King AbdulAziz University - Saudi Arabia, Jeddah

RedSea Rovers

2024 - 2025

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Abstract

We are **RedSea Rovers**, the first Saudi team participating in the worldwide MATE ROV Competition [1], proudly representing King Abdulaziz University. For the 2025 competition, we present our Remotely Operated Vehicle (ROV), designed to accomplish this year's mission objectives involving underwater inspection, manipulation, and data collection. Our ROV features a modular and robust design that balances compactness with advanced functionality. Throughout the development process, we leveraged many CAD tools such as SolidWorks, alongside sophisticated simulation software, to optimize performance and reliability. We are especially grateful to the Manufacturing Community at King Abdulaziz University, whose generous support as a sponsor provided access to high-quality resources, tools, advanced labs, and technical guidance. Their contribution played a crucial role in enabling our team to bring this project to life with professionalism and engineering in depth.

As a team with growing experience in ROV design, our primary goals focused on achieving precise control, efficient power management, enhanced vision capabilities, and reliable mechanical actuation. Rigorous testing and iterative refinement have resulted in an ROV that is agile, intuitive to operate, and dependable in challenging underwater environments.

This report details our complete engineering design process, highlighting our commitment to innovation, safety, and continuous improvement. By sharing our approach and lessons learned, we aim to contribute to the advancement of the underwater robotics community and inspire future teams in the MATE competition.

Teamwork

RedSea Rovers is based at King Abdulaziz University, formed by a group of driven undergraduate students passionate about underwater robotics. As a student-led initiative, RedSea Rovers is dedicated to advancing the field through innovation, hands-on engineering, and participation in the International MATE ROV Competition.

Our mission is to design, build, and compete with an ROV capable of performing complex underwater tasks that reflect real-world marine engineering challenges. Our team is united by a commitment to excellence, collaboration, and continuous improvement. Given the interdisciplinary nature of our work, RedSea Rovers is organized into four specialized divisions to ensure efficient project development and cross-functional collaboration:

- **Management**: This division manages budgeting, sponsorships, outreach, and marketing. Their work ensures the team has the resources, visibility, and community support necessary for successful operations and competition readiness.

- **Mechanical**: Responsible for the physical design and construction of the ROV, this division focuses on developing a durable, maneuverable frame and mechanical subsystems suited for challenging underwater environments, including waterproofing measures.

- **Power**: This division designs and integrates the electronic systems that power and control the ROV. This includes power distribution, component compatibility, and sensor integration.

- **Software**: Tasked with developing the control software, autonomous functions, user interface, and communication infrastructure, the Software division ensures the ROV responds accurately to commands and performs tasks with precision and efficiency.

Team Hierarchy

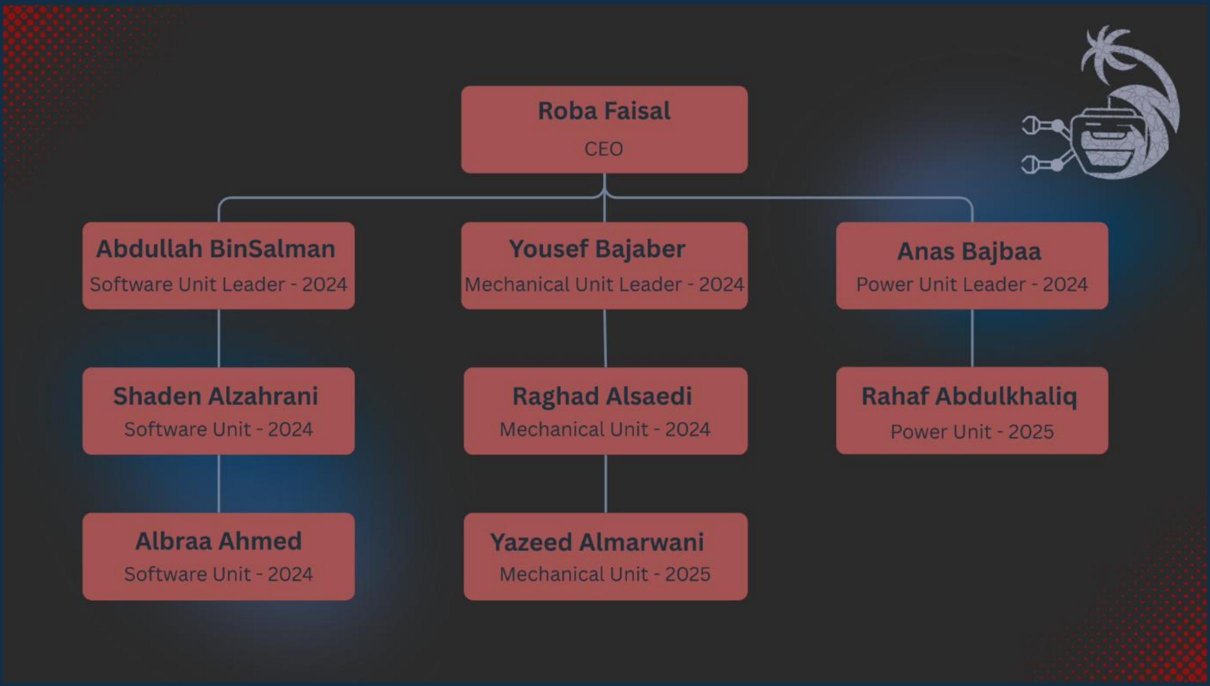

Figure 1: Team Hierarchy Tree

Project Management

At RedSea Rovers, effective project management is essential to delivering a functional and competitive ROV. We used the following strategies to maintain focus, ensure accountability, and foster seamless teamwork:

- **Smooth progression**: Our work is divided into weekly sections. At the end of each week, we conduct review sessions to assess progress, resolve issues, and adjust priorities as needed.
- **Milestone-based planning**: We established clear objectives at each stage of the engineering process: design, prototyping, testing, and targeted subsystem explorations. For example, we isolated components like the camera or sensor modules, tested them independently, and studied their behavior before integrating them into the larger submarine system. This structured, hands-on approach kept the team focused, informed, and motivated throughout the project.
- **Task tracking with Notion**: We utilized Notion to assign and monitor tasks, ensuring that every member understands their responsibilities and deadlines.

- **Weekly team meetings**: Whether online or in the team lab, weekly meetings provide a platform to share updates, troubleshoot challenges, and realign goals. Sub-teams also held frequent, focused sessions to advance their specific technical areas.
- **Detailed documentation**: We maintained comprehensive records using Google Drive and Notion, including technical specifications, meeting notes, design versions, and test results. This ensures knowledge continuity and easy reference.

At RedSea Rovers, we value growth, mentorship, and collaboration. Experienced members support and guide new recruits, fostering a culture of continuous learning. Through teamwork, technical rigor, and a shared passion for underwater robotics, we aim to represent King Abdulaziz University and Saudi Arabia with pride and innovation on the global stage.

Acknowledgements

We, the RedSea Rovers, would like to sincerely thank everyone who supported and guided us throughout our journey building this year’s ROV. First, King Abdulaziz University, for being the foundation of our growth and giving us the space and support to explore and push the limits of our engineering skills. The Manufacturing Community (MC), for playing a key role in our development process. The labs, resources, and technical insight, and financial support provided by them made a real difference in how we brought our ideas to life, and we’re incredibly grateful for the hands-on support. Our Faculty Mentors and Advisors for always being available to offer feedback, direction, and encouragement. Your guidance helped us grow as both engineers and team members. MATE for creating an international platform that challenges students to solve real-world problems through robotics. Being part of this competition pushed us to learn, adapt, and aim higher. And finally, to everyone who contributed to this project in one way or another, thank you. We’re proud to represent our university and our country as the first Saudi team in this global competition.

Figure 2: King Abdulaziz University

Figure 3: Manufacturing Community

Safety

At RedSea Rovers, safety is a foundational element of every operation, from design and prototyping to deployment and testing. We believe that a successful ROV is not only high-performing but also safe to build, operate, and maintain. Every decision is guided by this principle, and all team members are actively involved in upholding and improving our safety standards.

Manufacturing and Assembly Safety:

During the construction and assembly phases, all team members are required to wear appropriate personal protective equipment (PPE), including safety goggles, gloves, and, when necessary, ear protection. Respirators are used for operations involving sanding, soldering, spray painting, or exposure to fumes. Workstations are kept clean and organized to reduce clutter-related hazards, and flammable or toxic materials are stored in clearly labeled, ventilated containers.

Electrical Safety:

- Strict protocols are in place when working with electrical components. These include:
- Isolating low-voltage and high-voltage systems during testing and operation.
- Ensuring all circuits are de-energized before disconnection.
- Using insulated tools and wearing antistatic wrist straps during handling of sensitive electronics.
- Color-coding wires and labeling components to prevent wiring errors and short circuits.
- Incorporating fuses and circuit breakers to protect components and prevent overheating.

Operational Safety:

Before any in-water testing, a mandatory 10-minute leak test is conducted. The operating area is clearly marked and restricted, with only essential personnel allowed near the water. Communication protocols are enforced via headsets or hand signals to ensure real-time coordination. Additional procedures include:

- Tether management: Securing and organizing the tether to avoid entanglement or tripping.
- A safety perimeter: Marked around the control and deployment zones to prevent bystander interference.

- Emergency shutoff: Easily accessible and regularly tested to instantly power down the ROV in case of malfunction.
- Battery safety: Batteries are checked for swelling or damage before each use, and fireproof bags are used for storage and transport.

Testing & Emergency Protocols:

Each test and mission is preceded by a comprehensive safety checklist. All team members are briefed on:

- Evacuation routes and fire extinguisher locations.
- First aid kit availability and designated first aid responders.
- Proper lifting techniques to avoid back injuries when moving heavy equipment.
- How to respond to specific emergencies such as water leakage, electrical shorts, or signal loss.

Training and Continuous Improvement:

New members undergo a mandatory safety orientation before participating in hands-on work. Regular safety drills and debriefings are held to reinforce protocol adherence. Feedback is encouraged to improve existing procedures, and any safety incidents are documented and reviewed to prevent recurrence.

Design Rational

The RedSea Rovers ROV was designed to balance performance, reliability, and cost-efficiency while meeting the MATE ROV competition requirements. The frame is constructed from HDPE panels connected using PLA 3D-printed joints, chosen for their strength, buoyancy, and ease of customization. PVC was initially considered but dismissed due to its rigidity and lack of design flexibility. For propulsion, eight T200 thrusters were arranged to provide full six-degree-of-freedom control. Neutral buoyancy was achieved with foam inserts.

Two identical front-mounted manipulators, each with three degrees of freedom, were built using aluminum arms and 3D-printed joints for object handling and rotation. The control system includes a Raspberry Pi, Pixhawk, and Arduino modules, all communicating via a tether. Two onboard cameras—one for navigation and another near the manipulators—stream live video and telemetry to the surface using UDP.

Software is divided into three layers: QGroundControl handles user inputs, the Raspberry Pi manages MAVLink communication and video processing, and the interface provides real-time feedback. Power is delivered through a 48V, 30A tethered supply. Two DC-DC converters power the thrusters, while a 12V–5V converter supports low-power electronics. Six servo motors, managed by the Arduino, operate the manipulators. This setup ensures smooth, reliability, and responsive underwater performance.

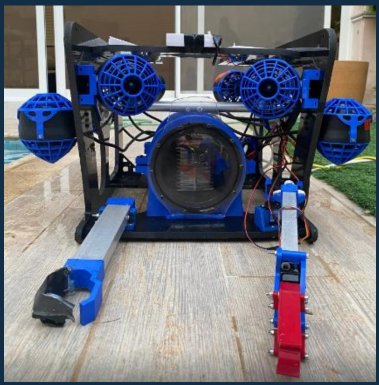

Figure 4: The ROV's Final Design

Product Design

Mechanical

All engineering innovations begin with a concept — and for us, the RedSea Rovers, those initial ideas were successfully transformed into a fully realized product design. In response to MATE’s requirements for complex, pioneer-class ROVs, the design process involved overcoming technical challenges through multiple iterations. One of the most demanding aspects was selecting the most efficient and functional design. The team evaluated various configurations, assessing their structural characteristics, functional benefits, and limitations.

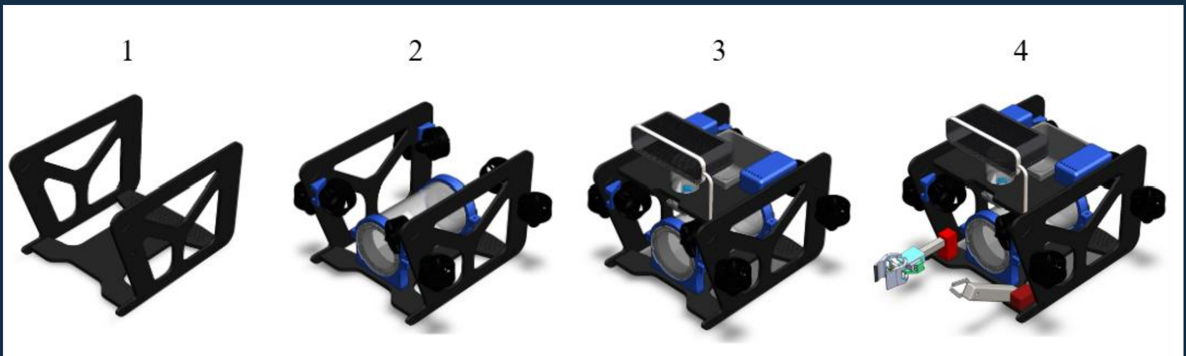

Figure 5: Progressive Assembly Stages of the ROV

Frame

The frame plays a crucial role in the overall structure and performance of the submarine. During the initial design phase, the primary objective was to develop a compact and modular chassis that allows for quick integration and replacement of key components such as tooling, buoyancy, and electronics. The frame consists of HDPE (High-Density Polyethylene) panels rigidly connected by PLA 3D printed parts extrusions, forming a durable and lightweight structure suitable for underwater applications.

At the center of the chassis lies a watertight electronics enclosure pipe mounted onto a HDPE tray, which provides protection for internal systems. The enclosure is securely housed within the frame using custom brackets and fasteners, ensuring vibration resistance and ease of maintenance. To fulfill its objectives, the ROV features two servo-controlled robotic arms that enhance its operational versatility.

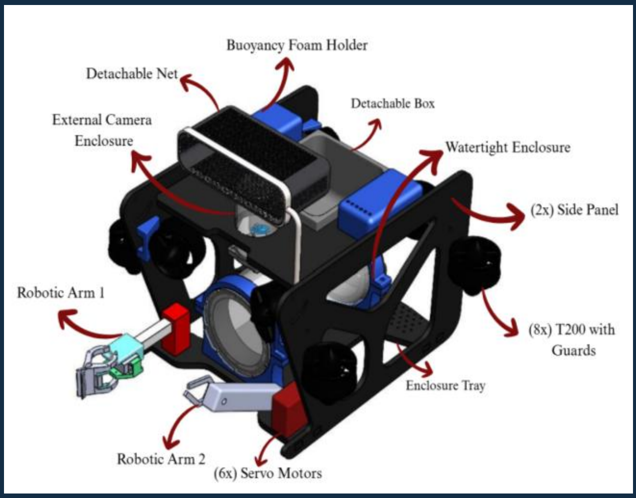

Figure 6: Annotated ROV model

Thrusters

The ROV is powered by eight Blue Robotics T200 thrusters [2], strategically positioned to enable six degrees of freedom in movement. These include three translational axes (forward/backward, lateral, and vertical) and three rotational axes (pitch, roll, and yaw).

Four horizontally aligned thrusters are mounted at the corners of the frame. These manage forward/backward movement, side-to-side strafing, and yaw control. The remaining four thrusters are vertically oriented, placed on both the left and right sides of the vehicle. These provide control over pitch, roll, and vertical ascent/descent.

This configuration offers a cost-effective solution while maintaining full maneuverability and simplifying control system implementation. The T200 thrusters were selected for their reliability, user-friendliness, and proven performance—they are widely used in Blue Robotics' own systems and supported by MATE as a sponsor.

Their brushless motors offer enhanced durability, efficiency, and power compared to traditional brushed motors. To ensure safety, thruster guards were installed at both the front and rear ends of each thruster to prevent accidental contact or injury.

Figure 7: Blue Robotics T200 Thruster and their 3D Printed Guards

Grippers

Designing the ROV's primary working tool posed a significant challenge for the team, as no existing prototype met the specific requirements of the project. Consequently, RedSea Rovers opted to develop a custom solution from the ground up, ensuring it aligned with both functional standards and operational needs.

The ROV is equipped with two identical front-facing manipulators—mounted symmetrically on the left and right of the front side of the frame. Each manipulator features three degrees of freedom, powered by three dedicated servo motors, enabling precise object grasping and unrestricted rotational movement. These manipulators serve as the core tools for executing mission tasks.

The structure of each arm consists of a robust aluminum framework for durability, complemented by 3D-printed components for the joints and servo mounts to reduce weight and facilitate modularity. At the end of each arm, two semicircular pincers (claws) are designed to grip objects securely. These are connected via linkages and power screws to the main shaft, ensuring reliable actuation and control.

To enhance operational flexibility, both manipulators are identical in design and function. This dual-arm configuration significantly expands the ROV's capabilities, enabling it to handle complex and simultaneous tasks with efficiency and precision.

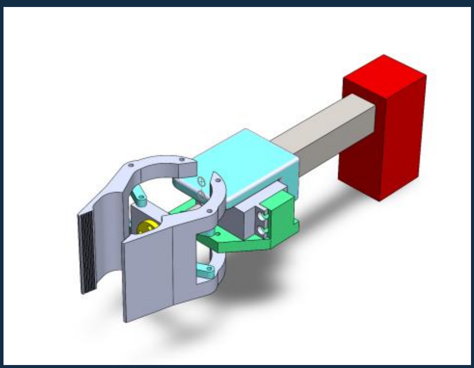

Figure 9: CAD Model of the Manipulator Arm

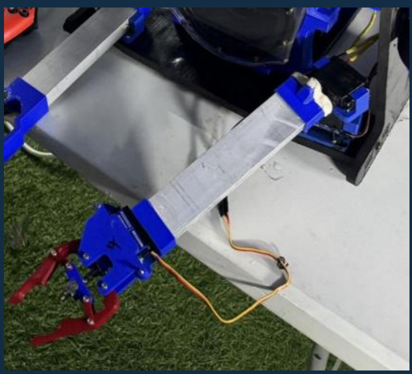

Figure 8: Physical Implementation of the Manipulator Arm

Control and Communication

Software

The software development was structured into three main sections:

1- Control Layer: Handles joystick inputs from the PS4 controller via QGroundControl (QGC). Inputs are transmitted using MAVLink to the onboard Raspberry Pi (RPi), which routes them to the Pixhawk for controlling thrusters and actuators.
2- Onboard Processing: Managed by the Rpi [3], this layer is responsible for MAVLink communication, telemetry handling, video stream encoding, and peripheral sensor integration. It acts as the intermediary between QGC and the Pixhawk.
3- Interface Interaction: Focuses on the operator interface within QGC, including real-time telemetry monitoring, live video feeds, mission tracking, and control feedback.

Our ROV system leverages QGroundControl, BlueOS, and the ArduSub firmware for real-time operation. QGC, running on the surface control system, enables the team to operate the ROV via the PS4 controller, view live video, and monitor sensor data. BlueOS runs on the onboard Raspberry Pi, managing system configuration, camera streaming, and MAVLink routing between the Pixhawk and the ground station. The Pixhawk runs ArduSub firmware to interpret commands and control the thrusters, robotic arm, and connected sensors.

Figure 10: Control interface

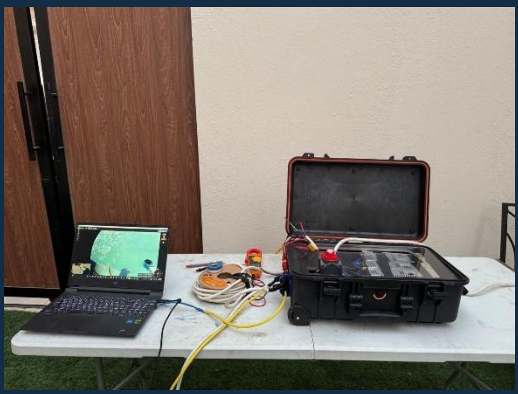

Figure 11: Control Station

Communication and Data Transfer

The communication pipeline for our ROV system integrates several components to ensure smooth and responsive operation. Inputs come from the PS4 controller connected to the Ground Control Station (QGC), which controls the movement of the ROV and its robotic arms in real time. Visual feedback is provided by two cameras: one mounted above the submarine for navigation and situational awareness, and a precision camera near the robotic arms to assist with detailed manipulation of tasks.

Data transfer between the ROV and surface station is established through a tethered connection. The onboard Raspberry Pi processes control commands from the station and relays them to the Pixhawk via MAVLink. Telemetry data, sensor readings, and live video streams from both cameras are transmitted back to the station over the same tether. Furthermore, MAVLink facilitated communication between QGC, Raspberry Pi, and Pixhawk. UDP was used for streaming live video feeds. Finally, serial communication is employed internally for sensor and data exchange among microcontrollers and peripherals. This setup enables continuous two-way communication, allowing real-time control of thrusters, robotic arms, and cameras, while providing the operator with live video feeds and telemetry for effective underwater mission management.

Figure 12: ROV's Controller

Electrical Design

The electrical architecture of the RedSea Rovers' ROV was carefully structured to ensure power efficiency, clean distribution, and seamless integration of all onboard and topside systems. The system is powered by a 48V DC supply rated at 30A, delivering a maximum of 1440W. From the topside, power is transmitted through the tether to the ROV via a busbar system that ensures secure and organized distribution. Two DC-DC converters (48V to 12V) are employed in parallel, each responsible for powering four of the eight T200 thrusters, with the load evenly divided to maintain thermal and electrical balance.

A separate 12V to 5V DC-DC converter is used to supply low-power electronics, including the sensors, camera, robot arms 1 and 2, Raspberry Pi, and Arduino. This separation of high-power and low-power subsystems improves stability and reduces the risk of electrical interference.

Eight T200 thrusters are installed, each connected to an Electronic Speed Controller (ESC), and controlled via PWM signals generated by the Pixhawk flight controller. ESCs 1 through 8 are powered from the 12V rail, with control lines routed independently to preserve signal clarity. Six 35kg servo motors are used to actuate the robotic arms, powered from the 5V line and managed by the Arduino, allowing precise motion control.

The Raspberry Pi serves as the main companion computer, handling mission logic, camera streaming, and user interface tasks. It communicates with the Pixhawk via a UART connection, which enables the reliable exchange of navigation data and high-level commands.

Integrated sensors include a depth/pressure sensor, an inertial measurement unit (IMU), and a pH sensor—all powered through the 5V bus. The camera module is interfaced directly with the Raspberry Pi using the CSI (Camera Serial Interface) port and powered via the same 5V converter, enabling real-time video streaming for surface operators.
The complete power and signal distribution is visualized in the system diagram shown in Figure (13), which serves as a reference for integration and maintenance.

ROV SID

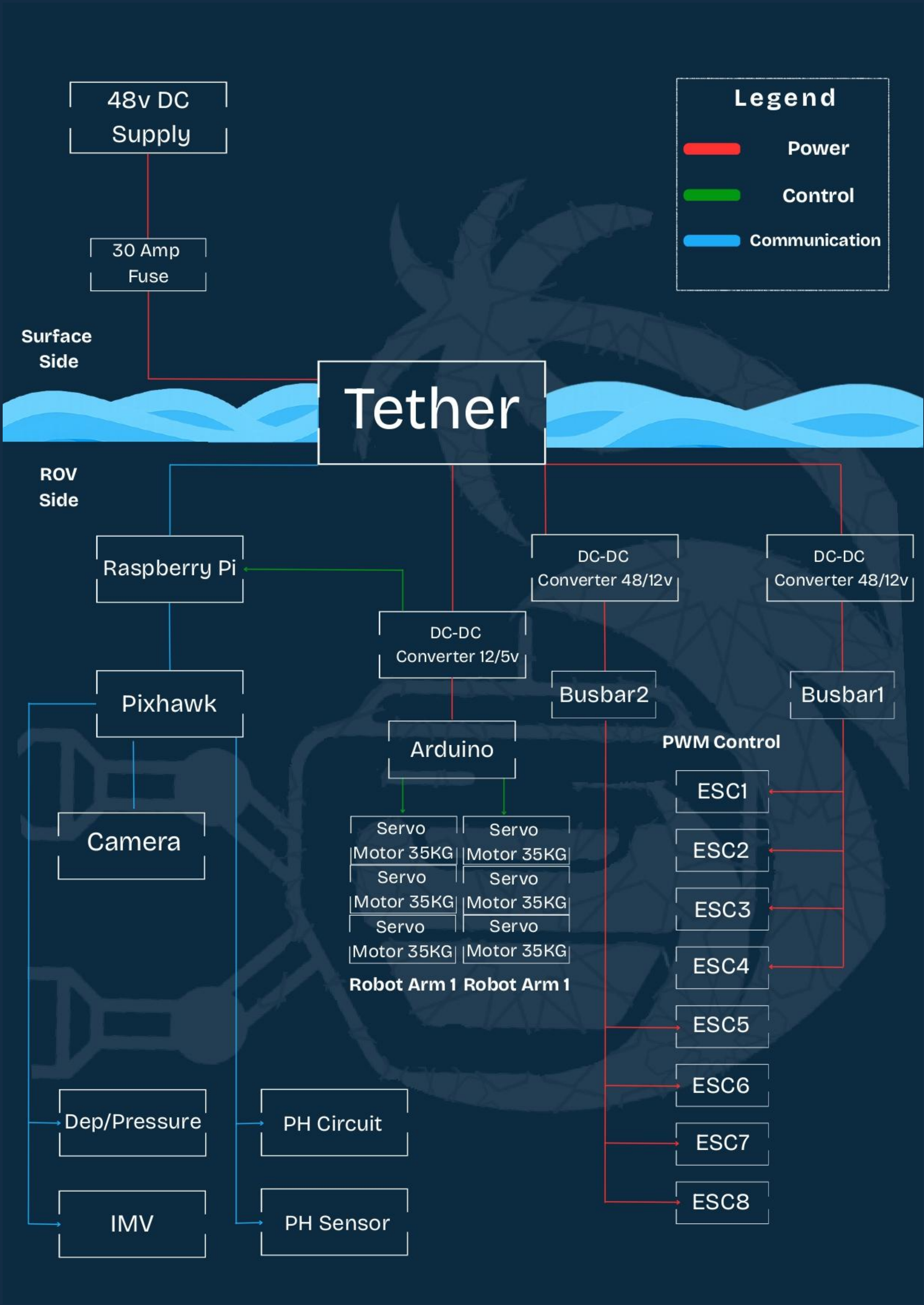

Figure 13: ROV SID (System Interconnection Diagram)

Float

Mechanical

The vertical profiling float developed by RedSea Rovers is designed to complete two vertical profiles during Task 3. Its operation is managed by a stepper motor-driven buoyancy engine that adjusts the float's depth by controlling water displacement. The mechanism functions through a motorized plunger system: as the lead screw retracts or extends the plunger within a 500 ml syringe, water is either drawn in or expelled, thereby altering the float's buoyancy.

The system is powered by eight AA batteries and controlled via an Arduino Nano ESP32. All internal components are housed within a 500 mm acrylic tube length with a 90 mm diameter. The assembly is sealed with 3D-printed end caps and components, insulated with epoxy to ensure water resistance and maintain cost efficiency.

Once deployed, the float begins its descent and communicates with the base station using wireless transceivers. Throughout the profiling process, it transmits pressure sensor data in real-time, enabling effective environmental monitoring.

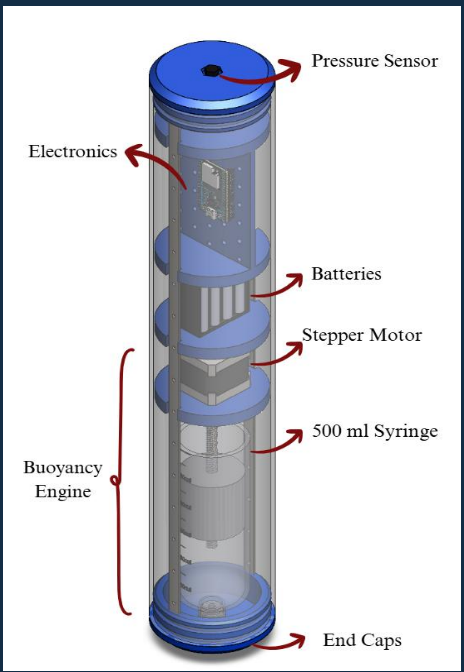

Figure 14: Non-ROV Device

Electrical

The ESP32 Nano serves as the brain of the float, managing its operations by controlling the NEMA 17 stepper motor, which is responsible for regulating the float's submerging and rising actions. It is also equipped with a pressure sensor and a real-time clock (RTC), which collects crucial data such as pressure, depth, and time. The float descends to the bottom, where it collects data, then waits for a specified duration before ascending back to the surface. Once it reaches the surface, the ESP32 Nano wirelessly transmits all collected data, including time, pressure, and depth, to the station via Wi-Fi. This setup allows for continuous monitoring and remote data collection, providing valuable insights into the system's operation.

Troubleshooting

Many technical and logistical challenges were faced during the development of the ROV system. These challenges were resolved through persistent trial and error, extensive simulations, peer consultations, and long hours of research and testing. Due to hardware and software compatibility constraints, we followed a dynamic and adaptive problem-solving path.

One of the earliest setbacks came from accurately calculating the power, voltage, and current requirements of the system. The electrical team had to undergo an iterative process of learning and discovery, scouring technical documentation, seeking guidance from instructors and experienced engineers, and running repeated simulations to verify results. Understanding the full electrical load and ensuring each component received adequate power without exceeding safe limits, continuous adjustment and learning.

Compounding this were the integration issues faced with the microcontrollers and peripheral components. Not all devices were compatible with one another, and some programming environments conflicted with the existing software frameworks. A particular challenge arose when attempting to interface the robotic arm directly with the Pixhawk flight controller. Although initial plans involved controlling the arm via Pixhawk, it soon became apparent that the firmware and manipulation capabilities were too limited for our needs. The team then pivoted to using an Arduino microcontroller to control the robotic arm. However, this introduced new hurdles: the Arduino codebase was written in a different programming language, requiring careful handling to ensure signal translation and timing.

One of the primary challenges faced during the development process was the identification of an optimal design and suitable material for the ROV's main structure. This task required extensive experimentation, with seven distinct design iterations explored, each presenting its own set of strengths and limitations—before the most functional and reliable configuration was finalized.

In the initial phases, PVC piping was evaluated as a potential construction material due to its affordability, availability, and water-resistant properties. However, several drawbacks were identified that rendered it unsuitable for the application. Most significantly, PVC's rigidity posed a limitation, as it could not be reshaped or customized to meet the specific geometrical and performance requirements of the design. Unlike materials such as aluminum or HDPE, PVC could not be easily bent, joined at non-standard angles, or adapted for complex structural configurations.

As prototyping progressed, more adaptable materials—such as HDPE panels—were adopted. These alternatives offered improved structural integrity, modularity, and ease of integration for key components. Their use enabled more precise mounting, adjustable dimensions, and ensured the watertight reliability essential for underwater operation.

The iterative design process played a critical role in shaping the final ROV structure. Each unsuccessful prototype contributed valuable insights that informed subsequent revisions. Ultimately, the experience underscored the importance of balancing cost-efficiency, manufacturability, durability, and adaptability when selecting materials for underwater robotic systems.

Another major challenge lies in waterproofing the system. The mechanical team experimented with a variety of sealing techniques such as epoxy resin, silicone-based adhesives, and reinforced mechanical methods such as using rubber bands within cylindrical housings to create pressure-resistant seals. Each solution underwent rigorous testing to ensure watertight integrity. Several iterations were needed after discovering minor leaks that could compromise electronics under real-world conditions. Eventually, the team achieved a stable configuration that protected the internal electronics.

Each setback provided the team with valuable lessons, strengthening their understanding of system integration, electronics, and real-world design constraints. These solutions, born from persistence and adaptability, formed the backbone of a resilient and functional ROV platform.

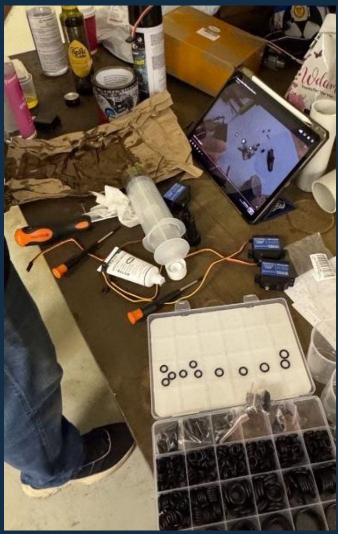

Figure 15: Insulation applied to protect electrical components

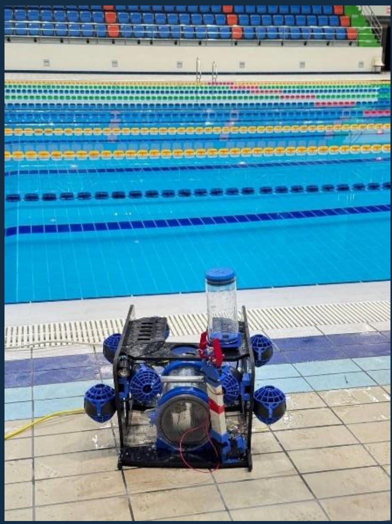

Figure 16: First Official Test

Conclusion

The development of the ROV by RedSea Rovers was marked by a series of technical challenges, iterative improvements, and valuable insights. As first-time participants in the MATE ROV Competition, a steep learning curve was experienced, encompassing design, system integration, and project management. Through this journey, numerous lessons were learned, and critical skills were developed.

One of the most significant challenges faced during the project was the identification of a suitable structural design and material for the ROV. Over seven different design iterations were explored, with each one revealing new limitation and providing important feedback.

Excessive design complexity was also encountered during the initial phases. Systems that appeared promising on paper often proved unreliable in real-world conditions. As a response, a modular and iterative design philosophy was adopted, allowing for more manageable integration and efficient troubleshooting.

Difficulties were also encountered in the integration of mechanical, electrical, and software subsystems. Compatibility and communication between these systems require repeated testing and refinement. These challenges highlighted the importance of comprehensive documentation, consistent naming conventions, and synchronized team coordination.

Delays due to unforeseen complications demonstrated the need for flexible time management. Although detailed planning was undertaken, unforeseen challenges necessitated the implementation of agile project management practices. Tasks were reprioritized as needed, and adaptive workflows were adopted to ensure steady progress.

Throughout the project, decisions had to be made within the constraints of limited resources, time, and budget. Trade-offs were frequently evaluated, and solutions were selected based on feasibility as well as innovation. These constraints helped cultivate critical thinking, risk assessment, and design optimization under pressure.

Valuable insights were gained as the project progressed. The collaboration between the mechanical, electrical, and software divisions was observed to be instrumental in the successful realization of the ROV. Each contribution, whether conceptual or technical, was integrated into a unified system through clear communication and shared objectives.

Participation in the MATE ROV Competition provided an immersive and practical learning experience. Exposure was given to real-world engineering practices, including systems engineering, safety protocols, component testing, and iterative prototyping. Tasks such as leak testing, tether management, and emergency shutoff planning were carried out in accordance with established safety procedures.

Through these efforts, the importance of resilience, teamwork, and attention to detail was underscored. The skills developed extended beyond technical knowledge, encompassing project coordination, documentation standards, and interdisciplinary communication. This experience was further enhanced by the invaluable support provided by mentors, sponsors, and the University of King Abdulaziz.

In conclusion, the journey undertaken during the design and development of the RedSea Rovers ROV was both demanding and enriching. A fully functional and mission-ready ROV was produced because of persistent effort, collaborative work, and iterative refinement. The experience has laid a solid foundation for future endeavors, and a passion for innovation in underwater robotics has been ignited. With the knowledge gained and lessons learned, readiness for future challenges has been strengthened, and continued advancement in the field is anticipated with confidence.

References

[1] MATE ROV Competition (2025) *MATE ROV Competition Website*. Available at: https://materovcompetition.org (Accessed: 22 May 2025).

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[3] Raspberry Pi (2025) *Raspberry Pi 4 Model B Specifications*. Available at: https://www.raspberrypi.com/products/raspberry-pi-4-model-b/specifications/ (Accessed: 22 May 2025).

Appendix

Organisation Chart

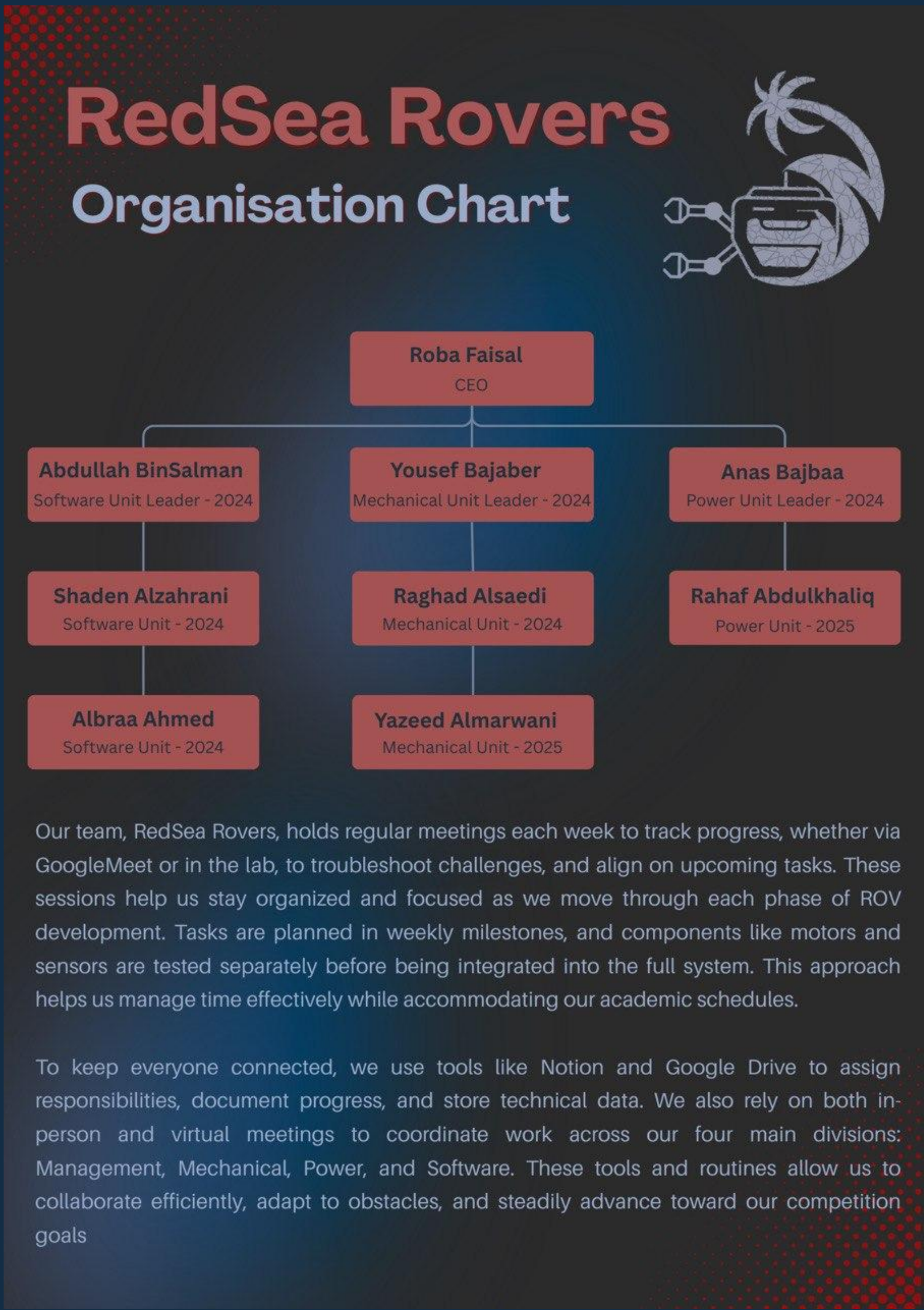

Figure 17: Team's Organisation Chart

Cost Accounting

Final ROV Mate BoM

Category	Name	Quantity	Unit price	Shipping	Total	Specs	Supplier	Link
Mechanical	T200 Thruster	6	200	165.98	1365.98		Blue Robotices	
Control	ESC for thrusters	6	38	0	228	ESC compatable with the thrusters	Blue Robotices	
Mechanical	Penetrators	35	10.2	0	357	different sizes as in the link	Blue Robotices	
Mechanical	PRV	2	28	0	56		Blue Robotices	
Mechanical	Other sealing tools and components	1	390	0	390	All items in the link	Blue Robotices	ps://bluerobotics.com/?share-cart=2071
Sensors	I2C Level Converter	2	25	0	50		Blue Robotices	
Control	Binder head and connect	1	28		28			
Sensors	Bar30 High-Resolution 300m Depth/Pressure Sensor	2	50		100		Blue Robotices	
Control	Raspberry Pi 4	1	101		101		Amazon	https://www.amazon.sa/-/en/Raspberry-
Sensors	PH sensor	1	300		300		Atas scientific	https://atlas-scientific.com/kits/ezo-com
Sensors	IMU	2	12.5		25			https://www.amazon.sa/-/en/REES52-M
Float	RTC for float	1	14.5		14.5			https://amzn.eu/d/3vlMaeh
Control	Float communication system	1	44		44	Arduino nano w ESP32		https://www.amazon.sa/-/en/Arduino-ES
Control	Arduino Mega	1	58.39		58.39		Amazon	https://amzn.eu/d/93ZfHxZ
Float	Nema17 stepper motor with lead screw	1	42	0	42	Lead screw length = 150mm	Amazon	Nema 17
Float	Stepper driver	1	20	0	20			Amazon link for the driver
Float	Syringe	3	7	20	41	200ml		Syringe link

Final ROV Mate BoM

Categor	Name	Quanti	Unit pri	Shippin	Total	Company	Link
Robotic arm	Servo driver	3	30		90		https://amzn.eu/d/92wBn89
Robotic arm	Locking nut sets	1	96		96		https://www.amazon.sa/-/en/Swpeet-100Pcs-Stainless-Assortment-Lock
General	Strain Releif 1/2''	1	114		114	Amazon SA	https://www.amazon.sa/-/en/LeMotech-Waterproof-Spiral-Strain-Gaskets/dp/B09P85WQTG?th=1
Mechanical	Micro servos	1	101	23	124		https://www.amazon.sa/%D8%A8%D8%A7%D9%84%D9%83%D8%A7%D9%85%D9%84-
Float	Large Syringe	1	92.6		92.6		Syringe
Robotic arm	Sevo 35 kg	4	97.5	183	573		https://www.amazon.sa/%D8%A7%D9%86%D8%AC%D9%88%D8%B1%D8%A7-%D8%B3%D9%8A%D8%B1%D9%81%D9%88-
Robotic arm	Sevo 25 kg	4	86	180	524	Amazon US	https://www.amazon.com/Wishiot-TD-8125MG-Digital-Waterproof-500%CE%BCs-2500%CE%BCs/dp/B08JCT4P3B/ref=sr_1_29?crid=2C4BHLF0SHR5H&dib=eyJ2IjoiMSJ9.dayXWg9e0lMl-
Robotic arm	Servo 45	8	127.5	509	1529		https://a.co/d/94foLqX
Robotic arm	O-ring set	1	30		30		https://a.co/d/ilzEUaq
Power system	power distribution board (4-Output)	5	31.87		159.35		https://a.co/d/8uLzX7C
Robotic arm	Silicon grease	3	30		90		https://a.co/d/cvNcp9V
Power system	power distribution board(more than 2-Output)	3	54		162		https://amzn.eu/d/aF0UDdb
Sensors	PH sensor	1	113		113	Amazon SA	https://amzn.eu/d/0QVf73b
Power system	48V to 12V Converter	2	453		906		https://amzn.eu/d/il2v95L
Power system	12-5 converter	1	97		97		https://amzn.eu/d/15uLyOn
Power system	Connector	1	29		29		https://amzn.eu/d/38Z8lcE
Power system	blue robotics	1	2866.71		2866.71		https://bluerobotics.com/?share-cart=210997
Power system	blue robotics	1	4504.95		4504.95	Blue robotics	https://bluerobotics.com/?share-cart=209489
Control	Camera	2	281		562	Amazon US	https://a.co/d/6ZsO4F2
Control system	Pixhawk + power module	1	411		411	Ali express	https://ar.aliexpress.com/item/33058886931.html?srcSns=sns_More&sp

Figure 18: Final BOM

Income		
Income	Type	Amount
University funding	grant	SAR10,000.00
University funding	grant	SAR15,000.00
Mentor	Donation	SAR5,000.00
Companies	Sponsorship	SAR5,000.00
total		SAR35,000.00

Expenses		
department	description	amount
Mechanical	mechanical requirments for the F	SAR6,642.00
Control and communicatio	including mircocontrollers and se	SAR3,837.00
Power system	converters and wiring requirment	SAR9,093.00
Total		SAR19,572.00
Remaining		SAR15,428.00

Figure 19: Income& Expenses