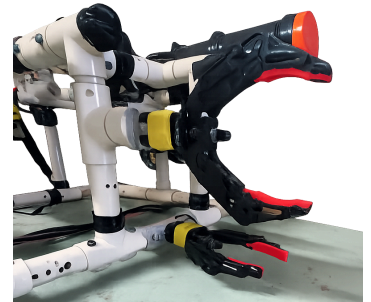




St. Mark's Robotics St. Mark's School *Bonabot*

King's Cove, Newfoundland & Labrador, Canada
Technical Report



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ABSTRACT

St. Mark's Robotics is proud to compete in the MATE ROV 2026 Ranger Class World Championships for the first time with our newest ROV model, Bonabot. Our design prioritises simplicity and reliability to reduce troubleshooting and improve performance. The lightweight PVC frame allows for easy movement, while air-filled tubing provides stable flotation and balance. Strategically placed underwater cameras give clear, wide-angle views of the claws for precise operation. Carefully designed grippers help us navigate tight spaces and complete retrieval tasks efficiently. Our simple switch-based double-pole double-throw control system enables smooth movement in all directions. These features combine to deliver strong visibility, dependable performance, and effective task completion during demonstrations.

1. PROJECT MANAGEMENT

A. Company Overview

St. Mark's Robotics has been in operation since 2011, with a mission to "Design and operate innovative ROVs that tackle real-world underwater challenges through teamwork, creativity, and problem-solving".

Our student-run company is based out of the small rural community of King's Cove on the Bonavista Peninsula, Newfoundland. This year, the company consists of members from grades 9 to 11. In fact, the company is actually composed of ALL of the members of grades 9 to 11, as the K-12 school itself only has 20 students. Members of our team have worked together consecutively for 4 years in the scout class, however 2026 will be the first year the team will enter Ranger class, as well as the World Championship, together.

Our close-knit team of six has developed valuable transferable skills such as creativity, critical thinking, problem-solving, and teamwork. We show creativity through innovative designs and continuous improvements to our ROV. Critical thinking and problem-solving are demonstrated when troubleshooting issues and finding effective solutions under pressure. Teamwork is evident in how we support one another, share responsibilities, and make decisions together. This season has challenged us to grow through real-world tasks. Redesigning our flotation system strengthened our creativity, repairing a defective claw improved our ability to think

quickly, and managing schedules and differing ideas taught us cooperation and respect for others' perspectives.

B. Company Organization

St. Mark's Robotics is based out of a very small school consisting of only 20 students. This specific crew of St. Mark's Robotics have been working together for 4 years consecutively, and have maintained their role assignments since competing together in Scout class in 2023.

The maintenance of similar roles from year to year allows members to build valuable skills and techniques in areas where they excel, which also allows time to lend their expertise to other areas of the ROV realm. Being a small group means everyone must work together both in and outside of their comfort zones to create a smooth, well-oiled machine-like performance during product demonstrations.



Figure 1. Company Organization of St. Mark's Robotics - Designed by Kimmie Long

C. Operational Challenges

St. Mark's Robotics takes pride in being a well-organised and collaborative company, as shown by its Design Schedule (Figure 2).

Operation	Nov	Dec	Jan	Feb	Mar	Apr	May
Claw function	Reinforcement design	Reinforcement design	Testing	Testing	Mission Practice	Mission Practice	Mission Practice
Camera operation	Purchasing & delivery wait time	Designing mounts	Installation	Mission practice	Mission practice	Mission practice	Mission practice
Frame design	Evaluation of frame design	Frame modifications	Testing, Buoyancy adjustments	Modify PVC for new cameras	Mission practice	Mission practice	Mission practice
Tether management			Testing, buoyancy	Testing, buoyancy	Mission practice	Mission practice	Mission practice
Prop and mission task preparation	Planning prop building, purchase & delivery wait time	Purchase & delivery wait time	Building props	Building props	Mission practice	Mission practice	Mission practice
Buoyancy management	Removal of old buoyancy, design of new methods	Planning new buoyancy	Measures & purchasing tubing	Installing new PVC buoyancy tubing	Mission practice	Mission practice	Mission practice

Table 1. St. Mark's Robotics yearly schedule of action -Designed by Olivia Taylor

St. Mark's Robotics began the season by creating a detailed practice schedule in November 2025. Following this plan allowed us to stay ahead of schedule and dedicate more time to practice runs, modifications, and backup planning.

As a small team of six busy high school students involved in activities such as sea cadets, figure skating, hockey, and dance, we focused on making our time together efficient and productive. We often worked in smaller groups on concurrent tasks such as building the ROV, preparing the marketing display, and developing our engineering presentation.

One of our biggest challenges was a major electrical outage that affected the section of our school containing our practice tank. A water leak and storm damage caused electrical issues that left us without power or tank access for an extended

period. With support from school staff, parents, community members, and facilities management, partial power and temporary heaters were eventually provided so we could resume testing. Although this reduced our available testing time, we were still able to evaluate buoyancy, claw movement, and propeller performance.

Throughout the season, St. Mark's Robotics held weekly meetings outside school hours to monitor progress, share updates, and adjust schedules when needed. As regionals approached, we met daily to finalise details and complete adjustments to Bonabot. Through strong teamwork, careful planning, and dedication, we successfully completed all planned tasks, finished Bonabot ahead of schedule, and tested every major update before the competition.

3. DESIGN RATIONALE

A. Design Evolution

The overall structural design of our ROV has remained essentially unchanged for the past 4 years. This simple design has competed (and competed well) in both Scout and Ranger classes. While we have modified minor components of Bonabot, our PVC framing, electrical system, and tether mechanisms, have all remained consistent.

Our ROV frame was first constructed in September of 2022. Our original design used backup cameras intended for vehicles, but the image quality was less than optimal underwater. We then upgraded to Garmin fishing cameras, which provide a much better view of our underwater environment, as the cameras are now functioning in their intended environment. We not only changed the camera types, but also the positioning of them. One was placed directly above the claws, pan-tilt style, while the other was positioned on the transverse plane so we could see directly in front of or peripherally to the ROV. Both of these innovations made navigating the mission tasks much easier and less time-consuming, as we could see our surroundings better, and get a more solid sense of direction.

B. Innovation

St. Mark's Robotics is located in a very small rural community, and has limited resources readily available. The creation of a high-performance ROV with

a simple design and easily modifiable components was most important to us. The vast majority of components found on Bonabot are relatively low-cost and easily replaceable. This allows us to make modifications at a fraction of the cost other teams may spend and in a fraction of the time. As a result, Bonabot has an innovative, serviceable, and cost-effective design.

The company's most significant innovations include our claws or grippers. When considering extensions for tasks, we used simple trial-and-error practices to decide on what worked best for completing mission tasks. After having tested everything from hydraulic claws, simple hooks and even parallel 3D printed fingers-like designs, we decided that mechanical, pre-made claws worked the best for us.

This is extremely cost-effective for the company, as the claws we use can be easily fixed. Even though they appear fairly delicate, we found the best way to reinforce them was with bolts and zipties, leaving us with stronger claws that still boast enough flexibility to retrieve samples during mission tasks.

4. SYSTEMS APPROACH

St. Mark's Robotics approaches every decision with simplicity in mind, which allows customers to be provided with the best product possible. Simple designs mean simple fixes. Our design team has spent many hours perfecting the final design of Bonabot. Our team agreed that our ROV required two simple fundamental systems: propulsion and cameras. We decided that the bulk of our work for mission tasks would be completed from our extensions- two MakeBlock grippers - one mounted vertically, and another horizontally. Bonabot's simplistic cube-like frame and motors ensure Bonabot's ability to meet the demanding mission requirements of the product demonstration

A. Vehicle structure

Bonabot's frame is constructed entirely out of PVC piping. We chose this material as it is lightweight, rust-proof, and easy to modify if needed. In our long history of ROV manufacturing, we have continued to utilize polyvinyl chloride

(PVC) due to its easy accessibility and low cost. We have found that it continues to prove to be reliable in tool mounting and positioning motors effectively

5. VEHICLE SYSTEMS

A. ROV electrical system

The electrical control system on board Bonabot is completely housed in a watertight, poolside control box. All wiring is shrink-wrapped with adhesive-lined heat shrink tubing. Bonabot is powered using 12V DC power, and controls are communicated using a very simple double-pole double-throw (DPDT) switch design.

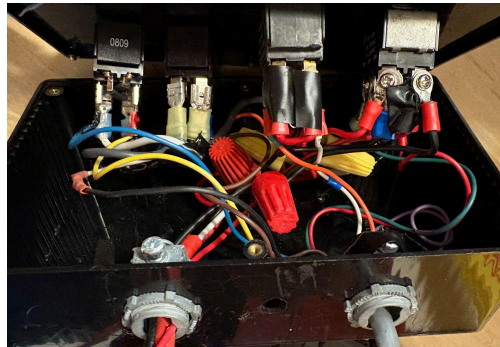


Figure 2. Bonabot electrical system - Photo by Jacinda Elson

B. Control system

The control system ROV is designed for efficient set up and operation during product demonstration runs. It comprises a hard-shell control box, facilitating portability and quick deployment. It houses the poolside electrical components responsible for propulsion and extension controls.

C. Tether & tether management

The tether is 14.94 metres long and consists of 5 wires. Of the five wires, the tether houses a power wire, another for motors turning left and right, as well as one for vertical movement. The connection for our two cameras also feeds into our three prong switchbox.

For organizational and safety purposes, we used zip ties for every 4 feet of tether length to keep all wires bundled together. Styrofoam was also used along every 4 feet to help maintain neutral buoyancy. During demonstrations, tether technicians work simultaneously, completing 3 courses of action: One technician will monitor tether needs in terms of length. Another is responsible for lowering and retrieving the frame of the ROV in the water. The final tether technician is responsible for prop and extension management, which involves removing specimens from the grippers or placing props efficiently in the grippers for a safe journey to the ocean floor.

D. Propulsion

St. Mark's Robotics uses an underwater payload system that uses four 12-volt DC motors to provide propulsion and maneuverability for the best operation of Bonabot. Our motors operate in a simple ON/OFF configuration, meaning each motor runs at either full thrust or none at all. Propulsion is controlled using a double pole double throw switch design from our control box

Direction	Controls
Horizontal Motors 1 and 2	Forward movement Reverse movement Turning left/right Both at the same time for hard left/right
Vertical Motors 1 and 2	Diving downward Rising upward Stabilization underwater

Table 2. Bonabot propulsion breakdown - Designed by Olivia Taylor



Diagram 3. Propulsion Protection - Photo by Olivia Taylor

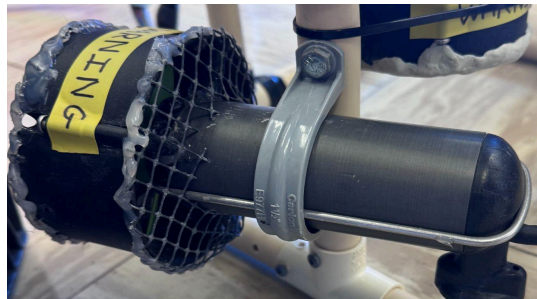


Diagram 4. Vertical positioning of Bonabot's thruster - Photo by Olivia Taylor

E. Buoyancy

Bonabot is designed for neutral buoyancy. St. Mark's Robotics originally began experimentation with Styrofoam as the main buoyancy method. As we struggled to find the perfect amount, placement and length that worked best for Bonabot, we also noticed that pieces of foam were breaking and leaving detritus in the mission task practice tank. We then decided to seek out alternate methods of floatation and decided on ditched two air-filled PVC piping tubes that are each 21cm in length. This is what the team refers to as the “goldilocks” zone for neutral buoyancy.



Diagram 5. Bird's eye view of Bonabot and its buoyancy. - Photo by Jacinda Elson

6. PAYLOAD TOOLS

A. Cameras

Bonabot consists of a very simple frame design while providing ample space for mounting cameras to give optimal viewing for the pilots. The camera system consists of two cameras, one main underwater Garmin fishing camera, and one basic back up camera. We chose to keep our simple backup camera because we enjoyed its small size and how it can easily pivot and adjust to acquire a better angle of the ROVs surrounding. The primary Garmin fishing and our backup camera were both approximately \$50. Our engineers developed simple mounting solutions that were used for each camera on the ROV



Diagram 6. Bonabot's camera system - Photo by Faith Aylward

B. Claws

Our ROV claws payload system is designed with two independently operated mechanical claws mounted at different orientations to maximize the efficiency and versatility during underwater tasks in the MATE ROV Competition. The first claw is mounted vertically at the front of the vehicle, allowing it to grip, pull, and manipulate objects directly in front of the ROV with precision and stability. This orientation is ideal for tasks such as retrieving tools, turning valves, or carrying objects through the course. The second claw is mounted horizontally, giving the ROV the ability to grasp objects from above or below, which is especially useful for lifting items off the seafloor, collecting samples, or handling objects positioned at awkward angles. By combining both claw orientations, the ROV can complete a wider range of missions without needing to reposition the entire ROV, improving maneuverability, task speed, and overall operational accuracy. Both claws are constructed from lightweight, corrosion-resistant

materials to withstand harsh underwater environments, such as the saltwater ocean and cold water tanks, all while minimizing added drag and power consumption. The dual-claw design increases adaptability, allowing our pilots to perform complex underwater operations more effectively and reliably during competition missions.

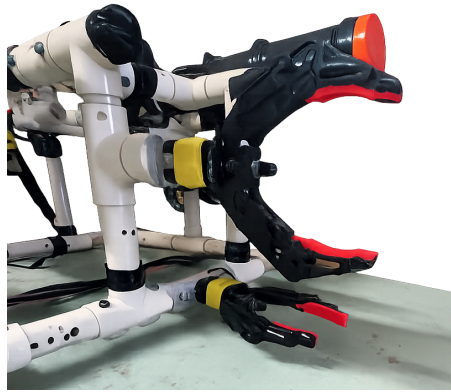


Diagram 7. Gripper extensions for completing mission tasks - Photo by Kimmie Long.

C. Build Vs. Buy, Old Vs. Used

At St. Mark's Robotics, we collectively decide what we should purchase new at the beginning of every manufacturing season and what tools and extensions we will continue to use. St. Mark's Robotics aims to spend funds effectively when necessary, but we are also mindful of being wasteful of materials that can be repurposed or used again from year to year. If we are able to fix it with the tools and pieces we have available in our building, we do just that.

For example, during this year's practice season, our vertical claw malfunctioned, which led to us being unable to open or close the gripper. So we decided to buy an actuator so we could resolve this issue, as opposed to purchasing a brand new gripper. Using an actuator to fix this saved us some money, which is always useful since we are just a small school with 20 students. Some things aren't always fixable though, so we have to buy some things to upgrade our ROV a little from year to year. Our main viewing camera malfunctioned this season as well, and decided to invest in one that was more suited for underwater viewing. We purchased a new garmin fishing camera for approximately \$50 which was still very much so in our budget but a well needed upgrade for our ROV.

7. PROBLEM SOLVING

At St. Marks Robotics, we have run into our fair share of scheduling, mechanical and operational issues. Over time we have all grown in our skill sets to be able to identify, analyze and correct these issues over the years.

For example, our claw extensions are very delicate in structure, and have broken a number of times. With continued practice time, the pilot was able to become familiar with techniques that prevented any damage to the claws and we all took safety/careful precautions when handling them. We purchased these claws in bulk originally, as we found their capabilities to be highly effective. We have learned to reinforce them with bolts in the middle of the closing portions of the claws for long term maintenance.

Buoyancy was another conflict that we had to resolve prior to this competition season. We had trouble finding neutral buoyancy with Styrofoam, which was actually Bonabot's main flotation device for years. This season, St. Mark's invested in new PVC air filled tubing as a flotation substitution. This change offered better maneuverability and a cleaner look for the ROV.

This season, our cameras have run into some problems with connectivity and display. Our reception and quality was not satisfactory because we used backup cameras that were not intended for underwater use. To eliminate these issues, we upgraded our cameras and purchased an underwater Garmin fishing camera, which are meant for underwater performance.

St. Mark's Robotics has also struggled with passing safety checks in the past due to what appears to be complex and hectic wiring within our control box. We've worked diligently this competition season to ensure that all wires are secured, separated, and safely sealed to prevent electrical problems. The control box has now been effectively organized and waterproofed using both liquid and solid electrical tape.

By overcoming these issues, we have learned some troubleshooting techniques that have better prepared us for our tasks. St. Mark's Robotics has been able to make Bonabot strong and agile for competition.

8. SAFETY

A. Safety Philosophy

At St. Mark's Robotics, the philosophy of ocean preservation begins with safety. The ability to observe, explore, and conserve ocean environments without direct human contact is a milestone of its own. However, as humans work to operate and collect data using ROV's, safety must always remain our top priority. We ensure proper tools, and clearly defined procedures are in place to prevent accidents. Safety is a vital part of every aspect of our company's philosophy, whether in the workshop or during ROV testing. If any employee has a safety concern regarding the ROV or another individual, they are instructed to notify the safety officer or mentors. We ensure everyone has a thorough understanding of basic safety practices before we begin any hands-on work. By putting safety first, St. Mark's Robotics ensures the best practices, products and outcomes for all involved.

B. Safety Features

<i>Safety features</i>	<i>Description</i>
Waterproofed Electronics	Watertight housing (poolside) to prevent and water damage
Power Supply Fuse	There is a 15A fuse within 30cm of the positive end of the power supply
Shrouded thrusters	The brushed thruster electrical CTP motors are shrouded, made in house secured with hot glue, for protection and efficiency
Strain relief	The tether has a rope to ensure that there is no strain on the tether
Rounded edges	Rounded edges prevent injury and prevent damaging any holding tanks or environmental objects
Caution labeling	All potential hazards are labelled with yellow electrical tape

Table 3. Safety Features of Bonabot - Designed by Grace Newell

9. CRITICAL ANALYSIS

A. Troubleshooting

The ability to solve any immediate issues during Bonabot's missions both quickly and effectively has been a priority for St. Mark's Robotics throughout our years of practice. During competitions we have run into issues with camera reception, as well as both claw and motor malfunction. We have had to quickly fix these problems either poolside or under a tight time constraint for successful product demonstrations. This year in particular, at the regional competition, during our testing time we encountered gripper malfunctions when both claws seized and would not open or close. We also experienced viewing issues when our camera reception would black out when motors were in use. We came to the realization that our RCA adapters were the issue, and we were able to resolve this problem as well as change our claw wiring/position while on deck during a practice time.

Our ability to think and act quickly on our feet while working together as a team are skills that have proved very useful at this year's regionals. These are also skills that St. Mark's Robotics prides itself on.

B. Testing Methodology

At St. Mark's Robotics, each system is tested and evaluated independently before full integration into the ROV. In order to isolate potential issues, initial tests are conducted before entering the water. Once individual components are verified that they are in working order, in-water testing is performed to ensure that all systems are able to work in the water and can work together. This step-by-step process helps to isolate any issues that may be directly water-related, such as leaks or breaks in wiring. These full system tests help identify any existing or potential issues, to ensure the Bonabot is performing at its highest level. St. Mark's Robotics tested the Bonabot in water, alongside each prop, in MATE's mission tasks this year. The mission task practice tank allows the team to test the Bonabot multiple times prior to competition product demonstrations, ensuring confidence that Bonabot is capable of completing mission tasks within the given time limit.

C. Propulsion & Buoyancy Testing

At St. Mark's Robotics, our propulsion testing is limited. This is due to the double-pole double-throw nature of our motor system. This type of system means our thrusters only operate at full speed or not at all. As a result, we had to try some innovative ways to test propulsion. We measured 3 metres in our pool and timed how long it would take. The time it took to travel 3 metres forward was 8.8 seconds.

10. BUDGET

A. Budget

Budgeting was a priority for us at St. Mark's Robotics during the building and marketing processes. Our CFO, in agreement with the team, set a number of financial goals for the season.

We allowed expenses of \$350 for marketing expansion, approximately \$500 to replace any outworn or older parts, and \$3000-\$4000 for accommodations and travel to both regional and world competitions.

Our marketing outreach expenses encompassed \$75 for our poster display, \$100 for a digital photo frame, \$75 for custom tattoos and stickers, and \$175 for custom shirts. In terms of parts and equipment, we purchased new HDMI splitters and adapters and PVC flotation tubing.

However, we upcycled our frame, motors, and cameras that have been used for the past 3-4 years. St. Mark's Robotics also contacted several local businesses to gain monetary support for our efforts after being graciously offered the 5th place wild card entry to the world competition.

<i>Source</i>	<i>Notes</i>	<i>Amount (CAD)</i>
Balance forward	Started the year with this amount accumulated in our ROV funding account	\$5500.00
MATE-NL Regional Grant	Funds to travel to and prepare our ROV for the regional competition	\$1300.00
MATE-NL World Championship Grant	Funds to travel to the World Championship in St. Johns	\$8000.00
Company Donation from various local companies	Donations given after acceptance into MATE World ROV competition	\$525.00

Table 4. Budget for St. Mark's Robotics for 2025/2026 year. Designed by Faith Aylward

B. Project Cost

While we managed to stay within our budget this season due to a fair amount of upcycling, the original cost of our ROVs parts has been spaced across years of building.

<i>Part</i>	<i>Cost (CAD)</i>
Cameras (2)	\$50 each - \$100 total
Claws (2)	\$100 each - \$200 total
Motors (4)	\$800 each - \$3200 total
Tether	\$300
Control box	\$250
Total cost	\$4050

Table 5. Project cost for St. Mark's Robotics 2025/2026. Designed by Faith Aylward.

11. ACKNOWLEDGEMENTS

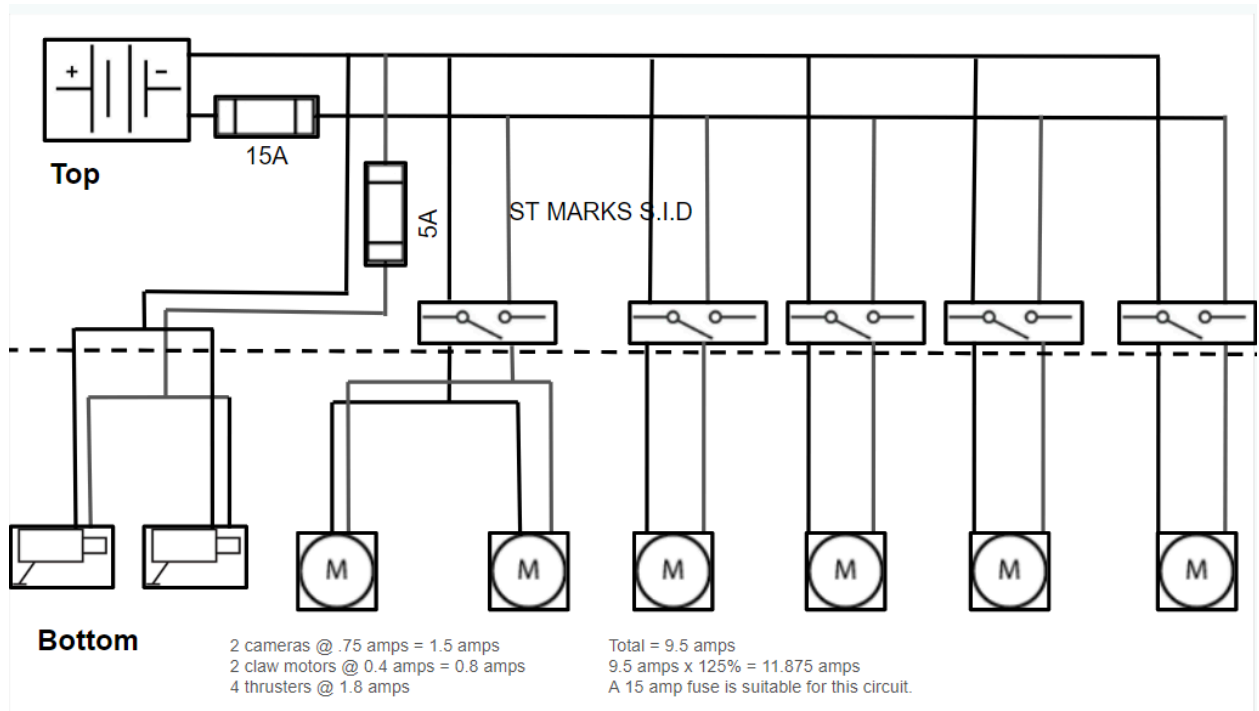
St. Mark's Robotics would like to sincerely thank the following individuals and organizations for their support:

- MATE
- Memorial University and Marine Institute
- Mrs. April Churchill, Teacher Mentor
- Mrs. Alaina Aylward, Teacher Mentor
- Mr. Glen O'Driscoll, Founder of St. Mark's Robotics & Retired Teacher Mentor
- Total Home Care
- Plate Cove Recreation Committee
- Therapy Works
- Round Da Bay Inn

We are incredibly grateful for the opportunity to participate and showcase Bonabot. A special thank you goes to our teacher mentors; their guidance, encouragement, and dedication have been essential throughout the entire process. We would also like to thank the staff at the Marine Institute for their support with safety inspections, practice runs, supplies, and assistance along the way. Their time and effort have helped make this experience both successful and enjoyable. Many people have contributed to our ROV journey, and we are so thankful to everyone who has supported us.

Appendices

Appendix A - Electrical SID



Appendix B: Safety Checklist

- *We ensure that all members are wearing closed-toed shoes*
- *PFDs are required when around the water*
- *All electrical equipment, except the tether, should be kept away from water*
- *Ensure all members have hair tied up, sleeves rolled up, and any jewelry is put away before we use any tools*
- *It is important that all members establish clear and effective communications with all team members*
- *Ensure that all wires are carefully and effectively covered*
- *Ensure that all members are safety glasses*
- *We ensure that the power connection and controller before turning on the power control box*

Appendix C - Operation Protocols

Pre-power (All crew members):

- ☐ Area is clear and safe
- ☐ All power switches are off
- ☐ Tether is untangled, free of damage
- ☐ Tether strain relief is secure
- ☐ Visual inspection of electronics for damage
- ☐ Thrusters are securely fastened & shrouded, free from obstructions
- ☐ All crew members are wearing close-toed shoes and safety glasses

Power-up (All crew members):

- ☐ Power on
- ☐ Verify 12 volt power is being received
- ☐ Test thrusters, all directions
- ☐ Test video feeds from both cameras
- ☐ Test grippers (close and open, both grippers)

ROV launch and retrieval (All crew members):

- ☐ Pilot advises of launch into or out of water
- ☐ Co-pilot monitors camera systems upon ascent and descent
- ☐ Tether technicians call out “hands on” or “hands off”, dependent on ascent or descent of ROV
- ☐ Pilot and co-pilot power down ROV upon ascent.
- ☐ Team begins to demobilize once Pilot gives the go-ahead.

Troubleshooting (All crew members):

- ☐ Visually inspect ROV to identify issue - camera, claw, loss of communication, leak etc.
- ☐ Determine if issue needs immediate attention on deck or must be moved to workshop to troubleshoot
- ☐ Create a plan to troubleshoot, follow through.
- ☐ Check all systems for damage, verify proper operations
- ☐ Document the source and cause, detail corrective actions and design changes made.

Appendix D - Project Budget

St. Mark's Robotics

School Name:
St. Mark's School

Mentor(s):
April Churchill
Alaina Aylward
Glen O'Driscoll

Reporting Period: Sept 2025- June 2026

<i>Source</i>	<i>Notes</i>	<i>Amount (CAD)</i>
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Appendix E - Project Cost

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Table 5. Project cost for St. Mark's Robotics 2025/2026. Designed by Faith Aylward.

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