

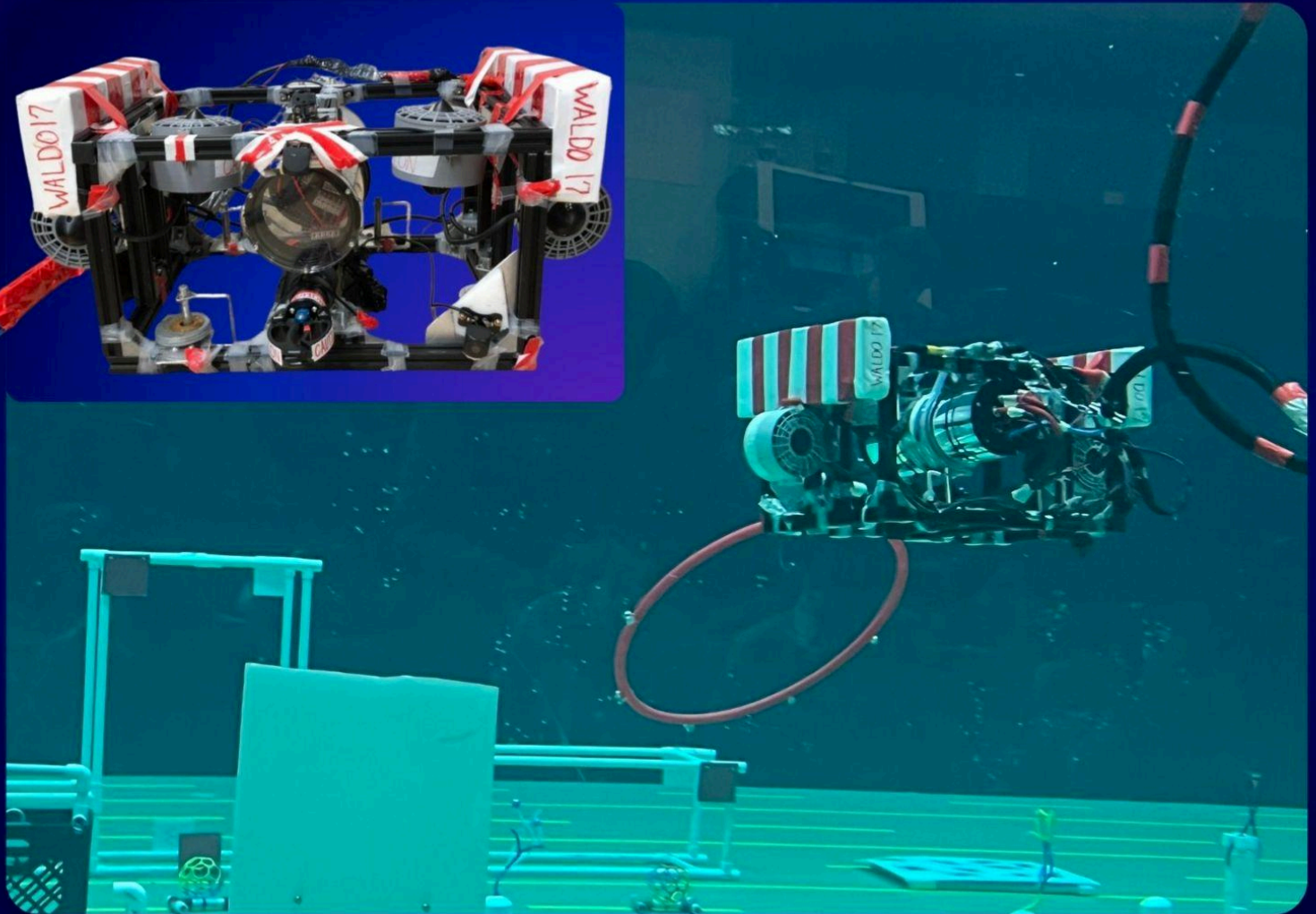
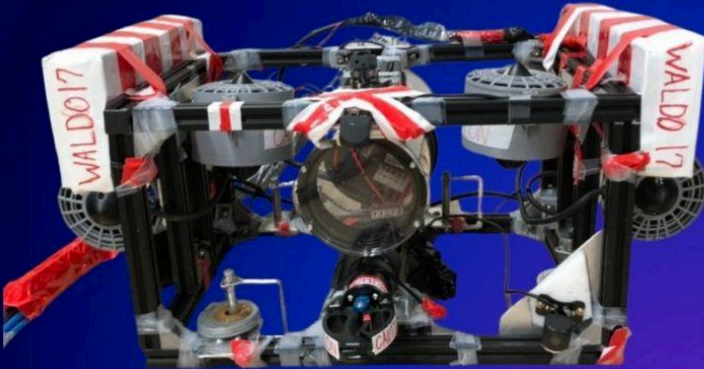


WHERE'S WALDO

Trafalgar Castle School

401 Reynolds St, Whitby, Ontario, Canada

Technical Report



TEAM MEMBERS

Taara Gill	CEO	Grade 12	Class of 2026
Natalie Calnek	Head Engineer	Grade 11	Class of 2027
Charlotte Schussmann	Co-Head Mechanical	Grade 11	Class of 2027
Nini Cao	Head Business	Grade 11	Class of 2027
Sophia Di Vizio	Co-Head Mechanical	Grade 12	Class of 2026
Leila Salem	Head 3D Printing	Grade 9	Class of 2029
Lisa Wang	Head Electrical	Grade 11	Class of 2027
Daisy Hu	Electrical Member	Grade 10	Class of 2028
Anna Xiaomu	Electrical Member	Grade 11	Class of 2027
Abeeghaa Nishangan	Pilot	Grade 9	Class of 2029
Neha Kirthiraj	Mechanical Member	Grade 12	Class of 2026
Lorelei Von Bargaen	Mechanical Member	Grade 9	Class of 2029
Lucy Wu	Business Member	Grade 11	Class of 2027

MENTORS:

Mrs. Senior
Mr. Lyew
Mr. Spessot



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1. Abstract

We are Waldo, an all-girls robotics team from Trafalgar Castle School in Whitby, Ontario, dedicated to advancing women in STEM through engineering innovation. We designed and built a modular ROV, Waldo XVII, which features a durable, lightweight aluminum frame, high-definition cameras for real-time navigation, and a waterproof claw system for precise object manipulation. An adjustable buoyancy system ensures optimal stability during complex underwater tasks. These integrated tools enable Waldo XVII to retrieve and transport objects, survey icebergs and coral gardens, and successfully execute simulated real-world underwater missions.

ROVs like Waldo XVII are vital for exploring underwater environments that are too cold or dangerous for human divers, and our system can also install micropiles on the seafloor to secure sea turbines and marine infrastructure, improving safety and sustainability.

Through rigorous safety oversight and strategic task management, our leadership team ensures all members operate safely and efficiently.

Our company connects engineering design to real-world environmental challenges while empowering the next generation of young women in technology.



Figure 1: Where's Waldo, Trafalgar Castle School Robotics Team 2026 - Photo taken by Mrs. Reinink

Back row (L-R): Lucy W, Anna X, Daisy H, Nini C, Charlotte S, Natalie C, Taara G, Sophia D, Lorelei V, Leila S, Abeeghaa N.

Middle Row: Waldo XVII

Front Row (L-R): Lisa W, Neha K., Mrs. Senior (Mentor), Mr. Lyew (Mentor)

2. Project Management

a. Company Overview

For decades, the “Where’s Waldo” branding has been a proud tradition at Trafalgar Castle School, representing the school in a variety of robotics competitions. For 17 years, students competed in various robotics programmes, including VEX, Lego SPIKE, and FIRST Robotics, developing advanced skills in engineering, programming, problem-solving, and project management while facing teams from across North America and beyond.

Throughout that time, the programme achieved notable success, including earning spots at the FIRST World Championship in St. Louis, where students had the opportunity to showcase their work on an international stage, and won Women in Engineering awards for multiple years.

In 2022, the team entered a new chapter by transitioning into the MATE ROV Competition, shifting its focus from land-based robotics to underwater engineering and exploration. This expansion introduced students to new areas of technology, including underwater robotics, marine science, electronics, and remote vehicle operation. As Trafalgar Castle School continues to heighten their awareness of environmental knowledge, the blending of technology and the environment becomes more essential as demonstrated by earning a platinum standing in the *EcoSchools Canada* certification programme.

Today, Trafalgar Castle’s robotics programme blends nearly two decades of experience in competitive robotics with the innovation and technical challenges of underwater robotics, continuing a tradition of hands-on learning, teamwork, and exploration.

b. Company Organization

Our team not only operates as a club, but as a professional student-led engineering firm that mirrors the structure of a real-world technology company. Each member takes on a specialized role in one of the Mechanical, Electrical, Business and Safety, or Vertical Profiling teams, allowing students to focus on their individual strengths while collaborating across departments to achieve a common goal.

1. The Mechanical team is responsible for the physical design and construction of the robot, including the frame, motors, buoyancy, and overall durability and safety of the vehicle. The team members follow safety protocol to work through multiple stages of prototyping, testing, and refining to ensure the ROV can complete competition tasks efficiently and reliably.

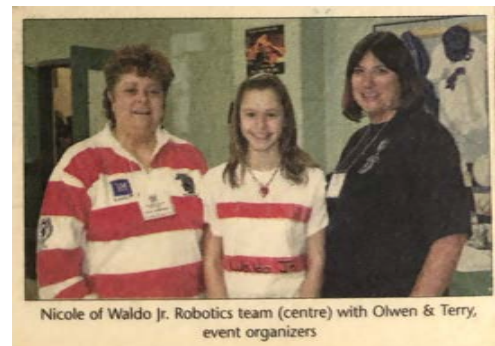
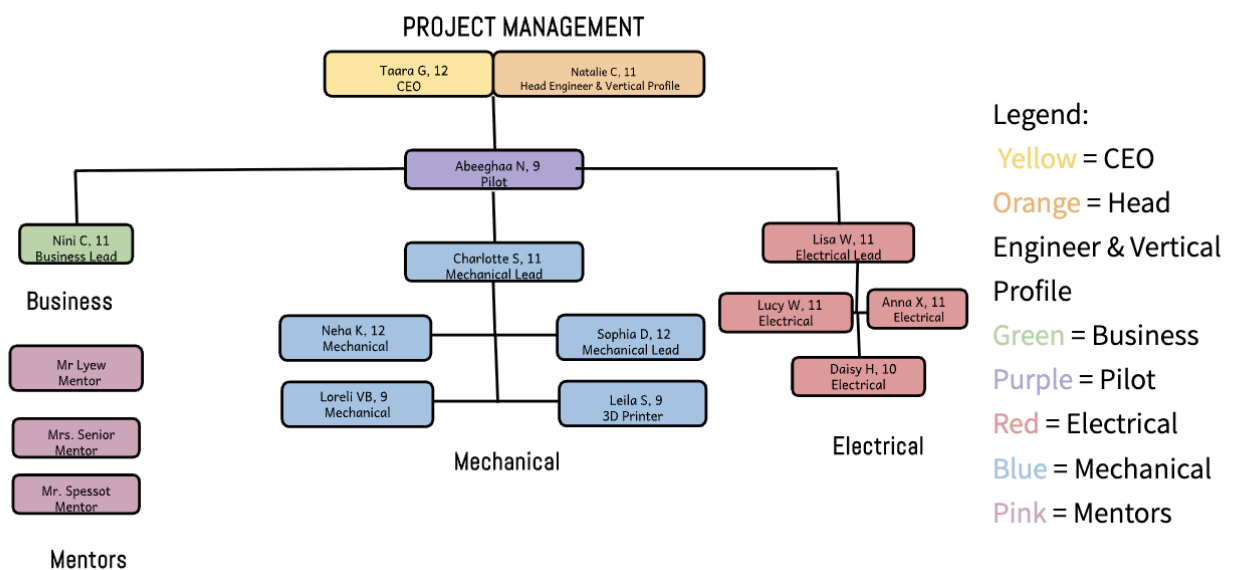


Figure 2: Photo of Waldo Robotics Members (2006)
Photo taken by: Natalie Calnek

2. The Electrical team focuses on circuit work, wiring, power distribution, sensors, and troubleshooting, ensuring that all systems can function safely and effectively, especially in the underwater conditions.
3. Our Vertical Profiling team works with mechanical and electrical teams to prepare and build our vertical profiler to successfully measure the depth of objects.
4. Our Business and Safety team manages areas such as safety, budgeting, sponsorship outreach, fundraising, marketing, social media, and documentation, playing a critical role in maintaining communication with supporters and ensuring the team has the necessary resources for success.

Figure 3: Where's Waldo Company Organization Diagram

Created by: Neha Kirthiraj



With each member working within their own field to contribute to the creation and overall success of our ROV, our CEO plays the most vital role at the centre of our organization, overseeing the team operations and communication, helping to guide members in the creation of the robot and the overall company.

Trafalgar Castle's leadership model helps students to develop their technical abilities and valuable professional skills such as communication, time management, teamwork, and adaptability.

c. Operational Challenges

As a small school with under 300 students, Trafalgar Castle faces unique challenges in maintaining a competitive robotics programme. Our team's members often balance multiple extracurricular commitments, from sports and arts to academic clubs, which requires careful coordination of time and resources. Despite these constraints, our team demonstrates remarkable dedication and perseverance, ensuring that every member can contribute to the success of the programme and our ROV.

A great challenge we face is the distance from the MATE ROV competitions. Travelling from Ontario to Newfoundland requires significant transportation costs, including flight tickets, vehicle/bus rentals, and the transportation of our physical robot. Unlike larger schools, we do not have access to grants, so our main source of financial support comes from the fundraising initiatives and community support; our business team works hard to organize campaigns and secure sponsorships, but most importantly, they run the "Candy Gram" fundraiser in our school that allows students to support their school's robotics team while still receiving holiday-themed treats to gift to their friends.

Figure 4: Schedule for Construction of Waldo XVII

Created by: Leila Salem

		Months									
Operations		Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Mechanical Team	Claw	Designing the Claw			Testing the Claw			Practicing and Alterations			
	Camera	Examination	Designing Mounts		Testing and Alterations						
	Frame	Designing the Frame		Assembly of Frame							
	Tether	Assembly of the Tether									
	Safety	Training New Members	3D-Printing Motor Covers					Ensuring Safety of ROV			
Electrical Team	Arduino	Planning	System Design			Development and Testing					
	Python	Research and Development			Testing						
	Water Tight Enclosure	Planning	Testing and Assembly of Watertight Seal								
Vertical Profiling		Research and Development			Testing and Iterating						
Business Team		Scouting for Sponsors	Planning Fundraisers			Bringing in Sponsors and Donations					
Management		Training New Members	Overlooking and Guiding Operations								

3. Design Rationalee

a. Design Evolution

A key managerial change this year was shifting our design philosophy to preface every engineering decision by asking the question "WHY?", forcing us out of comfortable habits and preventing the repetitive use of past design elements without critical justification. This rigorous planning process was coupled with digital modelling, where we designed the entire internal architecture of our vertical profiler using Onshape CAD software to ensure a precision-fit before physical assembly.

Driven by this analytical framework, our vehicle underwent several critical iterations to meet demanding mission specifications. First, we executed a major structural pivot from a glued PVC frame, which failed under motor torque during a previous mission, to a T-slot extruded aluminum system. Backed by engineering data from the American Society for Testing and Materials proving aluminum is over 23 times stiffer than PVC, this new modular frame delivers long-term reliability and allows us to easily adjust components or attach mission-specific tools on the go without completely rebuilding the chassis. Second, to address previous visibility limitations where our tether became tangled during a mission, we expanded our camera array to a three-camera system. By positioning dedicated cameras forward, at the claw, and facing backward toward the tether, we achieved full 360-degree situational awareness to prevent future entanglements and ensure operational safety.

b. Innovation

A major innovation in design was the development of a fully custom internal architecture using 3D printing. The internal structure of *Waldo Floats* was designed entirely in Onshape, allowing precise integration of mechanical and electronic components into a single optimized layout. This approach enabled the creation of a compact, purpose-built internal frame rather than relying on generic mounting solutions, improving space efficiency and overall system organization. The frame was manufactured using PETG, selected for its high durability, water resistance, and improved thermal stability compared to standard PLA, making it better suited for repeated underwater use.

This custom 3D-printed structure also reduced overall system cost by minimizing the need for additional brackets, fasteners, and off-the-shelf mounting hardware. By integrating component mounts directly into the printed design, the team was able to simplify assembly while maintaining strong structural support and alignment accuracy.

Another key innovation was the integration of low-cost parking-style cameras as the primary vision system for *Waldo*. These cameras provided a wide field of view at a significantly lower cost than traditional underwater imaging systems. In addition to cost savings, they simplified wiring complexity and reduced waterproofing requirements due to their compact size and straightforward integration. This improved both reliability and ease of maintenance while maintaining effective visual coverage for piloting and task completion.

Overall, these design choices focused on increasing functionality while reducing cost and system complexity through integrated design and material selection.

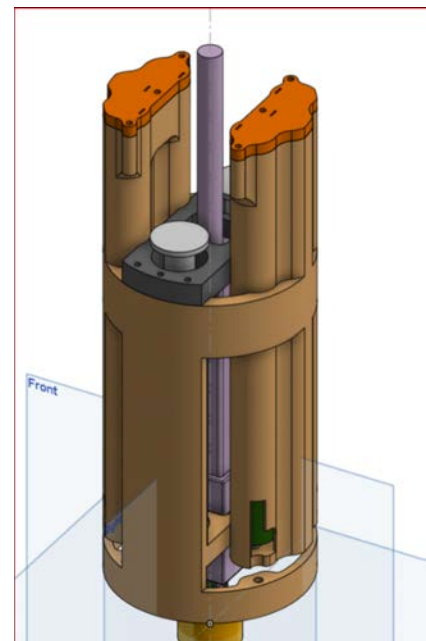


Figure 5: CAD Model for Waldo Floats
Created by: Natalie Calnek

4. Systems Approach

Waldo strives to create an accessible and cost-effective ROV that can support smaller-scale science companies in advancing ocean research. Throughout the design process, the team carefully evaluated every component and system to ensure the final design prioritized strength, sustainability, reliability, and overall performance. By analyzing previous years' ROVs, the team identified past weaknesses and implemented improvements to create the most effective version of Waldo to date. The team used a balanced systems approach by ensuring all vehicle systems worked together efficiently and reliably. The frame, propulsion system, cameras, claw, tether management, and topside controls were designed to integrate seamlessly to improve maneuverability, pilot awareness, and mission performance. Camera placement was strategically chosen to maximize visibility while minimizing interference with other components, and the modular aluminum frame allowed systems to be securely mounted while remaining adaptable for future upgrades and repairs. This holistic design approach ensured that each subsystem contributed to the overall effectiveness, safety, and reliability of Waldo 17.

a. Vehicle Structure

According to material property data published by ASTM references and The Engineering Toolbox, aluminum has a modulus of elasticity of approximately 69 GPa, while PVC has a modulus of about 3 GPa. This makes aluminum over 23 times stiffer than PVC, providing significantly greater structural stability and durability for Waldo's frame design. The team selected extruded aluminum for the frame because it offered the best balance between strength, weight, modularity, and long-term cost efficiency. Although aluminum was more expensive than PVC, the cost was justified because the modular T-slot design can be reused and modified for future years, reducing the replacement costs over time. The integrated slots for screws and washers simplified assembly and allowed the frame to be easily adjusted and customized. In addition, extruded aluminum has a high strength-to-weight ratio, helping reduce overall vehicle weight while maintaining structural integrity. The material was also easy to cut using a bandsaw, enabling precise customization of the frame's size, structure, and weight distribution.

b. Watertight Enclosure

A sealed, pressurized electronics tube housing the ESCs, Arduino, tether splicing, with wires entering and exiting using epoxy-sealed penetrators. It protects electronics from water damage and pressure fatigue while keeping components organized for quick maintenance. Easy to attach and detach in case we need to open it and adjust the Arduino's code or replace an electrical element. All electrical is attached via lever terminals and can be replaced without compromising the rest of the system; there is no need for resoldering. Sealed with zero exposed wiring and internal desiccant packs to eliminate condensation and micro-shorts.



Figure 6: Photo of Watertight Enclosure

Photo taken by: Taara Gill

5. Vehicle Systems

a. ROV Electrical System

The ROV's electronic system was designed to provide stable power distribution, reliable communication, and efficient control of all onboard components. A 12V battery supplies power to the vehicle and distributes electricity through the main power system to the ESCs, motors, camera, and claw mechanism. Each motor is connected to an individual ESC, which receives signals from the main controller to adjust the speed and direction of movement based on pilot input from the surface station. The claw is also electronically controlled, allowing the operator to grab and manipulate objects underwater during missions. The cabling system was carefully organized to improve reliability and simplify maintenance. Wires were secured using zip ties and protective cable sleeves to prevent tangling and movement during operation. Waterproof connectors, heat shrink tubing, and insulated wiring were used to protect electronic components from water damage and short circuits. Power cables and signal cables were arranged separately whenever possible to reduce electrical interference. The tether connecting the ROV to the surface station was designed to be lightweight and flexible, reducing drag while maintaining stable communication and control underwater. Safety was also an important consideration in the design, so protective measures such as fuses, waterproof seals, and strain relief supports were included to improve the durability and safety of the system.

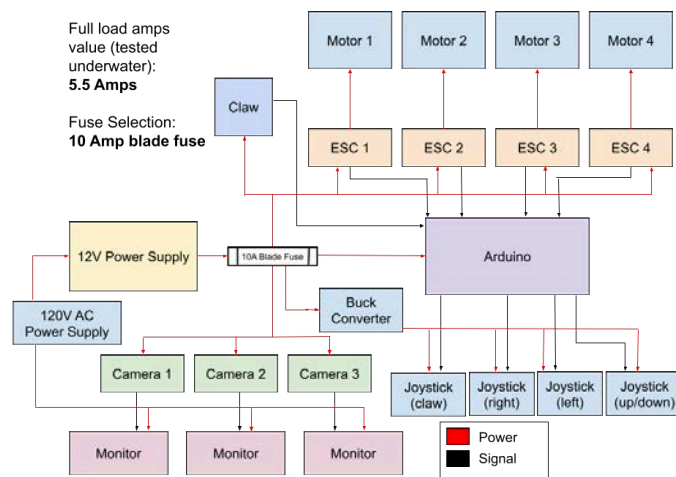


Figure 7: SID for the Waldo XVII ROV

Photo taken by: Taara Gill

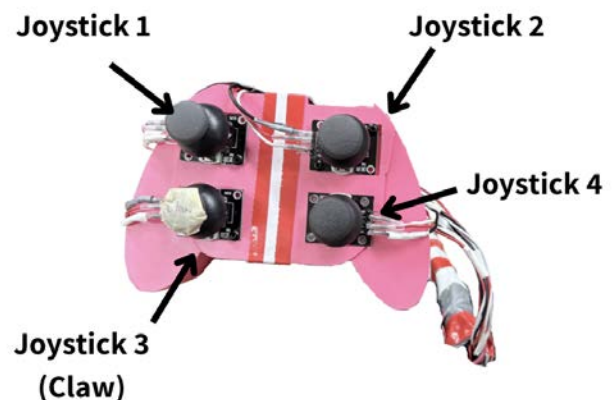
b. Topside Control System

Our control system is used by the pilot to control the remotely operated ROV during underwater operations. The controller is designed with four joystick controls, with one joystick each for our left and right vertical motors, each assigned a specific movement or function to ensure efficient operation.

The Joysticks 1 and 2 are responsible for controlling the forward and backward movement of the ROV. When both joysticks are pushed forward simultaneously, the ROV moves forward, while pulling both backward causes it to reverse. The dual-joystick placement also allows the pilot to steer the ROV by controlling each side independently.

Figure 8: Photo of Waldo Controller

Photo taken by: Nini Cao



Pushing one joystick forward and another back will cause the ROV to turn to whichever side you desire, providing greater maneuverability underwater. The third joystick operates the claw attached to the front of the robot, allowing the pilot to open and close the claw for object retrieval and other task missions. The last joystick, number 4, controls the vertical movement of the ROV, enabling the robot to ascend and descend underwater with stability and precision. This controller was designed to provide the pilot with maneuverability, accuracy, and overall operational efficiency during competition tasks and underwater exploration activities.

c. Tether and Tether Management

Our tether was designed to provide reliable power and camera transmission between the ROV and the surface control station. The tether contains several different wires bundled together based on their functions.

- The tether includes two CATS6 network cables connected to the joystick systems. These are the thickest cables because they contain multiple internal wires and are responsible for transmitting each joystick's communication signals.
- One blue network cable is used as the primary connections, while the second serves as a backup for additional reliability during operation.
- Three medium-sized black coaxial cables are used for the camera system. These wires transmit live video signals from the underwater cameras to the surface station.
- The tether also contains two 14 gauge power wires: one red wire for positive power and one black wire for ground. These wires supply electrical power to the vehicle's systems and complete the electrical circuit.

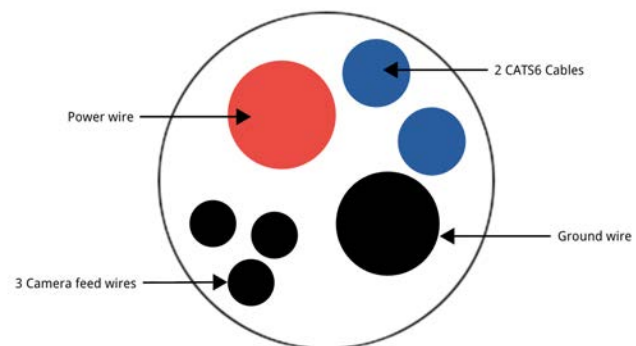


Figure 9: Tether Cross-section
Created by: Lisa Wang & Anna Xiaomu

To organize and protect the tether, all wires are bundled together using duct tape. After bundling, a protective outer sleeve is placed around the entire cable group to protect the wires from water.

Before deployment, the tether is inspected for loose connections, damage, or tangles. During operation, one team member monitors the tether to prevent knots and excessive tension. The tether is kept slightly loose to allow smooth movement of the ROV while reducing stress on the cables. After use, the tether is cleaned, dried, and carefully stored to maintain cable quality and prevent long-term damage.

d. Propulsion

Table 1: Motor Comparison
Created by: Charlotte Schussmann

Motor Type:	Cost (per thruster):	Current Draw (Amps):	Weight in Air:
Blue Robotics T200 Thruster	\$196.00 USD	17	427 g
APISQUEEN Subsea Thruster	\$157.85 USD	28	450 g
APISQUEEN U2 Mini Thruster	\$32.00 USD	8	210 g

improving structural reliability. The propulsion layout consists of two horizontal thrusters for left and right rotation and two vertical thrusters for lift and vertical movement. The thrusters were strategically positioned to maximize water flow through the frame while maintaining an effective balance between maneuverability and propulsion efficiency. To further improve operational safety, Waldo designed and 3D-printed custom shrouds for the motor covers. Multiple design iterations were required to achieve proper alignment, ensuring the motors could still mount securely to the frame while keeping the shrouds firmly attached during testing and operation.

The propulsion system of Waldo is built around four 17 A motors selected for their strong thrust-to-weight ratio and cost-effectiveness, as the team reused motors from previous years. These thrusters provide reliable power delivery while reducing overall system costs. Each motor comes pre-shrouded to meet IP20 safety standards and includes integrated mounting brackets, simplifying installation and

e. ROV Software Design

Our **control system is software based**. The software uses a single-tier architecture written in C++ for the Arduino platform. This year, we prioritized simplicity. In previous seasons, overly complex code created unnecessary failure points, so we condensed our entire control loop into just 54 lines of direct, highly efficient code. Running continuously, this synchronous loop reads analog joystick inputs (pins A4–A7), filters the data, and utilizes the [Servo](#). The library to write PWM signals directly to the claw and ESCs (pins 8, 9, 10, 12, and 13).

A key problem-solving feature in our code handles a critical hardware constraint: our thrusters can draw up to 17 Amps at full throttle, but our thin, flexible 14-gauge tether wire is only rated for 15 Amps. To keep the tether lightweight and flexible without risking a blown fuse or melted wire, we used software to limit the thrust. Instead of using the standard 0 to 180 servo range, we restricted the mapping boundaries to narrower windows, such as 65 to 115. This artificial ceiling safely caps the maximum current draw well below the 15-Amp wire limit while giving the pilot much finer control for precise maneuvering. Additionally, the software eliminates vehicle drift by establishing a mechanical dead zone; any joystick reading between 500 and 524 is automatically forced to a true neutral center of 512.

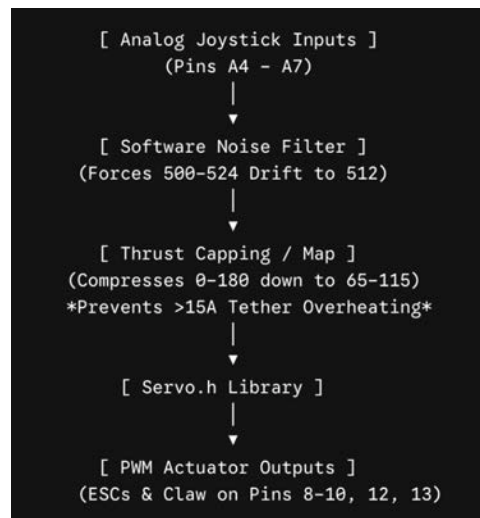


Figure 10: Software Flow Chart
Created by: Taara Gill

f. ROV Code

```
Servo ESC_Right;
Servo ESC_Left;
Servo ESC_Up1;
Servo ESC_Up2;
Servo Claw;

int joystick1;
int joystick2;
int joystick3;
int joystick4;

void setup() {

ESC_Right.attach(13, 1000, 2000);
ESC_Left.attach(12, 1000, 2000);
ESC_Up1.attach(9, 1000, 2000);
ESC_Up2.attach(10, 1000, 2000);
Claw.attach(8,1000,2000);

}

void loop() {

// Right Motor - Forward/Backward Front Motor Right
joystick1 = analogRead(A5);

// dead zone + reduced sensitivity
if (joystick1 > 500 && joystick1 < 524) joystick1 = 512;
joystick1 = map(joystick1, 1023, 0, 65, 115);
ESC_Right.write(joystick1);

// Left up joystick - blue stripe
joystick2 = analogRead(A6);

if (joystick2 > 500 && joystick2 < 524) joystick2 = 512;
joystick2 = map(joystick2, 1023, 0, 65, 115);
ESC_Left.write(joystick2);

// Right down joystick - green stripe
joystick3 = analogRead(A7);

if (joystick3 > 500 && joystick3 < 524) joystick3 = 512;
joystick3 = map(joystick3, 1023, 0, 60, 120);
ESC_Up1.write(joystick3);
ESC_Up2.write(joystick3);

// Left down joystick - orange stripe
joystick4 = analogRead(A4);

if (joystick4 > 500 && joystick4 < 524) joystick4 = 512;
joystick4 = map(joystick4, 1023, 0, 70, 110);
Claw.write(joystick4);
}
```

g. Buoyancy & Ballasts

We used rigid foam insulation, which is an inexpensive buoyancy foam material that is found at most local hardware stores, providing us with an affordable and available buoyancy option. The pieces can perfectly withstand the water depth environment as it does not compress nor soak in the water. We decided to make the change to this material compared to the pool noodles we had used in past years, which got soggy and absorbed water, affecting the buoyancy and influenced our switch to rigid foam insulation. These foam insulation pieces were cut precisely to fit on either side of the robot to ensure the robot stayed upright as well as slightly above the robot's frame to ensure there is no damage to the surrounding environment if the robot were to surface. To top it off, we added red and white stripes for the sea life's visibility—as well as to match our theme!

On the tether, we had also added rigid foam insulation pieces to certain sections of the tether to ensure it didn't displace the calculated buoyancy of the robot and wouldn't affect its movement in the water. We attached ballasts to all 4 sides of the bottom frame of the robot using aluminum flat bars as a mount. This ensured we could add and take away washers to our liking to adjust the robot's mass depending on the specific body of water and temperatures.



Figure 11 & 12: Photos of Waldo XVII's Buoyancy System
Photo Taken by: Taara Gill



6. Payload and Tools

a. Camera System

To improve navigation and task performance, the team integrated three waterproof cameras onto the ROV, each positioned for a specific operational purpose. One camera was placed facing the tether to allow the pilot to monitor and prevent interference during missions, along with a stronger view to survey above structures. A second camera was mounted at the front of the ROV to provide a clear forward-facing view for navigation and maneuvering. The third camera was positioned toward the claw to give the pilot full visibility while performing mission tasks such as collecting and transporting. The

team selected automotive backup cameras because they were cost-effective, compact, and waterproof with an IP-69K rating, which is suitable for underwater use. The integrated parking guidelines serve as a physical scale, allowing the pilot to extrapolate underwater measurements and estimate object lengths in real time.



Figure 13: Photo of Waldo XVII Camera
Photo Taken by: Nini Cao

b. Claw

The team selected a Blue Robotics claw because it offers greater reliability and durability compared to a custom claw design. Although purchasing the claw increased initial costs, it reduced the risk of mechanical failure during competition and improved overall mission consistency. The team designed a custom mount to position the claw higher above the bottom of the frame, preventing interference with the seafloor and improving access to mission elements such as coral bases and collection tasks. The claw mount also supports mission adaptability, as the claw can easily be rotated by removing and repositioning a zip tie. Regarding the claw mounting system, the team initially planned to use simple metal brackets attached to the frame with a securing zip tie around the claw. The team brainstormed multiple ways to develop a creative and secure attachment method for the claw and ultimately selected adjustable metal hose clamps, which could be placed around the circular circumference of the claw to provide a strong and reliable connection fastened with metal brackets to the frame. However, after analyzing the mission tasks and testing the design, the team realized the original configuration positioned the claw too low on the frame, limiting maneuverability and increasing the chance of contact with the seafloor. Therefore, the design was revised to raise the claw-mounting position, allowing the ROV to perform a wider range of tasks more efficiently.



Figure 14: Photo of Waldo XVII Claw

Photo Taken by: Nini Cao

c. Software Tools

Species	Number Seen	% Frequency
Snow crab (<i>Chionoecetes opilio</i>)	7	8.05%
Acadian hermit crab (<i>Pagurus acadianus</i>)	14	16.09%
Western Atlantic Hairy Hermit Crab (<i>Pagurus arcuatus</i>)	2	2.30%
European Green Crab (<i>Carcinus maenas</i>)	0	0.00%
Rock Crab (<i>Cancer pagurus</i>)	8	9.20%
Jonah Crab (<i>Cancer borealis</i>)	5	5.75%
Spiny Sunstar (<i>Crossaster papposus</i>)	21	24.14%
Sea Urchin (<i>Strongylocentrotus droebachiensis</i>)	3	3.45%
Boreal Sea Star (<i>Boreas asterias</i>)	1	1.15%
Daisy brittle star (<i>Ophiopholis aculeata</i>)	26	29.89%
Total	87	

Figure 15: Macro-Enabled Spreadsheet

Created by: Taara Gill

Outside of the core flight code, we developed two specialized software tools to handle post-dive data analysis. The first is a macro-enabled spreadsheet that automatically cleans raw environmental DNA (eDNA) sensor data, filtering out background noise and flagging genetic matches in minutes rather than hours.

The second is a custom computer vision application that leverages the Gemini API to analyze recorded dive footage. This tool automatically segments video frames to count specific crab species while ignoring moving seaweed and marine debris, converting hours of raw footage into structured ecological data.

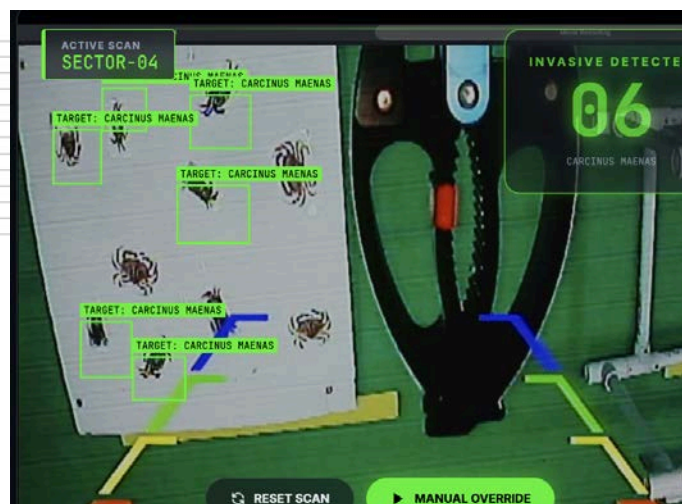


Figure 16: Photo of Crab Identification Software

Photo taken by: Natalie Calnek

d. Waldo Floats

Waldo Floats is an autonomous vertical profiling float capable of performing precise depth-profiling missions using a custom syringe-based variable buoyancy system. The profiler operates independently from the primary ROV tether and is controlled by an ESP32 microcontroller selected for its dual-core processing capabilities, integrated Wi-Fi communication, and compatibility with FreeRTOS software architecture. The ESP32 interfaces with a dedicated H-Bridge motor driver that controls a linear actuator connected directly to two 20 mL syringes acting as the ballast system. By extending or retracting the actuator, the syringes intake or expel water to dynamically adjust buoyancy, allowing the profiler to descend, maintain target depths, and ascend autonomously. A Blue Robotics Bar02 pressure sensor continuously transmits real-time depth data to the ESP32 using I2C communication, allowing the profiler to autonomously regulate depth while simultaneously collecting environmental data. Once surfaced, the ESP32 hosts a local Wi-Fi network and transmits collected data wirelessly to a custom webpage on the operator's computer, allowing operators to monitor profiler status and review mission data without requiring a tethered connection.

The profiler is powered entirely by onboard NiMH battery systems separated into dedicated logic and motor power circuits to improve electrical reliability and reduce signal interference during actuator operation. Multiple 2 A fuses were integrated throughout the power distribution system to provide overcurrent protection, with current draw testing confirming the actuator remained within safe operating limits under full load conditions. All electronics and mechanical systems are housed within a waterproof acrylic enclosure featuring custom 3D-printed mounting structures designed specifically for the syringe ballast assembly.



Figure 17: Photo of Waldo Floats Competing in Flume Tank
Photo taken by: Ms. Senior

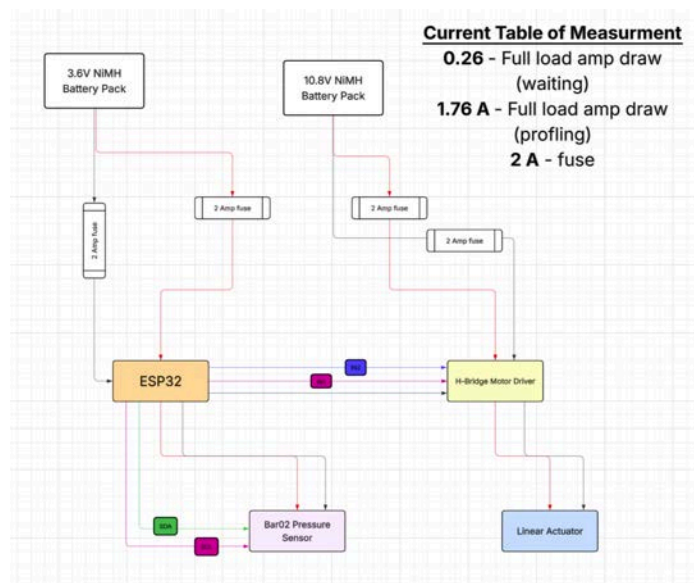


Figure 18: Waldo Floats SID
Created by: Natalie Calnek

7. Safety

a. Safety Philosophy

Safety is a core value at Where's Waldo and is integrated into every aspect of our work, whether in the lab, on the pool deck, or during ROV deployment. We are committed to ensuring that all team members understand and consistently follow essential safety practices when working with tools such as the band saw and drill press, handling chemicals like epoxy, and soldering safely using a fume hood and appropriate personal protective equipment, including safety glasses

Where's Waldo also prioritizes safety during testing and operations. The team has three in-house certified lifeguards who are always present during pool testing of our ROV. In addition, the majority of our senior team members (Grade 11 and 12 students) are trained in First Aid, ensuring that qualified support is readily available if needed.

All team members are encouraged to speak up about any safety concerns related to the ROV or any aspect of our work environment. Concerns are taken seriously and should be communicated to our CEO or our mentors so they can be addressed promptly

b. Safety Features

Where's Waldo takes pride in designing a versatile and safe ROV that complies with all MATE safety guidelines. Waldo XVII integrates multiple safety systems to protect operators, equipment, and the marine environment during deployment, testing, and task completion



Figure 19: Photo of Waldo T200 Thruster
Photo taken by: Taara Gill

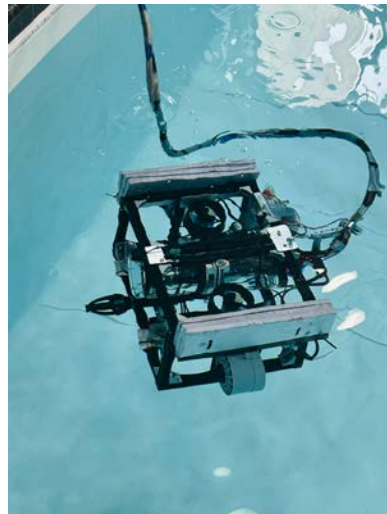


Figure 20: Photo of Waldo XVII in Pool
Photo taken by: Ms. Senior

Table 2: Safety Features of Waldo XVII ROV**Created by:** Neha Kirthiraj

ROV Component	Safety Features	Description
☒ Frame	Robust modular extruded aluminum frame	Provides structural integrity during transport and underwater tasks. Smooth and sealed edges reduce the risk of injury during handling and prevent environmental damage during contact with surfaces.
☒ Buoyancy & Stability	Base weights, buoyancy floats, and an adjustable balance system	Maintains neutral buoyancy and stability during task execution, preventing uncontrolled tipping or drift that could damage the ROV or interfere with task objects. Secure attachment prevents loss of components on the seafloor.
☒ Motor	2 vertical + 2 directional motors with shrouded propellers	Enables controlled movement during precise task navigation. Propeller guards reduce the risk of entanglement with marine life, tether, or operator fingers during handling and testing.
☒ Claw	Protected gripping system with hazard markings	Allows safe manipulation of objects during tasks. Warning markings increase operator awareness of moving parts to reduce pinch or crush risk during operation and testing.
☒ Camera	Three waterproof cameras (forward, claw-facing, rear/tether view)	Provides full situational awareness during tasks, reducing collision risk, tether entanglement, and improper object interaction. Protective coverings and waterproof sealing prevent electrical hazards.
☒ Controller	Wired joystick controller with ergonomic 3D-printed housing	Ensures precise real-time control during underwater tasks. Strain relief and organized tether wiring prevent electrical exposure, tangling, and trip hazards during pool deployment.
☒ Electrical	Sealed pressure-rated electronics tube with ESCs and Arduino	Protects components from water exposure during operation. A single 10A inline fuse prevents electrical overload during task loads. Anderson connectors and strain relief reduce the risk of short circuits or disconnection during deployment.

8. Critical Analysis & Problem Solving

a. Troubleshooting

Our robot underwent extensive testing and iterative redesign throughout the development process to improve reliability, maneuverability, and overall mission performance. Individual subsystems, including the motors, claw, cameras, and electronics, were first tested independently before being integrated into the full vehicle, allowing the team to isolate problems and simplify troubleshooting. Initial frame prototypes were constructed from cardboard to evaluate sizing, mounting locations, and overall geometry before manufacturing. The team originally intended to laser cut the frame from acrylic; however, prototyping revealed significant limitations, including cracking, mounting difficulties, and challenges in producing accurate mounting holes within the constraints of the available laser cutter and project timeline. As a result, the team transitioned to an aluminum frame design due to aluminum's improved strength-to-weight ratio, modularity, and corrosion resistance compared to PVC systems used in previous years. CAD software was used extensively to visualize the frame, refine mounting positions, and reduce construction errors before manufacturing. During water testing, buoyancy and balance were continuously adjusted using removable corner-mounted weights to compensate for varying pool conditions and improve stability. Additional aluminum reinforcement structures were also added to the sides of the vehicle after reviewing failures from previous seasons, where motor mounts detached from the frame under operational stress.

b. Testing Methodology

Testing also focused heavily on waterproofing, electrical reliability, and operational safety. The electronics enclosure was pressure tested prior to water operations and was repeatedly submerged for progressively longer intervals to verify waterproof integrity and protect critical electronics. Lessons learned from previous seasons, including enclosure scratches causing sealing issues and ESC overheating, resulted in the adoption of a larger enclosure with improved cooling and sealing reliability. During full-system testing, the team discovered significant electrical interference between motors caused by signal induction within the Cat5 tether wiring, resulting in all thrusters activating simultaneously when a single motor was powered. Through incremental troubleshooting and subsystem isolation, the team resolved this issue by adding grounded coiled wiring and reducing motor throttle limits, which both eliminated interference and improved piloting precision. Additional testing identified tether drag that caused the robot to pull left during operation, leading the team to reposition the strain relief point higher on the frame to improve maneuverability. Prior to each operation, the team followed a pre-dive inspection procedure that included verifying enclosure seals, checking tether routing, inspecting camera connections, and ensuring all components were securely fastened to the vehicle.



Figure 21: Photo of Waldo XVII at Pool
Photo taken by: Ms. Senior

9. Budget & Accounting

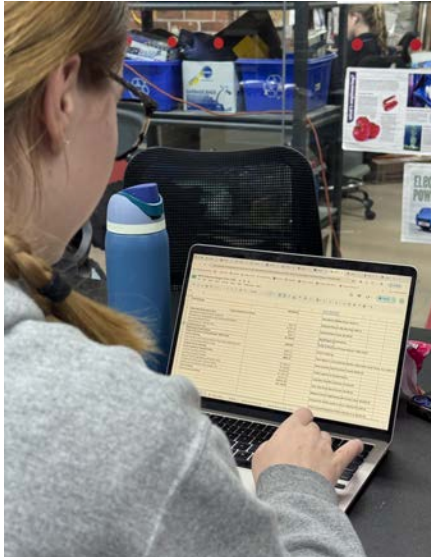


Figure 22: Photo of Charlotte S. Adjusting the Budgeting Sheet
Photo taken by: Taara Gill

As a growing company, effective budgeting is a critical component of long-term stability and success. Since the start of the year, the business team has established the annual budget. The total budget for the year is set at \$29,400.00 USD (\$40,500.00 CAD). This budget encompasses a range of expenses, including the travel costs of attending competitions. This financial report outlines the budget planning, resource allocation, and overall accounting for the initiative. Every effort was made to maximize the effective use of funds by leveraging existing assets, securing key donations, and maintaining strict oversight on travel and procurement expenses.

a. Income Sources

Funding for this initiative was secured through a combination of direct cash grants, organizational allocations, and generous in-kind donations.

Table 3: Accounting Revenue of Where's Waldo 2025/2026
Created by: Nini Cao and Charlotte Schussmann

Revenue (Inflow)		
	CAD	USD
Initial Budget Balance Brought Forward	\$18,200.00	\$13,208.56
Parent Contributions	\$5,500.00	\$3,991.60
School Support & Funding (For World Championships)	\$10,000.00	\$7,257.45
Fundraising (Candy Cane Sales)	\$2,390.00	\$1,734.53
Student Direct Contributions	\$2,000.00	\$1,451.49
Corporate Sponsorships (ASI Sponsor, etc.)	\$2,500.00	\$1,814.36
Total Revenue	\$40,590.00	\$29,457.99

b. Project Expenses

Table 4: Accounting Expenses of Where's Waldo 2025/2026
Created by: Nini Cao and Charlotte Schussmann

Project Expenses (Outflow)		
	CAD	USD
Robot Manufacturing & Parts:		
BlueRobotics Waterproof ROV Gripper Kit	\$942.79	\$684.23
Miscellaneous Components & Tools (Amazon/RobotShop)	\$1,962.06	\$1,423.96
Raw Metals (Metals Shop)	\$208.41	\$151.25
Bulkhead Wrench (Worlds Prep)	\$36.73	\$26.66
Subtotal Robot Costs	\$3,149.99	\$2,286.09
Marketing & Presentations:		
Poster & Brochure Printing (Staples / Math Dept)	\$240.00	\$174.18
Food & Catering:		
Team Meals & Local Catering (Bestco, Pizza Pizza, Sushi Ninja, etc.)	\$552.13	\$400.71
Team Lunches (Newfoundland Travel)	\$300.00	\$217.72
Subtotal Food & Catering:	\$852.13	\$618.43
Travel Logistics & Transportation:		
Local Bus Transfers (Ontario)	\$1,053.50	\$764.57
Inter-City Group Bus Charters	\$1,186.50	\$861.10
Regional Tours & Sightseeing (McCarthy's Bus)	\$2,820.59	\$2,047.03
Competition Airfare (Lyew & Senior Flights)	\$12,320.23	\$8,941.35
Hotel & Accommodations (Hilton Garden Inn)	\$5,537.00	\$4,018.45
Total Travelling:	\$22,917.82	\$16,632.49
Total Operating Expenses:	\$27,159.94	\$19,711.19

Project Summary:

Net Surplus = Total Revenue - Total Operating Expenses = \$30,590.00 - \$27,159.94 = **\$3,430.06** (Final account balance is surplus) (Excluding School Support & Funding (For World Championships))

c. Funding for worlds:

Qualifying for worlds created an unexpected expense, considering our team had never qualified in the past.

This leaves \$13,430.06CAD, or \$9748.21USD of funding for worlds. We've estimated it will cost approximately \$18,000CAD or \$13065.30USD for travelling to worlds in Newfoundland (taking into account \$9600CAD for 14 people's flights, \$7500CAD for hotels, and \$900 for other expenses). Hence, we will need to raise \$4,570CAD, or **\$3317.13USD** more. To do so, we've reached out to our sponsors and informed them of our success in qualifying for worlds, requesting more funding. We've also set up a fundraising event at our school's "May Day" festival, selling trinkets for profits going towards funding for our world trip.

d. Build Vs Buy

Table 5: Pros & Cons Table for Waldo's Construction
Created by: Nini Cao, Charlotte Schussmann, Lisa Wang & Anna Xiaomu

Components:	Build:		Buy:		Reuse:		Final decision:
	Pros	Cons	Pros	Cons	Pros	Cons	
Propulsion (Motors)	N/A	N/A	Ensures 100% operational reliability.	Costs more money.	Saves money and works.	Wear and tear.	Reuse
Cameras	N/A	N/A	Product tailored to mission/task. Saves time.	Extra expense.	N/A	The screen from last year was not clear, and it doesn't work because the connection leaked during last year's competition.	Buy
Electrical system	Customizable. It allows us to easily fix things immediately when there is a leak or other emergencies during the competition.	Takes a lot of time. Possible errors may occur	Made by professionals	Too expensive and not customizable.	N/A	Last year's electrical system was messy and was on land instead of in the water with the robot, which led to long-distance signals travelling from the system to the motors.	Build
Frame	Customizable. It can also customize the buoyancy system to control the robot's weight.	Takes time to build	N/A	Not customizable.	Save time from building a new one.	Parts failed under the torque of the motors. It was not modular.	Build
3D controller	It doesn't cost any extra money.	No extra cost and customizable	Professionally made	More expensive	N/A	N/A	Build

10. Acknowledgements

We want to thank:

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- A big thank you to Mr. Lyew, Mr. Spessot, and Mrs. Senior as our tutors and mentors.
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- General Motors, Jennifer Schussmann - Director of Product Safety, Canada, Scott Calnek - Director of Data Engineering, for mentorship and engineering support
- MG Chemicals, mentorship on material selection and use, and provision of materials

Donations & Sponsorship:

- **ASI Group**, \$500 sponsorship
- **Mr. Spessot**, \$1,000 donation/support and mentorship
- **Dr. Gill (Windfields Dental)**, donation/support
- **The Di Vizio Family**, donation/support



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