UNITED INTERNATIONAL UNIVERSITY

TECHNICAL REPORT

UIU MARINER

MATEROV 2025 - Pioneer Class

H.Y.D.R.A - SCORPION
UNITED INTERNATIONAL UNIVERSITY
BANGLADESH

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MARINER BANGLADESH

PREFACE

In April 2025, a group of students at **United International University (UIU)** discussed Underwater Robotics Projects and expressed their interest in participating in global competition events. After searching through relevant online content and watching many photos and videos of such events, the MATE ROV Competition piqued their interest. The nature, scale, and beauty of the competition inspired the group of students to aim at being the first team ever to qualify for the MATE ROV World Championship. With this grand ambition in mind, in May 2025, the **UIU Advanced Underwater Robotics & Automation Crew (AURA Crew)** was founded to not only participate in the MATE ROV competition, but also learn new things about Underwater Robotics in the process, aiming to apply the knowledge for the betterment of local & global Marine Environment, and aspire future generations to follow through the path paved. Finally, after a few months of tireless training and experimentation, the **AURA** Crew created **UIU MARINER**, the team that will one day represent not only the UIU but the entire nation on the Global Stage at the MATE ROV 2025 World Championship. The journey wasn't easy, but after 5 months of rigorous work following an iterative method, 6 ROV prototypes were created, with the methods growing and improving after each iteration. Finally, with all the experience from rigorous iterative prototyping, UIU MARINER built their latest ROV, Hydra Scorpion. After all the effort and hard work, UIU MARINER proudly presents Hydra Scorpion and its technical report. To us, this is not just a technical report, but an epic story reflecting upon all those sleepless nights spent working and brainstorming.

Fig. 1: UIU MARINER with mentors after a demonstration session

TABLE OF CONTENTS

ACKNOWLEDGEMENT

We express our heartfelt gratitude to all these organizations and individuals for providing us with their help and support when we needed them the most:

MATE - For organizing such an amazing and inspiring event like the MATE ROV competition, and for their continuous support and openness to newly participating teams.

United International University (UIU) - Providing Academic, Administrative, and Financial Support for our project and always staying by our side through tough times.

Sir John Wilson School - For supporting us by giving us access to their swimming pool to use.

Team Chief Advisor - **Dr. M. Rezwan Khan, Professor Emeritus, Dept. of EEE & Director, IAR, UIU -** For guiding, inspiring, and encouraging us to do such projects and participate in STEM competitions, and being the great tree that continues to give us shade to nurture and accelerate our growth.

Dr. Md. Abul Kashem Mia, Vice Chancellor, UIU - For his encouragement, unwavering trust, and unconditional support for our team in this project.

Team Supervisor - Dr. A.K.M. Muzahidul Islam, Professor, Dept. of CSE - For his constant effort in supporting and supervising the team.

Additional Mentors - Raiyan Rahman, Fahim Hafiz, and Shekh. Md. Saifur Rahman -For their continuous support and guidance that brought fruition to this project.

Our Family and Friends - For their support and Encouragement.

Dr. M. Rezwan Khan

Dr. Md. Abul Kashem Mia

Dr. A.K.M. Muzahidul Islam

1. DESIGN RATIONALE

1.1 ROV OVERVIEW

As complete newcomers to underwater robotics, our team began with no prior knowledge, not even familiarity with the term "ROV." Through extensive research, including documentaries and past MATE ROV Championship footage, we built a basic understanding and set a bold goal: to design a world-class ROV. After five months and six prototypes, we developed our final design—*HyDRA Scorpion*.

Scorpion features a transparent acrylic enclosure with traditional O-ring flanges, inspired by proven designs like the BlueROV2 and ROVMAKER. It's mounted on a modular HDPE chassis for strength, stability, and balanced weight. With near-neutral, slightly negative buoyancy, it descends smoothly. Powered by eight independently controlled T200 thrusters on a 48V system, it achieves full six-degree-of-freedom movement. Despite being our first underwater robotics project, our refined design enabled *HyDRA Scorpion* to complete the Pioneer Video Qualifier Tasks within the 15-minute limit—a major milestone for our debut.

1.2 DESIGN EVOLUTION

Our very first prototype, **HyDRA Crab 1.0**, started as an attempt at building our first waterproof vehicle that runs semi-submerged in water. Our main aim was to test and ensure waterproofing, observe a motor-propelled vehicle's behavior in water, and get first-hand experience on piloting a vehicle that runs on water. From then on, we grew step by step with each iterative prototype, and finally, we succeeded in building our current ROV, **HyDRA Scorpion**.

Fig. 2: Six Prototypes created through Agile Iterative Prototyping

2. SYSTEM DESIGN

2.1 ROV STRUCTURE

2.1.1 CHASSIS

The ROV Chassis is one of the most important parts and the skeleton of the ROV. We aimed to make the ROV Chassis strong, durable, anti-corrosive, chemical and weather resistant, yet also make it lightweight and near-neutral buoyant with a density close to water (95% of water density). That's why we chose Carbon Black Reinforced High-Density Polyethylene Sheets for our Chassis Material. We not only chose this material from an engineering viewpoint, but also considered the environmental impact. While there were other options to choose from, we chose HDPE for both its **reliability** and **recyclability**. We manufactured the chassis by machining 10 mm HDPE sheets into designed parts.

Fig. 3: 10mm HDPE Sheets Purchased

Fig. 4: HyDRA Scorpion Initial Chassis Frame Fully Assembled

The chassis was made in a **modular design**, ensuring that it can be disassembled into smaller parts to ensure replaceability, flexibility, and portability. The individual modular parts are then assembled using properly sized Allen Screws based on load and position. This makes our chassis a unique production in our country, using the best of locally available materials.

2.1.2 ELECTRONIC COMPARTMENT

The waterproof electronics compartment follows the Blue Robotics ROV enclosure design—an acrylic cylinder sealed on both ends with O-ring-fitted end caps. While not our original design, it offered the most reliable and adaptable solution.

During prototyping, we built ***HyDRA Archeleon*** using locally sourced aluminum sheets. Though rated for 15 feet, it proved too heavy, had recurring seal failures, and posed structural risks due to metal joint limitations and our limited fabrication experience. It was ultimately deemed unsuitable for the MATE ROV Competition.

Fig. 5: Scorpion Electronics Holding Tray (3D Printed)

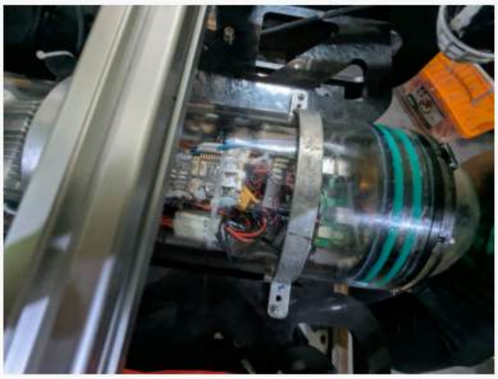

Fig. 6: Pressure Housing

Due to budget constraints, high shipping costs, customs duties, and USD payment issues, we chose not to purchase from Blue Robotics. Instead, we sourced a lower-cost Chinese sample for testing and reverse engineering, then attempted local fabrication.

We used a 1-meter, 6" acrylic pipe from the local market, cut into 500mm sections, and manually finished. End caps were made from shipyard aluminum. Initial tests with local O-rings failed, so high-quality O-rings were imported from China. Our enclosure achieved a depth rating of 20–30 meters,

, less than the 50–100 meters of the Chinese sample, but within MATE requirements. As the Chinese sample was too small to house all electronics, we proceeded with our locally built enclosure. The result was ***HyDRA Scorpion***—an ROV constructed entirely in-house.

2.1.3 MANIPULATOR ARM

Scorpion's Major Manipulator Arm, ***Stinger***, is a 4-DoF Robotic arm driven by Four Planetary Gear DC Motors in **12V**, controlled by BTS7960 motor drivers for precise control and high power delivery. The two motors at the base joints drive the Arm up, down, forward, and backward through Lead Screw Actuation. The other two motors are inside the gripper section of this Arm, one of these drive another smaller lead screw mechanism to open and close the Grip of the Arm, and the other rotates the entire gripper system from the inside using a Planetary Gear System to achieve a rotating motion for the gripper, which comes in handy for tasks like 'Replacing the Anodized Anode'. All motors are completely sealed and waterproofed inside acrylic compartments using O-ring seals and multi-layered protection.

Fig. 7: Manipulator Motors Waterproof Sealing

Fig. 8: ***Stinger***, Scorpion's main manipulator arm

2.1.4 SECONDARY MINI GRIPPER

Scorpion features a mini robotic gripper, ***Pincer***, designed to assist in accessing objects near the pool floor where the main manipulator has limited reach. It also supports the main arm during complex tasks. In product demonstrations, *Pincer* is used to release the Hydrophone pin efficiently, minimizing movement compared to the main manipulator. It uses a single motor for lead screw actuation as a gripping mechanism.

Fig. 9: ***Pincer***, Scorpion's secondary gripper

2.1.5 TETHER

The tether for **Scorpion** consists of **three** cables merging into one tether. Two **10 AWG** cables, one black and one red, for ROV power supply ground and positive wiring, and a single **CAT-7 S/FTP** shielded gigabit Ethernet twisted pair cable, taking advantage of the Gigabit Ethernet port of Raspberry Pi 5 for fast, smooth, and real-time communication and minimal delay in ROV camera feedback. Although a CAT-6 would've been enough for transmission speed, and a CAT-7 wouldn't increase it due to bottlenecks on both the ground station laptop and the Raspberry Pi 5 ethernet port, we still went with CAT-7 due to its availability in S/FTP shielding, which protects it from noise and interference from the thrusters and other high current motors in the ROV, for tether ensuring signal and data Integrity.

Fig. 10: CAT-7 Cable

2.2 BUOYANCY & PROPULSION

2.2.1 BUOYANCY

Scorpion was designed to be near-neutral buoyant, with its buoyancy being slightly negative. The slightly negative buoyancy makes the ROV naturally sink when deployed in water without thrusters on, and the ROV behaves like a falling object. This allows its **4 vertical/Z-axis thrusters** to maneuver the ROV in any direction at any height, like a quadcopter drone behaves in the air. The additional thrusters at the front and back allow the ROV to move freely in any direction at a fixed height, and they are used to maneuver the ROV, especially when the ROV is at the bottom of the pool performing tasks.

2.2.2 THRUSTER ORIENTATION

Scorpion uses an eight-thruster configuration with T200 thrusters, each controlled by a dedicated ESC for independent operation. Four thrusters are mounted at the upper corners, all aligned along the positive Z-axis. The bottom front pair is angled at 45° between the positive X and Y axes, while the rear pair is angled at 45° between the positive X and negative Y axes. This configuration enables full 6-DoF control, allowing precise movements, rapid 360° spins, and omnidirectional maneuverability using one or more thrusters as needed. This entire orientation of eight thrusters allows **Scorpion** Six Degree of Freedom (**6-DoF**) Movement.

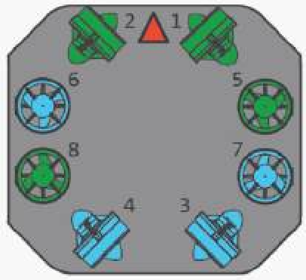

Fig. 11: Thruster Orientation

2.2.3 CONTROL

Scorpion is controlled by a gaming joystick from the control station. The joystick keys are calibrated and configured to suit **Scorpion's** needs. The pilot can control thrusters individually or change mode to use preset control of UP, DOWN, LEFT, RIGHT, and STOP. The pilot can also toggle Constant Thrust Mode or Incremental Thrust Mode depending on the scenario. Constant Thrust Mode makes the ROV move at a constant speed in any direction, while the Incremental Thrust Mode allows the ROV to slowly gain speed till it reaches maximum velocity while moving in a direction, as long as the pilot is keeping the button pressed. This control system, although slightly complex, allows the pilot to do versatile maneuvering with enough training.

Fig. 12: Joysticks Used For Control

2.3 ELECTRONIC SYSTEM

2.3.1 ELECTRONIC SYSTEM OVERVIEW

The ROV uses a **48V** system. The main processing unit for **Scorpion** is the **Raspberry Pi 5** single-board computer with **8 GB of RAM**. A Pixhawk-4 flight controller drives the 8 ESCs for the 8 thrusters. A barometric pressure sensor (**BMP388**) is used to measure the internal temperature and pressure of the ROV, while the Blue Robotics Bar02 sensor is used to measure the in-water depth of the ROV. An **SOS Leak Sensor**


Fig. 13: Raspberry Pi 5

with **multiple probes** is used to detect water leaking into the ROV. **Two Raspberry Pi Noir Camera 3** modules, one **standard** and one **wide-angle**, are used for ROV Vision. The Robotic Manipulator Arm is driven by **4 single-channel BTS7960** motor drivers driving 4 different motors. **Another BTS7960** motor driver drives the small gripper at the bottom. The Ethernet cable in the tether is directly connected to a laptop on the surface control station, and the other end of the Ethernet cable enters the gigabit LAN port of the Raspberry Pi 5.

2.3.2 POWER SUPPLY & MANAGEMENT

The ROV is powered by a **48V** power supply. The ROV power cable is **crimped** to an **Anderson Powerpole SBS50** connector, which acts as the **single point of power connection** for the ROV.

Based on its **FLA,** which is **27.58 amps**, it uses a **LittleFuse 30A JCASE** Cartridge Fuse installed in a **Littlefuse JCASE Series Fuse Holder**, where the fuse is placed **within 30 cm** of the Anderson Powerpole connector. The **48V** power line then enters the ROV, and that's where the power conversions happen. Inside the ROV are **4 parallelly connected 48V to 12V 30A DC-DC Golf Cart Buck Converters,** which can supply adequate power to the ROV in **12V.** The **12V line** then enters the **Pixhhawk PM07 Power Module.** All **12V** power lines in the ROV are distributed to each component by the Pixhawk PM07 Power Module. For all 5V components, such as the Raspberry Pi 5 and the sensors, LM7805 voltage regulator ICs are used to regulate **5V.** If more than 1A current is required for a 5V component, multiple **LM7805 ICs** in parallel are used to provide adequate power. The LM7805 ICs are equipped with a proper heatsink to dissipate heat and ensure stable performance. **48V** System has been chosen for this ROV because of the maximum power limits (12V 25A) of the 12V system.

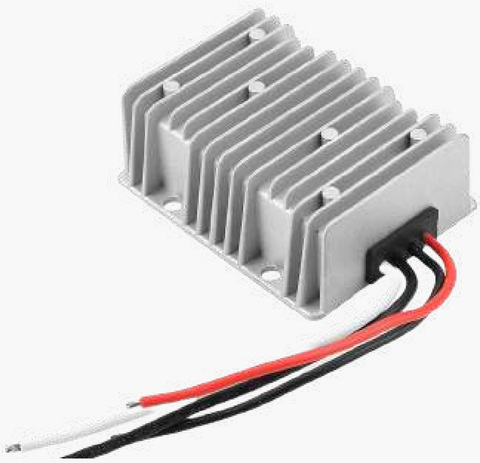

Fig. 14: Buck Converter

2.3.3 POWER CONSUMPTION

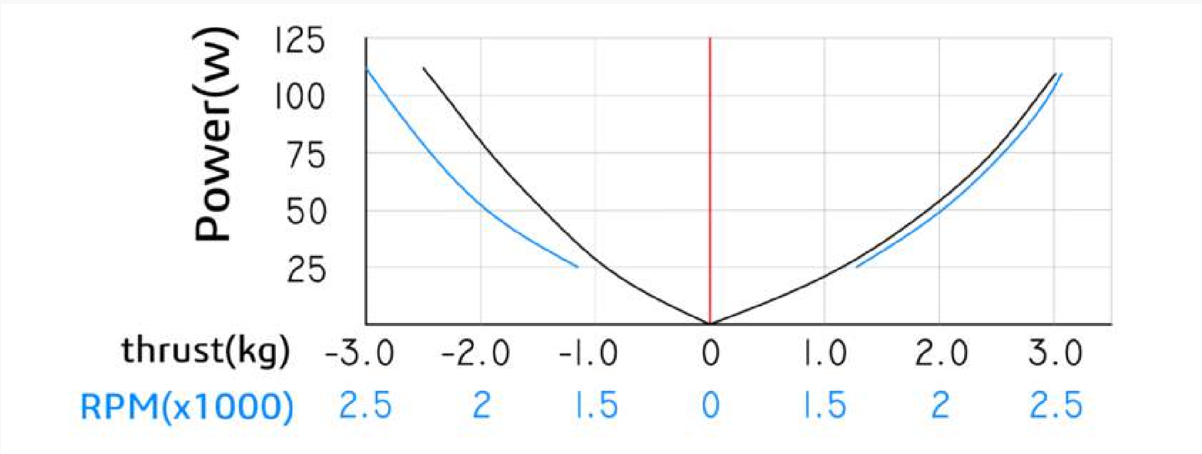

Fig. 15: T200 Single Thruster Power vs Thrust Chart.

Table 1: Full Load Amps Measurement Table (48V)

SL No.	Condition	AVG Amps	Max Amps	Thrusters Running
1	Max Forward/Backward Thrust	12.67	13.23	2
2	Max Up Thrust	24.33	**27.58**	4
3	Max Down Thrust	23.89	26.73	4
4	Thrusters off, Arm Only	1.17	1.95	0

2.4 SURFACE CONTROL STATION

2.4.1 CONTROL STATION SETUP

To ensure simplicity in the surface control station, the surface control station uses only a laptop, two joysticks, and an 18-inch IPS monitor. AC power is marked separately for the surface station. The station is set up on a single table, allowing the Pilot and Co-pilot to focus on their jobs. **No control box** is used.

2.4.2 SOFTWARE & PILOT INTERFACE

Our ROV software enables **full vehicle control**, **navigation**, and **live video streaming** for tasks like shipwreck measurement and cargo identification. Developed in Python for seamless hardware integration, it uses OpenCV for image processing and computer vision.

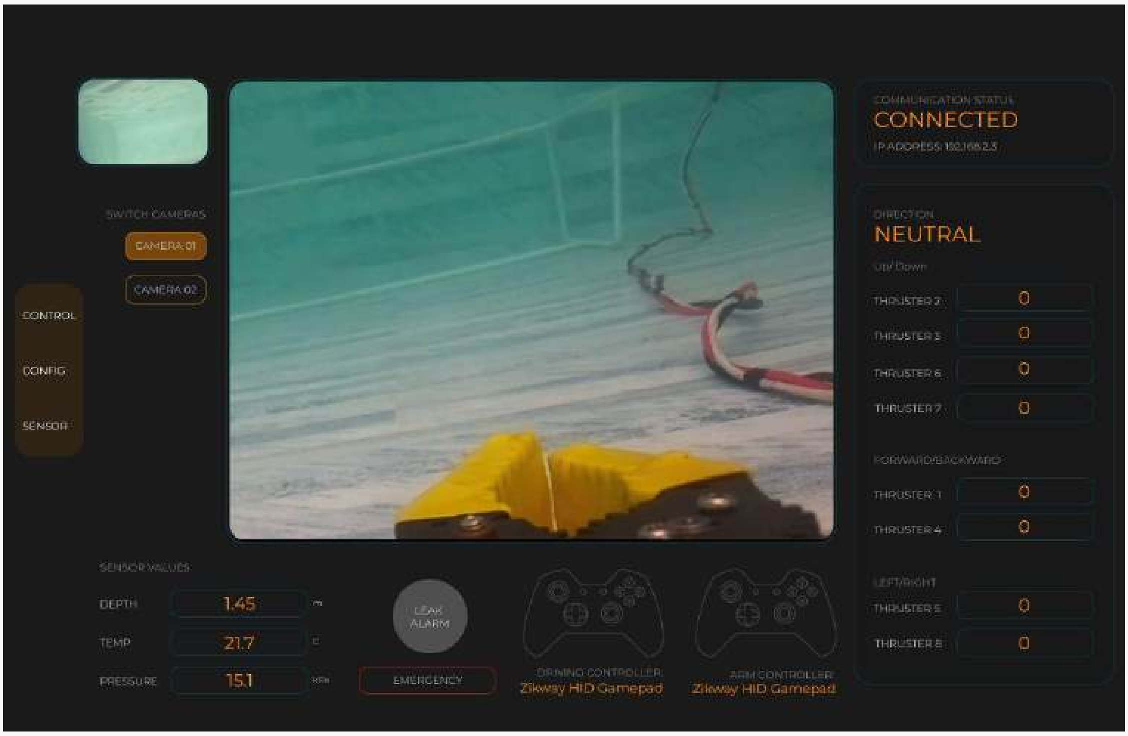

Fig. 16: Pilot Interface

The GUI, built with PyQt6, offers real-time video and command control. Socket programming on the Raspberry Pi 5 ensures real-time, bidirectional communication between the ROV and control station. Hardware components are managed via **RPi.GPIO**, and the camera feed is handled using the GStreamer pipeline. The Pilot Interface of the software is kept simple yet concise, with adequate features for the pilot to quickly access and monitor ROV information to make fast and accurate decisions.

2.4.3 CAMERA VIEWS & MONITORING

One of the camera views is streamed on the surface control station laptop screen at the center of the pilot interface, while the other camera view is projected on the additional display monitor connected to the laptop. The pilot can use software hotkeys to switch between the main and secondary camera whenever necessary.

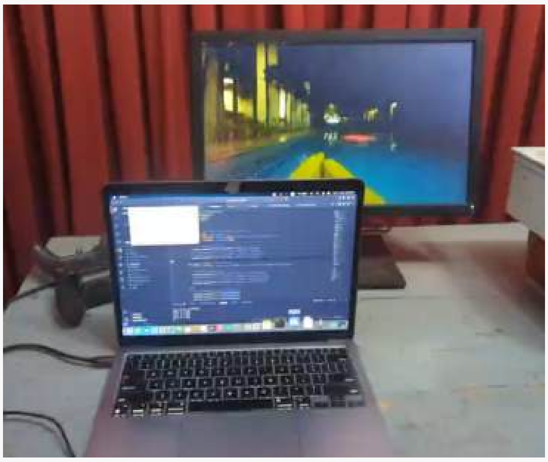

Fig. 17: Camera Feed Monitoring

2.5 ROV VISION

2.5.1 UNDERWATER VISIBILITY

Scorpion uses the Raspberry Pi Camera Module v3 NoIR, which lacks an IR filter for enhanced low-light and underwater sensitivity. It captures up to 12MP video at high frame rates, enabling real-time monitoring. The NoIR capability improves visibility and object detection in murky water by capturing near-infrared light. The camera is housed in a waterproof enclosure for reliable underwater operation.

2.5.2 CAMERA CALIBRATION

Underwater noise from low light, turbidity, and suspended particles is mitigated through hardware and software methods:

Hardware:

- Raspberry Pi Camera Module v3 NoIR for enhanced low-light and IR sensitivity
- External LED lighting for improved underwater illumination

Fig. 18: Raspberry Pi Camera Module

Software:

- Gaussian Blur and Median Filtering (OpenCV) to smooth random noise
- Adaptive Thresholding for clearer object-background separation
- Temporal Averaging to reduce flicker and transient noise
- Optional image stabilization to minimize motion blur from ROV movement

2.5.3 SMART ROV VISION

Scorpion Computer Vision Features include:

- Color Correction & Identification
- Aspect Ratio Measurement
- Length and Distance Measurement
- **Detecting "T" Shapes:** "T" shape detection uses **OpenCV**-based color segmentation to identify distinct colored markers. Frames are converted to **HSV** for better filtering, then masked to isolate the target color. Morphological operations reduce noise, and contours are analyzed by shape and aspect ratio to confirm "T" patterns. Valid detections are highlighted and tracked in the GUI, ensuring reliable performance in visually complex underwater environments when the target color is distinct.

2.6 ROV SPECIALIZATION

HyDRA Scorpion specializes in:

- **Underwater Computer Vision:** Object detection and identification, color detection, correction, and identification, size and distance measurement, and low-light visibility.
- **Underwater Inspection & Sample Collection:** Collecting marine biological samples like edna, jellyfish, coral, algae, water samples for testing, and onboard pH measurement.
- **Underwater Maneuvering:** Accessing underwater regions physically inaccessible to human divers (narrow caves, coral reefs, etc.).
- **Underwater Intervention (Repair, Removal, Replacement):** Repairing underwater devices, removing debris, replacing worn-out underwater components like sacrificial anode, hydrophone, etc.

3. CRITICAL ANALYSIS

3.1 ROV TESTING & TROUBLESHOOTING METHODOLOGY

3.1.1 WATERPROOF TESTING & TROUBLESHOOTING

The ROV's electronics chamber is tested for leaks in its waterproofing by putting the chamber several feet underwater for a few hours. Also, a handheld airtightness detection kit is used to ensure that the ROV is free of leakage under the pressure of at least 4 bars. The test is done before the ROV is put underwater to ensure that the ROV is depth rated for at least 42 meters, which is 4 times the pressure requirement of 7 bars for the world championship.

3.1.2 MECHANICAL TESTING & TROUBLESHOOTING

Mechanical tests, such as vibration tests and impact tests, are performed to make sure that the ROV remains waterproof and can operate despite moderate vibration or impact while maneuvering underwater. Loose joints, nuts, bolts fasteners are checked for tightness before missions to ensure successful operation.

3.1.3 ELECTRICAL TESTING & TROUBLESHOOTING

All electrical components are tested with reliable multimeters, oscilloscopes, and other diagnostic tools for proper connectivity and functionality before ROV deployment underwater to ensure mission success. Bucks are tested for regularly tested for performance, testing ripple, and efficiency. Sensors are tested for accuracy and calibrated properly whenever necessary.

3.1.4 SOFTWARE TESTING & TROUBLESHOOTING

Our ROV Software, which is custom-built by our team, has inbuilt features for testing and troubleshooting. Also, we use the ideal development environment for software and interface, such as using the most suitable version of Ubuntu OS for Jetson, or an appropriate version of Raspberry Pi OS for successful troubleshooting. We also run Q&A tests, unit tests, and appropriate Software Testing Models to debug, test, and troubleshoot software code. Before version updates are made, previous versions are properly backed up. Any new code is properly tested and verified before pushing to GitHub. This ensures that software end failures do not disrupt ROV performance.

3.1.5 FULL SYSTEM TEST

A Full System test is a test we perform systematically, step by step, following an algorithm and maintaining a checklist. For Full System Test Procedure, See **Appendix C**.

4. SAFETY

4.1 PHILOSOPHY

For UIU MARINER, safety is the foundation of everything we do. We firmly believe that an ROV is only as effective as it is safe, and every design decision is made with this principle at the forefront. Our team is dedicated to fostering a culture of continuous improvement, where every member is encouraged to identify and implement ways to strengthen our safety practices. For us, safety is not just a set of rules—it is a core value that drives our work and ensures the well-being of our team and the integrity of our projects.

4.2 AWARENESS & TRAINING

UIU MARINER believes that safety begins with awareness. The members of the team are always made aware and reminded of the potential dangers and hazards. Additionally, every one or two work weeks, our team members go through safety drilling sessions, to keep them prepared with hands-on experience for unforeseen and unexpected situations.

4.3 SAFETY STANDARDS

UIU MARINER and the ROVs we build adhere to the safety regulations and standards followed by the industry, and align with the Safety Requirements set by MATE for the specific competition class, exactly according to the manual. We follow the standard to not only ensure that our ROV is presentable and acceptable to the industry, but also to sync with the specific environment of the MATE ROV Competition, so that our ROV can adapt to the competition setup and operate safely under MATE's requirements.

4.4 SAFETY FEATURES

Since our ROV operates on a 48V System, the safety features include:

- Anderson Powerpole SBS50 Connectors
- Properly crimped power cables with the connector using Anderson's recommended crimpers.
- LittleFuse JCASE Cartridge Fuse Properly sized according to the ROV's FLA.
- LittleFuse JCASE Fuse Holder
- Fuse installed within 30 cm of the Anderson Powerpole Connectors.
- No power conversion before the ROV. Single attachment point to the power source.
- ALL propellers are completely shrouded to IP-20 standards. Mesh size<12.5 mm.
- All items securely attached to ROVs using industry grade screws, bolts, and fasteners.
- No exposed copper or bare wire. All wiring is securely fastened and properly sealed.
- Tether is properly strain relieved on both ends. All wires entering and leaving the surface control station have adequate strain relief and wire abrasion protection.
- No exposed motors. All components using electric power are properly sealed and waterproofed.
- All connectors utilized are properly rated for their application.
- No sharp edges or elements of the ROV design that could cause injury to personnel or damage the pool surface.

5. PROJECT MANAGEMENT

5.1 TEAMWORK

UIU MARINER represents the MATE division of the UIU Advanced Underwater Robotics & Automation Crew, a student-led organization at United International University (UIU). As a team of driven undergraduate students, Hydra is passionate about pushing the boundaries of underwater robotics through innovation, teamwork, and competitive excellence. Our primary mission is to design, build, and compete with Remotely Operated Vehicles (ROVs) in the prestigious International MATE ROV Competition. For UIU MARINER, efficient project management is the backbone of our success in developing and deploying our ROV, ***HyDRA Scorpion***. To maintain organization, productivity, and consistent progress, we implement the strategy of Iterative Reviews.

We follow an **Agile Framework**, organizing our work into **2-3 week sprints**. After each sprint, we conduct thorough reviews to assess progress, tackle challenges, and adapt our plans as necessary. This iterative process ensures continuous improvement and allows us to respond effectively to new requirements or unexpected issues. To encourage excellence, we use a marking system to recognize the best performers in every sprint, promoting healthy competition and rewarding outstanding contributions.

5.2 PROJECT SCHEDULING AND TIMELINE

We set clear milestones and deadlines for every project phase, including design, prototyping, testing, and final implementation. By regularly tracking these checkpoints, we ensure the

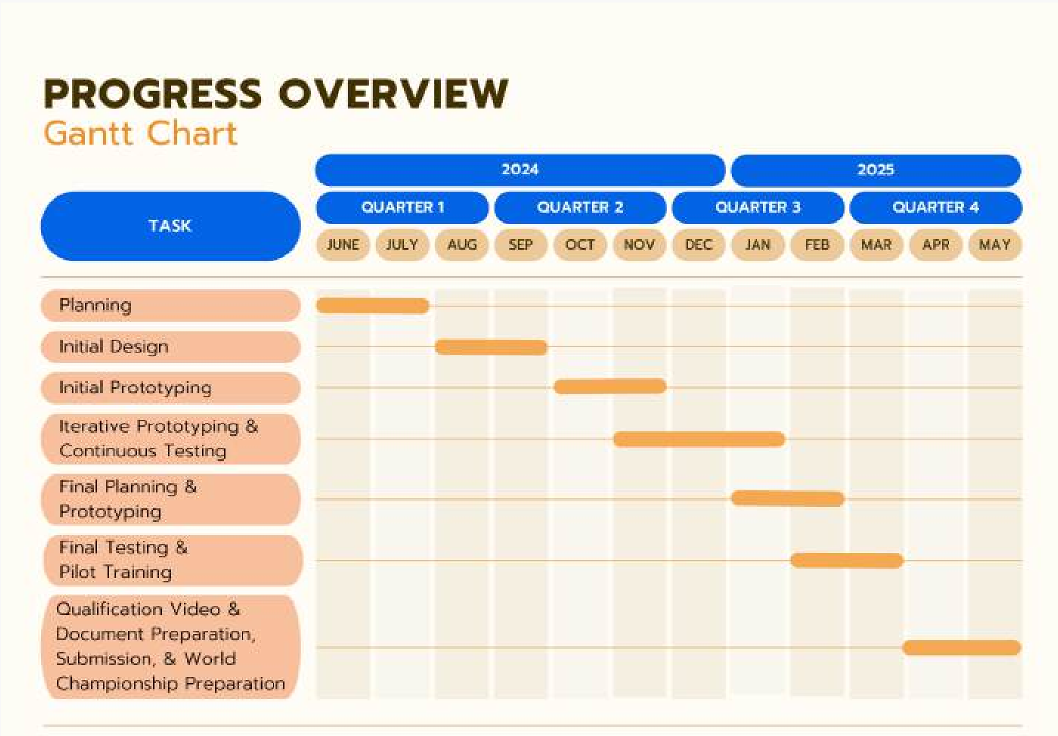

Fig. 19: Progress Overview (Gantt Chart)

project stays on schedule and can quickly address any delays or roadblocks. We use the following elements to ensure proper work scheduling:

1. Task Management Dashboard (See Fig. 20)
2. Team Meetings
3. Progress Documentation
4. Individual Member Weekly Performance Grading

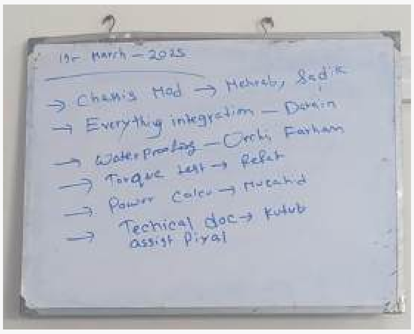

Fig. 20: Task Management Dashboard

5.3 ACCOUNTING

Responsible accounting has been integral to our project from the outset. Even during the planning phase, we prepared a detailed estimated budget to present to our university, securing approval and administrative support through transparent financial planning. Since then, all expenses have been carefully managed under the supervision of the Team Lead, Project Manager, and Logistics Lead. The following screenshots of accounts show the procedure of tracking our proposed budget, expenditures for our latest ROV prototype—qualified for the 2025 MATE ROV World Championship Pioneer Class—and the proposed budget for U.S. travel and related expenses. **Note:** As we are first-timers, there are **no reused or donated components**. **All components are newly purchased**.

Propoesed Budget-Estimated

Institute: United International University		**Project Name:** MATE ROV		**From:** 3 September 2024		
Sponsor: United International University				**To:** 16 May 2025		
Category	**Component**	**Unit Cost (USD)**	**Quantity**	**Total Cost (USD)**	**Prics Reference**	**Buying Source**
Electrical/Electronic	Blue Robotics T200 Thrusters	200	12	2800	Blue Robotics	Import
	Blue Robotics 30A ESC	38	14	532	Blue Robotics	Import
	Electronic Controllers and Sensors	N/A	N/A	1500	Estimated	Import
	Power Guard 3000VA Online UPS	300	1	300	Ryans	Local
Mechanical	T200 Thrusters Mounting Bracket	8	14	112	Blue Robotics	Import
	Mechanical Components, PVC & Fittings	N/A	N/A	2000	Estimated	Mixed
	3D Printing Materials, Manufacturing, & Assembly	N/A	N/A	1500	Estimated	Mixed
	Anodizing	N/A	N/A	199	Estimated	Import
	Crodless Power Screwdriver Set	16	2	32	TechshopBD	Local
	Pro'sKit 1PK-618B Maintenance Kit	35	1	35	TechshopBD	Local
	Dewalt Impact PVC Cutter	81	1	81	Amazon	Import
	Marine Epoxy	15	20	300	Amazon	
	Epoxy Potting Kit	10	10	100	Blue Robotics	Import
	3D Printer	1250	1	1250	Estimated	Import
Project Development	Testing & Prototyping	N/A	N/A	600	Estimated	Mixed
	Contingency	N/A	N/A	1000	Estimated	Mixed
		USD			**BDT**	
	Net Total	**12341**			**1,554,966**	

Fig. 21: Initial Estimated Budget

Component Name	Quantity	Price (BDT)	Price in USD
T200 Thrusters	8	৳250,680.00	$2,058.61
Raspberry pi 5	1	৳15,420.00	$126.63
Arducam Noir wide angle camera	1	৳9,120.00	$74.91
Pixhawk 4	1	৳14,610.00	$120.01
bt60 motor driver	5	৳3,125.00	$25.66
joystick	2	৳16,000.00	$131.42
bar sensor	1	৳10,323.59	$84.86
bmp390	1	৳1,330.00	$10.92
sos leak sensor	1	৳4,266.50	$35.03
Current sensor	1	৳150.00	$1.23
60 feet 10 awg silicon cable	60ft	৳15,000.00	$123.30
Anderson connector	1	৳1,581.60	$13.00
Anderson connector pin	2	৳487.60	$4.00
Power supply (48V 30A)	1	৳40,000.00	$328.63
buck converter 48V to 12V, 30A	3	৳6,476.55	$53.21
Multimeter	1	৳1,145.00	$9.40
Soldering iron with stand	1	৳1,250.00	$10.27
Vero board	1	৳35.00	$0.28
Body Manufacturing	1	৳45,000.00	$369.78
Arm Manufacturing	2	৳46,000.00	$378.16
3D printer	1	৳39,000.00	$320.61
Chassis Material	1	৳32,000.00	$263.06
TOTAL		**৳553,000.84**	**$4,542.98**

Fig. 22: Actual Expenses

Segment	Quantity	Unit Cost (USD)	Total Cost (USD)	Total Cost (BDT)
Visa Fee	10	185	$1,850	৳240,500
Round Trip Air Ticket(Dhaka-Chicago-Dhaka)	10	2200	$22,000	৳2,860,000
Local Transport+Food+Lodgistics (Tareq Bhai)	N/A	N/A	$14,000	৳1,820,000
AirBNB Rent Charge	N/A	N/A	$7,800	৳1,014,000
T-Shirt V1	40	4	$160	৳20,800
T-Shirt V2	30	5	$150	৳19,500
Bubble Wrap, Stickers, Labels, National Flag	N/A	N/A	$50	৳6,500
ROV Container Box	1	100	$100	৳13,000
Contengency	N/A	N/A	$7,000	৳910,000
Net Total	-	-	**$53,110**	**৳6,904,300**

Fig. 23: Estimated Budget for USA Travel

5.4 CHALLENGES

We have faced many challenges throughout our journey to the **MATE ROV World Championship**. Right after we started the project, when everything was still in the planning phase and the Project Budget was waiting for approval, a national uprising happened in Bangladesh, the July Revolution. During the July 2024 Revolution against the autocratic regime, students were the front-runners in the movement. All educational institutes were shut down till the end of August 2024, and many students died in protest. One of them, Irfan Bhuiyan, was a student of our university. The entire nation was in chaos. Our funding and campus activities for the project were delayed, but with the inspiring spirit of the martyrs in our hearts, we put much more effort into the success of this project. With efforts beyond our best efforts, we tried not to lag too far from the deadlines.

We faced two other major hurdles. First, our local market lacked the parts and manufacturing facilities we needed. Importing was impeded by long shipping times, high fees for faster service, foreign-currency payment limits, import regulations, steep customs duties, and a budget strained by the rising USD rate. We therefore relied on the best foreign suppliers we could access and, where possible, adapted local components.

Second, finding a pool to test our ROVs was difficult. Only two nearby public pools were accessible, and transporting our equipment over poor roads was challenging. We persuaded a small park's pool owner to rent us a few hours daily, but its water quality and facilities weren't sufficient for our underwater tasks or qualifier video. In that critical period, Sir John Wilson School generously let us use its pool after hours.

5.6 LESSONS LEARNED

Building a ROV and participating in an Underwater Robotics Competition for the first time, we have learned numerous things throughout the project. From learning about methods of **Waterproofing sealing** to **Manufacturing Methods & Material Engineering** suitable for the

Marine Environment, it was a great leap in our engineering knowledge and experience. We also gained further knowledge and experience in **3D Printing**, **CAD Design**, **PCB Design**, **CNC Machining**, and **Laser Cutting**. We also learned a lot of new things in computer vision, like underwater vision, underwater distortion adjustments, color detection and correction, length and distance measurement through computer vision. From the MATE Tasks, we learned about new things like **sacrificial anodes**, **spotter buoys**, **vertical profiling floats**, **carp behaviors**, **edna sampling**, etc. From the Management perspective, we've learned substantially about Project Management, Accounting, Leadership, and Teamwork.

5.7 FUTURE PLANS

Based on our performance and results in the World Championship, we plan to participate in the Explorer class and train a new team for the Pioneer class next year. We also want to experience other underwater robotics competitions like RoboSub and SAUVC. Further into the future, we want to bring affordable and efficient ROV and AUV solutions & technologies to our riverine country of Bangladesh.

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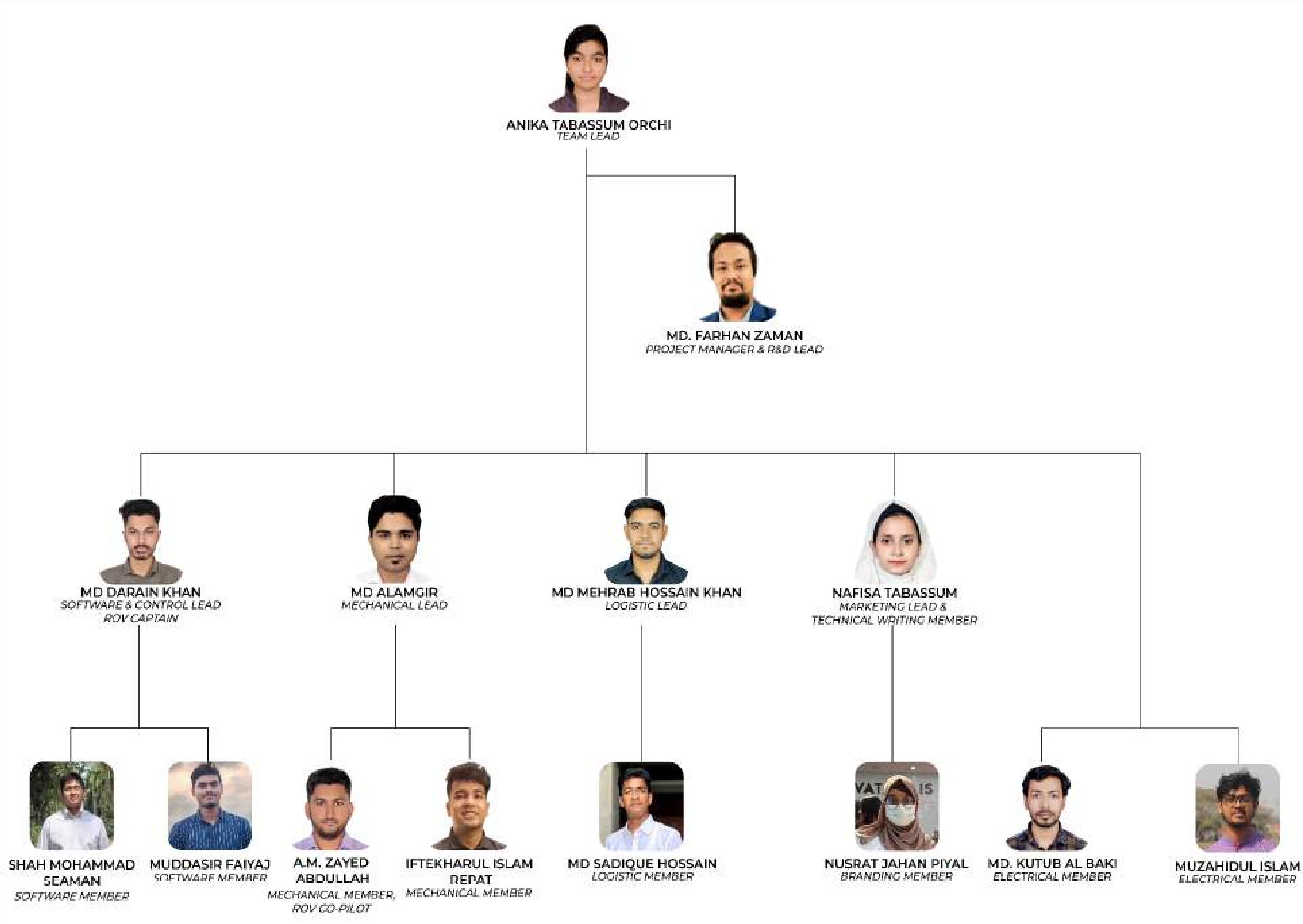
APPENDIX A: COMPANY STRUCTURE



APPENDIX B: SAFETY CHECKLIST

UIU MARINER follows a rigorous safety protocol to ensure secure operations. Before every operation, the safety checklist printouts are handed to the responsible team members to carry out a safety check and verify.

Pre-Deployment Checks:

- ☐ Ensure that the Power Supply is off.
- ☐ Inspect all power connections and ensure all electronics are functional.
- ☐ Verify waterproof seals
- ☐ Ensure the tether is secured with strain reliefs to prevent damage.
- ☐ If Necessary, run **Full System Test**.

Operational Safety Measures:

- ☐ Use personal protective equipment (PPE) during assembly and testing.
- ☐ Maintain clear communication among team members during deployment.
- ☐ Monitor electrical connections to prevent overheating or short circuits.

In-water Safety Measures:

- ☐ Continuously monitor ROV from poolside by assigning responsibility to a member.
- ☐ Monitor Tether Excessive Strain or Entanglement.
- ☐ If leak detected/monitoring member gives an alert, proceed with **Emergency Procedures**.

Emergency Procedures:

- ☐ Identify emergency shutoff points.
- ☐ Co-pilot Turns Off Power.
- ☐ Have designated personnel for rapid intervention in case of failures
- ☐ Deployment Members Recover ROV after receiving "Turned Off" call from Co-pilot.
- ☐ Swiftly dry the ROV and check for damage or failure points.
- ☐ Document and report any safety incidents for process improvements.

APPENDIX C: FULL SYSTEM TEST PROCEDURE

Date: __________ **Time:** _________ **Checked By:** ___________ **Verified By:**

Full System Test Procedure Checklist:

Pre-Deployment Test:

- ☐ Turn On Control Station AC Power
- ☐ Check Control Station Functionality
- ☐ Turn On 48V DC Power Supply
- ☐ Check Power Supply Voltage Output with Multimeter
- ☐ Turn Off 48V DC Power Supply
- ☐ Properly Connect the Tether Anderson Powerpole to Power Supply Anderson Powerpole
- ☐ Power On the 48V DC Power Supply
- ☐ Verify ESC Tone
- ☐ Connect Ethernet to the Control Station Laptop
- ☐ Verify Camera Feeding
- ☐ Confirm Communication
- ☐ Confirm Software GUI Readings
- ☐ Check Thrusters at Low Speed
- ☐ Test Main Manipulator Functionality
- ☐ Test Mini Gripper Functionality
- ☐ Verify Everything Above is Checked
- ☐ Properly Deploy the ROV in water
- ☐ Proceed to Underwater Test

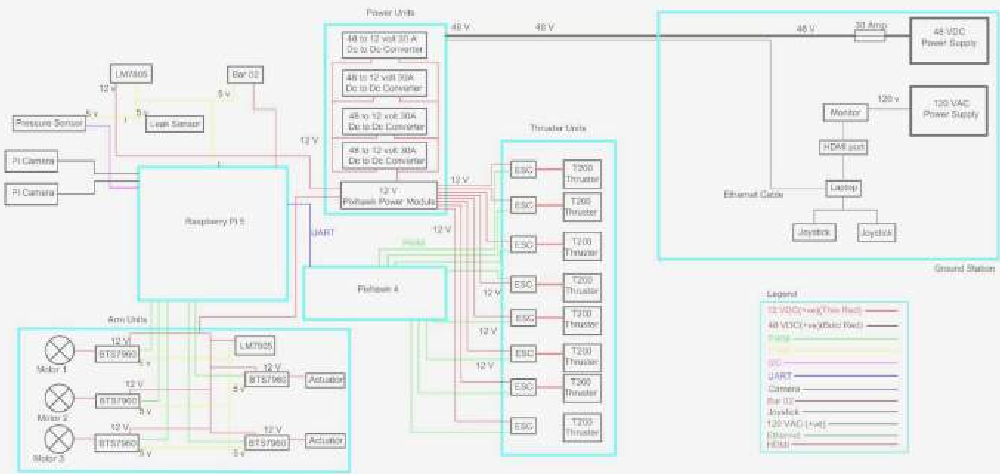
Underwater Test:

- ☐ Adjust Orientation
- ☐ Adjust Flotation
- ☐ Test Motion & Control
- ☐ Test ROV Balance
- ☐ Check for SOS Leak Alerts
- ☐ Test PID and Calibrate if necessary
- ☐ Test ROV Surfacing
- ☐ Return ROV to Shore
- ☐ Turn Off ROV through Software
- ☐ Power Off 48V DC Power Supply
- ☐ Disconnect Ethernet from Laptop
- ☐ Retrieve the ROV

Notes/Comments:

APPENDIX D: SYSTEM INTEGRATION DIAGRAM (SID)

ELECTRICAL SID



Full Load Amps (FLA) in Water: *27.58 A*
Selected Fuse Size based on FLA: *30A*

SOFTWARE SID