EGH400 Project Proposal: Scope of Work

Development of a Small-Scale Underwater Remotely Operated Vehicle (ROV)

Faculty of Engineering

September 2, 2025

Unit Code:	EGH400 - Research Project 1
Assessment:	#1 - Project Proposal
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This proposal is submitted in partial fulfilment of the requirements for EGH400.

Contents

Acronyms

AUV Autonomous Underwater Vehicle. 3–5

CAD Computer-Aided Design. 5

CFD Computational Fluid Dynamics. 5

DOF Degrees of Freedom. 2, 5

GUI Graphical User Interface. 6, 7, 9

IMU Inertial Measurement Unit. 3

ML Machine Learning. 1, 4–7

PID Proportional-Integral-Derivative. 4, 6

QUT Queensland University of Technology. 1, 5, 8

ROS Robot Operating System. 4

ROV Remotely Operated Vehicle. 1, 3–7, 9

1 General Objective

This project aims to address a gap in the availability of small-scale, research-grade Remotely Operated Vehicle (ROV) platforms by designing, developing, and validating a small scale underwater ROV. The primary objective is to create a fully operational vehicle for use in Queensland University of Technology (QUT) demonstrations and as a testbed for novel Machine Learning (ML) control pipelines. The research will investigate hardware and software solutions that enable robust functionality in a compact form factor, a challenge not fully addressed by larger, commercially available systems or existing white papers.

2 Literature Review

2.1 Introduction

Unmanned Underwater Vehicles (UUVs) have become indispensable tools for a vast range of applications, including oceanographic surveys, infrastructure maintenance, and military defence [9, 22]. As technology has advanced, these vehicles have evolved from simple teleoperated platforms into complex autonomous systems capable of executing sophisticated missions [9]. However, the literature reveals that a significant portion of research and commercial development has focused on large-scale, work-class vehicles or highly specialised Autonomous Underwater Vehicles (AUVs), which are often financially and logistically inaccessible for educational institutions or rapid prototyping research [25]. This is due to the cost of setting up demonstrations with large scale ROV and larger ROV designs call for larger scale prototyping solutions which may not be realistic. This has created a gap for small-scale, low-cost, and modular ROV platforms that are not only suitable for demonstration but are also powerful enough to serve as testbeds for advanced control and perception algorithms. The aim of this review is to explore the current state-of-the-art in small-scale ROV design by analysing key themes in existing literature, thereby identifying best practices and informing the design methodology for a novel research platform. which are often financially and logistically inaccessible for educational institutions or rapid prototyping research [25]. This is due to the cost of setting up demonstrations with large scale ROV and larger ROV designs call for larger scale prototyping solutions which may not be realistic. This has created a gap for small-scale, low-cost, and modular ROV platforms that are not only suitable for demonstration but are also powerful enough to serve as testbeds for advanced control and perception algorithms. The aim of this review is to explore the current state-of-the-art in small-scale ROV design by analysing key themes in existing literature, thereby identifying best practices and informing the design methodology for a novel research platform.

2.2 Methodology and Scope

The literature review was conducted using a systematic approach, focusing on peer-reviewed journal articles, conference papers, and technical reports from the last decade. The search was primarily conducted using the database IEEE Xplore, with keywords including "small-scale ROV", "underwater vehicle design", "ROV control systems", and "modular underwater robotics". The review is structured to cover key design themes, hardware and software selections, control system architectures, and system modelling approaches, providing a comprehensive overview of the current state of small-scale ROV research. The scope of this review is limited to reviewing current literature on ROV design methodology and hardware selections. It is important to consider that methodology on improving autonomy algorithms, underwater communication, underwater vision processing pipelines and control modeling are valid current gaps that could be explored in future work.

2.3 Key Design Themes

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2.5 Key Design Themes

2.5.1 Chassis and Mechanical Design

The physical architecture of an ROV is a foundational design choice that dictates its hydrodynamic performance, modularity, and durability. The literature presents a clear dichotomy between open-frame and enclosed, torpedo-style chassis designs.

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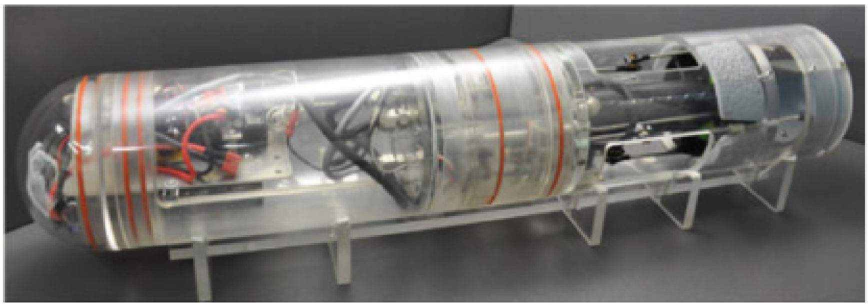
Open-frame designs, such as those seen in the KCROV [8], MarmaROV [24], and eROV [7], are praised for their modularity, allowing for easy mounting of sensors, payloads, and thrusters. This configuration simplifies maintenance and is highly adaptable for research platforms. In contrast, streamlined, enclosed hulls are often selected to minimise hydrodynamic drag for greater efficiency and speed, as demonstrated by the MASUV-1 [14] and X4-ROV [29].

The thruster configuration is critical for maneuverability, with designs ranging from underactuated 3-thruster systems providing basic 3-Degrees of Freedom (DOF) motion [27], to fully actuated 6 or 8 thruster systems enabling full 6 DOF control [16, 18]. The placement of thrusters in a vectored arrangement is common for achieving high agility, allowing for coupled control of surge, sway, and yaw from a set of horizontal thrusters [12, 25]. Figure 3 illustrates the impact of different thruster orientations on maneuverability, highlighting the trade-offs between simplicity and control complexity. Having a vectored thruster arrangement allows for more maneuverability with a smaller form factor. It is seen in figure 3, that the orientation of the upward facing thrusters can significantly impact the vehicles ability to roll and pitch efficiently. This makes the amount and orientation of thrusters a key consideration as the goal for the QUT demonstration ROV is to have a small form factor, while still being able to perform complex maneuvers.

2.5.2 Material Selection and Waterproofing

Material selection directly impacts the vehicle's weight, durability, and operational depth. For low-cost educational platforms like the ArduinoSub and the vehicle proposed by Anwar et al. [5], PVC and acrylic are common choices due to their affordability and ease of fabrication. For more robust applications, designs progress towards aluminium frames and hulls [8, 22], with high-performance vehicles intended for deep-sea operation employing materials like carbon fibre and syntactic foam to achieve high strength-to-weight ratios [15].

(a) Open-frame chassis (eROV)[7]



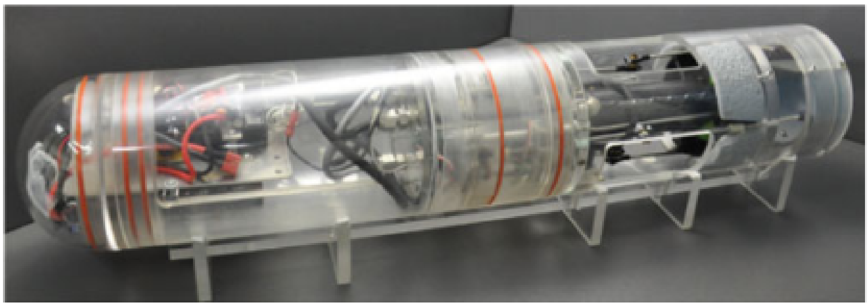
(b) Enclosed hull design (MASUV-1)[14]

Figure 1: Examples of ROV chassis designs: (a) open-frame and (b) enclosed hull

Waterproofing remains a critical and persistent challenge. Standard solutions include O-ring seals for static enclosures and potted cable penetrators [18]. However, the literature presents several innovative approaches to overcome the limitations of these methods. The Jeff Autonomous Underwater Vehicle (AUV) uses a novel non-penetrative magnetic coupling to transmit torque from internal motors to external propellers, completely eliminating the need for a dynamic shaft seal [19]. The design by Tang et al. [23] also highlights custom-developed connectors as a significant improvement over permanently potting electronics, allowing for easier maintenance and repair.

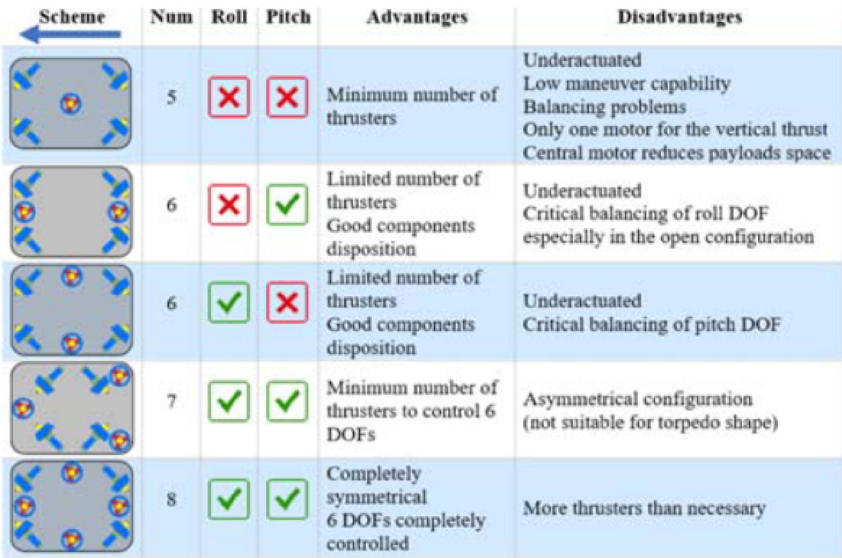
For the QUT demonstration ROV, waterproofing will be a key challenge due to its small form factor. The best method seen in multiple designs is the use of a water tight acrylic enclosure with O-ring seals on the ends. This allows for electronics to be bundled and waterproofed in a single enclosure, with waterproof connections to thrusters and sensors. The next key consideration is ensuring all electronics like sensors, thrusters and electronic speed controllers are waterproofed, as these are exposed and vulnerable to water damage. Conclusive and reliable testing of the waterproofing techniques will be required before any ROV design is submerged in water.

(a) Open-frame chassis (eROV)[7]



(b) Enclosed hull design (MASUV-1)[14]

Figure 2: Examples of ROV chassis designs: (a) open-frame and (b) enclosed hull



Scheme	Num	Roll	Pitch	Advantages	Disadvantages
	5	✗	✗	Minimum number of thrusters	Underactuated Low maneuver capability Balancing problems Only one motor for the vertical thrust Central motor reduces payloads space
	6	✗	✓	Limited number of thrusters Good components disposition	Underactuated Critical balancing of roll DOF especially in the open configuration
	6	✓	✗	Limited number of thrusters Good components disposition	Underactuated Critical balancing of pitch DOF
	7	✓	✓	Minimum number of thrusters to control 6 DOFs	Asymmetrical configuration (not suitable for torpedo shape)
	8	✓	✓	Completely symmetrical 6 DOFs completely controlled	More thrusters than necessary

Figure 3: Comparison of different thruster orientations and their impact on maneuverability.[20]

2.5.3 Hardware Selections

Propulsion and Sensing. The choice of thrusters and sensors is dictated by the vehicle's mission profile and budget. Propulsion systems range from modified low-cost($50) bilge pumps in budget designs [21] to commercially available, high-performance brushless DC thrusters like the BlueRobotics T200($350 per unit), which are noted for their power and reliability [7, 12]. Sensor suites vary significantly; educational kits may only include a basic Inertial Measurement Unit (IMU) and a camera [25], while advanced research platforms like EVA and Mesobot are equipped with a comprehensive array of high end high-cost sensors, including Doppler Velocity Logs (DVLs) for measuring velocity relative to the seafloor($12,500), USBL positioning systems for underwater localization($3000), and high-resolution waterproofed cameras for visual navigation($300) [17, 28]. The choice of thrusters and sensors is dictated by the vehicle's mission profile and budget. Propulsion systems range from modified low-cost($50) bilge pumps in budget designs [21] to commercially available, high-performance brushless DC thrusters like the BlueRobotics T200($350 per unit), which are noted for their power and reliability [7, 12]. Sensor suites vary significantly; educational kits may only include a basic IMU and a camera [25], while advanced research platforms like EVA and Mesobot are equipped with a comprehensive array of high end high-cost sensors, including Doppler Velocity Logs (DVLs) for measuring velocity relative to the seafloor($12,500), USBL positioning systems for underwater localization($3000), and high-resolution waterproofed cameras for visual navigation($300) [17, 28].

Control Hardware. The selection of onboard electronics reflects a trade-off between cost, computational power, and development complexity. At the low-cost end of the spectrum, microcontroller based systems are prevalent. The D20-ROV and ArduinoSub, for instance, use an Arduino Mega 2560 as the central brain, which is sufficient for basic manual control and sensor interfacing [4, 27]. For more advanced capabilities, single-board computers like the Raspberry Pi are frequently adopted, as seen in the BlueRov2 and PolROV designs, providing a Linux-based environment capable of handling networking, video streaming, and more complex algorithms [12, 13]. High-performance vehicles designed for significant autonomy, such as EVA and Mesobot, employ multi-computer architectures with powerful CPUs and dedicated GPUs (e.g., Nvidia Jetson TX2) to process large volumes of sensor data in real-time [17, 28].

ML and object recognition capabilities are becoming less resource intensive as algorithms improve, however powerful hardware is still required to run these algorithms. This becomes quite a key consideration as a powerful computer is now required on the small ROV. This sets design requirements like minimum size, power and cooling requirements, along with the need for a robust software stack to run the ML algorithms.

2.5.4 Software and Communication Frameworks

The software stack and communication architecture are integral to the ROV's functionality. For complex, modular systems, the Robot Operating System (ROS) is the framework of choice, as seen in the Autonomous ROV for Marine Growth and the EVA hybrid vehicle [16, 17]. ROS is valued for its extensive libraries, hardware drivers, and robust inter-process communication, which significantly accelerates development time. On simpler platforms, custom firmware is often developed in C++ within the Arduino IDE or using Python on a Raspberry Pi [25]. Open-source firmware like ArduSub, used in the VITA1 prototype, provides a powerful and well-supported alternative to developing a control system from scratch [11].

Communication is almost universally handled via a physical tether for ROVs, which provides both power and a high-bandwidth data link. This link is typically Ethernet over twisted pairs, though high-end systems may use fibre optics for greater bandwidth and distance [15]. Hybrid AUV/ROV systems like EVA and

Mesobot feature multiple communication methods, including acoustic modems for low-bandwidth untethered command and control, and Wi-Fi or RF links for high-speed data transfer when surfaced [17, 28]. For this project, leveraging an existing framework like ROS or ArduSub could significantly reduce development time and increase reliability, as these frameworks come with extensive documentation and community support. However, a custom software stack based in a language like python may be necessary to meet specific as these frameworks come with extensive documentation and community support. However, a custom software stack based in a language like python may be necessary to meet specific project requirements or to optimize performance for the unique hardware configuration like acoustic communication or sensor integration. For smaller scale ROVs, a lightweight framework or even a bare-metal approach may be more appropriate to minimize resource usage and complexity.

2.5.5 Control System Architectures

Control strategies for underwater vehicles have matured from direct teleoperation to sophisticated autonomous behaviours [27]. The foundational control method discussed in much of the literature is the Proportional-Integral-Derivative (PID) controller, used for fundamental tasks like depth-hold and heading-hold in vehicles such as the PolROV and Ariana-I [13, 18]. These controllers are well-understood and relatively simple to implement. However, due to the highly non-linear dynamics of underwater vehicles, more advanced techniques are often required for robust performance, especially in the presence of external disturbances like currents [27]. To address this, some designs implement Sliding Mode Control (SMC) for its robustness to parameter uncertainties [27], or Fuzzy Logic controllers which do not require a precise mathematical model of the system [10]. The Kambara AUV represents the cutting edge, employing model-free reinforcement learning to allow the controller to learn the vehicle's dynamics through trial and error, avoiding the need for an explicit model altogether [26].

2.5.6 System Modelling Approaches

The development of a control system is often preceded by system modelling to simulate and predict the vehicle's behaviour. A key distinction in the literature is the approach taken to derive this model. Many research-grade projects, such as the eROV and the spherical AUV by Zavari et al. [30], develop a comprehensive 6-DOF dynamic model from first principles. This process involves using Computer-Aided Design (CAD) software to determine rigid-body parameters (mass, inertia) and Computational Fluid Dynamics (CFD) simulations to estimate hydrodynamic coefficients (drag, added mass) [7, 12]. This model-based design allows for extensive simulation and controller tuning before physical construction. An alternative, empirical approach is system identification, where experimental data from a physical prototype is used to derive a transfer function model. This was successfully demonstrated by Aras et al. [6] for the UTERG-ROV2, providing an accurate model for depth control without complex theoretical analysis. The choice of modelling approach represents a trade-off between theoretical rigour and the practicalities of physical testing.

2.6 Conclusion

The review of existing ROV designs highlights a clear and consistent set of themes and trade-offs. Design choices regarding chassis, materials, and thruster configuration are heavily influenced by the vehicle's intended mission, balancing modularity against hydrodynamic efficiency. The selection of hardware and software follows a similar pattern, scaling from simple microcontrollers for educational kits to powerful, networked computers for autonomous research platforms. The literature demonstrates that while numerous solutions exist for large-scale or highly specialised vehicles, there remains a significant gap for a small-scale, low cost platform that is both modular and computationally equipped for modern ML research. The findings from this review directly inform the proposed methodology for this project.

3 Stakeholders & Resources

3.1 Stakeholders

The stakeholders for this project are identified in the table below. Regular updates will be provided to the supervisor, with final outcomes presented to the QUT engineering faculty.

Table 1: Project Stakeholders

Stakeholder	Interest / Role
Project Supervisor	Provides technical guidance, assesses progress, ensures academic rigour.
QUT Faculty of Engineering	End-user of the ROV for demonstrations and future student projects.
Future EGH400 Students	Potential users of the ROV as a platform for software/control projects.
Technical Staff	Provide access to workshops and advice on fabrication.

3.2 Resources

Successful completion of this project requires the following resources:

- **Lab Access:** Access to QUT's electronics and fabrication labs for assembly and testing.
- **Funding:** A project budget for purchasing components (thrusters, sensors, electronics, frame materials).
- **Software:** MATLAB/Simulink for control system modelling, and Python for ML pipeline development.
- **Testing Facilities:** A water tank or pool for vehicle testing and validation.
- **Existing Hardware:** A standard BlueROV2 for benchmarking and scale comparison.

4 Project Methodology

The project will follow a systems engineering approach, beginning with a detailed design phase informed by the literature review, followed by iterative prototyping and testing.

4.1 Design Choices

The mechanical and electrical design will focus on modularity and miniaturisation. Key decisions will involve:

- **Frame and Materials:** After reviewing existing designs, a mix of a open chassis for mounting sensors and thrusters, and a waterproofed acrylic enclosure for electronics will be selected. the material used for the open chassis will be aluminum item [3], due to its strength and light weight, while the acrylic enclosure will picked from BlueRobotics's section of enclosures[1]. To ensure the correct size and weight for slightly positive buoyancy, current designs use buoyancy foam. This approach will also be used with 3D printed dichtol[2] coated PLA mounts for foam, thruster and sensor mounting. A area below the ROV will be left for a general mount solution for future sensors and payloads.

- **Autopilot:** To interface with Thrusters and any additional standard sensors, a Pixhawk 6 will be used. This small device will allow for thruster configuration and contains a IMU for orientation data and barometer for depth control. The Pixhawk 6 will run PX4 which is a open source autopilot software that will allow for easy integration with the Graphical User Interface (GUI) and ML pipelines. This will simplify the control system development and allow for future users to work with industry standard software.

- **Computing:** The companion computer to communicate with ground stations, process image data and run path finding algorithms will be a pi 5. This is the latest Raspberry Pi model and has enough processing power to run a basic ML pipeline for object detection and classification. The Pi 5 also has well documented support for PX4 communication and the possibility to run ROS2 for future control methods.

- **Additional hardware:** Additional hardware includes batteries for 1 hour operation time, a raspberry pi camera module 3 for image data, a power management board to control power, a kill switch for safety, A light for the camera to ensure viability, a module like fathom-x [1] for wired communication and a audio based module for wireless communication.

- **Thrusters:** The choice of thruster will be the widely used BlueRobotics T200 thrusters[1]. These are a well documented and widely used thruster that will allow for easy integration with the Pixhawk 6. The T200 thrusters are also waterproofed and have a good thrust to weight ratio.

4.2 Control System Development

The control system will be developed in stages:

- **PX4 Intergration and Setup:** Configure the Pixhawk 6 with the T200 thrusters and basic sensors (IMU, barometer) to establish a stable control loop for depth and orientation.

- **Sensor Integration:** Gradually integrating sensors (Audio, tether, camera, light) into the control loop to enhance stability and performance.

- **Crude Simulation:** Using MATLAB/Simulink or Engine based simulations to simulate the ROV's dynamics and validate the control system/design before physical testing.

4.3 Testing and Validation

Testing will be conducted in a controlled environment (e.g., QUT's water tank) to validate the ROV's performance against design specifications. The testing phases will include:

- **Static Tests:** Verifying waterproofing and basic electronics functionality.

- **Dynamic Tests:** Assessing maneuverability, depth control, and sensor data reliability in a controlled water environment.
- **Performance Metrics:** Collecting data on depth rating, speed, and stability to compare against design expectations.
- **Autonomy Pipeline:** Developing a basic automation routine which employs the use of ML models for object detection and classification, using the camera feed and sensor data.

5 Deliverables

The key deliverables for this project are:

1. A fully assembled and operational small scale underwater ROV.
2. A complete set of CAD drawings and electrical schematics.
3. The control system software, including a basic GUI for manual operation.
4. A set of performance metrics demonstrating the ROV's capabilities, including depth rating, maneuverability, and sensor data reliability.
5. A basic automation pipeline for ML model training and inference, including a basic dataset of sensor readings and control actions.
6. A final project report detailing the design, methodology, and results, in line with professional engineering standards.
7. Interim status reports to the project supervisor as required.

6 Quality & Sustainability

6.1 Quality

The quality of the final deliverable will be validated against a set of performance criteria:

- **Maneuverability:** The ROV must demonstrate stable control in all degrees of freedom.
- **Depth Rating:** The main electronics enclosure must remain watertight at a target depth of $10\,\mathrm{m}$.
- **Functionality:** The camera feed and all sensor data streams must be reliable and accessible via the control GUI.

Quality will be checked at each milestone through supervisor reviews and adherence to design documentation.

6.2 Sustainability

Sustainability will be considered through:

- **Life Cycle:** Designing for modularity and repairability to extend the ROV's operational life for future cohorts.

- **Materials:** Where possible, using recyclable materials like PETG for 3D-printed components.
- **Knowledge Transfer:** Producing comprehensive documentation to ensure the project's findings and design are sustainable and can be built upon in the future.

7 Risks, Requirements & Constraints

7.1 Constraints

- **Time:** The project must be completed within the 280-hour allocation for EGH400.
- **Safety:** All work must comply with QUT's lab safety policies and procedures.
- **Testing Area:** The testing area required for the final product is large(pool or aquarium) and will need to be sourced and used safely.

7.2 Risks

The following key risks have been identified. Mitigation strategies will be actively managed. A risk assessment has been completed for use of laboratories/workshops and future testing in water, this can be found in the appendix.

Table 2: Project Risk Assessment

Risk	Likelihood & Consequence	Mitigation Strategy
Waterproofing Failure	High likelihood, High consequence (equipment damage)	Iterative pressure testing of all enclosures before full system integration. Use of redundant seals.
Component Delays	Medium likelihood, Medium consequence (timeline impact)	Order critical components early. Identify alternative suppliers for key parts like thrusters and sensors.
Software Integration	High likelihood, Medium consequence (timeline impact)	Develop and test software modules independently before integration. Use version control (Git).
High Speed Prop Safety	Medium likelihood, High consequence (injury)	Implement safety guards around propellers. Ensure there is a clear risk assessment in place and there is a exclusion zone when tests occur. Use low-voltage, low-current thrusters to minimize risk.
Electronic Safety and Use	Low-Medium likelihood, High consequence (injury)	Ensure all electronics are properly insulated and waterproofed.Ensure safety equipment is used when soldering and batteries are stored and used inline with the consumer guidelines. Follow QUT's lab safety policies.

8 Timeline & Deliverables

The project is scheduled over two semesters (EGH400-1 and EGH400-2), totalling approximately 280 hours.

Milestone	Focus	Deliverable(s)	Due Date
1	Literature Review & Planning	Project Proposal (this document)	Week 7
2	Conceptual & Detailed Design	Complete CAD models, electrical schematics, bill of materials	Week 10
3	Component Procurement	All essential hardware ordered and received	Week 11-12
4	Electronics Integration	Electronics installed and basic power-on tests completed	Week 12-Sem1,Week 1
5	Frame & Enclosure Assembly	Assembled mechanical frame and waterproofed enclosures	Semester 1, Week 4-5
6	Software & Control System	Basic manual control software functional	Semester 2, Week 5-9
7	System Testing & Validation	Full system wet-testing, performance validation	Semester 2, Week 9-12
8	Final Reporting	Draft Final Report, Final Report, Oral Presentation	Semester 2, Wk 12-13

9 Management of Project Changes

Any requested changes to the project scope by the supervisor or other stakeholders will be formally managed. A change request will be documented, outlining the nature of the change, its impact on the timeline and resources, and the reason for the change. This document will be reviewed with the supervisor before any new work is undertaken. This scope of work will be updated to reflect any approved changes, and version control will be maintained.

10 Sign off

By signing below, the Student Engineer agrees to undertake the project as outlined in this Scope of Work.

02/09/25

STUDENT ENGINEER **DATE**

References

[1] (2014). Blue robotics - rov and marine robotics systems and components.

[2] (2025a). dichtol am hydro - metall-polymer-systeme: höchste qualitäät von diamant.

[3] (2025b). item | modular components & aluminum profiles mechanical engineering.

[4] Ali, A. F. and Arshad, M. R. (2017). Design and development remotely operated vehicle for anode ship hull inspection. In *2017 IEEE 7th International Conference on Underwater System Technology: Theory and Applications (USYS)*, pages 1–5.

[5] Anwar, B. M. M., Ajim, M. A., and Alam, S. (2015). Remotely operated underwater vehicle with surveillance system. In *2015 International Conference on Advances in Electrical Engineering (ICAEE)*, pages 255–258.

[6] Aras, M. S. M., Azis, F. A., Teck, L. W., Abdullah, S. S., and Rahman, A. F. N. A. (2015). System identification of a prototype small scale rov for depth control. In *2015 10th Asian Control Conference (ASCC)*, pages 1–6.

[7] Binugroho, E. H., Sanggar Dewanto, R., and Pramadihanto, D. (2018). erov: Preliminary design of 5 dof rov using 6 thrusters configuration. In *2018 International Electronics Symposium on Engineering Technology and Applications (IES-ETA)*, pages 281–287.

[8] Choi, H., Chung, S., Park, H., and Seo, J. (2012). Design and control of a convertible rov. In *2012 Oceans - Yeosu*, pages 1–7.

[9] Coccolo, E., Delea, C., Steinmetz, F., Francescon, R., Signori, A., Au, C. N., Campagnaro, F., Schneider, V., Favaro, F., Oeffner, J., Renner, B.-C., and Zorzi, M. (2023). System architecture and communication infrastructure for the robovaas project. *IEEE Journal of Oceanic Engineering*, 48(3):716 – 739. Cited by: 14.

[10] Jayasundere, N. and Gunawickrama, S. (2016). Underwater rov with fuzzy logic motion control. In *2016 IEEE International Conference on Information and Automation for Sustainability (ICIAfS)*, pages 1–6.

[11] Jorge, V. A. M., Gava, P. D. d. C., Silva, J. R. B. F., Mancilha, T. M., Vieira, W., Adabo, G. J., and Nascimento, C. L. (2021). Vita1: An unmanned underwater vehicle prototype for operation in underwater tunnels. In *2021 IEEE International Systems Conference (SysCon)*, pages 1–8.

[12] K, J., S M, R., S V, S., and K, K. (2023). Remotely operated underwater vehicle (rov). In *2023 2nd International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA)*, pages 1–4.

[13] Khoirunnisa, H., Abadi, S. C., Anggraeni, P., and Rudi (2024). Polrov (polman education platform of underwater robot) monitoring navigation design using pid controller method. In *2024 IEEE International Conference on Computing (ICOCO)*, pages 225–230.

[14] Kopman, V., Cavaliere, N., and Porfiri, M. (2012). Masuv-1: A miniature underwater vehicle with multidirectional thrust vectoring for safe animal interactions. *IEEE/ASME Transactions on Mechatronics*, 17(3):563–571.

[15] Laidani, A., Boudria, M., Faci, I., Bouhamri, A., Kebdani, O., Rahmoun, L., Bellahcene, Z., and Bouhamida, M. (2022). Design and modeling of a low-cost observation class rov for dam inspection. In *2022 2nd International Conference on Advanced Electrical Engineering (ICAEE)*, pages 1–6.

[16] Mai, C., Benzon, M. v., Sørensen, F. F., Klemmensen, S. S., Pedersen, S., and Liniger, J. (2022). Design of an autonomous rov for marine growth inspection and cleaning. In *2022 IEEE/OES Autonomous Underwater Vehicles Symposium (AUV)*, pages 1–6.

[17] Martins, A., Almeida, J., Almeida, C., Matias, B., Kapusniak, S., and Silva, E. (2018). Eva a hybrid rov/auv for underwater mining operations support. In *2018 OCEANS - MTS/IEEE Kobe Techno-Oceans (OTO)*, pages 1–7.

[18] Marzbanrad, A., Sharafi, J., Eghtesad, M., and Kamali, R. (2011). Design, construction and control of a remotely operated vehicle (rov). *Volume 7: Dynamic Systems and Control; Mechatronics and Intelligent Machines, Parts A and B*.

[19] Mintchev, S., Donati, E., Marrazza, S., and Stefanini, C. (2014). Mechatronic design of a miniature underwater robot for swarm operations. In *2014 IEEE International Conference on Robotics and Automation (ICRA)*, pages 2938–2943.

[20] Pagliai, M., Ridolfi, A., Gelli, J., Meschini, A., and Allotta, B. (2018). Design of a reconfigurable autonomous underwater vehicle for offshore platform monitoring and intervention. In *2018 IEEE/OES Autonomous Underwater Vehicle Workshop (AUV)*, pages 1–6.

[21] Qi, H., Cao, X., Lv, L., Cong, Z., Lin, L., and Zhang, D. (2020). A design of high mobility auv cost $325. In *2020 IEEE/OES Autonomous Underwater Vehicles Symposium AUV*, pages 1–3.

[22] Segovia Ramírez, I., Bernalte Sánchez, P., Papaelias, M., and García Márquez, F. P. (2021). Autonomous underwater vehicles and field of view in underwater operations. *Journal of Marine Science and Engineering*, 9:277.

[23] Tang, J., Chen, Z., Fu, B., Lu, W., Li, S., Li, X., and Ji, X. (2024). Rov6d: 6d pose estimation benchmark dataset for underwater remotely operated vehicles. *IEEE Robotics and Automation Letters*, 9(1):65–72.

[24] Ulu, C., Canbak, O., Altunkaya, M. U., Taşkin, H., and Yayla, S. (2017). Development of the marmarov remotely operated underwater vehicle system. In *2017 International Artificial Intelligence and Data Processing Symposium (IDAP)*, pages 1–6.

[25] Vasileiou, M., Manos, N., and Kavallieratou, E. (2021). A low-cost 3d printed mini underwater vehicle: Design and fabrication. In *2021 20th International Conference on Advanced Robotics (ICAR)*, pages 390–395.

[26] Wettergreen, D., Gaskett, C., and Zelinsky, A. (1999). Autonomous guidance and control for an underwater robotic vehicle. In *Proceedings of the International Conference on Field and Service Robotics (FSR'99), Pittsburgh, USA*.

[27] Yildiz, Ö., Gökalp, R. B., and Yilmaz, A. E. (2009). A review on motion control of the underwater vehicles. In *2009 International Conference on Electrical and Electronics Engineering - ELECO 2009*, pages II–337–II–341.

[28] Yoerger, D. R., Curran, M., Fujii, J., German, C. R., Gomez-Ibanez, D., Govindarajan, A. F., Howland, J. C., Llopiz, J. K., Wiebe, P. H., Hobson, B. W., Katija, K., Risi, M., Robison, B. H., Wilkinson, C. J., Rock, S. M., and Breier, J. A. (2018). Mesobot: An autonomous underwater vehicle for tracking and sampling midwater targets. In *2018 IEEE/OES Autonomous Underwater Vehicle Workshop (AUV)*, pages 1–7.

[29] Zain, Z. M., Noh, M. M., Ab Rahim, K. A., and Harun, N. (2016). Design and development of an x4-rov. In *2016 IEEE International Conference on Underwater System Technology: Theory and Applications (USYS)*, pages 207–211.

[30] Zavari, S., Heininen, A., Aaltonen, J., and Koskinen, K. T. (2016). Early stage design of a spherical underwater robotic vehicle. In *2016 20th International Conference on System Theory, Control and Computing (ICSTCC)*, pages 240–244.

A Risk Assessment

The following document is the official QUT risk assessment for this project, covering laboratory work, electronic work, and water testing procedures.

Risk Assessment : 18339 (Pending Review)

Customer Details:-

Owner:	Josh Hecke (joshua.hecke@connect.qut.edu.au)	Review:	Yes
Email:	joshua.hecke@connect.qut.edu.au	Endorsement:	Yes

Assessment Type:	Plant/Equipment	MAPS ID:	
Division/Faculty:	Faculty of Engineering	QUT Team:	School of Electrical Engineering & Robotics
School/Depart:	School of Electrical Engineering & Robotics	QUT SubTeam:	
Start Date:	8/25/2025	Est End Date:	6/25/2026

Title: Design of small scale Remotely Operated Vehicle - Underwater Robot

Description: This is an risk assessment to support the design of a new small scale ROV on campus.

The primary risks relate to electrical safety during development, manual handling, operation, electrical safety including charging and packing and storage for travel.

Only Tobias Fischer, Joshua Hecke will be able to operate this device during development, due to its experimental nature. Other team members can operate this vehicle after contacting said operators and receiving a induction.

In addition to this risk assessment, Approval of any commercial areas(i.e qut pool) needs to be organized with the appropriate body accordingly.

Location Details:-

Campus	Building	Floor	Room	Adional Info
Off Campus				These are operated on-water in the field at approved locations(A key example would be QUT Pool or Personal Pool)
Gardens Point	S Block	Level 11	1145-Post-Graduate Lab.	Mobile Robots Lab Soldering Station

Hazard Details:-

Haz ID	Hazard	Cause of Harm	What could go wrong	L	C	Risk Score	Hide Items
79996	Slip-Trip-Fall	Slippery surfaces	Slipping getting in and out of boat, on boat ramps or on shore close to water.	Possible	Minor	Low	
		Control	Hierachy: Administration Control: Assess conditions before moving around location. Must wear suitable footwear according to location (e.g. shoes, or wet booties). Only hop onto boat once fully secured. Do not run. Use multiple people to carry equipment on shore or loading boat.				
79997	Plant and Equipment	Operation	Rotating propellers - cuts, injuries, equipment in motion.	Unlikely	Minor	Low	
		Control	Hierachy: Engineering Control: For the BlueRov, the remote operator interface controls the motors and touching any control will disable the system and put it into idle mode.				
		Control	Hierachy: Isolation Control: On the BlueRov, the motors have shrouds minimizing the possibility of accidental contact with the propellers.				

79998	Manual Tasks	Posture - sustained/awkward/static	During deployment on shore/surface: - awkward posture (kneeling, squatting, balancing etc) - bending/twisting - duration of work - load handling - long standing/sitting - muscular force exerted - repetitive movement	Unlikely	Moderate	Medium	
		Control	Hierachy: Other Control: Take regular breaks, Keep area tidy, Position body (and maneuver boat) to life appropriately Use the handles on the equipment				
79999	Electrical	<50 volts AC/<120 volts DC	Fire or damage to batteries due to charging or discharging	Possible	Minor	Low	
		Control	Hierachy: Administration Control: After being approved/checked by lab tech, operators can now keep batteries on their person and conduct charging in designated charging areas in s11.				
		Control	Hierachy: Administration Control: Follow the operating manual for the chargers and ASVs				
		Control	Hierachy: Engineering Control: Only use official supplier and tagged chargers.				
		Control	Hierachy: PPE Control: Ensure batteries are charged and transported in lipo safe bags				
		Control	Hierachy: PPE Control: Fire extinguisher and/or fire blanket at working site.				
80000	Other	General assembly, building and installation of sensors and payloads.	- injury due to misuse of tools - pinch points	Possible	Minor	Low	
		Control	Hierachy: Administration Control: Standard operating procedures General assembly of the main hull and location of pinch points are clearly marked. An online SOP for the ASVs is maintained (QUT wiki). Each participant is aware and has access to these manuals and the latest is attached to this risk assessment.				
		Control	Hierachy: Administration Control: Training and education Ensure each participant is appropriately trained for the tools and equipment they are using and if required inducted into the work-zone.				
80001	Fieldwork	Other	Public hazards Unauthorized persons approach the vessel during operation such as swimmers or canoes. - knocking someone into the water - collision with a swimmer - collision with another vessel - public interfering with the vessel	Rare	Minor	Negligible	
		Control	Hierachy: Administration Control: Standard Operating Procedures Follow the SOP and exception permit requirements for notifying the public and locations for operation.				
		Control	Hierachy: Engineering Control: The overall mass is to be kept low so that there is minimal kinetic energy in any collisiot. Ensure all motors are shrouded and the shrouds are intacts.				
		Control	Hierachy: Isolation Control: Remote control devices All vessels have at least one level of wireless estop of wireless e-Stops. For the BlueRov2, the first is a hardwored heartbeat which must be maintained from the shore to allow power to the motors. The other is the remote control unit (e.g., RC controller or tablet) which can manually overide the computer and when switched off will also trigger the e-Stop.				

80001		Control	Hierachy: Isolation Control: The test location will be selected (moved within the site) to areas where there are no public visible or planned to be in the area. Conditions of applicable permits will be followed. If possible, on inland water storages, select sites that have no public access and seek approval from the land owners.				
80003	Fieldwork	Other	Working near water - drowning - slipping and falling - cuts from debris in the mud (e.g. broken glass, sharp rocks	Unlikely	Major	Medium	
		Control	Hierachy: Administration Control: Prepare and train for emergency response Details of the trained first-aiders made aware to the team on arrival at site as well as the location (in-vehicle) of the emergency contacts and closest hospital.				
		Control	Hierachy: Administration Control: Standard operating procedures The captain on boarding the boats will advise the team and crew of the standard operating procedures for all aspects of working at sea. This includes location of life□jackets, procedure for man overboard. These procedures are documented on-board the vessels and placards are placed around the vessel. For people that cannot swim or are uncomfortable around the water, they are encouraged to wear life-jackets whenever working near the edge of the boat.				
		Control	Hierachy: Administration Control: WAM-V SOP - Initially, the boat will be assembled on the waters edge following a visual inspection of the area and assessment of water depth. With a bow rope attached, the boat will be carried until the the stern is in the water (approximately 5 inches deep) and then pushed from the bow until completely in the water. Recovery will involve remote controlling the boat to the shore bow first, dragging the boat back onto shore (lifting the bow slightly) until the rear handles are at the shoreline and then lifted onto shore. This means that only shallow water sites are needed				
		Control	Hierachy: PPE Control: Each participant will wear enclosed footwear to allow walking at the water edge without risk of cutting feet due to debris and with enough grip to minimise slipping.				
		Control	Hierachy: PPE Control: Ensure suitable and fit for purpose life-jackets are available for all personal. These must be worn whilst on the boats when required by the skippers and vessels operating procedures.				
80004	Manual Tasks	Setting up equipment/furniture	Strains and sprains. Lifting equipment and transport cases for launching from shore.	Unlikely	Minor	Low	
		Control	Hierachy: Administration Control: Assess weight and size of load. Use more people to lift if awkward, slippery or unable to lift. Use trolleys on campus.				
		Control	Hierachy: Other Control: General assembly of the main hull and location of pinch points are detailed in the manufacturers manual (see attachment). Each participant is aware and has access to this manual.				
80005	Electrical	<50 volts AC/<120 volts DC	General hazard: Working with ultra low voltage DC (5-24Volts) Electrical equipment such as electric motors and sensors. - low voltage shock - burns - electrical fires	Possible	Minor	Low	
		Control	Hierachy: Administration Control: Ensure all participants working with low-voltage electrical are trained in the use of the equipment and have the appropriate laboratory inductions if required to undertake the work.				
		Control	Hierachy: Administration Control: Follow procedure for installation and removal of batteries. Ensure the equipment is turned off before installation or removal.				

80005		Control	Hierachy: Administration Control: Keeping equipment and plant well maintained. Use only fit-for purpose equipment. Ensure all wiring is documented and appropriately labelled where necessary.				
		Control	Hierachy: Isolation Control: Isolation switches and/or quick release plugs/connectors (such as Anderson or XT connectors) for isolating power to the components being worked on.				
		Control	Hierachy: Other Control: Fire extinguisher and/or fire blanket at the work site. Also LiPo safe bags for transporting and charging LiPo batteries				
		Control	Hierachy: PPE Control: Ensure batteries are charged and transported in lipo safe bags				
80006	Other	Loss of robot during missions	- Losing contact with the robot during missions - Leaking of water into robot	Unlikely	Minor	Low	
		Control	Hierachy: Administration Control: Standard operating procedures The missions are planned such that the ROV will operate in within a defined range. The ROV are tethered and in loss of power the robot can be located and most likely retrieced using the tether. In the event of leaking of water into the ASV, the robot should have sufficient remaining buoyancy to remain at the surface In the event of a leaking robots, the batteries have been selected to minimize risk of fire or explosion and on recovery the robot will be isolated for up to 3 hours to ensure no fire risk before further handling.				
		Control	Hierachy: Administration Control: The Operation of the ROV in navigable waters are covered under the AMSA Specific Exemption permit. This has requirements in the equipment required such as radios for alerting people in the vacinity, markings and the use of a ground control station (tablets and/or computers).				
		Control	Hierachy: Other Control: The BlueRov have a hearthbeat sent over the teather. The operational status and approximate possition are always known wihin a few meters.				
80008	Electrical	Operation of electrical equipment	Burn, Shock, Breathing in solder fumes	Possible	Minor	Low	
		Control	Hierachy: PPE Control: Ensure Glasses and extraction fan are used when soldering.				
		Control	Hierachy: PPE Control: When handling parts and chemicals ensure gloves are warn and safety gear including masks are worn.				
80178	Chemicals	Handling and use	Use of non-hazardous dichtol for waterproofing 3d parts. Standard handling risks include inhalation, skin contact, eye contact	Possible	Minor	Low	
		Control	Hierachy: Administration Control: The chemical will be stored in s9 store when not in use and be lent out when used in s11. To be returned at end of use				
		Control	Hierachy: Isolation Control: Remove risk by storing in carefully closed container upright with lid on tight				

80178		Control	Hierachy: Other Control: General information In all cases of doubt, or when symptoms persist, seek medical advice. If unconscious but breathing normally, place in recovery position and seek medical advice. Following inhalation Remove casualty to fresh air and keep warm and at rest. In case of irregular breathing or respiratory arrest provide artificial respiration. Following skin contact Remove contaminated, saturated clothing immediately. After contact with skin, wash immediately with plenty of water and soap. Do not use solvents or thinners. Wash contaminated clothing before reuse. After eye contact Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Seek medical advice immediately. Following ingestion If swallowed, rinse mouth with water (only if the person is conscious). Seek medical advice immediately. Keep victim calm. Do NOT induce vomiting. Self-protection of the first aider First aider: Pay attention to self-protection! Most important symptoms and effects, both acute and delayed Symptoms In all cases of doubt, or when symptoms persist, seek medical advice. Indication of any immediate medical attention and special treatment needed First Aid, decontamination, treatment of symptoms.				
		Control	Hierachy: PPE Control: gloves, eye protection, respiratory protection				
80320	Electrical	Design/modification	Water could enter electrical storage containers causing damage and potential shock. This is due to waterproof seals failing or not being sufficient	Possible	Moderate	Medium	
		Control	Hierachy: Elimination Control: Try to use certified/standard waterproofed containers (BlueRov product) where possible and only use custom made containers where necessary				
		Control	Hierachy: Engineering Control: Ensure all waterproof containers are tested multiple times at the required depth before being used to store components.				

Participant Details:-

Participant Name
Scarlett Raine (sg.raine@qut.edu.au)
Josh Hecke (joshua.hecke@connect.qut.edu.au)
Tobias Fischer (tobias.fischer@qut.edu.au)

Reviewer Details:-

Reviewer Name	Review Status
Tobias Fischer (tobias.fischer@qut.edu.au)	Pending
Steven Bulmer (steven.bulmer@qut.edu.au)	Pending

Approver Details:-

Approver Name
Firuz Zare (f.zare@qut.edu.au)

Approval Details:- (No Approval(s)!!!)

ID	Approval	Approver Name	Approval Status

Note Details:-

Subject	Note	Category	Created Date	Created By

Reviewer Note	Hi Josh, Overall well done and comprehensive RA! - I've added Scarlett Raine as a participant as she's leading a lot of our marine robotics work, please update description accordingly. - Other team members need to contact operators + get induction - Remove everything boat related from the RA (loss of robot, ...), this is out of scope for this RA. If boat operation will happen in the future, we'll need to submit a separate RA. - Need to add water leakage as hazard + appropriate controls; describe tank etc. - Need to provide detailed information on where chemicals will be stored (Krishna to advise) - Need to provide detailed information on where batteries will be stored (Krishna to advise) - Change "low voltage" to "ultra low voltage" to be consistent with regulation Let me know if you have any questions. Best, Tobi	Customer Notes	8/27/2025 3:55:08 PM	Tobias Fischer (tobias.fischer@qut.edu.au)