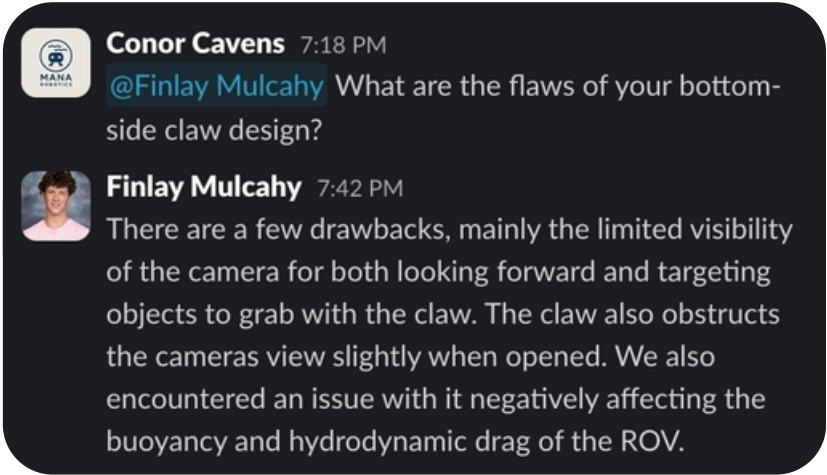


Figure 3: Slack workspace - Photo by Finlay Mulcahy

At the start of the 2026 season, the company built a master build schedule, owned by the COO, that divides the project into five phases plotted against the calendar. The schedule was constructed by working backward from the competition date to set firm deadlines for each phase, then assigning every major task to a specific sub-team with a priority label: high priority for tasks that would block downstream work if delayed, and standard priority for those with more flexibility. Tasks are tracked with statuses of "not started," "in progress," or "done," giving every member visibility into the vehicle's overall completion status at any point in the season. The schedule below is reproduced in summary form, but a full Gantt chart is maintained and updated throughout the season.

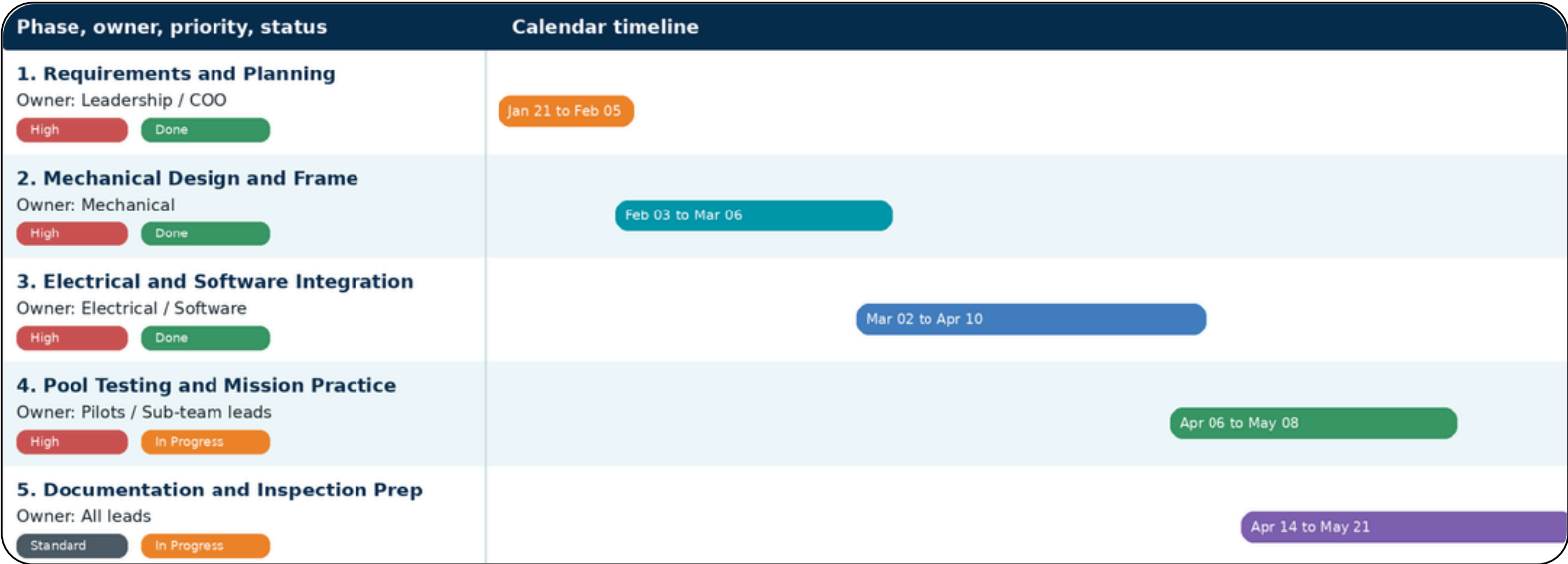


Figure 4: Meeting schedule - Made by Conor Cavens

2.4 Work Philosophy

Mana Robotics operates on the principle of accountable independence: each engineer owns their subsystem end-to-end, from initial design through testing and documentation, but is expected to engage actively with adjacent systems to ensure integration succeeds. No subsystem is designed in isolation — mechanical decisions inform electrical routing, software requirements shape hardware choices, and buoyancy calculations feed back into frame geometry. This holistic approach reduces the risk of late-stage integration failures and ensures every member understands how their work connects to the whole vehicle.

The team's geography, located on the Big Island of Hawai'i, thousands of kilometers from most parts suppliers, is a defining engineering constraint. Long shipping lead times mean design decisions must be made carefully

and early, with fallback options identified before orders are placed. This has built a culture of deliberate planning, creative problem-solving with materials on hand, and a strong preference for in-house fabrication wherever it is feasible.

The design of 'Ōmilu was driven by the 2026 MATE Ranger mission requirements and shaped by the lessons of Mana Robotics' first competition season. The team opened the design phase with a full teardown review of Ulua, the 2025 vehicle, identifying structural weaknesses, electrical bottlenecks, and control-system limitations before committing to any new direction. Every significant decision was run through a documented trade-off process, with alternatives evaluated against cost, fabrication complexity, reliability, and mission performance.

3. Design Rationale

3.1 Vehicle Design

'Ōmilu is built around a three-plate aluminum frame in an H-configuration, providing a rigid, stable platform for every subsystem. The waterproof electronics enclosure sits centrally above the frame, keeping the center of mass low and predictable. Eight thrusters — four horizontal vectored units and four vertical units — are distributed symmetrically around the frame to give full six-degrees-of-freedom (6-DOF) control. The pneumatic claw is mounted at the front of the vehicle on a dedicated bracket, positioned for maximum visibility from the forward camera and optimal reach during manipulation tasks.



Figure 5: CAD Model of frame - Design by Conor Cavens

The governing design philosophy is repairability and modularity. The 2025 vehicle lost pool time to maintenance that required near-total disassembly; in response, every major subsystem on 'Ōmilu — the enclosure, the claw assembly, and the thruster mounts — can be removed and serviced independently without disturbing the rest of the vehicle. Fastener sizes are standardized across the frame to minimize the tools needed for poolside maintenance.

3.2 Frame Prototyping

The single most consequential design decision of the 2026 season was the choice to abandon the previous year's frame entirely rather than iterate on it. The 2025 vehicle was built on a frame that, in hindsight, was

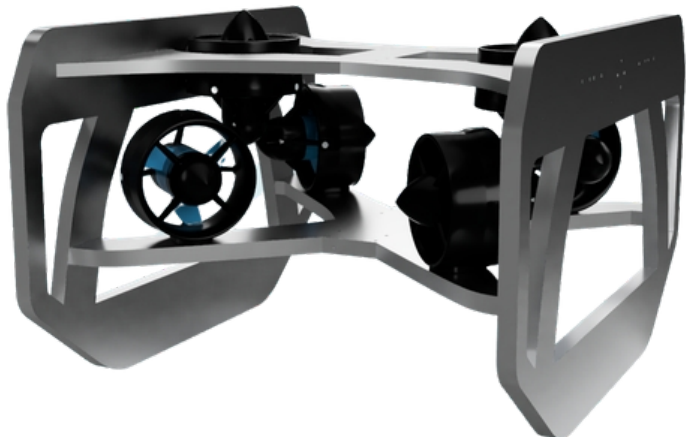


Figure 6: 2025 model Ulua - Design by Wyatt Schumacher

severely constraining: its geometry dictated where every subsystem could be placed, left almost no room for servicing the electronics enclosure, and locked the team into a thruster footprint that limited maneuverability. The company instead committed to a clean-sheet redesign, treating the structure as something to be designed around the mission rather than something the mission had to be squeezed into. Rather than have a single person produce a single concept, Mana Robotics ran a structured parallel-prototyping process. The company split into small teams, each independently developing prototypes

across three footprint-critical subsystems: the structural frame, the electronics enclosure layout, and the thruster configuration. Each team's prototypes were presented to the whole company and scored side by side against a common rubric. Scores are 1–4 per criterion; the weighted totals below drove the final selection.

Criterion	Weight (%)	H-Frame Aluminum	Box Frame HDPE	Tube Frame PVC
Serviceability	25	4	2	3
Structural rigidity	25	4	3	2
In-house fabrication feasibility	20	4	3	4
Thruster placement flexibility	20	4	3	2
Cost	10	3	4	4
Weighted Total		3.90	2.90	2.90

Figure 7: Frame trade study - Made by Leia Benioff

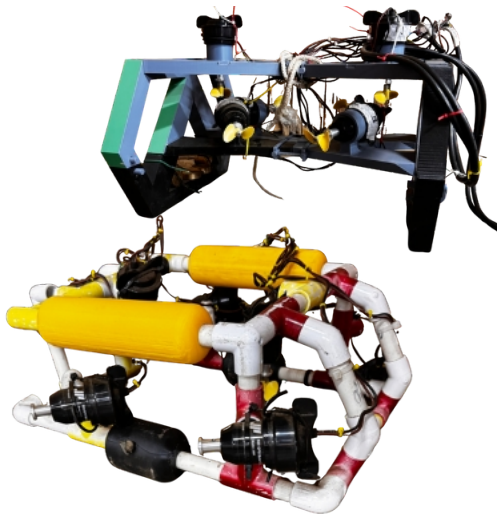


Figure 8: Original prototypes of ROV - Photo by Leia Benioff

The H-frame in 5052-series aluminum scored highest, principally because the flat plate geometry allows thruster brackets and enclosure mounts to be placed at arbitrary positions without the geometric constraints imposed by tube joints or box walls. HDPE was evaluated as an alternative but was eliminated because its lower stiffness-to-weight ratio would have required significantly more material to achieve equivalent rigidity. The aluminum frame was laser-cut to DXF specification by a vendor and required no in-house machining beyond deburring.

3.3 Frame Construction and Buoyancy Analysis

'Ōmilu's frame is fabricated from three pieces of 5052-series aluminum sheet, with the two vertical side plates 6.35 mm (1/4 in) thick and the horizontal center plate 12.7 mm (1/2 in) thick. The thicker center plate was chosen because it carries the concentrated load of the enclosure clamp and the claw bracket; analysis in Fusion 360 confirmed that stress at these mounting points remained below the yield stress of 5052 aluminum (193 MPa) under the maximum expected loading. The side plates provide lateral structure and serve as the primary mounting surface for the vertical thrusters. All three plates are joined with stainless steel hardware, and connection points are reinforced with gussets at locations where load concentrations were identified during design.



Figure 9: Assembling the frame - Photo by Luke Vincent

The vehicle mass budget was established at the start of the build season and updated as components were weighed during assembly. The final measured breakdown is shown to the right.

Subsystem	Mass (kg)
Aluminum frame (3 plates + hardware)	1.82
Electronics enclosure (tube, endcaps, penetrators)	0.78
Raspberry Pi 4B, Pixhawk 4, buck converter, power board	0.38
8 × T200 thrusters (344 g each, per Blue Robotics spec)	2.75
8 × Basic ESCs (27 g each, per Blue Robotics spec)	0.22
Pneumatic claw assembly	0.46
Buoyancy foam (pool noodle)	0.12
Tether (inboard 0.5 m)	0.19
Wiring, connectors, miscellaneous	0.28
Total vehicle mass	7.00

Figure 10: Spreadsheet of ROV weight - Made by Conor Cavens

To achieve slight positive buoyancy, the total upward buoyant force must exceed the vehicle weight. The dominant buoyant contributors are the sealed electronics enclosure and the foam. The enclosure is a Blue Robotics 150 mm diameter, 400 mm long cast acrylic tube with two sealed endcaps. Its displaced volume is:

$$V_{\text{enclosure}} = \pi \times (0.075 \text{ m})^2 \times 0.400 \text{ m} = 7.07 \times 10^{-3} \text{ m}^3$$

The buoyant force from the enclosure alone (in fresh water, $\rho = 1000 \text{ kg/m}^3$):

$$F_{\text{b,enclosure}} = \rho \times g \times V = 1000 \times 9.81 \times 7.07 \times 10^{-3} = 69.4 \text{ N}$$

The total buoyant force must exceed the vehicle weight ($7.00 \text{ kg} \times 9.81 \text{ m/s}^2 = 68.7 \text{ N}$). The foam volume required to make up the remaining buoyancy deficit was calculated as:

$$V_{\text{foam,required}} = (m_{\text{vehicle}} - m_{\text{displaced,enc}}) \div \rho_{\text{water}}$$

where the displaced mass of the frame is computed from the submerged volume of the aluminum plates. The foam was sized to provide approximately 5% positive buoyancy margin, which is sufficient to ensure passive surface ascent on power loss without making depth hold excessively thruster-intensive. Foam placement was tuned empirically across pool sessions to confirm the vehicle hovered mid-water with less than 5% vertical thruster duty cycle at the neutral depth command.

3.4 Enclosure and Electrical Architecture

'Ōmilu's electronics are housed in a sealed, depth-rated Blue Robotics 150mm x 400mm cast acrylic enclosure. The enclosure is mounted centrally on the frame's horizontal center plate. The enclosure is held by a custom 3D-printed clamp system designed and printed in-house, which fixes it rigidly in position while allowing rapid removal for maintenance. The interior is organized by a 3D-printed bracket assembly that partitions the available volume and holds each component in a fixed, accessible position, addressing the loose wiring and component shifting that caused intermittent faults on the 2025 vehicle.

Inside the enclosure, a 12 V-to-5 V buck converter provides clean, regulated 5 V to the Raspberry Pi and logic-level components, while the full 12 V rail feeds the eight bidirectional Electronic Speed Controllers (ESCs) that drive the thrusters. A power distribution board splits the 12 V supply to all eight ESCs. A Blue Robotics leak detector is mounted at the lowest point of the interior; its output is read by the Raspberry Pi and surfaced as an alert in the BlueOS topside interface.



Figure 12: CAD model of electrical design - Design by Wyatt Schumacher

Every cable penetration through the enclosure endcaps uses a Blue Robotics WetLink Penetrator, with marine-grade epoxy applied as a secondary sealant. O-rings on both endcaps are inspected before each dive, lubricated with Molykote 111 silicone grease, and replaced at the first sign of deformation. All enclosures are vacuum pressure tested before every dive per the pre-dive checklist in Section 6.3.

3.5 Control System

'Ōmilu runs a software-based control system built on a modified BlueOS distribution, the open-source ROV operating system maintained by Blue Robotics. The software team implemented custom modifications to the



Figure 11: Pool noodles on ROV- Photo by Piper McGuire-Turcotte

standard distribution that improve compatibility with the team's topside MacBook Pro and increase reliability during competition runs. These include custom network configuration scripts that keep the Ethernet-over-tether link established and stable across the full 15 m tether, and adjustments to the BlueOS cockpit interface that optimize the control layout for a game-controller input.

The topside control station is a MacBook Pro running the BlueOS cockpit web application, with a USB game controller providing all vehicle movement inputs. The cockpit application receives live video from the onboard camera, displays real-time depth and attitude telemetry from the Pixhawk and the Bar30 sensor, and relays controller commands to the vehicle over the Ethernet link.

All software development was managed in a private GitHub repository with branches for each feature under development. The main branch required a passing review from at least one other team member before merging, enforced by branch protection rules. Commits were made at the end of each working session, maintaining a recoverable snapshot history throughout the build.

Several features were added specifically to reduce pilot workload and increase reliability during the high-pressure competition run window. The team remapped the controller layout so that the left joystick controls surge and sway, the right joystick controls yaw, with dedicated shoulder buttons command depth up and depth down in fixed increments for the iceberg keel measurement task, and the remaining face buttons are unassigned to prevent accidental input. Additionally, a custom startup script configures the Raspberry Pi's network interface to suppress the automatic link renegotiation behavior that occasionally caused the Ethernet-over-tether connection to drop and require a manual restart. Since this failure mode appeared during the 2025 season under tether stress, eliminating it was a high priority for the 2026 build.

```
223 void missionUpdate(const SensorReadings r) {
224     if (mode == MissionMode::NONE) return;
225
226     // Surface breach check - only after descent has begun
227     if (descentBegan && compState != CompState::FAULT) {
228         float checkDepth = r.depth_m + SENSOR_OFFSET_BOTTOM_M;
229         if (checkDepth <= SURFACE_BREACH_THRESHOLD_M) {
230             faultActive = true;
231             faultReason = "SURFACE_BREACH";
232             stepperOff();
233             sendFaultPacket(r);
234             if (mode == MissionMode::COMPETITION) {
235                 transitionComp(CompState::FAULT);
236             } else {
237                 testState = TestState::IDLE;
238             }
239             mode = MissionMode::NONE;
240             return;
241         }
242     }
243
244     if (mode == MissionMode::COMPETITION) updateCompetition(r);
245     else if (mode == MissionMode::TEST) updateTest(r);
246 }
```

Figure 15: Example of coding - Made by Finlay Mulcahy

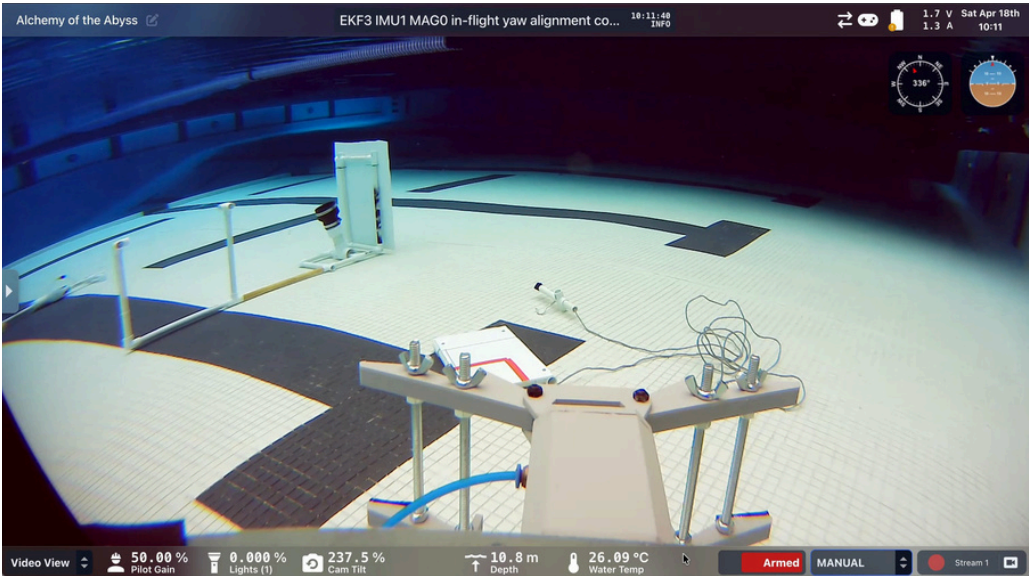


Figure 13: Screenshot of ROV display while in use - Photo by Conor Cavens

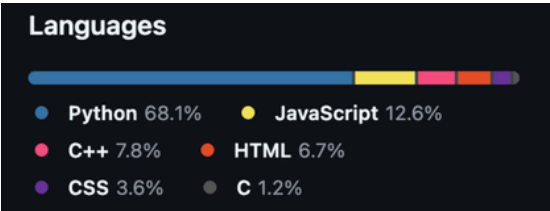


Figure 14: Percentage of coding languages used in Github Repo- Photo by Conor Cavens

The primary limitation of this system architecture is boot time. The Raspberry Pi and BlueOS take approximately 45 seconds to initialize from cold power, so the vehicle is powered during the tether-connection step of the pre-dive checklist rather than immediately before deployment. This allows initialization to complete while the team finishes other setup tasks. A second limitation is that the camera stream and control traffic share the same Ethernet link; under maximum thruster load, the available bandwidth occasionally causes brief frame drops. This is mitigated by capping the H.264 encoder bitrate at 4 Mbps, which keeps the stream stable at the cost of a slight reduction in image quality at full throttle

3.6 Propulsion

'Ōmilu is propelled by eight Blue Robotics T200 thrusters. The selection of thruster count, type, and placement followed a documented trade study. The 2025 vehicle used six thrusters in a configuration that provided surge, sway, yaw, and heave but required coupled thruster commands to correct roll and pitch. This coupling slowed the vehicle's response and introduced instability during claw operations. The team evaluated three configurations for 2026:

The 8-thruster vectored H-configuration was selected because it provides full independent authority in all six degrees of freedom without the fabrication

complexity of tilted vertical mounts. The additional current draw relative to the 6-thruster design was accepted because the tether power cable was already sized for a 22 A full-load budget. The four horizontal thrusters are mounted at 45° to the vehicle centerline, giving equal thrust authority forward and laterally with no dead zones.

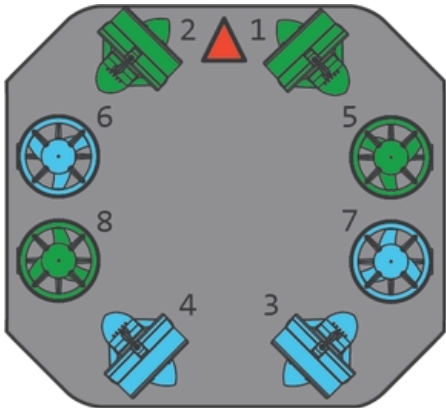


Figure 17: Diagram of Motor Arrangement on 'Ōmilu - Made by ArduSub

Configuration	DOF	Roll/Pitch Authority	Est. Full-Load Current (A)	Repairability
6-thruster	5 effective	Coupled / limited	17	High
8-thruster vectored H	6 independent	Full independent	22	High
8-thruster w/ tilted verticals	6 independent	Full independent	22	Low

Figure 16: Diagram of Motor Arrangement on 'Ōmilu - Made by Conor Cavens

The four vertical thrusters are mounted in a square pattern at the outer corners of the frame, equidistant from the center of mass. This placement minimizes the moment-arm difference between thruster pairs, so pitch and roll corrections are applied symmetrically, and the vehicle responds predictably to pilot input. All eight thrusters are protected by 3D-printed motor guards based on the open-source UWROV design, which are IP2X-compliant and prevent accidental contact with the rotating propellers during handling and deployment.

3.7 Cameras and Sensors

'Ōmilu carries a single primary camera: a Sony IMX323 image sensor in a USB module with onboard H.264 hardware encoding,

fitted with a 180° fisheye lens. The camera is mounted centrally inside the front face of the electronics enclosure, looking forward through a polycarbonate endcap. The 180° field of view was chosen specifically to give the pilot maximum awareness of the area directly in front of and below the vehicle without the cost, drag, and wiring of a separate downward camera.

Depth sensing is provided by a Blue Robotics Bar30 high-resolution pressure sensor mounted on the rear endcap of the enclosure. The Pixhawk 4's depth-hold mode uses the Bar30 data as its primary feedback signal, allowing the vehicle to autonomously maintain a commanded depth while the pilot focuses on lateral positioning and claw operation. A Blue Robotics leak detector completes the sensor suite, mounted at the lowest point inside the enclosure and surfaced as a high-priority alert in BlueOS.



Figure 18: The Depth Sensor used - Photo by Blue Robotics



Figure 19: The Sony IMX323 used in enclosure - Photo by Matthew Schwarting

3.8 Tether

The tether is 15 meters long and carries power and data between the topside station and the vehicle in a single managed bundle, with pneumatic tubing running alongside. The data path is a neutrally buoyant 8-conductor cable that carries all digital communication between the MacBook Pro and the Raspberry Pi over a standard TCP/IP link. The power path is a 10-conductor neutrally-buoyant cable, carrying 12 VDC to the vehicle; the power cable was selected because the combined conductor cross-sectional area limits voltage drop to approximately 2 V over the 15 m tether at full-load current. This keeps the ESC supply voltage within tolerance even when the thrusters draw peak current. Keeping power and data on separate conductors prevents the high, fluctuating thruster current from disturbing the communication link. A pneumatic tube runs alongside the two electrical cables, carrying compressed air from the topside compressor to the claw actuator. Both ends of the tether are terminated with strain-relief thimbles, 3D-printed in-house, so the cables are never pulled directly at the connector bodies during deployment and recovery. Additionally, the bundle is wrapped in braided sleeving for abrasion resistance and to keep the cables and pneumatic tube as one manageable unit.



Figure 20: Tether – Photo by Conor Cavens

3.9 Build vs. Buy, New vs. Used

Component sourcing decisions are evaluated against four criteria: technical performance, fabrication feasibility, timeline risk, and cost. In-house fabrication is preferred wherever the team’s tools and capabilities allow, as it provides full geometric control and supports rapid iteration. Procurement is reserved for components where validated performance specifications, depth ratings, or manufacturing precision cannot be achieved in-house. For items like this, Blue Robotics is the primary supplier. Blue Robotics was selected because of their quality and depth of technical documentation. Custom components are designed in Autodesk Fusion 360 and fabricated on the team’s Bambu Lab P1S 3D printers using PLA filament. PLA was selected for its balance of low weight, sufficient compressive strength at high infill, and compatibility with the team’s printers; infill density is varied by component based on the structural loads each part is expected to carry. The electronics organization bracket, enclosure clamp, claw fingers and linkage, motor guards, and float chassis were all produced through this workflow. The aluminum frame is designed as custom DXF geometry in Fusion 360 and laser-cut to specification by OSH Cut. Components with no depth-rating requirement, including the float’s stepper motor, threaded rod, motor drivers, and antenna hardware were procured from general suppliers on a cost basis. High-cost, long-life avionics, including the Pixhawk 4, Raspberry Pi, and prior-year frame hardware, are reused from the 2025 build where they continue to meet current requirements. All reused items are carried at current market value in Section 9.

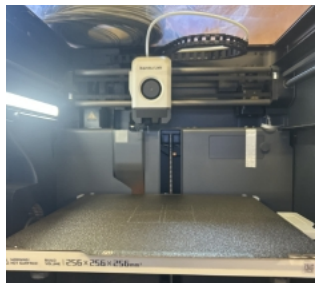


Figure 21: Bambu Labs P1S – Photo by Matthew Schwarting

4. Payload and Tools

4.1 Pneumatic Interleaving Claw

The claw operates on a pneumatic actuation system. Compressed air supplied by a topside compressor travels down the pneumatic tube integrated into the tether and drives a linear pneumatic actuator inside the claw assembly to open and close the two prongs. A secondary rotary actuator allows the claw orientation to be switched between vertical and horizontal, enabling the pilot to adapt grip angle to the object being retrieved without repositioning the vehicle. The pilot controls claw state with a 3-way rotary manual valve on the topside station, giving open, closed, and vented positions. The mechanism uses a two-prong pincher design in which opposing PLA prongs close around the target object. The prongs provide a secure, repeatable grip across the

range of cylindrical, spherical, and irregular objects encountered in the Ranger task set. The prongs are 3D-printed in PLA at high infill

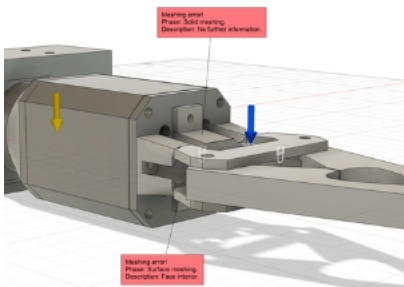


Figure 23: Manipulator CAD model - Design by Conor Cavens

density for compressive strength, and the rotary actuator and connecting hardware are off-the-shelf pneumatic components. The claw assembly mounts to the front underside of the vehicle on a dedicated bracket that places it centrally within the forward camera’s field of view. The mounting interface uses a standardized bolt pattern so the claw can be swapped for alternative tools in future seasons without frame modification.

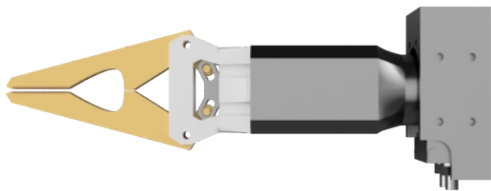


Figure 22: Manipulator CAD Model - Design by Conor Cavens

4.2 Automated Photogrammetry Processing

For the coral garden ridge modeling task, Mana Robotics developed an automated photogrammetry workflow. The pilot drives ‘Ōmilu in a controlled grid pattern around the coral garden structure while the Sony IMX323 fisheye camera records overlapping video. After the survey pass, a custom Python script extracts still frames from the video and processes them through Meshroom, an open-source photogrammetry pipeline, to generate a 3D point cloud and mesh. The model is then imported into Autodesk Fusion 360, where it is scaled using the true length provided by the station judge. Once scaled, the height of the coral structure is measured from the model and displayed to the judge. This system reduces manual measuring error and connects the mission task to real-world reef documentation and underwater survey work.

4.3 Invasive Species Identification

For the invasive species identification task, the team developed a custom image recognition pipeline to identify

European Green crabs and distinguish them from native Rock crabs and Jonah crabs. The pipeline is built in Python using a YOLOv8 model fine-tuned on the three crab species images provided in the MATE competition resources. The training set was augmented with rotated and rescaled instances of each species image to simulate the varied orientations and sizes the competition panel may present.

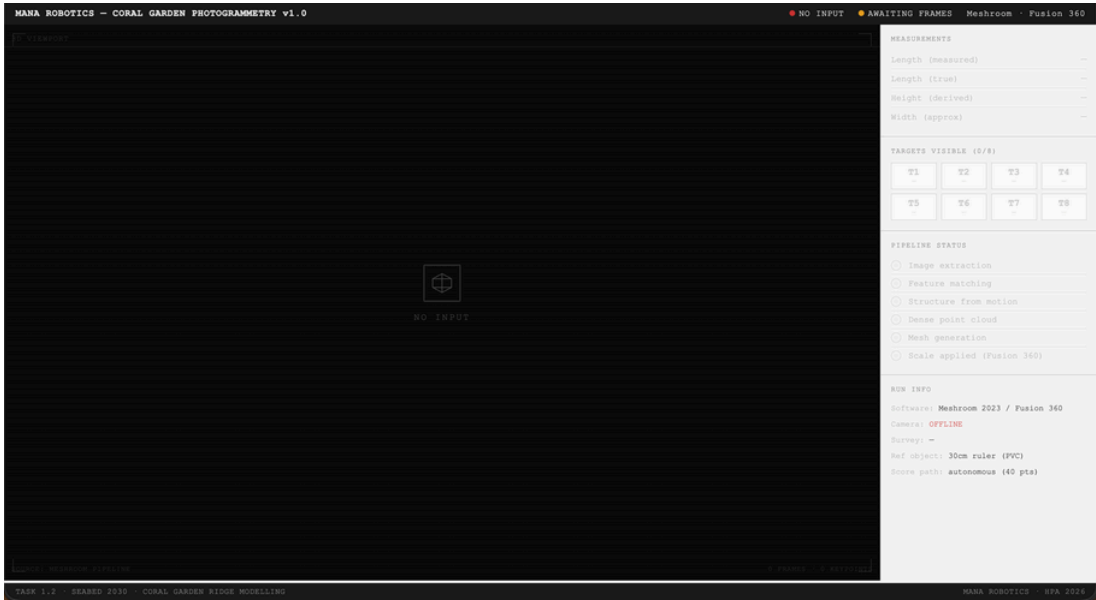


Figure 24: Software for the autonomous modeling script - Made by Finlay Mulcahy

At the mission station, the pilot maneuvers the vehicle to frame the crab identification panel in the video display; the topside MacBook Pro runs the detection script in real time, drawing bounding boxes around identified European Green crabs and displaying a running count on screen. The output is presented to the station judge directly from the display. The Invasive Species Reporting Form is pre-loaded in a browser tab on another laptop next to the pilot so the count can be submitted immediately once confirmed.

4.4 Iceberg Survey and Threat Assessment

For the iceberg survey task, the pilot maneuvers the vehicle to each of the five numbered survey points around the iceberg perimeter, confirming each number on the video display for the station judge. Keel depth is measured by descending alongside the keel PVC pipe with the Bar30 sensor active; the cockpit display shows live depth, and the pilot records the reading at the lowest visible point of the keel. The measured keel depth

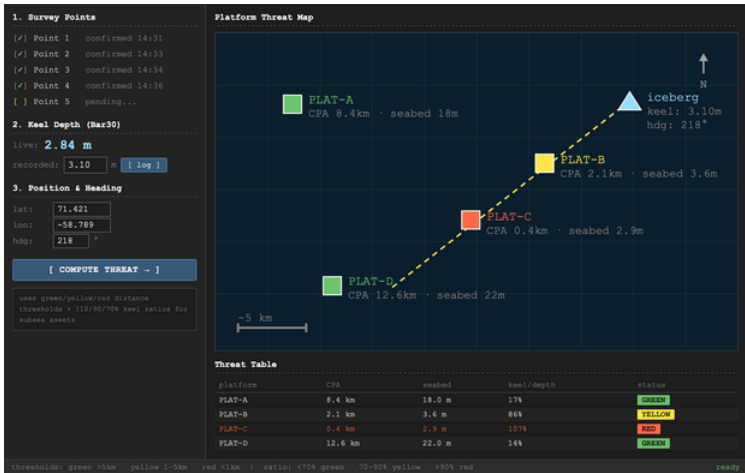


Figure 25: Iceberg Tracking Software - Made by Finlay Mulcahy

is entered into a pre-built threat assessment spreadsheet on the topside MacBook Pro, which automatically calculates the projected iceberg track from the provided latitude, longitude, and heading, computes the closest point of approach to each of the four oil platforms, and evaluates threat levels using the green/yellow/red distance thresholds and the 110%/90%/70% keel-to-depth ratios for subsea assets. Results are displayed as a color-coded platform map shown directly to the station judge. The spreadsheet was validated against multiple synthetic iceberg scenarios during pre-competition preparation to confirm the geometry and threshold logic were correct before competition day.

5. System Integration Diagrams

5.1 Fluid System Integration Diagram

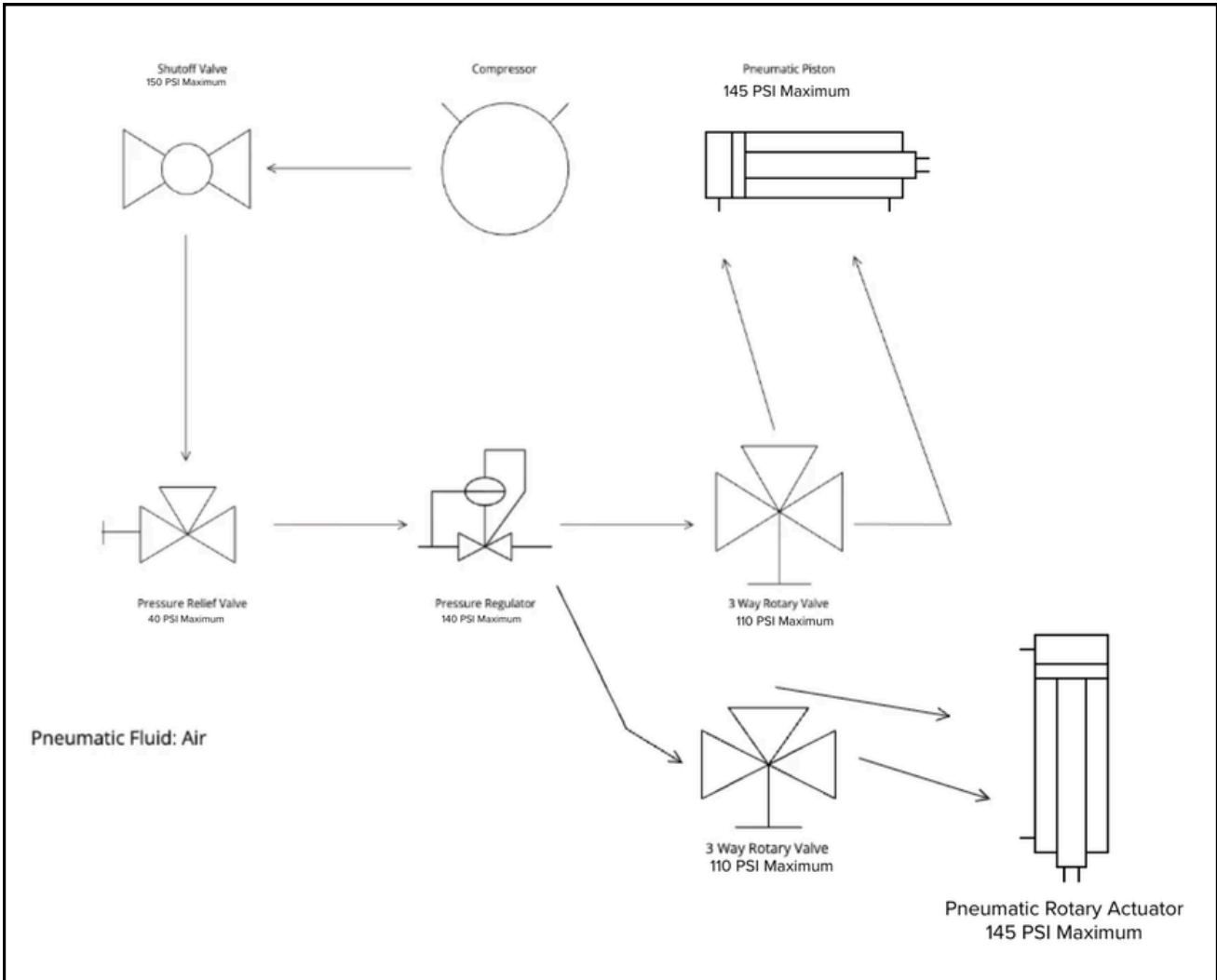


Figure 26: Fluid SID - Made by Robert McIntosh

5.2 ROV Electrical System Integration Diagram

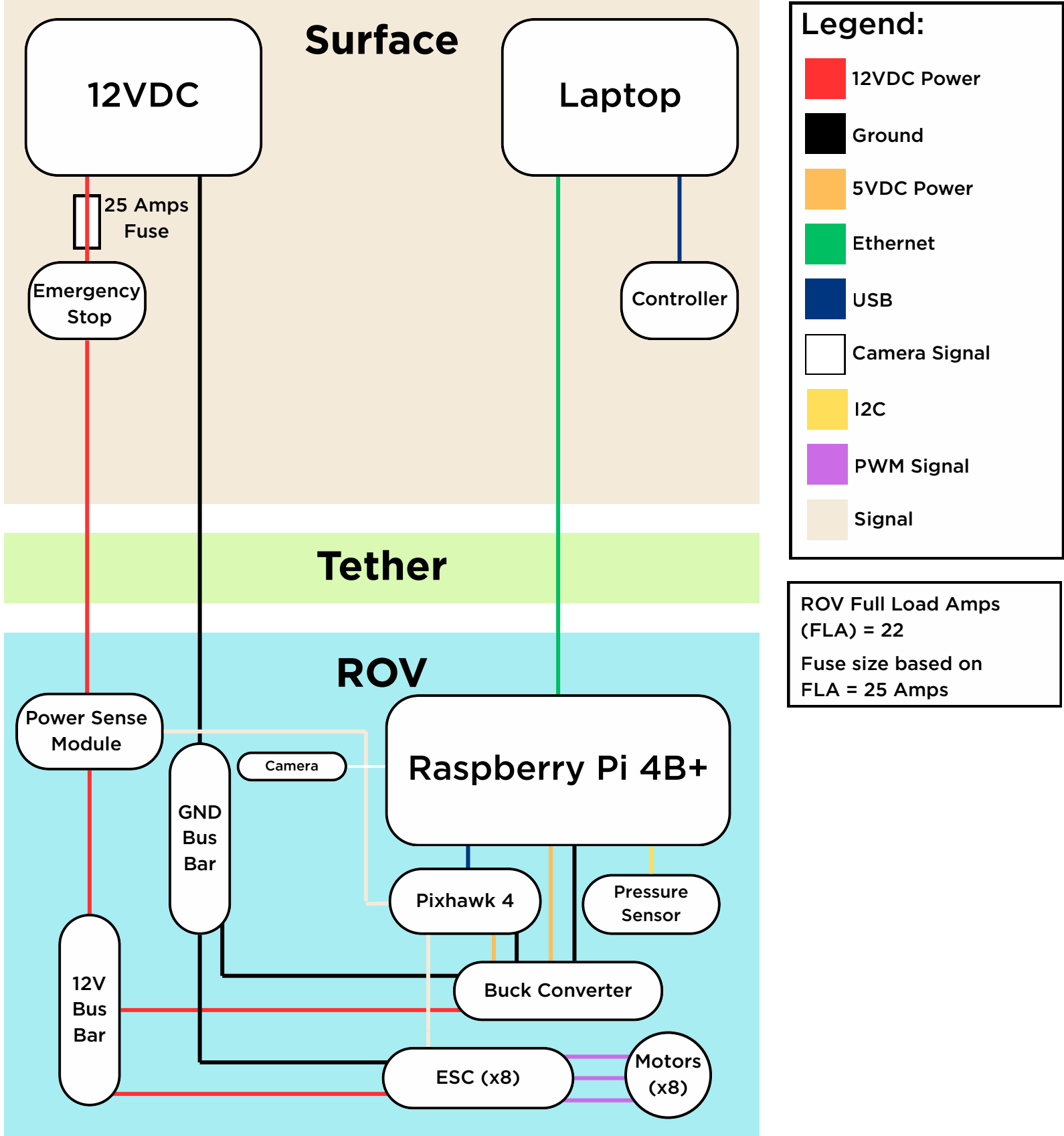


Figure 27: ROV SID - Made by Wyatt Schumacher

5.3 Float Electrical System Integration Diagram

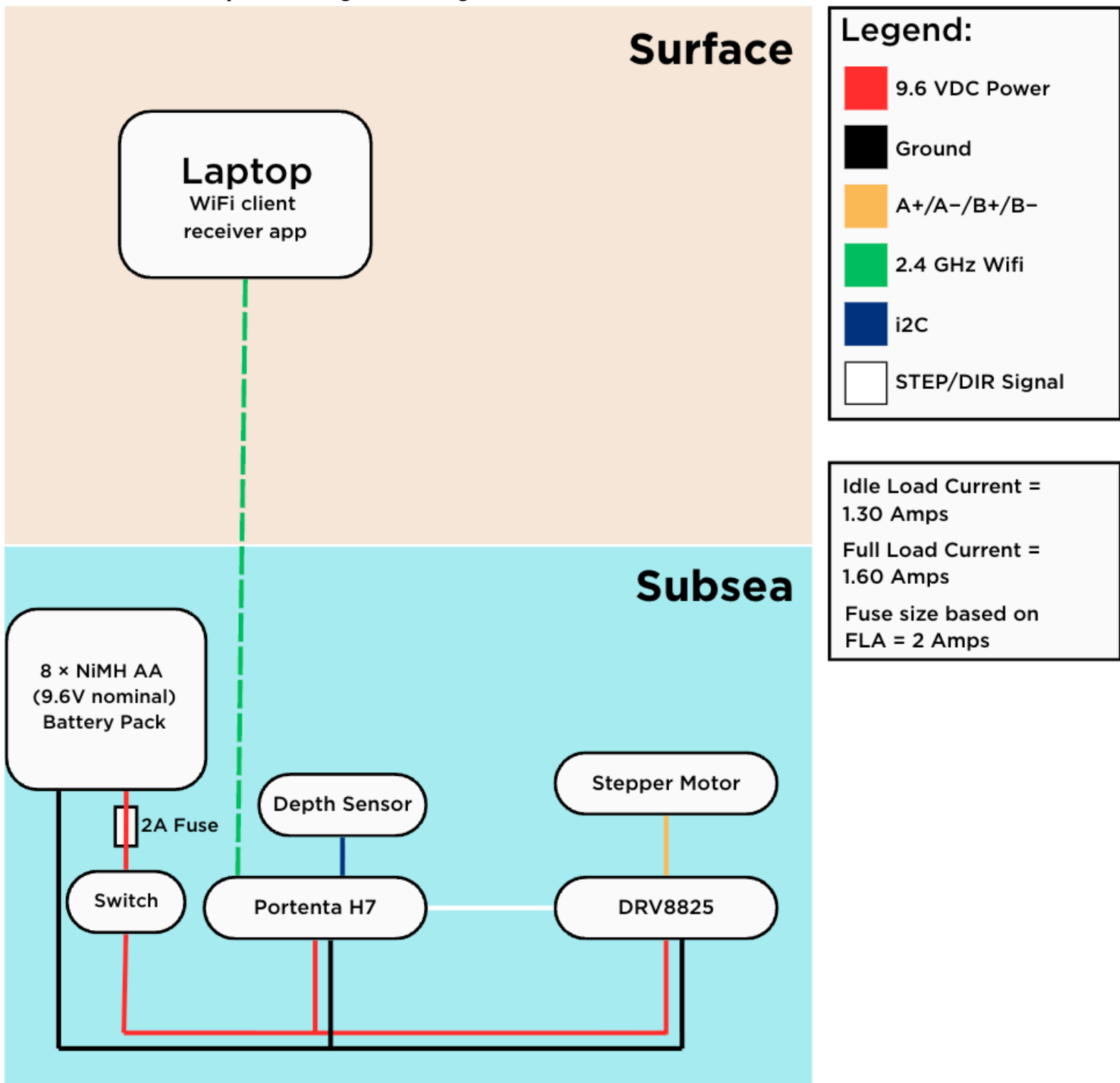


Figure 28: Float SID - Made by Matthew Schwarting

6. Safety

Safety is a foundational design constraint for 'Ōmilu and the Kulia float. Physical, electrical, and software-level safety features are integrated into the vehicle from the earliest stages of the build, and every safety system is verified as part of the pre-dive checklist before each pool session. The Safety Officer maintains all safety documentation and enforces compliance with the protocols below.

6.1 Safety Features

Mechanical safety is built into the vehicle structure. All eight T200 thrusters are fitted with 3D-printed motor guards based on the open-source UWROV design, providing IP2X-compliant protection against accidental contact with rotating propellers during handling, deployment, and recovery. All laser-cut aluminum frame edges are deburred and rounded after fabrication to eliminate sharp edges that could cause cuts during maintenance. Strain-relief thimbles at both ends of the tether prevent load from being transferred directly to connector bodies. Electrical safety is enforced at the system level. A single in-line fuse on the main 12 VDC supply, located within 30 cm of the supply entry and sized to the measured full-load current, protects all onboard wiring against overcurrent. A topside emergency-stop switch on the ROV power line allows operators to cut vehicle power instantly in an emergency. A Blue Robotics leak detector inside the enclosure raises an immediate high-priority alert in the BlueOS cockpit on any water ingress, allowing an emergency ascent before damage occurs. All cable penetrations are sealed with WetLink Penetrators and marine epoxy and validated by vacuum pressure testing before every dive. To avoid condensation and internal moisture buildup, our electronics enclosure includes silica gel packets that wick away humidity.

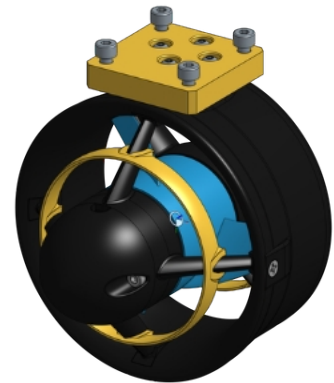


Figure 29: motors with motor guard model -
Made by UWROV



Figure 30: Emergency Stop -
Photo by Luke Vincent



Figure 31: Leak detector that is inside of
the enclosure to detect water - Photo by
Blue Robotics



Figure 32: Silica Gel to remedy moisture
buildup - Photo by Robert McIntosh

The pneumatic system incorporates independent safety controls at the topside station. The claw operates at a regulated pressure set below the rated limit of every fitting and tube in the circuit. A pressure relief valve in the topside assembly prevents over-pressurization, and a shutoff valve isolates the pneumatic supply completely during set-up and breakdown.

6.2 Safety Procedures

All team members follow established safety protocols during every build, test, and competition activity. New members receive a safety orientation at the start of the season and are paired with experienced members when using power tools or working near water until competency is demonstrated and documented.

All team members are required to wear safety glasses and closed-toe shoes at all times in the build space and poolside, and nitrile gloves are worn when handling epoxy or sealant. All electrical connections are made and inspected with the supply disconnected, and power is applied only after all members confirm they are clear of

the vehicle. On the pool deck, the tether is fully laid out before the vehicle enters the water and a dedicated tether manager is assigned for every run. Compressor pressure is set and verified against the regulator gauge before any dive, and the pilot announces every claw actuation verbally. Power tools are used only by trained members and only under mentor supervision.

6.3 Pre-Dive Checklist

The following checklist is completed and signed off by the Safety Officer or a designated mentor before every dive.

- ☐ Perform a vacuum pressure test on the electronics enclosure — hold vacuum for a minimum of 60 seconds with no measurable drop.
- ☐ Inspect O-ring seals on both enclosure endcaps — confirm intact, correctly seated, and lubricated with silicone grease.
- ☐ Verify all WetLink Penetrators are hand-tight and the epoxy seal is intact.
- ☐ Confirm the leak detector is powered and shows a clear status in the BlueOS cockpit.
- ☐ Tug each thruster body to confirm secure mounting — check all mounting bolts on each thruster.
- ☐ Verify motor guards are installed on all eight T200 thrusters.
- ☐ Confirm all tether connections are secure at the ROV end and the topside end.
- ☐ Attach and tug the tether strain-relief thimble at the ROV end.
- ☐ Test the emergency-stop switch — confirm it cuts power to the ROV when activated.
- ☐ Power on the vehicle and verify all eight thrusters respond correctly to controller input in manual mode.
- ☐ Verify the live camera feed is visible in the BlueOS cockpit on the topside MacBook.
- ☐ Verify Bar30 depth readings are updating in the cockpit display.
- ☐ Test the pneumatic claw — open and close three times; confirm full travel and no audible air leaks at the fittings.
- ☐ Confirm the pilot and tether manager are in position and have confirmed readiness before the vehicle enters the water.

Checklist signed off by: _____ Date: _____

Figure 33: Pre-dive checklist used before pool testing - Made by Santino Tribuiano

7. Vertical Profiling Float

7.1 Float Overview and Structure

Alongside Ōmilu, Mana Robotics has designed and built Kulia, an independent vertical profiling float that completes the 2026 competition’s non-ROV vertical profile task without thruster assistance. Kulia is a self-contained system, which means it descends, holds depth, ascends, and transmits its data autonomously.

Kulia is built around a 500 mL syringe buoyancy engine inside a Blue Robotics tube measuring 400 mm in length by 100 mm in diameter, chosen for its dual O-ring end caps and proven depth rating. A fully custom 3D-printed PLA chassis bolts inside the tube, locating the motor, lead screw, and syringe along the float’s central axis and keeping the center of mass aligned below the center of buoyancy for passive vertical stability.

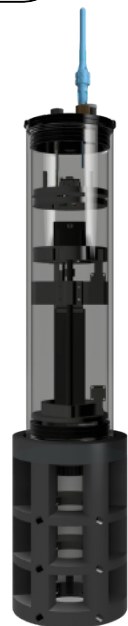


Figure 34: Float CAD Model - Design by Conor Cavens

7.2 Buoyancy Engine

Kulia’s buoyancy engine moves water into and out of the syringe chamber using an 8 mm T8 lead screw turned by a NEMA 17 stepper motor with 59 N·cm of holding torque. When the motor drives the lead screw inward, the plunger retracts and draws water into the syringe; the resulting increase in system mass makes the float negatively buoyant and it descends. Reversing the motor pushes the plunger forward, expels the water, and returns the float to positive buoyancy.



7.3 Profile Sequence and Communication

Before deployment, the Portenta H7 wirelessly transmits the first data packet to the shore-station receiver. Each packet carries the company number, elapsed float time in seconds, pressure in kPa, and computed depth in meters. Once the shore station confirms receipt, the float is released and the buoyancy engine begins its descent. All packets recorded during both profiles are stored onboard and retransmitted in full after the float completes its vertical profiles.

Communication is handled by the Portenta H7's integrated 2.4 GHz WiFi radio. The Portenta operates as a WiFi access point, and the shore-side laptop joins the float's network and runs a custom receiver application that logs every incoming packet and renders a depth-over-time graph in real time. The WiFi antenna exits the enclosure through a cable penetrator epoxy-potted into the upper end cap.

7.4 Float Power and Safety

Kulia runs on eight NiMH AA cells wired in series, producing a nominal 9.6 V supply rail. The pack is seated in a printed retention tray and held with mechanical clips so no cell can shift during a profile. A Blue Robotics watertight switch mounted on the end cap controls power without opening the enclosure. All onboard power passes through a single 2 A ATO blade fuse within 5 cm of the battery positive terminal. If internal pressure rises above external pressure, the float housing is designed to release pressure through the non-fastened O-ring end cap before dangerous pressure can build inside the tube. No fasteners are used to restrain the pressure-relief end cap.

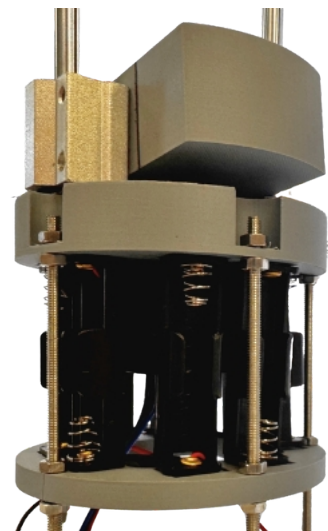


Figure 36: Battery Cell Holding System - Photo by Matthew Schwarting

Figure 35: Vertical Profiling Float Interior- Photo by Robert McIntosh.

8. Critical Analysis

8.1 Vehicle Testing Methodology

Vehicle testing followed a staged methodology: bench validation of individual subsystems, integrated dry testing of the assembled vehicle, and progressive wet testing in the HPA pool. Each stage had to be passed before advancing to the next. After every wet session the enclosure was opened, all internal components were inspected for moisture or wear, and the pre-dive checklist was used to document seal condition before resealing.

8.2 Troubleshooting Strategies

When failures occurred during testing, the team applied an isolation-first troubleshooting method: identify the smallest system boundary containing the failure before replacing any hardware. Multimeters, the BlueOS diagnostic interface, and serial console output from the Raspberry Pi were the primary diagnostic tools. One recurring challenge was the long shipping lead time of operating from Hawai'i. A failed component could mean a one-to-two-week wait for a replacement from mainland suppliers. This drove a deliberate strategy of ordering critical spares, such as ESCs, O-rings, and WetLink Penetrators, at the start of the season, before any failures occurred, to maintain a poolside spares inventory.



Figure 37: Engineers Testing a Control Board. From Left to Right, Robert M. (11th), Finlay M. (11th) - Photo by Conor Cavens

8.3 Prototyping and Design Iteration

Prototyping was used extensively in the development of 'Ōmilu, particularly for the claw mechanism and the electronics organization bracket. Early claw prototypes were printed at reduced infill density to accelerate print time and surface geometric issues before committing to full-strength production prints. Each claw iteration was bench-tested for grip force, actuator compatibility, and prong travel before the next design was modeled. The electronics organization bracket went through a similar process. The first version was modeled from datasheet dimensions; the second corrected errors found when the actual components were measured and placed in the enclosure; the third and final version added retention clips for the ESC wiring harness after vibration during testing caused cables to shift and make intermittent contact.



Figure 38: Prototype of claw design - Photo by Robert McIntosh

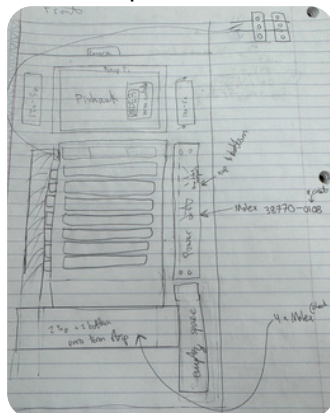


Figure 39: Prototype sketch of electronics inside ROV enclosure-Made by Wyatt Schumacher

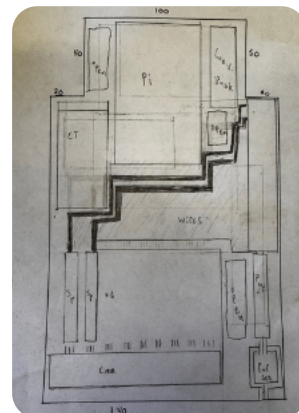


Figure 40: Final sketch of electronics inside ROV enclosure - Made by Wyatt Schumacher

8.4 Engineering Challenge: Designing and Building an In-House Clean Room



Figure 41: Clean room interior - Photo by Robert McIntosh

Mana Robotics designs and builds every vehicle in a renovated shed behind the school. The space is safe and serviceable, but it is uninsulated and sits in what is effectively a wind tunnel, as it is a consistently dusty, windswept site on the Big Island. Airborne dust proved to be more than a nuisance: it repeatedly contaminated O-ring seals and sealing surfaces during enclosure assembly, and a single particle trapped on a sealing face is enough to compromise a waterproof joint. After tracing several seal failures and vacuum-test problems back to dust contamination, the company recognized that no amount of careful assembly technique would solve a problem that was fundamentally about the environment in which it was assembled. Rather than accept the constraint, the team treated it as an engineering problem and designed a clean room from scratch. The structure was built from a frame of PVC pipe, walls of thick construction plastic sheeting supplemented with trash bags to close gaps, and a plastic zipper door to allow entry and exit without



Figure 42: Clean room while being built - Photo by Robert McIntosh

breaking the seal. To push contamination control further, the team implemented a homemade positive-pressure system. By maintaining the interior of the clean room at a slightly higher pressure than the surrounding shed, air flows outward through any small gaps rather than inward, so dust-laden outside air is actively kept from entering during assembly. Positive pressurization is the same principle used in professional clean rooms and electronics manufacturing facilities, reproduced here with improvised hardware. Since the clean room was built, dust-related seal contamination during enclosure assembly has been substantially reduced.

9. Accounting

Mana Robotics maintained financial oversight throughout the 2026 season by separating budget planning from project cost accounting. The budget was used as a projected plan for vehicle construction, the Kulia float, electronics, waterproofing, registration, and travel. Project cost accounting was used to record the actual value of purchased items, reused components, and secured funding. All costs are reported in USD. Purchased items are listed at the amount paid by the company. Reused components from the 2025 vehicle are listed at current market value so the accounting reflects the true cost of recreating the system. No part donations were recorded in the current project costing; cash donations and fundraising are included as income sources.

9.1 Budget

At the start of the season, the CFO/COO created a budget based on the expected cost of building ‘Ōmilu, building Kulia, registering for the competition, and traveling from Hawai‘i to the World Championship. Because Mana Robotics is located on Hawai‘i Island, travel was one of the largest budget categories. The original flight estimate was \$18,500 for 12 people. After routes and attendance were updated, the flight estimate was reduced to \$10,750 for 13 people. Hotel costs were estimated at \$5,400 for six rooms over nine nights. No rental car was budgeted because shuttle transportation is available.

The budget changed throughout the season as the company made design decisions, reused working 2025 components, and selected lower-cost fabrication methods where they did not reduce performance. The final budget reflects both the direct cost of building the ROV and float and the larger cost of bringing the company to competition.

Table 9. Mana Robotics 2026 Budget Summary

Category	Type	Amount (USD)
Vehicle, float, tools, and materials purchased new	Purchased new	\$3,075.04
Reused / prior-year components at market value	Re-used	\$1,872.99
Competition travel: flights	Purchased new	\$10,750.00
Competition travel: hotel	Purchased new	\$5,400.00
MATE Competition registration	Purchased new	\$450.00
Total documented project value		\$21,548.03

Figure 43: 2026 Budget Summary - Made by Leia Benioff

9.2 Income and Funding

Mana Robotics funded the 2026 season through existing team funds, camp fundraising, and donations. The company’s robotics camp program served two purposes: it supported STEM outreach for younger students and raised funds for the competition season. Camp sessions raised \$2,970. The remaining secured funding came from existing team balance and donations, including a major donation entered in March.

Table 10. Sources of Income for Mana Robotics 2026

Source	Notes	Amount (USD)
Existing team balance and donations	Secured team funds, including major March donation	\$12,487.00
Robotics camp fundraising	Funds raised through student-led robotics camps	\$2,970.00
Total secured funding		\$15,457.00

Figure 44: 2026 Sources of Income - Made by Leia Benioff

9.3 Project Cost

Mana Robotics used project cost accounting to track both the cash spent during the season and the fair market value of reused components. Purchased items are listed at actual cost. Reused components from the 2025 vehicle are listed at current market value so the accounting reflects the true cost of recreating the system. Cash donations and fundraising are included as income sources, while reused parts are counted as project value but not as new cash spent. The company reused major working components from the 2025 vehicle when they still met the 2026 mission requirements. This reduced the amount of new money required while still showing the full value of the vehicle system. Reused components included six Blue Robotics T200 thrusters, six Basic ESCs, a Pixhawk 4 flight controller, and a Raspberry Pi 4B. New spending focused on systems redesigned for 2026, including the aluminum frame, waterproof enclosures, float components, sensors, and fabrication supplies.

Item/Description				Category		
#	Type		Qty	Line Total	Unit Cost	
1	Cash donated / raised	Existing team balance and donations	1	\$12,487.00	\$12,487.00	Income
2	Cash donated / raised	Robotics camp fundraising	1	\$2,970.00	\$2,970.00	Income
3	Purchased new	WetLink Penetrator M10 6.5 mm LC	4	\$46.80	\$11.70	Enclosure / Waterproofing
4	Purchased new	WetLink Penetrator Blank M10	8	\$43.20	\$5.40	Enclosure / Waterproofing
5	Purchased new	Cast acrylic tube, 6 in, 298 mm	1	\$200.00	\$200.00	Enclosure / Waterproofing
6	Purchased new	O-ring flange, 6 in series	2	\$180.00	\$90.00	Enclosure / Waterproofing
7	Purchased new	End cap, aluminum, 6 in, 15 x M10	1	\$58.00	\$58.00	Enclosure / Waterproofing
8	Purchased new	End cap, acrylic blank, 6 in	1	\$53.00	\$53.00	Enclosure / Waterproofing
9	Purchased new	M10 enclosure vent and plug	1	\$12.00	\$12.00	Enclosure / Waterproofing
10	Purchased new	Potted cable penetrator M10 6 mm	4	\$24.00	\$6.00	Enclosure / Waterproofing
11	Purchased new	Potted cable penetrator M10 8 mm	4	\$24.00	\$6.00	Enclosure / Waterproofing
12	Purchased new	Spare O-ring set, 6 in series	2	\$28.00	\$14.00	Enclosure / Waterproofing
13	Purchased new	Spare bulkhead O-ring set M10	1	\$3.00	\$3.00	Enclosure / Waterproofing
14	Purchased new	O-ring flanges, 100 mm / 4 in	2	\$100.00	\$50.00	Enclosure / Waterproofing
15	Purchased new	End cap, aluminum, 100 mm, 10 x M10	1	\$42.00	\$42.00	Enclosure / Waterproofing
16	Purchased new	Spare O-ring set, 100 mm / 4 in	4	\$12.00	\$3.00	Enclosure / Waterproofing
17	Purchased new	Cast acrylic tube, 100 mm, 400 mm	1	\$300.00	\$300.00	Enclosure / Waterproofing
18	Purchased new	Vacuum plug	1	\$8.00	\$8.00	Enclosure / Waterproofing
19	Purchased new	T200 thruster	2	\$460.00	\$230.00	Propulsion
20	Purchased new	Basic ESC	2	\$80.00	\$40.00	Electronics & Control
21	Purchased new	Bar02 depth/pressure sensor, 0-2 bar	2	\$160.00	\$80.00	Sensors
22	Purchased new	Pressure relief valve	1	\$32.00	\$32.00	Pneumatics / Fluid Power
23	Purchased new	Watertight switch	1	\$28.00	\$28.00	Electrical & Safety
24	Purchased new	Molykote 111 silicone grease, 6 g	2	\$8.00	\$4.00	Adhesives & Consumables
25	Purchased new	Loctite marine epoxy	1	\$10.00	\$10.00	Adhesives & Consumables
26	Purchased new	WetLink Bulkhead Wrench M10	1	\$17.00	\$17.00	Tools
27	Purchased new	WetLink Penetrator Assembly Block	1	\$21.00	\$21.00	Tools
28	Purchased new	WetLink penetrator plug wrench, 14 mm	1	\$15.00	\$15.00	Tools
29	Purchased new	WetLink penetrator plug wrench, 11 mm	1	\$16.00	\$16.00	Tools
30	Purchased new	Tariff surcharge	1	\$181.68	\$181.68	Tax / Shipping / Fees
31	Purchased new	Taxes, Blue Robotics order	1	\$99.16	\$99.16	Tax / Shipping / Fees
32	Purchased new	Shipping, Blue Robotics order	1	\$40.33	\$40.33	Tax / Shipping / Fees
33	Purchased new	BotTop.dxf laser-cut plate, OSH Cut	1	\$144.47	\$144.47	Frame Fabrication
34	Purchased new	NewSide.dxf laser-cut side plates, OSH Cut	2	\$204.56	\$102.28	Frame Fabrication
35	Purchased new	Shipping, OSH Cut	1	\$69.70	\$69.70	Tax / Shipping / Fees
36	Purchased new	Bambu Lab PLA matte filament, 1 kg, ash gray, including sales tax	3	\$77.25	\$25.75	3D Printing Materials
37	Purchased new	Fastener kit M2-M4 countersunk, 1280 pc	1	\$18.99	\$18.99	Hardware & Fasteners
38	Purchased new	Fastener kit M2-M5 pan head, 1315 pc	1	\$22.54	\$22.54	Hardware & Fasteners
39	Purchased new	Paracord 4 mm, 1000 lb reflective	1	\$5.98	\$5.98	Tether / Rigging
40	Purchased new	Micro paracord, 1.18 mm, 125 ft	1	\$6.64	\$6.64	Tether / Rigging
41	Purchased new	Sales tax, fasteners/paracord order	1	\$2.54	\$2.54	Tax / Shipping / Fees
42	Purchased new	25 A ATO blade fuses, 50 pc, including sales tax	1	\$5.36	\$5.36	Electrical & Safety
43	Purchased new	Cyanoacrylate super glue, 4 g x 8	1	\$8.99	\$8.99	Adhesives & Consumables
44	Purchased new	Sales tax, super glue order	1	\$0.42	\$0.42	Tax / Shipping / Fees
45	Purchased new	Rigid shaft coupler, 5 mm to 8 mm	1	\$9.98	\$9.98	Float / Non-ROV Device
46	Purchased new	Sales tax, shaft coupler order	1	\$0.47	\$0.47	Tax / Shipping / Fees
47	Purchased new	DRV8825 stepper motor driver modules	1	\$9.99	\$9.99	Electronics & Control
48	Purchased new	M4 x 500 mm threaded rod, 10 pc	1	\$33.59	\$33.59	Float / Non-ROV Device
49	Purchased new	SMA to U.FL coaxial cable, 5 pc	1	\$7.22	\$7.22	Float / Non-ROV Device
50	Purchased new	NEMA 17 stepper motor, 84 oz-in, 3 pc	1	\$32.96	\$32.96	Float / Non-ROV Device
51	Purchased new	Meshtastic 915 MHz LoRa antenna	1	\$18.95	\$18.95	Float / Non-ROV Device
52	Purchased new	TMC2209 stepper motor driver, 2 pc	1	\$13.99	\$13.99	Electronics & Control
53	Purchased new	Bingfu dual-band WiFi antenna, 2 pc	1	\$5.39	\$5.39	Float / Non-ROV Device
54	Purchased new	A4988 stepper motor driver, 5 pc	1	\$9.97	\$9.97	Electronics & Control
55	Purchased new	SMA male-to-female bulkhead cable, 2 pc	1	\$7.25	\$7.25	Float / Non-ROV Device
56	Purchased new	AA battery holder with wires, 10 pc	1	\$5.98	\$5.98	Float / Non-ROV Device
57	Purchased new	M5 x 400 mm threaded rod, 4 pc with nuts	2	\$27.38	\$13.69	Float / Non-ROV Device
58	Purchased new	SMA female-to-female bulkhead, 2 pc	1	\$6.99	\$6.99	Float / Non-ROV Device
59	Purchased new	SMA bulkhead adapter coupler, 2 pc	1	\$6.55	\$6.55	Float / Non-ROV Device
60	Purchased new	Sales tax, float components order	1	\$8.77	\$8.77	Tax / Shipping / Fees
61	Re-used	T200 thruster, reused from 2025	6	\$1,374.00	\$229.00	Propulsion
62	Re-used	Basic ESC, reused from 2025	6	\$234.00	\$39.00	Electronics & Control
63	Re-used	Pixhawk 4 flight controller	1	\$209.99	\$209.99	Electronics & Control
64	Re-used	Raspberry Pi 4B 4GB	1	\$55.00	\$55.00	Electronics & Control
65	Purchased new	Flights, competition travel, 13 people	1	\$10,750.00	\$10,750.00	Travel
66	Purchased new	Hotel, 6 rooms, 9 nights, 13 people	1	\$5,400.00	\$5,400.00	Travel
67	Purchased new	MATE Competition registration fee	1	\$450.00	\$450.00	Competition

Figure 45: 2026 Itemized Project Cost - Made by Leia Benioff

Table 12. Project Cost Totals

Category	Amount (USD)
Total purchased-new expenses	\$19,675.04
Total re-used components at current market value	\$1,872.99
Total documented project value	\$21,548.03
Total secured funding	\$15,457.00
Remaining shortfall	\$6,091.03
Per-member contribution if divided across 11 members	\$553.73

Figure 46: 2026 Project Cost Totals - Made by Leia Benioff

Mana Robotics used funds effectively by reusing high-value prior-year components while purchasing only the parts needed to improve reliability, safety, and mission performance. The largest cash expenses were travel and lodging, which were unavoidable because the company is traveling from Hawai'i. On the engineering side, the company controlled costs through in-house 3D printing, laser-cut frame fabrication, and reuse of tested 2025 electronics and propulsion components.

10. Conclusion

10.1 Challenges

The 2026 season presented challenges in several broad areas. The first, carried over from the team's first year, was the shipping lead time inherent to operating from the Big Island of Hawai'i; the company addressed it through early procurement and a maintained spares inventory. The second was the step up in vehicle complexity; moving from a six-thruster vehicle to a full eight-thruster 6-DOF platform with a customized control stack demanded significantly more integration and tuning work than the 2025 build. The third was building two complete systems in parallel, 'Ōmilu and the Kulia float, which the company managed through its sub-team structure and master schedule. The fourth was environmental: dust contamination in the team's uninsulated, wind-exposed build space repeatedly compromised waterproof seals, a problem the company solved by designing and building its own positive-pressure clean room, as described in Section 8.4.

10.2 Lessons Learned

The single most valuable lesson of the 2026 season was the importance of treating post-competition review as an engineering input rather than a closing formality. After the 2025 World Championship the company conducted a structured debrief of every subsystem, including vehicle architecture, documentation, schedule management, and budget accuracy, and converted each identified gap into a concrete design or process change for the following season. That discipline is visible throughout this report: in the schedule graphic, the tether subsystem documentation, the depth of the design-rationale trade studies, and the precision of the budget figures. Beyond documentation, the team strengthened its testing methodology, its troubleshooting process, and its understanding of how decisions in one engineering domain propagate into constraints on another.

10.3 Future Improvements

Looking ahead, the company has identified several directions for future development: adding a second camera dedicated to the manipulator for improved task visibility, refining the claw toward a fully electric actuation system for tighter software integration, and continuing to improve the modularity of the tool-mounting interface so new payloads can be developed without frame changes. Each of these will be evaluated through the same documented trade-off process used throughout this report.

11. References

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