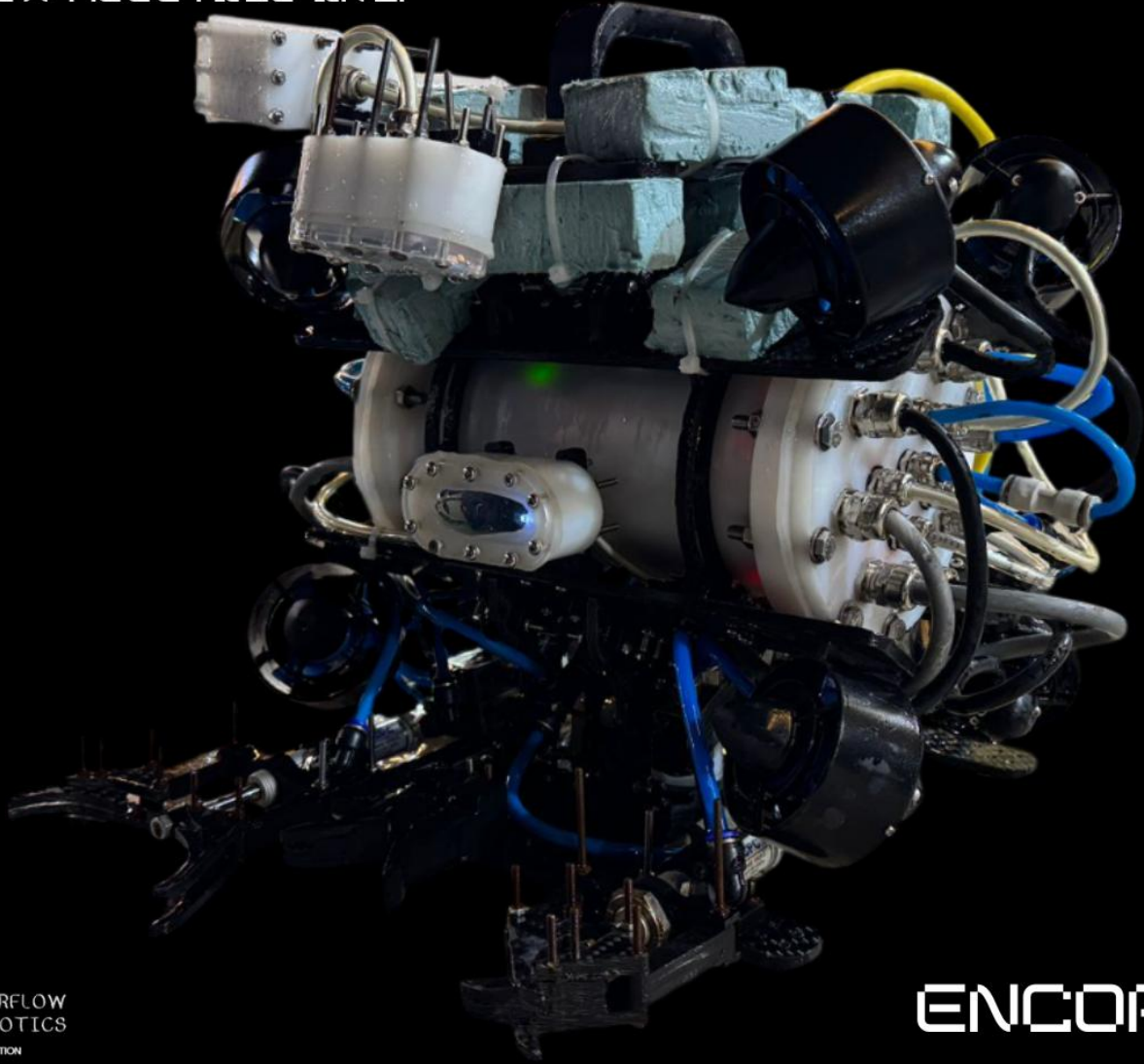


OVERFLOW ROBOTICS

ALEXANDRIA , EGYPT EST . 2021 

OVERFLOW ROBOTICS INC.



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1.0 Abstract

Overflow Robotics developed a mission-specific remotely operated vehicle (ROV) to address the 2026 MATE competition's offshore engineering and environmental mission objectives. Backed by five years of organizational experience and executed by a 31-member multidisciplinary team (**Refer to figure 1 for company photo**), the system was engineered to deliver reliable performance, precise control, and efficient task execution in constrained underwater environments. The ROV features an Eight-Thruster vectored propulsion layout that enables full six-degree-of-freedom maneuverability and stable station-keeping. A modular mechanical architecture supports rapid subsystem access, streamlined maintenance, and flexible integration of mission tooling. Electrical power distribution and control systems were designed to maintain operational efficiency and thermal safety while sustaining consistent performance over extended mission durations. Visual feedback and operator control are supported through a sensor-integrated vision system, 7 high-definition cameras, and a pilot interface optimized through iterative testing. Mission-specific end-effectors enable effective manipulation, inspection, and data collection while reducing operator workload and task execution time. The final vehicle represents a deliberate balance between mechanical simplicity and functional capability, achieved through iterative prototyping, in-water testing, and system-level validation. This ROV **Encore** demonstrates Overflow Robotics' emphasis on disciplined engineering decisions, test-driven refinement, and dependable underwater system design.



Figure 1 Company Photo

2.0 Project management

A. Management Structure, Planning, and Team Responsibilities

Overflow Robotics managed the 2025 ROV project using a centralized project management system to coordinate a 31-member multidisciplinary team (**Refer to home page for personnel**). The team was structured into specialized sub-teams with clearly defined responsibilities to ensure accountability and efficient execution (**Refer to figure 2**).

- **Mechanical Sub-Team:** Responsible for frame design, buoyancy configuration, structural analysis, and integration of propulsion and tooling systems.
- **Electrical Sub-Team:** Responsible for power distribution, wiring, sealing, safety systems, and electrical reliability under submerged conditions.
- **Software and Controls Sub-Team:** Responsible for vehicle control logic, sensor integration, pilot interface development, and system responsiveness.
- **Tooling Sub-Team:** Responsible for the design, fabrication, and testing of mission-specific end-effectors and manipulators.
- **Operations Sub-Team:** Responsible for pilot training, mission planning, system checks, and operational procedures during testing and competition runs.

Project planning, scheduling, and task ownership were managed through an advanced team Notion workspace, which served as the central platform for timelines, task assignments, subsystem documentation, and design decision tracking (**Refer to figure to 5 for Notion dashboard**).

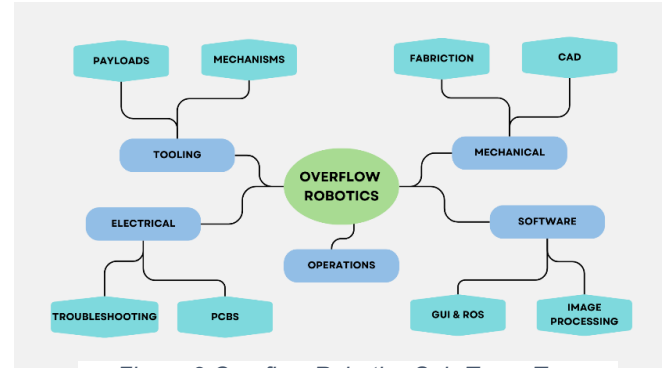


Figure 2 Overflow Robotics Sub-Team Tree

B. Project Execution and Operational Control

Overflow Robotics structured its project timeline in Notion. The timeline was built by breaking the season into phases—concept development, prototyping, integration, testing, and refinement—with clear task ownership and measurable checkpoints for each subsystem. Day-to-day execution and time-sensitive coordination were supported through a dedicated WhatsApp community, enabling rapid cross-team communication while remaining aligned with the structured timeline and task management system. This workflow enabled efficient resolution of technical and logistical challenges while preserving documentation integrity, decision traceability, and on-time milestone completion. The distribution of effort across sub-teams, illustrated in the adjacent man-hours graph (**Figure 3**), reflects this planned timeline structure and highlights how responsibilities were balanced to sustain both technical progress and project management stability. Our company had one big milestone planned; getting the vehicle in water before January and after sticking to all the deadlines and handing out all the deliverables on time.

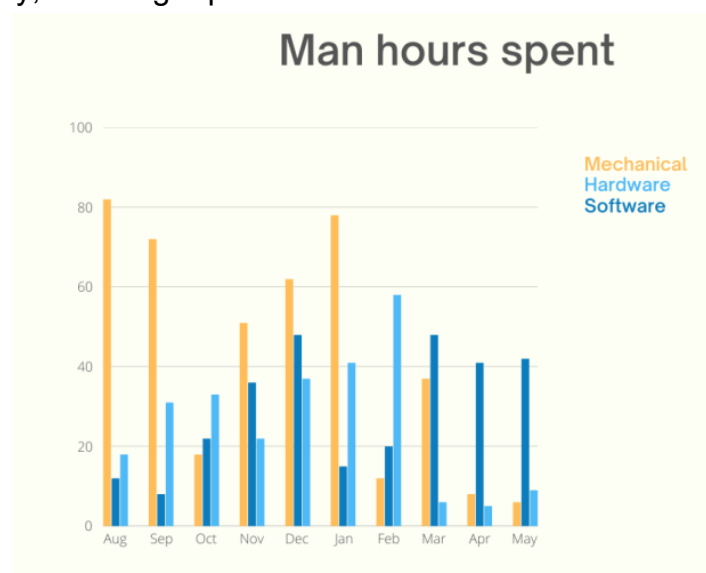


Figure 3 Sub Team Man hour Tracking graph

C. Communication, Documentation, and Risk Control

Technical files, CAD models, electrical schematics, software repositories, and official documentation were stored and version-controlled within a shared Google Drive to ensure consistent access to current information. Formal communication, including external correspondence and competition-related matters, was conducted through official team email accounts to maintain clarity, accountability, and proper record keeping. Risk management was integrated into the project workflow through early identification and tracking of potential technical and organizational risks, including water ingress, electrical failures, subsystem integration conflicts, and schedule compression. Mitigation strategies—such as modular system architecture, conservative design margins, and early subsystem testing—were implemented and reviewed throughout the development cycle to reduce the likelihood and impact of failures. The accompanying task completion graph (**Refer to figure 4 for task completion graph**) reflects this structured management approach, illustrating steady progress and effective tracking of deliverables across the development timeline.



Figure 4 Tasks Completion Graph

D. Team Development, Operations, and Organizational Support

To support consistent execution across a 31-member multidisciplinary team, Overflow Robotics implemented structured training, operational procedures, and organizational support practices throughout the development cycle. Early in the season, subsystem onboarding sessions were conducted to introduce new members to safety standards, design conventions, and project workflows documented in the team's Notion workspace (**Refer to figure 5 for notion dashboard**). This reduced onboarding time and allowed members to contribute effectively to subsystem tasks sooner. Operational procedures were applied during fabrication and testing activities to improve repeatability and reliability. For example, pre-test checklists and role assignments were used during in-water testing sessions to ensure that electrical sealing verification, thruster inspection, and communication checks were completed before deployment. Post-test reviews were documented in Notion to capture observations and define corrective actions, which informed subsequent design refinements. Administrative and logistical challenges, such as scheduling conflicts and documentation deadlines, were managed through centralized planning and early coordination. For instance, shared calendars and task dependencies in Notion were used to align fabrication timelines with testing availability, while official team email accounts were used for external coordination and submission-related communication. By

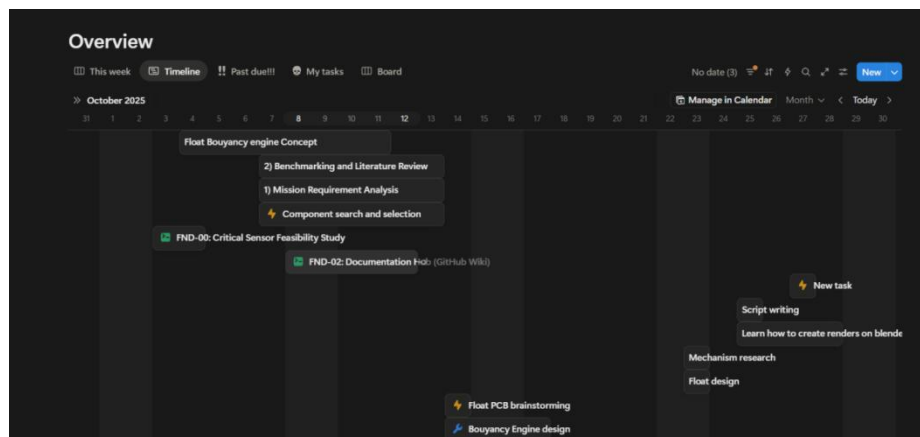


Figure 5 Notion Team Timeline Dashboard

integrating these support activities into the overall management framework, the team minimized disruptions and maintained focus on technical objectives throughout the season.

E. Problem solving

Solving at Overflow Robotics, effective problem-solving is integral to our daily operations and project success. Our approach emphasizes proactive communication, collaboration, and a structured framework that empowers team members to tackle challenges as they arise. Open Communication Channels: We ensure a setting in which members can easily report issues and challenges. Frequent reminders in our weekly Main Meetings enable all members to speak out against challenges, so no problem falls through the cracks. Furthermore, leveraging tools such as WhatsApp and Trello makes real-time discourse possible, allowing for quick resolution of urgent matters. Collaborative Brainstorming Sessions: When faced with difficulties, we have a series of brainstorming sessions. The sessions include people from various departments bringing different perspectives and inventive solutions. **(Refer to figure 6 for the flowchart followed for brainstorming)** For example, if a technical problem arises during the designing process, the mechanical and software engineers sit together to identify the cause of the problem and come up with an effective solution to address it. Designated Problem-Solving Teams: Small group teams are organized to address specific issues. These groups, guided by a designated team member, examine the issue at hand, generate potential solutions, and uphold their findings during our Progress & Goals Meetings. This rather inclines toward delegate technocracy, which stimulates a greater degree of accountability and allows for more detailed exploration of complex problems.

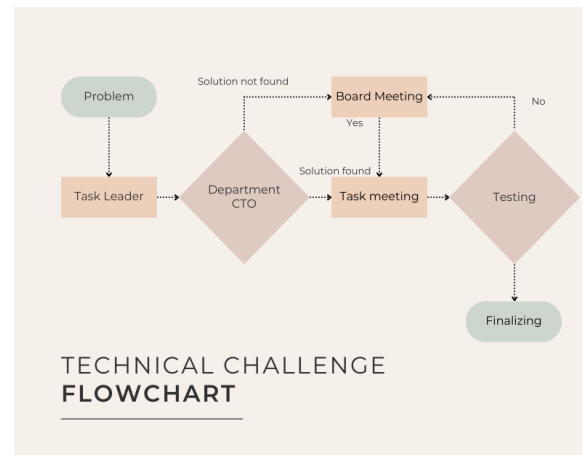


Figure 6 Technical challenges solution Flowchart

3.0 Design rational

Encore is a durable and serviceable modular remotely operated vehicle (ROV) designed to meet the mission-specific requirements of the 2026 MATE ROV Competition **(Refer to figure 7 for Encore Picture)**. Through the integration of customized design features, the vehicle enables efficient task execution while maintaining compliance with the Marine Advanced Technology Education (MATE) Request for Proposals (RFP) and supporting the United Nations Sustainable Development Goals.

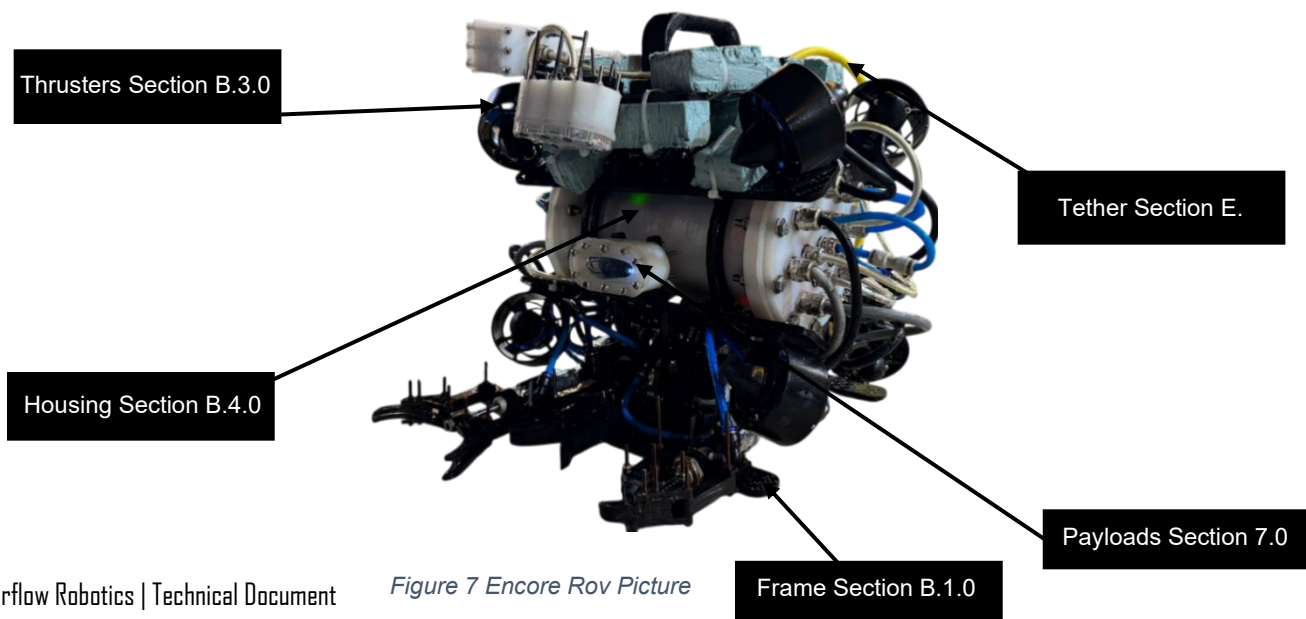


Figure 7 Encore Rov Picture

A. Design methodology and process

The design methodology behind **Encore** is centered on rapid iteration, continuous improvement, and mission-driven decision-making. Initial concepts are treated as exploratory starting points rather than final solutions, allowing the team to evaluate ideas critically and refine them through repeated testing and feedback. For every subsystem, development begins with clearly identifying the mission task to be completed, ensuring that mission objectives remain the primary driver throughout all design iterations. Each iteration follows a structured engineering design process. The problem to be solved is first defined, including its rationale, performance criteria, and operational constraints. Potential solutions are then generated through brainstorming and evaluated by comparing advantages, limitations, and implementation trade-offs. Promising concepts are refined through design reviews, prototyping, and testing, with test results directly informing subsequent iterations. This cycle emphasizes producing reliable, cost-effective, and high-performing solutions tailored to specific mission requirements. **Encore** represents the culmination of Overflow Robotics' accumulated design experience over multiple competition seasons. Lessons learned from previous vehicles informed key decisions related to structural design, material selection, and subsystem integration. Earlier designs prioritized accessibility and rapid prototyping, which supported learning but revealed limitations in durability, precision, and long-term performance. These insights guided the transition toward more robust construction methods and improved design standards in **Encore**. The final design was refined through detailed trial drawings and CAD modeling, followed by precision fabrication to ensure dimensional accuracy and structural integrity. This approach supported modularity, serviceability, and repeatable assembly, while reducing integration risk during testing and competition preparation (**Refer to figure 8 for Gantt chart**). As a result, **Encore** reflects a deliberate balance between performance, reliability, and maintainability, making it well suited for the demanding operational conditions of the 2026 MATE ROV Competition.

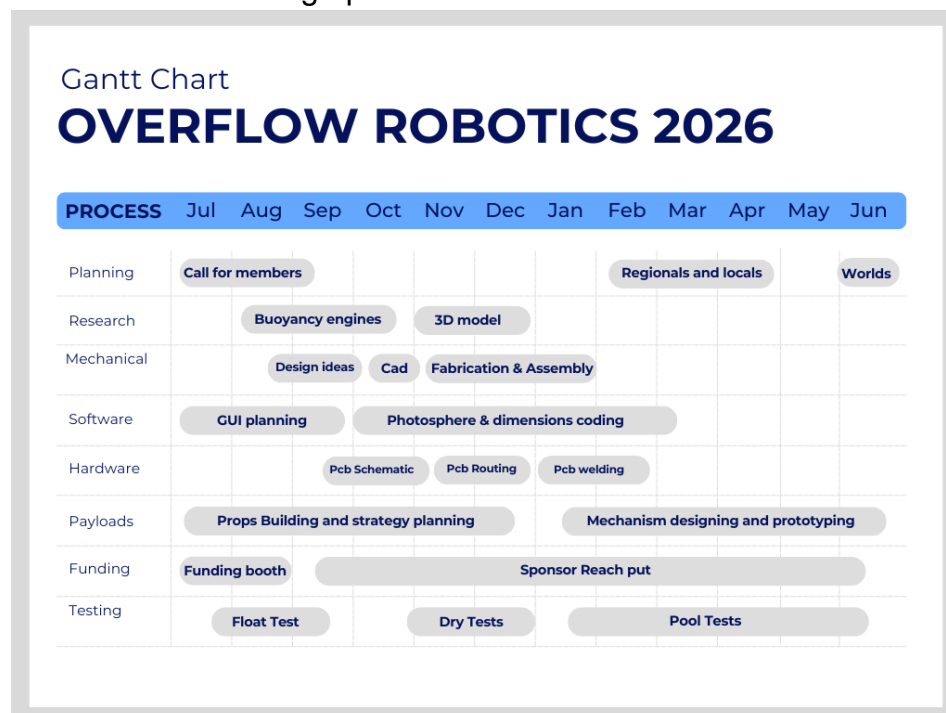


Figure 8 Overflow Robotics 2026 Gantt chart

B. Mechanical Systems

Encore's mechanical systems form the structural foundation of the vehicle, supporting propulsion, buoyancy, and mission tooling while maintaining a compact and balanced configuration. The design emphasizes structural strength, modular integration, and serviceability to ensure reliable operation during testing and competition.

1.0 Frame

In the last season, Overflow Robotics used Carbon fiber as the main material for the ROV frame. In the evaluation of materials, acrylic and aluminum alloys were examined in conjunction with carbon fiber. Eventually, carbon fiber was selected as the main material for the **Encore** frame due to its special features. The peculiar merit of carbon fiber was the great strength-to-weight ratio, corrosion resistance, and design flexibility which would help to realize the objectives. Acrylic, while lightweight and economical, is no match for this material for strength and durability. Aluminum, while strong, neither lightweight nor resistant to corrosion and does not afford the same flexibility with nifty designs. **(Comparative analyses are displayed in a chart in trade off section)** Hereby, the frame for the **Encore** was entirely manufactured from carbon fiber and this frame was assembled using 3D-printed joints, thus resulting in a very lightweight structure with a great strength-to-weight ratio. While the carbon fiber comes at a high cost, this investment was definitely well worth it for the performance and durability achieved **(Refer to Figure 9 for frame only render)**.

Encore features a unique and highly functional design, equipped with 8 thrusters, 3 manipulators, 7 cameras, and an electronic housing. Its frame is primarily composed of four main components:

1. Upper Plate: Used to mount cameras and the handle.
2. Lower Plate: Provides mounting points for manipulators and additional cameras.
3. Thruster Fixation Plates: Secure the thrusters and light casings in place.
4. Electronic Housing Fixation Plates: Connect all frame parts and securely hold the electronic housing. All views of the frame design are shown below.

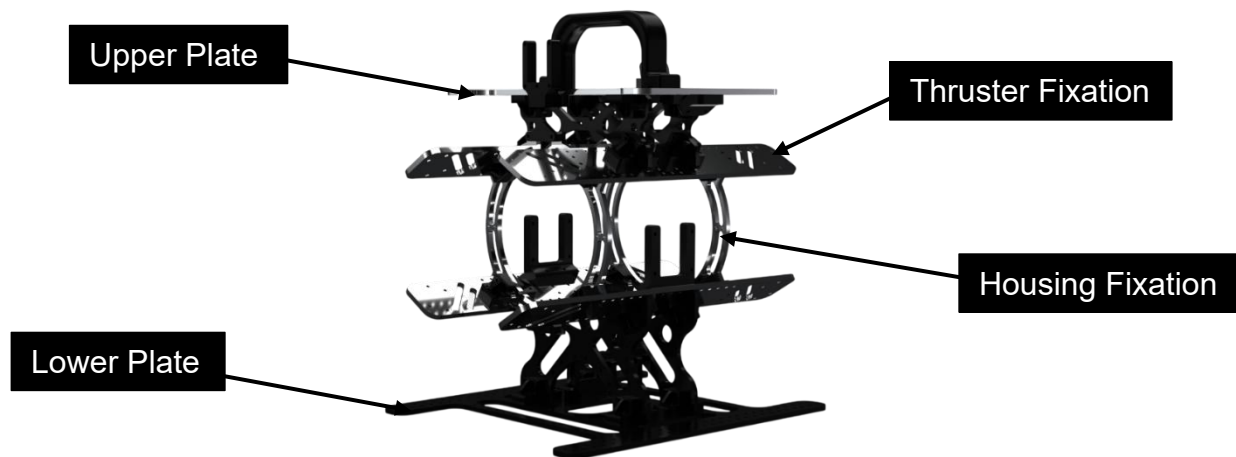


Figure 9 Encore Frame isometric view

With speed being a critical factor for the 2026 ROV, Overflow Robotics implemented several strategies to enhance **Encore's** performance:

- Streamlined Body Design: A streamlined frame was prioritized to reduce drag and enable higher speeds underwater **(Refer to figure 10 for roV front view)**.
- Carbon Fiber Frame: The use of carbon fiber for the main frame significantly reduced the ROV's overall weight, contributing to faster movement.
- 3D-Vectored Thruster Configuration: This configuration increased speed by 20% compared to the previous model, CFD Analysis and Drag Reduction: Computational Fluid Dynamics (CFD) analysis identified areas of high drag, allowing the team to implement more streamlined solutions resistance.

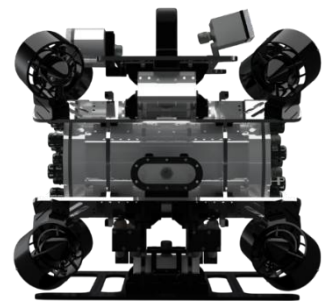


Figure 10 Encore Front View

2.0 Buoyancy and ballast

Encore demonstrates buoyancy; which is the ability of an object to stay afloat. Buoyant force is the one that decides whether an object will sink or float based on its weight and surface area in contact with fluid. When an object floats, it pushes away that mass of water equal to its own weight. Conversely, if the weight of the object is greater than that of the displaced fluid, the object will sink. This principle is influenced by the density or weight of the fluid; denser fluids can prop up heavier bodies. In a divided fluid pressure. Increases with depth due to the weight of the overlying fluid. Therefore, the pressure at the bottom of a submerged object is greater than at the top, creating an upward buoyant force. Using this concept, a spreadsheet was developed to calculate the volume, buoyant force, and weight of each component in water. The analysis revealed that **Encore** was slightly negatively buoyant, requiring additional foam to achieve neutral buoyancy. Reducing excess material helped decrease **Encore's** weight to 14.71 N, with a displacement volume of 9630 cm³. Archimedes' principle, expressed as $F_{\text{Buoyancy}} = V \times \rho \times g$, was applied to determine neutral buoyancy. The buoyant force was calculated at 71.56 N, which was less than **Encore** weight, resulting in a 1.4 kg negative buoyant force. To counteract this, floating foam was added, ensuring the vehicle became neutrally buoyant as a key design consideration (**Refer to Figure 11 for buoyancy component breakdown**).

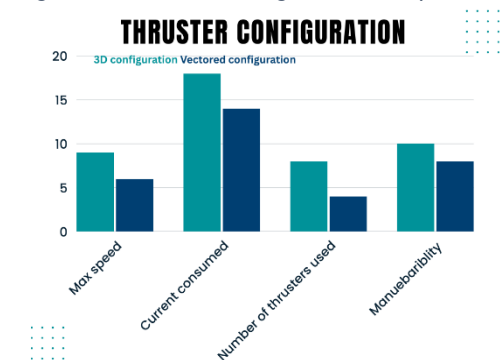
Category	Component	Mass in Air (kg)	Volume (cm ³)	Buoyant Force (N)	Underwater Weight (N)
Structural	Carbon Fiber Frame	1.69	1000	9.81	-6.77
	3D-Printed Joints	0.24	250	2.45	0.15
	HDPE Housing (body)	0.94	3100	30.4	21.19
	HDPE End Caps (2x)	0.47	580	5.69	1.08
Propulsion	Thrusters (8x U2)	2.25	600	5.88	-16.22
	Thruster Shrouds (8x)	0.28	240	2.35	-0.41
Electronics	Jetson Orin Nano	0.14	60	0.59	-0.79
	Arduino nano	0.04	20	0.2	-0.17
	PCBs (4x custom)	0.24	150	1.47	-0.83
	USB Cameras (7x)	0.33	300	2.94	-0.28
	RealSense Camera	0.08	80	0.78	0.05
	Sensors	0.09	50	0.49	-0.43
Tools	Dual Horizontal (2x)	0.47	180	1.77	-2.84
	Vertical Scissor	0.33	150	1.47	-1.75
	Servo motor	0.38	160	1.57	-2.11
	Mission Mechanisms	0.24	120	1.18	-1.13
Cabling	Internal Wiring	0.24	110	1.08	-1.22
	Pneumatic Lines	0.14	90	0.88	-0.5
	Connectors & Glands	0.24	60	0.59	-1.71
SUBTOTAL		8.8	7300	71.59	-14.71
---	---	---	---	---	---
Correction	Foam Flotation	0.5	2300	22.56	17.65
	Ballast Weights	0.3	30	0.29	-2.65
FINAL	Total Analysis	9.60 kg	9630 cm ³	94.44 N	+0.29 N*

3.0 Propulsion and Thrusters

Figure 11 Rov Breakdown Buoyancy Calculation

In previous seasons, Overflow Robotics relied on Blue Robotics T200 thrusters due to their strong thrust-to-current performance and proven reliability. For the 2026 season, the propulsion system was re-evaluated to better align with the MATE ROV RFP requirements for repeated vertical motion and dynamic maneuvering in the waves and currents expected at the Newfoundland competition site. Testing and analysis showed that the previous six-thruster vectored configuration, while effective for horizontal maneuverability, and was not optimally efficient for sustained vertical operation under these conditions, prompting a comprehensive redesign. Multiple propulsion layouts were evaluated through spreadsheet-based force analysis (**Refer to figure 12 for comparison**), simulations, and in-water testing. The selected eight-thruster, three-dimensional configuration allows all thrusters to contribute across all six degrees of freedom, improving thrust distribution, responsiveness, and overall vehicle control. Thrusters were mounted at strategic angles of 30° and 60° in the XY and YZ planes, enabling efficient forward propulsion while maintaining strong vertical and lateral stability.

Figure 12 Thruster Configuration Comparison



Comparative analysis demonstrated smoother maneuvering, improved station-keeping, and higher performance during vertical ascent and descent. To complement the redesigned layout, Overflow Robotics transitioned from T200 thrusters to ApisQueen U2 thrusters (**Refer to trade-off section for comparison**). The U2 thrusters were selected for their lower mass, compact form factor, and favorable efficiency characteristics, which simplify buoyancy management, reduce inertial effects, and ease mechanical integration. Additionally, the significantly lower cost of the U2 thrusters allowed resources to be allocated to other mission-critical subsystems. While the eight-thruster configuration increased overall power demand, this trade-off was carefully evaluated and determined to be justified by the gains in vertical efficiency, depth control, and handling. Extensive simulation and in-water testing confirmed that the final propulsion system meets the performance, power, and reliability requirements of the 2026 competition environment.

4.0 Sealing

Encore is equipped with a cylindrical electronic housing made of HDPE, positioned sideways at the center of the vehicle to minimize drag. HDPE plates with stainless steel glands are mounted on both sides to securely seal the cables. Gaskets are fitted on both sides and fastened with screws to ensure a watertight seal for the HDPE plates. Our housing was designed to withstand pressure up to 1 bar = 10 meter deep.

C. Electrical Systems

Encore's electrical systems form the backbone of vehicle control and power delivery, supporting propulsion, sensing, and tooling subsystems. The system was engineered with an emphasis on electrical safety, consistent performance, and simplified troubleshooting to ensure dependable operation during testing and competition (**Refer to figure 13 for Electrical System**).

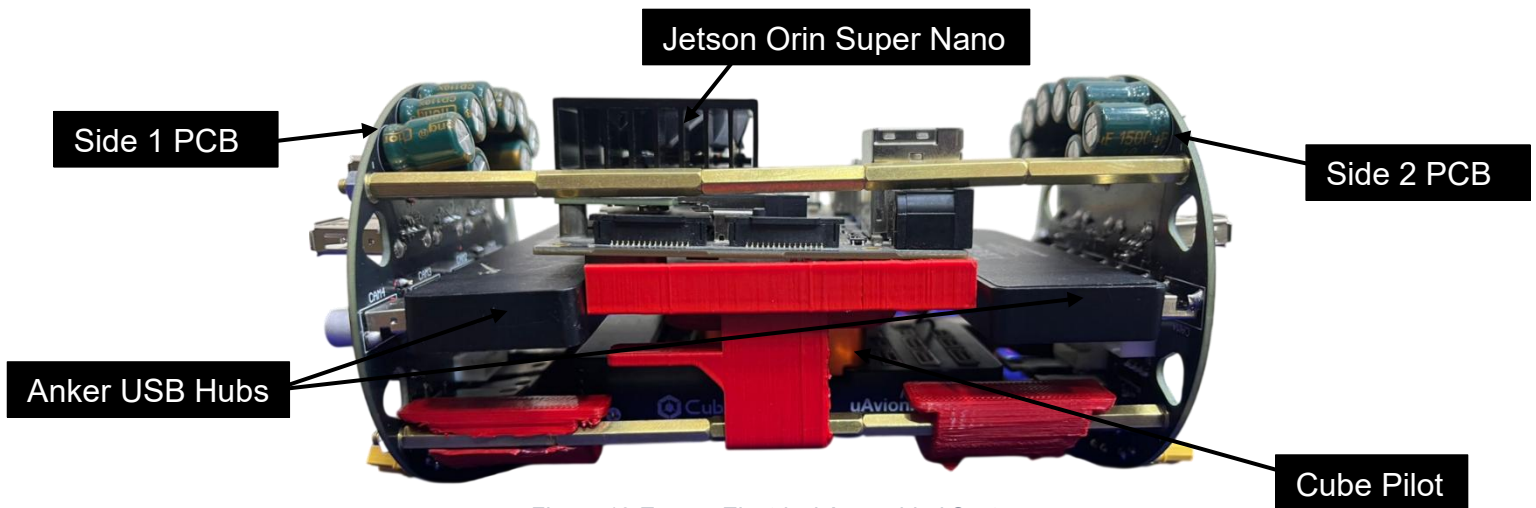


Figure 13 Encore Electrical Assembled System

1.0 Major Electrical Components and Selection Rationale

Encore's electrical system is built around a modular, mission-driven architecture designed to balance processing capability, reliability, and system integration. Components were selected based on performance requirements, subsystem compatibility, and proven reliability in underwater robotics applications. At the core of the system is the **NVIDIA Jetson Orin Nano Super**, which serves as the primary onboard computer. It was selected over the Jetson Nano for its significantly higher computational performance and improved efficiency, enabling real-time processing of data from multiple cameras while supporting advanced vision algorithms and future software expansion. Although it consumes more power, the performance benefits were necessary to support the vehicle's multi-camera vision system. Low-level control is handled by a **Cube flight controller**, responsible for stabilization, sensor fusion, and actuator control. The Cube was chosen over a microcontroller-based

solution due to its integrated high-quality IMU, real-time processing capabilities, and proven control firmware, reducing system complexity and improving reliability. Depth sensing is provided by the **Blue Robotics BAR030** pressure sensor for accurate depth measurement and stable vertical control. Motor actuation is handled by **Blue Robotics ESCs**, selected for their reliability, smooth control, and electrical isolation between high- and low-power systems. The vision system includes seven USB cameras for full situational awareness and redundancy, along with an Intel RealSense depth camera for spatial perception and future autonomy support. **Two USB hubs** connect all cameras to the Jetson (**Refer to figure 15**). **Three custom PCBs** were developed to streamline power and signal routing, including camera connections, actuator interfaces, regulated power distribution, and current backflow protection. System Breakdown (**For reference see figure 14**):

- Side 1: This PCB connects four camera USBs to the USB hub, links four actuators to the Cube via JST connectors, and provides a stable power supply to the Jetson.
- Side 2: Similarly, this PCB connects four additional cameras and four actuators.
- Main Power: The system uses ten XT-60 connectors—one serves as the main input, eight distribute power to the thrusters, and one powers the other PCBs. This board also includes diodes to prevent backflow of current.

Together, these components form a layered electrical architecture that separates computation, control, sensing, and actuation, providing the performance, reliability, and flexibility required for the 2026 MATE ROV Competition. MATE ROV Competition.

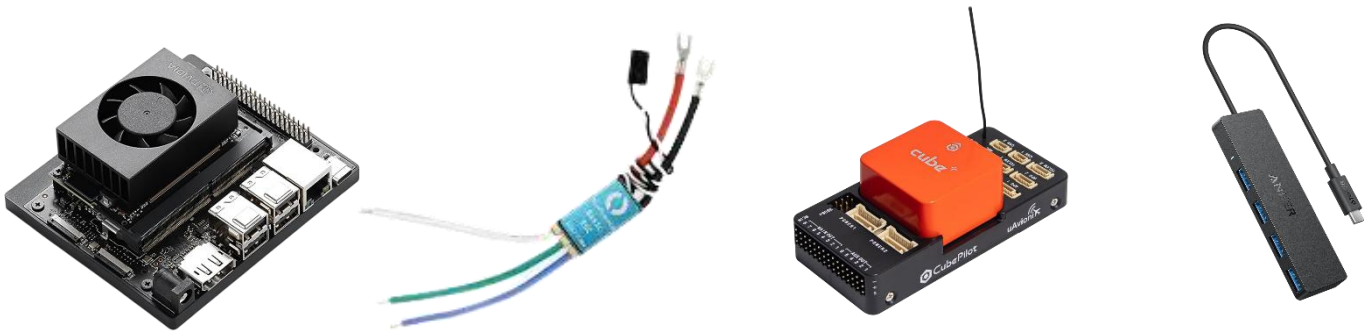


Figure 14 Electrical components; Left to right: NVIDIA Jetson Orin Super nano | ESC | Cube flight controller | Anker USB hub

2.0 Power Architecture and Protection Strategy

Power is delivered from the surface station via two 3 mm copper cables with XT60 connectors, chosen for low resistance and high current capacity. Onboard, a dedicated Power Distribution PCB regulates and distributes power to all subsystems, incorporating diodes to prevent reverse polarity and fault propagation. A boost converter provides a 19 V rail for the Jetson Orin Nano Super, while a DC–DC buck converter supplies 5 V to low-voltage systems, including the USB cameras, reducing interference between high- and low-power circuits. Sixteen bulk and decoupling capacitors mitigate voltage drops from thruster startup and load changes, ensuring stable operation. This power architecture enhances electrical stability, protects sensitive electronics, and supports reliable performance under dynamic competition loads (**Refer to figure 15 for electricity flowchart**).

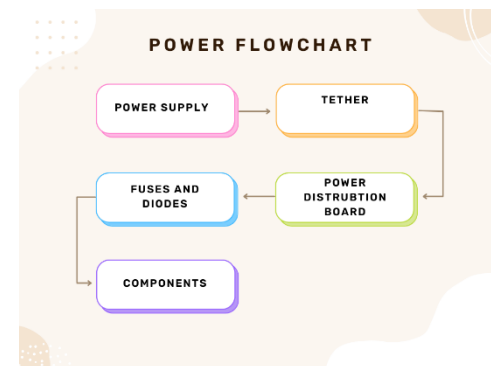


Figure 15 Power Flowchart

3.0 Signal Architecture and Control Integration

Data communication between the surface station and the vehicle is established through a Cat6 Ethernet tether, providing high bandwidth and low-latency transmission of commands and telemetry. Commands are received by the Jetson Orin Nano Super, which handles high-level processing and forwards structured control inputs to the Cube flight controller. This separation isolates computationally intensive tasks from time-critical control functions, ensuring stable operation under high processing loads. The Cube executes low-level control loops and distributes signals to actuators, with thrusters controlled via dedicated PWM channels and other actuators connected to auxiliary outputs. Physical separation of power and signal wiring reduces electromagnetic interference. The Cube also provides operational redundancy, maintaining basic control in the event of degraded communication with the main computer. This architecture ensures reliable communication, precise control, and consistent vehicle behavior (**Refer to figure 16**).

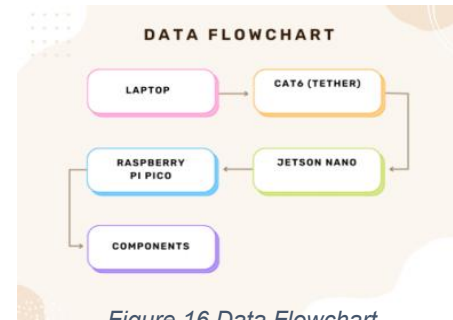


Figure 16 Data Flowchart

D. Software architecture

The software architecture of **Encore** was designed to provide reliable, modular, and scalable control of the vehicle while supporting real-time operation and future system expansion. The system is structured around a layered architecture that separates high-level decision making, perception, and operator interaction from time-critical control and actuation. This approach improves system stability, simplifies debugging, and allows individual software modules to be developed, tested, and updated independently.

1.0 Sensors and perception

The perception system is centered on an Intel RealSense sensor suite, which includes two stereo depth cameras, an RGB camera, a laser sensor, and an IMU. The stereo cameras estimate depth by comparing images from different angles, while the laser provides accurate distance measurements and the RGB camera captures color information. Each frame produces both an RGB image and a depth map, allowing the system to understand how far every pixel is from the camera. The IMU tracks movement and orientation, helping align consecutive frames in space. All this data is processed on the Jetson, where SLAM (Simultaneous Localization and Mapping) combines RGB, depth, laser, and IMU information to build 3D models. As the ROV moves around an object or area, multiple views are merged together, allowing each pixel to be placed correctly in 3D space and enabling accurate modeling of objects or mapping of larger environments. For object recognition, a YOLO-based deep learning model is used for real-time crab detection. The model analyzes live camera frames, identifies crabs, and estimates their position by linking detection results with depth data. Navigation is guided using vision-based line detection. Blue lines define the intended path, and the ROV continuously adjusts its motion to stay centered between them. If it drifts or tilts, the system automatically corrects its position. Red lines represent restricted zones and are intentionally ignored by the navigation logic.

2.0 Communication protocols

The ROV communication system is based on Ethernet networking, ROS messaging, and the MAVLink protocol. Ethernet is used to establish a fixed local area network (LAN) connecting the Jetson, the Cube flight controller, and the control laptop. Both the Jetson and laptop are configured on the same IP network, enabling direct device discovery and low-latency data exchange. The Jetson runs ROS (Robot Operating System), which manages sensor data, control signals, and perception outputs through ROS topics. Data from the Intel RealSense camera including RGB, depth, laser, and IMU measurements is published to ROS topics, processed on the Jetson, and transmitted over Ethernet to the control laptop.

for visualization, monitoring, and operator feedback. For vehicle control, MAVLink is used as the primary communication protocol between the Cube and the control station. MAVLink Router is deployed on the Jetson, allowing it to function as a transparent MAVLink bridge between the Cube and any device connected to the Jetson. With the Cube directly connected to the Jetson and an Ethernet link established between the Jetson and the laptop, MAVLink Router forwards MAVLink packets without modification, making the laptop and Cube appear as if they are directly connected. This enables seamless integration with ArduPilot ground control software such as QGroundControl and Mission Planner, allowing joystick input, flight controller configuration, motor control, and gripper setup to be handled directly from the laptop. Without MAVLink Router, joystick commands would require custom Python scripts to capture inputs on the laptop, relay them to the Jetson, and then transmit MAVLink commands to the Cube, eliminating compatibility with standard ground control software and requiring manual implementation of control logic. The use of MAVLink Router therefore simplifies communication architecture while providing reliable control and configuration capabilities.

3.0 Control System

The control architecture is organized into two layers: an inner loop and an outer loop. The inner loop runs on the Cube Orange flight controller and uses PID control to stabilize the ROV's motion. It continuously processes sensor data such as orientation and position and adjusts actuators in real time to maintain stability and track commanded motion, operating independently of operator input. The outer loop serves as the high-level control layer, where commands originate from either the joystick or autonomous scripts running on the Jetson or laptop. This layer provides guidance to the inner loop, enabling tasks such as path following, alignment between blue lines, and obstacle avoidance. When autonomous mode is enabled, the ROV performs mission tasks without human intervention using feedback from onboard perception systems.

4.0 Software Stack

The software stack is organized in layers (**Refer to Figure 17 for stack flowchart**) to ensure smooth and reliable operation. At the base, it runs on a Linux operating system, which provides stability, manages hardware resources, and handles networking. On top of this, ROS (Robot Operating System) acts as middleware, connecting all the different software modules and allowing them to exchange data easily through ROS topics, without having to manage low-level hardware details. High-level software is mainly written in Python and C++, relying on tools that are central to the ROV's operation. OpenCV is used for general image processing, the Intel RealSense SDK handles RGB and depth data acquisition, SLAM libraries provide real-time 3D mapping and localization, and YOLO enables fast object detection. NumPy supports numerical computations, while Ethernet over IP ensures reliable communication between the Jetson and the control laptop.

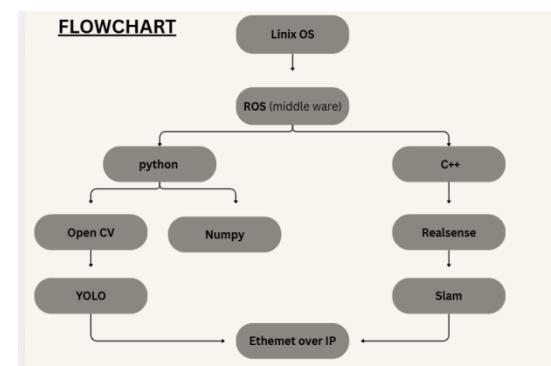


Figure 17 Software Stack Flowchart

5.0 Assisted and autonomous functions

- Transect:** This system uses computer vision to autonomously detect and navigate between two blue lines using real-time video. HSV color space was chosen over BGR for robustness under varying lighting conditions. Morphological filtering reduces noise and fills gaps, while contour-based detection identifies valid lines based on size and aspect ratio. Line centers are calculated using image moments, and the midpoint between them is used for alignment. Forward motion is commanded when centered, and realignment occurs if one line is lost. Traditional computer vision was selected over deep learning to avoid training requirements, and Canny edge detection was rejected due to noise sensitivity.

- **Crab Detection:** Crab detection was implemented using a YOLO-based deep learning model for real-time object detection. YOLO was chosen over R-CNN due to its superior processing speed. A dataset was created by extracting frames from videos of printed crab images, manually annotating them in RoboFlow, and applying automated data augmentation to increase dataset size. RoboFlow was selected for its integrated annotation, augmentation, and export capabilities.
- **3D Model:** A 3D reconstruction system was developed using Intel RealSense RGB, stereo, and IMU data. ROS with the RTAB-Map SLAM algorithm running on the NVIDIA Jetson was used to generate real-time 3D models by simultaneously tracking camera position and mapping the environment. Offline photogrammetry tools were rejected as they do not support live pose tracking. The final model is saved onboard and later viewed using Cloud Compare.
- **Measuring Distance:** Distance measurements are obtained using Intel RealSense RGB, stereo, and IR depth data to provide pixel-level distance information. Stereo and IR sensors enable full-object distance measurement, unlike ultrasonic sensors, which were rejected due to limited range and point-only measurement. Distances are extracted and displayed using RealSense Viewer.

E. Tether and Tether management

The tether is a critical component of the ROV system. After finalizing the electrical design, the team adopted a commercially available Video Ray multi-conductor tether to handle both power delivery and data communication through a single integrated cable (**Refer to figure 18**), alongside one dedicated pneumatic line for actuator operation. This approach simplified deployment, reduced cable management complexity, and improved overall reliability compared to multiple separate cables. Tether management focused on buoyancy, flexibility, and strain relief. Foam flotation was incorporated to maintain near-neutral buoyancy, preventing the tether from sinking or interfering with vehicle motion.



Figure 18 Video Ray Used tether

The tether jacket was selected for flexibility to support smooth maneuvering, and a 360° rotating strain-relief mechanism was implemented at the vehicle termination to prevent torsion loads and protect electrical and pneumatic connections during operation. Tether was wrapped with colored points at different positions to mark the amount of tether the pilot have for smoother operations (**Refer to Figure 20**)

Scenario	Immediate Action (Step 1)	Secondary Action (Step 2)	Pilot Comms
Snag / Tension	STOP all movement	0.1 m/s reverse for 5s	"Tether Snagged"
Data Dropout	Check surface connectors	Monitor ping/video feed	"Loss of Comms"
Pressure Loss	Check manifold gauge	Abort pneumatic tasks	"Pneumatic Fail"
Prop Tangle	EMERGENCY KILL power	Visual camera inspection	"Tether in Prop"
Human Hazard	Handler signals "Stop"	Clear 1m deck safety zone	"Deck Hazard"

Figure 19 Tether emergencies call outs

Marker	Depth	Color Code	Handler Call-Out (Mandatory)	Status
M1	5m	● Blue	"5 meters deployed - Flotation 1 clear"	SAFE
M2	10m	● Green	"10 meters deployed - Flotation 2 clear"	SAFE
M3	15m	● Yellow	"15 meters deployed - Flotation 3 clear"	SAFE
M4	20m	● Orange	"20 meters deployed - Approaching depth"	CAUTION
M5	25m	● Red	"25 METERS - APPROACHING LIMIT"	WARNING
M6	30m	● Black	"STOP - 30 METERS - MAX DEPLOYMENT"	CRITICAL

Figure 20 Color Coding for tether length

4.0 Safety

A. Safety Philosophy

Safety is the foundation of all team activities in Overflow Robotics, guiding every stage of **Encore's** design, construction, and operation. A proactive safety culture is maintained through comprehensive

training, clear procedures, and constant supervision. All members receive instruction in tool, electrical, pneumatic, and physical safety, ensuring they understand both the capabilities and risks of the equipment they use. No individual is permitted to work alone, and experienced members or supervisors oversee operations to reinforce best practices and accountability.

B. Safety Procedures and Training

Strict safety protocols are enforced in laboratories, workshops, and poolside environments of Overflow Robotics. Personal protective equipment such as goggles, gloves, closed-toe shoes, and additional situational PPE is mandatory when required. Equipment is handled only under the guidance of trained personnel, and all operations follow established safety checklists, job safety analyses, and emergency procedures (**Refer to figure 40 for Safety checklist**). Clear communication among team members especially during ROV deployment and recovery is essential to preventing accidents, and trained lifeguards or first aiders are present during water operations (**Refer to JSA for specific safety protocol**).

C. Vehicle Safety Features

Encore is engineered with multiple built-in safety features that exceed standard competition requirements. These include rounded and deburred edges, shrouded thrusters (**Refer to figure 21**), strain-relieved tethers, clearly labeled hazards, and waterproofed electronic enclosures. Electrical protection is ensured through fuses, current-limiting software, and continuous power monitoring, while internal sensors track pressure, humidity, and temperature to detect unsafe conditions. Together, these features protect operators, bystanders, and the environment while ensuring reliable and safe **Encore** performance.



Figure 21 U2 Shrouded Thruster

5.0 Testing and trouble shooting

A. Testing Methodology and Validation

Vehicle testing follows a structured, bottom-up approach, beginning with individual component testing and progressing to full system validation. Subsystems are evaluated independently before integration to ensure reliability and performance. For example, thrusters are tested in controlled water conditions to measure thrust output, efficiency, current draw, and thermal behavior. System development is driven by rapid iteration based on testing results. Weekly pool tests assess buoyancy, stability, maneuverability, and control responsiveness, allowing quantitative comparison of design revisions. Performance data is logged and analyzed to guide hardware and software improvements. Final validation requires **Encore** to consistently perform predefined maneuvers such as depth changes, station-keeping, and obstacle avoidance, ensuring reliable and predictable operation under mission conditions. (**Refer to figure 22 for testing summary**)

TESTING STATISTICS SUMMARY	
Total Testing Sessions	45 sessions
Total Pool Time	350 hours
Issues Identified	6 issues
Issues Resolved	6 issues (100% resolution rate)
Success Rate After Fixes	100% (all retests passed)
Maximum Depth Tested	6.0 meters
Longest Continuous Operation	3 hours 15 minutes (Jan 26)

Figure 22 Testing Summary

B. Troubleshooting Strategies and Diagnostic Techniques

The Overflow Robotics Team has developed an organized and cooperative troubleshooting procedure for diagnosing and documenting problems using a systematic process. When experiencing problems due to an event (e.g., loss of power, sensor failure, leakage) (**Refer to figure 23 for various tests**), the team will follow a systematic workflow to help isolate the problem step-by-step. For instance, if there are thrusters that do not respond, the team will first verify that power and signal are being delivered to the thrusters. Once they have verified power and signal, they will individually test each thruster to

determine the electrical, software or mechanical problem that is causing the thrusters to be unresponsive. The team has created a standard troubleshooting checklist to support consistent and efficient diagnostics, as they look at items such as checking the connectors, monitoring sensors in real time, verifying communication from the Jetson to the flight controller, and validating the firmware. Using logging and optical indicators, the team will be able to identify whether any component or combination of components has been performing outside of normal parameters. Finally, once a problem is resolved, the team will document and review the events that led to the problem in order to improve reliability and develop a better understanding of how systems interact.

COMPREHENSIVE TESTING RESULTS — Encore ROV (Fall 2026)				
Test Date	Test Type	Issue Found	Fix Applied	Retest Result
15-Dec	Dry Run (Electronics)	Camera 3 not detected (USB hub #2)	Replaced USB cable (faulty connector)	PASS
22-Dec	Pool Test (2m)	Depth sensor drift (+0.3m error)	Recalibrated IMU; zero offset at surface	PASS
29-Dec	Pool Test (5m)	Housing leak detected at 4.2m depth	Retitned 2nd gasket; increased compression	PASS (tested 6m)
5-Jan	Thruster Power Test	Thruster 3 drawing 3.5A (exceeds spec)	Software current limit set to 2.0A max	PASS
12-Jan	Mission Sim (Task 3)	O-Ball mechanism dropped ball on ascent	Tilted collection arm 15° to prevent fallout	PASS
19-Jan	Full Mission Simulation	Tether snagged on thruster mount	Added 4 guide loops; rerouted tether path	PASS
26-Jan	Endurance Test (2 hours)	No issues observed; all systems nominal	-	PASS
3-Jan	Competition Dress Rehearsal	All tasks completed within time limits	-	PASS
10-Jan	Final Systems Check	No issues observed; ready for competition	-	PASS

Figure 23 Different tests and their results and how they were fixed

C. Prototyping and Iterative Development

In Overflow Robotics, prototyping is an integral aspect of the engineering design process. Instead of designing a product at one time, the Overflow Robotics team uses an iterative prototyping methodology that allows them to test, evaluate, and refine ideas rapidly. The team is able to verify and validate fundamental principles through the use of early prototype testing for integral designs such as the frame geometry, the Bush cousin distribution, waterproofing methods, and what components are positioned where in the product's design. There are several iterations of each prototype for both structural components and custom PCBs, allowing the team to verify the ease, durability, and serviceability of assembly. Prototypes at this time are produced and tested both in dry conditions and in water to identify flaws within the design before producing the final version(s) of the product. In addition, the feedback obtained from testing the prototypes within the pool

Subsystem	Component	Phase	Configuration/Material	Test Results & Issues	Engineering Solution / Benefit
FRAME	Structure	Iteration 1	HDPE Frame	Failed stress test; excessive flex under load.	Switched to Carbon Fiber for rigidity.
	Joints	Iteration 2	CF + Aluminum	Galvanic Corrosion at interface.	Developed 3D-Printed isolating joints.
	Final	Proven	CF + 3D Joints	PASSED all structural/corrosion tests.	High-stiffness, zero-corrosion frame.
PROPULSION	Layout	Iteration 1	6-Thruster Vectored	45s to 5m depth; insufficient vertical thrust.	Added 2 thrusters for 8-Thruster 3D config.
	Efficiency	Iteration 2	8-Thruster 3D	28s to 5m depth (38% improvement).	25% drag reduction via CFD analysis.
	Final	Proven	8-Thruster 3D	Optimized for 5.5m competition depth.	Superior vertical stability and speed.
ELECTRONICS	Architecture	Proto 1	Single Integrated PCB	Failed thermal test; high replacement cost.	Moved to Modular 4-PCB design.
	Repair	Proto 2	Modular 4-PCB	Passed thermal test; easy component access.	Individual board replacement: \$30 vs \$120.
	Final	Proven	Modular Stack	75% reduction in potential repair costs.	Field-serviceable and thermally stable.

Figure 24 various iterations with their results

environment (**Refer to figure 25**) will shape how the team modifies the prototypes' design so that any modifications will be based on the data accumulated as a result of testing in the real world. The prototyping strategy decreases risk, allows for a quickened development timeline, and enables the team to maximize the given resources and time constraints when optimizing the Encore design. Continuing to modify prototypes through testing data allows Overflow Robotics to create a final vehicle that

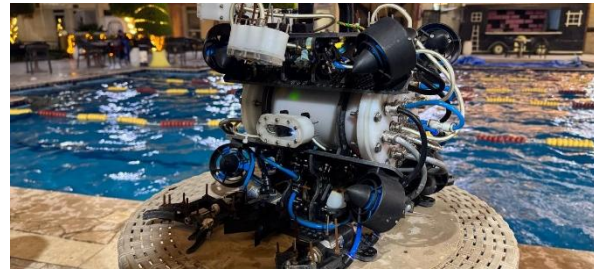


Figure 25 Encore pool test

is strong, easy to maintain, and ready to go to a competition. The iterative nature of the development cycle has created an emphasis on the need for early integration testing, cross-discipline communication, and design-for-maintenance principles with regards to underwater robotic systems. (**For Prototyping Examples and Iterations Refer to Figure 24**)

6.0 Payloads

A. Camera

Equipped with seven strategically placed cameras, **Encore's** cameras delivers comprehensive visual coverage for navigation and task execution (**Refer to figure 26**). The cameras provide simultaneous forward, downward, side, rear, and tool-facing views, allowing the pilot to maintain full situational awareness at all times. This configuration supports precise maneuvering, accurate payload manipulation, and effective obstacle avoidance while reducing blind spots. The multi-camera setup improves mission efficiency by limiting unnecessary repositioning and ensuring critical operations can be performed with confidence and accuracy.



Figure 26 Intel Realsense D435i render

B. Sensors

Encore utilizes a Bar030 pressure sensor from Blue Robotics (**Refer to figure 27**) along with a Cube IMU that integrates a compass and accelerometer to provide accurate and reliable navigation data. The Bar030 sensor enables precise depth measurement, allowing **Encore** to maintain stable depth control and execute missions that require consistent vertical positioning. The Cube IMU supplies real-time orientation, heading, and acceleration data, which are essential for maintaining vehicle stability, smooth maneuvering, and accurate directional control. Together, these sensors enhance **Encore's** ability to perform controlled movements, navigate complex underwater environments, and collect dependable data throughout each mission.



Figure 27 Bar030 Depth Sensor

C. Manipulators

Encore is equipped with three manipulators pneumatically operated used in various tasks, all manipulators are fabricated from carbon fiber and 3d printed parts.

Dual horizontal manipulators (Refer to figure 28):

- Constructed from a combination of 3D-printed components and Carbon fiber.
- Operated by a double-acting pneumatic piston.

- Functions: Removing the cap, installing the power connector, and connecting the sensor.

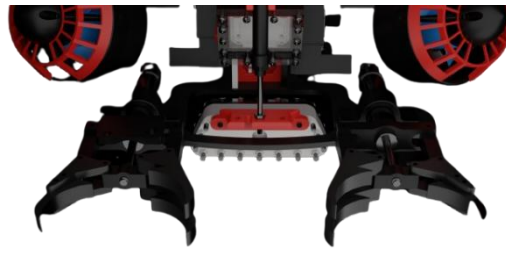


Figure 28 Dual Horizontal Manipulators Render

Scissor vertical manipulator (Refer to Figure 29):

- Constructed from a combination of 3D-printed components and Carbon fiber
- Operated by a double-acting pneumatic piston.
- Functions: releasing the pot and recovering it, recovering the coral baskets by the substrate and stars.



Figure 29 Scissor manipulator render

D. Mission specific mechanisms

Different 3d printed mechanisms were designed to solve specific mission tasks;

- Airbag was used for easy pot retrieval, once the vehicle holds the handle an airbag starts inflating to add more buoyancy for the vehicle to carry heavy weights.
- A one way entrance flexible mechanism (**Refer to figure 30**) was designed to cover 360 degrees of the u bolt for the buoy anchor connected to a spooling wheel using a fishing rod rope, bearings were added for easy spooling.
- A tilted arms (**Refer to Figure 31**) were used to collect the O-Balls since the O-balls were negative buoyant.



Figure 30 Flexible mechanism for the anchor buoy



Figure 31 O-Ball tilted mechanism

7.0 Build Vs buy & New Vs reused

The team categorized components based on whether in-house production would provide a significant advantage or if the complexity of the part necessitated a commercial purchase.

- Pressure Sensor (**Buy**): The team purchased the Blue Robotics Bar030. While expensive, the decision avoided the extensive trial-and-error costs associated with developing a custom sensor capable of maintaining high-precision depth data.
- Waterproof Thrusters (**Buy**): ApisQueen U2 were purchased off-the-shelf. The R&D required to reliably seal brushless motors in-house was deemed impractical compared to the immediate reliability of a commercial solution.
- Electronic Enclosure (**Build**): Designed and manufactured in-house to achieve a 70% cost reduction compared to market alternatives. This approach provided total flexibility in dimensions and modularity for internal mounting.

- Electronic System (**Build**): Custom PCBs were designed in-house. Although this required significant engineering effort, it proved more cost-effective and ensured the system could be easily upgraded for future iterations.

Component	Buy Cost (USD)	Build Cost (USD)	Decision	Justification	% Savings
Electronic Housing	\$250.00	\$75.00	BUILD	70% savings; custom dimensions for internal stack.	70%
Power Dist. PCB	\$180.00	\$102.70	BUILD	43% savings; custom layout for 8-thruster config.	43%
Camera PCB	N/A	\$102.70	BUILD	No commercial equivalent meets specific project requirements.	N/A
Pressure Sensor	\$75.00	\$250.00+	BUY	R&D cost too high; calibration is extremely difficult in-house.	-233%
Thrusters (8× U2)	\$498.00	\$800.00+	BUY	Waterproof sealing and dynamic balancing require expertise.	-60%
Frame (Carbon Fiber)	\$350.00	\$205.50	BUILD	41% savings; allows for custom design iterations.	41%
Manipulator Grippers	\$540.00	\$141.00	BUILD	74% savings; mission-specific geometry for tasks.	74%
IMU (BNO055)	\$48.00	\$120.00+	BUY	Precision sensors require factory-grade calibration.	-150%

Figure 32 Build Vs buy decision matrix

New vs. Reused: Resource Optimization Reusing existing inventory was a key tactic for reducing overhead. To ensure "reused" did not mean "compromised," all components underwent a rigorous testing phase before integration.

- Thrusters (**New**): Company decided to invest in new ApisQueen u2 thrusters as it meet company new design methodology.
- Tether (**New**): The vehicle's tether was a new component as company used video ray single cable buoyant tether.
- Pneumatic Components (**Reused**): Various valves and fittings underwent performance and pressure tests to ensure safety and functional integrity under operational loads.

8.0 Trade offs

Various component choices influenced the vehicle's overall cost, dimensions, weight, and performance.

- Jetson Nano vs. Jetson Orin Nano (Refer to Figure 33):** Both NVIDIA modules were evaluated to determine the primary processing hub for the vehicle, with the **Jetson Orin Nano** ultimately being selected. While the original Jetson Nano offers a solid foundation for entry-level AI, the Orin Nano provides a generational leap in performance, delivering up to **67 TOPS** of AI compute—roughly 80 times the processing power of its predecessor. By leveraging the **NVIDIA Ampere architecture** and high-speed **LPDDR5 memory**, the Orin Nano allows the vehicle to execute complex, multi-modal AI pipelines and real-time sensor fusion that would otherwise bottleneck on the older Maxwell-based hardware.
- Carbon Fiber vs. HDPE (Refer to Figure 34):** While both materials demonstrated excellent suitability for ROVs, carbon fiber was selected for its exceptional durability and lightweight properties, despite its higher cost.

Feature	Jetson Nano (Original)	Jetson Orin Nano Super
AI Performance	0.472 TFLOPS (FP16)	67 TOPS (INT8)
GPU Architecture	Maxwell (128 CUDA Cores)	Ampere (1024 CUDA Cores + 32 Tensor Cores)
CPU	Quad-core ARM A57	6-core ARM A78AE
Memory	4GB LPDDR4 (25.6 GB/s)	8GB LPDDR5 (102 GB/s)
Power Draw	5W – 10W	7W – 25W
Generative AI	Not Supported	Native Support (LLMs, SLMs, Stable Diffusion)
Launch Price	\$99 (Dev Kit)	\$249 (Dev Kit)

Figure 33 Jetson Orin Vs Jetson trade-off

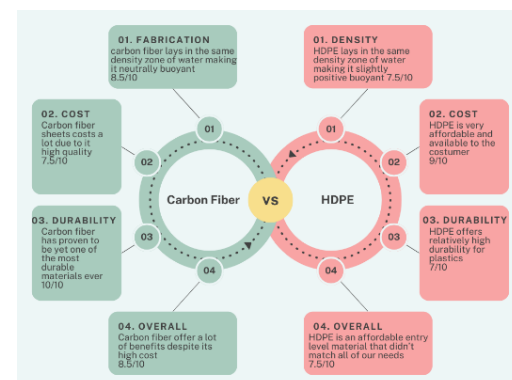


Figure 34 Carbon Fiber Vs HDPE Trade-off

- **Thruster Configuration (Refer to Propulsion section):** A comparison between a 3D-configuration and a vectored configuration was made when increasing the number of thrusters to 8. Although the vectored configuration provided 4 thrusters for each direction, it resulted in a larger vehicle and reduced speed. Instead, the 3D configuration was adopted, leveraging all 8 thrusters for every direction, improving speed and minimizing size.
- **Thruster Choice (Refer to figure 35):** While the T200 is a powerhouse, the ApisQueen U2 is often the superior choice for compact, agile ROV designs where every millimeter counts. Its smaller footprint significantly reduces the overall vehicle profile, which in turn minimizes the drag force experienced during lateral movement. Despite its size, the U2 maintains impressive efficiency in water operations, allowing for Impressive thrust force compared to its size. For Encore saving 70% of the thruster size and weight while getting roughly 0.8 kgf out of it made the U2 a blind choice, the U2 offers the perfect balance of "small but mighty" performance.

Feature	ApisQueen U2	Blue Robotics T200
Max Thrust (FWD)	~1.7 kgf to 3.4 kgf*	3.85 kgf (12V) / 6.7 kgf (20V)
Max Power	150W – 300W	300W (12V) / 645W (20V)
Current Draw	2 A - 9 A	2 A - 12 A
Price (Single)	~\$40 – \$55	~\$240
Build Materials	Composites / Plastic	316 Stainless, Polycarbonate, Epoxy
Mission specific features	Light weight / small size / high thrust to current ratio	Medium Sized / Heavy / Low thrust to current ratio

Figure 35 T200 Vs U2 Trade-off

9.0 Non-ROV Device

A. Float

Buoyancy Control System: The float operates using a buoyancy engine that controls ascent and descent by regulating the volume of water inside the system; negative buoyancy is achieved by drawing water into the float to increase mass and cause sinking, while positive buoyancy occurs when water is expelled, allowing the system to rise. This process is driven by a motor driver and power screw linear actuator that extends three 50-mL syringes to intake water, with a limit switch protection mechanism preventing overextension that could lead to syringe separation or internal leakage. For ascent, the actuator reverses direction, retracting the syringes to expel water until stopped by a second limit switch, ensuring controlled and safe operation. **Structural Design:** The internal frame consists of six precisely machined iron rings with mounting holes for mission-specific components, enclosed within a transparent cylindrical acrylic shell that provides maximum internal visibility; the complete assembly measures 90 cm in height and 17 cm in diameter, maintaining a compact yet functional form factor. **Sealing and Safety Mechanisms:** The float is secured using two pop-off valves designed to release excess internal pressure to prevent structural damage, while each cap incorporates dual rubber O-rings to maintain a watertight seal at depths of up to six meters. The top cap includes two sealed cable glands housing pneumatic lines directly connected to the syringes for controlled water transfer. **Control and Electronics:** System operation is managed by an ESP32 microcontroller, which provides communication capability and controls the motor driver responsible for bidirectional actuator motion, enabling precise buoyancy adjustment.

10.0 Acknowledgements

The success of Overflow Robotics and the development of "The New Dawn" were made possible through the collaborative efforts of our partners, mentors, and community. We extend our deepest gratitude to the following:

Strategic Partners & Organizations

- **MATE ROV Egypt & MATE Center:** We are immensely grateful for their invaluable technical support. MATE ROV Egypt, in particular, was instrumental in navigating the complexities of the registration process and providing solutions to critical challenges.

- **The Mechanism Fabrication Center:** Beyond providing access to advanced machinery, their team offered expert guidance throughout the entire fabrication phase, ensuring our design transitions from concept to reality.
- **PCBWay & Blue Robotics & Raspberry Pi:** We thank our industry sponsors for providing high-grade components and services at subsidized rates. Their support allowed us to integrate professional-grade hardware while maintaining project cost-efficiency.

Mentorship & Technical Guidance

We owe a debt of gratitude to our mentors for their unwavering commitment to our professional growth. Their technical oversight and constant motivation pushed us to exceed our perceived limits: **Ezz Eldin Hany || Ahmed Amr || Moazz Mahmoud**

We would like to also thank for their continuous support the mate Egypt rov board including: **Dr: Ahmed El-Shenawy || Eng. Mohab Eweda || Eng. Mohammed Mongy || Eng. Karim Elnaggar**

Community & Personal Support

- **Friends & Family:** Behind every late night in the lab was a support system of family and friends. Their belief in our vision, patience during the most demanding phases of the competition, and emotional encouragement provided the foundation for our determination.

11.0 Accounting

A. Budget

At the beginning of the season, Overflow Robotics adopted a responsible and proactive approach to budgeting, drawing on insights from the previous year's financial records alongside research into local suppliers to secure reasonable pricing for major components. Each sub-team contributed detailed cost assessments and technical justifications for their proposed expenses. After review and approval by the CEO and CFO, teams proceeded with technical development while ensuring that design decisions remained aligned with the established financial plan. In addition to direct technical expenses, portions of the budget were allocated to team identity and outreach initiatives such as team apparel, marketing materials, and social media engagement, which support visibility and long-term sustainability. A significant portion of the project funding was achieved through self-funding efforts by team members, supplemented by organized fundraising activities throughout the season. These included the establishment of fundraising booths, hosting a mid-year robotics camp, and organizing robotics-related events that both

Income Source	Projected Income	Actual Income	Type	Description
Employee dues	\$5,020	\$5,020	Cash	Monthly Employee due 145 \$
Mid Year Camp	\$290	\$320	Self-Fund	Mid Year Camp profit
Funding Booth	\$150	\$150	Donations	Funding booth Donations
Robotics Events	\$100	\$100	Donations	Robotics courses / Events profit
Total Income = 5,590 \$				
Expenses	Budgeted cost	Type	Category	Description
Thrusters	500 \$	Purchased	General	Apis Queen U2
Float Components	145 \$	Purchased	General	Monitor And HDMI Cable
Registration	500 \$	Purchased	General	Competition Registration
Joystick	25 \$	Purchased	General	PS4 Controller
Travel	N/A	Purchased	General	Airfare, Accomdation and food
Fluid power quiz	25 \$	Purchased	General	Fluid power Quiz
Frame	250 \$	Purchased	Mechanical	Carbon Fiber material
Machining	250 \$	Purchased	Mechanical	Router and Center lathe machining
3D printing	350 \$	Purchased	Mechanical	PETG Filament and its printing
Tools & PVC	350 \$	Purchased	Mechanical	Screwdrivers and different tools
Nuts, Bolts, Screws	250 \$	Purchased	Mechanical	Stainless steel nuts and bolts
Electronics housings	250 \$	Purchased	Mechanical	Hdpe for housing and camera casing
Cable Glands	300 \$	Purchased	Mechanical	Stainless steel cable galnds
Aclyric	120 \$	Purchased	Mechanical	Adclyrc covers for cameras
Pneumatics	200 \$	Re-Used	Mechanical	Pneumatic pistons and valves
ESCs	100 \$	Purchased	Electrical	ESCs for thrusters
Cameras	350 \$	Purchased	Electrical	High quality Usb cameras for vision
Jetson Orin nano	250 \$	Purchased	Electrical	Microcomputer
Cube Flight Controller	350 \$	Purchased	Electrical	Flight controller
Tether	380 \$	Donated	Electrical	Videoray Bouyant Tether
PCBs	150 \$	Purchased	Electrical	PCBs Fabrication
Electical Components	700 \$	Purchased	Electrical	Components for PCBs
Adafruit Imu	35 \$	Purchased	Electrical	BNO05 Imu
Total Estimated Out Of Pocket Cost : 5,250 \$				
Total Estimated Cost Including Reused and Donated Components : 5,830 \$				
AIRFARE (Alexandria → Newfoundland, round-trip per person)				
Economy class airfare per person	1050	USD/person	Cairo (CAI) → St. John's (YYT) via Montreal/Toronto; estimate Jul 2026	
Checked baggage fee per bag	60	USD/bag	Most carriers charge extra for 2nd bag on transatlantic	
Bags per team member (average)	2	bags	1 personal + 1 for equipment / tools	
ROV equipment excess/oversize fee	200	USD flat	One-time charge for oversized ROV box or equipment crate	
ACCOMMODATION (St. John's / venue area)				
Hotel nightly rate per room	130	USD/night	Mid-range hotel; rate may spike during competition week — book early	
Persons sharing per room	2	persons	Double occupancy standard	
Extra nights (arrival/departure)	1	nights	Arrival the evening before competition starts	

Figure 36 Total Income and Estimated Budget Spreadsheet

supported financial needs and promoted STEM engagement within the community. For travel planning, a structured budget allocation was provided to each team member, encouraging personal responsibility for expenses and fostering a culture of accountability. Overall, the budgeting process enabled effective resource allocation while maintaining financial sustainability, supporting both the technical development of the ROV and the broader growth of Overflow Robotics' initiatives (**Refer to Figure 36 for estimated cost and total income spreadsheet**).

B. Costs

Due to fluctuations in component pricing and broader economic instability in Egypt, budget planning required continuous reassessment throughout the season. However, these constraints encouraged cost-efficient engineering solutions, including selective in-house fabrication, material reuse, and targeted fundraising initiatives. A large portion of expenses was directed toward electrical components and specialized tools, which are essential for ROV reliability but were significantly affected by high import tariffs and price volatility in international markets (**Refer to Figure 38**). To address these challenges, Overflow Robotics implemented practical budgeting strategies that included seeking donations, prioritizing fair resource allocation across sub-teams, and carefully evaluating whether components should be purchased, fabricated in-house, or recycled from previous projects. Designing custom in-house components became an effective way to reduce costs while maintaining performance standards, although it required additional effort in design and manufacturing. These proactive measures allowed the team to continue progressing toward a well-engineered, highly specialized ROV while maintaining financial responsibility and sustainability (**Refer to Figure 39 for total cost breakdown**).

Item	Amount (USD)	Notes
Total Budgeted (Out-of-Pocket)	\$5,250.00	Initial projection
Total Actual Spent	\$4,562.00	Final out-of-pocket costs
Budget Variance (Savings)	\$688.00	13.1% under budget
Reused Value	\$1,528.00	Fair Market Value of parts
Donated Items/Services	\$380.00	Pro-bono work/equipment
Total Project Value	\$5,923.00	Total actual spent and reused components

Figure 37 Accounting Summary

Category	Budgeted	Actual	Difference
Mechanical Systems	\$2,120.00	\$1,682.00	\$438.00
Electrical & Vision	\$1,935.00	\$1,700.00	\$235.00
General & Admin	\$1,195.00	\$1,180.00	\$15.00
TOTAL	\$5,250.00	\$4,562.00	\$688.00

Figure 38 Sub-System Cost and Budget Breakdown Summary

12.0 References

- [Nvidia Jetson Developer Documentation](#): Used for onboard computing setup, camera interfacing, GPU acceleration, and software environment configuration.
- [Blue Robotics Technical Resources & Thruster Documentation](#): Provided guidance on underwater thrusters, ESC integration, waterproofing techniques, and ROV design considerations.
- [MATE ROV Competition Documentation and Technical Guidelines](#): Referenced for competition requirements, safety practices, technical documentation expectations, and scoring rubrics.
- [SolidWorks Official Documentation and Tutorials](#): Used for CAD modeling, assembly design, rendering, and engineering visualization workflows.
- [Ubuntu Linux Documentation](#): Supported operating system configuration, networking, and software development on the onboard computer.
- [OpenCV Computer Vision Library Documentation](#): Referenced for image processing, camera calibration, and machine vision implementation.
- [ROS \(Robot Operating System\) Documentation](#): Used for robotics middleware concepts, communication frameworks, and modular software design approaches.
- [IEEE Engineering Standards Resource](#): Consulted for general engineering practices related to electronics, system safety, and technical design methodology.
- [Company Notion Website](#): Timelines, Tasks and progress tracking

	Item	Description	Quantity	Status	Estimated Budget	Cost	Difference
General	Registration	Regional registration	1	Fees	200	187.5	12.5
	International	International registration	1	Fees	300	280	20
	Thruster	Apisqueen u2	8	New	500	498	2
	ESC	Blue robotics 30A	3	New	100	103	-3
	Tether	VideoRay bouyant Tether	2	Donated	0	0	0
	POOL	250 hours	250	Fees	500	450	50
	UTILITES	internet , electricity	4	Fees	250	258	-8
	Markiting	flyers ,posters	2000	New	80	74	6
	Tools	screwdrivers,bits,caliper	21	New	68	42	26
Electrical	Nvidia Jetson	Orin Nano Super	1	New	250	249	1
	Cube pilot	Cubeorange	1	New	350	385	-35
	SSD	WD NVME 256gb	1	New	35	55	-20
	power brick	cube power brick	1	New	30	30	0
	pwm expander	pwm expander	1	New	10	8	2
	Depth camera	intel realsense d435i	1	Reused	0	0	0
	camera	HD webcams	8	New	350	252	98
	usb hubs	anker 4 port 3.0 usb hub	2	Reused	0	0	0
	pcbs	3 x custom pcbs	15	New	150	126	24
	pcb components	resistors, capacitors, transistors	150	New	200	180	20
	connectors	xt 60 & mt 60	100	New	60	75	-15
	Fuses	Fuses	500	New	50	41	9
	IMU	IMU BNO055	1	New	50	48	2
	pressure sensor	blue robotics bar030	1	Reused	0	0	0
	Cables	HDMI, Ethernet	4	New	30	29	1
Mechanical	Carobon fiber	6 layer 100x50 cm sheet	1	New	250	257	-7
	HDPE	Sealing box body	1	New	70	65	5
	3D printing	PETG ,TPU	150	New	350	95	255
	Rubber silicon	1X1M	3	New	50	47	3
	Chemical sealing	Epoxy , akfix ,silicone spray	15	New	100	88	12
	Pneumatic	pistons , pistons	20	Reused	0	0	0
	Pneumatic	Compressor	1	Donated	0	0	0
	Fasteners	Screws,nuts,bolts	1000	New	250	150	100
	Magnets	Cuboid magnets	16	Reused	0	0	0
	PVC	pipes,joints	50	New	150	139	11
	Machining	cnc laser, Centerlathe ,router	11	New	250	147	103
Float	Motor drivers	IBT2	4	New	30	23	7
	ESP 32	ESP 32 38 devkit	3	New	12	12	0
	Linear Actuator	Boyancy engine motor	1	New	45	41	4
	sd card	kingstone 32gb	3	New	30	27	3
	HDPE	Float Body and end caps	1	New	40	42	-2
	Weights	Metal parts for bouyancy	8	New	20	22	-2
	battries	Batteries for float power up	9	New	10	7	3
Training	Raspberry pi 5	Pi 5 8gbs	6	Sponserd	0	0	0
	Raspberry pi pico		12	Sponserd	0	0	0
	components	final project	3	New	30	30	0
	Total		4395		5250	4562.5	687.5

Figure 39 Total Cost Breakdown

A. Safety Checklist

SAFETY CHECKLIST

TETHER

Pre-Run

- ☐ Straighten and eliminate any kinks in the tether.
- ☐ Safely plug the tether into the control box.
- ☐ Secure strain relief to prevent accidental disconnection from the control box.
- ☐ Inform other employees about the deployed tether to prevent accidental stepping.
- ☐ Attach the strain relief to the ROV.
- ☐ Connect the tether to the ROV.

Post-Run

- ☐ Safely disconnect the tether from the control box.
- ☐ Safely disconnect the tether from the ROV.
- ☐ Neatly roll up the tether on the hose reel.

PRE-RUN

- ☐ Inspect electrical power connections
- ☐ Perform a dry run to ensure unobstructed and functional cameras.
- ☐ Confirm the security of all waterproof seals.
- ☐ Check thrusters for proper function and clearance.
- ☐ Verify proper functioning of the claw.

ON-DECK

- ☐ Follow the tether setup protocol.
- ☐ Connect the power supply and set it to 12v.
- ☐ Power up the ROV.
- ☐ Test the thrusters and claws.
- ☐ Verify camera views on the designated deck screens.
- ☐ Carefully lower the ROV into the water.
- ☐ Release any trapped air bubbles.
- ☐ Await the "ready" signal from deck crew.
- ☐ Initiate launch with a countdown.

POST-RUN

- ☐ Power off the Control Box.
- ☐ Turn off the power supply.
- ☐ Follow the tether disconnect procedure.
- ☐ Dry the ROV and place it safely on the cart.

Figure 40 Safety Checklist

B. Electrical Sid

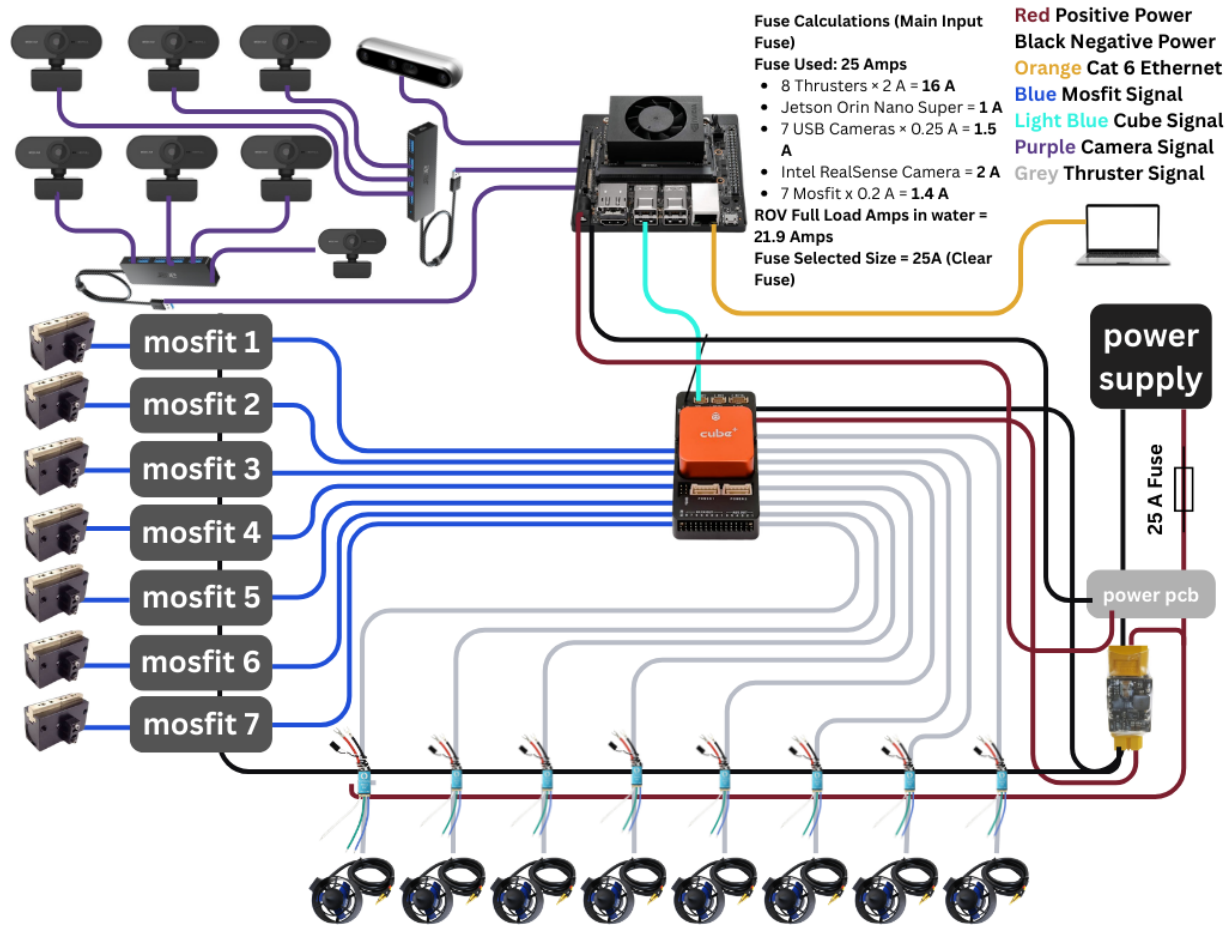


Figure 41 Electrical Sid

C. Pneumatic Sid

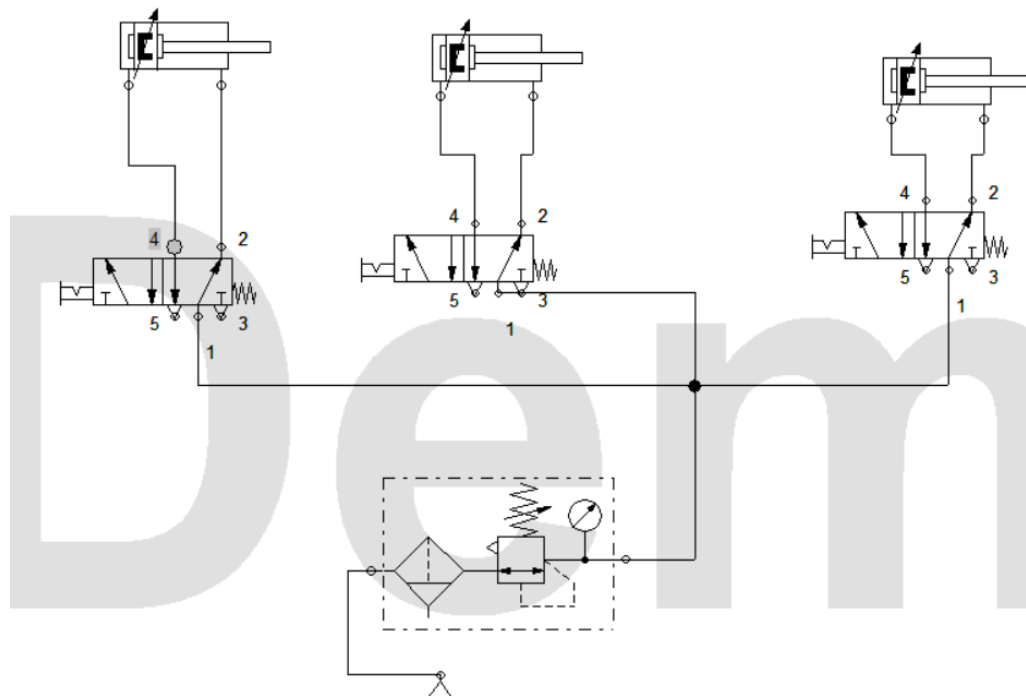


Figure 42 Pneumatic Sid