UBC Okanagan Marine Robotics: RoboSub 2026 Technical Design Report

Amber Hawker, Hasan Mohammad, Uplove Parhar, Alexis Wong, Kezia Wong, Sam Yoskovitz
UBC Okanagan Marine Robotics
University of British Columbia, Okanagan
Kelowna, Canada

***Abstract*—In 2026, UBC Okanagan Marine Robotics (OKMR) presents a new and improved *Ogopogo*, the third submission by the team to RoboSub. Building on feedback from last year's competition, the third design cycle focuses on substantial upgrades to enhance durability, modularity, and efficiency in system integration. These include a simplified aluminum frame for additional actuators, geometric infill thruster mounts to increase Ogopogo's buoyancy, a scaffold electrical tray for straightforward access to PCBs, improved firing consistency of the torpedoes, a transition electrically to an STM32F7-based architecture, CAN bus communication, and reworked power distribution and kill switch systems to maintain reliability and efficiency. Additionally, significant software improvements include a reworked PID control system, transitions to a smoother movement generation system, and a YOLO model for object detection, resulting in functionality for more diverse environments. This year, OKMR faced significant integration and funding challenges; however, the team maintained steadfast momentum through uninterrupted cycles of design, build, and testing while remaining committed to system-wide improvements through weekly pool tests. With this, OKMR aims to complete the Gate, Slalom, Dropper, and Return Home tasks, with systems ready to attempt the Torpedo, Gripper, and Random Pinger tasks.**

I. INTRODUCTION

Founded in 2023, UBC Okanagan Marine Robotics (OKMR) is a student-led engineering design team devoted to the construction of autonomous underwater robotic systems. The team equips students with mechanical design, electrical PCBs, software frameworks, and project management skills through an applied learning model. By offering these practical learning experiences, OKMR combines fundamental concepts with authentic industry practices, producing skilled graduates who can manage demanding marine engineering systems. The team collaborates with community partners, such as Kelowna Secondary School, UBC Okanagan School of Engineering, Lego League First Robotics, Kelowna Yacht Club, and the Sea Cadets to inspire the next generation through sharing our journey of ideating, building, and testing at UBC Okanagan (Appendix G).

II. COMPETITION STRATEGY

Prior to the competition, the strategy involved targeting specific symbols and colors to mimic competition settings. With the entire task set being divided into Survey and Repair or Search and Rescue, the objective is to train the computer vision models on a single option, determined by the test data. Training the vision model on a single option allots additional time dedicated towards the specific details on certain symbols. A significant goal this year is to maximize the model's ability to consistently identify the details on the Gate and Slalom tasks, increasing the probability of scoring points.

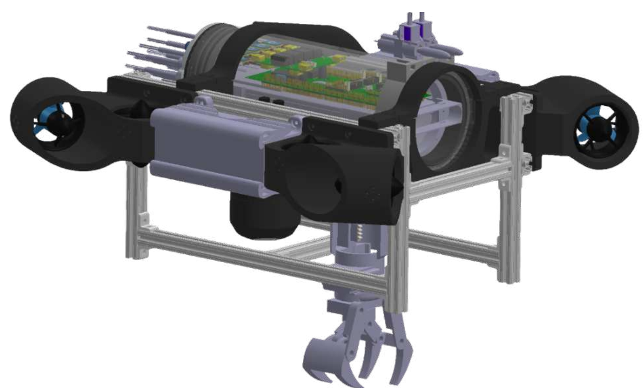

Fig. 1. SolidWorks Rendering of Ogopogo

The key objectives for RoboSub 2026 remain similar to those presented in the 2025 competition, with a few modifications. Based on observations from 2025, the team prioritized reliability in core tasks while expanding into new challenges. With this in mind, tasks are categorized into Baseline, Competitive, and Reach, where placements are justified by the allocation of points and performance in previous attempts.

Baseline objectives include the Gate, Slalom, and Return Home tasks. Since there is data from previous attempts, the team focuses on accurate implementation of adjustments and consistent performance in attempts to overcome these challenges, significantly increasing the success rate. Specifically, the team intends to train and test the AUV before the competition to score on the advanced criteria of the capability matrix.

*1) **Gate**:* A primary objective for this year is to pre-qualify; a milestone the team is targeting for the first time since joining RoboSub. To achieve this, the Gate task has been prioritized for reliable execution. Using data from previous attempts and testing, the AUV will also attempt the coin flip maneuver for additional points. Furthermore, the complete overhaul of the power distribution system ensures that Ogopogo can execute complex 'style' maneuvers without the risk of system shutdowns due to power overloads.

*2) **Slalom**:* Given Ogopogo's strong performance in this task last year, the team anticipates a high level of reliability for the current cycle. Furthermore, pre-qualification will provide an updated assessment of the system's ability to navigate precisely relative to color-coded objects.

Competitive objectives focus on the Recon and Deploy tasks, finding scoring opportunities using newly developed or improved systems. Solutions for both tasks are actively progressing, with the team aiming to have relevant subsystems ready for competition. To manage this change, the team will divide during the competition: a specialized subgroup will handle these competitive tasks, while the majority of members focus on securing baseline successes. By targeting the 'core' level of the scoring matrix, the project scope remains manageable while still allowing us to pursue advanced goals.

*3) **Recon (Dropper)**:* The dropper has been re-engineered as an independent subsystem to ensure reliable and repeatable actuation. This modular design isolates the 'bin' task from other objectives, preventing potential subsystem failures from impacting the remainder of the competition run.

*4) **Deploy (Torpedo)**:* The torpedo was redesigned to incorporate variable launch parameters based on the confidence intervals of the computer vision model (Fig. 2). By adjusting the launch force, the team can optimize for maximum reliability or higher point potential depending on real-time performance. Once the image recognition model is validated, the testing will focus on characterizing the relationship between target distance and firing accuracy to establish reliable operational thresholds.

Fig. 2. Torpedo

Reach objectives, specifically the Octagon and Pinger tasks, still stand outside our current project scope.

*5) **Octagon**:* This task focuses on validating the redesigned robotic arm. Given its experimental status, the primary objectives are limited to resurfacing and orientation relative to target imagery. While pre-competition testing is planned for the gripper mechanism, resource allocation will prioritize Baseline and Competitive tasks. Consequently, the 2026 competition will function as a research phase to gather data for future Octagon development.

*6) **Pinger**:* The pinger task remains outside of our current operational capacity, as it requires a dedicated acoustics suite that is not yet integrated into the AUV.

III. Design Strategy

A. Mechanical Systems

*a) **Structures**:* Compared to the previous iteration, the revised aluminum frame utilizes fewer individual members and simplified joints. These changes streamline the assembly process and allow additional space for future actuation features. Furthermore, the new thruster mounts have been redesigned with a continuous volume infill, allowing them to be foam filled, minimizing the likelihood of waterlogging and increasing overall buoyancy.

*b) **Electronics Tray**:* Collaboration between the electrical and tray subteams resulted in a redesigned assembly with a significantly reduced volumetric footprint. By eliminating redundant structural support, the tray frame achieves a more compact profile while optimizing cable routing and component placement (Fig. 3). Additionally, custom push-fit fasteners were engineered to create a secure friction fit, isolating the assembly from previous failure points, while modular 'pop-in' clips facilitate rapid PCB access and serviceability.

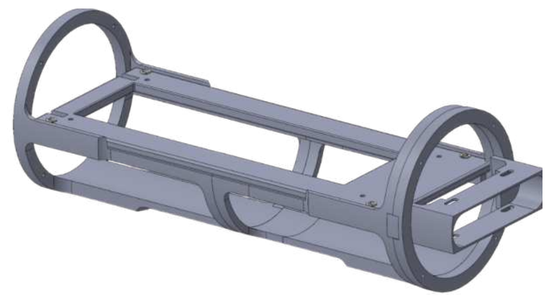

Fig. 3. Electronics Tray

*c) **Torpedo**:* SolidWorks simulation of computational fluid dynamics and weight distribution analysis were used to optimize stability during torpedo deployment. A refined launcher design improved firing consistency, introducing an option to adjust the launch force to enhance the overall launch stability and performance of the torpedoes.

*d) **Robo-Arm**:* The redesigned Robo-Arm replaces the previous 3-axis gripper arm with a simplified, one-degree-of-freedom (1-DOF) extension mechanism (Fig. 4). By utilizing a streamlined four-bar linkage, the system ensures reliable linear actuation while facilitating rapid design iterations and implementation adjustments during the development cycle.

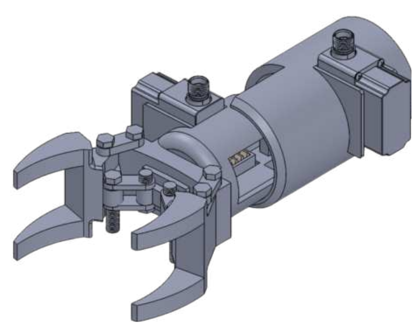

Fig. 4. Robo Arm

*e) **Dropper Mechanism**:* The redesigned dropper is a modular subsystem utilizing a single servo to deploy two markers via a rotating assembly (Fig. 5). This intentional simplification improves serviceability, allowing rapid maintenance and adjustments during competition.

*f) **Battery Enclosure**:* The updated battery enclosure, centered on feedback from previous competition, includes an over-center latch mechanism that ensures a uniform clamping force between the lid and the hull, allowing quick access to the batteries (Fig. 11). Machined from ABS to minimize mass, the enclosure utilizes an O-ring and groove configuration for reliable waterproofing.

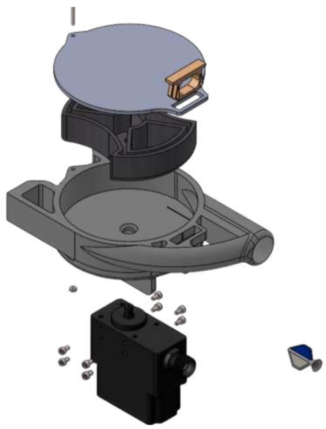

Fig. 5. Dropper Mechanism

B. *Electrical Systems*

*a) **Main MCU**:* The control board features an STM32F7 microcontroller (Fig. 6), which was chosen for its balance of performance and power efficiency, as well as the availability of multiple CAN controllers. The design includes an integrated USB-to-UART converter, enabling remote firmware updates via the Jetson interface, eliminating the need to remove the electrical tray for software iterations.

*b) **Actuator Boards**:* Features variable voltage regulators to independently power and control up to 5 servos and 2 linear actuators in the AUV. All actuators can be controlled via CAN bus, with direct PWM signal support as a fallback in the event of a communication failure.

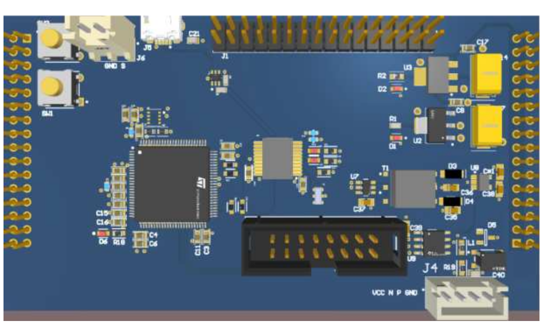

Fig. 6. Main MCU

*c) **Power Distribution Board**:* The power distribution board steps down and regulates the 16V battery input to a 12V transmission voltage (Fig. 7). Pin headers on both sides allow PCBs to slot directly into the board, delivering power without excess wiring. Each PCB further regulates the 12V to its desired operating voltage. TVS diodes protect all circuitry against voltage spikes by clamping excess voltage and shunting transient currents to ground, while fuses provide an additional layer of protection for electrical components in the event of an unforeseen fault.

*d) **Killswitch**:* The killswitch uses normally open relays to physically disconnect the motors from the batteries, ensuring all motor power is cut in the event of a failure (Appendix B, Fig. 20). A magnetic reed switch enables a simple pull mechanism that is easy to activate underwater, with no external electronics required. The killswitch is also software-controllable for remote or automated shutdown. Optocouplers isolate the microcontroller from the motors, protecting against noise and voltage spikes.

*e) **Communication**:* Transitioned from I2C to CANBUS to improve communication, addressing the noise concern from the prior year. Each PCB contains CAN circuitry that enables the electronics on board to communicate, sharing the same bus type protocol as I2C but optimized for the electronic systems in the AUV.

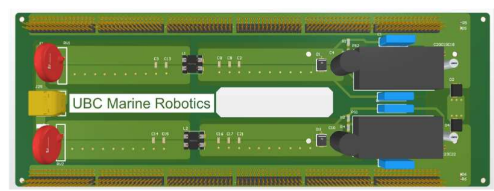

Fig. 7. Power Distribution Board

C. *Software Systems*

*a) **Actuation**:* Software development prioritized the kinematic modeling and control of the robotic arm [1] [2]. Research findings, including the necessary linear algebra, coordinate transformations, and forward kinematic processes, were compiled into a technical reference for future on-boarding [7]. Following an evaluation of inverse kinematics methodologies, the IKpy library was selected for implementation (Fig. 8). The current road map specifies an interim 1-DOF arm for this cycle, establishing the foundation for a full 6-DOF system next year. Furthermore, ROS2 Action Servers were implemented to provide a robust framework for the asynchronous operation of the torpedo launcher and ball dropper [5] [8].

*b) **Movement and PID**:* Throughout the development cycle, the controls module exhibited persistent reliability challenges. Empirical analysis and expert consultation identified that the feedforward control architecture, which relied on a non-robust mechanical model, was the primary source of system instability. When coupled with high latency and low refresh rates, these model inaccuracies induced sustained oscillations and cascading errors within the PID framework [10]. To

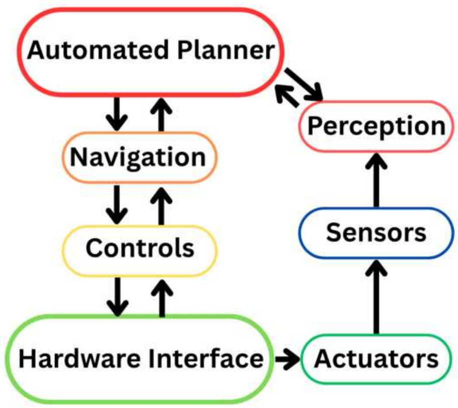

Fig. 8. Heavily simplified Software System Diagram, please see Appendix C for full diagram. This version shows the overall data flow from Automated Planner (L5) to Hardware Interface (L1)

mitigate these effects, the software team replaced the feedforward loop with a proper integral term (K_I). This modification allows the controller to account for cumulative error more effectively, providing a more stable response despite model uncertainties. Concurrent system optimization focused on reducing I/O delay and implementing robust tuning to achieve faster, more accurate outputs. Furthermore, the movement system was upgraded from a linear, point-to-point approach to a smooth curve generation architecture. By leveraging SciPy's CubicSpline generator, the AUV now utilizes piecewise cubic polynomials to fit trajectory data [9]. Because these splines are twice continuously differentiable (C2 smooth), the resulting paths maintain continuity across segments. This transition has significantly enhanced the hydrodynamic fluency, accuracy, and operational efficiency of the AUV in aquatic environments.

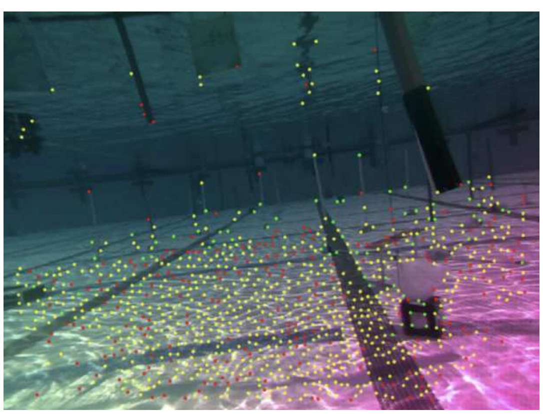

Fig. 9. Computer data points used to train object detection model

*c) **Object Detection**:* This year, the software team designed a completely new pipeline for training the object detection models. This was implemented by feeding training data into GroundingDINO, which rapidly labeled objects of interest from natural language prompts. After reviewing the labels, the team utilized them to train a YOLO model for specific object detection tasks. This method enabled efficient iteration of the object detection models, greatly reducing the amount of manual work required for model training. Additionally, in the future the software team plans to add depth sensor data into the object detection models to expand functionality in diverse aquatic environments.

*d) **Simulation**:* Simulation environments presented significant technical challenges for the software team, necessitating a transition to the Stonefish simulator as the primary platform for system verification (Fig. 15). However, extensive cross-platform compatibility issues, specifically regarding macOS hardware, resulted in persistent operational unreliability for several team members. These technical impediments required a redirection of developmental resources toward comprehensive troubleshooting and the identification of alternative simulation frameworks. The team is currently conducting a comparative performance analysis of the Gazebo open-source engine and the MATLAB RoboSub simulation environment to establish a stable, high-fidelity testing suite for autonomous underwater applications.

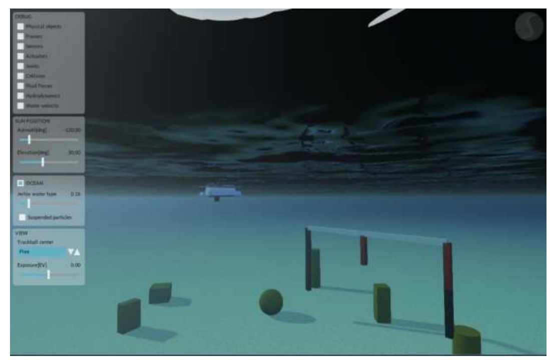

Fig. 10. Rendered computer simulation from Foxglove

*e) **Integration**:* To enhance system accessibility and streamline developmental workflows, the software team engineered TuneGUI, a custom graphical user interface (GUI) designed for the dynamic configuration of ROS2 node parameters. This utility enables real-time parameter tuning without necessitating direct manipulation of configuration files or source code, effectively lowering the technical entry barrier for contributors without extensive programming experience. Furthermore, the team implemented robust Continuous Integration and Continuous Deployment (CI/CD) protocols to ensure high standards of repository reliability and operational efficiency throughout iterative development cycles.

*f) **Automating Planner**:* To enhance mission scalability and operational flexibility, the software architecture incorporates a modular and dynamic mission planning framework designed to facilitate the rapid integration of auxiliary task configurations [7]. This automated planner synthesizes discrete subsystem contributions into a cohesive, high-level execution strategy, ensuring robust synchronization between autonomous decision-making logic and the underlying kinematic control protocols. By utilizing a modular approach, the system allows for the integration of new behaviors without compromising the integrity of baseline mission objectives. This methodology aligns with standard academic objectives for advanced industrial and autonomous robotics applications.

IV. Testing Strategy

A. Mechanical Testing

Mechanical testing revolved around applying feedback from previous competition experience and pool tests. Rapid application of feedback reduced downtime between tests, aiding in the identification of critical weak points. Because most substantial problems did not pose severe issues due to the solid foundation of the prior AUV design, the mechanical team directed their attention and resources towards ideation, prototyping, and refining current designs.

*a) **Battery Enclosure**:* The testing strategies for the battery enclosure involved an iterative prototyping process, beginning with FDM-printed models to validate internal volume and component sizing. Throughout the design phase, various manufacturing methods, such as SLA resin printing and resin-infused FDM, were empirically evaluated but ultimately rejected due to structural failures and sealing inconsistencies. To guarantee operational reliability, the final machined ABS hulls were designed to undergo regular inspections and pressure testing, utilizing a redundant O-ring and groove configuration to prevent water ingress. Furthermore, the enclosure was subjected to translational and rotational docking tests to ensure the hull geometry properly interfaced with the guide rails for accurate coil alignment.

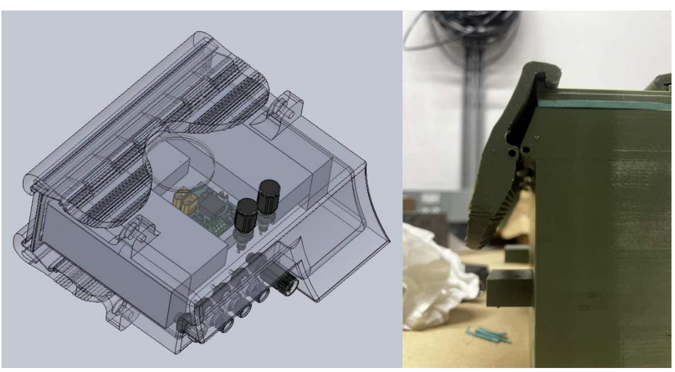

Fig. 11. Battery Hull and Physical Locking Mechanism

B. Electrical Testing

*a) **Overview**:* Electrical testing was conducted throughout all development phases, prioritizing circuit design verification and system-level integration testing. This approach ensured that individual components performed as intended before being integrated into the full AUV architecture.

*b) **Circuit Simulation**:* Each PCB design underwent simulation using Falstad to verify the behavior of the power distribution board and kill switch logic. As illustrated in Figure 11, these simulations confirmed the kill switch's reliability, demonstrating successful activation via both hardware and software triggers.

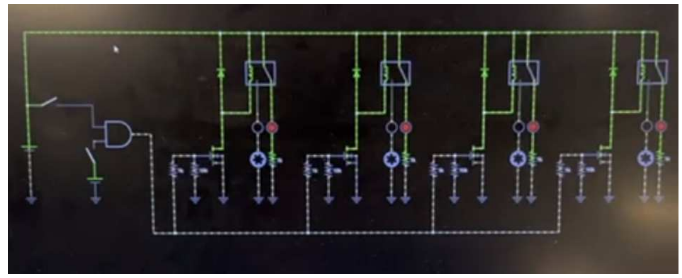

Fig. 12. Circuit Simulation

*c) **Noise Testing**:* To ensure data integrity, an oscilloscope was used to quantify electrical interference at the AUV endcap. This characterization of the noise environment informed the selection of a more robust communication protocol for the system.

*d) **Thermal Camera Validation of PCBs**:* High-resolution thermal imaging was employed to monitor PCB thermal performance and identify localized temperature spikes. This process facilitated the detection of shorts and manufacturing defects while ensuring components operated within safe thermal limits.

*e) **Power System Testing**:* Validation of the power and killswitch systems involved verifying control logic and power throughput. An Arduino provided a simulated 5V PWM signal to the isolation board, with motor outputs subsequently verified using multimeter probes. Additionally, thermal cameras monitored high-power copper pours during throughput tests to identify high-resistance areas caused by pour geometry or manufacturing anomalies.

C. Software Testing

*a) **Overview**:* Following a post-competition review, the team adopted a structured testing methodology to prioritize early error detection. Close coordination between the Movement and Integration sub-teams ensured data reliability and reduced total debugging time by identifying root causes during initial development phases.

Fig. 13. Software lead Graeme and software member Cain running out-of-water testing with Ogopogo at the Kelowna YMCA.

*b) **Codebase Verification:*** In September, the team established Ogopogo's baseline performance benchmarks through a layer-by-layer validation of the codebase. This decision proved critical, as it allowed for the early identification of oscillation, latency, and drift within the PID control system, facilitating immediate technical consultations with Dr. Rudolf Seethaler, Dr. Mehran Shirazi, and Dr. Klaske van Heusden from the UBC Okanagan Faculty of Engineering to address the root causes of system instability.

Fig. 14. Graeme debugging with Ogopogo, President David, and Leith.

*c) **Pool Testing:*** Weekly sessions established baseline performance metrics, which revealed critical oscillation and drift within the PID controller. Testing progressed from fundamental system characterization to the validation of advanced features, including cubic spline trajectories and object detection.

*d) **Simulation Testing:*** The team conducted a comparative analysis between Gazebo and MATLAB. Gazebo was selected as the primary simulation environment due to its robust cross-platform support and proven reliability for marine robotics, enabling faster development cycles.

*e) **Pathing and Integration:*** Implementing curvilinear pathing required rigorous validation of SciPy's spline generation libraries. Following an initial proof-of-concept, regression testing was performed to ensure compatibility with the existing codebase.

*f) **System Refinement:*** Final refinements were conducted during in-water testing to quantify the impact of updated trajectory generation on the automated planner, ensuring full system integration.

V. Conclusion

The 2026 UBC Okanagan Marine Robotics program exemplifies resilient system-level redesign, upgrading the AUV beyond a competitive platform through focused enhancements to subsystem integration, modularity, and reliability. The team concentrated on streamlining mechanical designs, enhancing electrical robustness, and redesigning autonomy and control systems to develop a more capable and maintainable AUV platform, building on lessons learned from earlier RoboSub challenges. From September to June, weekly pool tests and high-fidelity simulations produced significant improvements. The work completed throughout this design cycle establishes a stronger technical foundation for future development of Ogopogo's autonomy and robotic manipulation capabilities, supporting OKMR's continued growth and long-term development within the RoboSub competition.

VI. Acknowledgments

The ongoing advancements and achievements of the UBC Okanagan Marine Robotics would not be made possible without the continuous support and mentorship from our sponsors (Appendix A), and our faculty members.

We would like to express our perpetual gratitude for **Eric Jackson's** generous sponsorship and exceptional guidance. Eric is deeply invested in the development of our members through mentorship on independent research projects in the control systems fields and access to unreleased co-op opportunities. Cellula continues to enable our members to pursue co-ops at their company, bringing a total of four students in the lifetime of this club.

We are also thankful for **Carley Hunt** and the staff at the **Kelowna YMCA** for providing access to pool facilities, which were essential in our journey to making it to Robosub 2026.

Our appreciation extends to the **UBC Okanagan School of Engineering, the Students' Union of UBC Okanagan,** our faculty advisor, **Dr. Rudolf Seethaler,** and Student Professional Development Officer **Grant Topor** for their continued guidance, lab access, and technical support throughout the development process.

We extend our gratitude to **RoboNation** for their leadership and organization of the RoboSub competition, which continues to provide an essential environment for student engineering teams. Most importantly, we acknowledge the UBC OKMR team members. This year's technical milestones are a direct result of their technical curiosity, resilience, and collaborative effort (Appendix D).

Fig. 15. UBC OKMR Team Photo

VII. REFERENCES

REFERENCES

[1] Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2010). Robotics: Modelling, Planning and Control. Springer.
[2] Lynch, K. M., & Park, F. C. (2019). Modern robotics. Cambridge University Press.
[3] Texas Instruments, ”BQ76952 Technical Reference Manual,” Revised May 2022. Available: https://www.ti.com/lit/ug/sluuby2b/sluuby2b.pdf
[4] Engineering Simplified, Robotics 101. (2023). YouTube. https://www.youtube.com/playlist?list=PL1YrgW7ROFofBqPGiWAmTqIwDc5SrzZrA
[5] Buss S. R., (2009) Introduction to Inverse Kinematics with Jacobian Transpose, Pseudoinverse and Damped Least Squares methods,
[6] Aristidou, A., & Lasenby, J. (2011). FABRIK: A fast, iterative solver for the Inverse Kinematics problem. Graphical Models, 73(5), 243–260. https://doi.org/10.1016/j.gmod.2011.05.003
[7] Modeling, Motion Planning, and Control of Manipulators and Mobile Robots by Akshit Lunia; Ashley Stevens; Cavender Holt; Rhyan Morgan; Joshua Norris; Shailendran Poyyamozhi; and Yehua Zhong https://opentextbooks.clemson.edu/wangrobotics/
[8] Introduction to Open-Source robotics by Quang-Cuong Pham and Francisco Suárez-Ruiz https://osrobotics.org
[9] SciPy Developers. (n.d.). *CubicSpline — SciPy v1 Documentation*. https://docs.scipy.org/doc/scipy/reference/generated/scipy.interpolate.CubicSpline.html
[10] MathWorks. (n.d.). *PID Controller Documentation*. https://www.mathworks.com/help/control/ref/pid.html
[11] Nortek. (n.d.). *A Complete Guide to Underwater Navigation*. https://www.nortekgroup.com/insight-hub/a-complete-guide-to-underwater-navigation

VIII. Appendices

A. Appendix A: Sponsors

1) Platinum Sponsors:

- UBC Professional Activities Fund – For their crucial monetary funding, academic support, and equipment procurement for travel to RoboSub 2026.
- Cellula Robotics – For their donation of a Doppler Velocity Logger, 4 internships in the lifetime of this club, and the ongoing guidance on both the AUV and hydrofoil projects
- UBC Okanagan Engineering Society – For their monetary funding.
- Ipmos - For their crucial cash supply and industry connections for mentorship.
- 4AG Robotics – For their monetary donation, internship opportunities, and facility tours that continuously enrich the professional development of our members

2) Gold Sponsors :

- Blue Trail Engineering – For their discount on parts
- Cadence – For their monetary donation, multiphysics fluid modelling simulations and guidance

3) Silver Sponsors :

- Mearl's Machine Shop – For their machining of our copper parts
- Blue Robotics – For their discount on parts
- Molicel – For their generous discount on parts
- Metal Supermarkets – Discount on parts
- Zaber – For generously coordinating machining of our metal parts

4) Bronze Sponsors :

- Rocky Mountain Motion Control – For the discounted T slots
- YMCA – For providing pool facilities for pool testing
- BlueSub – For their monetary donation
- Signcraft – For the donation of the custom banner
- Kelowna Yacht Club – For waiving the fee to hold a booth at the Kelowna Boat Show
- Blair's Sportswear – For the donation of our custom competition shirts
- Home Depot – For their discount on respirators for the safety training courses

B. Appendix B: 3D Models of Custom PCBs

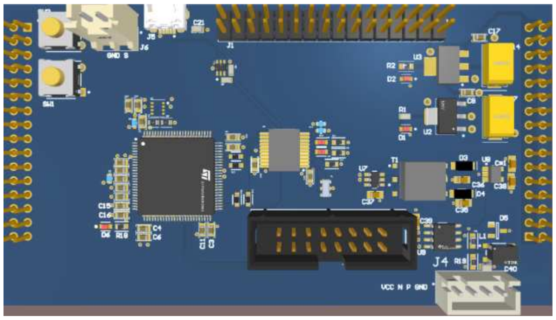

Fig. 16. 3D model of the Main Microcontroller Board

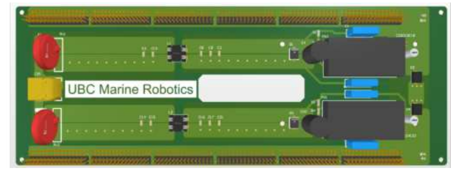

Fig. 17. 3D model of the Power Distribution Board

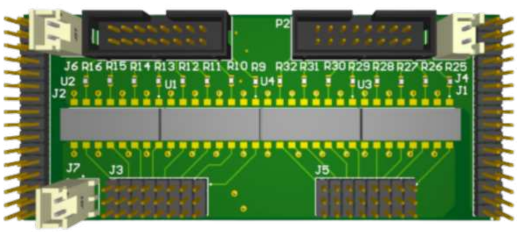

Fig. 18. 3D model of the Isolation Board

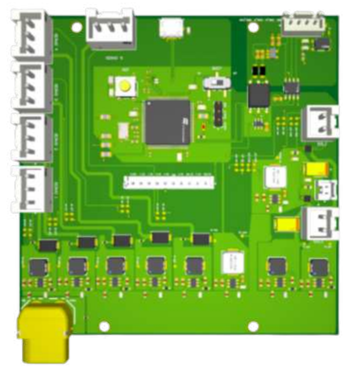

Fig. 19. 3D model of the Actuation Board

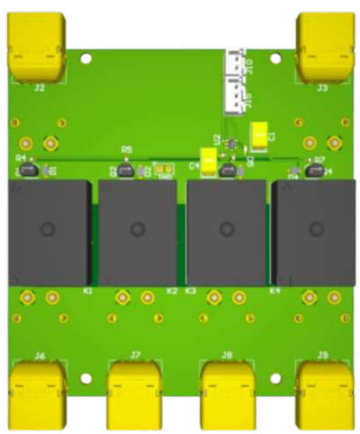

Fig. 20. 3D model of the Killswitch Board

C. Appendix C: Software System Diagram

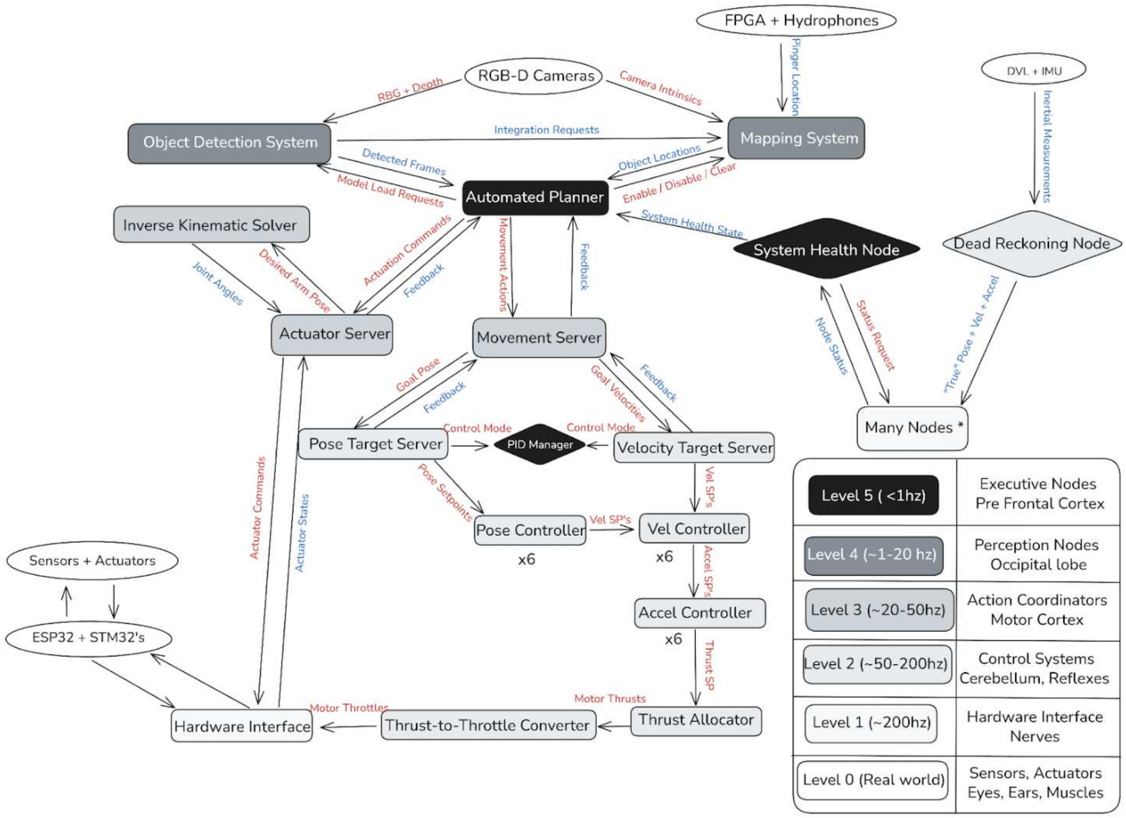

Fig. 21. Full Software System Diagram. Bottom Right Legend shows biological analogies for different parts of the system, as well as the colouring scheme for the control hierarchy (Black for L5 to Light Gray for L1). Note: the "Many Nodes" block represents most nodes in the system, and drawing connections between them all would result in a difficult-to-read diagram.

D. Appendix D: Vehicle Information

Component	Vendor	Model/Type / Specs	Custom / Purchased	Cost	Year
Buoyancy Control	N/A				
Frame	Rocky Mountain Motion Control	T-Slot and brackets assembled into custom frame	Custom	500 CAD	2026
Waterproof Housing	Blue Robotics	6” Series Watertight Enclosure	Purchased	400 CAD	2024
Waterproof Connectors	Blue Robotics	Potted Cable Penetrator	Purchased		2024
Waterproof Connectors	Blue Trail	Various bulkheads and connectors	Purchased	3,703.94 CAD	2025
Thrusters	Blue Robotics	T200	Purchased	1850 CAD	2024
Motor Control	JLCPCB, DigiKey	Custom	Purchased	135 CAD	2026
High Level Control	N/A				
Actuators	Blue Trail	Underwater Servo SER-202X	Purchased	1500 CAD	2025
Propellers	N/A				
Battery	Amazon	HOOVO 2S LiPo Battery, 7.4V 8200mAh 120C	Purchased	500 CAD	2024
Converter	LCSC	Power Distribution Board	Custom	150 CAD	2026
Regulator	JLCPCB	Power Distribution Board, Battery Management System: TI Bq76952, ACS770-150U	Custom		2025
CPU	Nvidia	Jetson Orin Nano: 1024 CUDA cores, 32 tensor cores, 8GB RAM, 25W, Jetpack 6.2	Purchased	650 CAD	2024
Internal Comm Network		Ethernet + I2C, STMG030K8T6-based PCB	Custom		
External Comm Interface		Ethernet	Purchased		
Compass	N/A				
IMU	Bosch	BMI055, inside Intel D455	Purchased	N/A	2024
DVL	Nortek	DVL 1000 Gen 3: 0.1–75m bottom track, 8Hz max	Sponsored / Donated	N/A	2024
Manipulator	Custom	3D Printed	Custom	40CAD	2026
Algorithms	N/A	A* Pathfinding			
Vision	Intel	Realsense D455 and D405	Purchased	650 CAD (D455) + 450 CAD (D405)	2024/2025
Acoustics	Aquarian, Mouser, JLCPCB	S1 Hydrophones, Zynq 7020, filter and connector PCBs	Purchased / Custom	1598 USD	2025
Localization	N/A	**Localization:** Dead reckoning using DVL and IMU fusion **Mapping:** Point cloud insertion using Bonxai library **Rates:** 200Hz localization, 5Hz mapping	Custom	N/A	2024/2025
Autonomy	N/A	Nested state machines using PyTransitions	Custom	N/A	2025
Open Source Software	N/A	ROS2 Jazzy, IntelRealsenseSDK, PyTransitions, PyTorch, Bonxai			
Inter-Vehicle Communication	N/A				
Programming Languages	N/A	Python, C++			

TABLE I
VEHICLE INFORMATION SUMMARY FOR ROBOSUB 2026

E. Appendix E: Example Pool Test Plan and Results

<table>
<tr><td>Date:</td><td rowspan="5">Notes/Comments:</td></tr>
<tr><td>Test Topic/Name:</td></tr>
<tr><td>Test Description:</td></tr>
<tr><td>Overall Pool Test Goal(s):
1.
2.</td></tr>
<tr><td>Results:
1.
2.</td></tr>
<tr><td rowspan="2">Next Steps:

1.
2.</td><td>Success Level:</td></tr>
<tr><td>Learning Opportunity ▼</td></tr>
</table>

Fig. 22. Sample Empty Test Plan

<table>
<tr><td>Date: January 16th</td><td rowspan="5">Notes/Comments:
- Competition /ogopogo/*controls launch file working intermittently.

- Issues found with rotation commands not completing still present.

- Vertical oscillations found after various movement commands given in quick succession

- A light/gradual push would yield desired behavior in fighting to return to target pose. However, pushing the AUV quickly more often than not resulted in a cascading system.</td></tr>
<tr><td>Test Topic/Name: PID</td></tr>
<tr><td>Test Description: Identify issues resulting in a faulty control system</td></tr>
<tr><td>Overall Pool Test Goal(s):
1. Record a PID cascading event for analysis.
2. Identify issues and make a plan to fix.</td></tr>
<tr><td>Results:
Late arrival to the pool + electrical and software issues. While symptoms were found, we didn't find any root causes</td></tr>
<tr><td rowspan="2">Next Steps:
Further analyze recording and speak with mech team about the oscillatory behavior.</td><td>Success Level:</td></tr>
<tr><td>Failure</td></tr>
</table>

Fig. 23. January 2026 Test Plan Example

Date: Feb 6th

Test Topic/Name: First Actuation Pooltest

Test Description: Post dry-run of torpedo software system. Testing in the underwater environment to make note of any changes or issues.

Overall Pool Test Goal(s): 1. To stress test our torpedo systems via launching projectiles from both of our tubes with repeated action.

Results:
1. Results yielded no major issues after 30 minutes of testing.

Next Steps:
Actuate from a mission state, ie. in position.
Mount the dropper and drop payload via software.

Notes/Comments:

- Computer side of tether (RJ45) recrimped shortly before test. Resulted in a connection to the jetson with no dropouts. (Thanks David).

- Laptop-jetson-connection order of operations established. Bandaid fix, network settings will be worked on in the future.

Success Level:

Successful

Fig. 24. February 2026 Test Plan Example

Date: March 6th	Notes/Comments: - uses 'nmcli' tooling -> https://networkmanager.dev/docs/api/
Test Topic/Name: Dry Day - network fixing	
Test Description: Using scheduled test period to fix network connection issues between Laptop and Jetson.	
Overall Pool Test Goal(s): - Reliably establish a method to allow for both remote operation (via commandline) and autonomous operation (self contained)	
Results: - Established network profiles in commanding Laptops + Jetson, allowing for deterministic Hosting and Client ip addressing in both remote op. and auto op.	
Next Steps: - Create a BASH script to allow for ease of switching between profiles on jetson	Success Level:
	Successful

Fig. 25. Second March 2026 Test Plan Example

F. Appendix F: Club Structure

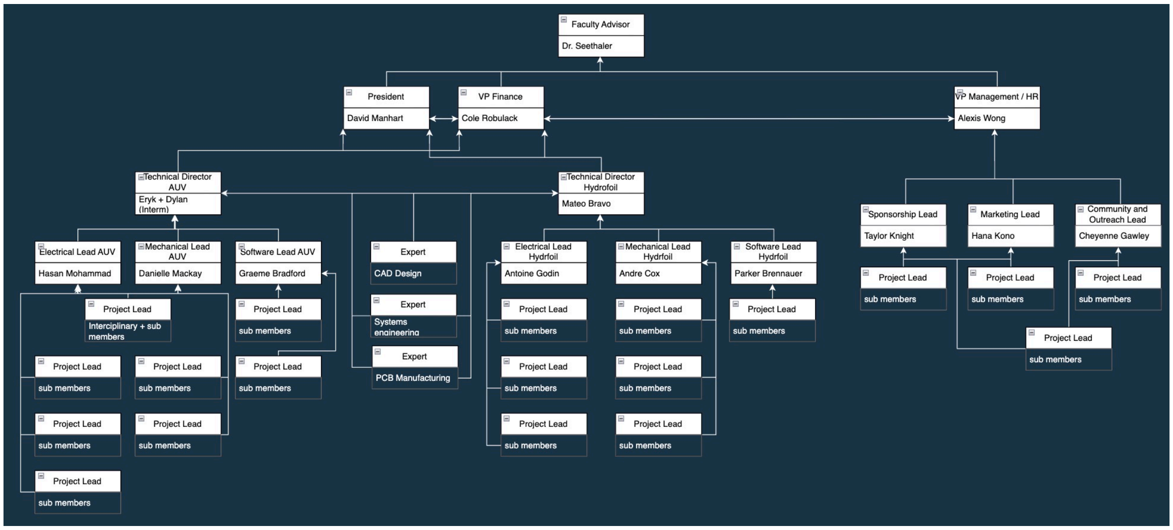

Fig. 26. UBC Okanagan Marine Robotics club structure and projects.

Club Subteam and Project Members

1) ***Sponsorships and Finance (Management):*** Taylor Knight, Jaden Lau

2) ***Outreach (Management):*** Cheyenne Gawley, Kezia Wong, Jonny Dabrowski

3) ***Club Internal and Events (Management):*** Hana Kono, Kamin Tangsujaritvichitr, Isabella Mendoza

4) ***Marketing and Social Media (Management):*** Alexis Wong, Hana Kono, Isabella Mendoza

5) ***Killswitch Subteam (Electrical):*** Joey, Soren Engel, Anderson Chang

6) ***Power Delivery Board Subteam (Electrical):*** Tomi Shittu, James Williamson, Arsh Mehta

7) ***Main MCU Subteam (Electrical):*** Uplove Parhar, Hasan Mohammad, Armaan Gill

8) ***Actuator Subteam (Electrical):*** Rhea Deshpande, Alex Caspers, Aditiya Patel

9) ***Communications Subteam (Electrical):*** Esteban Herrera, Trevor Xu, Chigo Okpanku, Hengzhi Zhu

10) ***Hydrophones Subteam(Electrical):*** James Williamson

11) ***Perception (Software):*** Cain Tipton, Kieran Cline, Himmat Dhadli, Lakshay Dang, Peter Nguyen, Isaac Kohler-Mergel

12) ***Actuation (Software):*** Tariq Wadi, Dhruv Nikalwala, Esteban Herrera, Jarrett Eisenbarth, Tomi Shittu

13) ***Integration (Software):*** Amber Hawker, Evan Bowness, Kezia Wong, Isabella Mendoza, Michael Zhang

14) ***Movement (Software):*** Patrik Balazsy

15) ***Battery Enclosure (Mechanical):*** Cheyenne Gawley, David Straehl, Isabella Mendoza

16) ***Robo-Arm (Mechanical):*** John Mabbayad, Evan Kappes, Sophia Moss, Zahidul Islam Bayzid

17) ***Structures (Mechanical):*** Leith Rigby, Ryan Busch, Hammad Tariq

18) ***Dropper (Mechanical):*** Cooper Ross, Ethan Perez, Ruben Botes

19) ***Electronics Tray (Mechanical):*** Max Landgraff, Ayrton Daniels, Samuel Yoskovitz

G. Appendix G: Community Outreach

1) Kelowna Secondary School: UBC Okanagan Marine Robotics continues to strengthen community partnerships with Kelowna Secondary School (KSS) and led several outreach initiatives with students in grades 10 through 12. Primarily, the Grade 10 robotics class as well as the KSS Robotics Club expressed significant interest in the university-level work that our team is producing. During the visit, we brought the physical model of our Autonomous Underwater Vehicle (AUV), giving students a close-up look at the design's complexity and new additions that were added on, different from prior visits. As there were new students in this class, we began by introducing the team and explaining our operational style as a university design team. We also shared insights on the ways our team is able to show creativity with our solutions, even with our limited sponsorship funding this year. In addition, we also shared some competition logistics and media with the students. By sharing these aspects of the team, we emphasized the importance of real-world skills such as marketing and financial management, which are just as crucial as the technical work. The visit also covered our software systems, including the use of sensors

Fig. 27. KSS Robotics Club hands-on learning and engagement

and data input with the AUV. We walked through how the AUV collects data using sensors like the Doppler Velocity Logger (DVL), which tracks motion relative to the seabed, and the Inertial Measurement Unit (IMU), which includes a gyroscope and accelerometer. We explained how RGBD cameras, combined with object detection algorithms, are used to map the environment and identify targets. We explained how these inputs feed into our autonomy framework, enabling the AUV to make decisions, plan paths, and execute tasks, such as grasping an object, firing a torpedo, or navigating an obstacle course. Later in the year, we reconnected with the Engineering 11 and 12 class, following our last visit. While the last time we presented to this group was with other UBCO Engineering Design Teams, this time, we were personally invited to give a more in depth technical presentation about the AUV. We showcased each subdivision of our team in a manner through which the high school students could easily engage, relating the work they were doing in their courses to the physical concepts of the AUV. These small presentations foster an immersive environment where students are able to closely view and interact with the AUV, inspiring many inquiries and connections.

Beyond the demo, we worked directly with KSS students on their robot. Our team provided troubleshooting help, shared programming strategies, and supported them through design challenges. One of our members served as a dedicated liaison, keeping regular contact and connecting them with more specialized advice from other team members. This mentorship continued through their competition preparation, providing them with consistent support and feedback.

Fig. 28. Club members helping elementary student with STEM Engagement Day project.

2) STEM Engagement Day: Hosted by UBC Okanagan, students from grades three to five from across the Okanagan region participated in the annual STEM Engagement Day. At this event, students experienced a variety of STEM activities hosted by different student-led grounds across the campus. UBC Okanagan Marine Robotics volunteered to host a robot making workshop that explored the physical mechanisms of a closing gripper hand. In addition to the hands-on design activity we presented on the AUV through the use of pre recorded videos and interactive simulations. We explained the different mechanisms and the obstacles that the AUV needs to overcome during the Robosub Competition, relating it to the design task we gave them. This presentation was altered based on the age group of the participants; younger attendees were given a simplified explanation while older kids we gave a slightly more technical talk; but overall still simplifying most things. Along with the guidance of OKMR members, students designed a mini robot utilizing toilet paper tubes, straws, and yarn. While a basic design was shown to students, they were encouraged to experiment with the placement of the joints, the number of ‘fingers’ used, different adhesives, and more. The concepts of adaptive engineering and prototyping were reinforced in these experiments. To simulate Robosub competition, the OKMR outreach team prepared an obstacle course challenge which required the students to use the hands of their robot to lift a cotton ball, complete a set of movements like jumping up and down and spinning, and to then drop it to the correct spot. From this experience, the OKMR outreach team was asked to repeat the activity with a smaller, advanced education class of students in the sixth grade. The event organizer that reached out to us remains a wonderful community connection who has allowed us to connect more deeply with students in our community. The presentation was adjusted to be more technical to adapt to the students’ needs and interests. As it was with a smaller group of less than 10 students, experimentation and more phases of prototyping were strongly encouraged.

H. Lego League First Robotics

At the recommendation of our connection from the STEM Engagement Day, UBC Okanagan Marine Robotics members volunteered as judges at the Regional Qualifiers for the Lego League FIRST Robotics Competition (Fig. 29). During our time at the competition, OKMR members graded teams on their creativity, collaboration and perseverance when competing in the FIRST Robotics Competition. We shared many core values with the FIRST program as a robotics team, because while

Fig. 29. Club members volunteering as judges at the regional qualifiers.

technical skills are valuable, they can be taught through the use of instruction manuals; and soft skills can only be developed through high intensity situations like First Lego League competitions. For the closing ceremonies, OKMR members presented and announced the list of teams qualifying for the next round. We worked hard to encourage students to continuously learn and refine. Additionally, we brought the physical AUV to the competition to share about our own work, allowing attendees to see the complexity of the AUV and encourage teams to keep pursuing the field of robotics in the future. We showcased the many similarities between the work we do for the Robosub competition and their Lego League obstacle course. A great emphasis was placed on relating our experience to theirs throughout the presentation. The primary goal with our presentations like these, especially involving such motivated and interested students, are to make our accomplishments seem attainable for them in their futures, wherever their skills may take them. After the closing ceremonies, attendees, parents, guardians and coaches approached OKMR team members with many questions about university, engineering, and overall the technical aspects of the AUV in which our team happily answered and explained. A student team in particular remained in contact with our team after the event to organize a tour of our team's lab space.

I. UBC Welcome Day

OKMR collaborated with the School of Engineering and UBCO Motorsports to welcome incoming engineering students to the University of British Columbiam Okanagan. OKMR members participated in a panelist session, answering questions about university life and their experiences within engineering, research and design teams. Attendees were later split off into two groups, rotating between tours of the engineering research labs and the STEM activity. OKMR members hosted a booth table with the physical AUV, allowing for students to witness the complexity in each project.

J. UBC Open House

We took part in a UBCO-hosted tour for incoming and prospective engineering students. During this session, we introduced visitors to our AUV and explained how our interdisciplinary team, spanning mechanical, electrical, and software roles, comes together to build a fully autonomous system. We broke down how each subsystem fits into the bigger picture and what each subteam focuses on. The tour received a high level of interest, with many attendees expressing enthusiasm about joining or supporting the team.

K. Experience UBC

At the annual on-campus Experience UBC event, up to 900 prospective high school students toured a showcase of UBCO's student-led teams from across many disciplines. OKMR was invited to join as an Engineering Design Team showcase booth, presenting the divisions of our club and the impact students can have on the work we do as a design team at UBCO.

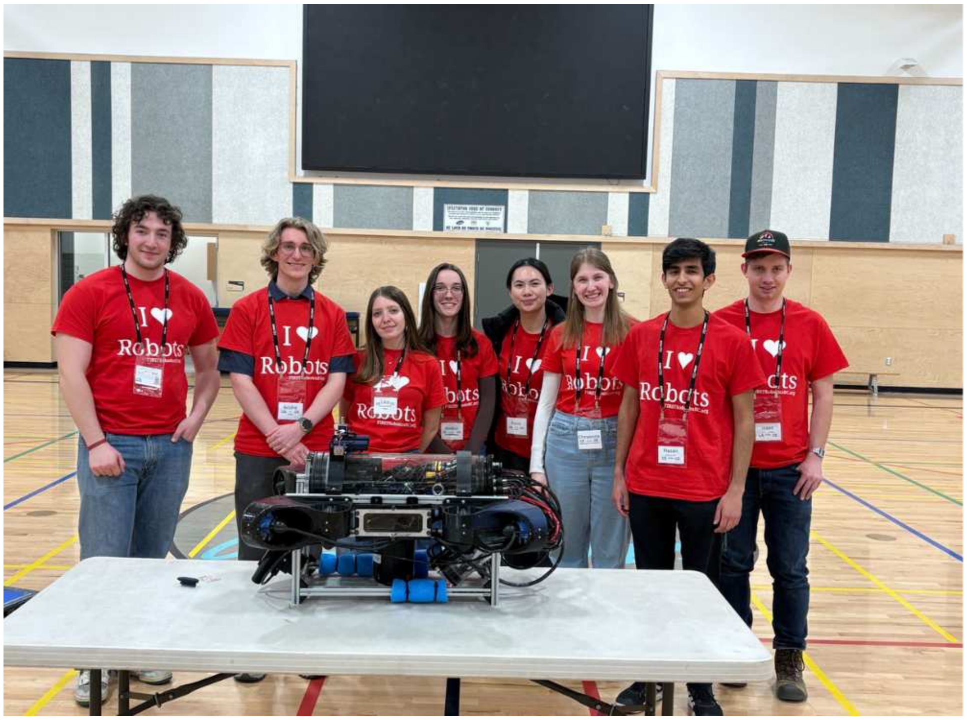

Fig. 30. Club members with the physical AUV at the closing ceremonies.

L. Kelowna Boat Show

This year, the Kelowna Yacht Club generously sponsored our participation in the Kelowna Boat Show, where our team held a booth and presented a demonstration of the AUV in the Okanagan Lake, broadcast onto a monitor for attendees to experience. Tourists, students, industry professionals, families, and friends experienced firsthand the projects being built at our club. The AUV demonstration attracted large crowds, enriching the civilians of Kelowna with the technology, talent pool, and potential of marine robotics occurring at UBC Okanagan.

M. IEEE Okanagan Innovation and Technology Expo

OKMR, UBCO Motorsports, UBCO Aerospace, Heat Robotics, and eight other teams and companies hosted booths at the KF Centre of Excellence where each design team spoke to industry members, professors, and university students from TRU, Okanagan College and other post secondary schools about the projects our clubs are developing at UBC Okanagan. At the end of the night, OKMR was awarded best booth at the event.

N. Sea Cadets

UBC Okanagan Marine Robotics rekindled relationships with the sea cadets with set plans in June 2026 to present our work and bring the physical AUV model for a demonstration in their lagoon. Two years ago, OKMR presented to the sea cadets when Ogopogo only had a sketch. With a functional, full-scale AUV now complete, the team will reconnect with the Sea Cadets to share the technical aspects of the vehicle, discuss competition logistics, and showcase the journey from an early sketch to a working AUV.

O. Mentorship Program

This year, OKMR jumpstarted a mentorship program in hopes of connecting club members with high schoolers to utilize industry-level technology to build projects and spark their interest in engineering. Due to insurance and liability issues, the project was unable to launch this year. However, this summer, the team plans on revamping the idea from a mentorship program to a series of workshops where club members share their knowledge and skills in CAD design, PCBs, and programming to aid high schoolers in developing a project that follows the ideation, build, and test cycle.

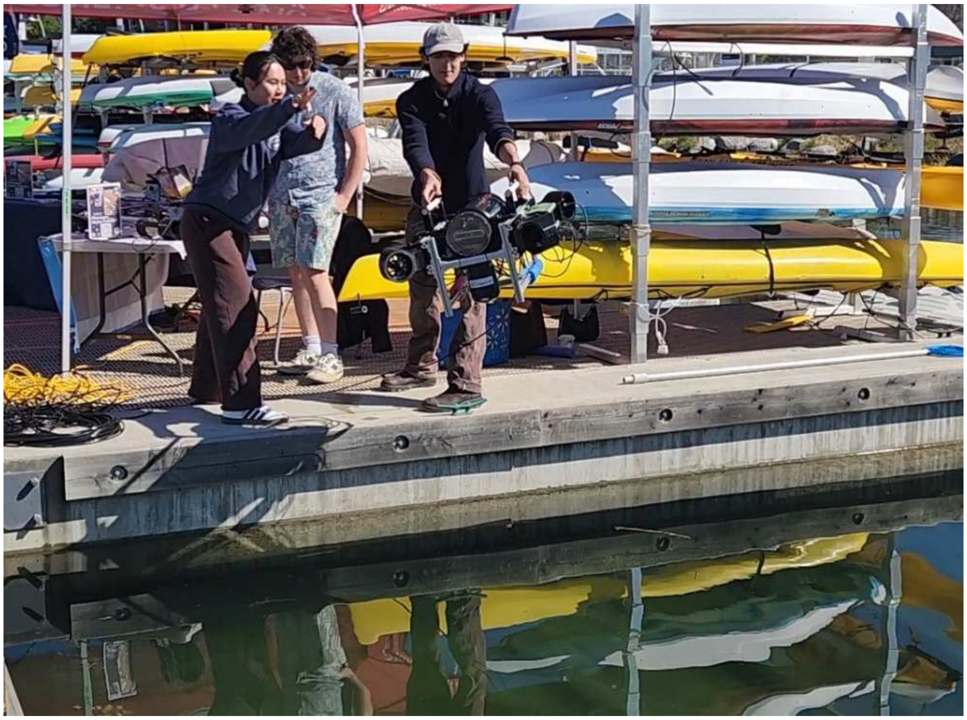

Fig. 31. Club members throwing Ogopogo into the Okanagan Lake for AUV demonstration at the Kelowna Boat Show.

Fig. 32. Club members bringing the physical AUV to KSS

P. Appendix H: Automated Planner Diagram Examples

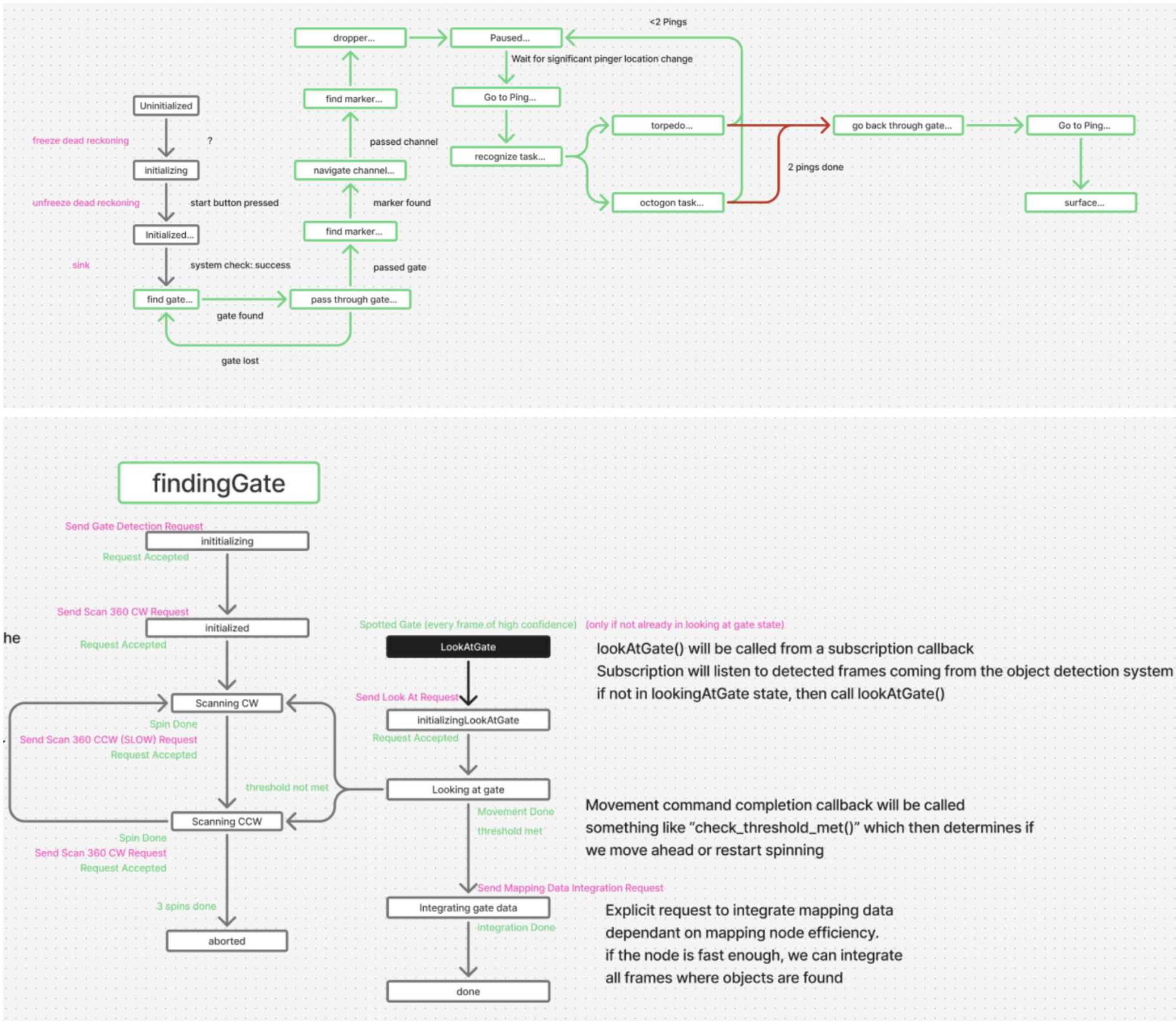

Fig. 33. Automated Planner Figma Diagrams

Q. Appendix I: Competition Strategy Risk Mitigation Plan

To ensure the successful execution of our ambitious 2026 competition strategy, we have identified key risks tied to our primary and secondary goals. The following table outlines these risks and our corresponding mitigation strategies.

Risk Area	Impact on Competition Strategy	Mitigation Plan
Control System Volatility (Cascading Error)	The volatility in the control system produces inharmonious movement, velocity, and acceleration of the AUV. Induces error buildup in automatic and programmed mobility, resulting in precarious movement and failure to execute majority of the tasks.	• **Fallback Models:** Stable PID models, previously recorded to perform adequately in primary tasks, are quickly deployed when the present model malfunctions. • **Pool Test Data Collection:** Weekly pool testings are utilized to capture ROS2 bag data, which further influences tuning decision making. • **Apply Simulator Testing:** Our recently constructed Gazebo simulation discontinues the complete reliance on physical testing. This implies that errors in the PID loop can be identified and adjusted promptly.
Overdrawal of Voltage in Motors	Due to a sudden rapid withdrawal of power from the AUV, this induces an overload of power and data. A manual power reset, terminating ongoing attempts, will offset the overhaul	• **Electrical Overhaul:** Our new MCU and Power Distribution PCB's were partially designed with this error in mind. Varistors were added to the Power Distribution board to protect against voltage current spike. • **Implement Software Power Clamp Values:** We have implemented specific maximum and minimum voltage values for the AUV's thrusters in order to prevent 1 or more thrusters from drawing more power than required.
Undertrained Object Detection Model	Heightens discrepancy to the Gate and Slalom tasks. Visually obstructs attempts at the Torpedo, Gripper, and Dropper tasks.	• **Focused Model Training:** Utilized preselected symbols, provided by the Robosub 2026 handbook, to train computer vision models, resulting in an expected path that can be tested at pool tests. • **Compiling Robust Datasets:** Maximizing variation in training sets ingrained precision and accuracy into the vision model. Underwater images additionally aid rigor and preciseness regarding the detection of symbols in the expected environmental conditions.

Risk Area	Impact on Competition Strategy	Mitigation Plan
Inaccuracy In Automated Planner	AUV misaligns the perceived objective with the real objective, yielding tasks that are unordered or dysfunctional.	• **Rigorous Planner Testing:** Octagon, Bins, and Pinger pose difficulty to recreate; however, remaining tasks are replicated to assess the functionality of the automated planner. During testing, instant adjustments to the planner are fulfilled for the Gate, Slalom, Torpedo, and Return Home tasks, reducing potential errors at competition. • **Built-in Failsafes:** Internally, the planner contains programmed precautionary failsafes, to prevent the AUV from being unable to complete a task. Should the AUV be unable to detect a target in a set timeframe, it is programmed to return home & try again. In addition, sensor reading watchdogs can be toggled on to flag highly irregular AUV movement, reverting the planner to a reset/calibration function.