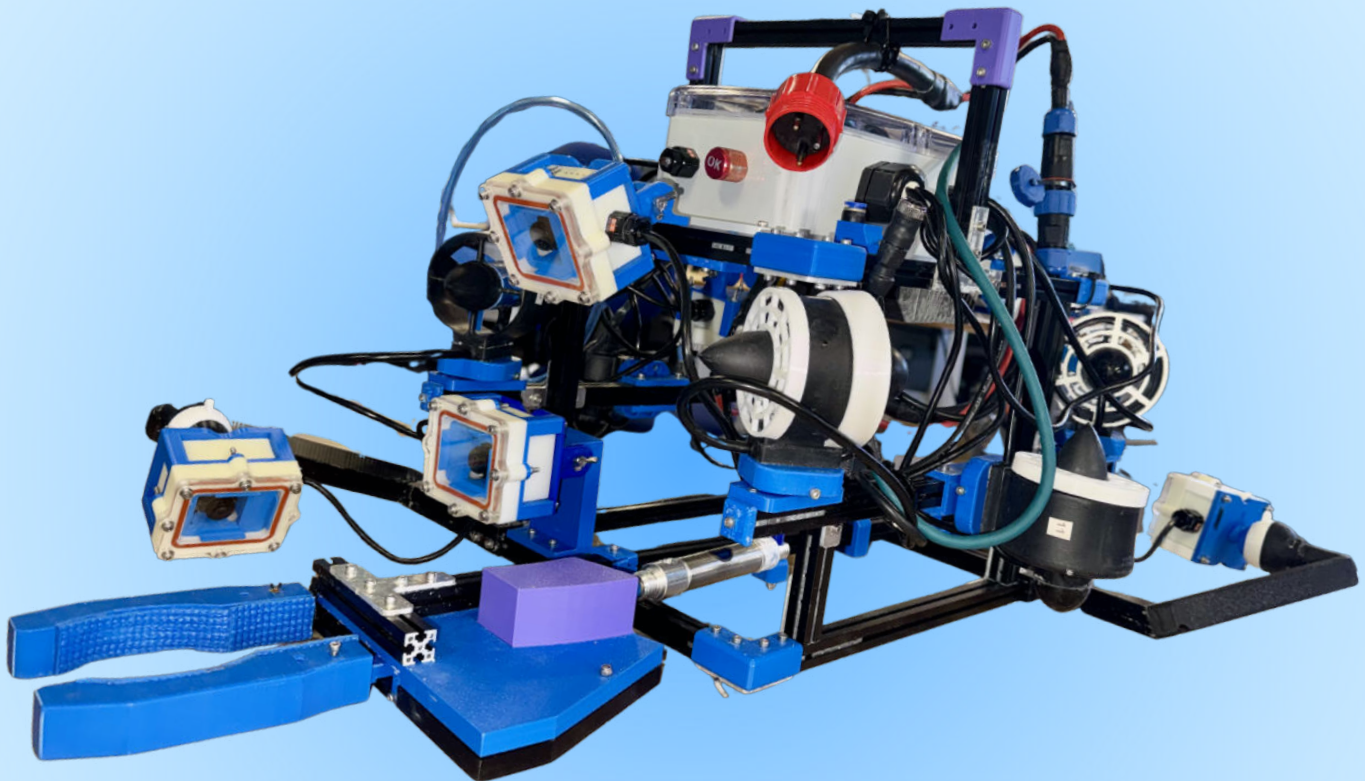


GENESEAS

ST. FRANCIS HIGH SCHOOL • SACRAMENTO, CA USA • TEAM 0371A



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**RETURNING GENESEAS MEMBERS

*PREVIOUS MATE ROV COMPETITORS, NEW GENESEAS MEMBERS

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1. ABSTRACT

Geneseas is proud to present *Aurelia*, our seventh-generation remotely operated vehicle (ROV) specifically engineered to meet the goals of the Decade of Action for Cryospheric Sciences and successfully complete the tasks outlined in the 2026 Marine Advanced Technology Educate (MATE) Request for Proposal (RFP). In *Aurelia's* design, Geneseas focused on improving safety, serviceability, and reliability through a redesigned pneumatics system, transitioning from Power Line Communications to M12 ethernet connections, a second generation custom USB hub supporting future expansion of up to 16 cameras, and the addition of image recognition capabilities. *Aurelia* is paired with *Aviva*, a sophisticated vertical profiling float that uses a buoyancy engine to monitor water column health. Engineered for enhanced safety, serviceability, and reliability, *Aurelia* and *Aviva* support ocean sustainability tasks - including coral garden modeling, lobster pot recovery, and iceberg threat assessment - by using purpose-built tools such as photogrammetry software, an inflatable lift bag, two multifunction grippers and advanced image recognition. The *Aurelia* ROV and *Aviva* float directly advance marine ecosystem protection while contributing to the United Nations Sustainable Development Goals. This technical document details *Aurelia* and *Aviva's* design processes, testing methodologies, project timelines, and cost analyses needed to address the efficacy of offshore wind turbines in powering offshore oil rigs, map the seabed and document discoveries, deploy instrumentation and monitor the health of cold-water habitats, and operate equipment under the ice.



FIGURE 1. GENESEAS 2026 TEAM MEMBERS

2. TEAMWORK

2.1 PROJECT MANAGEMENT

A. COMPANY PROFILE

Geneseas is a Sacramento-based, all-female underwater robotics company composed of 24 engineers dedicated to advancing marine technology and promoting ocean sustainability by developing submersible ROVs. Since 2019, Geneseas has developed a sustainable company model that emphasizes leadership and technical mentorship while also supporting long-term organizational growth.

Geneseas' talent pipeline is critical to future success. This year, Geneseas mentored both a MATE NAVIGATOR team, composed of St. Francis students with no prior experience in robotics, and a MATE SCOUT team, consisting of middle school girls from the greater Sacramento area. Through these programs, Geneseas members were able to continue the team's peer-to-peer mentoring system while strengthening the pipeline of future EXPLORER class engineers to ensure team sustainability.

Geneseas operates with a two-level leadership structure (Figure 2). The Executive Leadership Team (ELT) focuses on the long-term success of the program and team dynamics by driving organizational strategy, leading meetings, developing schedules, tracking department progress, and resolving logistical or interpersonal challenges. Operating underneath ELT is the Functional Leadership Team (FLT), which is

composed of department leads. FLT directs subsystem development and testing while mentoring and supporting team members. Together, ELT and FLT lead the organizational and technical aspects of the company throughout the build season.

Geneseas is structured into five departments: Mechanical, Float, Tools, Software, and Electrical. Each department is responsible for the design, creation, testing, documentation, and integration of their subsystems. Members gain hands-on experience in Computer-Aided Design (CAD), programming, soldering, circuit board fabrication, system integration, and safety procedures. Departments regularly collaborate through design reviews and clear communication of requirements and constraints to ensure components function reliably and cohesively once assembled into the final ROV.

B. SCHEDULE

Geneseas maintains a structured schedule tracker to keep goals organized, on schedule, and within budget. At the start of the year, ELT and FLT assign specific projects to employees based on interest, as members are encouraged to pursue projects they are genuinely curious about. This approach allows employees to develop new skills while fostering a more self-driven team

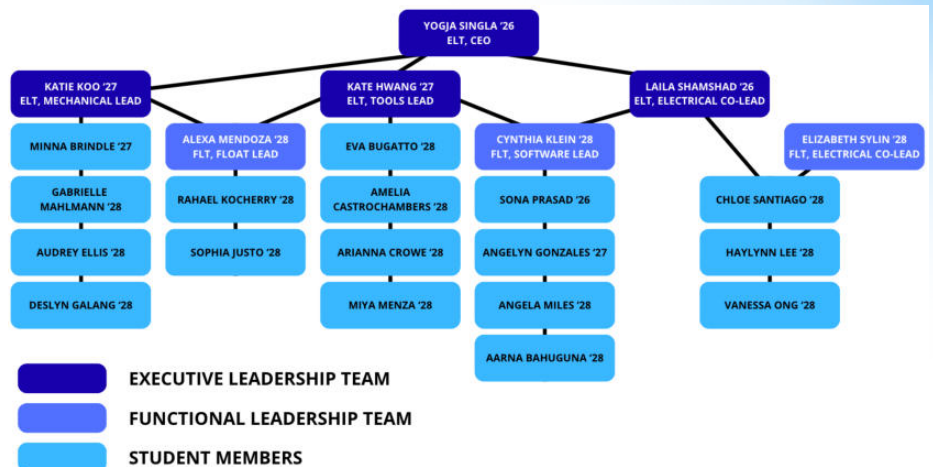


FIGURE 2. COMPANY ORGANIZATIONAL CHART

culture, reflecting *Geneseas*' philosophy of prioritizing growth over prior experience.

Schedule	Owner	9/20	9/20	9/27	9/27	10/4	10/4
Float							
Software	Rahael	Look at old software and see what it does	Start making Theory of Operation for the BE	Figure out the logistics for how the pump changes how the code works from the syringe.	Start on changing the code to fit the pump if ready. If not figure out logistics for the algorithm that is stabilizing the BE.	Look at the code for the up and down motion see how it can be streamlined (absent)	Clean up some of the code for the up and down motion and the increments of motion (absent)
Mechanical	Sophia	Brainstorm ideas for frame (make smaller) (absent so alexa will take over)	determine size of tube and housing (absent so Alexa will take over)	Take a look at last year's CAD designs (choose what we like, what we want to change)	Start CADing for parts of engine, add modifications ?	Continue CADing and make buy list	Finish CADing and conclude designs
Electrical	Alexa	Refer to SID from last year + begin SID	Work on SID	Finish SID and begin schematic on KICAD	Work on schematic	Work on schematic and complete	Start layout

FIGURE 3. PART OF SCHEDULE TRACKER

Geneseas uses a spreadsheet to track all projects while keeping subteams aligned and members accountable (Figure 3). Every employee has access to this tracker and is responsible for consistently outlining their goals for each practice, specific deadlines, and project progress. Additionally, the schedule tracker utilizes a color-coded system, making it easy to identify which projects are falling behind and which are on track.

Starting in September, the team met every Saturday to design, build, and test the ROV, with extra, optional lab days during the week. Each Saturday work session began with a group kick-off meeting and ended with a group, end-of-day check-in session, allowing employees to communicate obstacles and goals while solving problems collaboratively. Additionally, ELT and FLT held weekly Thursday meetings to review the schedule tracker, reallocate tasks, and refine plans for Saturday meetings.

Through active use of the schedule tracker and frequent team meetings, *Geneseas* was able to ensure timely completion of *Aurelia*, meeting our initial in-pool testing deadline of January 10th and mission tools test on February 28th.

C. RESOURCES

Geneseas uses the full Google Workspace platform for communication, file sharing, and file management. Google Drive is used for documenting system development processes, Google Meet and Google Chat are used for meetings and communication, and Google Sheets is used for tracking schedules and budget. *Geneseas* also uses Github for software updates, documentation, and version control, OnShape for CAD, and Canva for creating presentations and MATE technical documentation.

3. DESIGN RATIONALE

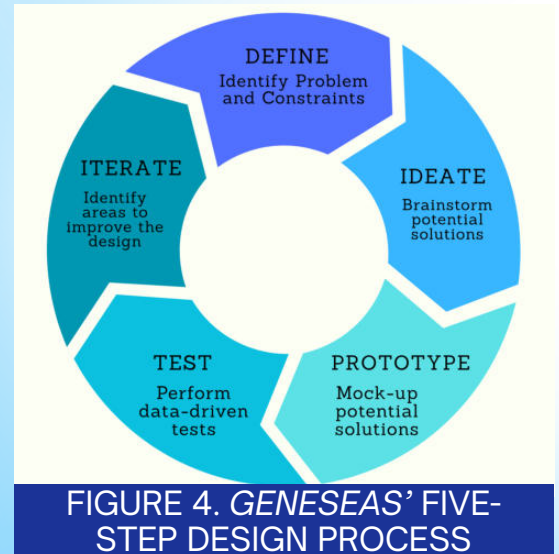
This year, *Geneseas* maintained its core design philosophy of focusing on ROV safety, serviceability, and reliability. Serviceability was especially emphasized this year after the team spent excessive time replacing damaged thruster and camera mounts last season. This focus led to the design and development of custom twist-off thruster mounts that allow for faster repairs and replacements. Safety was improved through new gripper casings that fully cover previously exposed pinch points. Reliability was also enhanced by transitioning to an Ethernet-based communication system.

3.1 SYSTEMS DESIGN APPROACH

Once design objectives were identified, *Geneseas* followed an effective, five-step design

process to ensure all components integrate seamlessly into the final ROV system. Within each subteam, employees responsible for individual projects completed their own version of the five-step process (Figure 4).

The key to this iterative process is the early inclusion of the relevant subject matter experts across subteams, a clear definition of the problem statement, and a comprehensive understanding of the design constraints. This process results in smoother integration of mechanical, electrical, and software components to support the pilot, deck crew, and mission operations.



3.2 VEHICLE SYSTEMS

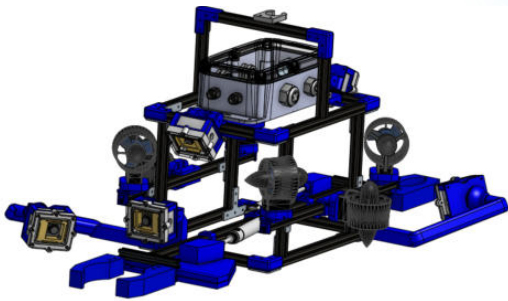


FIGURE 5. AURELIA CAD MODEL

Geneseas used Onshape to design *Aurelia*, updating the CAD model as subsystems were manufactured and assembled. Maintaining an accurate and complete model allowed the team to easily reference measurements and calculate buoyancy, center of mass, and component dimensions. The full CAD model also served as a reference for designing new tools and components, making future development and integration easier.

A. FRAME

Aurelia's frame measures 25 x 32 x 20 cm and consists of extruded aluminum beams connected by custom-designed aluminum brackets. Extruded aluminum beams were chosen because their T-slot rails provide easier access for mounting subsystems to the frame using T-slot nuts, while also offering increased durability to withstand harsh conditions. Aluminum brackets were chosen over 3D-printed alternatives for their superior strength and smaller size. The vertical pillars are slightly inset from the perimeter of the ROV's top and bottom frames, allowing additional components to be mounted without increasing the ROV's overall dimensions.

To address potential safety concerns from exposed sharp aluminum edges, *Geneseas* designed and 3D-printed custom corner covers to protect both the frame and those operating the ROV.

B. PROPULSION

Geneseas maintained *Aurelia's* six thruster configuration from previous years: three counter-rotating thruster pairs that prevent counteracting rotation forces. The team chose to reuse Diamond Dynamic TD1.2 thrusters because of their consistent reliability and cost efficiency, while making new adjustments and enhancements to the thruster configurations (Figure 6).

Four diagonally oriented thrusters are positioned at each corner of the ROV to provide

horizontal translation and rotation. Two vertical thrusters provide vertical translation. *Aurelia* has four degrees of freedom using this arrangement and the included software (Figure 8).

Fixed thruster placement makes it difficult to align the thrust centerline with the center of pressure, resulting in induced pitch. This has been a challenge in the past for many of *Geneseas*' ROVs. In *Aurelia*, all six thrusters are mounted on adjustable bars, allowing the thrust centerline to be adjusted to account for changes in drag when tools are added or removed, and to ensure a level pitch attitude (Figure 7). Once the centerline of thrust is adjusted to account for the ROV's structure and tools, *Aurelia* moves both forwards and backwards while maintaining a level pitch attitude.

	COST	AVAILABILITY	EXPERIENCE	SIZE (mm)	INTEGRATION TIMELINE	PERFORMANCE
DIAMOND DYNAMICS TD1.2	\$	2 DAYS	✓✓	78	✓	✓
BLUE ROBOTICS T200	\$\$\$	1 WEEK	X	100	X	✓✓
BLUE ROBOTICS T100	\$\$	DISCONTINUED (REFURB ONLY)	✓	78	X	✓

FIGURE 6. THRUSTER CHOICE DECISION MATRIX

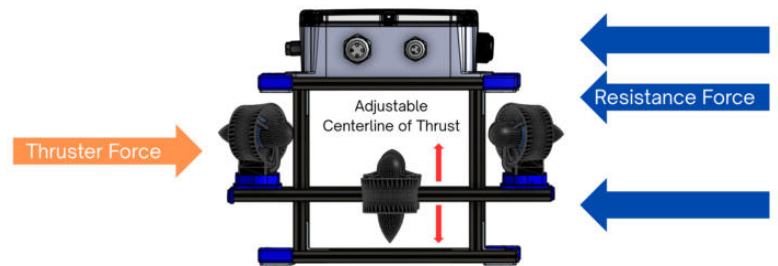


FIGURE 7. THRUST CENTERLINE ADJUSTMENT

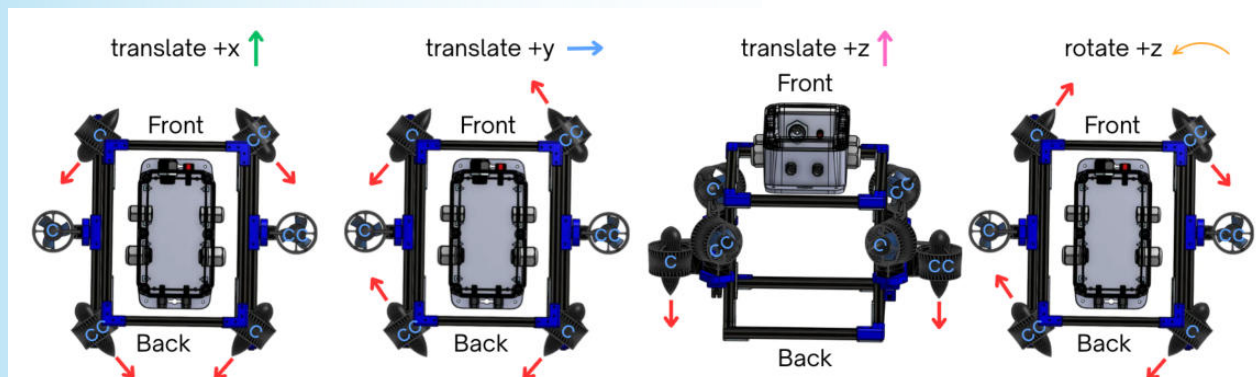


FIGURE 8. THRUSTER ORIENTATION AND OPERATION

Considering the specific performance needed to fight the current in the flume tank, the horizontal thrusters are angled at 60° instead of the standard 45°, maximizing forward/reverse translation while maintaining sufficient right/left translation performance. For enhanced safety, *Geneseas* designed and 3D-printed custom thruster guards, allowing for a precise fit that enhances propeller protection and meets the required IP-20 standard.

C. BUOYANCY AND BALLAST

Aiming to be the lightest possible ROV and still meet mission requirements, *Aurelia* achieves neutral buoyancy by utilizing a smaller electronics housing and three hydrostatic foam blocks. Last year, *Geneseas*' ROV required the addition of 1.4 kg of ballast to achieve neutral buoyancy. While this method worked, it resulted in a heavy ROV, which made handling the ROV difficult. This year, our goal was to initially have a negatively buoyant ROV and then add buoyancy to ensure a lighter, faster, and more maneuverable ROV. *Aurelia*'s smaller electronics housing holds 1.8 L of air, making it significantly easier to achieve neutral buoyancy.

After all components were added to the ROV, *Geneseas* used a hanging scale to weigh *Aurelia* under water. The ROV was 1080 g negatively buoyant. Three 360 cm³ blocks were added to the ROV. Each block provides 300 g of net buoyancy resulting in slight negative overall buoyancy.

Although expensive, hydrostatic foam was chosen for its closed cell structure that can resist penetration by water. In previous years, *Geneseas* used two water bottles to achieve buoyancy, resulting in an inefficient use of space. Hydrostatic foam can be cut to precisely fit the ROV.

D. ELECTRONICS HOUSING

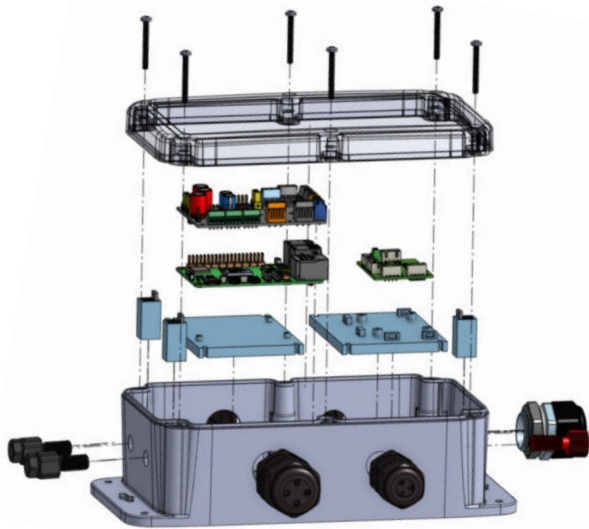


FIGURE 9. EXPLODED DIAGRAM OF ELECTRONICS HOUSING

Aurelia uses an ML-58F Polycase for the electronics enclosure (Figure 9). These enclosures are well established for reliable waterproofing, ease of machining, and cost effectiveness. Water tightness was ensured by selecting a housing that meets IP68 and NEMA 6P specifications - both well beyond mission requirements - and by integrating reliable submersible connectors and following well- established *Geneseas* machining procedures.

Considering the compact size of *Aurelia's* electronics housing, the team selected gland seal cord grips capable of routing multiple wires through a single penetrator.

To ensure reliability, vacuum-testing of the electronics housing after each reassembly is

completed at 10psi for ten minutes. Custom 3D-printed mounts with snap-in pillar joints allow for circuit board installation without tools. To further protect onboard electronics, the electronics housing contains easily replaceable 3D-printed silica-gel compartments to absorb internal moisture.

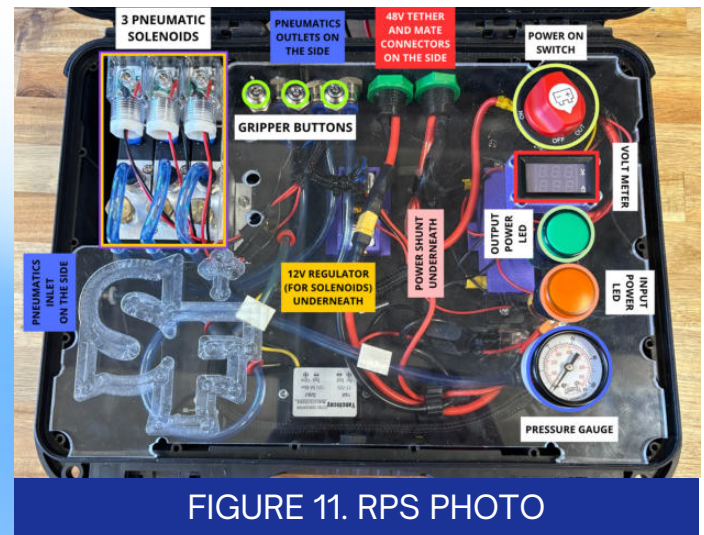
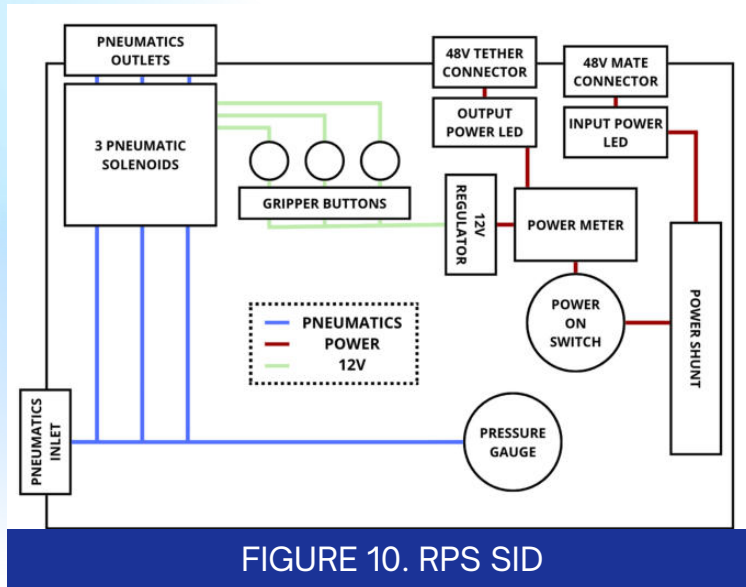
3.3 ELECTRICAL AND CONTROL SYSTEMS

A. RPS

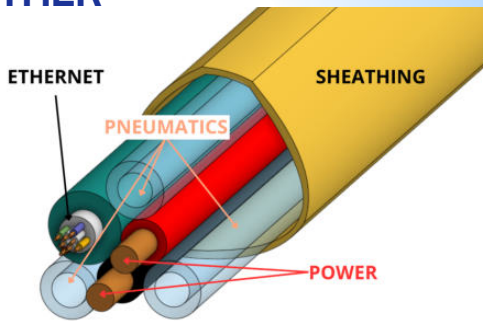
The Remote Piloting System (RPS) centralizes *Aurelia's* pneumatic controls and top-side electronics in a compact and serviceable enclosure (Figures 10 and 11). The system is housed inside of an extremely portable 33 cm x 23 cm x 10 cm NANUK 910 Hard Case, which is a durable case that protects internal components during transport while maintaining portability and ease of access. A transparent acrylic cover allows team members to easily identify and troubleshoot issues, while wire connectors enable straightforward disassembly and replacement of components.

Pressure regulated compressed air enters the RPS through a pneumatic connector. A manifold feeds a pressure gauge and three pneumatic solenoids to supply air to the ROV's two grippers and the lift bag as shown in the Pneumatics SID (Figure 15).

The RPS includes an Anderson SBS-50 for connection to the MATE power supply, power LED indicator lights, emergency power off switch, gripper buttons, voltage and current sensing, and a 12V regulator to power the three solenoids as shown in Electronics SID (Figure 16).



B. TETHER



Aurelia's tether is designed to safely connect all pneumatics and power to the ROV. *Geneseas* utilized a 15 m bright yellow mesh sheathing to contain and organize the tether, improving both visibility and cable management (Figure 12). The sheathing houses the power and ground wires, three pneumatic tubes, and the ethernet cable. The tether connects to the ROV via a two-pin Subconn power connector and an M12 ethernet connector.

The ROV-side fixed Kellem-style strain relief securely attaches the tether to the ROV while the top-side strain relief connects the tether to the control station. The wire mesh strain reliefs are wrapped with self-fusing silicone tape to cover exposed metal edges and ensure safety while handling the tether. Water bottles are attached throughout the tether for added buoyancy to prevent entanglement during missions.

C. ROV ELECTRONICS

Aurelia's electronics system was designed for reliability and serviceability through a modular setup consisting of three main boards: a Raspberry Pi 5, a custom Raspberry Pi HAT PCB, and a custom USB hub.

Geneseas uses a single watertight ethernet cable with an M12 connection to provide fast, stable connection with enough bandwidth to support all six cameras. Transitioning from *Geneseas's* previous Power Line Communication networking infrastructure to native Ethernet improved camera streaming reliability, eliminated disconnects, and increased bandwidth from 150 Mb/s to nearly 1 Gb/s.

Aurelia's fourth-generation, bottom-side PCB HAT connects the Raspberry Pi 5 to six

thrusters and Electronic Speed Controllers (ESCs) through screw-terminals, while also interfacing with mission tools through solid-state relays (Figures 13 and 14). The HAT includes a streamlined wiring layout, an onboard crystal oscillator for precise PWM control, and capacitors that prevent voltage spikes and supply power during sudden demand changes.

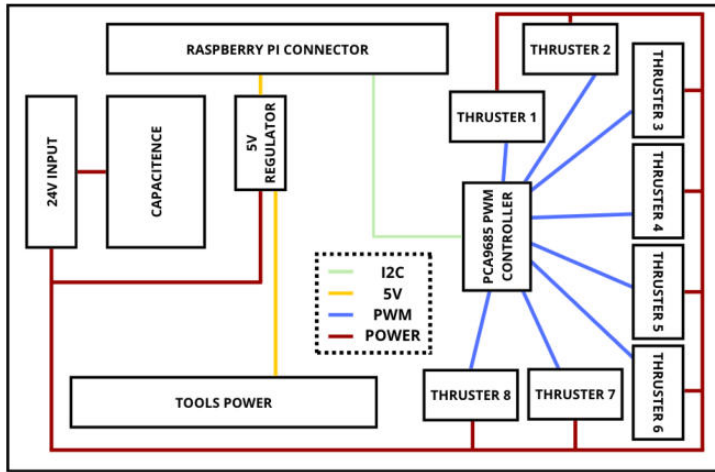


FIGURE 13. RASPBERRY PI HAT SID

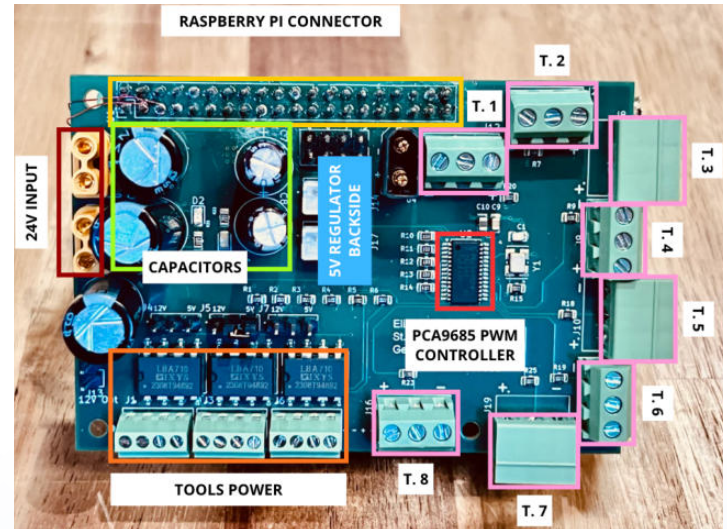


FIGURE 14. RASPBERRY PI HAT PHOTO

To meet EXPLORER class 48 V requirements, *Geneseas* upgraded *Aurelia* from a 12 V to 48 V system using two waterproof 480W 48 V-24 V DC regulators mounted beneath the electronics housing. Detachable waterproof power connectors allow the power converters to be serviced or replaced quickly. Given the decision to move to the EXPLORER class in mid-December, and the resulting compressed timeline, this architecture provides the right balance of schedule, risk, and performance.

D. SIDS

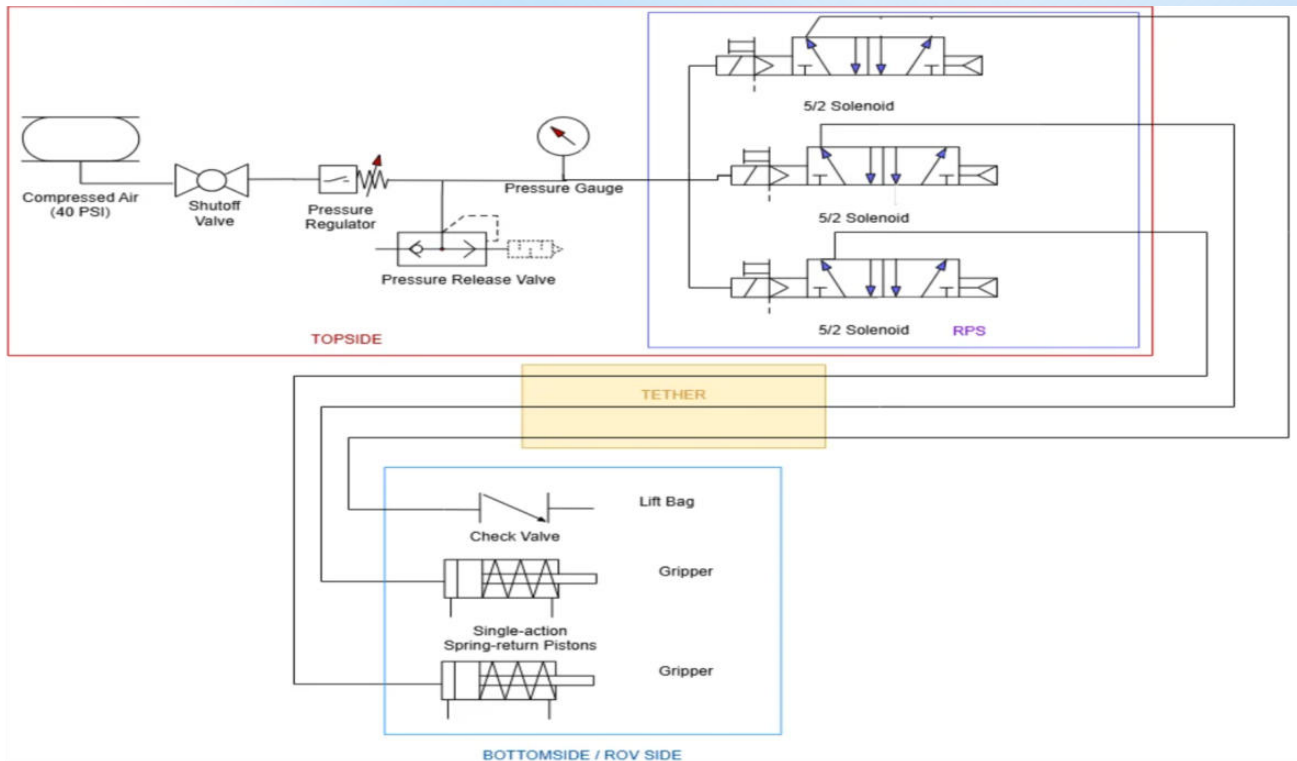


FIGURE 15. PNEUMATICS SID

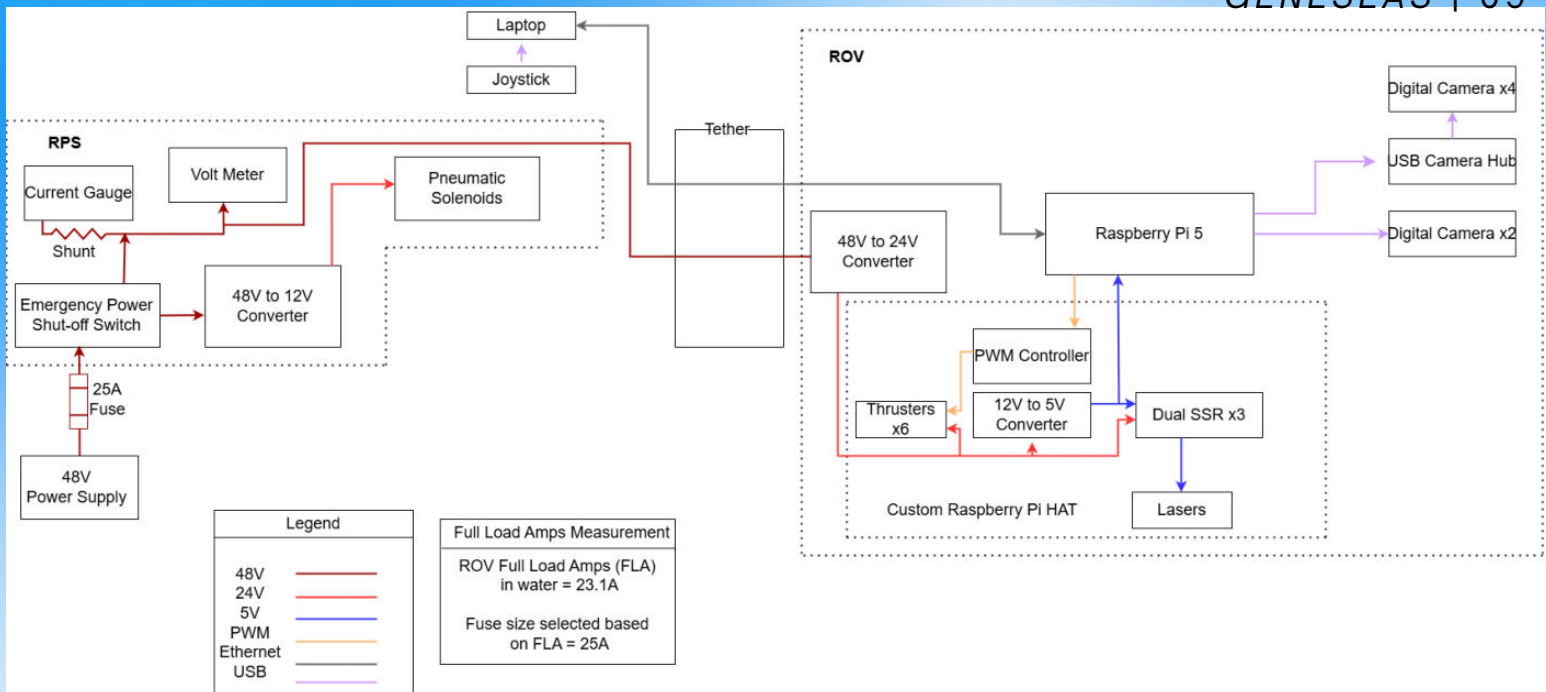


FIGURE 16. ELECTRONICS SID

E. SOFTWARE CONTROLS

Aurelia has three major software systems: the pilot laptop, the ROV-based Raspberry Pi and the operations laptop. Top-side software running on the pilot laptop performs three functions: reading joystick inputs, displaying camera streams (camera GUI) and taking high-resolution images for use on the operations laptop. The ROV-based software translates joystick values into movement direction and the resulting thruster PWM values, streams camera views, and

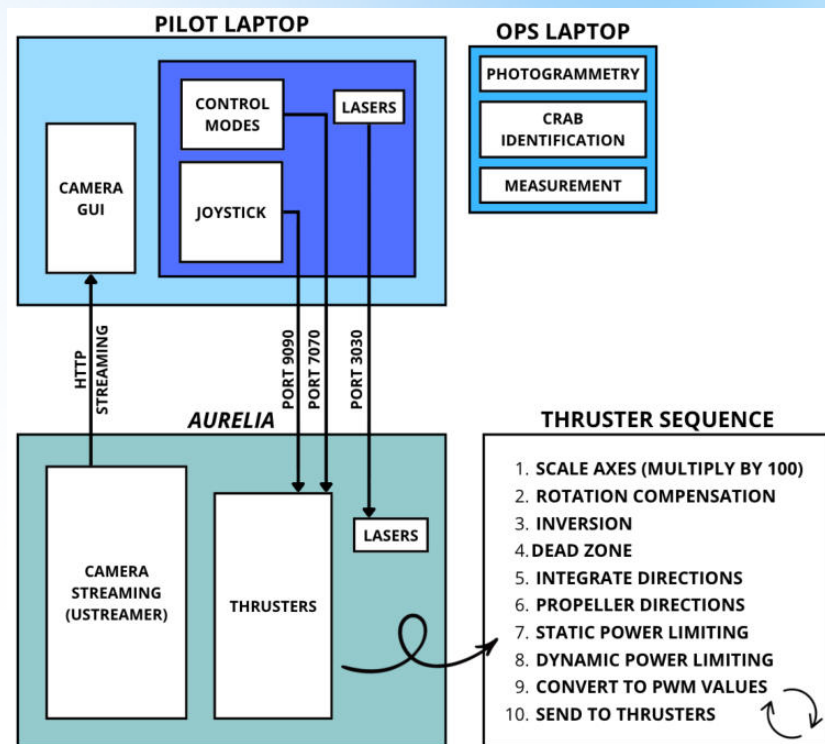


FIGURE 17. SOFTWARE CONTROLS ARCHITECTURE AND THRUSTER PROCESSING

ensures the ROV is in the correct mode. Communication between the pilot laptop and ROV is handled using websockets for software modularity. The operations laptop runs software for photogrammetry, image recognition, and object measurement.

Geneseas software is developed in Python. The camera GUI uses PyQt5 to display the camera feeds. All six cameras can be streamed simultaneously, and a single camera can be enlarged to enhance the pilot view. For streamlined support, *Geneseas* implemented timer and stopwatch widgets to aid the pilot.

The ROV features three performance modes: fast, slow and stop. Fast mode enables full capacity of the thrusters and is used for large movements across

pool. Slow mode reduces the output of the thrusters, allowing for finer movement adjustments and precise alignment. Stop mode ensures the thrusters are disabled for safe handling of the ROV. Pilot inversion controls allow intuitive navigation when operating the ROV backwards. *Geneseas* also added static and dynamic power limiting for stable voltage and consistent power delivery.

The thruster management code is modular, with each processing step in separate functions operating across a thruster array. This design allows for quick, low-risk adjustments. Changing a thruster's orientation only requires updating the thruster array to maintain proper performance.

Pilot feedback has identified limitations of the current *Aurelia* software. *Aurelia*'s current camera software streams all six cameras simultaneously at the same resolution. Future enhancements will allow the user to select specific camera streams and adjust their resolution to meet the pilot's needs for specific tasks. In addition, *Aurelia* does not implement the software to enable the thruster to roll the ROV around the X-axis. A future software update will include this capability.

Geneseas' development process leverages VSCode and Github for IDE and version control, respectively. All software is documented with comments, and the software leadership maintains a software overview document, allowing students to ramp up quickly on new areas of the software. Top side, bottom side, operations, and float software are all handled separately. Although rare, merge conflicts are reviewed and resolved by the software lead.

There was significant effort this year to make standing up a new ROV image, or pilot laptop, more consistent and reliable. All required libraries, including the correct versions, are documented in requirements.txt files and can be installed automatically. Any additional packages are listed in the required packages list, along with the correct version numbers. This proved invaluable when the ROV's image was corrupted and the team was able to exercise the recovery process using this newly enhanced process.

F. DIGITAL CAMERA SYSTEM

Aurelia utilizes a fully digital vision system designed to provide reliable, low-latency video for pilot navigation and mission execution. The system gives pilots clear, dependable visibility while keeping the vehicle compact and easy to maintain.

The ROV is equipped with six digital cameras, each dedicated to a specific function. The front and rear cameras provide the primary fields of view for ROV navigation while the three task-focused cameras improve the pilot's ability to manipulate tools and retrieve mission objects. A bottom-mounted camera is angled directly downward, giving the pilot a clear view of the seafloor, while two extended side-view gripper cameras are used during operation of the front and rear grippers.

Aurelia's digital camera system operates using built-in MJPEG streaming software optimized for low-latency video. At an operating resolution of 800 x 600 and a screenshot resolution of 3840 x 2160, the system achieves an average video latency of approximately 127 ms while delivering a 170° field of view from each camera.

Due to a defect in the firmware for the USB cameras used in *Aurelia*, *Geneseas* needed to customize the linux uvcvideo driver. Although not required, each camera requests the full 480 Mb/s of bandwidth that can be allocated to a USB2.0 device. As a result, after connecting

only three cameras, the Raspberry Pi reports that all USB bandwidth has been allocated, and refuses to allow additional cameras to operate. Using nethogs to monitor actual bandwidth consumption, the team decided to limit each camera's bandwidth to 120 Mb/s. This required downloading the source code for the uvcvideo kernel module and forcing the bandwidth request to 120 Mb/s. After recompiling and installing the updated module, all six cameras now operate simultaneously.

I. CAMERA USB HUB

Over the past two years, *Geneseas* has worked to refine our custom four-port USB hub (Figures 19 and 20). The custom USB hub reduces wiring, and eliminates time consuming debugging. The hub's main purpose is to power *Aurelia's* six cameras. The custom hub was evaluated against several commercially available USB hubs (Figure 19).

The powered hub ensures that each camera has sufficient power to operate, something that can be an issue with large numbers of cameras. In addition, *Aurelia's* custom USB hub enables GPIO control of power to each of *Aurelia's* cameras. This feature allows *Aurelia's* software to restart a camera if needed, without power cycling the entire ROV.

	COST	SIZE (mm)	# OF PORTS	PERFORMANCE	PORT POWER CONTROL	CONNECTOR TYPE
CUSTOM USB Hub	\$50	51 x 39	4	USB 3	✓	JST-XH
ADAFRUIT ZERO4U	\$10	65 x 30	4	USB 2	X	FULL SIZE USB
ADAFRUIT CH334F	\$5	32 x 20	4	USB 2	X	PIN HEADERS
SEALEVEL USB HUB	\$125	74 x 64	4	USB 2	X	JST-PH

FIGURE 18. CAMERA USB HUB DECISION MATRIX

Geneseas evaluated using USB-type connectors, screw terminals and JST-XH push connectors for the downstream USB camera connections. The chosen JST-XH connectors enable feeding fully completed camera connections through watertight gland seal penetrators, enabling ease of assembly, maintenance and replacement. These changes reduce the possibility of manufacturing and maintenance issues.

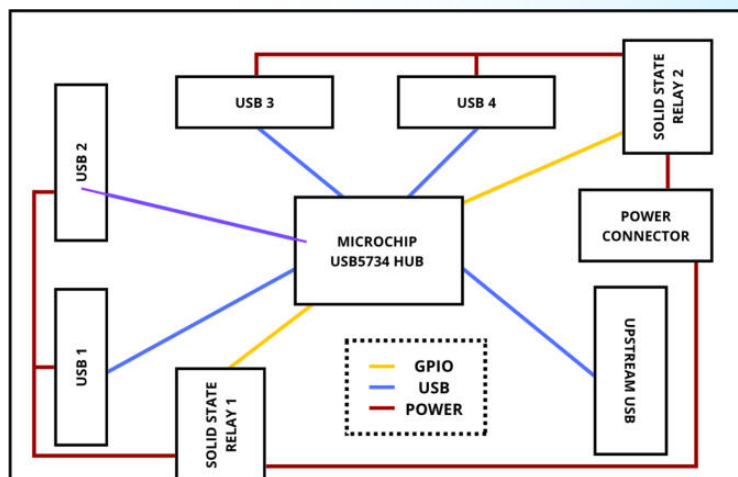


FIGURE 19. CAMERA USB HUB SID

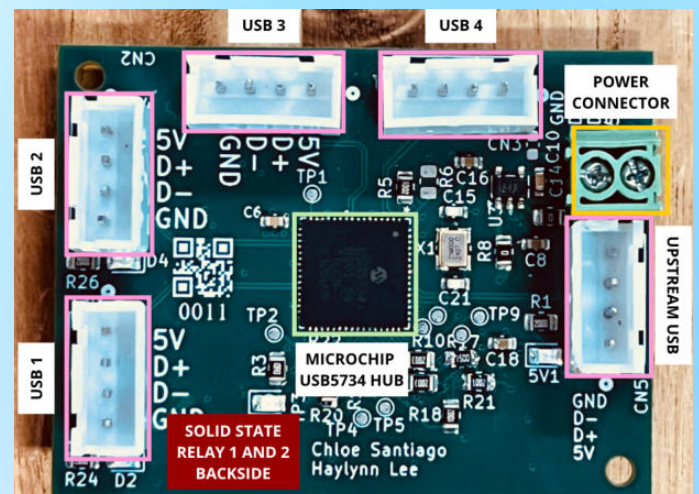


FIGURE 20. CAMERA USB HUB PHOTO

II. CAMERA MOUNTS AND ENCLOSURES

All camera mounts were redesigned this season to maximize modularity while minimizing the space occupied on the vehicle frame. Mounts were custom 3D-printed using polycarbonate filament, which was chosen for its strength and durability in marine environments. The front navigation, rear navigation, and photogrammetry cameras utilize adjustable mounts that are secured with stainless-steel butterfly wing screws, allowing users to rapidly adjust camera angles without tools during testing or competition.

The two gripper camera mounts employ newly developed ball-and-socket mounts, allowing for easy adjustment and rotation along both the X and Y axes (Figure 21). Unlike last year's single-screw design, this season's mechanism features a custom threaded socket system, where the ball joint sits inside a 3D-printed socket that consists of two parts. The threaded upper housing tightens onto the lower half, which compresses the socket around the ball, locking the camera securely at the desired orientation. This design enables fast repositioning of the cameras while keeping them steady when the vehicle is in motion.

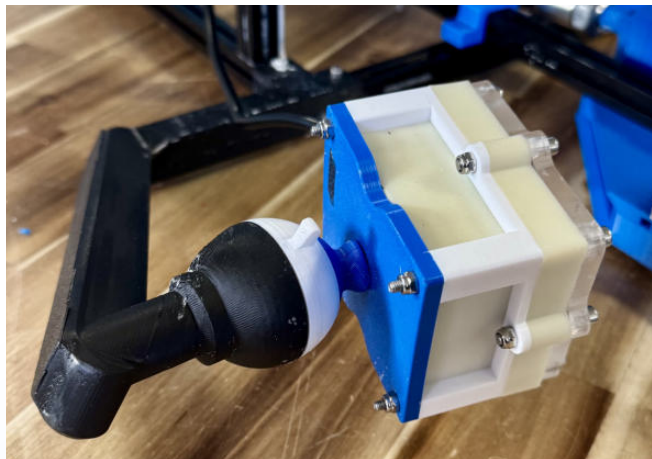


FIGURE 21. GRIPPER CAMERA MOUNT

Geneseas redesigned and manufactured six custom resin-printed camera housings this season to reduce size while also improving waterproofing (Figure 22). Each enclosure uses a WetLink penetrator to maintain waterproof electrical connections to the main electronics housing and custom designed acrylic lenses, allowing for fast and cohesive assembly.

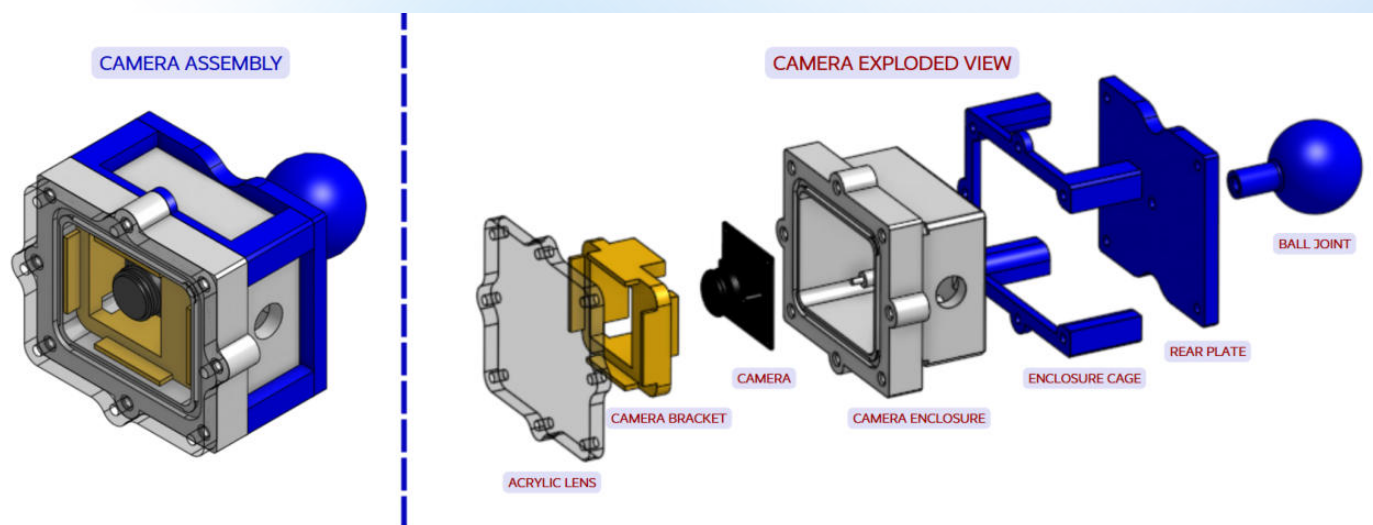


FIGURE 22. ASSEMBLED AND EXPLODED CAMERA HOUSING CAD MODELS

3.4 TOOLS

A. GRIPPERS

Aurelia is equipped with two pneumatically actuated grippers with 65 mm openings: a front gripper and a rear gripper (Figure 23). These grippers allow multiple tasks to be completed without surfacing. Each gripper uses the same core design, enabling the team to focus on

optimizing a single mechanism.

The grippers operate using a rack-and-pinion system powered by a double-action pneumatic piston. A double-action piston was selected over a single-action, spring return piston due to the typical corrosion of the springs in a single-action piston. Although the piston is double-action, only one pneumatic line is used, with a stretched rubber O-ring enabling retraction. This is a simple, strong, and extremely reliable solution. The rack-and-pinion system is fully enclosed, an enhanced safety feature that is innovated from previous grippers and completely eliminates pinch points.

Geneseas' grippers were designed in OnShape and manufactured using 3D printing, allowing for continuous prototyping and design adjustments. The team selected polycarbonate filament due to its strength and durability in underwater conditions. The gripper arms are replaceable using quick-release connectors to enable a range of mission needs. The standard arm fittings have curved jaws with a non-slip foamed PVC inner surface. This is particularly effective for tasks such as removing and replacing the eDNA sensor.

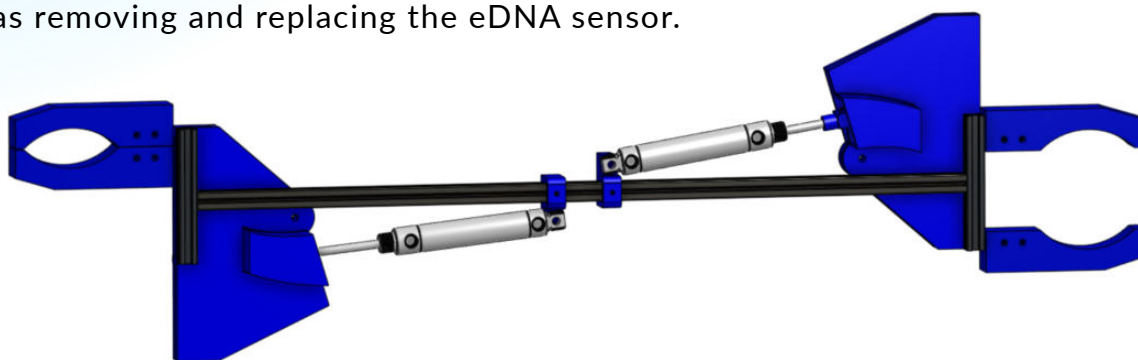


FIGURE 23. DUAL GRIPPER SOLUTION CAD

B. PHOTOGRAMMETRY

Aurelia uses a four step photogrammetry process to create a 3D-model using photos captured with our digital camera system (Figures 24 and 25). First, our pilot navigates to the object and begins to conduct a 180° circuit around it, ensuring enough of the object is captured to make an accurate model, taking pictures about every 20 degrees using the screenshot function on our GUI. The screenshots are automatically saved to a folder on an external USB drive and moved to the operations laptop. In the next step, *Geneseas* loads the images into RealityCapture, which stitches the images together to create the model. In the third step, the model is scaled using the known dimensions of the targets. Finally, the cleaned-up model is imported into Fusion 360 to adjust to the final scale, verify the measurements, and clean up the model background.

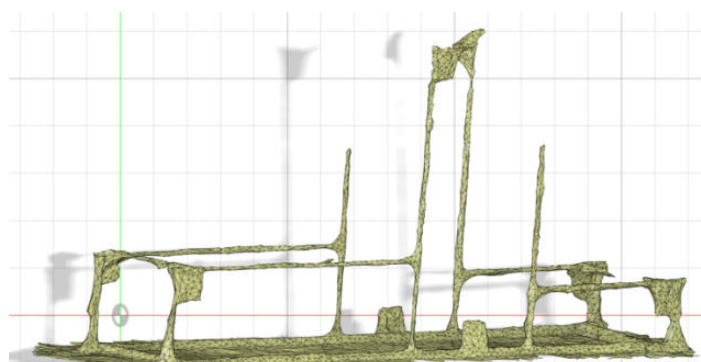


FIGURE 24. CORAL GARDEN 3-D MODEL



FIGURE 25. ACTUAL CORAL GARDEN MODEL

C. MEASUREMENTS AND LASERS

Aurelia's has two methods to measure objects. The first system includes two green lasers which project vertical lines underwater. Green lasers were chosen because water does not absorb green light as quickly as the typical red laser light. The lasers are set 100 mm apart, and project parallel beams which can be used as a 100 mm reference measurement on the object being measured. In addition, *Aurelia* has a 125 mm measurement block that can be placed near an object being measured. These systems are used together to obtain and verify measurements.

To perform the actual measurements, photographs are taken of the object to be measured, along with the reference object and laser markings. Using a custom measurement GUI to mark both the reference measurements and the object being measured, the measurement ratio is determined and the final measurements are calculated. The measurements are performed using *Aurelia's* camera system. Prior to any measurements, *Aurelia's* camera lenses are characterized using CV2's camera calibration functions and a checkerboard reference image. During image processing, the captured images are distortion corrected using the CV2's undistort function and the previously captured calibration data.

D. SPOOL TOOL

Geneseas' spool tool solves the problem of underwater recovery line management by containing the buoy anchor recovery line until deployment, reducing tangling, and allowing secure attachment to the buoy anchor for retrieval (Figure 26). The spool tool was designed as a compact rectangular box with the outer holder measuring 12 x 10 x 8 cm. This enclosure was designed to protect the recovery line from tangling while *Aurelia* completes the task. Inside the enclosure, an axle serves as a winding mechanism for the recovery line. This axle allows the recovery line to be manually wound into the enclosure prior to starting the task. As *Aurelia* executes the task, the tool releases the recovery line in a controlled manner, preventing entanglement with the ROV.



FIGURE 26. SPOOL TOOL CAD

E. BIOFOULING REMOVAL TOOL

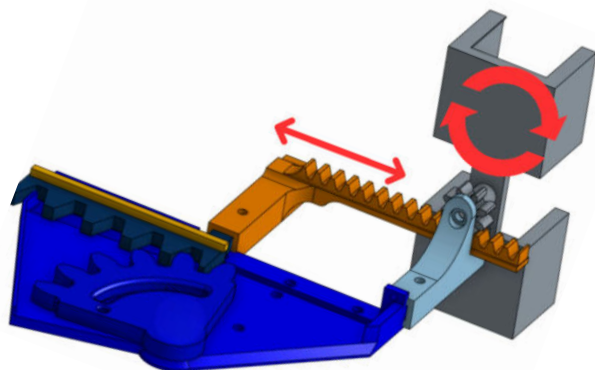


FIGURE 27. BIOFOULING REMOVAL TOOL CAD

The custom designed and 3D-printed biofouling removal tool was created to remove biofouling from the Holyrood Subsea Observatory camera (Figure 27). This gripper mounted tool translates the gripper's linear motion into the required rotation using a rack mounted to one gripper jaw and a pinion mounted to the opposite gripper jaw. As the gripper claws move towards each other, the biofouling removal tool will spin and turn the handle.

F. LIFT BAG

The lift bag is a tool made using a replaceable 4 L inflatable nylon bag with a hook. The bag is hooked onto the handle of the lobster pot, inflated using the pneumatic system, and lifts to the surface for retrieval. The 4 L lift bag provides 4 kg of positive buoyancy; significantly more than required to lift the 2.5 kg lobster pot.

There have been multiple designs and iterations of the lift bag. The five major iterations are shown in Figure 28. The first design was a basic proof of concept, which successfully demonstrated the ability to lift the lobster pot. The subsequent iterations were focused on refining the mechanisms for attaching both the hook and the lift bag.

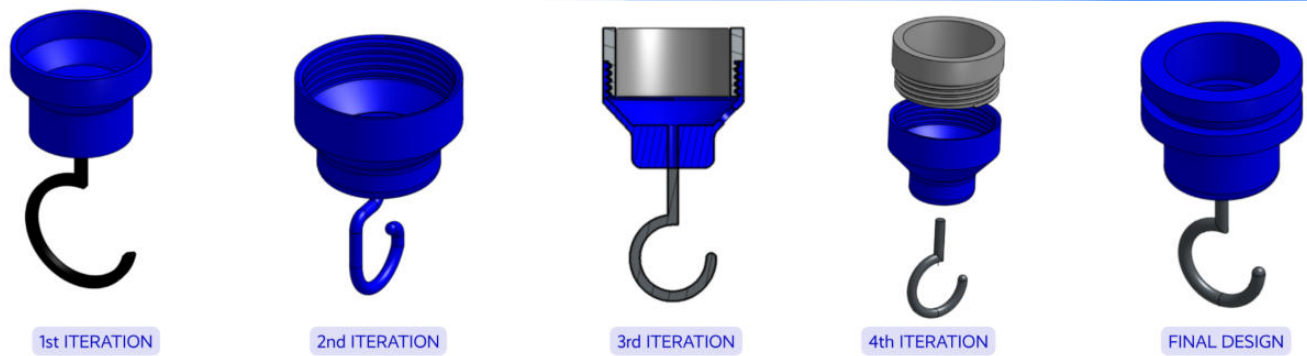


FIGURE 28. LIFT BAG DESIGN ITERATIONS

3.5 VERTICAL PROFILING FLOAT

Geneseas' Aviva is a vertical profiling float that uses a buoyancy engine mechanism to complete MATE Floats! (Figure 29). To provide faster response time and more precise control, *Geneseas* moved from a syringe to a bi-directional pump. This has proven to be extremely effective.

At the beginning of every mission run, *Aviva* starts at the surface and streams a control webpage over a closed WiFi network to a deck device. The only requirements for the control device are WiFi and a web browser. This user-friendly interface allows real-time monitoring and control without specialized hardware or software. When instructed to dive, the code directs the pump to take in water, decreasing buoyancy and initiating data collection with a Blue Robotics Bar02 pressure sensor, recording pressure, depth, and time.

The buoyancy holding algorithm works by

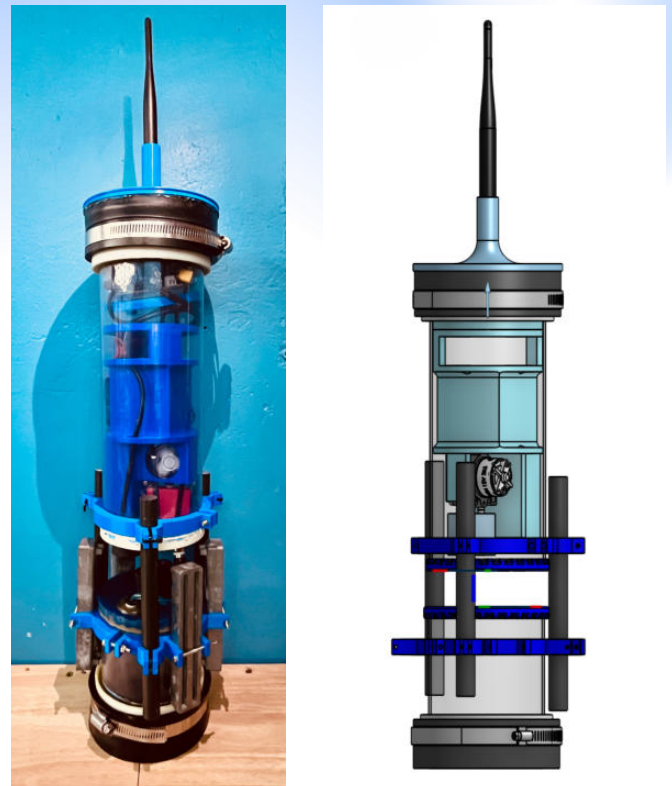


FIGURE 29. AVIVA PHOTO AND CAD MODEL

calculating “depth offset” (the difference between the current depth and the target depth) and “speed offset” (the difference between the target vertical speed and the actual vertical speed). At runtime, the buoyancy holding algorithm reads a table that sets target speeds for each depth offset, a bit like a Proportional-Integral-Derivative (PID) algorithm. The table can be updated to make the float move faster or slower at each depth offset. Water is pumped in or out depending the value of speed offset (Figure 30).

Depth	Depth Offset	Speed	Speed Offset	Pump Water
Too High	Negative	Too Fast	Positive	OUT
Too High	Negative	Too Slow	Negative	IN
Too Low	Positive	Too Fast	Negative	IN
Too Low	Positive	Too Slow	Positive	OUT

FIGURE 30. BUOYANCY HOLDING ALGORITHM TABLE

Geneseas then tuned the table to ensure that *Aviva* initially moves more quickly, and as *Aviva* approaches 2.5 m depth, the algorithm begins slowing the descent by expelling water and increasing *Aviva*’s buoyancy. The algorithm is tuned to

hold *Aviva* precisely 2.5 m below the surface. Then, *Aviva* expels more water to increase buoyancy rising up to a depth of 0.4 m using the same process. The bi-directional pump provides precise buoyancy control ensuring no deviation from the allowable depth range and pumps water in and out quickly.

At the surface, the antenna transmits pressure and depth data with Coordinated Universal Time (UTC) timestamps, displaying it on the web page alongside a depth-versus-time graph. This process is repeated twice.

Aviva’s electronics revolve around a Raspberry Pi ZeroW and a custom PCB that serves as a Pi HAT. The Pi HAT converts power from the batteries to supply power to the pump, LEDs, and Raspberry Pi. Two LEDs on the board are used to indicate the statuses of the PCB and pump: red for power-on and orange for low battery. This allows for the monitoring of the electronics system for *Aviva*. A 3D-printed custom mount was designed to securely fit all of the components, organize wiring and provide for easy maintenance. A 102 mm transparent PVC tube is used for both the electronics enclosure and the buoyancy chamber. The electronics chamber is separate from the water chamber to reduce the risk of water infiltration.

3.6 BUILD VS. BUY, NEW VS. REUSED

When deciding whether to build or buy a system, *Geneseas* evaluates each ROV component to ensure they balance affordability, sustainability, and reliability while meeting mission requirements and maintaining operator safety. This approach is reflected in *Geneseas*’ specialized tools, some of which are designed and 3D-printed in house to allow for greater customization, and some of which are commercially available tools that are purchased because of their superior practicality and cost-effectiveness.

Geneseas also assesses whether components should be newly designed, adapted from previous iterations or directly reused based on past performance and current mission needs. Proven designs that have demonstrated durability, reliability, and safety are refined and reused to reduce development time and costs. For example, *Aurelia*’s gripper was adapted from previous designs because it remained pinchpoint-free and versatile enough to complete

current tasks, which range from collecting basket stars to replacing power connectors. New designs, however, are developed when mission objectives require different or improved features. An example of this is *Aurelia*'s new twist-on thruster mounts, which were created to make thruster maintenance easier while still meeting mission requirements (Figure 31).

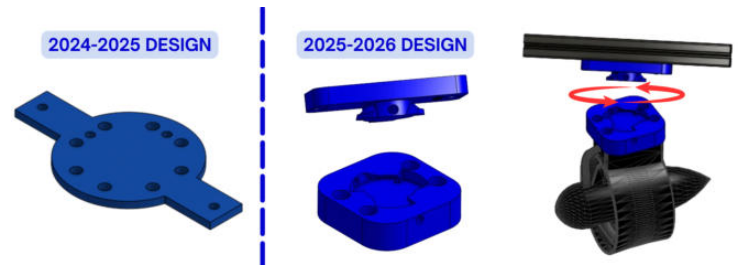


FIGURE 31. THRUSTER MOUNT COMPARISON

This process ensures that each design choice is purposeful and supports the development of a reliable, high-performing ROV system. Reference Appendix A for a list of components with build vs. buy and new vs. reused decisions.

4. SAFETY

A. SAFETY PHILOSOPHY

In every stage of production – development, testing, and operation – *Geneseas* places safety at the top of their list of priorities. Rigorous safety standards that combine innovation with established guidelines are upheld in and out of the workplace.

At the beginning of the work season, all employees are required to complete safety training led by an experienced employee. These sessions cover proper tool usage, electrical safety, handling of hazardous materials, and the standard of cleanliness in the workplace and pool side.

Geneseas employees designed and built features of *Aurelia* with safety in mind every step of the way. For the team, safety is not only a policy in the workplace, but at the core of every decision and action made.

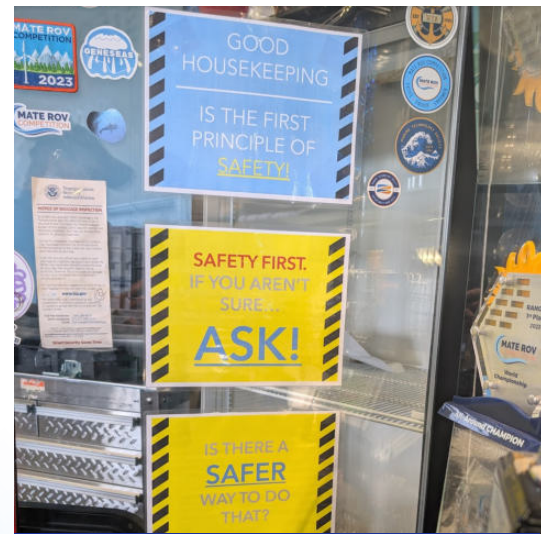


FIGURE 32. SAFETY SIGNS IN THE GENESEAS LAB

B. SAFETY IMPLEMENTATION

Geneseas practices the utmost safety at every step of the design and build process. In the workplace, employees wear closed-toed shoes, tie back hair, and use Personal Protective Equipment (PPE) such as gloves, goggles, masks, and ear protection when machining, soldering, or working on the ROV.

After joining the team, new members complete a safety training where senior members demonstrate proper machinery use and discuss hazard awareness. New members are required to have a more experienced member or coach supervise hazardous tool usage. *Geneseas*' uses a color coded tool labelling system to help define which tools require supervision and which tools can be used independently. This system ensures all employees practice safety when working on *Aurelia*.

Before in water testing, the team followed a detailed safety checklist and Job Safety and Environmental Analysis (JSEA). All members operating the ROV follow and enforce the outlined safety procedures to prevent hazardous events. For example, all electrical

systems, such as the RPS, power supply, and laptops, are placed on an elevated surface to ensure they do not come in contact with water. Additionally, a call-and-response system (“Thrusters On”, “Thrusters Off”, “Hands On”, “Hands Off”) is used by the poolside operations team in order to alert all members when the ROV is turned on or off. This system helps employees know when it is safe to interact with the ROV, in turn reducing the risk of injury from the thrusters, gripper, or other components.

When soldering in the workplace, employees are required to turn on the fume hood to limit the exposure of hazardous fumes. Members are expected to dispose of waste properly and return tools to their designated spots after usage to maintain a clean, organized workspace. Signs are placed next to each machine describing the steps for proper machinery usage and required safety gear to operate any machinery. Every member of *Geneseas* follows and teaches these safety protocols to reduce the risk of injury, cultivate a culture of safety within the team.

C. VEHICLE SAFETY FEATURES

For *Geneseas*, safety is the top priority. *Aurelia* includes a number of safety features that ensure complete safety during handling and operation.

Geneseas conducts multiple safety reviews throughout the season to identify and solve any potential safety hazards. This year, *Geneseas* identified *Aurelia*’s grippers as possible safety issues and incorporated these concerns into design processes. For gripper safety, *Aurelia*’s two grippers feature rack-and-pinion mechanisms shrouded to IP-20 standards, eliminating pinch points and preventing user injury. Additionally, *Aurelia*’s thruster guard protect users from contact with the thrusters, also complying with the IP-20 standard.

Aurelia also features a sheathed tether, preventing damage to ROV power, pneumatics lines, and communication lines, an emergency power off switch, which allows the user to quickly shut down the ROV in case of emergencies, and a newly-designed, Kellum-style aluminum strain relief mount that securely connects the tether to the ROV.

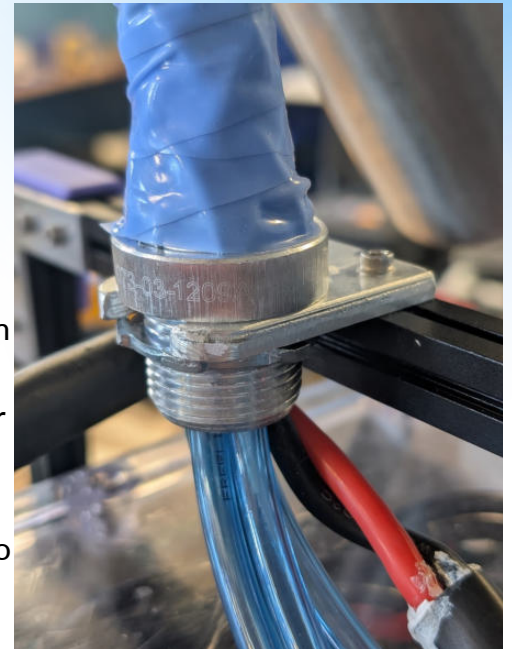


FIGURE 33. STRAIN-RELIEF MOUNT

D. SAFETY CHECKLIST

Geneseas developed a comprehensive safety checklist (Appendix D) to protect employees, customers, and bystanders during construction, launch, operation, and retrieval of the ROV. This structured approach reinforces the importance of strict safety protocols, reducing risks throughout every mission phase.

5. CRITICAL ANALYSIS

A. TESTING AND TROUBLESHOOTING

Geneseas’ testing methodology is rooted in consistent testing, data collection, data analysis

and iteration to effectively troubleshoot all parts of *Aurelia*. As engineers, *Geneseas* understands failure is expected in the design process and using effective troubleshooting techniques are key to developing a reliable and safe final product. This year, *Aurelia* underwent over 100 hours of in-pool testing.

All tools undergo a two step testing process involving both dry-testing and in-water testing. Tools are first dry-tested to identify design flaws and verify reliability, then tested in water, where pilots provide feedback for performance improvements. On-site 3D printers enable rapid redesigns and specialized tool development for each task.

Movement code and software are debugged outside of practice sessions. The software team locates errors with line-by-line print statements and log files, corrects issues, and tests components individually before re-running programs for optimization. This process ensures the deck crew trains with reliable, bug-free code, and makes pool tests more efficient. Before water testing, all six thrusters are calibrated to address minor hardware variation, synchronize startup and optimize movement software. This ensures consistent operation of all thrusters. To maintain camera reliability, *Geneseas* developed a custom bash script that monitors camera functionality and allows quick restarts of cameras or thrusters if failures occur mid-mission.

Additionally, *Aurelia*'s electrical housing undergoes a 10-minute 10-psi vacuum test to ensure watertight integrity before every pool test.

B. BUDGET AND COST ACCOUNTING

Geneseas is able to fund our projects through both school support and student fees. Throughout the year, *Geneseas* keeps a record of all expenditures in order to account for staying within our budget. We set our budget to \$8,025 based on the funding provided in Figure 34. Based on prior experience, we budgeted approximately 50% of the total for components that comprise the ROV and 50% for other expenses, equipment, tools, and damaged components.

Geneseas spent \$3,279.47 to manufacture *Aurelia* and *Aviva*. The budgeted and actual cost accounting of the ROV expenses is shown in Appendix C. This year, *Geneseas* consistently sought out opportunities to maximize cost efficiency and affordability (See Build vs. Buy, New vs. Reused, Appendix A). All order requests and expenses were documented in an online Google Sheets purchase list maintained by the team (Appendix C). Travel expenses for travel to Newfoundland are forecasted in Appendix B.

Category	Name	Amount (USD)
Sponsorship	SF High School	\$2,275
Tuition	Student Fees	\$5,750
		\$8,025
	50% Ratio	\$4,013

FIGURE 34. FUNDING CHART

6. ACKNOWLEDGEMENTS

Geneseas would like to express our appreciation and gratitude towards the organizations and individuals who have made our participation in the MATE program possible. Thank you to MATE, the Marine Technology Society and the U.S. National Science Foundation – sponsors of the 2026 competition – as well as MATE II, Oceaneering International, Ocean Infinity, and Reach the World for advancing hands-on STEM education and providing students with

We gratefully acknowledge the following contributors to our success:

- St. Francis Catholic High School – for generous funding, continued support, and providing laboratory space that allows our team to design, build, and create.
- Jesuit High School – for pool and laboratory space.
- Industry Partners – Tyler Schilling and Schilling Robotics, Nauticus Robotics, NASA, Green Circuits, Bay Area Circuits, The Aerospace Museum of California, SMUD, Bonney Plumbing, Electrical, Heating & Air, and the River City Waterway Alliance – for inspiring us through real-world applications of our work and helping expand our laboratory through the St. Francis STEM Zone initiative.
- St. Francis Coaches – Marcus Grindstaff, Siena Marois, Karen Jones, Maurice Velandia, LisaMarie Isaacs, Jeffrey Chamberlain, and Steve and Cheryl Kiyama – for your time, technical guidance, mentorship, and commitment to fostering learning, growth, and confidence within our team.
- Michelle Menza, Kitara Crain, Cheryl Kiyama, and Siena Marois – for serving as powerful role models who encourage us to lead proudly as “Women who change the world.”
- Our families – for your unwavering encouragement, patience, enthusiasm, and support throughout the season.

Thank you all for helping make this learning opportunity possible.

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APPENDIX A. BUILD VS. BUY, NEW VS. REUSED

Component	Build vs. Buy	New vs. Reused vs. Adapted	Justification
Camera Enclosure	Build	Adapted	3D resin printed watertight enclosures. Adapted design to fit new custom 3D printed adjustable mounts. Reused waterproof seal design due to proven durability and reliability.
Grippers	Build	Adapted	Created using 3D printed components and aluminum rail. Adapted rack and pinion design based on reliable operation and strong gripping force.
Tether	Build	Adapted	Created new tether in order to add three pneumatics lines, an ethernet line, and 2-pin SubConn connectors to suit the ROV's requirements.
Thruster Mounts	Build	New	Redesigned to eliminate 50% of the fasteners and allow thrusters to simply twist on, improving serviceability.
USB Hub	Build	New	New design to: incorporate JST-XH connectors, save space, improve power delivery, and add strain relief.
ROV tools	Build	New	Custom-built to meet updated mission objectives.
RPS	Build	New	Newly built in a larger box, improved wire management, pneumatics moved to topside.
Buoyancy Engine	Build	New	Built all-new buoyancy engine. Transitioned from syringe to pump. New custom PCB board to accommodate control of the pump.
Cameras	Buy	Reused	Camera system selected for consistent image quality and compatibility. Reused due to reliable past performance and high resolution.
Thrusters	Buy	Reused	Reused from last year due to its optimal thruster output, increased reliability, and up to MATE standards.
Electronics Housing	Buy	New	Smaller housing chosen to better fit frame of ROV and improve buoyancy.
Ethernet	Buy	New	Purchased an ethernet wire to replace the powerline communications system used previously. This allowed for more reliable and stable network connection and faster data transfer.

APPENDIX B. NEWFOUNDLAND TRAVEL EXPENSES

Item	Qty	# People	Cost each	Total
Flight-RT	4		\$916.93	\$3,667.72
Coach Hotel	4		\$1,494.64	\$5,978.55
Rental Cars	3		\$1,368.09	\$4,104.28
Student Flights	1	20	\$916.93	\$18,338.60
Student Hotel	5		\$1,494.64	\$7,473.19
Gas	3			\$500.00
Breakfast	5	24		\$0.00
Lunch	6	24	\$18.00	\$2,592.00
Dinner	5	24	\$25.00	\$3,000.00
Registration	1		\$650	\$650.00
Bus to / from SFO	2		\$1,500	\$3,000.00
Other trip costs	1		\$1,000	\$1,000.00
Snacks	1		\$300	\$400.00
			Total Cost	\$50,304.34

APPENDIX C. BUDGET VS. ACTUAL COST ACCOUNTING

Item	Type	Forecast (adj. from 2025)	Actual	Variance
Raspberry Pi 5	Purchased	\$100	\$174.95	\$74.95
Joystick	Reused	\$40	\$0.00	-\$40.00
Cameras	Purchased	\$300	\$370.31	\$70.31
Electronics Enclosure	Purchased	\$75	\$36.10	-\$38.90
RPS Box	Purchased	\$75	\$70.95	-\$4.05
Sleeving	Purchased	\$30	\$60.09	\$30.09
T-Slot Nuts	Purchased	\$40	\$91.70	\$51.70
ROV PCB Components	Purchased	\$250	\$229.77	-\$20.23
USB Hub Components & Assembly	Purchased	\$250	\$411.56	\$161.56
Cord Grip Fittings	Purchased	\$200	\$104.09	-\$95.91
Pneumatic Pistons	Purchased	\$160	\$140.68	-\$19.32
Pneumatic Tubing	Purchased	\$100	\$80.15	-\$19.85
Aluminum Rail	Purchased	\$150	\$113.66	-\$36.34
Frame Brackets	Reused	\$100	\$0.00	-\$100.00
Buoyancy Engine Hat	Purchased	\$200	\$115.60	-\$84.40
Buoyancy Engine Tube	Purchased	\$40	\$32.99	-\$7.01
Power Wire	Reused	\$80	\$0.00	-\$80.00
Blue Robotics Wet Link Penetrators	Reused	\$125	\$0.00	-\$125.00
Power Connectors	Reused	\$150	\$0.00	-\$150.00
Pneumatic Solenoids	Purchased	\$50	\$32.89	-\$17.11
Thrusters	Purchased	\$500	\$384.00	-\$116.00
Lasers	Purchased	\$80	\$39.98	-\$40.02
Various Consumables and Small Parts	Purchased	\$1,000	\$790.00	-\$210.00
		\$4,095.00	\$3,279.47	-\$815.53

APPENDIX D. SAFETY CHECKLIST

ROV Construction and Operation Checklist

Pre-Power (Pilot, Co-pilot, and Deck Crew)

- ☐ Area is clear and safe (no tripping hazards or obstructions)
- ☐ All team members are wearing safety glasses and long hair is tied back
- ☐ No loose clothing, no open toed shoes
- ☐ Verify RPS power switches are off
- ☐ Tether laid out on the deck and is free of damage
- ☐ Tether is connected to strain relief and secured to the RPS
- ☐ Tether is connected to strain relief and secured to ROV
- ☐ Power source connected to RPS
- ☐ Verify electronics housing is properly sealed and fasteners are tightened
- ☐ Visual inspection of electronics for damaged wires or loose connections
- ☐ Vacuum test electronics housing (see Vacuum Test below)
- ☐ Vacuum port is securely capped
- ☐ Thrusters are free from obstructions

Vacuum Test (Deck Crew)

- ☐ Verify electronics housing is properly sealed
- ☐ Connect vacuum pump to the electronics housing
- ☐ Vacuum down the electronics housing to ~10 Hg and verify they hold this pressure for 10 minutes
- ☐ Remove vacuum pump and securely cap vacuum port
- ☐ Return vacuum hand pump to case

Power-Up (Pilot, Co-pilot, and Deck Crew)

- ☐ Verify RPS is receiving 12V nominal
- ☐ Control computers up and running
- ☐ Ensure deck crew members are attentive
- ☐ The Co-Pilot calls out, "power on!"
- ☐ Power on RPS
- ☐ Co-Pilot calls out, "performing thruster test"
- ☐ Test thrusters and verify thrusters are working properly
- ☐ Verify video feeds from navigation and mission cameras
- ☐ Ensure Cameras are positioned correctly
- ☐ Test electrical and pneumatic components that require pilot input (See Pneumatic System Test Below)

Inspect and Test Pneumatic System (Pilot, Copilot)

- ☐ Verify all pneumatics lines on RPS and ROV are properly connected to the MATE air supply.
- ☐ Verify that the compressor is switched on
- ☐ Adjust pressure regulator to 40 PSI
- ☐ Activate pneumatics system and open main valve
- ☐ Verify there are no leaks and pneumatic lines are securely connected while under pressure
- ☐ Activate pneumatic tools and verify the pressure returns to 40 PSI after the tool is shut off.

ROV Launch (Pilot, Co-pilot, and Deck Crew)

- ☐ Deck crew members handling ROV call out, "Hands on!"
- ☐ Carefully place ROV in the water
- ☐ Check for bubbles
- ☐ Visually inspect for water leaks

- ☐ If there are large bubbles, pull to surface immediately and proceed with Leak Detection Protocol
- ☐ If no issues are detected call out, "Prepare to launch"
- ☐ Deck crew members handling ROV remove their hands from the vehicle and call out, "Hands off!"
- ☐ Co-pilot calls out "Thrusters engaged" and pilot begins mission
- ☐ Tether Manager follows designated tether management protocols to prevent entanglement

ROV Retrieval (Pilot, Co-pilot, and Deck Crew)

- ☐ The pilot calls out, "ROV surfacing"
- ☐ Deck crew calls out, "ROV on surface. Disable thrusters"
- ☐ Co-pilot calls out, "Thrusters disabled"
- ☐ Deck Crew call out, "Hands on," and remove ROV from water
- ☐ Co-Pilot calls out, "Safe to remove ROV"
- ☐ After securing the ROV on deck, deck crew calls out, "ROV secured on deck"
- ☐ Co-Pilot powers down RPS
- ☐ Team begins demobilizing

Leak Detection Protocol (Pilot, Co-pilot, and Deck Crew)

- ☐ Immediately power down the ROV and RPS systems and remove the ROV from the water if a mission is occurring
- ☐ Visually inspect ROV to identify the source of the leak. Do not disassemble any part of the ROV until the source of the leak is detected
- ☐ Install pressure testing equipment and use soapy water to verify the source of the leak.
- ☐ Create a plan and repair the leak
- ☐ Check all systems for damage and verify proper operation
- ☐ Document the source and cause of the leak and detail the corrective actions and design changes made.

Loss of Communication (Pilot, Co-pilot, and Deck Crew)

- ☐ Cycle power on RPS to reboot ROV
- ☐ If no communication, power down ROV, retrieve via tether
- ☐ If communication restored, confirm there are no leaks, resume operations
- ☐ If communication has not been restored, begin troubleshooting procedures and isolate the issue. Determine if the issue is with hardware or software.
- ☐ Document the problem and detail the corrective actions made to solve the problem.

Pit Maintenance (All Team Members)

- ☐ Pit is well organized and free of debris
- ☐ All tools, cables, and equipment are safely stored in their designated spaces and there are no tripping hazards
- ☐ Verify RPS, ROV and tether are clean, dry and stored.
- ☐ Protective caps for electrical connectors are in place
- ☐ ROV, RPS and tether have been readied for use on the next mission run