MANIPAL ACADEMY of HIGHER EDUCATION
DUBAI CAMPUS
(Institution of Eminence Deemed to be University)
INSPIRED BY LIFE

MATE ROV COMPETITION

JALPARI

TECH REPORT

TEAM JALPARI

T A B L E   O F   C O N T E N T S

TEAM MEMBERS

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‘25 - BILAL BASLAR
’25 - GAGAN PRAMOD
’26 - MOHAMED HANIF NAZAR

ELECTRICAL:-

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‘25 - ADARSH BABURAJ
‘25 - SHAIMA ZAFFAR

SOFTWARE:-

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1. INTRODUCTION

ABSTRACT

Team Jalpari Introduces N.I.M.O: (**N**avigational **I**nstrument for **M**arine **O**peration)

Team Jalpari is driven by a dual mission: to push the boundaries of engineering and to contribute meaningfully to ocean conservation. This passion led us to develop N.I.M.O., a next-generation Remotely Operated Underwater Vehicle (ROV) specifically designed for the demanding challenges of the MATE 2024 competition.

Motivation:

The ocean is a vast and vital resource facing unprecedented threats. We believe that technological innovation is key to unlocking solutions for sustainable exploration and conservation. However, existing ROVs often present a barrier due to high costs or limitations in efficiency.

Project Goals:

N.I.M.O. addresses this challenge by aiming to achieve two key goals:

- Engineering Advancement: We designed N.I.M.O. to be a platform for our team's engineering prowess. By focusing on affordability and advanced features, we sought to push our design and manufacturing capabilities to a new level.
- Ocean Conservation Impact: N.I.M.O.'s powerful and efficient design is specifically tailored for real-world ocean research and conservation tasks. We envision N.I.M.O. being a valuable tool for tasks like:
  - Coral reef exploration and monitoring
  - Studying and protecting marine life
  - Assisting in underwater clean-up efforts

Presentation Overview:

This presentation will delve into the design and development of N.I.M.O., highlighting the innovative solutions that contribute to its affordability and efficiency. We will showcase N.I.M.O.'s key features and capabilities, demonstrating how it addresses the needs of the MATE 2024 competition and contributes to a future of sustainable ocean exploration.

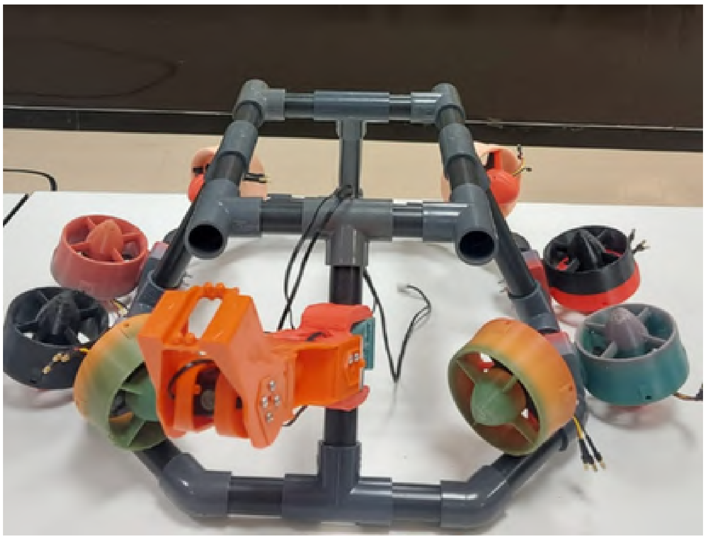
DESIGN RATIONALE:

1. DESIGN

1.1 Design Evolution

1.1.1 Frame

Initially, we opted for an 8 thruster design due to its advantages in achieving 6 degrees of freedom (6DOF). This choice aimed to reduce the complexity of the manipulator while enhancing the ROV's control. The frame design was centered around integrating these thrusters into a Vectored ROV with Four Vertical Thrusters frame. Initially constructed from PVC pipes and visualized using CAD, this design provided a foundational structure.



However, we soon realized the necessity for a more robust frame. Aluminum extrusions were selected for their strength and modular features, facilitating component additions and adjustments for buoyancy and component placement.

1.1.2 Electronic Box

Originally, a square box was planned to maximize volume efficiency and minimize hull volume. Yet, due to the unavailability of suitable watertight boxes, we shifted to a cylindrical structure. Exploring options such as acrylic tubes proved costly, leading us to construct the box from PVC piping, a waterproofing solution used in similar applications.

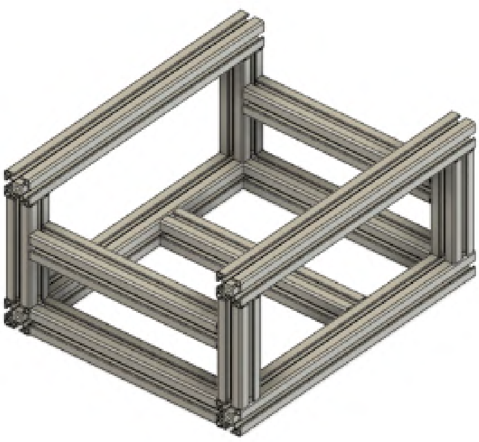
1.1.3 Thrusters

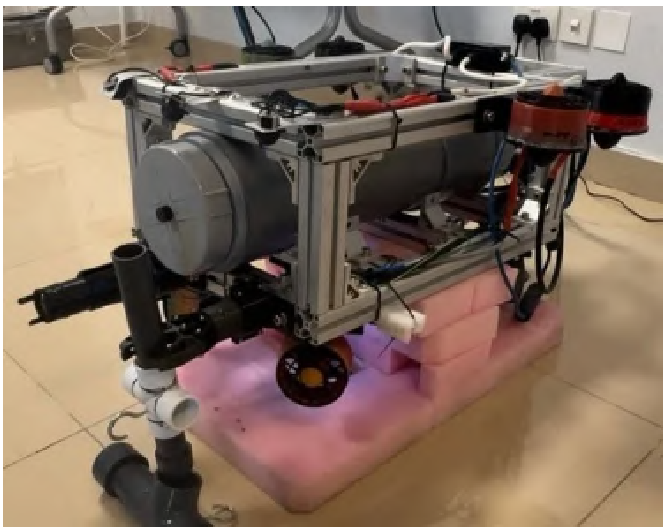
Initial plans to use industry-standard T200 thrusters were reconsidered due to cost, leading us to opt for drone BLDC motors paired with 30A ESC. Inspired by T100 thrusters, we 3D printed the bodies and propellers.

1.2 **Detailed Design**

1.2.1 Frame

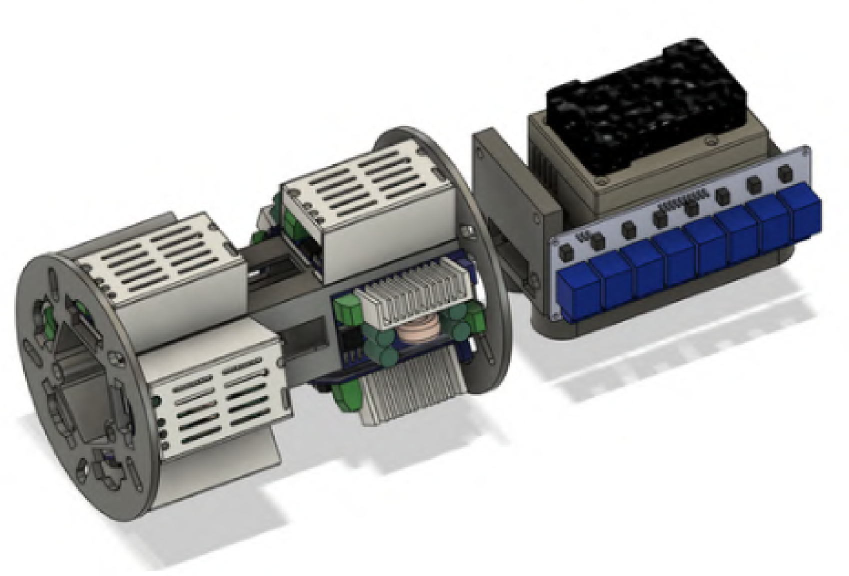
Constructed using a combination of 4040 extrusions to provide sufficient weight (approximately 10kg) to counteract buoyancy from the electronic box's hull volume. Thruster mounts were 3D printed with high infill to minimize water ingress, though ideal waterproofing methods were unavailable. Camera mounts were fabricated from 1.2mm aluminum flat bar. Grippers and mounts were also 3D printed. Waterproof strain reliefs were utilized for wiring.





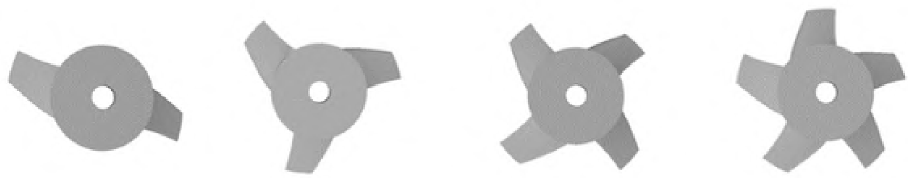
1.2.2 Electronic Box

A 6-inch PVC pipe with couplers and access caps formed the electronic box, chosen for its cost-effectiveness and waterproof properties. Waterproof connector glands were employed for thruster wirings and power connections, with resin used to enhance waterproofing. Internal components were compactly arranged using custom 3D printed casings.



1.2.3 Propulsion

Initially using A2212 BLDC motors, we later upgraded to A2217 950kV BLDC motors for improved torque. Customized propellers were tested with different blade configurations (2, 3, 4, and 5 blades), with a focus on achieving higher torque at lower currents. The 4-blade design struck a balance between torque and current consumption. Using this we achieved a 1.3kgf of push/pull at 7A continuous and 11A peak.



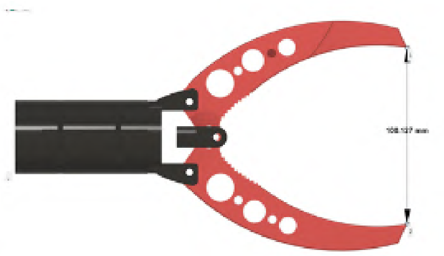
In summary, the design evolution saw a transition from initial concepts to refined solutions, addressing challenges of robustness, cost-effectiveness, and performance optimization.

1.2.3 Manipulation

All manipulators are designed per and allocated tasks, with varying end-effector, materials, and printing orientations to maximise strength and effectiveness. Nimo uses a total of three Grippers (1,2 and 3, respectively, shown in the image):

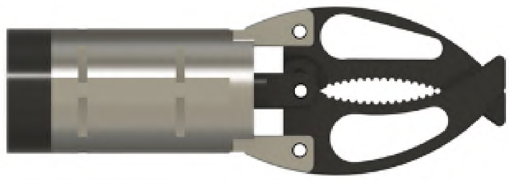
They all utilize the same 15 mm 150Nm actuator operating at 12v, meticulously customized to be water resistant, ensuring precision in every operation. All manipulators are assembled with 3mm and 4mm Nuts and Bolts. They are made from PLA and FDM-printed parts.

Gripper 1:
When actuated, it has a 100 MM opening space, which allows it to grasp larger objects with its fingers from the front.



Gripper 2:
This Gripper has a 1:50 reduction ratio geared DC motor that rotates at 50 RPM at 12V and is coupled to the actuator. When retracted, it turns into a key to rotate the given knob to activate the system.

Gripper 3:
This gripper is underneath NIMO and is designed to carry heavy loads.



All gripers are mounted onto NIMO with clamp-like mounts FDM printed

3.Electrical

N.I.M.O implements a robust waterproofing solution, encapsulating all its electronic components within 6-inch PVC pipe. Each component is precisely positioned on a custom-made 3D cast, with PVC pipe end caps coated in resin to prevent water access. Waterproof cable glands on these end caps ensures a secure seal. This comprehensive approach shields delicate electronics from seawater corrosion, facilitating maintenance and repair and enhancing the reliability and longevity of N.I.M.O's underwater operations.

N.I.M.O uses 12V buck converters to regulate the 48V input for the BLDC (Brushless DC) motors, with 8 motors one on each thruster, underlines N.I.M.O's sophisticated engineering. Each thruster operates independently, with each individual buck converter receiving power from a 48V bus bar. Safety measures include 15 ampere fuses on each converter's output, reflecting a sensible approach aligned with the motor's maximum current rating of 15 amperes, although operational requirements dictate a maximum draw of around 10 amperes per motor.

The buck converter used is rated at 200 watts with a current rating of up to 10 amperes is a device used to step down voltage efficiently. This means it can convert a higher input voltage to a lower output voltage while providing a maximum power of 200 watts to the load. The 10 ampere current rating indicates that the converter can supply up to 10 amperes of current to the load without exceeding its capacity. This makes it suitable for applications requiring substantial current at a lower voltage.

The bi-directional Electronic Speed Controllers (ESCs) in BLDC motor systems cannot be overseen. These devices regulate motor speed and direction by adjusting power supply based on input signals, performing electronic commutation synchronized with rotor position. ESCs feature thermal protection, current limiting, and regenerative braking, optimizing motor performance and efficiency while preventing damage. Their inclusion in N.I.M.O's design ensures precise and efficient motor operation.

Moreover, the selection of 16 AWG copper flexible wire for buck converter connections to BLDC motors demonstrates careful attention to detail. Despite the wire's nominal current carrying capacity of up to 13 amperes, it comfortably accommodates the motor's operational requirements, ensuring reliability and safety in N.I.M.O's underwater environment.

N.I.M.O utilizes a 12V buck converter to support grippers, cameras, and lights, maintaining a steady voltage for their functions. Moreover, a 5V converter is employed to operate microcontrollers, bringing the total number of converters for specialized tasks to ten.

3.1 POWER CALCULATIONS

Components	Quantity	Voltage (V)	Current (A)	Total Power (W)
BLDC Motors (A2217) + ESC	8	12	10	960
Actuations + Motor Driver	5	12	0.25	15
Analog Camera	4	12	0.05	2.4
USB Camera	1	5	3.5	17.5
LED Light	2	12	0.9	21.6
Pixhawk	1	5	0.5	2.5
Raspberry Pi 3	1	5	2.5	12.5
Arduino Nano	1	5	0.03	0.15
Raspberry Pi 4	1	5	3.5	17.5
Total Power Consumed (W)				1049.15

Current Calculations = Power/Voltage = 1049.15/48 = 21.85 A
Fuse = 1.5*Current = 1.5*21.85 = 32.79 A
*Considering 150% as the safety factor while calculating for the fuse.
30 Amp Fuse is used.

3.2 TETHER

Our N.I.M.O. ROV utilizes a 25-meter deployment tether for reliable communication and power delivery. This critical link incorporates:

- A high-gauge power cable to ensure sufficient electrical current for N.I.M.O.'s operations.
- Three CAT6 data cables for robust control and communication.
- Four coaxial cables to transmit high-quality camera signals, potentially from multiple onboard cameras.

This comprehensive tether configuration empowers effective N.I.M.O. operation throughout its underwater missions.

3.2.1 Tether Voltage Drop

Cable	Voltage (V)	Current (A)	Length (m)	Voltage Drop (mV/A/m)	Total Voltage Drop (Vd)	Power (After Vd)
8 AWG	48	30	25	4.9	3.675	1329.75
10 AWG	48	30	25	8.5	6.375	1248.75
12 AWG	48	30	25	12.8	9.6	1152

As the ROV consumes about 1051.65 Watts of power, the 12 AWG wire, at the length of 25 meters, is more than enough for the operation purposes.

3.2.2. Tether weight consideration

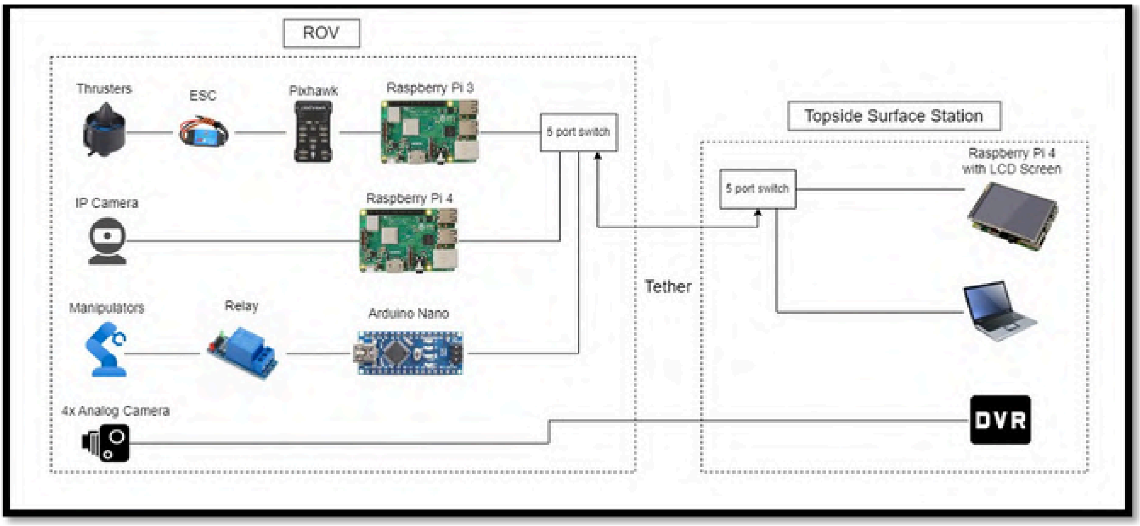
Cable	Weight (km/kg)	Total Weight (kg)
8 AWG (10 sq.mm)	552	13.8
10 AWG (6 sq.mm)	316	7.9
12 AWG (4 sq.mm)	240	6

Choosing the 12 AWG wire as N.I.M.O's primary power cable has the advantage of being lightweight over a 25-meter span. The reduced weight eases the load on N.I.M.O, enhancing its maneuverability and task performance. Moreover, the 12 AWG wire's ability to efficiently transmit power without notable voltage drop or power loss over this distance contributes to N.I.M.O.'s operational effectiveness.

4. SOFTWARE

4.1 Communication System

The communication infrastructure of N.I.M.O. is designed to ensure reliable and efficient data transmission between the ROV and the topside control station. The system features two network switches that manage Ethernet connections throughout the ROV and the surface station. One switch is located inside the ROV, while the other is positioned at the surface station, providing a direct communication link. RJ45 CAT6 UTP cables are used to communicate between different systems.
The Pixhawk flight controller inside N.I.M.O. is connected via ARDUSUB firmware running on a Raspberry Pi 3. This setup allows the Pixhawk to communicate with the surface station through the network. The ARDUSUB firmware on the Raspberry Pi 3 facilitates the transmission of control commands and sensor data between the ROV and the topside operators. Arduino Nano is being used for controlling the manipulators with the relay acting as the motor driver.



4.2 Control Systems

4.2.1 Pixhawk Flight Controller

N.I.M.O. utilizes a Pixhawk 1 flight controller, which is known for its robust performance and compatibility with various control algorithms. The Pixhawk 1 was selected for its ability to handle complex underwater navigation tasks and its integration with ARDUSUB firmware.

This firmware is specifically designed for underwater vehicles, providing advanced features and multiple flight modes, including:

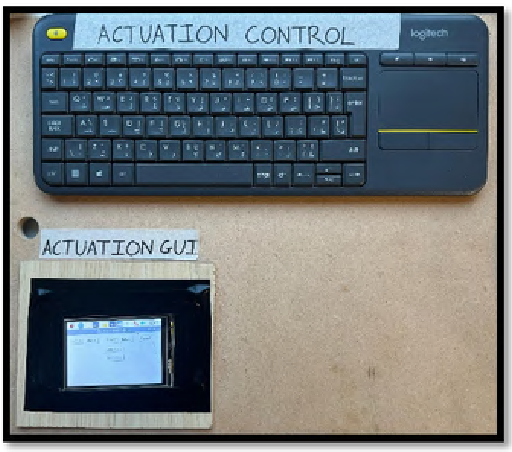
- Stabilize Mode: This mode uses onboard sensors to maintain a stable attitude, allowing the ROV to stay level in the water.
- Depth Hold Mode: Using the Bar30 pressure sensor, this mode maintains the ROV at a specified depth, essential for tasks that require precision.
- Manual Mode: In this mode, operators have direct control over the ROV's movements via joystick inputs, providing flexibility for complex maneuvers.

The Bar30 sensor integrated with the Pixhawk provides accurate depth and temperature measurements, critical for underwater navigation and environmental monitoring.

4.2.2 Thruster Configuration and Actuator Control

N.I.M.O. features an 8-thruster frame configuration, allowing for exceptional maneuverability with six degrees of freedom. This design enables the ROV to move forward/backward, up/down, left/right, and rotate along its three axes (pitch, roll, and yaw).
The actuator control system is managed by an Arduino Nano, which receives commands from a Raspberry Pi 4. The Raspberry Pi 4 runs the actuator control software written in Python, which processes input commands and sends signals to the Arduino. The Arduino then drives the actuators via a relay acting as a motor driver, enabling precise control over the ROV’s mechanical functions

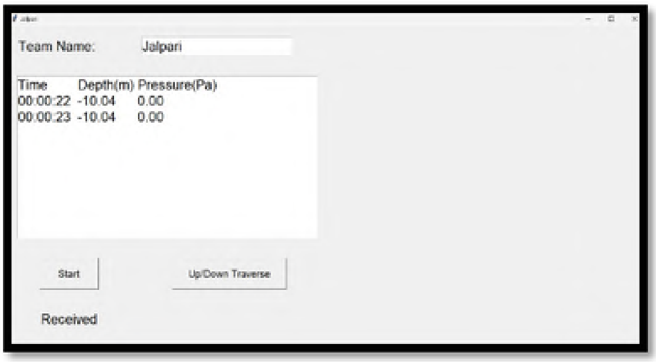
The Pixhawk is connected to a companion computer on network switch present in the topside surface station. The companion computer runs QGroundControl software, which provides a comprehensive interface for monitoring the Pixhawk’s status, including telemetry data, sensor readings, and flight mode adjustments.

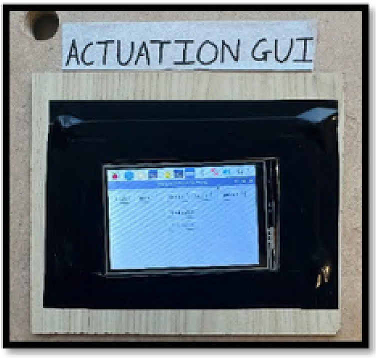


4.3 Graphical User Interfaces (GUIs)

N.I.M.O. is equipped with four specialized GUIs, each serving a unique purpose to streamline operations:

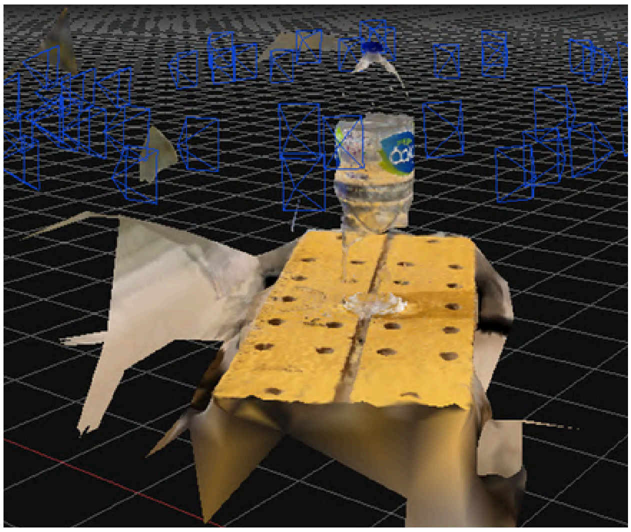
- Actuator Control GUI: Hosted on a dedicated Raspberry Pi 4, this interface allows operators to control the ROV's manipulators using a keyboard. The GUI offers a user-friendly platform with intuitive controls for precise actuator management.
- Data Plotting GUI: This GUI displays real-time plots of various sensor readings and operational parameters. It provides essential data visualization for analyzing the ROV's performance and environmental conditions.
- IP Camera Feed GUI: This interface shows the video feed transmitted from an IP camera on another Raspberry Pi 4. The GUI enables operators to monitor the ROV's surroundings, providing critical visual feedback for navigation and task execution.
- Float GUI: This GUI displays important information such as the team name/number, time, temperature, and depth. It serves as a comprehensive status dashboard, ensuring that all vital information is readily available to the operators.



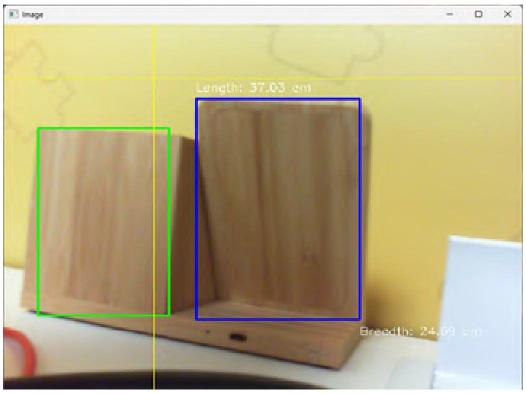


4.4 Photogrammetry:

A USB camera which is linked to Raspberry Pi 4, N.I.M.O is able to rotate around the object in the underwater environment, allowing the camera to capture the images. By simply pressing the 'p' key on the keyboard, the camera initiates the process of capturing photographs. Once the images are acquired, they are then imported software - 3DF Zephyr. This software utilizes the captured images to reconstruct a precise 3D model of the object. Then in the software we can use scaling adjustments to accurately measure the dimensions of the model. Using the measure option, the length and breadth of the 3D model is shown.



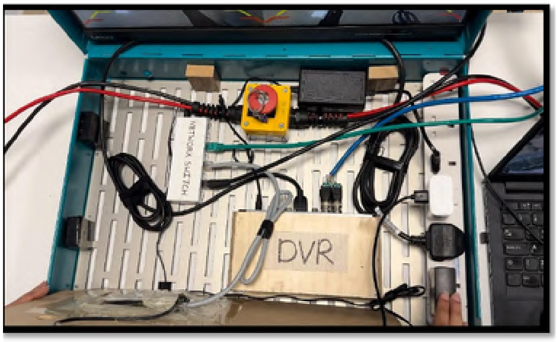
The code features that on a keystroke, the code creates a snapshot in which we then first select reference frame and on selecting the next frame we get the exact dimensions of the profile we need.



4.5 Topside Control Station

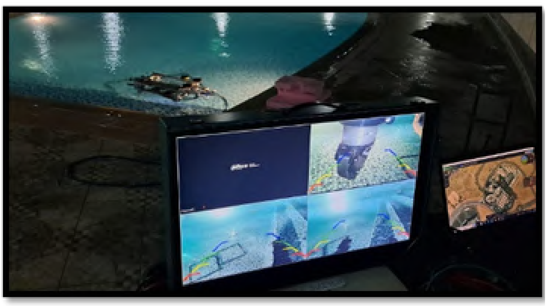
The topside control station is the command center for N.I.M.O., equipped with essential components for effective operation:

- Digital Video Recorder (DVR): The DVR captures and stores footage from the ROV's four analog cameras, providing a visual record of underwater missions.
- Monitor: Displays video feeds and other relevant data, offering a clear view of the ROV's environment.
- Network Switch: Manages Ethernet connections between the ROV and the surface station, ensuring flawless communication.
- Actuator Control Raspberry Pi 4: This device hosts the actuator control GUI and is connected to an LCD screen, providing a dedicated interface for manipulator control.
- Kill Switch: A safety feature that allows operators to quickly disconnect or connect power to the ROV, ensuring immediate response in case of emergencies.
- Logitech Extreme 3D Joystick: Used for navigating the ROV, this joystick provides intuitive control over its six degrees of freedom, allowing for precise maneuvering.



In addition to these components, the control station includes three laptops:

- Pixhawk Communication Laptop: Runs QGroundControl software, providing a comprehensive interface for monitoring and controlling the Pixhawk.
- Photogrammetry Laptop: Dedicated to processing visual data and creating 3D models of underwater environments.
- Float GUI Laptop: Displays the float GUI, offering a centralized display of critical information such as team name/number, time, temperature, and depth.



5. NON-ROV DEVICE VERTICAL PROFILING FLOAT-ROCKET

“Rocket”, our float, is a versatile and advanced mechanism which involves the monitoring of the marine ecosystem in which it circulates.

Our team Jalpari has developed this in order to combat marine problems as well as creating an accurate as well as versatile bot.

This float system is specifically designed for deployment in the center of a pool, where it plays a role in capturing data. At the core of this system lies a syringe mechanism controlled by a linear actuator, with all communication and control functions managed by ESP32 microcontrollers utilizing LoRa technology.

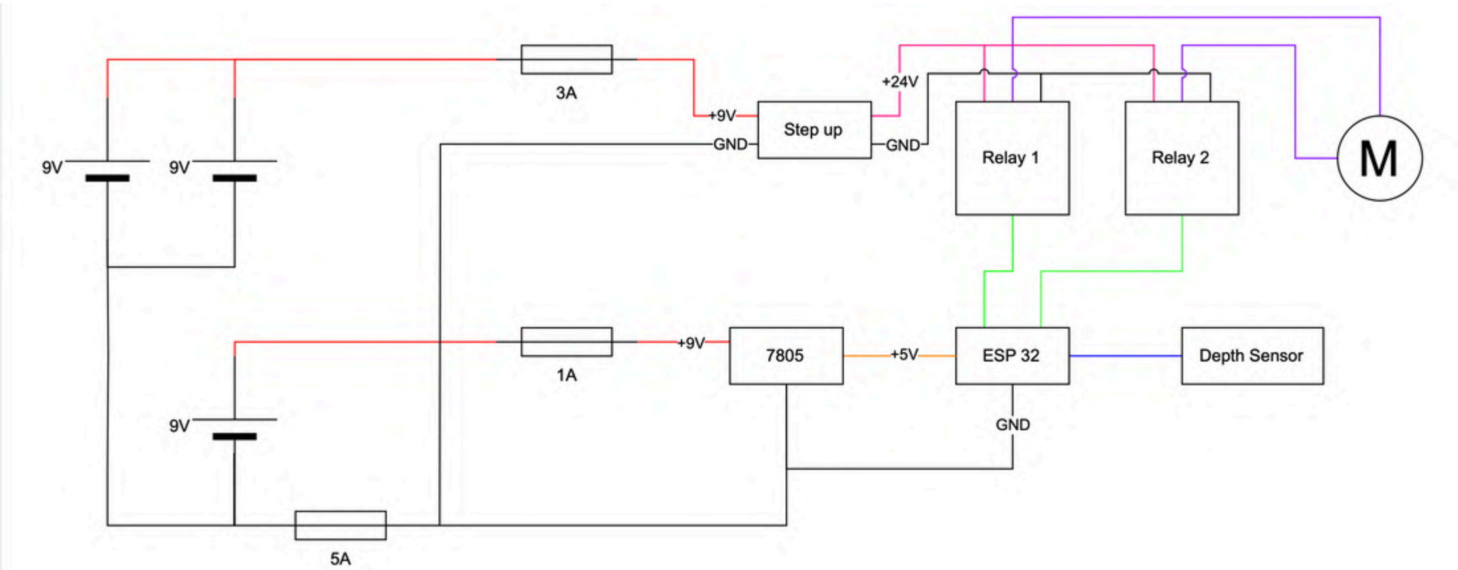
The system revolves around two ESP32 modules; one is situated within the float itself, while the other is positioned at the topside surface station. These modules communicate wirelessly through LoRa, a long-distance, low-energy communication protocol well-suited for underwater conditions. The onboard ESP32 is furnished with an SD card slot, enabling the logging of various environmental data like pressure, depth, and temperature during underwater missions, although we will only be utilizing pressure and depth during the mission.

The power management of the float system involves the use of a combination of 9V batteries, which is stepped up to 24V to power the linear actuator and stepped down to 3.3V to power the ESP32 microcontroller. This dual voltage regulation is crucial for the operation of both the high-power actuator and the low-power electronics.

Buoyancy regulation is accomplished through a linear actuator that operates the syringe. When the actuator is engaged, it either compresses or decompresses the syringe, allowing water to be drawn in or expelled out, respectively. This action alters the float's buoyancy, enabling the ROV to ascend or descend within the water column. The actuator is managed by a relay linked to the ESP32, thereby replacing a motor driver.

To safeguard the electronic components from water exposure, the entire system is enclosed within a PVC pipe. The internal structure housing the ESP32, linear actuator, syringe, and relay is 3D printed to ensure a precise and secure fit within the PVC casing. The PVC pipe is sealed with a cap, and additional waterproofing techniques such as silicone sealant as well as PVC glue and resin are applied to prevent water infiltration.

The cap of the PVC pipe is equipped with a 30bar pressure sensor that plays a crucial role in gathering essential data about the underwater environment. This sensor is responsible for measuring pressure, which directly corresponds to depth, and also records temperature readings. The information obtained by the pressure sensor is stored on the SD card within the ESP32, enabling thorough analysis after each traversal and guaranteeing the safe operation of the ROV.

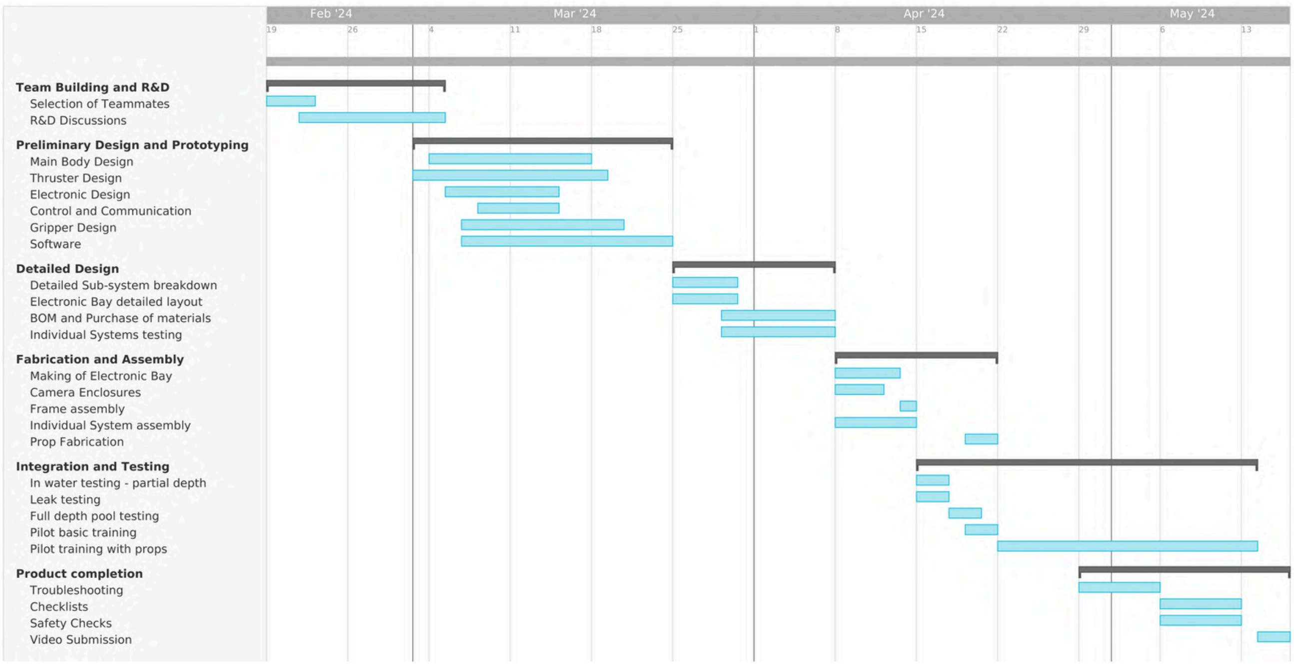


Components	Quantity	Voltage (V)	Current (A)	Total Power (W)
Linear Actuator	1	24	0.5	12
Depth Sensor	1	3.3	0.3	0.99
ESP 32	1	12	0.05	0.6
Total Power Consumed (W)				**13.59**

LOGISTICS

1. Company Organization and Teamwork

Our company consists of three main technical departments; mechatronics, electrical and software departments. Each department is subdivided into several project groups assigned with leaders in every department.
The leaders held frequent meetings and constantly gave tasks with deadlines to the team members to make sure that we were following our timeline.
The CTO held frequent meetings with the leaders to direct them and follow up the progress.
The CEO held general meetings such that the three departments communicated regularly and followed the progress of one another.
Tasks were assigned such that each member had a specific role to play.
For the mechanical department, members were responsible for each of the following: designing the frame, the manipulators and payloads, the electronics enclosure and sealing, pneumatic systems, manufacturing. For the electrical department, members were responsible for each of the following: SID & power calculations, Control panel and rewiring the enclosure. For Software, members were responsible for each of the following: Control system of ROV, GUI, photogrammetry



GANTT CHART

2. Project management

Goal: Design, develop, and build a cost-effective and advanced Remotely Operated Underwater Vehicle (ROV) named N.I.M.O. for the MATE 2024 competition.

Project Timeline:
Oct - Nov [2023]: Needs assessment, conceptual design, and initial budgeting.
Dec [2023] - Jan [2024]: Detailed design, component selection, and procurement.
Feb - Mar [2024]: Fabrication, assembly, and initial testing.
Apr [2024: System integration, comprehensive testing, and refinement.
May [2024]: Competition preparation, documentation finalization, and logistics.

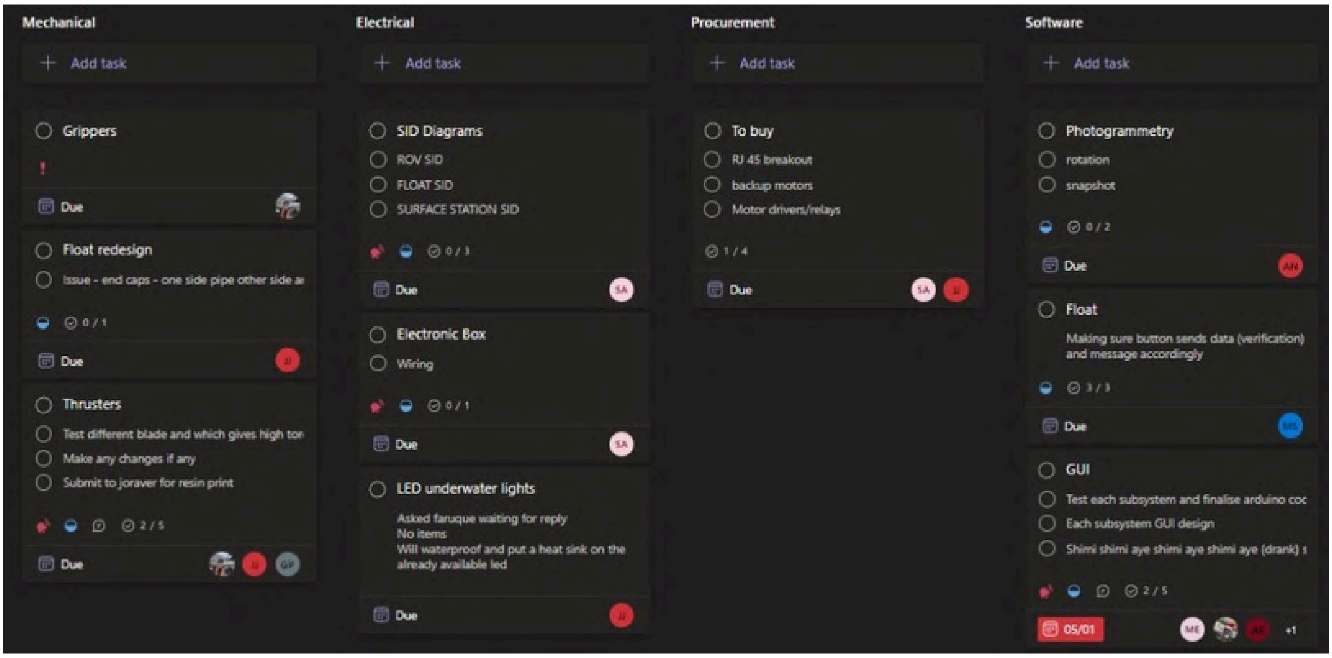


FIGURE: OUR TASKS

3. Accounting

Budget and Cost Planning:
After assessing the RFP(request for proposal), we initiated the process of selecting appropriate components for our ROV. Subsequently, we calculated the budget required for purchasing and manufacturing the remaining parts for N.I.M.O, covering expenses for the international competition, registration, USA visa, and accommodation ($27,000). To kickstart the project, we gathered equal contributions from our members, resulting in an initial funding amount of $1100. Following this, we sought out sponsors to support our endeavor. In the absence of sponsor funding, we resorted to pooling money internally, raising an additional $1650. The total amount accumulated for the ROV project reached $2750. Separate costs for travel and visas apply. We extend our gratitude to the 3rd Eye company for supplying us with aluminum extrusions. Both Budget and Project Costing details can be referenced in the Appendices.

CONCLUSION

1. Testing and Troubleshooting

We utilize three distinct testing methods, each tailored to a specific strategy for the department.
Mechanical: To test the sealing made on N.I.M.O, we tested each system individually by submerging them in water at a depth of 3m for 30 min. each.
Electrical: The first step in any electrical device is to check for power to make sure the device is safe to work on, make sure that the system is connected correctly, if there a problem, we test all component separately in the internal structure, check the communication network. Before powering it on we check for continuity on the positive and negative terminal to confirm that there are no shorts in the system.

2. SAFETY

Team Jalpari Focuses on Safety in ROV Development
Safety is the top priority for Team Jalpari, ensuring a secure environment during the construction and operation of N.I.M.O. by:

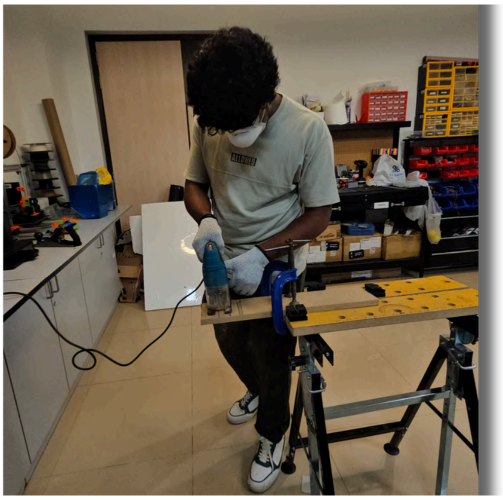
- Training: Initial tool usage training with adult supervision before independent work.
- Safety Gear: Wearing goggles, gloves, masks, closed-toe shoes, and maintaining a tidy workspace.
- Careful Testing: Maintaining a safe distance during testing, except for the tether person.
- Secure ROV Design: Integrating safety features into N.I.M.O. for operator protection.
- Emergency Preparedness: Having a first-aid kit and fire extinguisher readily available.

Emphasizing safety enables the team to work confidently on N.I.M.O. development.
Mechanical Safety Measures:
Preventing accidents is paramount at our company, with rigorous safety protocols in place from design to testing. Safety measures are incorporated into the ROV's construction, such as covering thrusters with 3D-printed meshes to meet MATE ROV regulations. These protective measures guard against foreign objects larger than 12.5 mm in diameter.
Electrical Safety Measures:

The components integrated by Team Jalpari in N.I.M.O. for safety include:

- LittelFuse holder with a 30-amp fuse for overheating protection
- Color-coded insulated copper cables for easy identification and safety
- Glands for watertight seals and stress relief mechanisms
- 5-amp float switch for water detection and power interruption

These components prioritize safety and ensure reliable electrical performance for N.I.M.O. and its operators.



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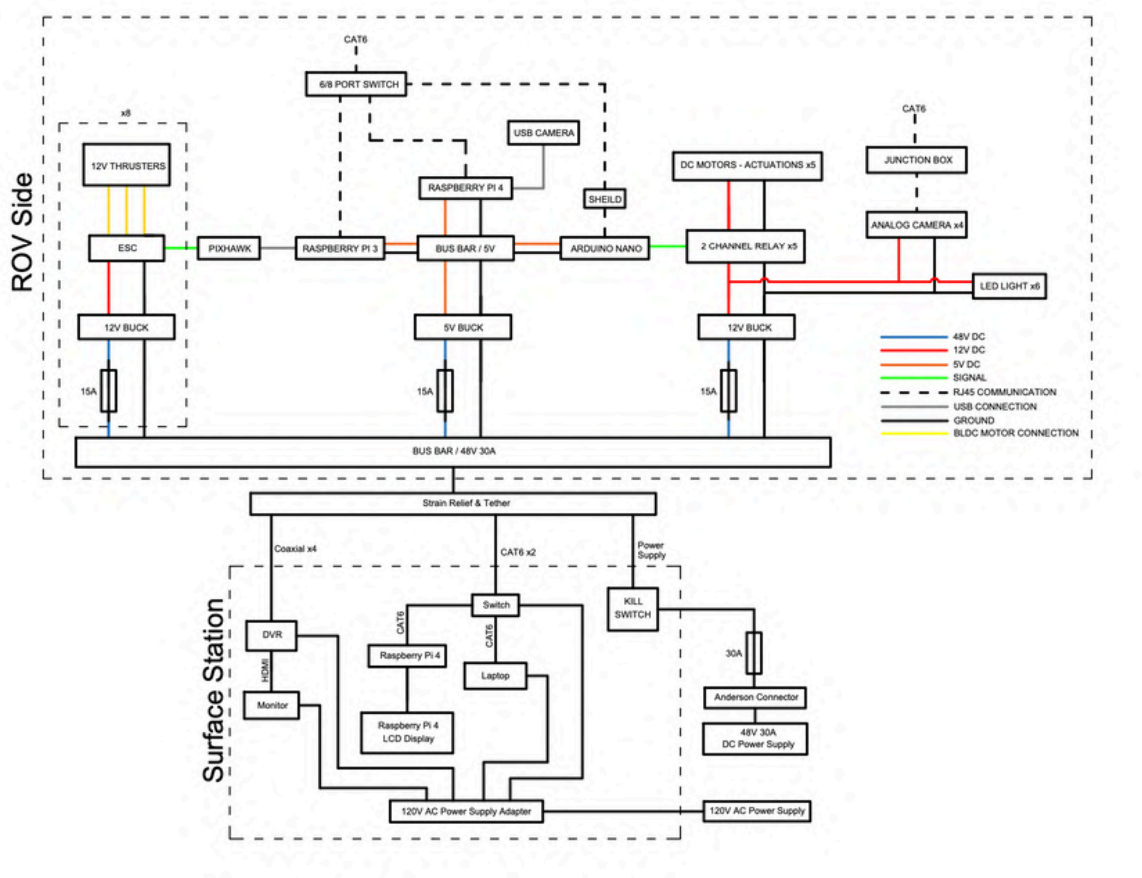
- Camera streaming Documentation https://abhitronix.github.io/vidgear/v0.2.5-stable/
- (AI) library Documentation https://pytorch.org/
- Python Documentation https://www.python.org/
- Pixhawk protocol Documentation https://www.ardusub.com/developers/pymavlink.html
- Main controller Documentation
- https://developer.nvidia.com/embedded/jetson-nano-developer-kit
- Thruster controller Documentation https://pixhawk.org/
- “Wire Gauge and Current Limits Including Skin Depth and Strength,” PowerStream. [Online]. Available: https://www.powerstream.com/Wire_Size.html
- MATE ROV Competition Manual Explorer https://files.materovcompetition.org/2022/2022_EXPLORER_Manual_21_JAN_2022.pdf

Appendices:

ROV SID:



Current Calculations = Power/Voltage = 1049.15/48 = 21.85 A
Fuse = 1.5*Current = 1.5*21.85 = 32.79 A
*Considering 150% as the safety factor while calculating for the fuse.
30 Amp Fuse is used.

Components	Quantity	Voltage (V)	Current (A)	Total Power (W)
BLDC Motors (A2217) + ESC	8	12	10	960
Actuations + Motor Driver	5	12	0.25	15
Analog Camera	4	12	0.05	2.4
USB Camera	1	5	3.5	17.5
LED Light	2	12	0.9	21.6
Pixhawk	1	5	0.5	2.5
Raspberry Pi 3	1	5	2.5	12.5
Arduino Nano	1	5	0.03	0.15
Raspberry Pi 4	1	5	3.5	17.5
Total Power Consumed (W)				1049.15

POWER CALCULATIONS

Budgeting

Income				
Source				Amount ($)
Team Members				2500
Competition Winnings				700
Expenses				
Category	Type	Description	Projected Cost ($)	Budgeted Value ($)
Hardware	Purchased	PCV Pipe & Fitting	205	200
	Donation	Aluminium Extrusions	330	0
	Donation	3D Printing Filament	50	0
	Purchased	Screw/Nuts/Bolts	20	20
	Purchased	Silicon Sealant	15	10
	Purchased	Epoxy Resin	50	40
	Purchased	Insulation Liquid	15	10
	Purchased	Waterproof Glands	10	5
	Purchased	Valves	120	100
	Donation	Control Station Box	30	0
	Purchased	Stress Relief	10	10
Electronics	Purchased	Power Supply	100	90
	Purchased	2 Core Rubber Flexible Cable	110	100
	Purchased	Microcontrollers	80	60
	Purchased	Fuse & Fuse Holder	45	40
	Purchased	Anderson Connector	100	90
	Purchased	Thrusters with ESC's	300	250
	Purchased	Linear Actuators	60	50
	Purchased	Buck Converters	45	40
	Purchased	Bus Bar	10	8
	Purchased	2 Channel Relay	10	10
	Purchased	Connecting Wire	200	150
	Donation	Monitors	50	0
Sensors	Purchased	Camera	90	80
	Purchased	Pressure & Depth Sensor	60	50
Travel	Purchased	Round Trip to Tennessee, USA	13000	14000
	Purchased	Visa	2000	2000
	Purchased	Accomodations	6000	5500
General	Purchased	Transportation	40	60
	Donation	Swimming Pool Rent	100	50
	Purchased	Registration Fee	465	465

Project Costing

Date	Type	Category	Expense	Description	Source/Notes	Amount ($)	Running Balance ($)
26/09/2023	Purchased	Electronics	Motors, ESC's and Sensor	Motors, ESC's and Tether float, BLDC Motors, Actuation, Sensors	Used for ROV Navigation & Actuation	411.13	411.13
03/10/2023	Purchased	Hardware	Nuts & Bolts	Nuts & Bolts x 0.7kg, Long Thred Rod	Used for Fastening Components	13.11	424.24
03/10/2023	Purchased	Hardware	PVC (PROPS)	PVC Pipes, Fitting Glue & Axo Blade, Gasket, Connectors, End Cap & Sockets	Used for Props	176.49	600.73
11/10/2023	Purchased	Hardware	Waterproof E-Box & Components	Electronic Waterproof Box	Used for Camera Connection	85.58	686.31
12/10/2023	Purchased	Electronics	Connectors & Fuse	Anderson Connectors, Flat Fuse 30A, Fuse Holder, RJ45 Couplers	Used in ROV Control System	153.05	839.36
16/10/2023	Purchased	Hardware	Assorted Tools	Ld 40, silicon, gun, sand paper, wires, Electrical tape, Sleeve or Heat Shrink, Heat Gun, Epo Putty, Step Drill Bit, Super Glue x 2	Used for Control Station Construction	96.95	936.31
22/01/2024	Purchased	General	Pool	Pool Owner (dubizle and Transport)	ROV Testing Zone	171.25	1107.56
19/03/2024	Purchased	Electronics	Main Components for Control System	Block Bus, DC Converter, Transformer, Connector, Aluminium Profile Connector, Syringe, Arduino Nano, ESP 32 (x2), Shield, Bus Bar & Lugs	Used in ROV Control System	373.95	1481.51
30/03/2024	Purchased	Electronics	Cables	16 AWG 3 Core cable, 8 AWG Cable 2 Core, Glands, 2 core 1.5 sq.mm wire, 2 core 4 sq.mm rubber wire	Used for Electrical Wiring	249.46	1730.97
30/04/2024	Purchased	Hardware	Epoxy	Epoxy Resin	Used for Waterproofing	33.86	1,764.83
06/05/2024	Purchased	Electronics	DVR & Camera	DVR x 1, Camera's x 3, Camera Plastic Dome, Waterproof Rear Car Camera x 2	Used for Camera Monitoring	85.70	1,850.53
06/05/2024	Purchased	Electronics	Joystick	Logitech Extreme 3D Pro	Used for Maneuvering	19.06	1,869.59
10/05/2024	Purchased	Hardware	TV Bracket	TV Wall Bracket	Used for Mounting Monitor	9.53	1,879.12
18/05/2024	Purchased	Travel	Transport	Transportation Charges	Transfering Materials	54.45	1,933.57

Operation and Construction Safety Checklists

Procedure

Check Mark

1. Pre-Power Checks

- Everyone on the team is wearing safety gear.
- Before conducting the safety check, power is turned off.
- Make sure the fuse isn't blown.
- Clear obstructions from propellers, shafts, and manipulators.
- "Safe" should be shouted.

2. Pre-Water Checks

- Connect the tether cable to the control station and turn on the power of the system.
- Test the video system.
- Compress the electronics enclosure to the called dive's rated depth.
- Turn off the system and say, "Water Ready."

Lower the ROV into the pool by two team members and the tether man."In Water," say it loudly.

1. In-Water Checks

- Check the warning lights after turning on the system.
- Verify that the internal pressure is steady at the surface.
- Check for air bubbles and look for leaks visually.
- "Pilot in Command," say it loudly.

Communication breakdown

- Restart the ROV
- Send another test package.
- If there is no communication, turn off the ROV.
- Bring the ROV to the surface with the tether and inspect it for damage or leakage.

Recovery Checks

- Make sure the ROV is at the surface and looking away from the pool wall.
- Turn off the system and say, "Crew in Command."
- Lift the ROV from the pool onto land by two crew members and a tether guy.

Safety officer signature:

- Entering the Lab or Workshop
- Wear the facemask and PPE provided by the company..

Operating Power tools

- Wear all PPE necessary for the tools.
- Always keep your hands away from the tool's head.
- Keep long hair tied back and spinning sections free of strings, ropes, and flexible fabrics/materials.

Working with Electrical Components and Soldering

- Use a solder fume extractor
- keep the soldering iron or hot air hand tool in its holder, When not in use.
- Check all electrical connections to ensure they are not in contact with liquids.

Employee Signature