Development of a Small Scale ROV for Research Purposes

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Acknowledgement of Traditional Owners

The Queensland University of Technology (QUT) acknowledges the Turrbal and Yugara, as the First Nations owners of the lands where QUT now stands. We pay respect to their Elders, lores, customs and creation spirits. We recognise that these lands have always been places of teaching, research and learning.

QUT acknowledges the important role Aboriginal and Torres Strait Islander people play within the QUT community.

Project Overview

Task Description:
This project involves designing, building, and programming a miniature autonomous underwater vehicle to serve as a demonstrator for educational outreach and testing platform for underwater robotics research. The objective of this project is to create a small-scale submersible capable of controlled diving, surfacing, and maneuvering in test tanks or demonstration pools.

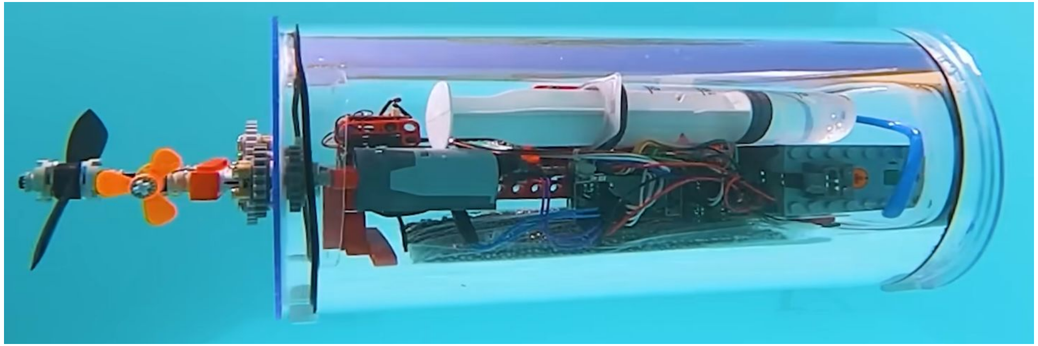


Photo of suggested approach by supervisor

The final demonstrator should include:

1. Perform pre-programmed missions including data collection.
2. Help Complement ongoing research with our BlueROV ROV by providing a cost-effective platform
3. Help guide algorithm development, open day demonstrations, and initial machine learning pipeline testing.

Project Breakdown

Research Topic: Development of a Small Scale ROV for Research Purposes

Research Question: How can a modular, small-scale ROV platform be developed using primarily Commercial Off-The-Shelf components to create a cost-effective and adaptable tool for undergraduate-level robotics education and system testing?

Research Problem: Currently the BlueROV2 ROV that QUT owns is too large and use requires additional steps including

- QUT pool approval and/or offsite setup
- Difficult manual handling
- This larger platform can be overkill for small tests

This project aims to design a smaller solution which directly solves these problems

?

Literature Review

~60–70 papers were identified

Modular Observation ROV(BlueROV2)

ROV Focus: Based on components mentioned, likely references the BlueROV2 or similar, focusing on surveillance, inspection, and mapping.

Design Philosophy: Emphasizes modularity, stabilized frame, ease of operation, and high maneuverability with 5 Degrees of Freedom (DOF) using vectored thrusters.

Key Technologies:
Controller: Raspberry Pi with Pixhawk running ArduSub.
Structure: Open-frame structure; polyurethane foam for buoyancy.
Propulsion: Six thrusters (4 vectored horizontal, 2 vertical) with integrated ESCs.
Sensors: Cameras, depth, temperature, pressure sensors. Suggests future addition of SONAR.
Communication: Tether with Fathom-X interface boards (Ethernet).
Power: Lithium-polymer battery pack.

Relevance to Small Scale: The modular hardware (Pi, Pixhawk) and open-source software stack is directly applicable and scalable to smaller designs. The 6-thruster vectored configuration is effective for maneuverability in smaller frames.

Jothikrishna et al. (2023)

Photo of the rov used in the paper

ArduinoSub: Leveraging Low-Cost Components for Education

ROV Focus: ArduinoSub, an observation-class ROV designed as an educational kit for middle school to university students.

Design Philosophy: Prioritize low cost (under $1000) and accessibility by using Commercial Off-The-Shelf (COTS) parts wherever possible.

Key Technologies:

- **Controller:** Arduino Mega 2560
- **Structure:** Polyethylene pipes.
- **Propulsion:** Four thrusters with integrated ESCs
- **Sensors:** Includes a 9-axis IMU (MPU-9250) and a depth sensor (MS5837-30BA).
- **Camera:** Analog HD CCTV camera mounted on a tilt servo.
- **Power:** Powered by eight 21700 lithium-ion batteries in a 4S2P configuration, housed in external tubes.

Relevance to Small Scale: Demonstrates a successful low-cost approach using accessible Arduino platform and COTS materials, highly relevant for budget-conscious small ROV projects.

Photo of ArduinoSub

Wang et al. (2019)

Hybrid ROV - Capstone Project

ROV Focus: Small-scale educational Hybrid ROV for shallow channel survey/exploration and MATE competitions. Operates tethered (manual) and tetherless (autonomous).

Design Philosophy: Educational platform for underwater robotics, enabling dual ROV/AUV modes and sensor data collection, including autonomous depth profiling.

Key Technologies:
Controller: Raspberry Pi Zero W (ROV), Raspberry Pi 3 B+ (Base Station).
Structure: Aluminum extrusion frame, waterproof enclosure.
Propulsion: Six thrusters with ESCs and 16-Channel PWM/Servo Driver.
Sensors: IMU, GPS, Pressure, Sonar, Water temperature.
Camera: 2.1 MP HD-SDI Camera, two LED lights.
Power: 12V Battery pack; tether-powered option.
Communication: Detachable tether, WiFi (surfaced).

Relevance to Small Scale: Robust, modular aluminum frame for prototyping. Hybrid tethered/tetherless design demonstrates small platform flexibility. Uses accessible components (Raspberry Pi, standard sensors).

Photo of the rov designed in the paper

Hur, B., & Alvi, M. (2022)

Hybrid AUV/ROV for Aquaculture

ROV Focus: Kalypso, a hybrid Autonomous Underwater Vehicle (AUV) and Remotely Operated Vehicle (ROV) designed for aquaculture inspection and intervention in the Mediterranean.

Design Philosophy: Enhance aquaculture management via dual modes: AUV for autonomous net inspection and ROV for teleoperated intervention. Prioritizes cost-effectiveness through 3D printing.

Key Technologies:
- **Controller:** Pixhawk board, Raspberry Pi 3, Mini PC.
- **Structure:** 3D printed main body, acrylic tube WTE
- **Propulsion:** Eight thrusters providing 6 Degrees of Freedom (DOF).
- **Sensors:** Leak sensors, underwater ultrasonic sensors, twin cameras IMU, compass, distance sensors
- **Power:** Two 14.8V, 10,000 mAh LiPo batteries.
- **Software:** Custom navigation algorithms and vision-based hole detection procedures.

Relevance to Small Scale: 3D printing provides adaptable, cost-effective construction for custom small-scale ROVs. The multi-board control architecture, distributing tasks across processors, is scalable to smaller platforms.

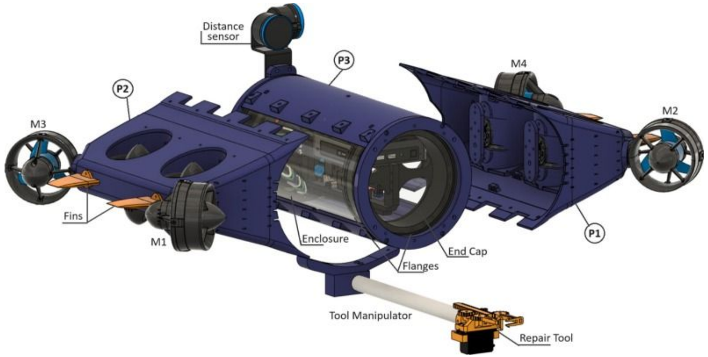


Photo of the rov design

Manos et al. (2024)

Motivation and Objectives

Motivation/Rationale:

- Address the distinct gap in accessible, low-cost, and modular small-scale ROVs that are computationally equipped for modern research.
- Large, work-class vehicles are often financially and logistically prohibitive for academic research and rapid prototyping.
- The primary objective is to create a versatile testbed for novel Machine Learning (ML) control pipelines and for use in QUT demonstrations.

Research Objectives:

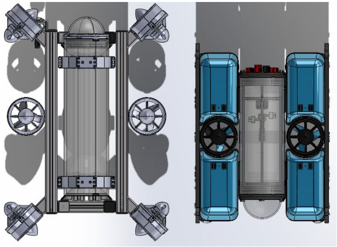
- Develop and test a small scale rov design that can be used to test ML pipelines, in demonstrations on open days and possibly carry small payloads.
- Create a digital model of the design so buoyancy, equations of motion can be simulated in more detail in the future
- Document and report the design process and outcomes with plans to open source solutions

A Three-Phase Approach to Reach Outcomes

Phase 1: Research and Design

Research: Research components and materials used in current solutions

Development: Iteratively design a first stage solution that meets research outcomes



Phase 2: Simulation and Prototyping

Simulation: Produce a digital twin that allows simulation of buoyancy and motion in ros2 using Solidworks documentation

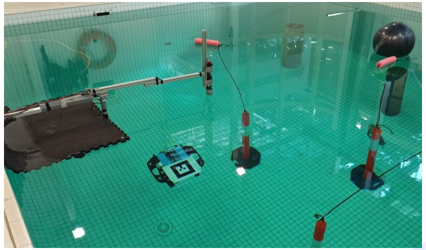
Prototyping: Develop a second stage refined design based off simulation results

Phase 3: Reporting, Testing & Refinement

Testing: Conduct waterproof tests, Manual motion tests and possibly autonomous identification tests

Refinement: Use test results to refine a third stage solution that has evidence meeting research outcomes.

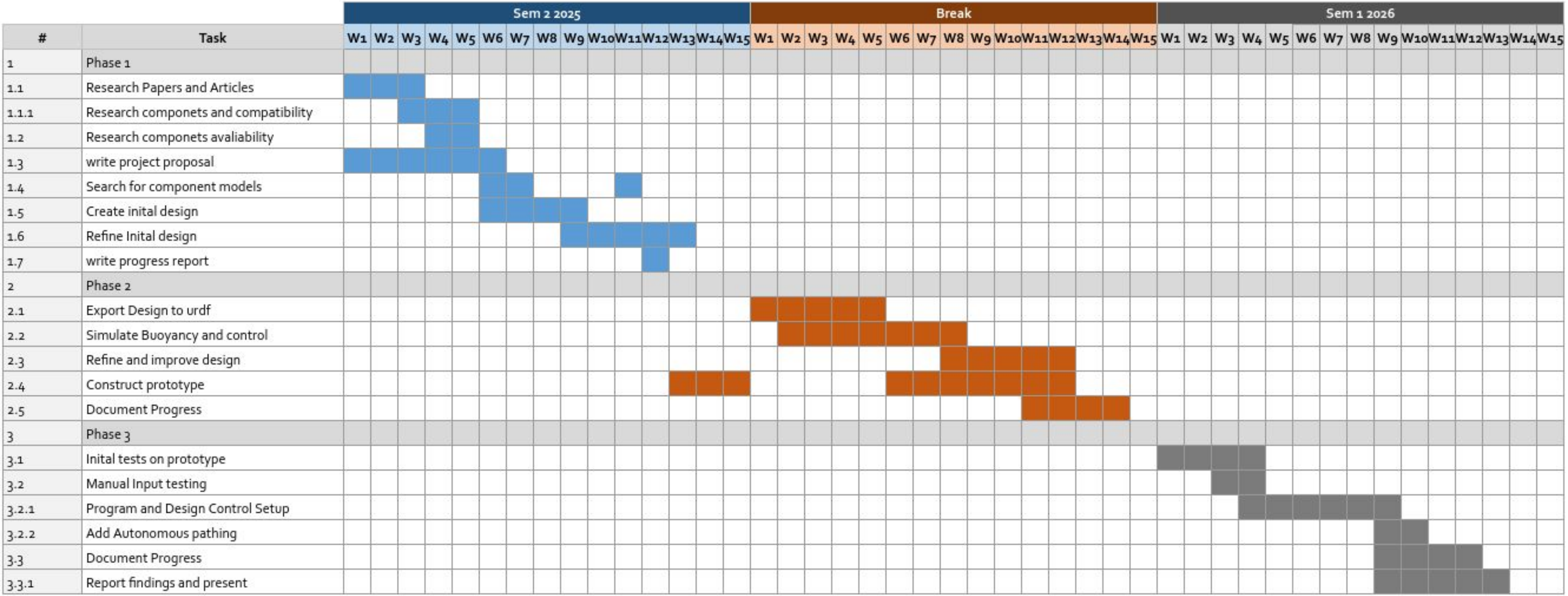
Reporting: Document all outcomes and finalize outcomes into a accessible package(Github repo)



Project Gantt Chart

GANTT CHART

Project Name: SubbyROV	COMPANY NAME	QUT	
Supervior: Tobias Fischer	DATE	16/10/2025	



Project Progress

Phase 1

Research

Comprehensive Literature Review

- Completed a review of existing ROV designs, informing key design themes and philosophies.

- Identified a gap for small-scale, low-cost platforms suitable for research.

- Adapted the plan based on new literature half way through design iterations, moving from a 6-thruster to a 4-thruster design to meet size and power constraints.

Component Research

- Components discovered from the literature review were research for suitability and accessibility.

- Components were also investigated for the compatibility with the desired approach.

- This was then reviewed half was through the design iterations and adjustments were made. The effect was the removal companion computer and internal ESC to meet sizing constraints

Milestones

Key Milestones Achieved

- Submitted a comprehensive Risk Assessment (ID: 18339) to the QUT HSE Hub.
- Completed multiple design iterations in SolidWorks 2023.
- Produced a detailed Bill of Materials (BOM)
- Began initial construction and assembly of the watertight enclosure (WTE) prototype.

Risk Assessment

HSE HUB Risk Assessment : 18339 (Pending Endorsement)

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 and Scarlet Raine will be able to operate this device during development and testing, due to its experimental nature. Other team members can operate this vehicle after contacting said operators and receiving a induction.

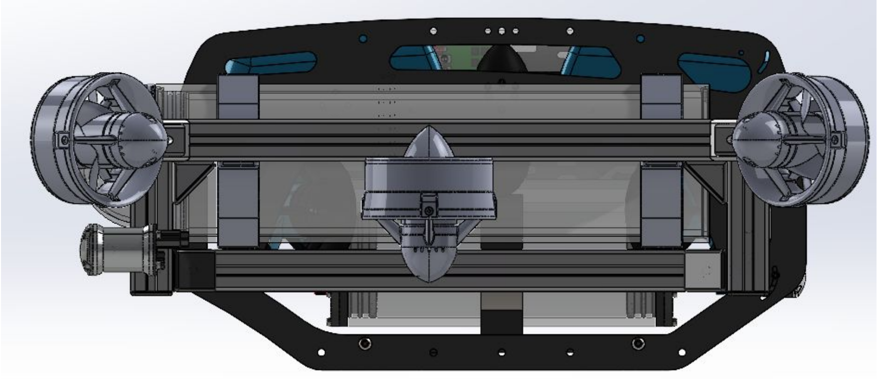
Main Risks-
5200mAh 14v LIPO Battery Use and Handling
Operation and Handling around water
IF USED
Safe use and Storage of Dichtol Waterproofing
Ensure-
S9 lab techs are aware of LIPO presence if battery is on campus for safe storage and charging.

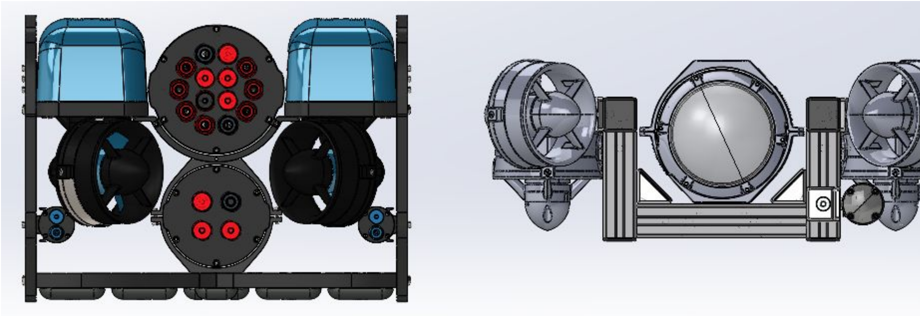
In addition to this risk assessment, Approval of any commercial areas(i.e qut pool) needs to be organized with the appropriate body accordingly.

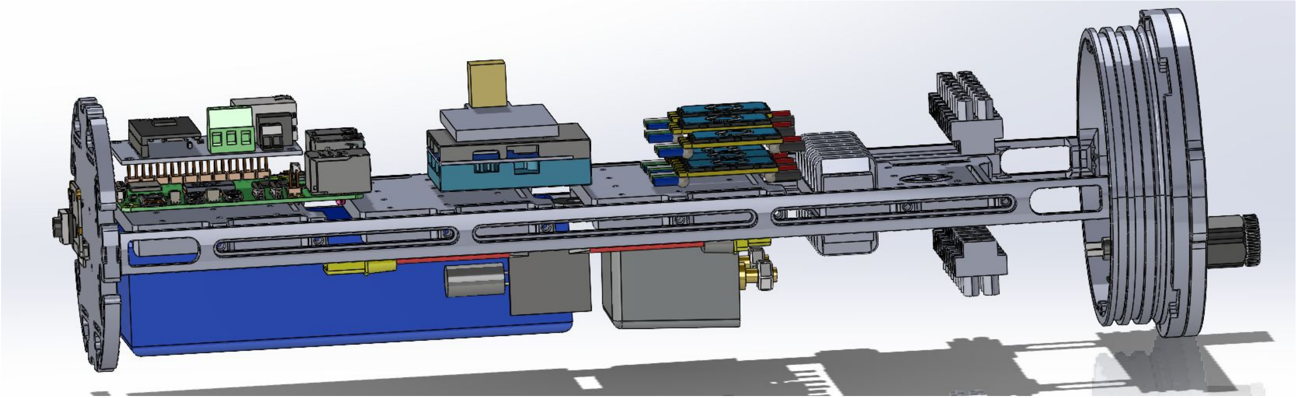
Location Details:-

Campus	Building	Floor	Room	Addional 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

Design Iterations #1







Review of Designs 1

Initial Concept (Design 1)

- Designs started with a 6-thruster vectored
- Aluminium Item to mount thrusters
- 4" diameter enclosure at 300mm length
- Use of Pixhawk 6C mini
- Use of large 18000mAh lithium-ion battery
- Novel Battery switch using automotive relay
- 3D printed parts to reduce purchasing costs

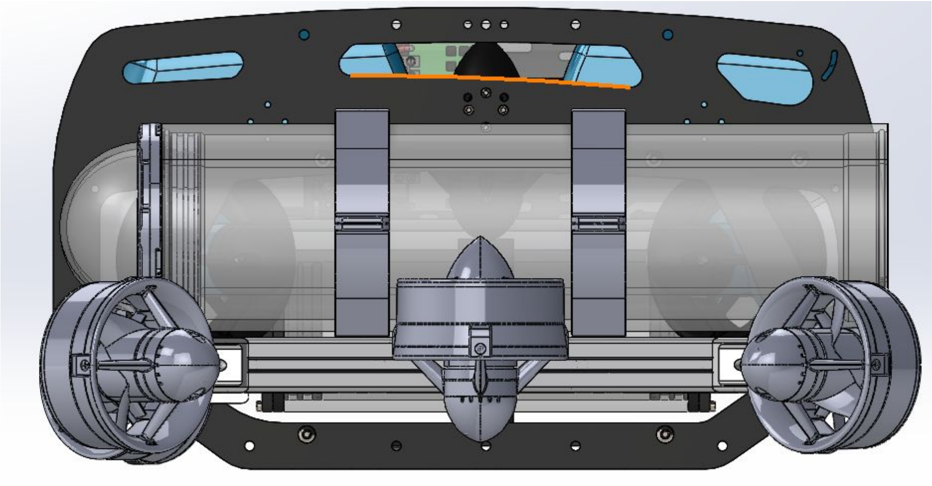
Supervisor Feedback & Redesign

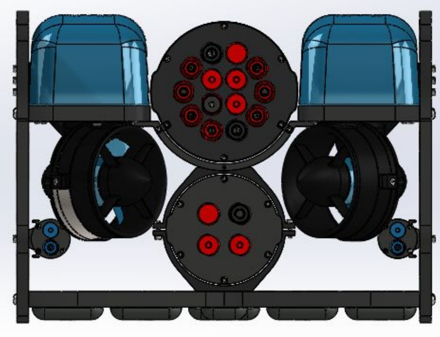
- After meeting the supervisor said the design is too large
- Detail explanation as to why the size was to big relative to the suggested approach from slide 1
- Need to reduce external profile

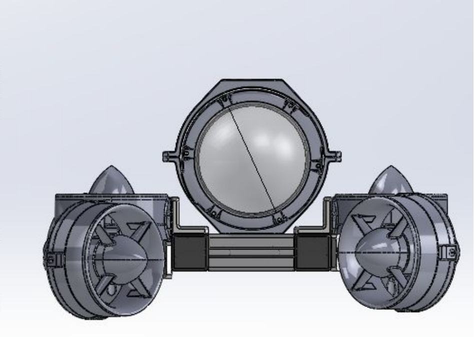
Key outcomes

- Smaller external profile required

Design Iterations #2







Review of Designs 2

Supervisor Feedback & Redesign

- A meeting resulted in a major design pivot.
- Key changes: Reduce thrusters to 4, research smaller thrusters, remove companion computer and go straight to ground control, ESC outside of WTE, smarter 6X autopilot to replace companion computer
- Due to the size reduction the Li-ion battery is now too large and a more energy dense LiPo battery is required.

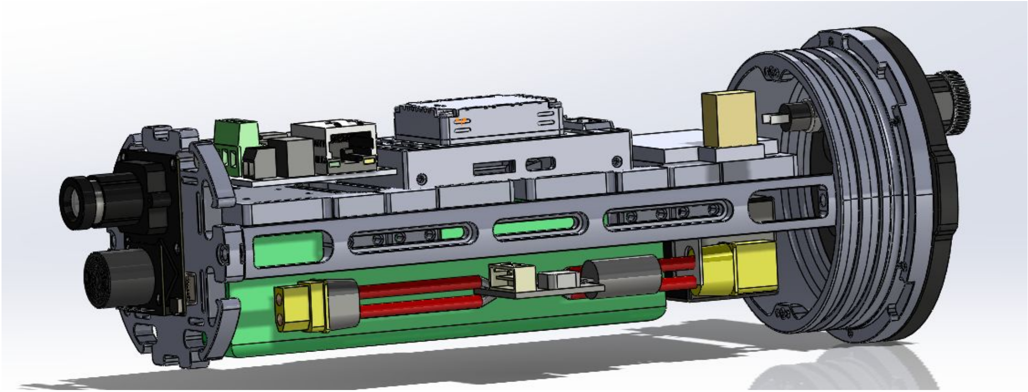
Initial Concept (Design 2)

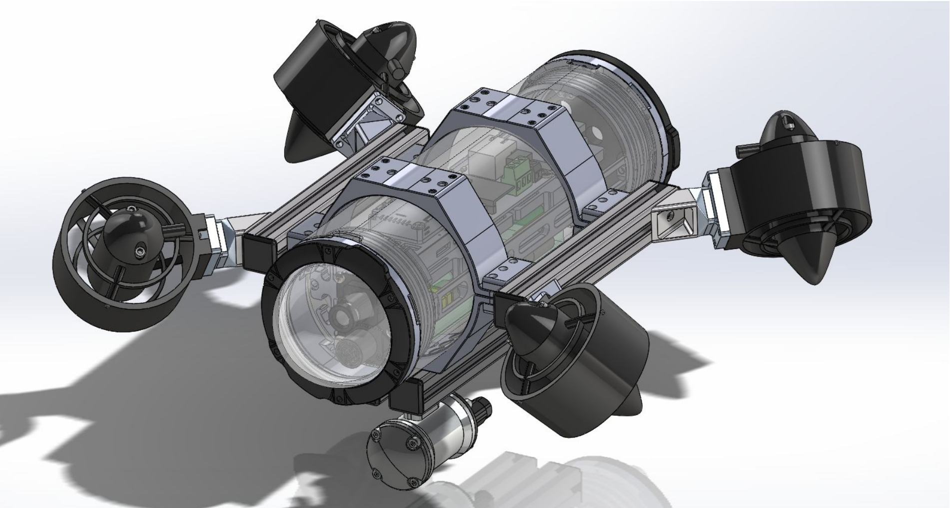
- Similar internal makeup however changes to the external profile made to reduce size

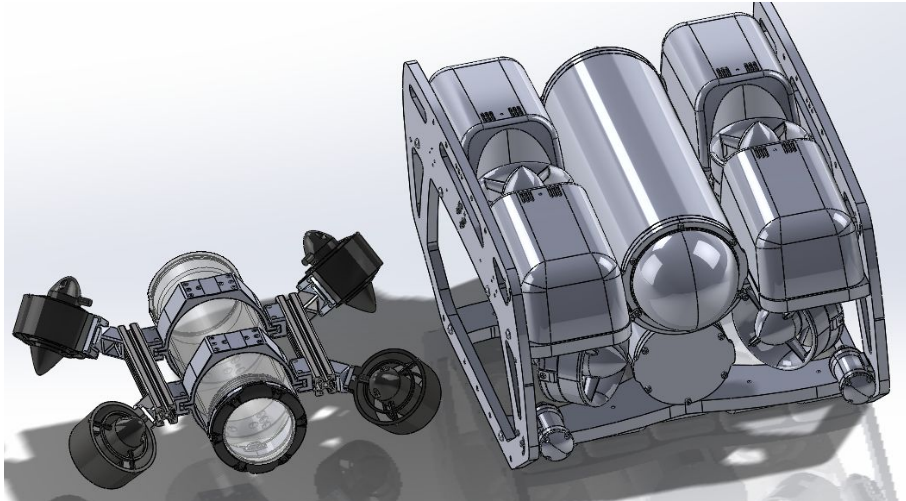
Key outcomes

- Less components inside WTE
- Smaller battery for smaller thrusters

Design Iterations #3







Review of Designs 3

Initial Concept (Design 3)

- This design now uses a 5400mAh LiPo battery
- The design is centered on a Blue Robotics 3" diameter watertight enclosure which reduces profile margin
- It features an experimental 45-45 degree bracket for the 4 thrusters to provide vectored force.
- New camera as companion computer is now removed
- New thrusters with smaller profile and external waterproof ESC

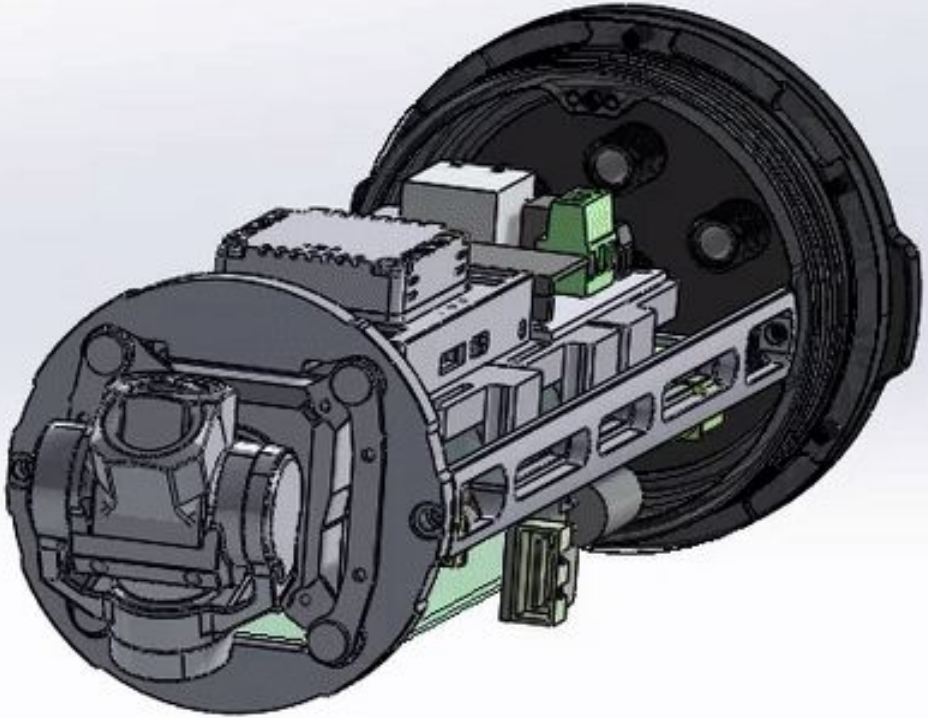
Core New Electronic Components

- Main Controller: Pixhawk 6X flight controller.
- Propulsion: 4x APISQUEEN U2 MINI thrusters with ESC.
- Camera: Px4Flow
- Power: Tattu 5200mAh 4S (14.8V) LiPo battery.

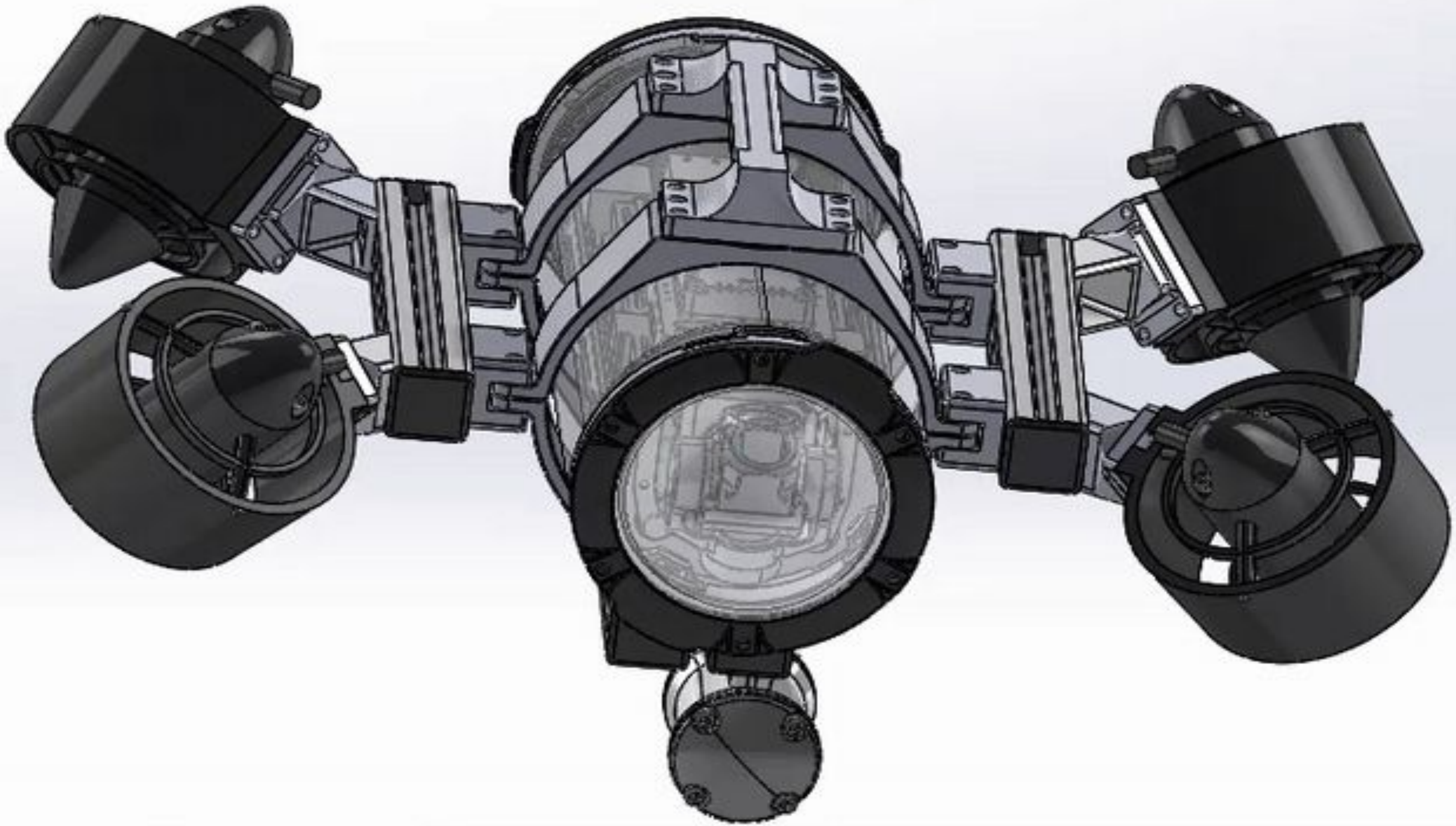
Key outcomes

- Px4Flow outdated
- Missing handling points

Design Iterations #4



Design Iterations #4



Review of Designs 4

Final SolidWorks Model

- New camera mount as design 3's camera was unsourceable
- Smaller relay as battery demand has decreased
- New handle for easier Handling
- Camera: Z-1 Mini gimballed camera.

Next Steps for the Design

- Validate the designs buoyancy through simulation and add additional volume according to simulations
- Investigate wire connections inside WTE
- Design Ground station connection
- Investigate Experimental 45-45 mount
- Prototype to validate custom 3D printed mounting solutions

Procurement & Initial Prototyping Status

Bill of Materials (BOM) & Procurement

- A full BOM has been produced.
- Total estimated cost for all components is currently at ~$3000.
- All critical long-lead items have been received, including the flight controller, thrusters, and enclosure components.
- Mounting hardware is on order; the power sensor is on reorder.

Initial Prototype Assembly

- To validate the SolidWorks design, the initial construction of the WTE has started.
- The internal electronics tray has been assembled, mounting the Pixhawk 6X, PDB-XT60, and Fathom-X boards.
- This test-fitting confirmed the components fit well, with only minor modifications needed for mounting holes.

Condensed BOM

#	Item ID	Sub-System	Part Name	Description	Manufacturer / Supplier	Part Number / SKU	Qty.	Unit Cost ($AUD)	Total Cost ($)	Weight (g)	Total Weight (g)	Status	Purchasing Link	Notes
	1	Propulsion												
	1.1		SQUEEN U2 MINI 1.3Kg Underwater Thruster 16V 13		underwaterthruster	U2 mini	4	63.65	254.6	210	840	Arrived	Link	ll sourced from sa
	1.2													
	2	Electronics												
	2.1		Pixhawk 6X + Mini Baseboard + PM02	FLAG	Dr.Uav / HolyBro	6X-ICM-45686-5	1	300	300	50	50	Arrived	Link	ne by, ensure its 6
	2.2		atek Systems PDB XT60 W/ BEC 5V / 12V 2oz Copp		dronesxpress	PDB-XT60	1	36	36	7.5	7.5	On Order	Link	cheaper source el
	2.3		Fathom-X Tether Interface Board		Blue Robotics	BR-100178	2	212.15	424.3	100	200	Arrived	Link	Need 2
	2.4		Tattu 5200mAh 4s 35c Lipo Battery Pack		NextFPV	TA52004S35	2	99.95	199.9	435	870	ON HOLD	Link	you can find altern
	2.5		Automotive Relay, 12V dc Coil Voltage, 90A Switchir		Rs	915-6644	1	7.99	7.99	14	14	Arrived	Link	
	2.6		Switch		Blue robotics	BR-100433	1	42.43	33.944	20.5	20.5	Arrived	Link	
	2.7		XF-Z-1MINI		UmmanedRC		1	363.98	363.98	69	69	On Order	Link	
	2.8		Assorted connections + Wires		Misc		0	0	30	0	0	S9/Custom		
	4	Frame & Enclosure												
	4.1		Fathom ROV Tether		Blue Robotics	BR-100985-050	1	379.29	303.432	600	600	Arrived	Link	slim 50m
	4.2		Watertight Enclosure		Blue Robotics	WTE-VP	1	521.96	417.568		0	Arrived	Link	See image ->
	4.3		150mm Item Profile	FLAG	Item		4		0	72	288	On order	Link	
	4.4		item end caps	FLAG	Item		8		0	0	0	On order	Link	
	4.5		T nuts Item	FLAG	Item		20		0	2	40	On order	Link	M4 Stainless stee
	4.6		Penetrators 7.5 HC(7.0+0.3mm)		Blue Robotics	BR-100870-175	4	19.74	63.168	14.5	87	Arrived	Link	it to account for t
	4.7		Clamps		Blue Robotics		4	66.83	213.856	161	966	Arrived	Link	
	7	Payload												
	7.1		Lumen Subsea Light		Blue Robotics	BR-100857	1	265.52	212.416	118	118	Arrived	Link	
	7.2													
	8	3D Printed	PLA filament		Anywhere		1	20	20	0	0	@ o Block/home		
	8.1		RailMount A-D		Custom		4	0	0	16	64	@ o Block/home		
	8.2		Rails		Custom		2	0	0	11	22	@ o Block/home		
	8.3		CircularMount		Custom		1	0	0	21	21	@ o Block/home		
	8.4		SideMount		Custom		4	0	0	6	24	@ o Block/home		
	8.5		Thruster Mount		Custom		4	0	0	13	52	@ o Block/home		
	8.6								0		0			
							TOTALS:		2881.154		4353			


Joshua Heck't
400-1
DURATECH
M4
8-32
10-24
M5
M6
1/4-20
5/16-18
M8
3/8-16
M10
Ø0.157 [Ø4.0]
Ø0.164 [Ø4.2]
Ø0.187 or 3/16"
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Ø0.236 [Ø6.0]
Ø0.250 or 1/4"
Ø0.281 or 9/32"
Ø0.312 or 5/16"
Ø0.315 [Ø8.0]
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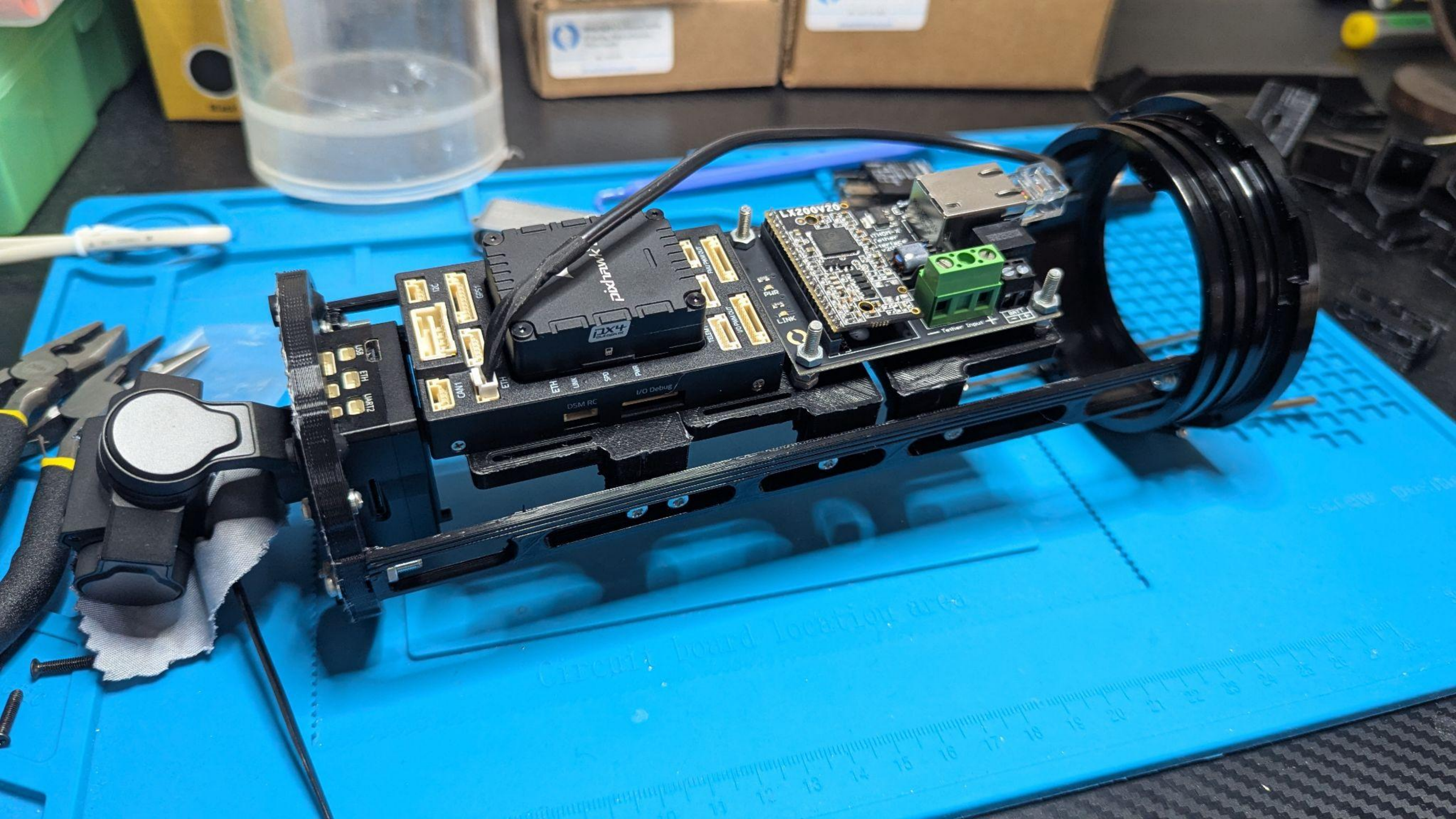
SMARTDEVIL
Weller
Equipment Parameters


pixhawk
PX4
LX200V20
PWR
LINK
Tether Input
ETH
CAN1
I/O Debug
DSM RC
USB
UART2
I2C
GPS1
Circuit board location area

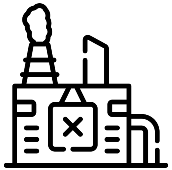
Project Outcomes and Broader Impact

Expected Outcomes:

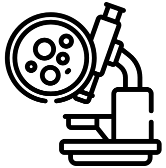
1. A fully assembled and operational small-scale underwater ROV.
2. Complete Computer-Aided Design (CAD) drawings and a detailed Bill of Materials (BOM) for the final design.
3. Control system software with a camera view.
4. A final report detailing the design methodology, validation, and performance results.

Benefits & Impact:

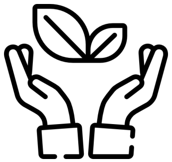
- Academic & Research: Creates a versatile, low-cost testbed for QUT demonstrations and future student projects, enabling hands-on learning in marine robotics, control systems, and sensor integration.



- Future Innovation: Provides an adaptable platform for testing novel Machine Learning (ML) control pipelines, serving as a foundation for more advanced research.



- Sustainability: Delivers a long-term, economically sustainable asset through a modular and repairable design using COTS components, maximizing the return on investment and ensuring knowledge transfer to future teams.



Conclusion and Future Directions

Phase 1 complete:

- literature review, CAD mechanical design, and component procurement are finalized.
- The 4-thruster vectored configuration is optimized for size and power, with a 30-minute theoretical runtime confirmed by power budget analysis.
- With most components on hand, the project transitions from theoretical design to physical assembly and integration.

Future Work: The start of Phase 2

- Assembly & System Integration This phase involves the complete physical assembly of the ROV frame and the integration of the internal electronics tray, including the Pixhawk 6X, PDB, and Fathom-X boards.
- Key tasks include flashing the ArduSub firmware , designing buoyancy modules based on the final mass , and simulating the ROV in ROS2/Gazebo to validate the control algorithms prior to physical testing.

Any Questions?

References

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