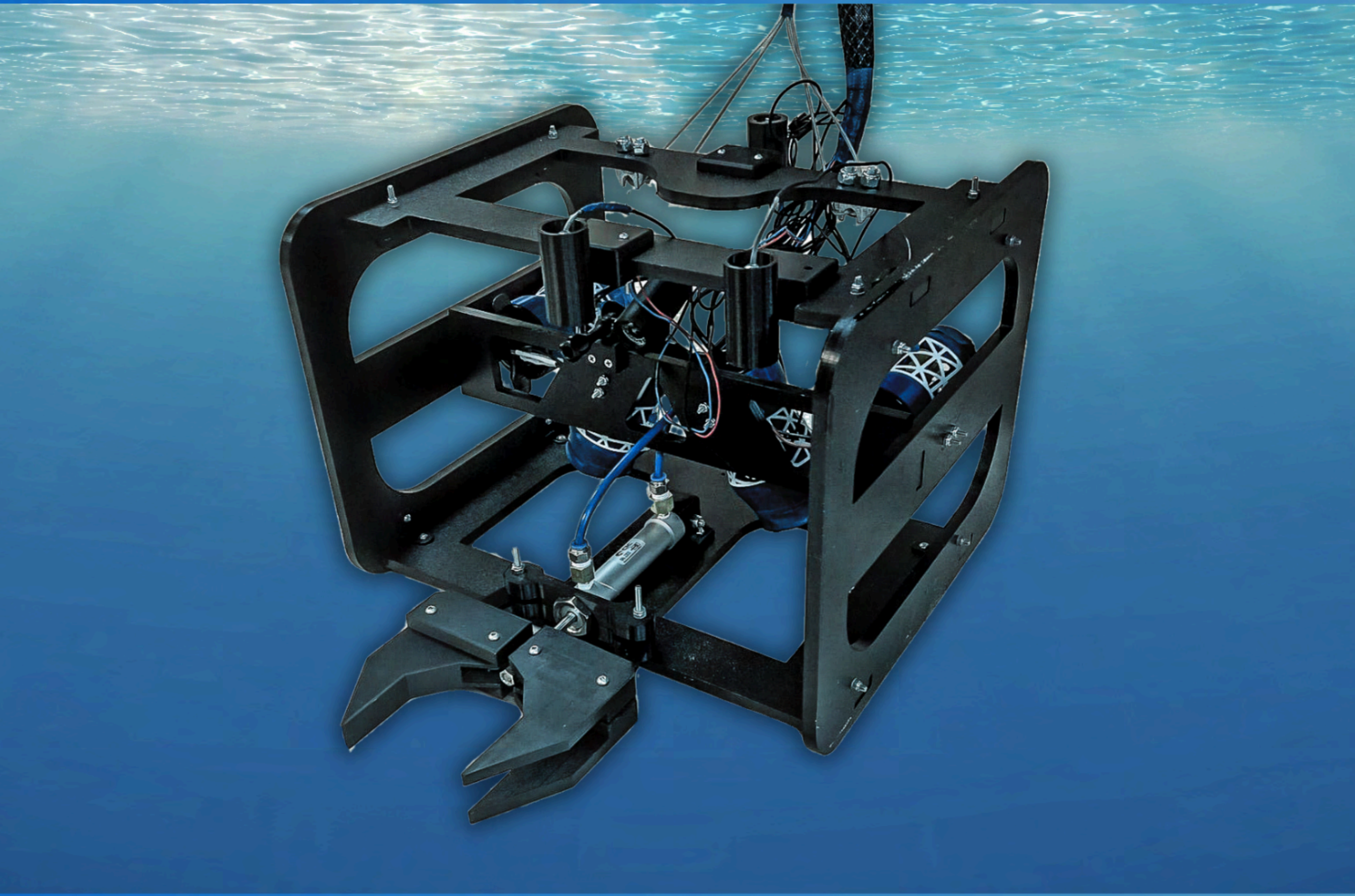
Shark Tech - LabraShark

Labrador Straits Academy
L'Anse au Loup, Newfoundland & Labrador, Canada
Technical Report



COMPANY MEMBERS:

Marcus Flynn**	CEO	Grade 10	Class of 2026
Yashveen Gunput*	CFO	Grade 9	Class of 2027
James Penney**	Pilot	Grade 10	Class of 2026
Luke Hudson**	Co-Pilot	Grade 11	Class of 2025
Finlay Jones**	Float Technician	Grade 11	Class of 2025
Logan Ryland**	Deck Manager	Grade 12	Class of 2024
Christian Roque**	Lead Prop Designer	Grade 11	Class of 2025
Owen Hudson**	Prop Designer	Grade 11	Class of 2025
Lucas Buckle**	Electrical Engineer	Grade 12	Class of 2024
Olivia Normore*	Safety Officer	Grade 9	Class of 2027
Julian Flynn*	Lead Technical Writer	Grade 11	Class of 2025
Brandon O'Dell*	Technical Writer	Grade 12	Class of 2024

MENTORS:

Mr. Ethan Allen
Mr. Riley Regular
Mrs. Amanda Chubbs
Mr. Priyanshu Gunput

*** - New Members**
**** - Returning Members**

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Abstract

Shark Tech is a leading developer of underwater Remotely Operated Vehicle (ROV), from L'Anse au Loup, Newfoundland and Labrador, Canada. For the 2024 MATE contract, Shark Tech designed and built LabraShark. To complete contract requirements, LabraShark is designed to be reliable, and maneuverable in a variety of applications from freshwater reservoirs to offshore installations. A pneumatic claw and vertical profiler were added to complete several mission tasks, and a temperature sensor was purchased and installed to monitor temperature changes in the water. Both the claw and vertical profiler were designed using Solidworks and then 3D printed.

Safety was paramount in importance for Shark Tech. A Safety Officer was enlisted to ensure the company followed strict safety policies. The CEO and lead engineers were responsible for the scheduling and planning which were strictly followed by the company members.

LabraShark is suited for duties related to oceans, lakes, and offshore renewable energies. These activities include protecting and restoring ecosystems to support biodiversity and achieving ocean-based solutions to combat climate change. The knowledge acquired through the design and construction process was crucial for the MATE duties: receiving assets for data collection, the utility of telecommunication tables, administering probiotics for afflicted coral, identifying health habits of lake sturgeon, and monitoring ocean health. This is elaborated on throughout this document.

Figure 1: The Shark Tech Company and Mentors - Photo by Laquita Normore

Back row (l-r): Finlay Jones, Julian Flynn, Logan Ryland, Luke Hudson, Christian Roque, Yashveen Gunput, James Penney

Second row (l-r): Marcus Flynn, Brandon O'Dell, (Mentor) Priyanshu Gunput, Owen Hudson, Olivia Normore, Lucas Buckle

Front row (l-r): (Mentors) Ethan Allen and Riley Regular.

Project Management

Company Structure

Shark Tech is a company run by high school students whose objective is to make the ocean more sustainable. This year, the company expanded from 10 members to 12. Every Shark Tech employee is self-driven and has a strong passion for engineering, underwater exploration and conservation. Employees were assigned roles that were best suited for them based on their interests and skill sets. All employees gather before every meeting to discuss what needs to be accomplished during that day. After this discussion, everybody breaks off to complete their assigned duties. The mentors provide help whenever needed, address any issues that occur during the construction/utilization of the ROV, and assist with communication within the company. All members work to foster an environment of collaboration, teamwork, and positivity. The primary objective is to maintain a safe workplace so that the employees stay safe and the mission isn't compromised.

Company Organization

At Shark Tech, roles were assigned based on individual skills and attributes. Marcus Flynn is the CEO, and as such, assigned roles to the other staff. Brandon O'Dell and Julian Flynn became technical writers, working on documents, and Shark Tech's poster. Logan Ryland, known for his strong discipline and advice, became Shark Tech's Deck Manager.

Lucas Buckle, an active member with a strong grasp of technology, is the Electrical Engineer responsible for designing and creating the electrical and functional systems of the ROV. Olivia Normore, the Safety Officer, ensures compliance with safety guidelines and secures tools and parts to prevent injury during ROV operations and modifications. Christian Roque and Owen Hudson are Prop Designers for LabraShark, posing real-life scenarios for James Penney, the Pilot, and Luke Hudson, the Co-pilot, to practice on. Finlay Jones is the Float Technician, and Yashveen Gunput was assigned as the Chief Financial Officer (CFO). This organization was implemented to allow members to flourish in their respective roles and provide the most benefit to the company's success.

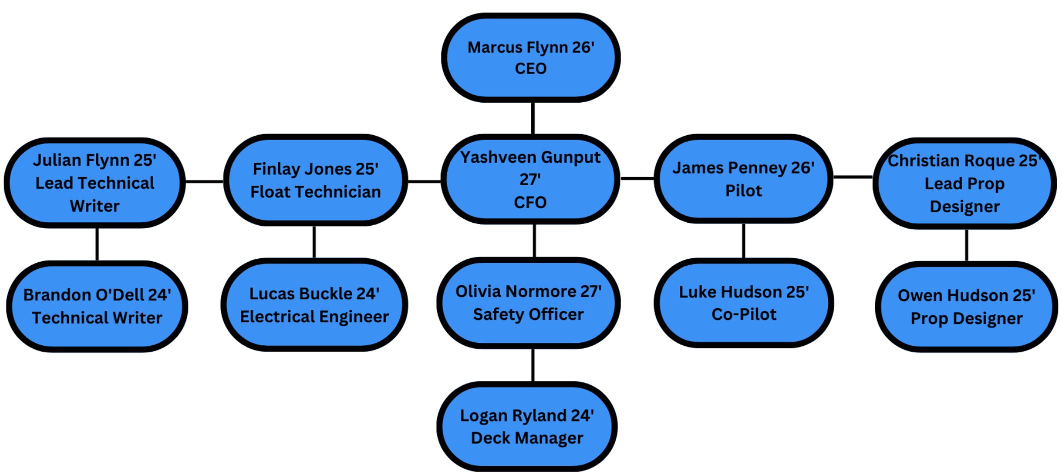


Figure 2: Shark Tech Company Organization Diagram - Made by Christian Roque

Operational Challenges

Shark Tech prides itself on being a very well-organized company. This is demonstrated in the company's Design Schedule as seen in *Figure 3.* Employees collectively constructed the Design Schedule in September 2023. While ambitious, the schedule helped deliver the company to a successful regional competition with time to spare for trial runs and the development of mission-specific contingency plans. The design schedule also simplified the organizational challenges that occurred while the company was simultaneously working on the ROV's manufacturing, marketing display, engineering presentation, and preparation. This schedule was followed closely, and progress was tracked with daily company meetings. These meetings provided company members an opportunity to report their department's progress on various tasks and to make scheduling adjustments where needed.

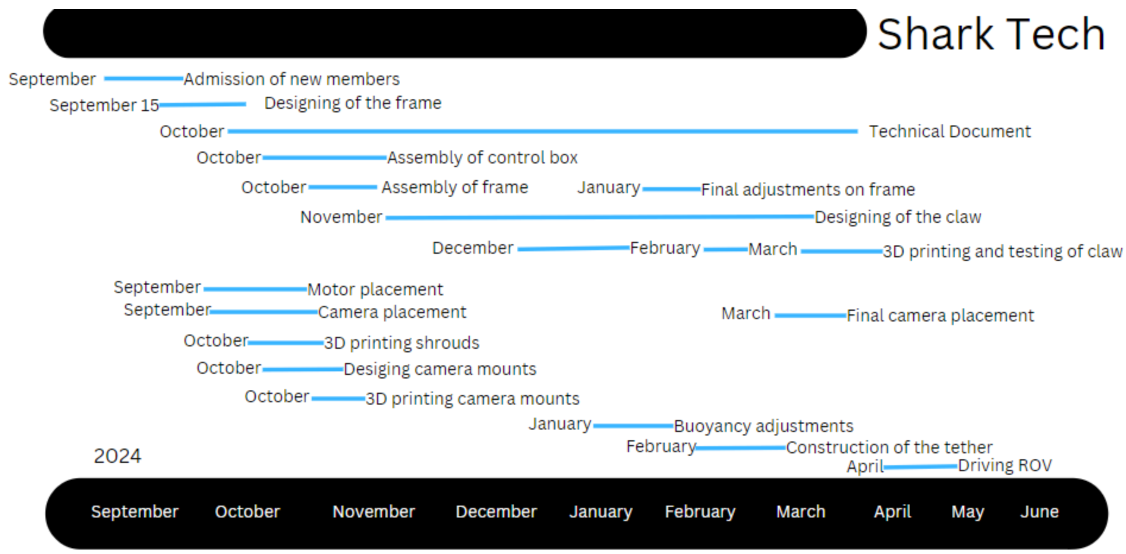


Figure 3: Design Schedule for the Construction of LabraShark - Made by Olivia Normore.

The largest operational challenge Shark Tech faces is shipping delays due to its remote location. During the project, employees needed to be proactive and plan extra time to allow for shipping time. A second challenge was inclement winter conditions. Despite all plans, Shark Tech lost numerous production days. Additionally, many members are involved in other extracurricular activities, often leading to meetings with a reduced number of employees. By sticking to the design schedule Shark Tech was able to overcome many of these operational challenges, and successfully construct LabraShark on schedule.

Aside from the product plan, Shark Tech has developed a series of versatile contingency plans, which enable them to mitigate potential issues that may arise during the missions. These plans include a variation of order in which tasks can be done, should issues arise. For example, in *Task 1.1 Release the Multi-Function Node*, in the event of two failed attempts to pull the release pin, our CEO will inform the deck crew, and the pilot will move on to attempt to attach a recovery line to the array instead. These contingency plans reduce inefficient use of time during the missions, by re-coordination of employees quickly and efficiently to address other aspects of the mission.

Design Rationale

LabraShark is designed to be a serviceable, modular, and durable ROV that contains numerous customized features. These features not only allow LabraShark to complete mission tasks efficiently, but to meet MATE's Request for Proposals (ROP), and help achieve the UN's Sustainable Development Goals. Shark Tech used many resources to design and construct LabraShark. 3D printers, soldering irons, CNC Routers, and various other in-house tools were utilized to manufacture LabraShark. Shark Tech also utilized design software such as SolidWorks, Canva, and ArduinoIDE to design and develop features on the ROV. As a result, LabraShark is an original design, with key components highlighted in the following sections.

Design Evolution

Shark Tech's development and design produced a brand new ROV that is most efficient for this year's MATE competition. Employees took into consideration the performance, versatility, durability, and convenience in designing an ROV that would be superior in all aspects of the product demonstration. LabraShark's design evolved during early company meetings, where employees collaborated to create the ROV together. These meetings elaborated on past experiences to draw potential prototypes of the new ROV. Once Shark Tech created the initial design, the company began to make a cardboard model to visualize and make further improvements before constructing the product. The company budgeted for four motors to maximize performance. Extensive research and testing resulted in LabraShark's motor placement.

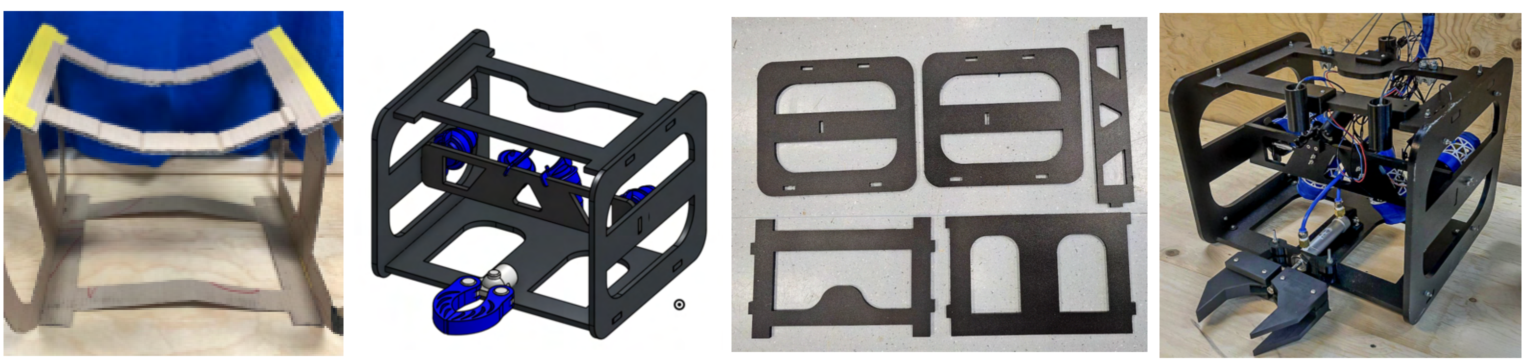


Figure 4: Evolution of LabraShark Design - Images by Olivia Normore

LabraShark is designed to have mission-specific tools and sensors. A claw is centrally placed on the front of LabraShark, as our design team felt it was essential to complete most mission tasks. Previously, Shark Tech's ROV only featured two cameras. However, based on feedback from our pilot, two additional cameras were added. These cameras allow the pilot to have an increased field of view. A temperature sensor is another key feature of LabraShark. This sensor provides the deck crew with a real-time temperature reading on a smart repeater. After various placement tests on LabraShark, the design team found the most accurate reading when the sensor was mounted on the bottom of the ROV. The buoyancy system of LabraShark is specifically designed to aid in lifting objects, such as an irrigation system, efficiently down to the bottom of a pool. The first design utilized pool noodles, however, upon further testing and research our design team opted to utilize high-density foam.

LabraShark is specially designed with MATE’s ROP in mind, enabling the ROV to excel in the product demonstration. All tools, sensors, and systems are tailored for both freshwater and saltwater environments. LabraShark has been constructed from corrosion-resistant materials. The frame is made out of High-Density Polyethylene (HDPE), the claw is made out of polylactic acid (PLA+), and stainless steel hardware is used throughout. LabraShark is designed to be incredibly modular, allowing for future applications.

Innovation

Due to its geographical location, Shark Tech has limited resources readily available. Innovation of a high-performance ROV design utilizing easily accessible components was paramount. The vast majority of components found on LabraShark have been 3D printed, allowing for replacements to be made at a low cost, and in a fraction of time. As a result, LabraShark has an innovative and cost-effective design.

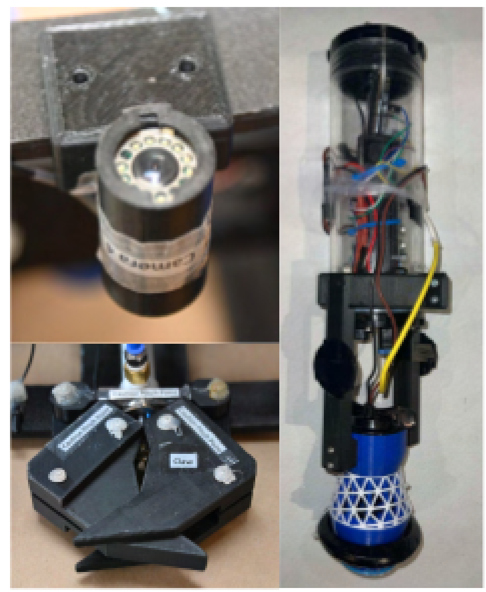


Figure 5: LabraShark’s Camera Mounts, Claw and MATE float. Images by Olivia Normore

The company's most significant innovations are the claw, the float, and the camera mounts (See *Figure 5*). The claw is designed to be simplistic and cost-effective, using SolidWorks and a 3D printer. The innovative claw is powered by a pneumatic system. This system provides the ROV with greater functionality, as it enables the pilot to grasp objects with a rapid yet strong grip.

The float consists of an acrylic water-tight enclosure with a bilge pump motor attached with a 3D-printed mount. An Arduino sends commands to the motor to control movement through the water column. The float is highly functional due to its user-friendly coding interface. It is also cost-effective since its electrical components can be replaced for a low cost in the event there is a leak.

The camera mounts on LabraShark are custom 3D-printed, providing greater functionality to the ROV at a low cost. Customization of the mounts enables budget-friendly ice-fishing cameras to effectively provide the pilot with a variety of angles during missions.

Each of these innovations is further discussed in detail in the *Payload and Tools* section of this report.

Systems Approach

Shark Tech approaches every decision with functionality and simplicity at the forefront. This allows customers to be provided with the best product possible. Shark Tech's design team spent countless hours creating the final design of LabraShark, balancing the trade-offs between the various systems and sensors on the ROV. The team agreed that the ROV required three fundamental systems: Propulsion, Cameras, and Pneumatics. Each system was designed to be integrated with the ROV frame to ensure LabraShark's ability to meet the demanding mission requirements of the product demonstration.

Vehicle Structure

In previous years, Shark Tech has used PVC (Polyvinyl Chloride) piping to construct the frame of their ROVs. LabraShark's sleek frame is constructed of HDPE (High-Density Polyethylene), which is machined using a CNC Router.

As seen in *Table 1*, HDPE material has several properties that make it a more desirable material for an ROV frame, despite the higher cost. HDPE is a stronger, and more buoyant material than PVC. This enables Shark Tech to mount sensors and tools, such as the company's temperature probe and claw, more securely. The density of the HDPE (0.93 g/cm^3) is lower than that of water (1.00 g/cm^3), allowing for increased buoyancy. Additionally, HDPE gives LabraShark a professional and more aesthetically pleasing look.

The ROV frame size is 32.5 cm long, 37.2 cm wide, and 30.5 cm tall. This measurement selection enables LabraShark superior maneuverability in the water, and therefore a greater performance in tight spaces. Additionally, this size provided the advantage of creating a lightweight ROV under 15 kg, while reducing overall material cost. As the MATE mission proposal stipulated, a lightweight ROV was preferred over a heavier design. Despite the smaller size, the ROV design still allows the attachment of all necessary tools and components required, such as the claw.

Table 1: Decision Matrix for Frame Materials - Made by James Penney

Material	**Availability**	**Density g/cm^3**	**Cost per Meter (CAD)**
PVC	Local	1.44	$6.50
HDPE	Order	0.93	$100*
Aluminum	Order	2.7	$60

**Cost for a 1m x 0.5m Sheet*

Vehicle Systems

Pneumatics System

LabraSharks pneumatic system is a critical system on the ROV, as it provides compressed air to our claws. Allowing the ROV to grip onto various objects in the water. The main components of the pneumatics system are based inside the control box. The system features a pressure release valve, an emergency shut-off valve and a regulator in the system that is connected to the ¼” (6.35 mm) Pneumatic Tubing - rated to 862 kPa, that runs through our pneumatic lever-style control valve (rated to 115 PSI (793 kPa). The pneumatic lines then run through the tether to the double-acting cylinder - rated to 130 PSI (896 kPa). The top side of the pneumatic system has a pneumatic line running to the ¼” (6.35 mm) M-Style plugs which are rated to 290 PSI(2000 kPa). The pneumatics system is connected to the compressor through the 9 mm x 3 m Ultra-light Rubber Whip Hose Rated to 115 PSI (793 kPa). A detailed systems integration diagram of all LabraSharks pneumatics systems can be found in *Figure 6* of *Appendix A*.

Electrical Systems

The electrical system of LabraShark consists of a main power board which is connected to the ROV via a buoyant tether. The tether connects the topside controls to the propulsion system and sensors on the ROV. All electrical wiring going to the ROV is powered by a 12V DC power supply connected using Anderson power pole connectors. The control box also features a power bar to supply power to the AV to HDMI converter, monitor, and air compressor. A detailed systems integration diagram of all LabraSharks electrical systems can be found in *Figure 5* of *Appendix A*.

Control System

The control system consists of two hard shell cases and a laptop allowing for efficient setup and take down during product demonstration runs. The first case houses the electronics to pilot LabraShark. The controller has two variable-speed analog joysticks to control the four thrusters. This provides LabraShark with the ability to make precise movements which aids in the pilot's ability to complete tasks such as transplanting branch coral. The control box also features a lever to operate LabraShark’s pneumatic system, and the main tether to connect the controller to the ROV. The controller also features a power meter to track voltage and amperage during missions. The secondary control box features a monitor mounted in the top section which the pilot uses to view the various video feeds on LabraShark. Additionally, this box houses the pneumatic systems pressure relief valve, an emergency shut-off valve and a regulator. The laptop is solely used by the float tech to operate and communicate with the vertical profiling float.

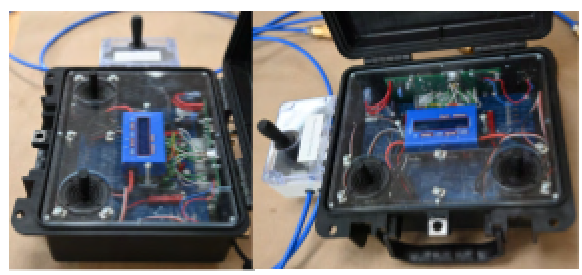


Figure 6: LabraShark's Control System. Image by Olivia Normore

Tether

The tether connects the topside control systems to the ROV. LabraShark has a 15 m neutrally buoyant tether which consists of 10 pairs of 16 gauge wires, leading to four motors and a temperature sensor. The tether also contains wires leading to 4 cameras and 6.35 mm diameter pneumatic tubing which controls the claw. A protective covering keeps wires and tubing from potential damage and entanglements. To maintain neutral buoyancy, HD foam is attached in 1 m increments along the length of the tether. This is required to prevent the weight of the tether from impacting the performance of the ROV while in the water.

Shark Tech understands the importance of good tether management during mission operations. The company safety officer and deck manager have developed a tether management protocol to efficiently manage the tether during product demonstrations. This protocol consists of having a designated staff member managing the amount of tether on the deck while maintaining communication with the pilot. This limits tripping hazards, entanglements, and potential damage to the tether itself.

Propulsion

The propulsion system of LabraShark consists of four 1250 GPH 12V bilge pump motors. These motors were the superior choice for Shark Tech due to their vast availability in the area and their low price point. These benefits limit the amount of delays Shark Tech may encounter with propulsion issues. These motors have a low Current Draw relative to their thrust output. Additionally, bilge pump motors have numerous ready-to-print 3D motor mounts available to be utilized to construct an ROV.

Figure 7: LabraShark's Propulsion system. Image by Olivia Normore.

As seen in *Table 2*, Shark Tech chose these motors over brushless motors due to the cost, availability, and technical challenges the company would face in upgrading to a digital system. Since Shark Tech employees already fully understood bilge pump motors, it was the most logical decision.

Two thrusters are horizontally placed on LabraShark to surge forward and backward, as well as adjust the heading with increased efficiency. The remaining two thrusters are mounted to LabraShark in a vectored configuration at 60^0 angles. The vectored configuration of thrusters allows LabraShark to agilely sway side to side, while still allowing efficient heaving up and down in the water column. LabraShark's innovative propulsion system allows the ROV to make fine adjustments to its course during complex mission tasks, such as threading the smart cable repeater wire through the three waypoints.

Table 2: Decision Matrix for Propulsion Motors - Made by James Penney

Motor Type	Cost	Current Draw (Amp)	Control Method
1250 GPH 12V Bilge Pump	$50.00 USD	3.2	Analog

500 GPH 12V Bilge Pump	$35.00 USD	2.5	Analog
Blue Robotics T200 Thruster	$240.00 USD	17	Digital/Programed

Buoyancy

LabraShark is positively buoyant in the water. During initial testing, employees noticed that whenever the ROV would pick up a prop in the water it would start to sink. To resolve this issue, LabraShark is purposely buoyant (in the water) to help lift heavier objects during missions.

Figure 8: LabraShark's HD Foam for buoyancy. Image by Olivia Normore.

The components responsible for the ROV's buoyancy are two 28 cm long rectangular pieces of high-density foam (HD foam) on the sides of LabraShark. HD foam was utilized on LabraShark, due to its density (50 kg/m^3) being very light compared to the density of water (1000 kg/m^3). Additional pieces of HD foam were added to the sides of the ROV to provide balance and stability. Lastly, a 21.5 x 16.2 cm “backpack” made of HD foam was added to give more stability and lift to the center mass of the ROV.

Payload and Tools

Cameras

Figure 9: LabraShark's Camera Images by Olivia Normore

Shark Tech prides itself on having a simple design for LabraShark while providing ample live viewing of missions through a series of cameras. The camera system consists of four easily replaceable repurposed underwater fishing cameras costing only $100 per camera. The company's engineers developed a simple mounting solution that was used for each camera on the ROV. Shark Tech has added one spare camera as a contingency plan should camera issues arise (Camera 4).

Camera 1 is mounted in the middle of LabraShark to provide a wide-angle view. This view was selected as it provides LabraShark with better situational awareness, and aids in positioning the claw. Camera 2 is placed above the claw to aid in the movement of coral heads during the “Understanding Ecosystems and Saving Species” mission task. Camera 2 is also utilized for the “SMART Cables for Ocean Observing” mission task, where it assists LabraShark in navigating through the assigned waypoints. Camera 3 is mounted facing the surface of the water to provide a view of the ROV’s launch area during its docking procedure. Camera 4 is mounted on the ROV as a spare, in the case that another camera becomes unusable. LabraShark employs these four cameras to provide the pilots with all the views essential to its operation, and the successful completion of missions.

Mission-Specific Tools

The MATE mission tasks set for this year have inspired and motivated Shark Tech to develop novel approaches and technologies for LabraShark. As a result, all tools are original designs, handcrafted by the company. LabraShark is designed to be compact to maximize speed and maneuverability in completing mission tasks. The design for each tool underwent extensive prototyping. Shark Tech began testing by using cheap materials (such as cardboard) to prototype before fabricating the final product. The vehicle and its tools have been tested using a fishing vat donated by The Labrador Shrimp Company. These processes aided Shark Tech in developing a claw and a temperature sensor before the regional competition.

Claw

Based on this year's mission tasks (Coastal Pioneer Array, SMART Cables for Ocean Observing, Understanding Ecosystems and Saving species, and MATE Floats), Shark Tech felt it would be beneficial to develop a claw for LabraShark. The claw is a Shark Tech original design that was 3D printed in-house. Shark Tech's claw consists of two main gripping apparatuses shaped to interlock and hold items using a smooth edge. Shark Tech conducted extensive testing before accepting that this would be the company's most effective option, as it consistently grips props at the same point every time. The design also grants the pilot the most flexibility and ease as to how they wish to attack each task.

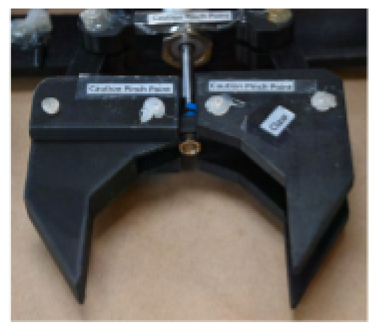


Figure 10: Labrashark's claw open
Image by Olivia Normore

Shark Tech's claw operates using the linear motion of a pneumatic piston. The piston pulls a wishbone mechanism, which is connected to both the piston and the gripping apparatus. As the wishbone moves backward, it rotates the gripping apparatus around the arms, which are connected to the base. This rotation causes the claw to close effectively. To open the claw, these principles are utilized in reverse.

Rock Collection Tool

LabraShark makes use of a rock collection tool for the "Understanding Ecosystems and Saving Species subtask: Bring up one Mexican Pebble". The rock collection tool employs a cylindrical container with a sliding bottom activated by the ROV's claw. To complete the task, LabraShark positions the container over the pebble. The pilot activates the claw, closing the sliding bottom and trapping the rock. This allows LabraShark to move the rock wherever it may be needed.

Temperature Sensor

LabraShark utilizes a thermistor temperature sensor to complete the task “SMART Cables for Ocean Observing”. A thermistor sensor was selected because it was the most cost-effective and easily accessible model. This model of temperature sensors works by detecting the changes of resistance in a thermistor resistor and translating that to a digital reading on a small LCD screen. Shark Tech utilizes this sensor by observing the difference between a pre-calibrated thermometer and Shark Tech’s thermistor sensor. The company mounted the sensor in the front bottom section of LabraShark allowing it to give an accurate reading when compared to the sensor found on the smart repeater.

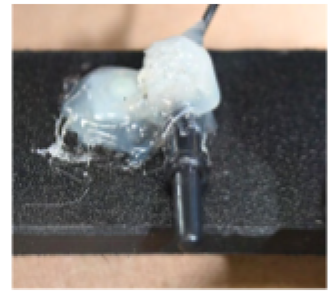


Figure 11: LabraShark’s temperature sensor Image by Olivia Normore

Vertical Profiling Float

Shark Tech designed and developed a vertical profiling float, Shark Fin. The Shark Fin utilizes a built-in Bluetooth module to communicate between the onboard Arduino UNO R4 Wifi, and a sister Arduino on the surface. Shark Tech utilizes Arduino as members are already familiar with the technology, and the user-friendly coding language that they use (C++). The onboard Arduino is connected to a Cytron motor driver that runs a 12V 1250 GPH bilge pump motor. The motor engages to start the descent of the Shark Fin once the surface Arduino has sent the command to descend. Once commencing a descent, a Bar30 pressure sensor will send the data it collects to the Arduino to be saved on an SD card for data storage. Once Shark Fin has finished its first profile, and the surface Arduino has received the data, the operator can send the command to the Arduino for the next descent of the vertical profiler. Shark Fin’s inner components are housed in a 40 cm acrylic waterproof enclosure. Shark Tech utilized a prebuilt container due to the company's lack of expertise with waterproofing.

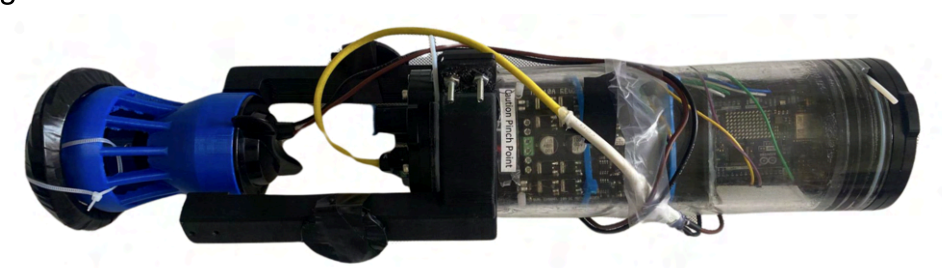


Figure 12: SharkFin Vertical Profiling Float - Image by Finlay Jones

Build vs. Buy

Shark Tech operations are prioritized to be as efficient as possible. These decisions take into consideration Build vs. Buy and New vs. Reused. Shark Tech’s decision to build or purchase new parts for LabraShark is dependent on the availability of adequate tools, materials, and skills available. Having in-house tools and materials enables the company to build custom components for the ROV. The company's motto is to build first and buy later.

An example of this debate is LabraSharks Claw, early in the design process the design team knew they would require a method to grab or manipulate things in the water for most mission tasks. LabraSharks designers had three options: buy a ready-made claw, reuse their claw from previous competitions or build a new claw. Ultimately it was decided to fabricate a new claw. This decision was based on the costs associated with buying a claw from a supplier and known issues Shark Tech's pilot faced with the previous claw design. Designing a brand-new claw allowed our engineering team to integrate features of the ready-to-buy claws with the known faults in previously used claw designs. This also allowed for the claw to be specially designed to meet all the mission requirements in MATE's proposal.

If it is necessary to buy, it is the top priority to make sure what is being bought is compatible with LabraShark. Shark Tech takes into consideration cost and shipping times. Building and producing new products, make the process relatively simple by using design software, and the correct tools and materials available to get the build done. Customization of these parts is done using specific software and manufacturing tools. Shark Tech's 3D Printers use PLA+ filament, which can be used to print the claw, camera mounts and motor shrouds. A CNC router was used to cut HDPE sheets into pieces for the frame of the ROV. Reused items are used based on the condition, performance, and overall savings on funds. The waterproof cameras and motors were all reused from the past ROV.

Problem-Solving

Shark Tech employees are a close-knit group of students who have the common goal of creating the best ROV possible. This factor alone leads to high efficiency in problem identification, and the formulation of a solution. The cooperation of members leads to a positive workspace and a continuous flow of innovation.

With that being said, there have been some challenges throughout the development of LabraShark. Meetings alone have been a considerable issue, as one of the mentors, Riley Regular, moved 716 km away from the company location. To combat distance, the use of *Google Meet* has been essential to connect regularly with the team. The usage of collaborative tools continues to lead to the success of the project. The most significant collaborative tools are *Google Classroom* and *Google Documents*, which enable Shark Tech members to work together in real-time on any area of the project. Additionally, these technologies enable real-time feedback from other staff members, which assists others with challenging jobs. Canva is another piece of technology employed, enabling company staff to work together on the poster while also enhancing the software workflow. Shark Tech makes use of a common message board to notify of company-wide updates and group chats to connect outside of working sessions.

Throughout various phases of the project, a rational and consistent approach has been well-known to the whole Shark Tech workforce. The process is as follows:

1. Determine the problem.
2. Determine the root cause of the problem.
3. Remove all other potential causes.

4. Reduce the problem to its most basic components.
5. Evaluate potential fixes; depending on cost, time, and simplicity.
6. Put the best potential fix into action.
7. Make sure the problem has been fully resolved while keeping an eye on the remedy.

Treatment of design, production, testing, and other types of issues has shown this strategy to be quite effective.

Safety

Safety Philosophy

At Shark Tech, the safety of employees is a top priority. The company has an in-house safety officer, who creates safety protocols for both construction and on-deck operations. Safety protocols are reviewed with members before each meeting to ensure safety while working. Each member is trained on how to use new tools as the ROV is being constructed. To ensure safety, long hair is always pulled back and fastened, long sleeves are rolled up, and safety glasses are worn when using potentially hazardous items. Supervision is a priority, and no member is allowed to operate equipment without a mentor present. Members are encouraged to ask questions and practice a safe workplace. The company safety officer is always present during construction operations to ensure that all employees follow proper safety measures. If a company member has a safety concern about the ROV or another member, they notify the safety officer, CEO, and mentor(s). This approach allows the company to work collectively to resolve any safety issues that arise.

To prevent damage to the electrical components of LabraShark, Shark Tech makes sure that each connecting wire is soldered, covered in hot glue, and shrunk with epoxy-filled heat shrink. To further prevent harm to the ROV's electrical components, as well as company employees from any injuries they could experience while working with the electrical items, a 25 amp fuse was placed to the circuit's positive side within 30cm of the power supply. This prevents the possibility of a power surge through the equipment. Electrical safety is of the utmost importance, particularly while using LabraShark for competition and poolside practice. Shark Tech always ensures that all electrical components are kept away from water. The tether management specialist also ensures no part of the tether is dragged across the ground. The tether was secured to the frame and control box using a strain relief system. This function is to prevent damage to the electrical system due to any employees pulling on the tether.

Shark Tech places an elevated priority on wearing safety glasses and building safety procedures into the vehicle from the beginning. When handling electrical equipment and parts, the company took great care. A pre-mission checklist is completed before the vehicle is started to ensure that all connections are safe, no wires are crossed and fuses are checked. All the technicians operating close to LabraShark are asked to keep their bodies, extremities, hair, and clothing away from the ROV while the electrical system is being handled and maintained.

All hazardous selections of LabraShark are properly labelled to warn employees of dangers. The thrusters and claws are marked with warning labels. Additionally, bolts are marked with tape, and 3D-printed plastic shrouds are applied to the motors to further safeguard against harm. The control system wiring is labelled to display which wires run to each specific component for the safety of the electrical engineers and pilots.

Safety Features

Shark Tech prides itself on creating one of the most versatile, yet safe ROVs on the market. LabraShark meets all safety guidelines outlined by MATE. A summary of key safety features can be found in *Table 3*.

Table 3: Safety Features of LabraShark ROV - Made by Olivia Normore

Safety Features	Description
Rounded Edges	All sharp edges on LabraShark have been sanded to prevent injury to any employees or others.
Waterproofed Electronics	All electrical components on LabraShark have been sealed and are wrapped in heat shrink and electrical tape to prevent electrical discharge.
Shrouded Thrusters	Every thruster on LabraShark has been covered by a protective shroud up to IP20 standard and is in place to prevent damage to the propellers and more importantly personnel.
Caution Labeling	All sharp or dangerous components on LabraShark have been brightly labelled to alert personnel of their existence and dangers.
Power Supply Fuse	LabraShark has a 25A fuse within 30cm of the positive end of the power supply.
Strain Relief on Both Ends of the Tether	The tether is secured on both sides by electrical strain relief fittings to ensure that there is no strain on the tether.

Critical Analysis

Troubleshooting

When troubleshooting the ROV, there were several techniques that Shark Tech used to identify and address any issues:

1. Check the connections: Ensure that all the cables and connectors are properly connected and secured. Loose connections can cause power and signal issues.
2. Review the documentation: Review the user manual and any troubleshooting guides that may be available to identify common issues and solutions.
3. Test the components: Test each component individually to isolate the problem. Check the power supply, motors, sensors, and other components to ensure they are functioning correctly.

4. Use diagnostic tools: Use diagnostic tools like a multimeter to measure voltages and continuity to identify any electrical issues.
5. Inspect for physical damage: Inspect the ROV for any physical damage, including cracks, breaks, and leaks that may affect its performance.
6. Seek help from experts: If the issue persists, seek help from experts or other experienced ROV Companies who may be able to provide guidance and support.

Overall, Shark Tech believes it is important to approach troubleshooting systematically and methodically, starting with the most common and easily fixable issues before moving on to more complex problems. Communication and collaboration among the company members help to identify and resolve issues that may occur.

Testing Methodology

As part of Shark Tech's testing process, every system is tested independently before the entire ROV unit is tested. To reduce the number of variables that could cause issues, the initial testing was conducted outside of the water whenever possible. The company then proceeded to test in the water to guarantee the functionality of every part of LabraShark as a whole, and to monitor any possible or existing problems with the ROV, to ensure that overall performance is optional.

Propulsion Testing

When testing LabraShark's propulsion systems the motors were placed on dry land to check for electrical issues before mounting on the ROV frame. Once the initial test was completed, the company looked at various locations to mount the motors, to ensure maximum efficiency and maneuverability. To test this, the company conducted many practical tests with the in-house water tank and observed how placement and orientation affected the movement of the ROV. After numerous trials as a company, Shark Tech concluded which angles worked best. Shark Tech ran a test to calculate the average velocity of LabraShark. The company completed three trial runs in a 7.3 m long pool and recorded the average time it took the ROV to travel this distance. This was important information because using the speed of the ROV the company was able to measure items underwater without the aid of measuring devices such as lasers or measuring tapes.

Table 4: Velocity of LabraShark in Trial Runs - Made by James Penney

Trial	Distance (m)	Time (s)	Velocity (m/s)
1	7.3	41.28	0.177
2	7.3	45.45	0.161
3	7.3	48.83	0.149

Average velocity = (0.177 + 0.161 + 0.149) / 3 = 0.162 m/s

Pneumatics Testing

To test the Pneumatic systems the company followed similar steps as outlined for the propulsion systems. The claw began as cardboard mock-ups, then early 3D-printed models, until fully functional products were developed. The company's engineers tested different tubing to determine which would produce the most force for the claw and support the proper pressure to use the claw. This allowed the company to calculate what tasks the ROV could complete without there being any issues. Shark Tech first tested the pneumatic connection to make sure it would work when the tether was fully out. The company then tested how well the pilot could maneuver with the new addition to the ROV.

Vertical Profiler Testing

Given that the idea of creating a vertical profiler was new to Shark Tech, an extensive amount of testing was involved at all steps. Testing began with comparing various methods of communication between the float and the mission station. WiFi, Bluetooth and RF communication methods were all researched and tested. Ultimately, our float technician decided to use Bluetooth communication as it was the most reliable and involved the least amount of code integration.

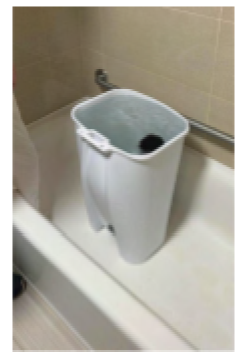


Figure 13: Buoyancy testing of SharkFin Image by Finlay Jones

Once SharkFIns code and internal components were functioning our float technician worked to adjust and test the buoyancy of the Float. This was a difficult process as the goal was to maintain a slightly positively buoyant float but not too much so that the float would not move downward in the water column. This took numerous trial attempts and had to be adjusted multiple times right up until the night before our regional competition. A photo of the testing can be seen in *Figure 13*.

Budget and Cost Accounting

Budget

As with any other company, budgeting is one of the most important pieces for success. At the beginning of the year the CEO and CFO with the aid of our mentors established a budget for the year. The budget for this year was set at $66,899 USD. The budget included the costs associated with 16 people travelling to competitions, ROV construction, Marketing, and miscellaneous expenses that the company may incur. A full breakdown of the budget can be found in *Appendix D*. This budget consists of higher-than-average travel expenses due to the company's remote location. Employees and mentors have to travel more than 1000 km to their regional competition in St. John's Newfoundland and almost 3500 km to the World Championships in Kingsport, Tennessee. Travelling such long distances leads to increased flight costs and additional nights in hotels.

To support such a large budget Shark had an income totalling $59,350.28 USD. A list of income sources can be found in *Table 4.* This left Shark in a deficit of $7548.72 USD for the budgeted project costs. To raise the required funds Shark Tech held various events including ticket draws on different items, a community BBQ, and weekly lunch fundraisers where Shark Tech served lunch at their school. The company also connected with various companies and community stakeholders in the region to acquire sponsorships.

Table 4: Sources of Income for Shark Tech 2024 - Made by Yashveen Gunput

Source	Notes	Amount
Balance from the previous Year	Funds that had not been used in the previous year	$8776.38
MATE-NL Regional Grant	Funds to travel to Regional competition and for construction of the ROV	$5229.26
MATE-NL World Championship Grant	Funds to travel to Kingsport Tennessee for World Championship	$18,284.13
Labrador Youth Network Grant	Funds to support travel to the Competition.	$18,284.13
Newfoundland and Labrador Government Support	Funds from the Provincial Government to support our efforts in the competitions	$8776.38

Project Cost

Shark Tech worked hard to remain within the established budget. The company worked diligently to identify components from previously built ROVs which could be reused on LabraShark. When company members established that a component had to be purchased, a specific process was followed. First, the CFO was notified of what needed to be purchased. The CFO then researched the internet and local companies to compare availability and price. Once the CFO established the best purchasing option, they brought the information to the mentors who then placed the order for the company. A detailed project cost breakdown can be found in *Appendix E*.

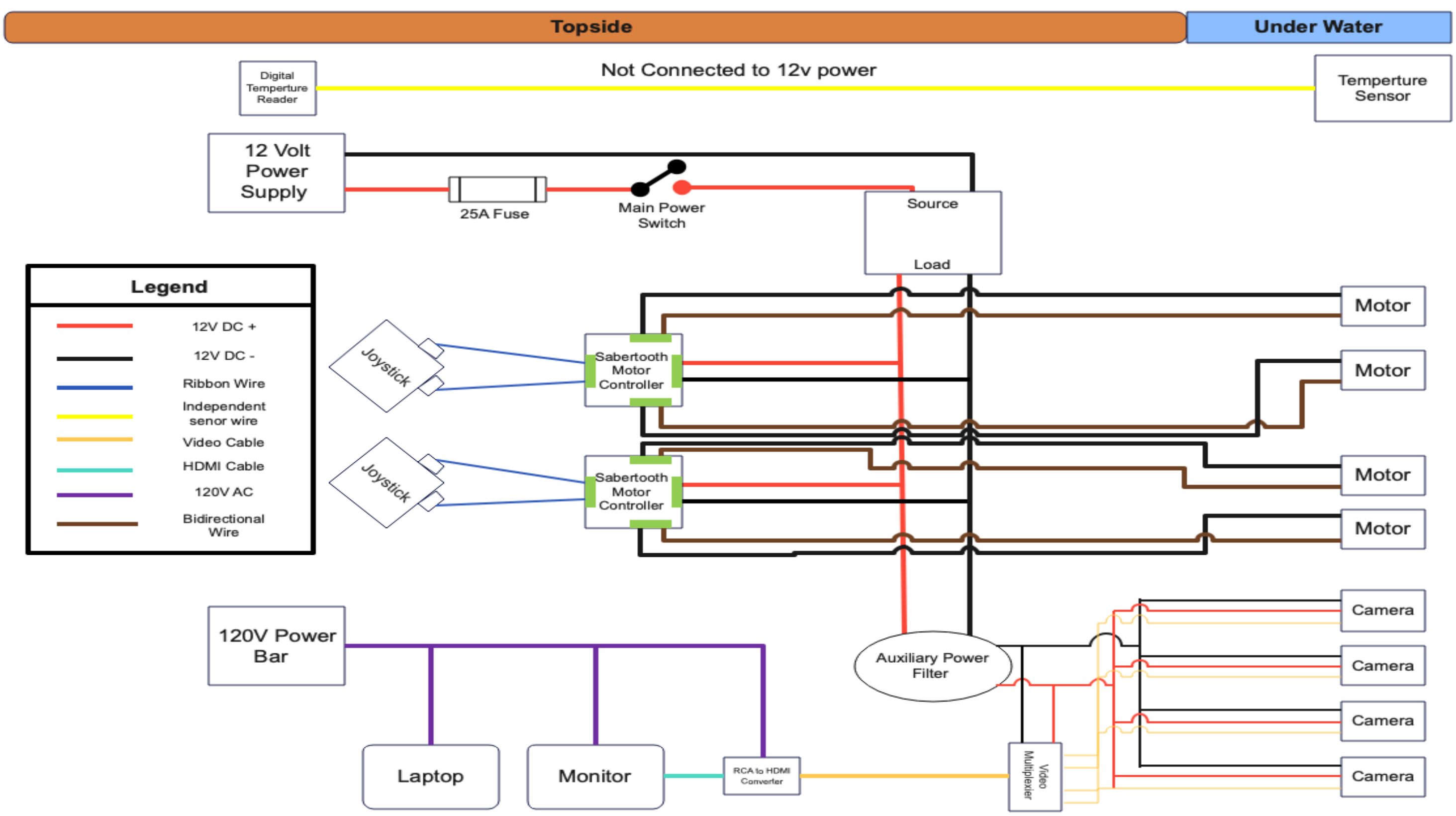
LabraShark cost a total of approximately $3,745 USD. Given that Shark Tech completely redesigned an ROV this year, the amount of reused components was limited to only reusing motors from the previous year. Reusing motors resulted in a savings of $200.92 USD. Travel (flights and rental vehicles) and accommodations cost approximately $44,060 USD. Shark Tech covered some meal costs and further travel costs for employees, which was approximately $14,686 USD. Variations in travel costs resulted from inclement weather and ice conditions, forcing short-term diversions of ferry and flights and longer hotel stays. Shark Tech did not receive donations of any ROV components. As seen in *Table 5*, the company was able to fundraise an additional $7,500.00 USD, leaving the company a surplus of $4,872.81 for future expenses.

Table 5: Total Project Cost of LabraShark in USD - Made by Yashveen Gunput

Budgeted	*$66,899.00*
Costs	*-$61,977.47*
Income	*$59,350.28*
Fundraised	*$7,500.00*
Account Total	*$4,872.81*

Appendices

Appendix A - System Integration Diagrams (SIDs)



Device	Total number on ROV	Current Draw per Device (Amps)	Total Current (Amps)
Thrusters	4	3.2	12.8
Cameras	4	0.1	0.4
Control Box	1	0.3	0.3
Float Controller	1	.15	.15

Total Calculated Current (Amps)	**13.65**
Overcurrent protection Factor	**150%**
Fuse Calculation	**20.475**
Rounded Fuse Size (Amps)	**25**

Figure 5: LabraShark Electrical SID - Made by Lucas Buckle

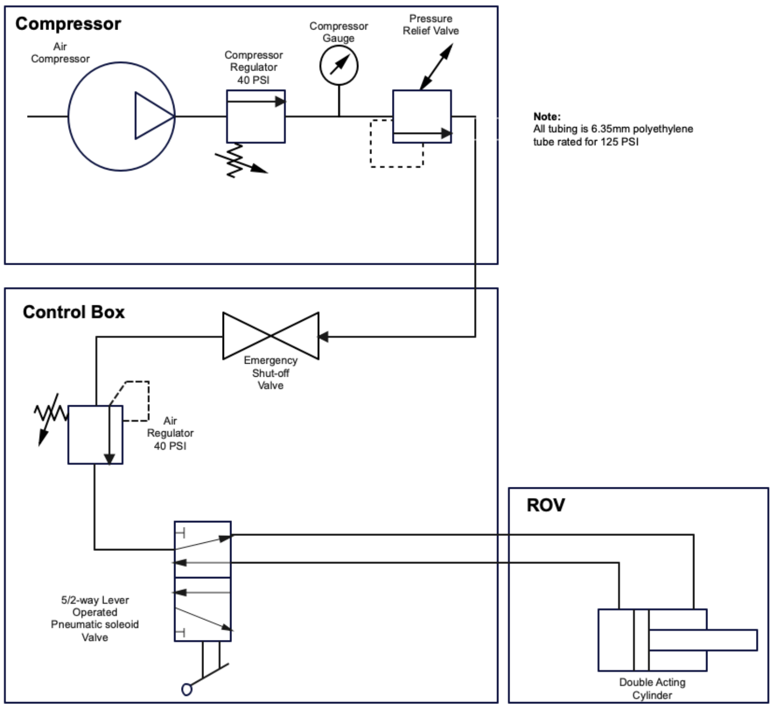
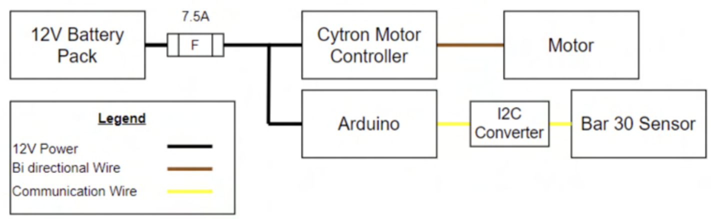


Figure 6: LabraShark Pneumatics SID - Made by Marcus Flynn



Device	Total number on Float	Current Draw per Device (Amps)	Total Current (Amps)
Motor	1	3.2	3.2
Arduino	1	0.4	0.4
I2C converter	1	0.15	0.15
Motor controller	1	0.10	0.10

Total Calculated Current (Amps)	**3.15**
Overcurrent protection Factor	**150%**
Fuse Calculation	**5.775**
Rounded Fuse Size (Amps)	**7.5**

Figure 7: SharkFin SID - Made by Finlay Jones

Appendix B - General Safety Checklist

- Ensure that all personnel have their hair securely tied up, sleeves rolled up, and earphones/jewelry put away before the use of any tools.
- Verify that all personnel are wearing closed-toed shoes.
- It is crucial to establish clear and effective communication with co-workers.
- Ensure that all personnel are wearing safety glasses.
- Make sure that passageways are clear of objects and wires.
- Hazardous objects and materials should be kept away from members and ROV when not being used.
- All electronics, except for the tether, should be kept away from water.
- Ensure that all wires are carefully and effectively covered.
- Ensure that the power connection and controller are connected before powering on the control box.

Appendix C - Operation And Construction Protocols

Tether Protocol And Set Up:
1. Straighten the tether, ensuring there are no kinks
2. Secure the strain relief to the control box to prevent any chance of disconnection
3. Communicate to all employees to avoid stepping on the tether once deployed

Post-run Checklist:
1. Ensure the ROV is securely out of the water
2. Neatly roll up the tether and place it in the container
3. Communicate with all employees to avoid confusion or disorganization

On Deck Checklist:
1. Proceed with the tether protocol
2. Plug in and connect all necessary components
3. Turn on the control box
4. Turn on the air compressor
5. Test the thrusters and the claw
6. Test camera views
7. Deck crew gives the “ready” signal
8. Pilot calls out “Launch!”

Pre-run Checklist:
1. Verify electrical power connections
2. Verify that all waterproof seals are secure
3. Perform a test run on deck to ensure all cameras, thrusters, and the claw are working and free of obstructions

Post-run Checklist:
1. Ensure the ROV is securely out of the water
2. Switch off the control box
3. Ensure the air compressor is turned off
5. Unplug all components
6 Follow the“post-run” tether protocol
7. Dry the ROV and set it in the container
8. Ensure no materials, props, supplies, or trash are left in our workspace

Appendix D - Project Budget

Shark Tech Budget 2023-2024 **Reporting Period:** Sept. 2023 - June 2024

School Name: Labrador Straits Academy

Mentor(s): Riley Regular and Ethan Allen

Expenses				
Category	**Type**	**Description**	**Projected Cost**	**Budgeted Value**
Hardware	Purchased	HDPE Board, Fasteners, PLA	$292	$292
Electronics	Purchased	Control System	$1,095	$1,095
	Purchased	LCD Screen	$292	$292
	Re-used	Motors	$219	$0
	Purchased	Temperature Sensor	$36.5	$36.5
	Purchased	Float Electronics	$730	$730
	Purchased	Cameras	$292	$292
	Purchased	Tether Wires	$109.5	$109.5
Travel	Purchased	Travel to Regionals	$4,380	$4,380
	Purchased	Mentor Visit	$876	$846
	Purchased	Travel to Worlds	$51,100	$51,100
General	Purchased	Marketing Materials and Misc. Items	$7,300	$7,300
		Total Budgeted Expenses (USD)		**$66,899**

Appendix E - Project Cost

Shark Tech Project Costing 2023-2024	**Reporting Period:** Sept. 2023 - June 2024
School Name: Labrador Straits Academy	**Mentor(s):** Riley Regular, Ethan Allen, and Priyanshu Gunput

Funds						
Date	**Type**	**Category**	**Expense**	**Description**	**Notes**	**Amount**
09/24/23	Purchased	Electrical	Motor System	Materials for Core Electrical Systems	Tools and Components	$598.26
10/06/2023	Purchased	Hardware	Fame	HDPE Board	24"x 54" HDPE Sheet	$112.95
11/14/2023	Purchased	Camera	Cameras	Cameras	4 HD Fishing Cameras	$301.78
11/14/2023	Purchased	Hardware	Mounting	Brackets and Bolts	Brackets and Hardware to Construct Frame	$69.36
11/14/2023	Purchased	Tether	Covering	Protective Covering	Covering for Tether	$61.52
11/14/2023	Purchased	Electrical	Control Box	SeaMate Controller	Control Box System from SeaMate Store	$1,030.12
02/01/2024	Purchased	Float	Computer	Hardware for Float	Motor Controllers and Arduinos	$327.43
03/06/2024	Purchased	Camera	Display	Display Screen	Screen and Hardware	$235.99
03/06/2024	Purchased	Pneumatic s	Claw System	Required Pieces for Pneumatic Claw	Full Pneumatics System	$503.18
04/01/2024	Purchased	Travel	Flight	Flight for Mentor Visit	Mr. Regular's Flight to Labrador for Weekend	$1,043.65
04/08/2024	Purchased	Float	Enclosure	Blue Robotics Order	Watertight Enclosure System	$547.04
05/01/2024	Purchased	Travel	Travel	Regionals Trip	Travel Expenses for Employees (Labrador to St.John’s)	$4,453.00
05/04/2024	Purchased	General	3D Printer	New 3D Printer	Replaced Broken Printer	$544.13
05/10/2024		Travel	Flights	Flights to Worlds	Flights	$15,457.75
05/10/2024		Travel	Hotels	Hotels for Worlds Trip	Hotels	$10,857.29
05/11/2024		Travel	Car Rental	Cars for 16 People	Cars	$4,015.00
05/13/2024		Travel	Misc. Expenses	Fund for Food & Other Travel Expenses for Employees	Food, Luggage, Additional Fees	$14,600.00
05/15/2024		Marketing	Displays and Clothing	Clothing & Marketing Materials for Trip	Polos, Hoodies, Hats, Posters and Paper Items for Worlds	$6,421.28
05/15/2024		Float	Enclosure	New Tube to Improve Float	Longer Tube for Float	$430.66

Total Spent (USD)	$61,977.47

Acknowledgements

We would like to thank the following individuals and organizations for their support:

- Mr. Regular, Teacher Mentor and Founder of Shark Tech
- Mr. Allen, Science Teacher, and Teacher Mentor
- Mr. Gunput, Student Mentor
- Mrs. Chubbs, English Teacher, and Teacher Mentor
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- Clubhouse Embroideries for making company polo shirts
- Normore Enterprises Limited, C&T Enterprises Limited, Cenovus Energy, SubC Imaging, The Government of Newfoundland and Labrador, Seamor Marine, GRI Simulations, eSonar, and Equinor for sponsoring Shark Tech
- MATE Center and Marine Institute for allowing us to compete in the competition
- Neil Rowsell, for letting us use his swimming pool for testing

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