

2026 Technical documentation



Networked Engineering for eXploration and Unified Systems
at City University of Cairo
Badr, Cairo, Egypt

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Abstract

The **Marineova** (the name of our Remotely Operated Vehicle (ROV)) is an advanced underwater robotic system developed for the **MATE 2026 competition**, designed to perform complex inspection, intervention, and data acquisition tasks in challenging marine environments. Inspired by the strength and stability of the **Marineova**, the vehicle features a streamlined structure that enhances maneuverability while maintaining robustness under varying pressure conditions. The system integrates multiple thrusters to achieve precise six-degree-of-freedom control, allowing smooth navigation in confined and open-water scenarios. A modular mechanical design enables easy maintenance and adaptability for different mission requirements. The **Marineova** is equipped with high-resolution cameras and a reliable gripping mechanism to perform tasks such as object retrieval and structural interaction.

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Teamwork

Project Management

Overview

NEXUS (Networked Engineering for eXploration and Unified Systems) is a multidisciplinary engineering Company based at City University of Cairo, Badr, Egypt. The Company focuses on **developing advanced robotic systems**, like ROV (Remotely Operated Vehicles). This is our Company Organizational Structure, as shown in this table.

Table 1.1 Company Organizational Structure

Position	Responsibility
CEO (Chief Executive Officer)	Leads the team, sets goals, and represents the company.
CFO (Chief Financial Officer)	Manages budget, tracks costs, and prepares financial documents.
CTO (Chief Technology Officer)	Oversees all technical design, development, and system integration.
Safety officer	Ensures safety rules and procedures are followed.
Team Leaders	Design, lead sub-teams, and coordinate daily tasks.
Employees	build, test, and operate the ROV.

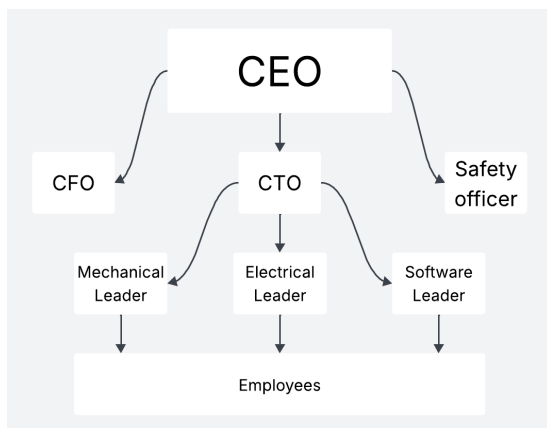


Figure 1.1 NEXUS Organization Chart

Schedule

NEXUS has developed a focused and aggressive development **roadmap** aligned with the **MATE ROV Egypt Regional Competition** scheduled for April 23-25, 2026, in Alexandria. Because we entered the competition late, and only for the last 3 months. This schedule excludes Fridays and Saturdays because all team members, from the CEO to the lowest-ranking worker, gather on ROV Lab of CUC (City University of Cairo) and continue working until we meet again tomorrow, adhering to what we have outlined. As shown in this table.

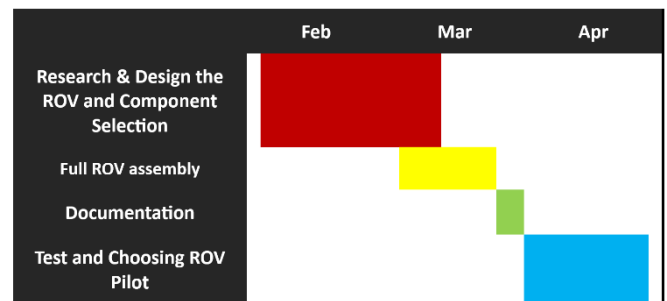


Figure 1.2 NEXUS 3 Month Schedule

Resource

We utilize a range of advanced tools to support efficient collaboration and high-quality engineering development. **Google Drive (Shared Drive)** is used for secure file storage and document management. **Outlook** is used for both internal and external email communications, while **Google Meet** is used for virtual meetings and team discussions.

For engineering design, **SolidWorks** is used for mechanical modeling and simulation, and **Altium Designer** is used for professional electrical and PCB design. Software development is managed through **GitLab**, which provides a powerful and competitive alternative to GitHub with enhanced DevOps capabilities.

Project management, tracking, and documentation are handled using **ClickUp**, offering a highly flexible and scalable environment for task management, documentation, and workflow automation.

Figure 1.2 NEXUS 3 Month ScheduleFigure 2.1 NEXUS Organization Chart

Procedures

Our workflow is designed to maximize efficiency, accountability, and cross-functional collaboration. Instead of rigidly separating teams into mechanical, electrical, and software divisions, we adopt a **project-based structure**, where each project integrates multiple disciplines.

Each project is managed through a centralized workspace in ClickUp, where tasks are clearly defined, assigned, and tracked. This includes detailed documentation, timelines, deliverables, and supporting resources such as files, links, and technical notes.

Protocols

We adopt an **Integrating Agile and the Systems V-Model: Proposing a Hybrid Solution**

which goes beyond traditional Agile methodologies. This approach combines structured planning with continuous iteration, making it more suitable for complex engineering systems.

The development process is divided into clear phases:

- Requirements Definition
- System Design & Architecture
- Subsystem Development (Mechanical, Electrical, Software)
- Integration & Testing
- Validation & Optimization

Weekly meetings are conducted using a structured technical review format

- Plan
- Follow-up
- Resolve
- Review
- Pre-review
- Familiarize

Design Rationale

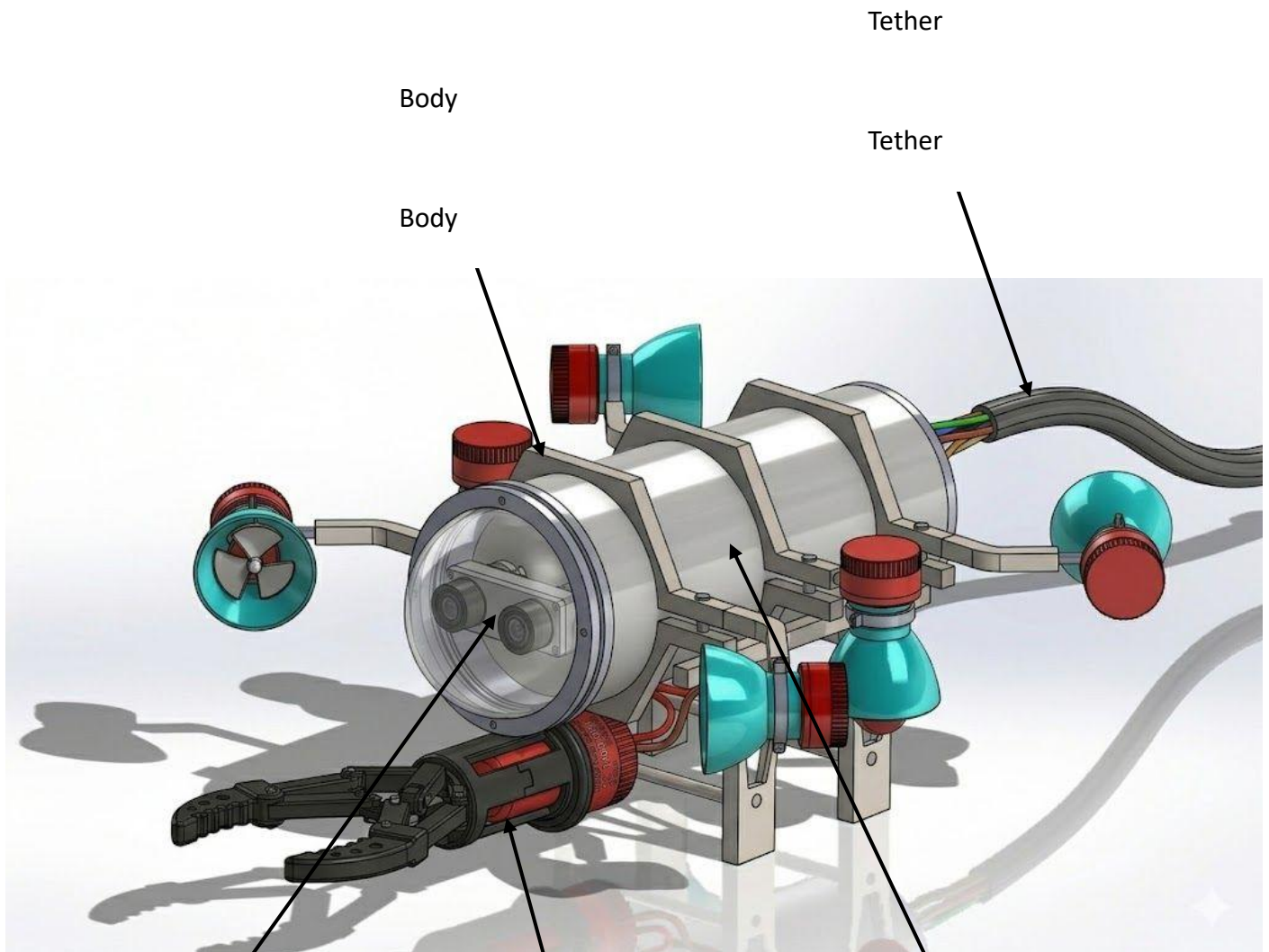


Figure 4.1 Marineova ROV Design

LUXONIS OAK-D-Lite
Camera A00483

Gripper

Hosing

Hosing

Gripper

Figure 3.1
Marineova ROV
DesignLUXONIS
OAK-D-Lite Camera
A00483

Planning and design process

The development of **Marineova** is based on a **Concurrent Systems Engineering approach**, where mechanical, electrical, and software subsystems are developed in parallel and continuously refined through integration feedback. This ensures that all design decisions reflect real operating conditions, not isolated assumptions.

Mission Definition & Constraints: Competition requirements are translated into clear engineering objectives, including performance targets, environmental conditions, and operational limitations. These constraints guide all design decisions.

Concept Development & Trade-Offs: Multiple concepts are generated for each subsystem and evaluated using trade-off analysis, considering performance, reliability, complexity, and manufacturability—the selected solutions balance efficiency with practicality.

System Architecture: A complete system layout is defined early, focusing on subsystem interaction, power and signal flow, and mechanical integration. Potential failure points and integration challenges are addressed at this stage.

Design & Prototyping: Designs are developed into detailed models and tested through rapid prototyping. This step validates functionality, simplifies manufacturing, and reduces risks before full implementation.

Integration & Validation: All subsystems are integrated and tested as a complete unit to ensure stability, compatibility, and mission readiness.

Testing & Iteration: Subsystems are tested under realistic conditions, and collected data is used to refine designs. Testing is treated as a continuous process to improve performance and reliability.

Systems Approach

The design of **Marineova** is driven by a practical, integration-focused systems approach, where all subsystems are developed together—not separately. Mechanical, electrical, and software components are continuously aligned to ensure the ROV performs reliably under real competition conditions, not just in theory.

Rather than waiting for final assembly to discover issues, integration is considered from the start. This helps the team make smart engineering decisions early, balancing performance, simplicity, and reliability based on actual needs during the MATE missions.

A key part of our workflow is building a **complete digital model of the ROV**. All components are designed and assembled virtually in their real configuration, allowing us to visualize spacing, wiring paths, and component interactions before physical manufacturing. This reduces trial-and-error and saves significant time during prototyping.

This digital setup also helps us test ideas faster. Instead of relying only on in-water testing, we can evaluate designs, identify problems, and refine solutions beforehand. As a result, when we move to physical testing, we focus on fine-tuning performance rather than fixing major issues.

The system is designed to be **modular and adaptable**, allowing quick changes based on mission requirements. For example, different tools or manipulators can be integrated without redesigning the entire ROV. This flexibility is critical for handling the variety of tasks in the competition.

Overall, our approach ensures that **Marineova is not just well-designed as individual parts, but optimized as a complete, working system**—ready to perform efficiently, reliably, and consistently in real-world conditions.

Vehicle Structure

Our ROV **Marineova** is designed to **balance low cost, compact size, and lightweight construction** while maintaining full operational capability. A smaller, lighter ROV offers several advantages:

- **Lower production cost** due to reduced material and component requirements.
- **Enhanced maneuverability**, enabling precise navigation in confined environments.
- **Single-operator handling** without the need for cranes or additional deployment equipment.
- **Minimized risk of accidental contact**, which is crucial for delicate tasks near underwater structures or shipwrecks

Table 2.1 Component structure

Component	Marineova
3D Prints	681.6g
	1400 Egyptian pounds
Aluminum frame	7948.4g
	9800 Egyptian pounds
Electronics Component	3380g
	18227.42 Egyptian pounds
Encloser	430g
	600 Egyptian pounds

Vehicle Systems

Component Selection Marineova: ROV employs a practical, low-cost architecture centered on a PVC pressure hull, aluminum flanges and dome system, aluminum frame, six bilge-pump thrusters with 3D-printed ABS propellers and Kort nozzles, and a 3D-printed ABS gripper. The design prioritizes affordability, ease of fabrication, rapid field serviceability, and reliable performance for MATE-style competitions while maintaining neutral buoyancy and lightweight construction.

Pressure Hull: The electronics housing uses standard PVC pipe, internally connected to a front-screwed aluminum flange, followed by a clear acrylic dome secured by a slip-on aluminum flange. A rear-screwed aluminum flange with a central tether hole completes the assembly. PVC was chosen for its low cost, excellent seawater corrosion resistance, and ease of machining without specialized tools. Aluminum flanges provide rigid, flat sealing surfaces for reliable O-ring performance. The clear dome allows direct visual inspection of internal electronics and cameras, improving troubleshooting speed. The entire hull is assembled with standard hardware for quick opening and maintenance on deck.

Frame: An aluminum frame is securely attached to the pressure hull using M8 nuts and bolts. M8 hardware offers high strength and universal availability, enabling a rigid yet easily modifiable structure that supports all thrusters, the manipulator, buoyancy modules, and tether strain relief.

Thruster System: Six 1100 GPH bilge pumps serve as propulsion motors. Each is equipped with a custom 3D-printed ABS pusher propeller and matching Kort nozzle. The pumps are mounted using simple clamps, allowing tool-free removal and thrust vector adjustment. Bilge pumps deliver an excellent thrust-to-cost ratio and proven reliability. ABS was selected for the propellers and nozzles due to its toughness, impact resistance, and ability to be printed at 100% infill, ensuring zero water absorption and stable buoyancy. The Kort nozzles significantly improve efficiency and reduce turbulence.

Manipulator: A dedicated 1100 GPH bilge pump powers a fully 3D-printed ABS gripper. Printed at 100% infill, the gripper provides sufficient strength for typical competition tasks while remaining extremely lightweight and inexpensive to replace.

Finally, we chose this component to do the tasks of the Mate ROV Pioneer 2026. As shown in this table.

Table 2.2 Component Selection

Material	Usage in Sturgeon	Primary Reason for Selection	Main Advantages	Acceptable Trade-offs
PVC Pipe	Main Pressure Hull (Electronics Housing)	Extremely low cost, widely available, and highly corrosion-resistant in seawater	Very cheap, excellent corrosion resistance, easy to cut and assemble, lightweight	Lower compressive strength than metals
Aluminum	Flanges (Front, Rear, Slip-on) + Frame	Excellent balance between strength, weight, and machinability with good sealing surfaces	Strong yet lightweight, easy to machine in-house, good thermal conductivity, affordable	May corrode slowly in saltwater (acceptable for competition duration)
ABS (3D Printed - 100% Infill)	Propellers, Kort Nozzles, Gripper	Tough, impact-resistant, and fully waterproof when printed at 100% infill	High toughness, impact resistant, low cost, fast to print, lightweight	Lower heat resistance than some metals
Bilge Pumps (1100 GPH)	Thrusters (6 for propulsion + 1 for Gripper)	Best thrust-to-cost ratio with proven reliability in student ROV projects	Inexpensive, locally available, easy to mount with clamps, reliable performance	Not specialized thrusters, but sufficient for competition tasks

Control and Electrical Systems

The Marineova ROV features a compact, waterproof, and modular electronic system designed to ensure reliability, ease of maintenance, and efficient power distribution under underwater operating conditions.

Electronics Housing Design

All sensitive electronic components are enclosed PVC cylindrical housing, chosen for its:

- Electrical insulation
- Corrosion resistance
- Low cost and availability

The housing is mechanically integrated using:

- Front aluminum threaded flange connected to an acrylic dome, providing visibility for internal status monitoring
- A slip-on aluminum locking flange to securely seal the dome

- Rear aluminum threaded flange with a sealed tether management

Waterproofing is achieved through:

- Threaded sealing
- Tight mechanical tolerances
- Proper cable routing through sealed points

The enclosure is mounted onto a rigid aluminum frame using M8 bolts and nuts, ensuring structural stability during operation.

Thruster System and Motor Control

The propulsion system consists of:

- Six bilge pump motors (1100 GPH each) used as thrusters
- Each motor is modified and coupled with:
 - Custom 3D-printed 6-blade propellers (ABS)
 - Kort nozzles (ABS) to:
 - Increase thrust efficiency

- Improve directional flow
- Enhance maneuverability

Thrusters are fixed to the frame using mechanical clamps, allowing:

- Easy replacement
- Adjustable positioning

Motor control is handled through:

- Electronic switching (Motor Drivers)
- Independent channel control for full (forward, reverse, yaw, vertical motion)

Manipulator (Gripper) System

A single bilge pump motor (1100 GPH) is repurposed to actuate a:

- Custom-designed 3D-printed ABS gripper

This provides:

- Lightweight manipulation capability
- Cost-effective solution for object handling tasks

Control Station

The **control station** serves as the primary interface between the pilot and the **Marineova ROV**, enabling precise and responsive operation. The system consists of a laptop paired with a handheld controller, providing intuitive control and real-time feedback during missions.



Figure 2.2 ROV Station test code

Communication with the ROV is established via a direct Ethernet connection, ensuring stable and low-latency data transfer. The onboard system is configured for plug-and-play functionality, allowing rapid deployment without the need for complex network setup.

This streamlined design prioritizes simplicity, reliability, and efficiency, making the control station highly practical for fast-paced underwater operations.

Control System Software

The **Marineova ROV** is a compact and efficient underwater robot designed for reliable control and real-time monitoring. It consists of a surface station for user control and data visualization, connected via a tether to the onboard system. A Raspberry Pi handles video streaming and communication, while an Arduino Mega manages motor control and sensor data. The ROV uses multiple cameras, an IMU, and a pressure sensor for navigation and feedback, with a PID control system to ensure stability. The design balances performance, simplicity, and low cost, making it ideal for competition use. As shown in this figure.

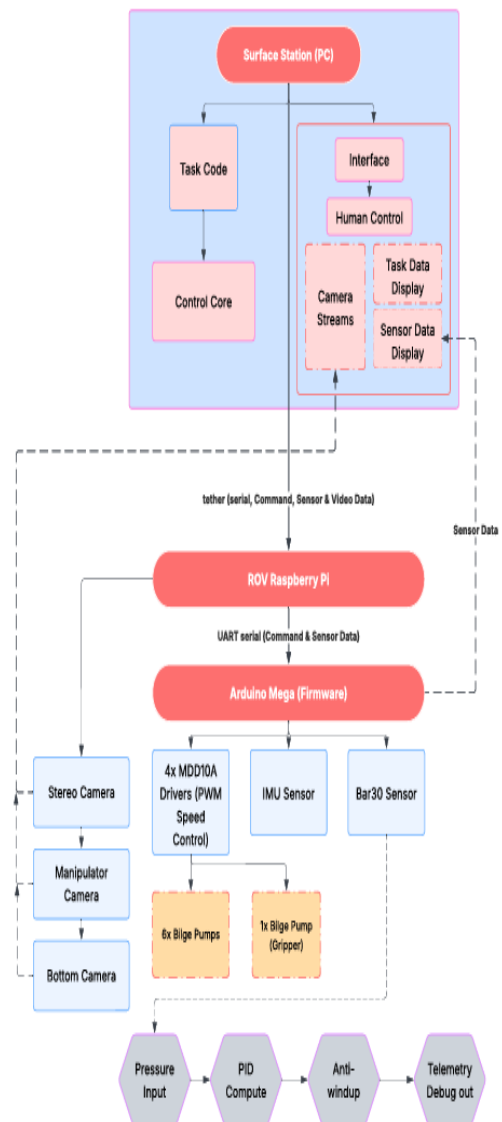


Figure 2.3 Software Diagram

Propulsion

Thruster Layout Analysis & Control Allocation

The **Marineova ROV** employs a six-thruster configuration strategically arranged to achieve full planar control with independent vertical actuation. Thrusters (1–4) are mounted at **45° angles** relative to the vehicle frame, forming an “X-configuration” that enables efficient force vector decomposition in the horizontal plane.

This layout allows combined control of **surge (X)**, **sway (Y)**, and **yaw (ψ)** through coordinated thrust distribution. Opposing thruster pairs — (1,3) and (2,4) — generate forward and lateral motion, while differential thrust between these pairs produces controlled yaw rotation.

The angled orientation introduces inherent coupling between translational and rotational components; however, this is leveraged advantageously through control allocation, enabling smooth omnidirectional motion without requiring dedicated lateral thrusters.

Thrusters (5–6) are vertically aligned near the vehicle’s center of mass, providing isolated **heave (Z)** control. Their symmetric placement minimizes induced pitch and roll, ensuring stable vertical translation and improved performance during manipulation tasks.

Overall, this configuration results in a well-balanced system with **efficient force distribution**, **reduced actuator count**, and **enhanced maneuverability**, while maintaining manageable coupling effects that can be compensated through software control. As shown in this figure.

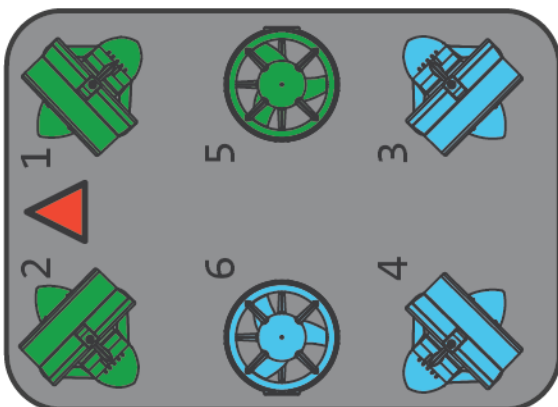


Figure 2.4 Thrusters Directions

Payload and Tools

Cameras & Sensors

The **Marineova ROV** is equipped with an integrated sensing and vision system designed to provide accurate feedback and high situational awareness during underwater operations.

At the core of the vision system is the **Luxonic OAK-D Lite camera**, which delivers high-quality imaging alongside onboard depth perception capabilities. This enables real-time spatial understanding while minimizing processing load on the main system. The forward-facing camera is positioned to provide the pilot with a clear view for navigation and manipulation tasks, while also supporting precise interaction with the environment.

For state estimation, the system utilizes an **IMU GY-87**, providing orientation and motion data across multiple axes. This allows the ROV to maintain stability and accurately track its attitude during operation. Sensor data is processed and filtered to reduce noise and improve reliability under dynamic conditions.

Depth measurement is achieved using an **analog water pressure sensor (G1/4)**, which continuously monitors external pressure to estimate depth. This data is critical for controlled descent, station-keeping, and safe operation near underwater structures.

The onboard processing architecture is built around a **Raspberry Pi 5**, which handles high-level computation, vision processing, and communication with the control station. An **Arduino Mega 2560** is integrated for low-level control tasks, ensuring reliable real-time interaction with sensors and actuators.

Together, these systems provide the **Marineova ROV** with accurate environmental awareness, stable navigation, and the precision required for complex underwater missions.

Modular Manipulator Interface

The **Marineova ROV** is engineered as a high-performance, multi-mission underwater platform that combines mechanical efficiency with precise operational control. Built around a modular architecture, the system enables seamless integration of various tools and manipulators through a unified interface, enhancing adaptability across diverse mission profiles.

At the core of Marineova's mobility is its optimized **pump-based propulsion system**, designed to maximize thrust while minimizing energy loss. The carefully engineered ducted housing and impeller geometry ensure efficient fluid flow, delivering stable and consistent propulsion. This design not only improves hydrodynamic performance but also extends operational endurance by reducing power consumption.

The mechanical interface incorporates a robust, **quick-lock retention mechanism**, allowing for rapid installation and secure attachment of modular components. This system enhances reliability under dynamic underwater conditions while maintaining ease of maintenance and reconfiguration. Special attention has been given to vibration reduction and dynamic balancing, resulting in smoother operation and improved control accuracy.

Marineova also features a compact and structurally efficient design, reducing overall mass without compromising strength or durability. This enables precise maneuverability in confined or complex underwater environments, making it highly effective for inspection, intervention, and delicate manipulation tasks.

Manipulator Design

The manipulator system combines **custom-designed components** and **off-the-shelf parts**

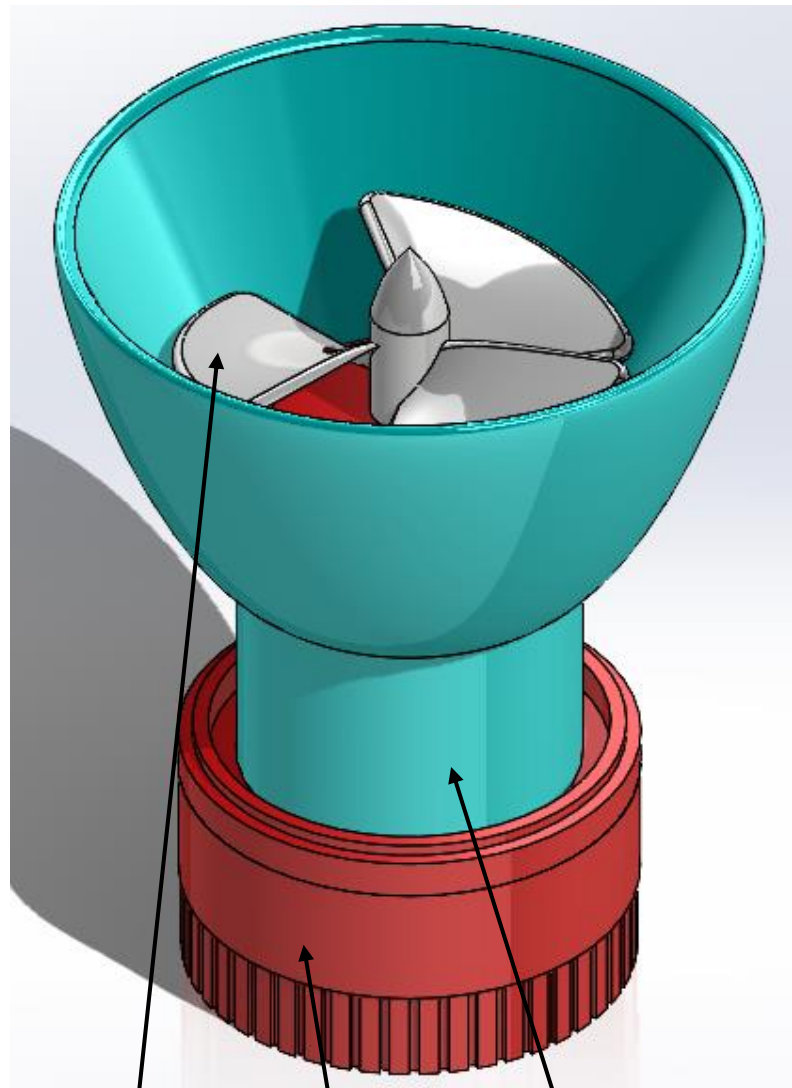


Figure 2.5 Marineova Thruster

Propeller Fan 60mm

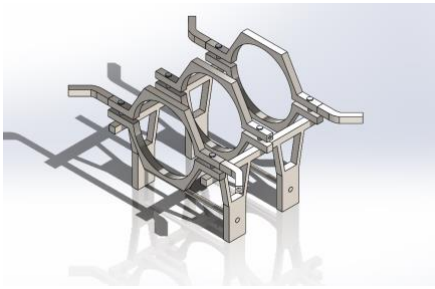
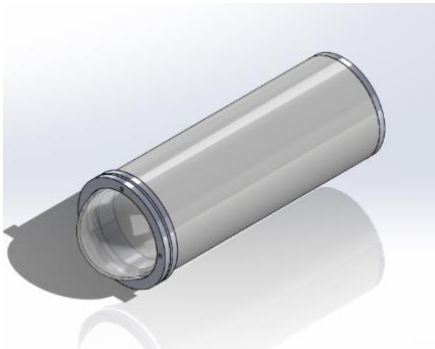
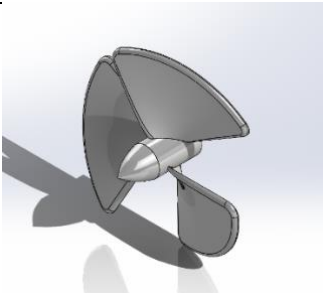
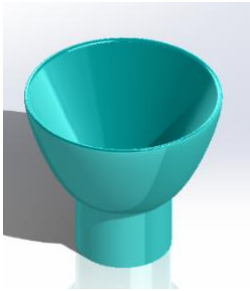
Blige Pump GPH1100

Kort Nozzle

Critical parts were developed using CAD, while standard components were selected to reduce complexity and development time.

to achieve a balance between performance, simplicity, and reliability.

Table 2.3 Manipulator Design

CAD Model	Photo	Description
		Aluminum Frame. “Body”
		PVC 6” inch inside Screw with three aluminum frame and acrylic dome thickness 6mm. “Encloser” or “Housing”
		ABS 3d printing fan 60mm “Propeller Fan”
		ABS 3d printing Nozzle “Kort Nozzle”

Float Design

Power System & Electrical Design

The Marineova ROV is powered by a 12V battery, providing a stable source for both propulsion and onboard electronics. A 5A fuse is integrated at the main power line to ensure system protection against overcurrent conditions.

High-power components, including the motor and its driver, are supplied directly from the 12V rail. For low-power electronics, a 5A DC-DC buck converter steps down the voltage to a regulated 5V output, ensuring safe and stable operation.

The control system is centered around an ESP32 microcontroller, which manages sensor acquisition and real-time control tasks. The regulated 5V line powers the ESP32, IMU (GY-87), and pressure sensor, maintaining consistent performance across all subsystems.

Based on current analysis, the system draws approximately 4.02 A under nominal conditions. The selected fuse rating provides an appropriate safety margin, balancing protection and operational reliability.

This architecture ensures clear separation between power and control domains, reducing electrical noise and enhancing overall system stability during operation.

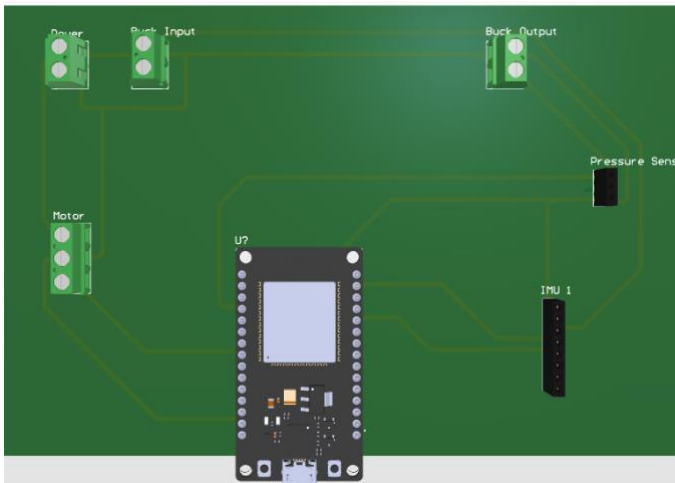


Figure 2.6 Float PCB



Figure 2.7 Float CAD Design

System Integration Diagrams (SIDs)

Marineova ROV Electrical SID

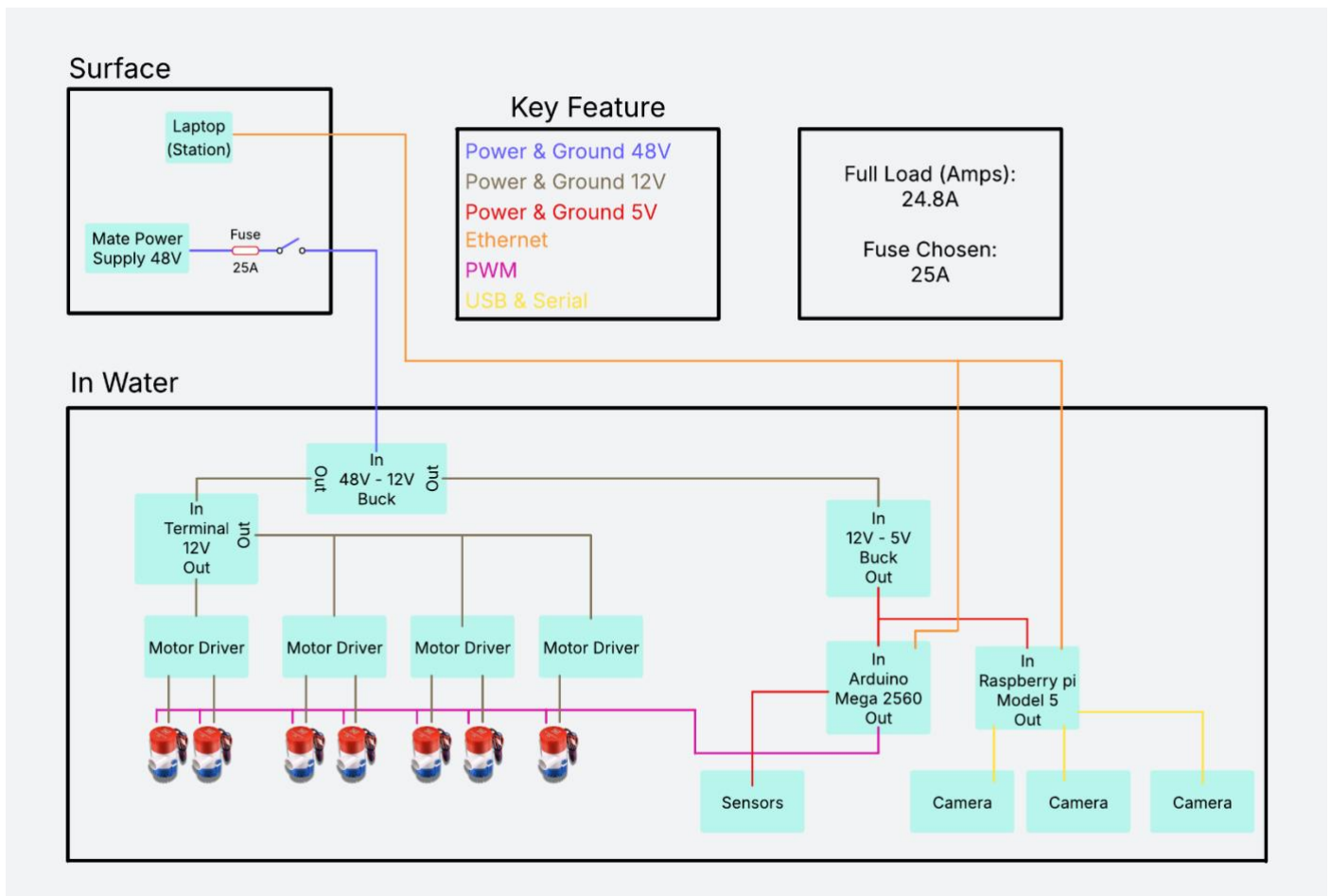


Figure 3.1 Marineova ROV Electrical SID

Marineova Non-Technical Device (Float) Electrical SID

Power

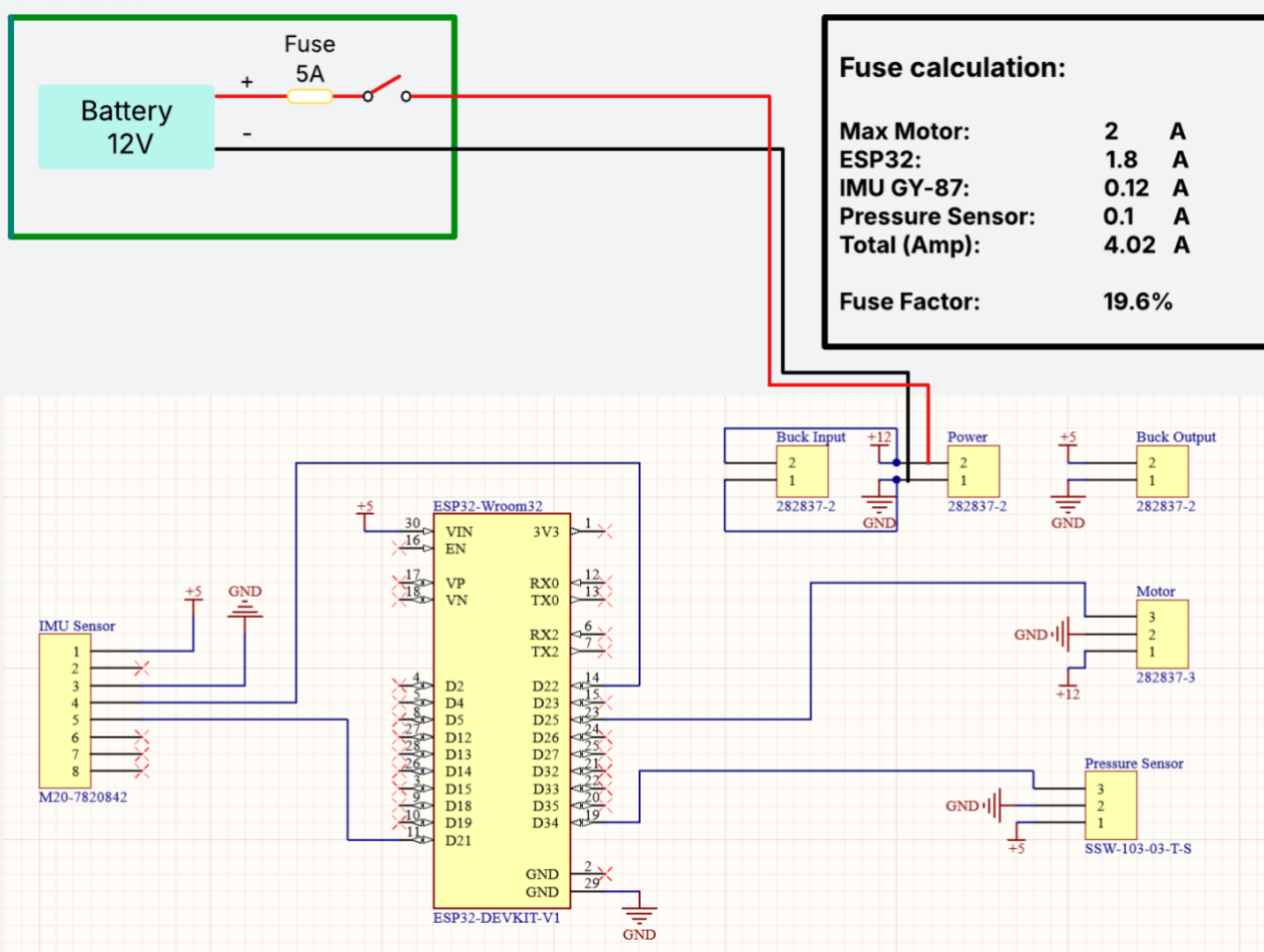


Figure 3.2 Non-Technical Device (Float) Electrical SID

Safety

safety is not just a requirement—it is a core value embedded in every aspect of our operations. Our philosophy is to anticipate and eliminate risks before they have the chance to develop into unsafe situations.

Personnel Safety

is treated as a fundamental responsibility. Before accessing the lab, every employee must complete mandatory safety training. This program ensures familiarity with safe handling of hand tools, the location and proper use of safety equipment (including first aid kits, fire extinguishers, and eye wash stations), accident response procedures, appropriate PPE and lab attire (such as safety glasses and closed-toed shoes), chemical storage protocols, and emergency contact information.

Equipment Safety

is a cornerstone of our design philosophy. Every stage of development is guided by the principle of preventing injury and minimizing hazards before they can occur. Potential risks are made clearly visible to employees, while dangerous features and sharp surfaces are either eliminated or covered with protective materials to safeguard both personnel and sensitive environments such as offshore wind farms.

Operational Safety

is ensured through proactive hazard identification and rigorous control measures. Before every deployment, a Jobsite Safety and Environment Analysis (JSEA) is conducted to anticipate potential risks and implement preventive checks. This includes securing tools and equipment, clamping materials during manipulation, and clearing any loose debris around the ROV to maintain a safe working environment.

Safety Procedures

are designed to eliminate risks during both assembly and deployment of the ROV. These procedures have been carefully drafted, reviewed, and validated by dedicated safety personnel to ensure clarity, consistency, and compliance.

For ease of use, all safety measures are consolidated into two key documents – [Table A.1 Safety Checklist](#) providing employees with straightforward guidance and immediate access to essential standards. By embedding these procedures into daily operations, NEXUS reinforces its commitment to protecting personnel, equipment, and the environments in which we operate.

Critical Analyses

Testing Methodology

The development of the **Marineova ROV** followed a rigorous and structured testing methodology to validate performance, reliability, and system integration. Testing began at the component level, where individual subsystems—including thrusters, motor drivers, sensors, and control electronics—were evaluated independently to ensure proper functionality and adherence to design specifications.

Following validation of individual components, subsystem integration tests were conducted to verify communication between the **ESP32**, sensors, and actuators. Particular emphasis was placed on signal integrity, power stability, and real-time responsiveness under varying load conditions.

Full system testing was then carried out in controlled environments to assess maneuverability across all axes (**surge, sway, heave, and yaw**). The ROV was subjected to a range of input commands while logging IMU and depth data, allowing for detailed analysis of system response and dynamic behavior.

Additionally, performance testing included stability evaluation during hover, vertical descent, and manipulation scenarios. These tests ensured that the vehicle maintains consistent positioning and control even under disturbances. The collected data was used to validate design assumptions and guide further optimization of both hardware and control strategies.

Troubleshooting Strategies & Techniques

A systematic and engineering-driven troubleshooting methodology was implemented throughout the development process to efficiently identify and resolve system issues. The approach relied on isolating subsystems and analyzing them independently before reintegration, allowing for precise fault localization.

Electrical debugging focused on verifying voltage levels, current draw, and signal continuity across all components. Special attention was given to power distribution, where issues such as voltage drops and noise interference were mitigated through

improved grounding and power regulation strategies.

On the software side, debugging involved monitoring real-time data streams from the **IMU** and pressure sensor to detect anomalies in orientation and depth readings. Filtering techniques and calibration routines were applied to reduce noise and eliminate sensor bias.

Mechanical and control-related issues, such as unintended rotational motion or instability, were addressed through iterative adjustments in thruster configuration and control logic. For example, thrust imbalances and induced motion were analyzed and corrected by refining motor control signals and ensuring symmetrical force distribution.

This iterative troubleshooting process significantly improved system robustness, resulting in a reliable and predictable ROV performance under various operating conditions.

Prototyping & Design Evaluation

The **Marineova ROV** was developed using an iterative prototyping approach, allowing continuous refinement of both mechanical and electrical systems. Multiple design iterations were created and evaluated to explore different configurations and optimize overall system performance.

Early prototypes focused on validating fundamental concepts such as frame structure, buoyancy, and basic propulsion. These initial designs provided critical insights into weight distribution, stability, and ease of assembly. Based on testing feedback, modifications were made to improve structural integrity and reduce unnecessary mass.

Subsequent iterations emphasized optimization of the thruster layout and control system. Different configurations were tested to minimize axis coupling and improve maneuverability. Data collected from experimental trials played a key role in refining the final thruster arrangement and enhancing control precision.

Accounting

Table 6.1 Marineova ROV budget

Budget				
Category	Item	Price	Quantity	Costs EGP
Electrical	Brushless motor	320	1	320
	Temperature sensor, waterproof	85	2	170
	DC step-down voltage converter 5V	160	2	320
	IMU, water pressure sensor module	475	3	1425
	BMP180 barometric pressure sensor	90	1	90
	Analog water pressure sensor G1/4	1550	1	1550
	Cable	5	1	5
	WAGO panel mount (2 to 4)	22	1	22
	WAGO panel mount (2 to 8)	38	2	76
	Power supply	1900	1	1900
	DC to DC converter	2900	1	2900
	PG9 white plastic gland	5	3	15
Mechanical	Bilge pump, small	900	4	3600
	Bilge pump, large	1700	2	3400
	6-inch pipe	130	1	130
	T 3/4" white (tee)	10.12	10	101.2
	Elbow 3/4"	7.14	4	28.56
	Squab pair (<i>buoyancy foam?</i>)	5.06	4	20.24
	1 m pipe 3/4	35.07	6	210.42
	Dom	150	1	150
	ECleric	750	1	750
	3D printer	200	1	200
	Flange manufacturing	2800	1	2800
	Frame manufacturing	4000	1	4000
	Fan manufacturing for 3D printer	200	6	1200
	Nail and frame	3115	1	3115
	Threaded Rod 8 m	65	1	65
	Threaded Rod 10 m	75	1	75
	Teflon	30	2	60
	Joan	15	4	60
	Clamp 11 mm	18	4	72
	Clamp 3 m	32.5	2	65
	Nylon cable 4.8 x 370	80	1	80
	Metal cable gland	48	9	432
FEES	Training	3500	24	84000
	MATE ROV fees – international	17490	1	17490

	Transportation	1670	1	1670
	MATE ROV fees – regional	2000	1	2000
Isolation	Welding material	55	1	55
	Heat shrink	55	1	55
	Silicone	60	4	240
	Silicone	60	4	240
	Chickerton	15	2	30
		Total		135187.42

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Appendix A: Safety Checklist

Table A.1 Safety Checklist

Jobsite Safety & Environment Analysis (JSEA) Checklist

MATE ROV 2026 Pioneer Division | City University of Cairo

1. ADMIN AND SETUP

- JSEA Sign-off: Every team member must sign this document before the first lab session. No exceptions. ☐
- Role Assignment: Formally designate the Safety Officer, Electrical Lead, and Software Lead for each shift. ☐
- Emergency Contacts: Ensure the contact table at the bottom is filled with active numbers for CUC Security and the Faculty Supervisor. ☐
- Safety Huddle: Conduct a 5-minute briefing on specific risks before starting high-risk tasks. ☐

2. WORKSHOP AND LAB (Assembly Phase)

- Power Isolation: Always unplug the 48V power supply before working on internal wiring. Never work on live circuits. ☐
- Voltage Verification: Use a multimeter to check for residual voltage before handling capacitors or power blocks. ☐
- Fire Prevention: Keep a fire extinguisher within 2 meters of the electronics bench. Clear all flammable scraps and paper from the area. ☐
- Personal Protection: Safety glasses are mandatory for everyone in the room during grinding, cutting, or soldering. ☐
- Fume Extraction: Always turn on the fume extractor when a soldering iron is in use. ☐
- Fuse Installation: Verify the 25A fuse is correctly installed on the tether before conducting any bench tests. ☐
- Buddy System: Never work alone in the lab. Ensure at least one other person is present to call for help if needed. ☐

3. POOLSIDE AND WATER TESTING

- Vacuum Integrity: Pull a vacuum to -50 kPa for at least 10 minutes. If the pressure drops more than 5 kPa, do not submerge the ROV. ☐
- Seal Inspection: Check O-rings for hair, grit, or damage. Lubricate seals and torque all Wet Link penetrators to specification. ☐
- Power Protocol: Place the ROV in the water first. The handler must shout "Hands Clear" before the pilot connects the power. ☐
- Arming Procedures: The pilot must announce "ARMING ROV" before enabling motors. The handler must reply "HANDS OFF" to confirm. ☐
- Tether Management: Use a figure-8 coil pattern. Keep lines organized to prevent knots and trip hazards on the deck. ☐
- Electronic Protection: Maintain the surface station and laptop at least 1 meter away from the pool edge on a stable surface. ☐
- Water Safety: Team members who cannot swim must wear a PFD (Life Jacket) and remain at least 1 meter away from the water. ☐

4. COMPETITION VENUE (MATE 2026)

- Inspection Clearance: Do not connect power until the MATE safety inspector has provided official clearance. ☐
- Voltage Limits: Confirm the power supply is capped strictly at 48V / 30A per Pioneer Division rules. ☐
- Software Limits: Verify the 55cm brake depth and 10cm hard ceiling are active in the software to avoid penalties. ☐
- System Redundancy: Keep a backup laptop synced with the latest code and ready for immediate swap. ☐
- Public Safety: The Tether Tender is responsible for keeping spectators clear of the tether and the operating zone. ☐

EMERGENCY CONTACTS

| Contact | Name | Phone Number

Ambulance (Egypt) | Emergency | 123 |

Fire Dept. (Egypt) | Emergency | 180 |

CUC Security | Emergency | +201152966762 |

Faculty Supervisor | Emergency | +201002629647 |

Team Safety Officer | Emergency | +201005522120 |