Technical Design Report of ARIEL, an AUV for RoboSub 2025

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***Abstract*—This paper presents the autonomous robotic instrument for exploration and learning (ARIEL), a fully student-designed and student-built autonomous underwater vehicle (AUV) developed by the Autonomous Navigation and Sensor Fusion Lab (ANSFL) at the University of Haifa. ARIEL was designed and fabricated with a dual purpose: competing in RoboSub 2025 and supporting marine research. The vehicle features a modular mechanical and electrical design, enabling easy integration of additional payloads. ARIEL operating frame is built on ROS2, is powered by an Nvidia Jetson Orin-Nano and controlled by the Pixhawk 2 flight controller. Its code is designed for robustness and simplicity in implementation. The software modules for perception, navigation, and control were tested iteratively for optimal performance. Additionally, a custom Gazebo simulation was built to allow parallel software development and mission rehearsals. This paper outlines the team's competition goals, strategic design decisions, testing methodology, and lessons learned from developing a reliable first-generation AUV.**

I. Introduction

ARIEL is a small two-person portable AUV, designed initially as a modular research platform to promote interdisciplinary marine and oceanographic research. The ARIEL team is led by a group of graduate students from the ANSFL at the Hatter Department of Marine Technologies, Charney School of Marine Sciences, University of Haifa. The team consists of eight M.Sc. and Ph.D. students, supported by the lab's engineer and mentored by the head of the lab.

ARIEL was fully designed and manufactured in-house. It is designed for quick deployment in the field for real-sea missions of up to a 100 meters depth. Its compact and modular design facilitates interdisciplinary marine research and reduces operational efforts. ARIEL is equipped with eight thrusters, four in the horizontal and four in the vertical planes respectively, thus enabling 6 degrees of freedom (6DoF). Such design enables wide range of application such as hovering.

Currently, the AUV's design is adjusted to compete in RoboSub 2025, therefore necessary payloads were added, such as the torpedo launcher. However, most payloads such as the inertial measurement unit (IMU), the Doppler velocity log (DVL), which are used for navigation [1] are integrated for both real-world missions and competition tasks.

ARIEL's mechanical and electrical designs are optimized for real-sea conditions, while its autonomy frameworks are currently adapted for RoboSub missions. As a first-time competitor, the team focuses on building a reliable, modular platform to establish a legacy design and gain expertise in marine engineering.

The rest of this paper is organized as follows: Section II describes the competition goals, Section III presents the competition strategy. Section IV describes in detail the design of ARIEL, in Section V the testing strategy is discussed, lastly the conclusions are presented in Section VI.

II. Competition Goals

ARIEL was designed not only for the RoboSub competition but also to serve as a research platform to support ongoing underwater robotics research in the lab. Given that this is our team's first time participating in RoboSub, our goals are intentionally modest and focused on building reliable core capabilities that can be expanded in future iterations. We aim to accomplish the following primary tasks:

- **Object identification and navigation:** ARIEL must identify gates and buoys, navigate toward them, pass through them and avoid obstacles autonomously. Our perception framework combines stereo vision and sonar data fused using an Extended Kalman Filter for robust detection and navigation.
- **Torpedo launch:** ARIEL must locate the target and launch a torpedo into a designated target hole. We plan to use vision-based targeting and a simple launch mechanism integrated with the main control system.
- **Dropping objects:**This task involves dropping items in specific marked locations using a servo-actuated dropper mechanism triggered by visual localization cues. Due to the difficulty of sequential localization over the target, we consider this task optional.

These goals will help us evaluate the performance of the integrated vehicle systems while laying the foundation for advancing ARIEL's capabilities in future competitions and research deployments.

III. Competition Strategy

As a first-time team, our strategic vision is focused on building a strong and reliable foundation for a legacy AUV. Therefore, early on we decided that our strategy for RoboSub 2025 should focus on maximizing points by focusing on reliability, simplicity, and deep integration between our mechanical, electrical, and software systems. This philosophy influenced every aspect of our vehicle design and mission planning.

A. Overall Philosophy

We prioritized creating a dependable, modular, and robust platform before attempting advanced missions. Our development process began with the mechanical and electrical build of the AUV to ensure structural integrity, proper buoyancy, and robust sensor and actuator integration. Only after this critical founding step was complete did we begin developing the software. Our software stack was developed in layers:

- **Low-level control:** First, direct interfaces for sensors and actuators were implemented to verify vehicle reliability and safety.
- **Mid-level architecture:** Next, navigation, perception, and control modules were implemented to allow the AUV to understand its environment and act accordingly.
- **High-level algorithms:** Finally, mission-level autonomy was developed. We evaluated each competition task according to difficulty, point value, and similarity to others. We intentionally selected tasks that share common requirements (e.g., object detection, basic navigation) to reuse code and maximize points with minimal complexity.

B. Task Prioritization

The competition tasks were prioritized by the following criteria:

1) **Similarity in technical requirements:** Tasks relying on shared capabilities (e.g., vision, movement) were grouped together.
2) **Difficulty:** Tasks that could be tested within our testing window were selected.
3) **Point value:** We selected tasks with favorable point-to-difficulty ratios.

C. Order of Attempt

The order in which the missions will be attempted is as follows:

1) **Collecting data:** Navigation and control – baseline for all tasks.
2) **Navigate the channel:** Simple object following – builds on Collecting Data
3) **Return home:** Simple object detection.
4) **Drop a BRUVS or perform tagging:** Attempt only if time permits; these tasks share object detection requirements but require greater precision.
5) **Ocean Cleanup:** Requires perception and minor control refinement and use of a gripper.

This ordering allowed us to build incrementally and thoroughly test, while reusing as much code and hardware configuration as possible.

D. Design Philosophy

Our design philosophy is based on the following principles:

- **Simple and proven technologies:** We chose components with strong documentation and community support.
- **Modular design:** Both hardware and software were designed in modular blocks to allow fast debugging, easy upgrades, and quick isolation of problems.
- **Fundamental capabilities first:** We ensured that the AUV could move, sense, and react reliably before investing in advanced behaviors.

E. Trade-Off Studies

In every major design decision, we weighed system complexity against reliability. For example:

- We opted for fewer sensors but ensured they were well-calibrated and thoroughly tested.
- A Pixhawk flight controller [2] was used rather than implementing a custom PID, to allow for simplify implementation.
- On the software side, we limited the number of autonomous behaviors and focused on making each one robust and testable in isolation.

These trade-offs allowed us to iterate faster and maintain a stable system throughout development.

F. Competition Strategy Conclusion

Our strategy as a new team is about establishing a strong functional baseline and executing a well-reasoned plan. By focusing on simplicity, re-usability, and testing, we aim to complete a core set of tasks, as described in Section II, confidently and score consistently, setting a strong foundation for future competitions.

IV. Design Strategy

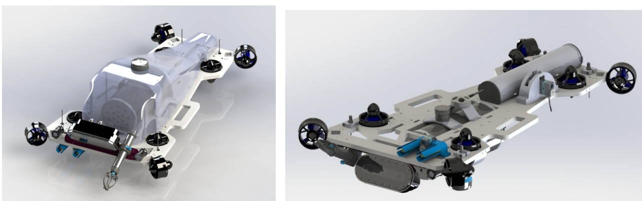
A. Mechanical Subystem

The overall shape of the vehicle is a rectangle shape with dimensions of $1024 \times 451 \times 220$ millimeter (mm). The required 0.5% buoyancy was achieved by first setting a neutral buoyancy using buoyant foam and adjustable weights, then the required bouncy was achieved by adding more buoyant foam. The vehicle's rectangular shape and motor configuration were chosen to provide stability, sufficient internal space, and enable easy handling in water.

The frame is constructed from Delrin, a strong, lightweight, and corrosion resistant plastic suitable for underwater use. All components are mounted to the frame using brackets and inserts, allowing modularity and ease replacement. The main hull houses the electronics, computing units, and sensors, while a secondary hull is dedicated to the battery.

Propulsion is provided by eight BlueRobotics T200 thrusters [3] placed at the frame corners. Four thrusters are placed in the horizontal plane and four in the vertical plane at a

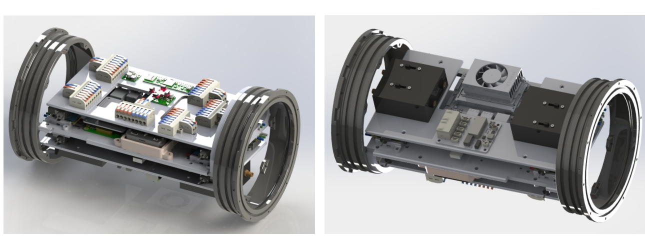
45 degrees angles from the frame side. This configuration provides full 6 DoF maneuverability, allowing the vehicle to move forward, backward, upwards, downwards, and rotate along all axes.
ARIEL is equipped with two Blue Robotics led light indicators [4] cast into perpetrators, which are located on the main pods, at the two ends. One light serves as a visual indicator that the Jetson receives a power supply, and the other indicates the battery status. A CAD model of the vehicle is shown in Figure 1.
The main pod is an aluminum hull with removable covers



(a) Front view (b) Back view

Fig. 1: ARIEL CAD-model figures. Figure 1a ARIEL from the front view, Figure 1b ARIEL the bottom view where the battery hull is visible.

by Blue robotics with a 1000 meters depth rating, its dimensions are $300mm$ in diameter and $150mm$ in length [5]. The main pod is organized into into three internal levels to keep components organized and accessible. The bottom level holds basic electronics, the middle level contains the Nvidia Jetson Orin-Nano [6], Pixhawk 2.4.8 flight controller [7], and Raspberry Pi [8]. The top level includes amplifiers for the Natako AquaHear 2.0 hydrophone [9] and the Ethernet switch by Blue Robotics [10]. This arrangement allows for efficient use of space and ease of maintenance. The internal mounting plates are custom designed and 3D printed in-house. The plates are equipped with inserts for screws to hold all the sensors and equipment in place.
In addition to the main pod, a second pod is dedicated to host the batteries. It is an aluminum hull by Blue Robotics with a 1000 meters depth rating, and its dimensions are $150mm$ in diameter and $400mm$ in length [5]. This pod ensures electrical isolation, safety, and ease of access during charging or replacement. Figure 2 shows the CAD model of the main pod front and back views.



(a) Main-pod Back-view (b) Main-pod Front-view

Fig. 2: Main-pod CAD-model views

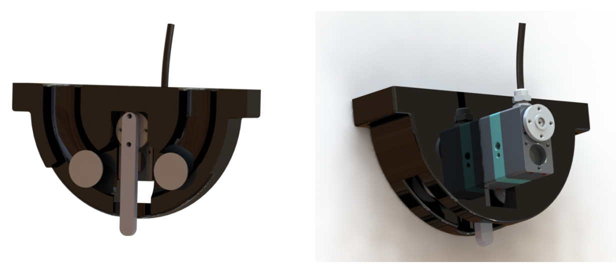
1) Gripper

ARIEL is equipped with the Newton Subsea Gripper from Blue Robotics as our underwater manipulator [11]. It is compact, lightweight, and specifically designed for underwater environments, making it ideal integration for the AUV. It provides one DoF (e.g. opening and closing) and integrates easily with the vehicle's control system. The gripper is shown in Figure 3.

Fig. 3: Blue Robotics Newton Subsea Gripper

2) Dropper

The dropper is a custom design and 3D-printed mechanism consisting of a half-cylinder chamber that holds two solid aluminum balls. An underwater servo with a short control arm operates the release mechanism: rotating the arm 45 degrees in one direction releases the first ball, while rotating it 45 degrees in the opposite direction releases the second. Figure 4 shows the dropper CAD model: the section view on the left displays the internal components, while the isometric view on the right shows the full assembly.



(a) Section of the dropper (b) Isometric view

Fig. 4: Dropper CAD-model views

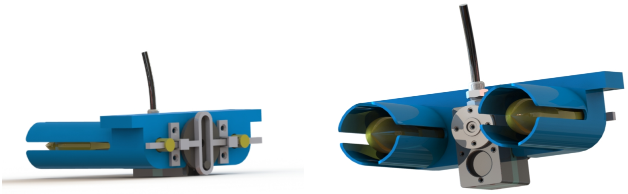
3) Torpedo

The torpedo launching mechanism was designed using an underwater servo and compression springs, with the goal of launching two torpedoes using only a single servo. To convert the servo's rotational motion into linear motion, a Scotch yoke mechanism was used. Each torpedo is held in place by a compression spring, then when the servo is rotated, the Scotch yoke converts its rotation into linear movement, releasing one torpedo at a time. Figure 5 shows the torpedo assembly CAD.

B. Electrical Subystem

1) Power System

The vehicle is powered by two high-capacity lithium polymer (LiPo) batteries [12], each rated for 14.8 V and 18 Ah,



(a) Front-view (b) Back view

Fig. 5: Torpedo CAD-model views

connected in parallel to provide a total capacity of 36 Ah at 14.8 V. This configuration ensures sufficient energy to power multiple thrusters, the onboard computer, and all sensors. Two step-down regulators are used to supply stable 5 V and 12 V rails for the computing hardware and peripheral sensors. The expected runtime is estimated to be over 4 hours under normal operating conditions, however, this has not yet been fully tested in the field. Fuses are also installed on the thrusters and central processing units to ensure safe operation.

2) Main Processing Unit

A Jetson Orin Nano [6] was used as the main onboard computer, running Ubuntu 20.04 with ROS2 Foxy as the primary operating system for mission-level autonomy, perception, and sensor integration. This module provides substantial parallel processing power, making it well-suited for real-time computer vision tasks and data fusion from multiple sensors. A Pixhawk 2.4.8 flight controller [2], equipped with ArduSub firmware version 4.5.1, was used to manage low-level control loops, actuator commands, and vehicle stabilization. The Jetson communicates with the Pixhawk via MAVLink over a serial connection, allowing for seamless integration of mission planning and low-level control. Such system architecture ensures robust integration between the Jetson and Pixhawk via USB, serial and Ethernet connection.

3) Sensors

The electrical system integrates multiple sensors, each serving a specific role in navigation, localization, and environment perception. The primary sensors are:

- **IMU and depth sensor:** Both provide the inertial and depth data for accurate underwater localization.
- **Doppler Velocity Log (DVL):** Supplies velocity information relative to the seabed.
- **Stereo camera:** Used for visual detection of gates, markers, and other competition elements.
- **Sonar:** Assists in obstacle detection and backup navigation in low-visibility conditions.

In addition to these primary sensors, there are several supporting hardware components, detailed in the component Table A in Appendix A A, such as an Ethernet switch for onboard communication, an altimeter, and lights for improved operation in low-visibility conditions. Most navigation sensors are combined using an Extended Kalman Filter (EKF) to improve the robustness and accuracy of the vehicle's state estimation. In case of sensor failure a backup approach is employed, for example, if camera-based vision fails due to turbidity or poor lighting, the sonar provides redundant obstacle detection and navigation capability.

4) Safety Features

To ensure operational safety, the electrical system includes multiple hardware and software kill switches that can immediately cut power to the thrusters in case of a malfunction or loss of control. An emergency surfacing mechanism is also implemented to return the vehicle to the surface if a critical system fault is detected or if the power system reaches a predefined low-voltage threshold.

To improve system safety and reliability, we implemented a fail-safe architecture using two Teensy 4.1 microcontrollers [13] Figure 6 connected to the Jetson via an I^2C interface. Each Teensy independently monitors two main parameters,

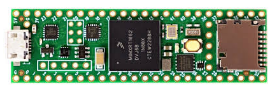


Fig. 6: Teensy 4.1 Development Board

first the pressure using a Blue Robotics Bar30 [14] high-resolution depth/pressure sensor, and the second the internal pod environmental data such as humidity, temperature and barometric pressure using a BME280 environmental sensor [15]. Both the Bar30 and BME sensors are shown in Figure 7a. These measurements ensure pressure data continuity

(a) Bar30 pressure sensor (b) BME280 atmospheric sensor

Fig. 7: Safety monitoring and fail-safe triggering Sensors

in the event of a sensor or microcontroller failure, and can be used to trigger automatic surfacing or shutdown procedures in case of out-of-range environmental readings. This fail-safe strategy ensures that in the event of communication loss, critical data failure, or out-of-bounds environmental readings, the system will execute the following:

- Immediately stop mission execution
- Trigger emergency surfacing
- Signal the kill switch if necessary

5) Kill Switch

A waterproof, pressure-rated mechanical switch is mounted externally on the vehicle backside on the batteries pod, this to allow immediate shutdown when needed. This external switch is connected to an internal switch in the batteries pod which cuts the power from the batteries to the main electronics pod. The switch is connected to a relay [16], as shown in Figure 8. The relay is connected in line with the battery power circuit, such that activating the kill switch immediately cuts or restores power to the AUV's main systems. This layered approach ensures redundancy and safe operation even in demanding underwater conditions.

Fig. 8: Automotive relay (Multicomp Pro MC25115) used in the kill switch circuit.

6) Electrical Integration

The electrical integration of the vehicle ensures reliable connections between all major subsystems, including power distribution, computing, and sensors. An overview of the entire electrical system layout can be seen in Figure 9 in Appendix B. All components are connected through a centralized wiring harness that routes power and data lines efficiently between the batteries, step-down regulators, Jetson module, Pixhawk flight controller, and sensors.

A clear cable management strategy was implemented to minimize clutter, reduce the risk of accidental disconnections, and facilitate maintenance. Wires are organized and secured along custom-designed mounting plates, with strain reliefs and waterproof connectors used where appropriate to maintain integrity in an underwater environment.

Electromagnetic compatibility was considered during the design phase. Power and signal cables are routed separately wherever possible to reduce interference, and shielding is applied to sensitive signal lines to mitigate noise from high-power thrusters and other electrical components.

C. Software Subsystem

This section provides a detail description of the software implementation architecture and design.

1) Overall Architecture

The software stack is built around the Robot Operating System 2 (ROS2) framework, enabling modularity, scalability, and real-time communication between components. The system architecture integrates ROS2 nodes written in Python using `rclpy`, alongside direct MAVLink communication through `pymavlink`. Custom ROS2 message packages facilitate communication between high-level autonomy nodes, control systems, perception, and hardware interfaces. Modules exchange data via ROS2 topics, services, and actions, with visualization and testing supported using RViz and QGroundControl. All ROS 2 topics are recorded using `ros2 bag` for post-mission analysis, with logs stored onboard and offloaded after each test. An overview of the software architecture is provided in Appendix A.

2) Real-Time Considerations

Critical control loops and sensor data streams (e.g., IMU, DVL, and depth) are prioritized using ROS 2 Quality of Service (QoS) profiles to ensure continues localization. Non-critical modules such as high-resolution camera logging and object tracking are decoupled to prevent interference with time-sensitive components.

3) Navigation

Navigation is handled by an Extended Kalman Filter (EKF) that fuses data from the IMU and DVL to provide robust state estimation [17]. Future implementation will include integrating the Bar30 pressure sensor and the stereo ZED2 [18] camera for higher navigation accuracy. The EKF is implemented via a custom node that continuously updates the vehicle's position and velocity estimates. When aiding sensors are unavailable or invalid, the system falls back on inertial dead reckoning using only IMU data and the Earth's gravitational models.

4) Perception

The AUV is equipped with a forward-facing stereo camera mounted at the front of ARIEL. This configuration enables depth-aware perception and robust 3D object localization. To overcome poor viability underwater, the underwater Blue Robotics led lights [19] were used to illuminate the camera field of view.

Object detection is performed using the YOLO v8 model, chosen for its balanced detection accuracy and computational efficiency. To detect objects such as the gate and marker, the model was trained using labeled images collected in controlled underwater environments.

Sonar data is integrated as a backup perception channel, particularly useful when vision fails. Planned future updates include object tracking and stereo-based 3D localization.

5) Control

Low-level control is performed using PID controllers for attitude stabilization and velocity regulation. Control outputs are sent to the Pixhawk, which executes motor mixing and actuator commands. Tuning was performed empirically to ensure smooth response in all degrees of freedom.

V. Testing Strategy

Testing and experimentation have been central pillars in the development of ARIEL. With limited time and resources, our team adopted a structured and iterative testing strategy to ensure the AUV performs reliably in the RoboSub 2025 arena. The testing process is divided into four overlapping phases: component-level testing, dry testing, pool testing, and simulation. Each phase targets specific validation goals and system metrics.

A. Phase 1: Component-Level Testing

This phase focuses on validating individual subsystems prior to full integration. Mechanical, electrical, and software components were tested independently to confirm the following core functionality:

- **Electrical testing** Bench testing of the power distribution board, battery, thruster control, and sensor communications.

- **Mechanical components** Assembly and vacuum test were carried out on the pressure hull, frame, and seals to simulate underwater pressure and integration.
- **Software modules** Unit tests of motor drivers, sensor interfaces, and safety logic in isolated ROS 2 environments using simulated inputs.
- **Sensor testing** Verification of IMU performance, depth sensor accuracy, and camera calibration under varied conditions.

Each test followed a defined test plan with measurable specifications, methods, and pass or fail criteria, ensuring traceability and repeatability.

B. Phase 2: Dry Testing

Following successful component verification in Section V-A, the following out-of-the-water (dry) testing were performed:

- All electrical subsystems were integrated on the frame and tested to validate end-to-end communication.
- Software-in-the-loop (SITL) simulations were connected to real hardware via ROS 2 to verify real-time behavior.
- Task-level autonomy such as object detection and waypoint execution was validated without the risks of underwater deployment.

C. Phase 3: Pool Testing

This is the most critical phase for RoboSub readiness. All systems were integrated, and mounted inside the pods, and then on the chassis for real underwater testing at a swimming pool with sufficient depth and maneuvering space. The following underwater test were tested:

- Hydrodynamic stability, buoyancy tuning, and thruster balancing were iteratively refined.
- Navigation and localization modules were calibrated and tested using predefined markers set by the team in the pool.
- Vision algorithms (e.g., object detection, color filtering) were validated using visual cues from those same elements under varying lighting and viewing angles.
- Autonomous missions were performed incrementally, beginning with simple waypoints and progressing to the full pre-qualification round.

After each pool test the data logs were reviewed to tune the overall sensor and autonomy performance.

D. Simulation Testing

A custom-built ROS 2 Gazebo simulation environment was utilized to test in parallel to the physical test, early software development, stress testing, and parallel code integration were performed in the simulation. The simulation objectives and case usage are as follows:

- Validate motion planning and recovery behaviors.
- Simulate depth, vision, and navigation inputs for software testing.
- Test edge cases such as sensor dropouts and localization failures.
- Execute full mission scenarios in a virtual RoboSub pool with multiple obstacles.

Simulation also allowed testing in conditions not yet accessible physically, accelerating mission-readiness during hardware downtime.

VI. Conclusion

ARIEL represents the first fully student-built AUV from the University of Haifa to compete in RoboSub. Over the past year and a half, the team designed, manufactured, and integrated the vehicle entirely in-house, creating a robust and modular system capable of both research and competition tasks. The development process emphasized reliability, simplicity, and re-usability - principles that guided all engineering decisions. A structured testing approach, combining dry runs, pool sessions, and a custom-built simulation, enabled rapid iteration and validation of mission-critical functions. As ARIEL enters RoboSub 2025, the team's focus is on evaluating performance, identifying areas for improvement, and continuing to build a platform that supports both academic research and future competition cycles. This work lays a strong foundation for advancing AUV capabilities at the Autonomous Navigation and Sensor Fusion Lab and building a legacy for future student teams.

VII. Acknowledgments

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APPENDIX A
COMPONENT LIST

Component	Vendor	Model/Type	Specifications	Custom/ Purchased	Cost (USD)	Year of Purchase
Buoyancy Control	Blue Robotics	R-3318	Density 288 kg/m^3, depth rated 300m	Purchased	380	2019
Frame	Designed In-House	Delrin	7 kg	Custom	350	2025
Waterproof Housing	Blue Robotics	Waterlight Enclosure	75 mm x 400 mm + small one, aluminum	Purchased	417	2024
Waterproof Connectors	Blue Trail Engineer	Cobalt Series	8 pin connector	Purchased	160	2024
Thrusters	Blue Robotics	T200	3.71 / 2.92 kgf, 8 pieces	Purchased	200 each	2024
Fans	Aliexpress	DC4010-5V x5	2 pieces	Purchased	0.29 each	2024
Servo	Full Depth Technology Co., Ltd.	D060-EDU	Torque 2–6 N·m, depth 100m, 5–8.4V, 270°, aluminum casing	Purchased	380	2025
Sonar	Blue Robotics	Ping360	50m range	Purchased	2750	2024
Gripper	Blue Robotics	Newton Subsea Gripper	Length: 309.2 mm, Grip Force: 124N	Purchased	680	2025
IMU	SBG	Ellipse-N2	Rugged, IP68 rated RTK GNSS/INS	Donation	Legacy	2024
DVL	Water Linked	A50	300m rated	Purchased	7890	2025
Camera	StereoLabs	ZED 2	1080p @30fps	Purchased	Legacy	2024
Hydrophones	Natako	Aquahear 2.5	1kHz to 46kHz	Purchased	200	2025
Humidity + Pressure Sensor	Bosch	BME280 x5	0–100% RH, 300–1100 hPa, 1s response time	Purchased	36 each	2024
Altimeter	Blue Robotics	Ping Altimeter	Range: 0.3–100 m	Purchased	Legacy	2024
Pressure Sensor (Low)	Blue Robotics	Bar30	–	Purchased	85	2024
Leak Sensor	Blue Robotics	SOS Leak Sensor	3.3–5V, 20 mA draw	Purchased	35	2024
Motor Control	Blue Robotics	Basic ESC	30A	Purchased	38	2024
High-Level Control	Pixhawk	2.4.8	Size: 110x145x18 mm	In-house	0	2021
Battery	Blue Robotics	Lithium-ion 18Ah	14.8V, 18Ah	Purchased	480	2024
Battery	Blue Robotics	Lithium-ion 18Ah	14.8V, 18Ah	Purchased	Legacy	–
Converter	Pololu	S13V30F5 x2	2.8–22V input, 5V 3A output	Purchased	20 each	2024
GPU + CPU	NVIDIA	Jetson Orin Nano	Six 2GHz ARM cores	Purchased	632	2024
Internal Comm Network	–	Ethernet / UART / I2C	–	–	–	–
External Comm Interface	–	Ethernet	–	–	–	–
Vision Algorithm	–	YOLO v8	Part of ZED2 system	–	–	–
Localization	–	EKF	Custom	–	–	–
Autonomy	–	State Machine	Probabilistic state machine, in-house design	–	–	–

Component	Vendor	Model/Type	Specifications	Custom/Purchased	Cost (USD)	Year
Open Source Software	–	OpenCV, ROS, YOLO v8	–	–	–	–
Inter-Vehicle Comm	–	Ethernet / UART / I2C	–	–	–	–
Programming Languages	–	C++, Python	ROS2-based	–	–	–

Appendix B
Electrical Components Overview

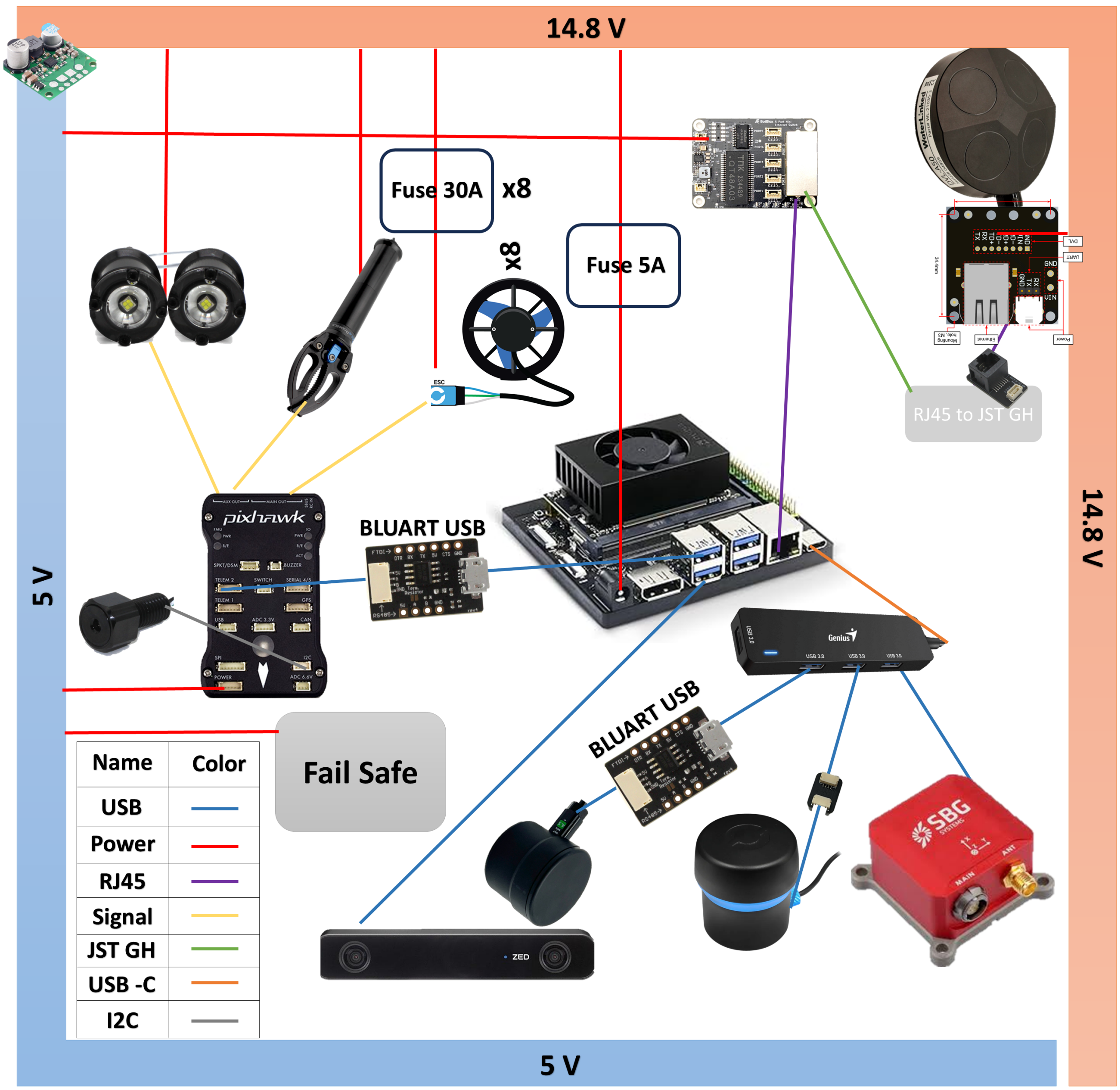

Fig. 9: Overview diagram of the AUV electrical system integration, showing subsystems, power rails, communication interfaces, and fuse protections.

Appendix C
Algorithm Flowcharts

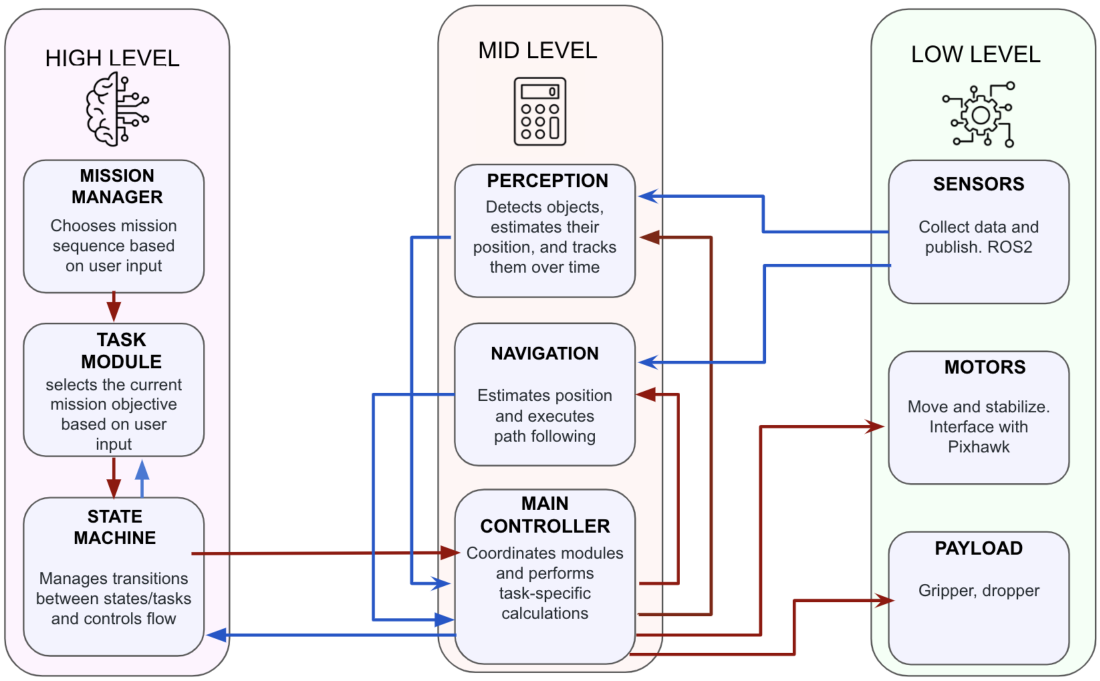

Fig. 10: Software Overview Architecture

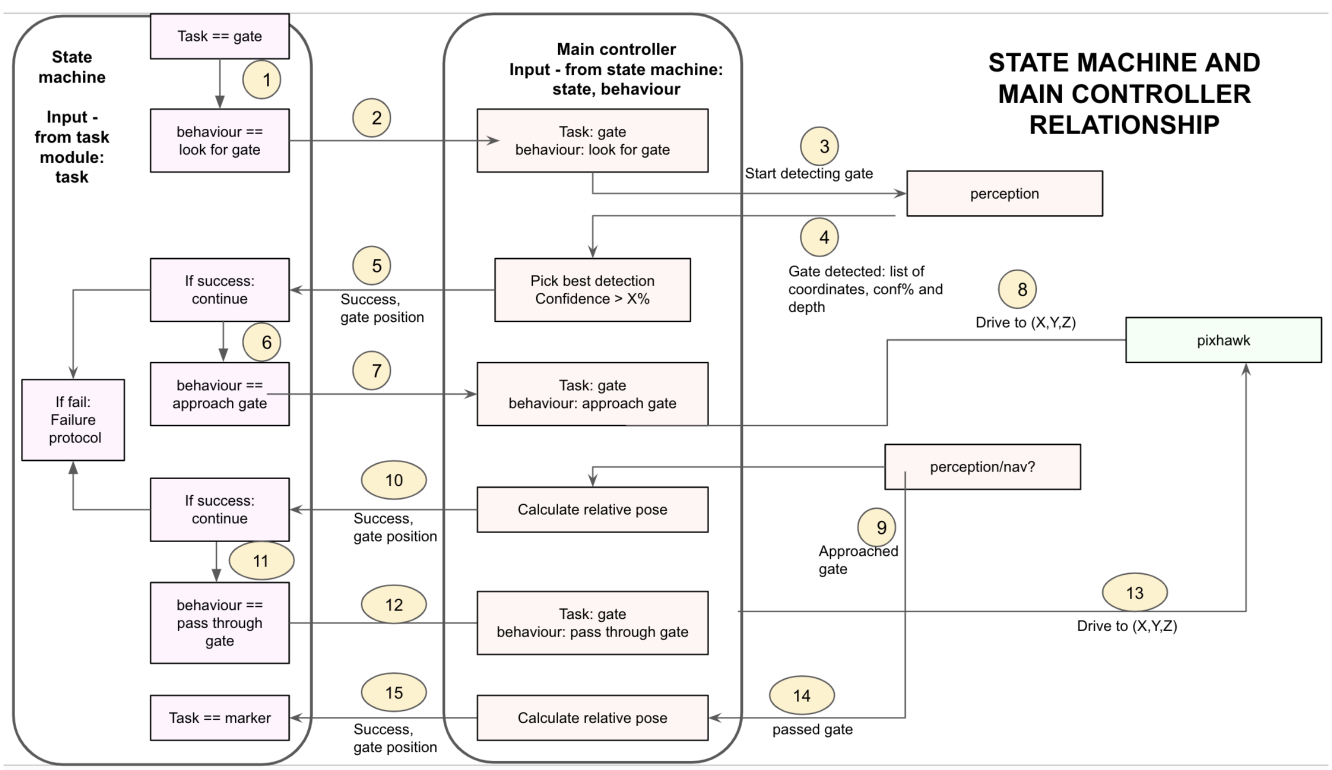

Fig. 11: State Machine and Mission Control Architecture

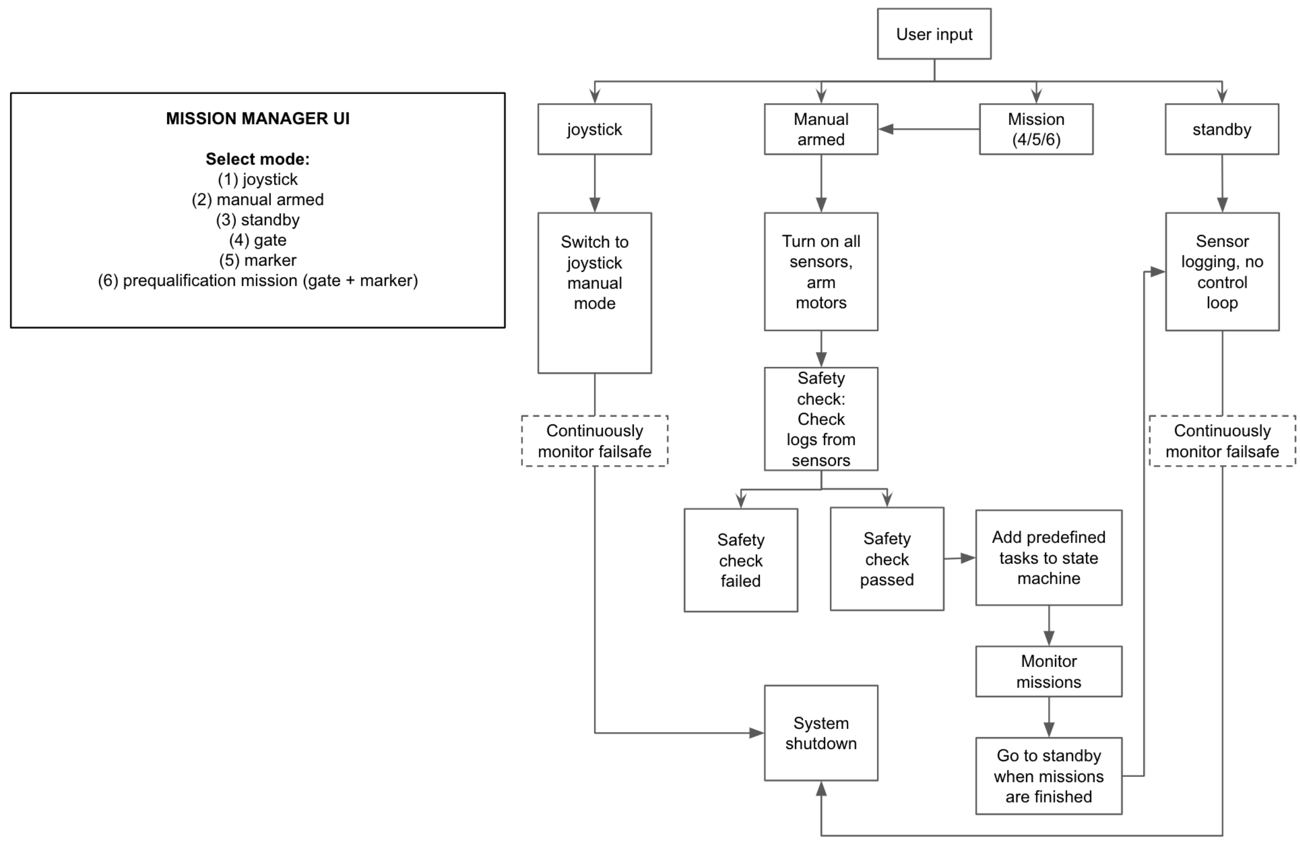

Fig. 12: Mission Manager Architecture