Using sub-sea ROV technology to support and enhance ocean quality globally

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TECHNOLOGY REPORT

Cougar Robotics Incorporated

Clarenville High School, Newfoundland and Labrador, Canada

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1. Abstract

Cougar Robotics

Cougar Robotics Incorporated

Clarenville High School, Clarenville, NL, Canada

https://sites.google.com/nlesd.ca/cougar-robotics-inc/home

Abstract

Oceans cover over 70% of the Earth's surface and play a crucial role in providing food and livelihoods for more than 3 billion people, as well as combating the effects of climate change (United Nations, 2024). The MATE ROV Competition empowers students to address climate change through missions like those of the 2025 Ranger class, which focuses on the Great Lakes trough collecting eDNA for invasive carp, surveying shipwrecks, and measuring dissolved CO2 – demonstrating the crucial role of ROVs in future climate action (Ocean Decade, 2023).

Cougar Robotics Inc.'s ROV Sagona is engineered for positive aquatic impact. Neutrally buoyant and hydrodynamically efficient, it features a custom 85-degree FOV camera for low-light underwater conditions. Sagona has several unique features including a custom-designed tether, a custom-made controller, and a quick connect system which altogether make ROV Sagona a user-friendly, adaptable robot. The design rationale of ROV Sagona clearly outlines its accessibility and affordability to protect and preserve aquatic environments.

ROV Sagona, with its focus on efficiency, versatility, and sustainability, offers a powerful solution for real-world ocean challenges.

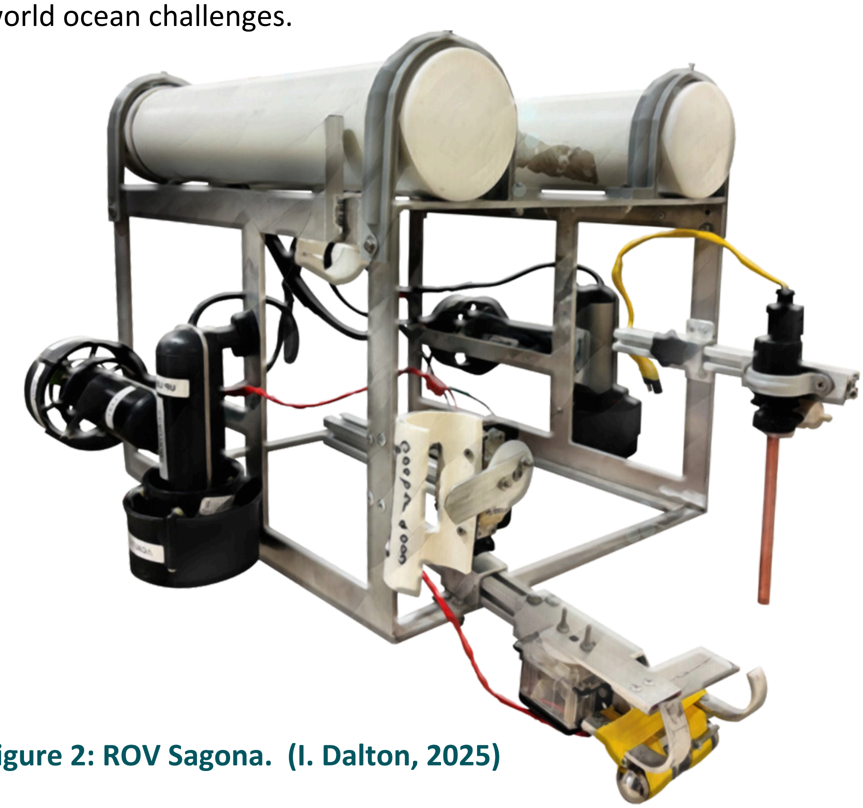


Figure 2: ROV Sagona. (I. Dalton, 2025)

Nomenclature

v = The speed of ROV [m/s]

Fd = Drag Force on ROV [N]

P = Pressure [Pa]

V = Voltage [V]

A = Reference Area [m^2]

Cd = Drag Coefficient

P = Mass Density of Fluid [kg/m^3]

W = Vehicle Weight [N]

m = Mass of Vehicle [Kg]

I = Current [A]

Fg = Force of Gravity [N]

T = Temperature [C°]

R = Resistance [Ω]

2. Teamwork and Project Management

Cougar Robotics

Cougar Robotics Incorporated is composed of six student members supported by teacher mentors Michael Spurrell and Allison Somers from Clarenville High School in Clarenville, Newfoundland and Labrador, Canada. The team is focused on designing and constructing ROVs to solve real-world marine challenges through innovation and teamwork. Company members adopt clearly defined roles to support project management. Isaiah Dalton, the CEO, oversaw team coordination and deck operations; Mark Spurrell, the Chief Designer, led electrical systems and CAD modeling; Natalie Poole, the Assistant CEO, managed tool development and presentation materials; Nathan Fillier, the CFO, was responsible for budgeting and piloting; Nicholas Reid, the Tether Manager, handled human resources and safety; and Rachel Walsh, the Strategic Planner, led long-term project planning and documentation. The team followed a structured meeting schedule, with each session beginning with a safety briefing, followed by task assignments and goal setting. Resources were managed through a centralized working document that tracked material inventories, design revisions, budgets, and project cost (Appendix A). Strict adherence to safety protocols, including the use of PPE and Canadian Occupational Standards and Policies (COSP), standards, kept operations organized and minimized risk. When faced with operational challenges, the team collaborated across disciplines to develop practical and data-informed solutions. This strong internal structure allowed Cougar Robotics to meet mission deadlines efficiently and responsibly.

Figure 3: Team Photo (A. Somers, 2025)
Back Row (L to R): Nathan Fillier, Mark Spurrell, Isaiah Dalton, Nicholas Reid
Front Row (L to R): Rachel Walsh and Natalie Poole

Cougar Robotics ROV Sagona - Project Schedule

December
- Team formation and role assignments
- Review of MATE ROV competition rules and mission tasks
- Commencement of Six-Step Design Process
- Initial sketches and conceptual designs for vehicle and tools

January
- Finalize frame material and propulsion system decision
- CAD modeling of frame and control box
- Design and prototype control system
- Order key components (thrusters, camera, electronics)

February
- Continue frame assembly and mounting of thrusters
- Build and test control box
- Begin prototyping mission tools

March
- Begin water testing of frame and propulsion
- Evaluate tool prototypes in water, revise designs
- Begin camera system testing and final positioning

April
- Conduct full mission run-throughs in test tank
- Finalize Safety Checklist and Tether Management Protocol
- Begin drafting Poster Presentation

May
- Final mission rehearsals and adjustments
- Fine tune for World Championship

3. Design Rationale

Cougar Robotics

3.01 Engineering Design Rationale

Throughout the design and construction of ROV Sagona, Cougar Robotics Incorporated prioritized efficiency, modularity, and mission performance, while building on the foundation of reliability established in previous designs. The company committed to using accessible and repairable materials to ensure that clients could maintain and adapt the ROV if needed. During production members strictly adhered to COSP, reinforcing a culture of safety and accountability within the group. Each subsystem of ROV Sagona was engineered to complete specific mission tasks. Advanced CAD software and simulation tools, including SolidWorks and Cosmos FloWorks, were used to optimize hydrodynamic performance and minimize drag. The design includes a quick-connect tool replacement interface that allows operators to rapidly change payload components mid-mission. The team's design process follows Cougar Robotics' six-phase development model (Figure 4). The process supports both innovation and continuous improvement and flexibility, enabling the team to adapt and revisit stages as new challenges arise.

Six-Step Design Process

- **Define**: Describing the problem in detail; analyzing all resources, specifications and limitations.
- **Research**: A studious inquiry in order to establish facts and learn as much as possible from others
- **Solutions**: Ideating possible solutions. Generate and formulate numerous options.
- **Prototype**: Construct a scaled model or operational version of a solution.
- **Test**: Test the solution and identify new problems. Determine if there were faulty assumptions.
- **Improve**: Make changes and test new solutions before settling on a final design.

Figure 4: Design Process (N. Poole, 2025)

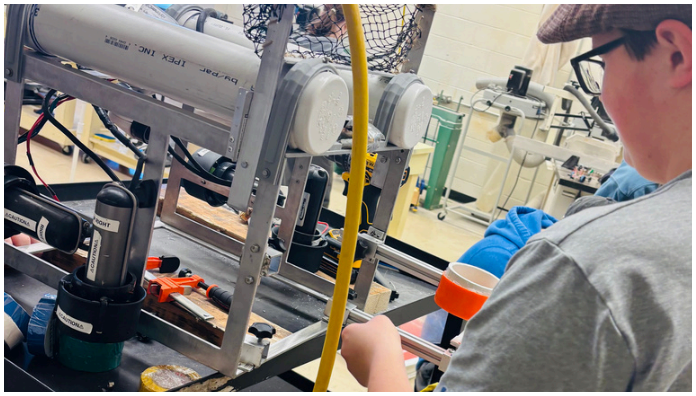


Figure 5: Brainstorming (N. Poole, 2025)

3.02 Innovation

Innovation was critical to the development of ROV Sagona, with Cougar Robotics introducing several custom-built features that boosted performance and reduced cost. The team engineered many elements in-house, including a custom-designed control system, a unique quick-connect tool interface, a custom-built main camera and 360-degree panoramic camera, pay load tools, and a purpose-built tether developed in partnership with Leoni Limited. Each of these systems was refined through repeated testing to maximize efficiency and functionality. The propulsion system was improved by replacing earlier thrusters with more powerful and energy-efficient BTD-150 units, strategically positioned to minimize drag and improve maneuverability. Through numerous innovations, ROV Sagona became an adaptable, mission-capable, and cost-effective ROV.

3.03 Problem Solving

Problem-solving played an essential role in the development of ROV Sagona. The team used a strategic and data-driven approach to solve engineering challenges. At the start of each design phase, Cougar Robotics held brainstorming sessions where all team members shared ideas, regardless of their roles. These sessions encouraged creative thinking and varied perspectives that led to a wide range of possible solutions. Once initial concepts were proposed, the team analyzed ideas further and evaluated each option based on key criteria such as cost, functionality, and durability. For example, when selecting the material for the ROV frame, the team compared PVC, polycarbonate, and aluminum using computational fluid dynamics (CFD) software to assess drag and fluid flow. Aluminum flat bar was selected as the optimal choice as it offered strength, corrosion resistance, and low drag. This data-informed process was used repeatedly for tool design to electrical layout. This ensured that every decision was a team effort and followed the company's step design process (Figure 6).

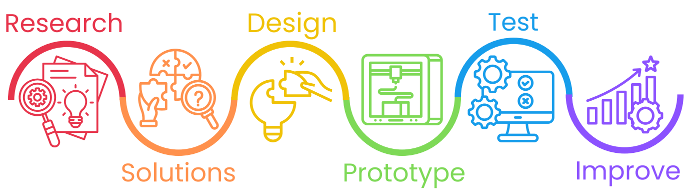


Figure 6: Six step design process (N. Reid , 2025)

3.04 Systems Approach

Cougar Robotics demonstrated a balanced systems approach in the design of ROV Sagona by ensuring seamless integration between all major subsystems -frame, propulsion, control, electrical, and tools. From the beginning, the team prioritized a well rounded design strategy, where each component was engineered, not in isolation, but in relation to the vehicle as a whole. The camera system was carefully positioned using trigonometric calculations to maximize field of view without obstructing tools or thrusters. Similarly, the buoyancy system was calibrated to complement the ROV's center of mass and thruster layout, improving overall stability and maneuverability. The company's quick connect system allowed tools to mount securely and interface smoothly with the electrical and control systems. This modular yet unified approach ensured that Sagona operated as a cohesive and reliable platform, capable of completing complex mission tasks with ease, efficiency and precision.

3.05 Vehicle Structure

The structure of ROV Sagona was the foundation of the vehicle's overall performance, and Cougar Robotics approached its design with careful consideration of cost, weight, size, and hydrodynamic efficiency. Early in the development process, the team decided to adopt a box-shape design to allow for easy tool attachment, low drag, and stability. Three potential frame materials were evaluated: PVC piping, polycarbonate thermoplastic, and aluminum flat bar.

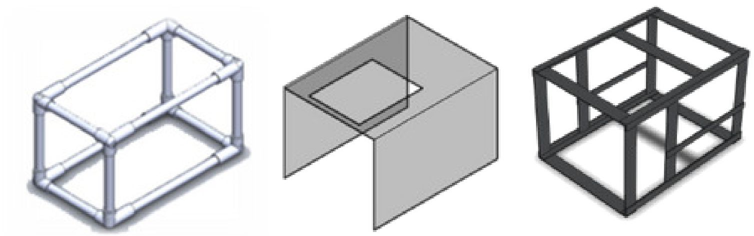


Figure 7: ROV Frame design (I. Dalton , 2025)

Each option was modelled in SolidWorks and analyzed using COSMOS FloWorks software to simulate fluid flow and calculate drag forces. The data indicated that while PVC was lightweight and inexpensive, it produced excessive drag and lacked the rigidity needed for ROV stability. Polycarbonate offered better performance but was prone to flexing under load. Aluminum flat bar, though slightly more expensive, outperformed both alternatives in every key area—demonstrating superior strength, minimal deformation, and the lowest drag profile.

Frame	Drag
0.025m Aluminum Flat Bar	-0.18465N
0.031m ID Polyvinyl Chloride (PVC) Pipe	-0.84657N
0.0047m Polycarbonate Resin Thermoplastic	-0.29845N

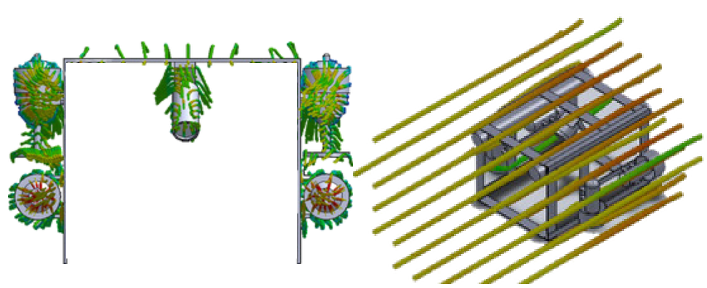


Figure 8 : Drag Data and Fluid Flow (N. Reid , 2025)

Selecting aluminum as the primary material presented an added challenge, as specialized skills were required to properly assemble and weld the joints. To overcome this, the team partnered with Coastal Machining Ltd., a local company. The staff provided a tour of their machine shop and guided our members through the welding process, offering hands-on support in constructing the ROV frame.

The final frame design featured an open, rectangular-shaped aluminum frame measuring 0.48m in length, 0.38m in width, and 0.31m in height. The ROV can navigate tight spaces during the mission due to its compact size while still having space for mounting thrusters, tools, buoyancy, and electronics. Fluid flow analysis proved that this frame minimizes water resistance which allows for smooth movement and improved thruster efficiency. To ensure the ROV is durable in marine environments, aluminum was the best material to use for the frame based on its corrosion resistance.

At just 9.2 kg, Sagona is a lightweight profile ROV that requires low energy for propulsion which contributes to the overall power efficiency. Cougar Robotics also factored in the vehicle's weight when designing the buoyancy system to ensure neutral buoyancy during operation. By making strategic decisions regarding the frame, the team produced a structurally sound, hydrodynamically efficient, and mission-ready ROV.

Frame Material: Aluminum	**Mass:** 9.2 kg
Propulsion: 12V Thrusters	**Speed:** 1.1m/s
Height: 0.31m	**Width:** 0.38m
Buoyancy: 4.1 N	**Voltage:** 12 V
Length: 0.48m	**Drag:** -0.184653 N

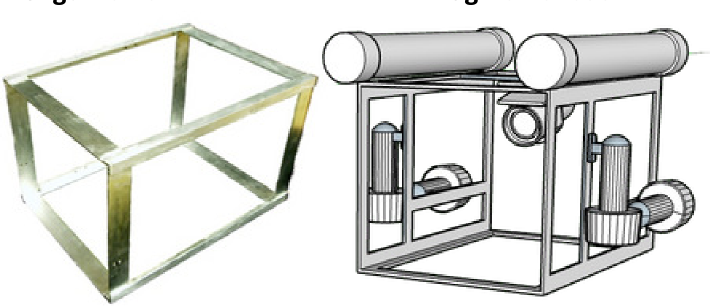


Figure 9: Frame Design and Spec. (I. Dalton, 2025)

3.06 Vehicle Systems

The vehicle systems of ROV Sagona were designed with a focus on functionality, reliability, and cost-effectiveness. When planning and building ROV Sagona, Cougar Robotics focused on the development of task specific tools that would ensure speed and accuracy of mission tasks. The team analyzed each mission and developed a tool that would accomplish each task. All tools and sensors can be attached to the ROV with a modular quick-connect system which allows the team to quickly change tools between surfacing during missions. This logical, systems-based approach ensured that every part of Sagona worked together to produce a high performance ROV without unnecessary complexity or expense.

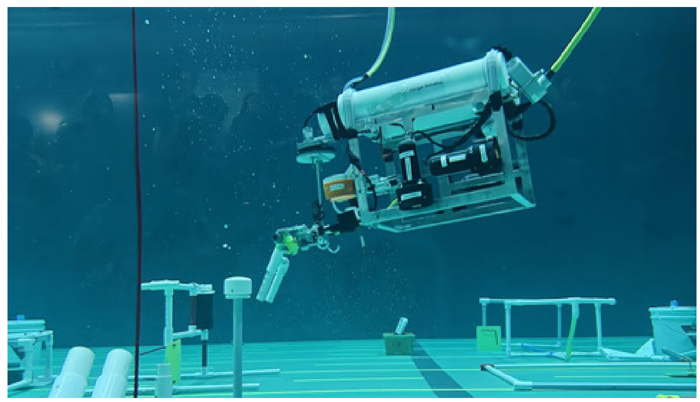


Figure 10: ROV Sagona (N. Reid, 2025)

3.07 Control/Electric System

The electrical system of ROV Sagona was custom-designed and assembled by Cougar Robotics. The system includes the manual control box, power cable, tether, onboard camera, and tool interfaces. These components were carefully engineered to operate on a standardized 12-volt DC system. Every component was selected not only for performance but also to comply with all MATE competition safety regulations. This ensures both operator safety and system functionality during missions. Each system and its functionality are described in the sections below, highlighting how they contribute to the overall performance and control of ROV Sagona during missions and tasks.

Control Unit

The controller was custom-designed and assembled by Cougar Robotics to ensure dependabiltiy, intuitive control and full compliance with MATE safety standards. Housed in a durable welded aluminum enclosure, the controller with a see-though acrylic back that allows instant view of the internal wiring.

The control system is hardware-based with a series of dipole switches. This decision was made to minimize the risk of system crashes or software bugs during operation, practice and competitions. Dipole switches operate both vertical and horizontal thrusters and activate mission-specific tools.

Safety was a top priority when designing the controller and its electric components. A master dipole kill switch provides an immediate power shutdown in the event of an emergency. Instantaneous voltage and current are displayed through a built-in voltmeter and ammeter, allowing pilots to monitor system performance and prevent electrical issues. All wiring is routed through aluminum busbars to ensure secure, low-resistance connections and maintain organization of the electrical systems.

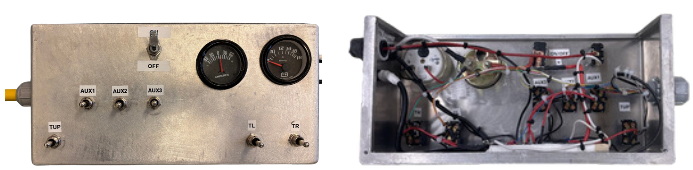


Figure 11: Controller (Back and Front) (N. Poole, 2025)

Engineered with field-serviceability in mind, the controller also features modular connectors, clearly labeled terminals, and a tether interface that allows for fast disconnection and repair.

Figure 12: CAD model and Connectors (I Dalton, 2025)

Power Cable

The power cable for Sagona was constructed using a 12-2 copper wire, an Anderson connector, and a fuse. The cable can be disconnected from the controller for convenient storage, and a 25-amp blade fuse was installed on the positive side of the cable to close the power source. If too much electricity flows because of a short circuit, overload, or broken part, the fuse will blow to keep the ROV and the people using it safe. A comprehensive Electrical SID (page 21) has been engineered under CSA C22 standards to enhance clarity and precision.

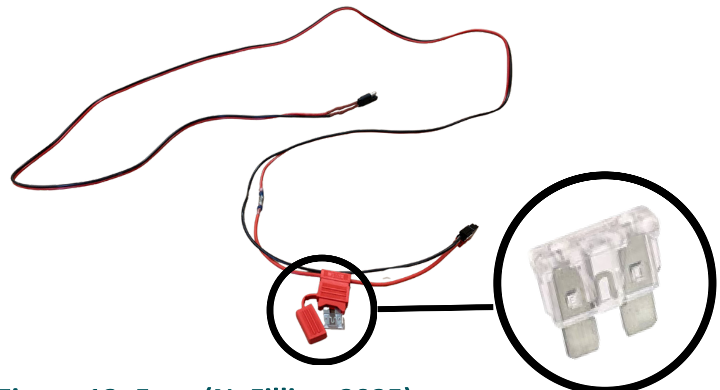


Figure 13: Fuse (N. Fillier, 2025)

Tether

The tether used for ROV Sagona is custom designed to optimize both performance and safety. Developed in collaboration with Leoni Limited, the tether spans 13.5 meters and integrates a carefully selected combination of wires to reduce weight while maintaining functionality. It includes six pairs of 24-gauge insulated wires for tool control, three pairs of 20-gauge wires for thruster power, and a coaxial video cable. The wires are enclosed in buoyant filler and a durable polyurethane shell to ensure waterproofing and neutral buoyancy. Additionally, the team implemented a robust tether management protocol to prevent tangling and protect the tether from damage. A free-form attachment system using rings and a carabiner allows the ROV to move freely without twisting the tether, which is critical for mission efficiency and safety. A tether management protocol and safety procedures were developed and adhered to at all times when constructing and transporting the ROV.

3.08 Propulsion

A reliable and efficient propulsion system is essential for any ROV. Cougar Robotics approached the design of Sagona's propulsion system with a focus on maximum thrust, minimal power consumption, and effective maneuverability. Through testing and analysis, the team selected and strategically positioned thrusters to meet the mission requirements.

Thruster Evaluation and Selection

Cougar Robotics considered two primary options: a custom-built thruster constructed from a dismantled 12V bilge pump, fitted with a machined brass hub and a hobby propeller; and the BTD-150, a commercially manufactured thruster developed by SeaBotix (Fig. 20).

Figure 14: Bilge Pump (N. Reid, 2025)

To evaluate the options, the team conducted a series of bollard tests and power comparisons. Results showed that while the bilge pump thrusters generated only 5.2N of force at 1.3 amps in water, the BTD-150 delivered a much stronger 21.5N at 2.6 amps. Despite drawing more current, the BTD-150 thrusters offered a far superior thrust-to-power ratio. The team concluded that the performance advantages of the BTD-150s justified the higher cost.

Current Comparison		
Thruster	**Current in air**	**Current in water**
BTD-150	0.2 Amps	2.6 Amps
Bilge Pump	0.9 Amps	1.3 Amps

Thruster	Bollard Test: Force
BTD-150	21.5N
Bilge Pump	5.2N

Figure 15: Thruster Data (R. Walsh, 2025)

System Integration: Number, Type, and Placement

Cougar Robotics selected a four-thruster configuration after extensive testing and evaluation of multiple propulsion layouts. The final design includes two horizontal SeaBotix BTD-150 thrusters for forward motion and steering, and two vertical BTD-150 thrusters to control depth. This configuration provided the necessary movement needed for precise underwater navigation.

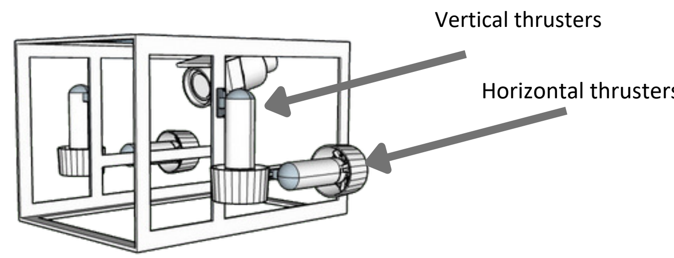


Figure 16: Thruster Placement (M. Spurrell, 2025)

Power Consumption and Electrical Integration

Each BTD-150 thruster draws approximately 2.6 amps under water (compared to 0.2 amps in air). With all four thrusters running concurrently, the system approaches 80% of the 25A safety limit set by the installed fuse, leaving room for other small load electronic components such as the camera and payload tools. Power is delivered through the custom tether, which includes multiple 20-gauge wire pairs assigned for thruster operation. A custom motor control panel, featuring dipole switches, was developed to operate the thrusters. These switches allow the pilots to engage and disengage precision movements.

Propeller Design and Hydrodynamic Performance

The SeaBotix thrusters are engineered for maximum thrust with minimum turbulence. Combined with the aluminum flat-bar frame design of Sagona, the total drag was reduced to -0.18N which improves energy efficiency and response time during quick directional changes. Thruster placement also takes into account the prop wash (the backward flow of water from the propellers), which can interfere with tools, speed and movement.

3.09 Buoyancy and Ballast

The buoyancy and ballast system of ROV Sagona was developed to ensure vertical stability, neutral buoyancy, and smooth underwater performance. Cougar Robotics applied principles of fluid dynamics and mechanical engineering to design a system that balances the forces acting on the vehicle, allowing it to hover, ascend, and descend with precision.

To achieve vertical stability and a state of neutral buoyancy, the gravitational force (Fg) experienced by the ROV had to be equal to the buoyant forces (Fb1 and Fb2).

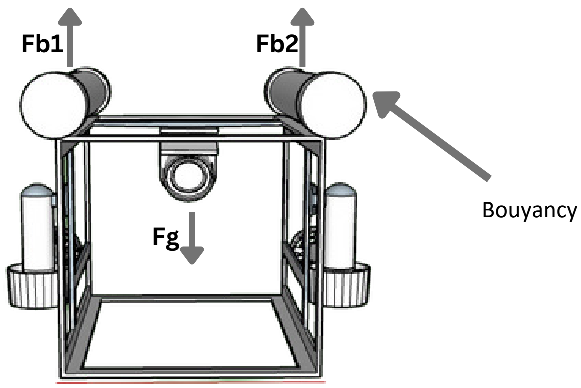


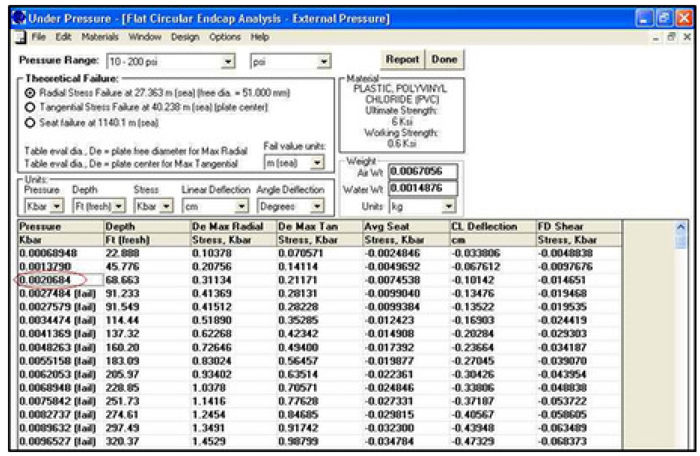
Figure 17: Buoyancy CAD (N. Poole, 2025)

With an assembled in-water mass of 9.2 kg, the team calculated that capsules with a volume of approximately 0.0083 cubic meters would be required to achieve neutral buoyancy.

The company explored several possibilities for the buoyancy. Initially, foam was considered, but it was found that the foam would compress and lose buoyancy as the ROV dived to deeper depths. Common polystyrene, for example, yields 10% deformation at 100 kilopascals of pressure which would compromise the buoyancy of the ROV. (Figure 18) As an alternative, the company decided to use a hollow pipe for floatation, as it is more resistant to compression. To test this theory a we used a software called Under Pressure 4.5, which is commonly used as an engineering design tool to aid in the design of pressure housings and pressure vessels in the marine industry.

The software evaluates structural capabilities, deflections and weights of common pressure vessels.

The data reported (figure 25) that a radial stress failure would occur at the endcaps if exceeding 0.0021013 kbar (plate center) of pressure. This force and subsequent failure would occur at 21 meters (69 feet) below sea level, which is deeper than the operating capabilities of the ROV.



Pressure Kbar	Depth Ft (fresh)	De Max Radial Stress, Kbar	De Max Tan Stress, Kbar	Avg Seat Stress, Kbar	CL Deflection cm	FD Shear Stress, Kbar
0.00068948	22.888	0.10378	0.070571	-0.0024846	-0.033806	-0.0048838
0.0013790	45.776	0.20756	0.14114	-0.0049692	-0.067612	-0.0097676
0.0020684	68.663	0.31134	0.21171	-0.0074538	-0.10142	-0.014651
0.0027484 (fail)	91.233	0.41369	0.28131	-0.0099040	-0.13476	-0.019468
0.0027579 (fail)	91.549	0.41512	0.28228	-0.0099384	-0.13522	-0.019535
0.0034474 (fail)	114.44	0.51890	0.35285	-0.012423	-0.16903	-0.024419
0.0041369 (fail)	137.32	0.62268	0.42342	-0.014908	-0.20284	-0.029303
0.0048263 (fail)	160.20	0.72646	0.49400	-0.017392	-0.23664	-0.034187
0.0055158 (fail)	183.09	0.83024	0.56457	-0.019877	-0.27045	-0.039070
0.0062053 (fail)	205.97	0.93402	0.63514	-0.022361	-0.30426	-0.043954
0.0068948 (fail)	228.85	1.0378	0.70571	-0.024846	-0.33806	-0.048838
0.0075842 (fail)	251.73	1.1416	0.77628	-0.027331	-0.37187	-0.053722
0.0082737 (fail)	274.61	1.2454	0.84685	-0.029815	-0.40567	-0.058605
0.0089632 (fail)	297.49	1.3491	0.91742	-0.032300	-0.43948	-0.063489
0.0096527 (fail)	320.37	1.4529	0.98799	-0.034784	-0.47329	-0.068373

Figure 18: Under Pressure screenshot (N. Poole, 2025)

The team chose to use two sealed, hollow flotation chambers constructed from Schedule 40 PVC pipe, each 0.42 meters in length with a 0.12 meters outer diameter. These chambers were securely mounted to the top of the ROV's frame to provide sufficient positive buoyancy.

The placement of these buoyant structures was a deliberate design choice. By positioning them above the ROV’s center of mass, the team created a stable system that naturally resists tilting or rotation—a principle similar to that used in boat and submersible design. This separation of buoyancy (high) and mass (low) creates a righting moment that helps the ROV maintain its horizontal orientation even when subjected to external forces like thruster wash or current. In addition to the capsules, fine adjustments were made using tiny masses. Weight was added using washers mounted to the lower frame. This allowed the team to fine-tune the ROV’s orientation and ensure even vertical movement when using the vertical thrusters.

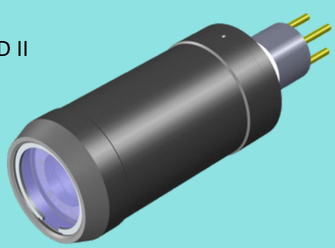
Camera System

A high-quality vision system is a requirement of any effective ROV. Cougar Robotics engineered a custom-built camera system that features clarity, and reliability to meet the demanding requirements of underwater missions. The team required a camera that provided high resolution for task precision, excellent low-light performance and a robust design. After visiting a local submersible camera producer (SubC Imaging), it was decided that the team would develop a custom-built camera.

The camera components were assembled using a KPC-E700NUB Module, SeaConn BH4 Bulkhead connector, 85-degree field of view lens, a saphire lens cover and acyrlic machined camera housing.

Figure 19: Camera (SubC Imaging, 2025)

Camera Specifications



- 750TVL Horizontal Resolution
- 1/3” 960H SONY EXview HAD CCD II
- Size: 30 x 30 mm
- Resolution: 1020 × 580 pixels
- Field of View: 85 degrees
- 3.6mm lens
- Low-Light Sensitivity: 0.0001 Lux
- Voltage: 12V DC operation
- Lens: Sapphire, for scratch resistance and optical clarity
  Depth Rating: Operational up to 500 meters underwater

Camera Components

The sapphire lens ensures that in abrasive underwater conditions or rough handling, the camera maintains a clear field of view without damage. The 85-degree field of view lens offers optimal visibility of mission tasks. To protect the sensitive electronics, the camera is enclosed in a custom-machined acrylic housing capable of withstanding underwater pressure.

Sagona’s camera system is integrated into the ROV’s electrical system via a coaxial video cable routed through the tether. The video is then transmitted live to the pilot’s station, allowing the operators to monitor and control the ROV during the mission.
MCBH3M bulkhead connectors we used to attach to the tether, allowing users to detach and swap cameras easily if required.

The camera was mounted 0.32 meters from the front edge of the ROV based on trigonometric calculations derived from its field of view. This position maximizes forward visibility while avoiding interference from mounted tools and structural components. The camera's orientation and angle allow it to monitor mission tasks, such as cable insertion and sample collection, in real time.

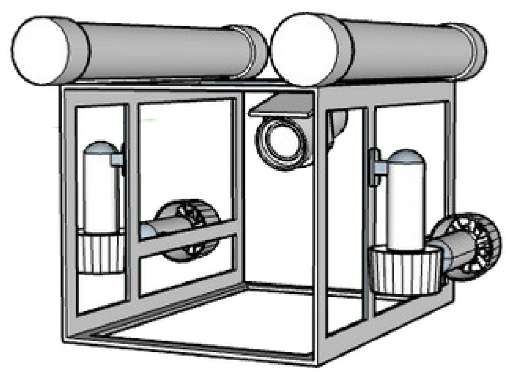


Figure 20: 3-D Model of ROV (I. Dalton, 2025)

The camera system was rigorously tested under various conditions including the results confirmed that the system reliably delivers clear, real-time video with minimal lag, distortion, or interference. Its resilience to pressure, vibration, and accidental impacts make it well-suited to competitive and field operations.

In line with Cougar Robotics’ design philosophy, the camera system is modular and easily upgradeable. The quick-connect system allows for camera repositioning or replacement without disassembling major components. This future-proofs the ROV and allows users to adapt to different mission requirements or technology improvements.

Barreleye Fish - Panoramic 360 camera

As part of the mission requirements, teams were challenged to capture a 360-degree photosphere of the mission area. In keeping with the company's commitment to creating reliable and easy-to-maintain components, Cougar Robotics chose to design and build a custom solution from the ground up—resulting in the development of the Barreleye Fish.

The Barreleye Fish is constructed using two automotive power window motors to allow full directional control of the camera system. Motor operation is managed via a custom-built control box located at the surface, allowing the user to scan all areas of its surroundings.

Video is captured using an underwater 12V, 360 TVL fishing camera. The footage is recorded at the surface using PotPlayer software. To create the photosphere, individual frames are captured from the video as screenshots. These images are then stitched together using a software called PTGui. This allows the user to generate a complete 360-degree photosphere of the mission environment.

Through extenxive design and troubleshooting, the Barreleye Fish provides a reliable and efficient solution to completing the photosphere task imaging requirements.

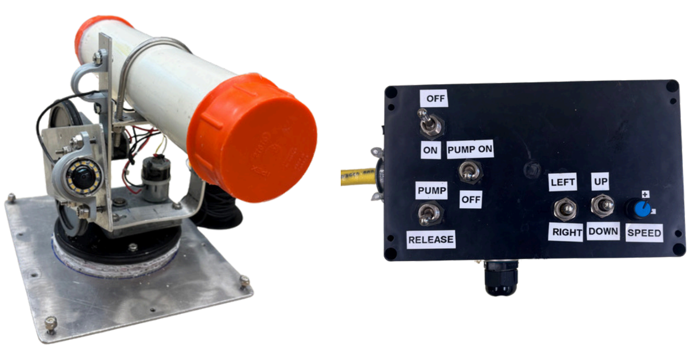


Figure 21: Barreleye Fish and Controller (N. Poole, 2025)

Specifications:

- 12V waterproof fishing camera
- 360 TVL Resolution
- Automotive powered window motors (2)
- PotPlayer: Software to record video
- PTGui: Image stitching software

3.10 Payload and Tools

Cougar Robotics was tasked by MATE to develop a specialized ROV focused on addressing challenges in the Great Lakes, including collecting eDNA to detect invasive carp, surveying shipwrecks, and measuring dissolved CO2. Cougar Robotics adopted a unique task-focused tool strategy. An approach where a unique tool was designed for most mission tasks. Drawing inspiration from the diversity and functionality of marine life, the team engineered these specialized tools modelled after marine organisms. The following pages highlight these innovative, mission-specific tools.

Quick Connect System

To compliment the task focused, payload approach, the company designed and constructed a quick-release tool attachment system. This system allows the ROV to be completely modular. Within seconds a user can interchange or reposition tools with ease.

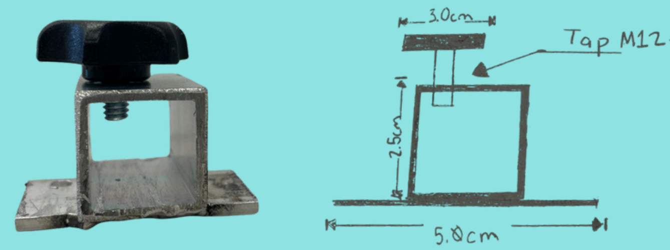


Figure 22: Quick Connect (I. Dalton, 2025)

The Dugong

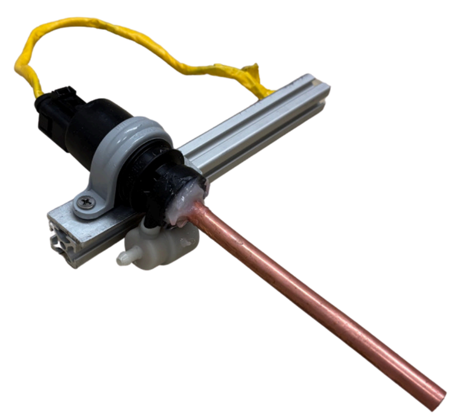


Figure 23: The Dugong (M. Spurrell, 2025)

To meet the mission requirement of collecting a water sample from the bottom of the pool, Cougar Robotics built the Dugong. Inspired by the marine mammal known as the "ocean's vacuum cleaner," the Dugong provides a reliable, efficient method for fluid retrieval at depth. The Dugong consists of several key components: an automotive windshield washer fluid pump, a 3/16-inch silicone hose, copper tubing, and a 15-meter tether. Once the sample is successfully transferred to the surface, it can be collected in a container for further analysis. A pH test is then conducted on the retrieved sample to assess the water's chemical properties, providing crucial data for mission objectives.

Through careful component selection, custom integration, and extensive testing, the Dugong system ensures consistent and accurate water sampling capabilities under a variety of operational conditions.

The Bullet Shrimp

Figure 24: The Bullet Shrimp (R. Walsh, 2025)

Inspired by the coral reef bottom feeder known for its powerful and precise claw, the company developed the Bullet Shrimp to perform secure connector retrieval and insertion tasks. The Bullet Shrimp is constructed from PVC piping, a 12V geared motor, and an acrylic locking gate. The catch opening is carefully engineered to interface directly with the screw hook on the power connector, ensuring a precise and reliable connection during operations. Once the Bullet Shrimp aligns and engages with the power connector, the motor-driven locking gate secures the connector firmly in place. This design guarantees safe transportation of the connector across the pool environment and allows for controlled insertion into the designated location.

Through careful material selection and intricate mechanical design, the Bullet Shrimp provides an effective, robust solution for underwater connector handling tasks, combining strength, precision, and operational reliability.

The Crayfish

Figure 25: The Crayfish (N. Fillier, 2025)

The Crayfish is designed to mimic the behavior of its namesake by using a mechanical locking mechanism to securely hold and transport the thermistor during removal, relocation, and installation tasks.

The system is constructed from a length of PVC tubing, a metal locking gate, and a 12V geared motor. During operation, the Crayfish approaches the thermistor, engages the locking mechanism to secure it, and carefully removes it from both the top and bottom connection points.

Once retrieval is complete, the Crayfish transports the thermistor to the surface, where it is exchanged for a new unit. The system then returns to the connection site and accurately installs the replacement thermistor into both designated connection points.

With its durable construction and precise motorized control, the Crayfish ensures reliable thermistor handling, minimizing the risk of damage and ensuring mission success.

Species Collection Package

ROV Sagona can be equipped with a unique species collection package. The Lamprey, influenced by an eel-shaped fish known for its distinctive sucker-like mouth, was specifically designed by the company to collect schools of carp, found along the surface of the water. This tool was constructed using sections of PVC tubing and a bilge pump to enable the capture of the aquatic species. The bilge pump generates suction, drawing the carp into the internal chambers along the tool's body when the ROV glides along the surface, ensuring secure containment during collection.

The second tool is tailored for gathering polyp jellyfish samples. It consists of an aluminum rod bent to a 20-degree angle above the horizontal plane and fitted with two metal prongs, allowing for delicate and precise collection.

The third tool included in the package is a Medusa jellyfish collection system. This device is specifically engineered to minimize physical pressure on the captured jellyfish. It is built from a section of clear acrylic pipe, equipped with two sliding gates to securely contain the sample, and operated by a 12V geared motor. The transparent pipe design enables continuous visual monitoring of the specimen during and after collection.

Together, these integrated tools provide a comprehensive and reliable solution for species collection, enhancing the versatility and research capabilities of ROV Sagona.

Figure 26: Species Collection Package (I. Dalton, 2025)

The Sunfish (Vertical Profiler)

The vertical profiler, referred to as the Sunfish, is a fully autonomous float developed by Cougar Robotics. The device is capable of performing ocean depth measurements and stabilizing itself at specific depths. The profiler is constructed from sections of Schedule 40, 3-inch diameter PVC pipe, capped with end caps and a rubber blow plug to create a watertight housing. Internally, the electronics are mounted on a 5 mm Lexan chassis and include an Arduino Uno microcontroller, a K166 dual-direction motor controller, a high-sensitivity pressure transducer (0–30 PSI), and an XBEE Series 1 wireless transceiver module. Vertical motion is achieved by a modified 12V DC bilge pump fitted with a model boat propeller. Power to the thruster is controlled via PWM signals generated by an Arduino Uno and motor controller. The system operates on a 12V battery pack housed internally, with a 5A inline automotive blade fuse located within 5 cm of the positive terminal for electrical current protection.

The Sunfish's software is written in C++ and is fully customizable. Users may define sampling intervals, thrust durations, and communication timing via serial commands. The float is also capable of transmitting data to the base station through a 2.4ghz wireless transceiver.

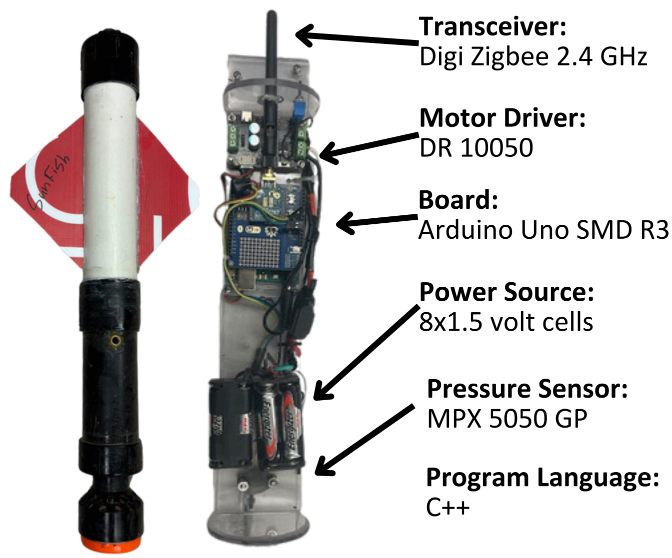


Figure 27: The Sunfish (N. Fillier, 2025)

3.11 Build vs Buy and New vs Used

Cougar Robotics carefully balanced building versus buying and using new versus reused components in the construction of ROV Sagona. Custom parts like the control system and tool mounts were built in-house to reduce costs and ensure compatibility, while critical components such as the BTD-150 thrusters and camera were purchased to meet performance and safety standards. Where possible, reused materials—like wiring and switches—were incorporated to lower expenses and reduce environmental impact. This strategic approach allowed the team to stay under budget while maintaining high functionality and reliability.

4. Safety

Cougar Robotics

4.01 Safety Content

Cougar Robotics prioritizes safety above all else. The company has adhered to the MATE safety standards and constructed ROV Sagona to meet all safety requirements.

Cougar Robotics also developed strict safety protocols and procedures to be followed when constructing and operating the ROV. When constructing the vehicle, many tools were used. Before any work was completed with these tools, a thorough safety discussion and demonstration was provided to guarantee that all team members knew how to operate the machinery safely. The development of ROV Sagona also required electrical wiring. The team was taught by a professional to ensure maximum safety and knowledge when wiring. All electrical work was verified by a supervisor before being tested. During construction, the appropriate PPE was used, most commonly safety glasses and hearing protection. When operating the vehicle, all Cougar Robotics members knew the flight plan of the ROV and their role.

To avoid any tripping hazards, one team member is designated as tether manager and they are also responsible for ensuring it is not damaged by the ROV itself while in the water. In the case of an emergency, the control box is equipped with an emergency shutdown switch to immediately turn off the ROV, mitigating any risks. Although the team at Cougar Robotics is highly trained, ROV Sagona itself has vehicle-specific safety features. The ROV has no sharp edges and the thrusters are shrouded with guards for protection. As well any potentially dangerous components, such as the thrusters, are clearly marked with caution labels.

4.02 Safety Procedures

Operational Safety Checklist

- Controller power switch is in OFF position
- Fuse is in place (correct amperage)
- ROV is disconnected from power source
- Check ROV for hazards: loose bolts, cracks
- No exposed wiring
- Complete resistance check
- Ensure guards are securely fastened
- Check end effectors for damage
- Step away from ROV and connect to power
- Check that all switches are working
- Designated personnel to place ROV in water
- Turn on power

Workshop Safety Checklist

- Controller power switch is in OFF position
- ROV is disconnected from power source
- All personnel working on the ROV have proper qualifications for the workshop
- Propeller guards are securely fastened
- Ensure that no corrosive materials or exposed wiring is present
- Team members are using required PPE

Tether Management

- Tether is stored safely and neatly coiled
- The tether manager is mindful of loose tether
- Tether is lax, but not loose enough to cause tangling
- Tether is carried and transported by sufficent number of people
- Tether is securely attached and free of knots and kinks
- Do not pull on tether or step on tether
- Always straighten tether prior to mission
- Release sufficient tether at mission start
- After the mission is finished, carefully collect the tether and neatly coil

5. Critical Analysis

Cougar Robotics

Critical analysis played a vital role in the development of ROV Sagona. Through the design process the team was able to evaluate performance, identify weaknesses and implement improvements. By combining data-calculations and hands-on testing, Cougar Robotics continuously refined systems to maximize ROV efficiency, reliability, and mission success. This cyclic approach ensured that each component met the technical demands of competition while aligning with the company's goal of safety and functionality.

Vehicle Testing

Cougar Robotics utilized a structured, multi-step testing procedure to ensure that ROV Sagona met performance, safety, and reliability standards. Initial bench testing was conducted on individual subsystems to verify function and safety. When each system passed initial tests, dry runs of the complete vehicle were conducted. Full testing was carried out in the company's test tank, where mock mission scenarios were also performed. These sessions were also used to test buoyancy and maneuverability. Data collected from these tests was used for tool adjustments, flight plan development, and tether management protocols. Testing was conducted under both controlled and variable conditions to simulate potential competition challenges. Regular team debriefs followed each session to analyze results, assign refinements, and document progress.

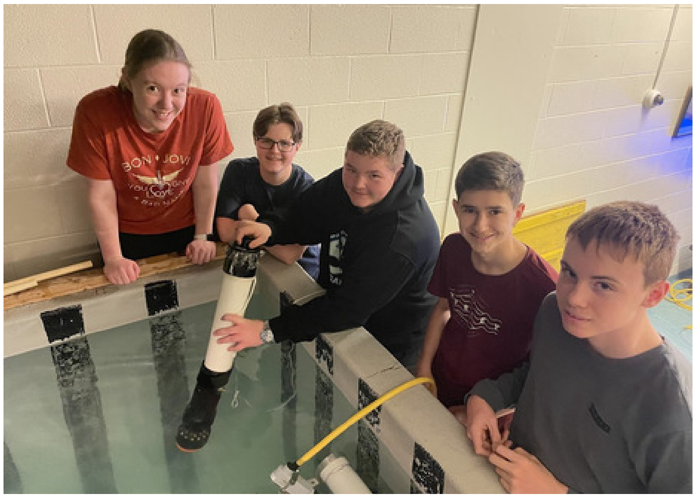


Figure 28: Testing ROV in Company's Tank (A. Somers, 2025)

Troubleshooting Strategies

Troubleshooting was approached systematically. When an issue was identified the team would first isolate the subsystem to determine whether the issue was mechanical, electrical, or control-related. Then the team would determine possible solutions and test and evaluate. All identified issues were documented in a troubleshooting log, which allowed the team to track recurring failures and refine future design choices. Prioritizing safety, power to the ROV was always disconnected before addressing hardware issues to ensure team protection and prevent equipment damage.

Prototyping and Design Evaluation

Prototyping was a central step in Cougar Robotics' Six-Step design process. For each mission task, multiple tool concepts were sketched, discussed, and fabricated. For instance, when designing a tool to transport the power connector, early prototypes used hooks, gates, and magnetic catches, which were tested against the actual mission props. Each prototype was tested both in the air and underwater to assess its alignment and grip strength. Feedback from these tests informed required changes in material choice and construction. This cyclic process allowed the team to optimize tool performance while maintaining reliability. Prototyping helped evaluate tool functionality and also highlighted challenges that needed to be addressed.

6. Accounting

Cougar Robotics

6.01 Budget

Cougar Robotics knew that a competitive budget would be essential for success. It was also important to create an itemized list of all materials used, to guarantee transparency with clients. To start, the team researched of all the materials which would be needed for the construction of the ROV. This included the framework, control box, motors, tether, camera, and materials needed to construct the end effectors. It was also considered if materials were purchased, reused, or donated. Then, the values were added to find the total amount the ROV would cost. This provided a comprehensive total for the project, which was then set as the budget. The team constructed an ROV that cost less than this estimate, building a very affordable vehicle. The travel expenses were thoroughly researched before any plans were confirmed. Multiple estimates were obtained to determine the most cost-effective form of travel. All forms of travel were considered, and the estimated travel expenses were $17,000.00. All expenses associated with the ROV and travel were accurate to the estimates determined, and there were no large unexpected charges. The team purchased many items to suit the ROV, but some materials were reused, such as the switches and thrusters, and some were donated, such as different components to make specific end effectors like a windshield washer pump for the Dugong tool. Refer to Appendix A for a comprehensive list of all materials used and their source. The expenses of the vehicle were covered by the company's income. Cougar Robotics received generous support from local businesses that helped ensure costs of ROV improvements and travel were within the budget. Overall, our budget reflects an accurate and effective use of our resources.

6.02 Cost Accounting

Cougar Robotics maintained a comprehensive and transparent accounting system throughout the design and construction of ROV Sagona. Each expense was carefully recorded, with a clear breakdown of items that were purchased, reused, or donated. High-value components such as aluminum frame and onboard camera parts were purchased new, while switches, thrusters, soldering tools, and other hardware were reused from previous builds. Donated materials and services were accurate estimates to ensure an accurate reflection of total costs. The team had some local sponsors to start the engineering season with $1,950 USD. In total, the project's expenditures amounted to $17,790.02 USD. We ended out the season with a net profit of $524.98 demonstrating strong financial management and a strategic use of funds that prioritized performance and durability without unnecessary spending.

This project would not have been possible without the generous support of our sponsors, whose contributions provided the resources needed to transform our ideas into a functional, mission-ready ROV.

7. Conclusion

Cougar Robotics

Conclusion

The accelerating impact of climate change on our oceans and freshwater ecosystems has placed numerous species at risk. Designing an ROV to address these challenges required technical skill, resilience and a deep sense of purpose. Six months ago, our team united around that purpose, driven by a shared goal to build a successful ROV. What followed was a journey defined by hard work, innovation, and determination. From late nights in the workshop to hours of after-school sessions, we poured ourselves into every detail of the project.

Constructing ROV Sagona from the ground up was no easy task. Nearly every system—mechanical, electrical, and structural—was designed and built entirely by our team. The switch-based control box, custom modular tools, vertical profiler and panoramic camera were the result of countless hours of prototyping, testing, and evaluation. Our goal was to create a vehicle that was efficient, reliable, and repairable. The end result is a robust, mission-ready ROV that reflects our core values of simplicity and innovation. Winning the regional competition was a proud milestone, but even more rewarding was seeing how far we had come together.
More than just a technical project, Sagona represents the power of collaboration and creativity. Along the way, we not only built an ROV—we built a team. The friendships formed, the skills developed, and the pride we feel in our work will last far beyond this competition. Cougar Robotics has proven that with passion and teamwork, a group of high school students can engineer real solutions to real-world problems.
Thank you for following our journey. See you in Michigan! *Cougar Robotics*

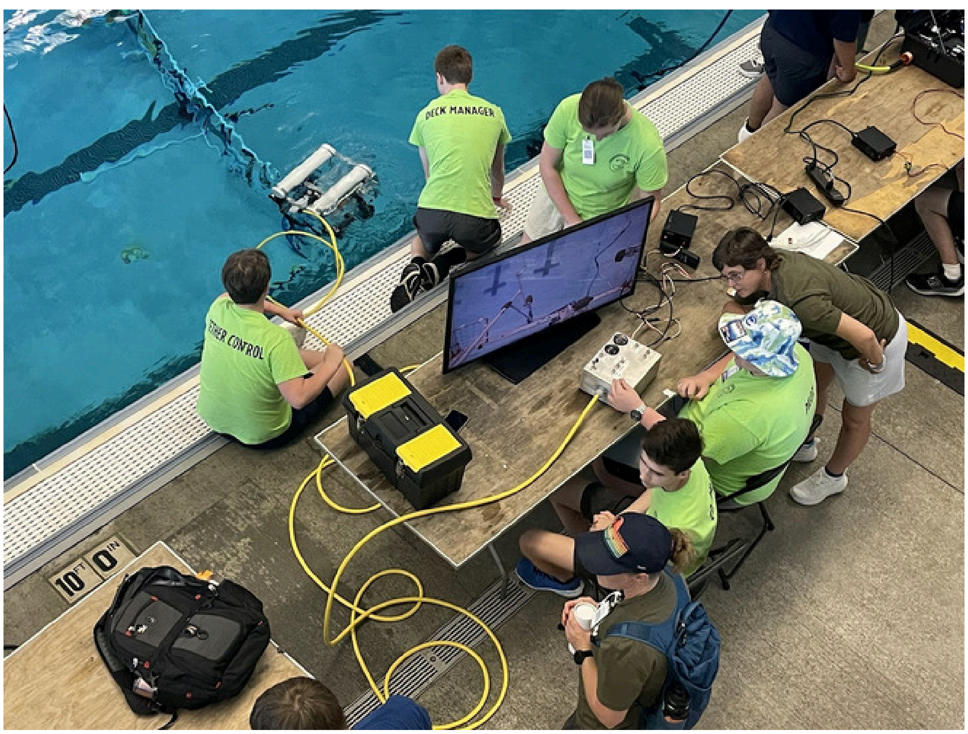


Figure 29: Flying a ROV at Tennessee 2024 (M. Spurrell, 2024)

6.01 BUDGET

School Name: Clarenville High School
Instructor/Sponsor: Michael Spurrell and Allison Somers

Income

SOURCE	CATEGORY	AMOUNT	DESCRIPTION
Marine Institute	Monetary	$16,365.00	Monetary donation
PharmaChoice	Monetary	$500.00	Monetary donation
Bird Construction	Monetary	$300.00	Monetary donation
Madsen Diesel	Monetary	$150.00	Monetary donation
SubC Imaging	Parts Donation	Parts Donation	Some minor parts of camera were donated from SubC
Parts for Trucks	Parts Donation	Parts Donation	Donation of windshield wiper pump for tools
Town of Clarenville	Monetary	$1,000.00	Monetary donation

Expenses

CATEGORY	TYPE	DESCRIPTION/EXAMPLES	COST	BUDGETED VALUE
Hardware	Purchased	PVC Pipe, caps, elbows, aluminum, heat gun, glue, foam, etc	~$1,900.00	~$1,900.00
Eletronics	Reused	Tether from Lioni Limited, switches	Reused	Reused
Thrusters	Reused	Professional thrusters from Seabotix	Reused	Reused
Camera Updates	Purchased	KPC-E700 camera module	~$800.00	~$800.00
Software	Reused	SolidWorks for drag/fluidflo analysis	Reused	Reused
Travel	Purchased	Return flights from St. John's to Michgan, car rentals, hotel rooms	~$17,000.00	~$17,000.00

Total Income: $18,315.00 USD
Total Expenses: $19,700.00 USD
Total Fundraising Needed: $1,385.00 USD

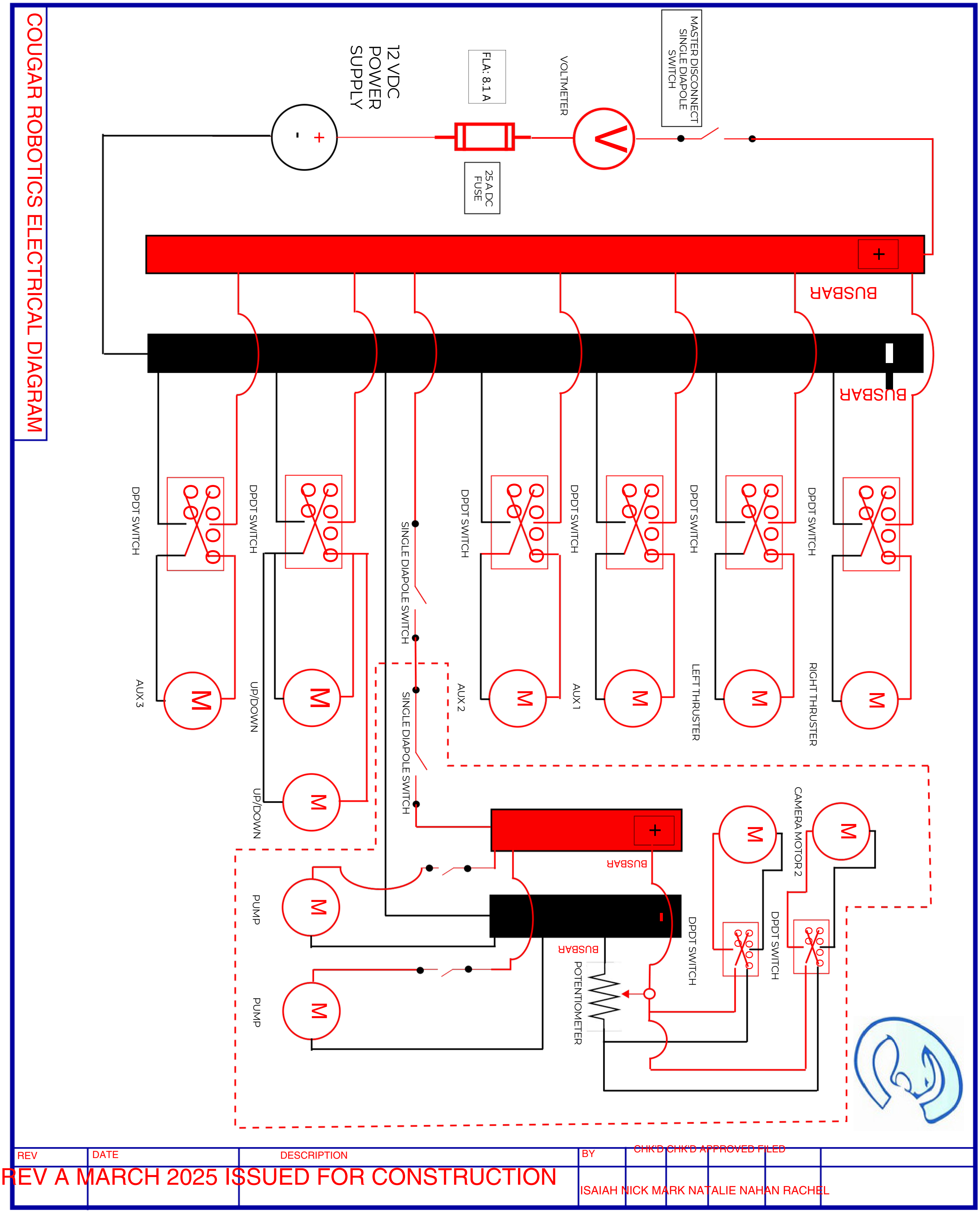
6.02 PROJECT COSTING

School Name: Clarenville High School
Instructor/Sponsor: Michael Spurrell and Allison Somers

DATE	TYPE	CATEGORY	EXPENSE	AMOUNT	BALANCE	DESCRIPTION
10/14/24	Purchased	Hardware	PVC pipe	$60.99	-$60.99	PVC Pipe, caps, elbows, etc
10/14/24	Purchased	Hardware	Aluminium	$30.99	-$91.98	Aluminum rods, frame, sheets
10/18/24	Resued	Eletronics	Tether	Reuse	-$91.98	Tether from Lioni Limited
11/05/24	Purchased	Hardware	Aluminium bar	$40.99	-$132.97	Aluminium bar for tools
11/08/24	Purchased	Hardware	Soldering wire	$6.99	-$137.96	Soldering wire and products
11/08/24	Purchased	Hardware	Heat Gun	$65.99	-$202.95	Heat gun, hot glue, and glue guns
11/08/24	Reused	Hardware	Thrusters	Reused	-$202.94	Professional thrusters from Seabotix
12/05/24	Purchased	Hardware	Camera Parts	$359.00	-$564.95	KPC-E700 camera module
12/10/24	Purchased	Hardware	End Caps	$8.99	-$573.94	More end caps for tools
12/10/24	Purchased	Hardware	PVC tee	$2.99	-$576.93	PVC tee for tools
12/10/24	Purchased	Hardware	Silica Gel packets	$15.99	-$592.92	Silica Gel packets for vertical float
01/11/25	Purchased	Hardware	Foam	$310.99	-$903.91	Foam for bouyancy
01/15/25	Reused	Software	SolidWorks Program	Reused	-$903.91	SolidWorks for drag/fluidflo analysis
02/05/25	Purchased	Hardware	Magnets	$20.99	-$924.90	Magnet for front of ROV for pulling
03/10/25	Purchased	Hardware	Epoxy	$12.99	-$937.89	Epoxy for gluing and fine tuning
03/12/25	Purchased	Hardware	Tape	$6.99	-$944.88	Electrircal tape for wiring
04/04/25	Purchased	Hardware	Clear PVC pipe	$15.99	-$960.87	Clear acrylic casing - jellyfish capturing
04/10/25	Purchased	Hardware	U-brackets	$9.99	-$970.86	U-brackets for tool constuction
04/10/25	Donated	Hardware	Bilge pump	Donation	-$970.86	Bilge pump for tools capturing species
04/14/25	Re-used	Electronics	Switches	Reused	-$970.86	Switches for control box
04/14/25	Re-used	Hardware	Lexan	Reused	-$970.86	Lexan acrylic for casing and tools
05/03/25	Purchased	Hardware	Glue	$12.99	-$983.85	Glue for fine tuning and construction
05/05/25	Donation	General	Donations/Fundrasing	**$18,315.00**	+$17,331.15	Donations/Fundrasing from sponsors
05/10/25	Travel	Travel	Flights/Travel/Hotel	$16,806.17	+$524.98	Return flights from St.John’s to Toronto, three car rentals, hotel rooms

GRAND TOTAL **$17,790.02 USD**

Total raised (+$18,315.00) USD
Total spent (-$17,790.02) USD
Final Balance (+$524.98) USD


COUGAR ROBOTICS ELECTRICAL DIAGRAM
12 VDC POWER SUPPLY
FLA: 8.1 A
25 A DC FUSE
VOLTMETER
MASTER DISCONNECT SINGLE DIAPOLE SWITCH
BUSBAR
DPDT SWITCH
SINGLE DIAPOLE SWITCH
AUX 3
UP/DOWN
AUX 2
AUX 1
LEFT THRUSTER
RIGHT THRUSTER
CAMERA MOTOR 2
PUMP
POTENTIOMETER
REV
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DESCRIPTION
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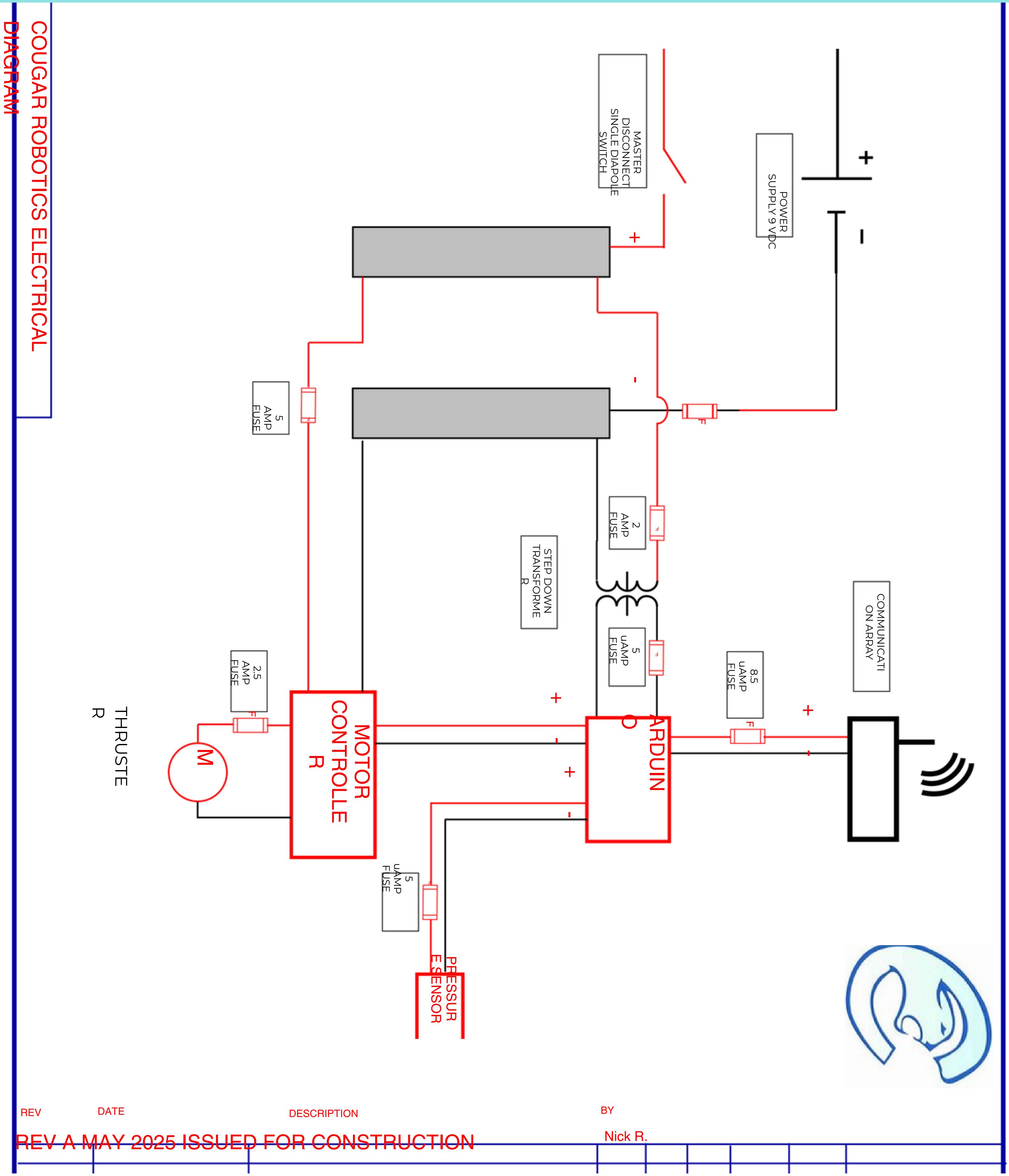
CHK'D CHK'D APPROVED FILED
REV A MARCH 2025 ISSUED FOR CONSTRUCTION
ISAIAH NICK MARK NATALIE NAHAN RACHEL


COUGAR ROBOTICS ELECTRICAL DIAGRAM
POWER SUPPLY 9 VDC
MASTER DISCONNECT SINGLE DIAPOLE SWITCH
5 AMP FUSE
2 AMP FUSE
STEP DOWN TRANSFORME R
5 uAMP FUSE
8.5 uAMP FUSE
COMMUNICATI ON ARRAY
2.5 AMP FUSE
THRUSTE R
M
MOTOR CONTROLLE R
ARDUIN O
5 uAMP FUSE
PRESSUR E SENSOR
REV
DATE
DESCRIPTION
BY
REV A MAY 2025 ISSUED FOR CONSTRUCTION
Nick R.

Flight Plan

Cougar Robotics Inc.

Descent One

- [ ] ROV Sagona places the 360-degree Photo Sphere
- [ ] Using the Lobster Claw, place the PCO2 Sensor
- [ ] Using the Ghost Crab, Plug in The PCO2 Sensor
- [ ] Collect Water sample using the Dugong
- [ ] Using the Ghost Crab, remove cargo cover and identify cargo
- [ ] Take image to identify ship length
- [ ] Using the Ghost Crab pick up and place Hydrophone to location
- [ ] Using the Ghost Crab, remove pin to release recovery float
- [ ] Using the Saltwater Crocodile, remove broken sacrificial anode
- [ ] Using the Ghost Crab, remove the broken thermistor

Descent Two

- [ ] Insert the new sacrificial anode using the Saltwater Crocodile
- [ ] Using the Ghost Crab, remove cover of the cargo box
- [ ] Using the Bullet Shrimp, pick up and plug in the power connector
- [ ] Using the Ghost Crab, release Medusa jelly fish
- [ ] Using the Medusa Capturing System, collect Medusa jellyfish
- [ ] Using the Lamprey Eel, capture carp samples
- [ ] Using the Sawfish, collect jellyfish samples

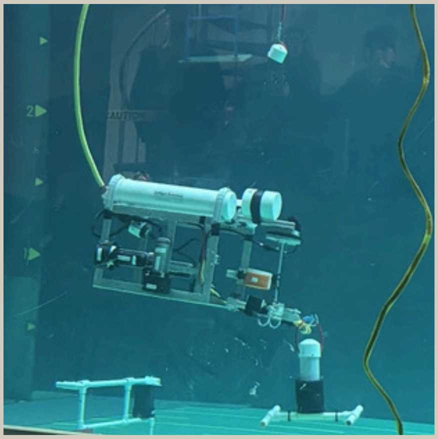


Figure 1: Team Photo (A. Somers, 2025) Page 1
Team photo of Cougar Robotics Members

Figure 2: ROV Sagona (M. Spurrell, 2025) Page 2
Image of ROV Sagona

Figure 3: Team Photo (A. Somers, 2025) Page 3
Team photo of Cougar Roboitcs members

Figure 4: Design Process (N. Poole, 2025)

Figure 5: Brainstorming (N. Poole, 2025)

Figure 6: Six step design process (N. Reid , 2025)

Figure 7: ROV Frame design (I. Dalton , 2025)

Figure 8 : Drag Data and Fluid Flow (N. Reid , 2025)

Figure 9: Frame Design and Spec. (I. Dalton, 2025)

Figure 10: ROV Sagona (N. Reid, 2025)

Figure 11: Controller (Back and Front) (N. Poole, 2025)

Figure 12: Controller CAD and connectors (I Dalton, 2025)

Figure 13: Fuse (N. Fillier, 2025)

Figure 14: Bilge Pump (N. Reid, 2025)

Figure 15: Thruster Data (R. Walsh, 2025)

Figure 16: Thruster Placement (M. Spurrell, 2025)

Figure 17: Buoyancy CAD (N. Poole, 2025)

Figure 18: Under Pressure screenshot (N. Poole, 2025)

Figure 19: Camera (SubC Imaging, 2025)

Figure 20: 3-D Model of ROV (I. Dalton, 2025)

Figure 21: Barreleye Fish and Controller (N. Poole, 2025)

Figure 22: Quick Connect (I. Dalton, 2025)

Figure 23: The Dugong (M. Spurrell, 2025)

Figure 24: The Bullet Shrimp (R. Walsh, 2025)

Figure 25: The Crayfish (N. Fillier, 2025)

Figure 26: Species Collection Package (I. Dalton, 2025)

Figure 27: The Sunfish (N. Fillier , 2025)

Figure 28: Testing ROV in school tank (A. Somers , 2025)

Figure 29: Flying ROV at Tennesee 2024 (M. Spurrell, 2024)

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