DRAGONLEAP TECHNOLOGY DOCUMENT

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Catalog

1 Abstract

The DragonLeap team comes from a coastal city rich in marine resources and characterized by a diverse marine ecosystem. Our team actively organizes water-based and underwater club activities, which have deepened our understanding of the marine environment and its technological applications. As marine ecosystems face growing challenges from climate change and human activity, we recognize the critical importance of ocean conservation and sustainable use. Through this competition, we aim to explore innovative solutions in underwater exploration, marine energy development, and environmental monitoring, contributing to the advancement of marine technology and ecological protection.

DragonLeap is a young team, founded less than two years ago, that has always upheld the principle of allowing members to independently choose their development direction and strongly supporting new ideas from members. This philosophy has created an atmosphere of openness and freedom within the team, where each member can pursue their own interests. If anyone has new ideas or innovations, the team provides a platform and opportunities for them to realize their ideas. This is also the origin of our team name "DragonLeap," symbolizing the members' determination to forge ahead like a soaring dragon, pursuing success and surpassing themselves. The name conveys both the team's unity and spirit of solidarity.

Figure 1 Group photo of the team

2 Teamwork

2.1 Project Management

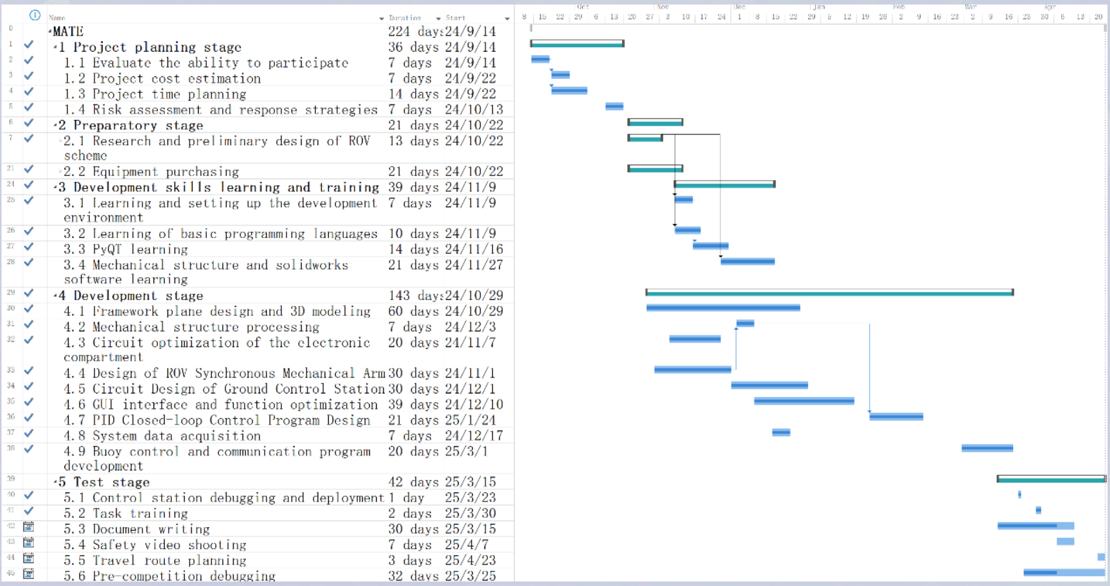
Company structure

DragonLeap is a corporatized underwater exploration robot team composed of undergraduates from Shenzhen University of Technology. With a business model of "hardware + software + service", our company is committed to using underwater robots to change the way of production and life in marine scenarios. Our company emphasizes an inclusive culture, team cohesion and members' self-realization. The team has a fixed R&D site of 120 m^2 in the University, and the members usually work in their respective directions in small groups. Every Wednesday, our team comes together to solve a problem in the R&D process.

DragonLeap consists of four departments: software, hardware, mechanical and documentation. Each member is assigned to different departments according to their interests and technical background. Within the project team, the CEO is the overall leader of the project and is responsible for determining the exact timeframe for each phase of the project as well as the hardware component and final integration of all paperwork components. The CTO is mainly responsible for the overall project management of the design, build, and testing of the robot. The CFO is also present to keep track of the company's budget monthly and to take note of any additional resources needed. In addition, she is also responsible for clerical writing and various types of design work.

2. 2 Project Schedules

Our schedule for developing "Pozhen" is divided into four stages: first, project planning to assess feasibility, budget, and timeline; then the preparation stage, which includes research, equipment purchase, and skill development; next is the development stage, where we focus on design, programming, and system integration; and finally, the testing stage for debugging, task training, and pre-competition setup. The whole process is managed and traced by using the Gantt chart as Figure 2 to ensure steady progress.



	Name	Duration	Start
0	MATE	224 days	24/9/14
1	1 Project planning stage	36 days	24/9/14
2	1.1 Evaluate the ability to participate	7 days	24/9/14
3	1.2 Project cost estimation	7 days	24/9/22
4	1.3 Project time planning	14 days	24/9/22
5	1.4 Risk assessment and response strategies	7 days	24/10/13
6	2 Preparatory stage	21 days	24/10/22
7	2.1 Research and preliminary design of ROV scheme	13 days	24/10/22
21	2.2 Equipment purchasing	21 days	24/10/22
24	3 Development skills learning and training	39 days	24/11/9
25	3.1 Learning and setting up the development environment	7 days	24/11/9
26	3.2 Learning of basic programming languages	10 days	24/11/9
27	3.3 PyQT learning	14 days	24/11/16
28	3.4 Mechanical structure and solidworks software learning	21 days	24/11/27
29	4 Development stage	143 days	24/10/29
30	4.1 Framework plane design and 3D modeling	60 days	24/10/29
31	4.2 Mechanical structure processing	7 days	24/12/3
32	4.3 Circuit optimization of the electronic compartment	20 days	24/11/7
33	4.4 Design of ROV Synchronous Mechanical Arm	30 days	24/11/1
34	4.5 Circuit Design of Ground Control Station	30 days	24/12/1
35	4.6 GUI interface and function optimization	39 days	24/12/10
36	4.7 PID Closed-loop Control Program Design	21 days	25/1/24
37	4.8 System data acquisition	7 days	24/12/17
38	4.9 Buoy control and communication program development	20 days	25/3/1
39	5 Test stage	42 days	25/3/15
40	5.1 Control station debugging and deployment	1 day	25/3/23
41	5.2 Task training	2 days	25/3/30
42	5.3 Document writing	30 days	25/3/15
43	5.4 Safety video shooting	7 days	25/4/7
44	5.5 Travel route planning	3 days	25/4/23
45	5.6 Pre-competition debugging	32 days	25/3/25

Figure 2 Project Schedules

2.3 Company Operation

For budgeting, we adopted the Weighted Matrix Principle, categorizing expenses into four types: non-self-made and important, self-made and important, non-self-made and less important, and self-made and less important, to prioritize spending and purchasing decisions. The budget is allocated as follows: hardware and circuitry (33%), mechanical and assembly (29%), software and testing (11%), Team development and traveling (27%), ensuring balanced resource distribution while maintaining flexibility to address unforeseen challenges.

3 Design Rationale

3.1 Engineering Design Rationale

The "Pozhen" is built on our previous platform with a systems-engineering mindset to balance performance, reliability, and cost. We began by analyzing mission needs—depth, maneuverability, and serviceability—then defined our architecture.

It is a modular PP frame (10 mm thick) with quick-release mounts for tools, a budget-friendly aluminum electronics bay with rapid-disassembly seals, and a snap-on buoyancy block. All joints use 304 stainless hardware for underwater durability. Choices like PP over aluminum cut weight without sacrificing strength, and sleek side panels reduce drag. We iterated from concept to material trials, prototype tests, and structure tweaks, arriving at a 455×341×225 mm robot with 4 m depth rating and ±0.2 kg buoyancy control.

3. 2 Problem Solving

Figure 3 Team members brainstorm meeting

DragonLeap uses a data-driven, collaborative approach. Our cross-functional team meets weekly to tackle thruster placement, power management, and task planning. When thrusters underperformed, engineers and developers teamed up to test PID tuning and hardware redundancy.

The solution evaluation adopted a data-driven trade-off analysis approach, using a weighted decision matrix to assess alternative options. Key evaluation criteria included cost, performance, reliability, and implementation difficulty. For example, when selecting a pressure sensor, the team compared the MS5837 (accuracy: ±0.5 mbar, cost: $45) and the BMP388 (accuracy: ±0.4 mbar, cost: $65). The MS5837 was ultimately chosen to offer a better balance between cost and performance. For solutions involving higher uncertainty or risk, physical prototyping was used for validation. One such case involved testing three sealing mechanisms—Viton O-rings, silicone gaskets, and epoxy resin—under simulated 4-meter pressure conditions in the buoyancy chamber. The Viton O-ring was selected for integration with waterproof housing, as it achieved a 100% success rate in waterproof testing.

3. 3 Systems Approach

The "Pozhen" underwater robot exemplifies a balanced systems design approach, integrating mechanical, electrical, and software systems to ensure seamless collaboration among subsystems for optimal overall performance. The team adopted a systems engineering mindset, treating the robot as a unified functional entity rather than a mere collection of independent components.

System integration is mainly reflected in the hardware architecture design. The propulsion system is precisely matched to the robot's weight distribution and hydrodynamic profile. The positions of the eight thrusters were optimized through calculations to align the thrust center with the robot's center of mass. The electronics compartment was designed with thermal management in mind, with critical heat-generating components (e.g., motor drivers, main control chips) directly contacting the compartment walls via thermal pads to form an efficient heat conduction path. The electrical system adopts a modular design, with functional boards interconnected through standardized interfaces, simplifying system integration and maintenance.

This holistic systems approach ensures that the "Pozhen" underwater robot achieves high performance, reliability, and adaptability, making it well-suited for diverse underwater tasks.

3. 4 Vehicle Structure

The structural design of the "Pozhen" underwater robot carefully balances cost, functionality, and weight. The robot measures 455mm (length) × 341mm (width) × 225mm (height), weighs approximately 9.5kg, and is capable of operating at depths of up to 4 meters. These parameters were determined after thorough consideration of mission requirements, portability, and maneuverability.

The frame is constructed from 10mm thick PP engineering plastic instead of traditional aluminum alloy. While this choice increased thickness requirements, it reduced the overall weight by 20% while maintaining sufficient bending strength. PP material also offers excellent corrosion resistance and machinability, significantly lowering manufacturing costs. The baseplate incorporates a composite structure of a "well" shaped main beam and quadrilateral auxiliary supports, ensuring structural stability while minimizing material usage.

The electronics compartment is made of 6061 aluminum alloy, with an anodized surface to enhance corrosion resistance. The compartment design effectively balances sealing performance, thermal management, and weight control. Through optimized internal layout, the compartment efficiently integrates all control circuits and power components within a limited space while maintaining adequate access for maintenance.

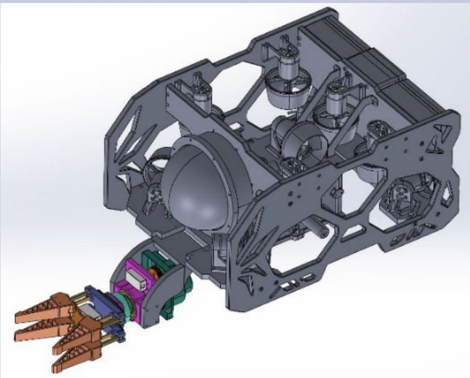


Figure 4: Overall Framework design

Figure 5: overall Framework Parts

3. 5 Vehicle Systems

Electronics compartment Redesign

Our old cylindrical hull with a single bottom hatch was a pain to service. We tried a rectangular 3D-printed shell with a top lid, but it flexed too much. Then we tested a solid-block CNC case—rock-solid but way over budget. Finally, we settled on a square-tube body with CNC-cut aluminum top and bottom plates sealed by O-rings. This gives us IP68 waterproofing, easy assembly, solid rigidity, and keeps costs in check.

Quick-Detach Actuator

To speed up mission swaps, we built a modular actuator that snaps on and off. Optimized task sequences let the robot pop back to base, swap tools in seconds, and dive back out—saving complexity, time, and money.

Camera Degrees of Freedom

We added pan and tilt axes to our onboard camera, letting us aim anywhere without moving the whole robot. This extra freedom improves target tracking and mapping precision.

Real-Time Image Analysis

By streaming video over TCP into QGroundControl (opensource software), we've hooked up live image feeds to our vision algorithms. Operators can tweak parameters on the fly and run object detection in real time, ensuring we never miss a critical visual cue.

3. 6 Electrical and Control System

Electrical Design Overview

The electrical system of the "Pozhen" underwater robot strictly adheres to MATE competition technical specifications, emphasizing cost-effectiveness, modular design, and operational stability. The system core utilizes an industrial-grade high-power switching power supply module to achieve efficient conversion from 220V AC to 48V DC, serving as the main power bus. Circuit boards are modularized by function and interconnected through standardized interfaces (Ethernet, XT-60 connectors, and custom PCB connectors), optimizing space utilization and system reliability.

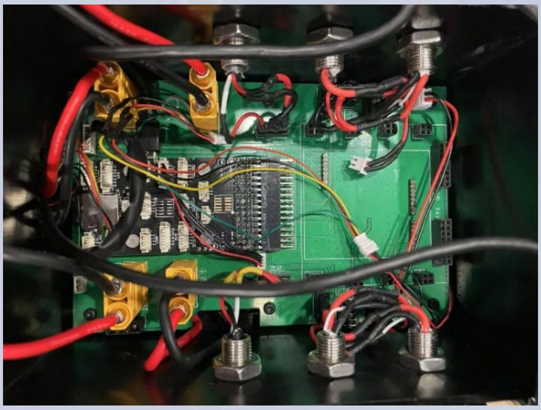


Figure 7: Electrical Design Overview

Electronics compartment

All modules of electronics compartment feature a quick-detach design with self-locking connectors, enhancing assembly efficiency, significantly reducing maintenance time and costs.

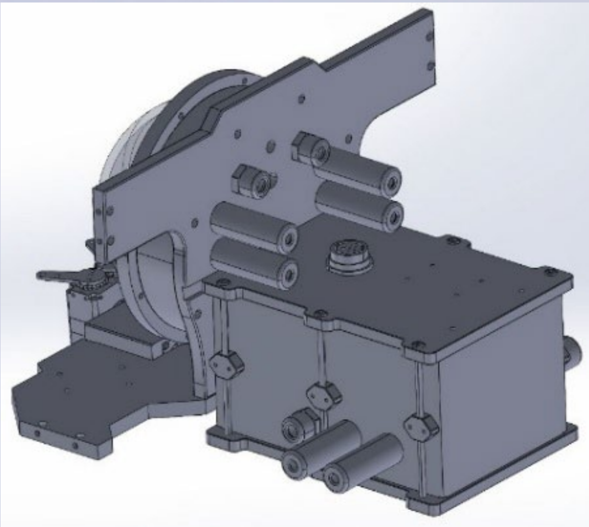


Figure 8 Model of Electronics Compartment

The tether cable links the "Pozhen" to the Ground Workstation, consisting of two power lines and two signal lines. They are bundled with cable ties and protected by mesh sleeves, which absorb pulling force to prevent connector strain, ensuring stable, safe underwater operation.

Figure 9: Tether

Control system

Figure 10: Flight control board

The hardware of control system is based on the STM32H743 chip, a high-performance ARM Cortex- M7 microcontroller. The board includes interfaces for generating 8 PWM signals for thrusters, 2 PWM signals for servos, UART interfaces for camera and ground station communication, and an I2C interface for hydrophone connection.

The software of control system is built on the QGroundControl platform, offering mission planning, real-time telemetry monitoring, and manual control. The control architecture is divided into high-level control (ground station, processing operator inputs) and low-level control (flight control board, executing PID algorithms). The system supports both manual mode (direct operator control) and autonomous mode (executing pre-programmed tasks), using the MAVLink protocol for efficient and reliable communication. Safety features include automatic fail-safe in case of communication loss and a battery monitoring system.

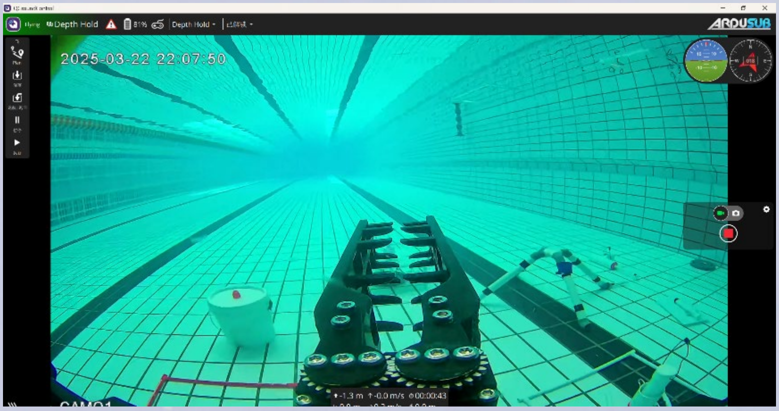


Figure 11: Software interface

3. 7 Propulsion

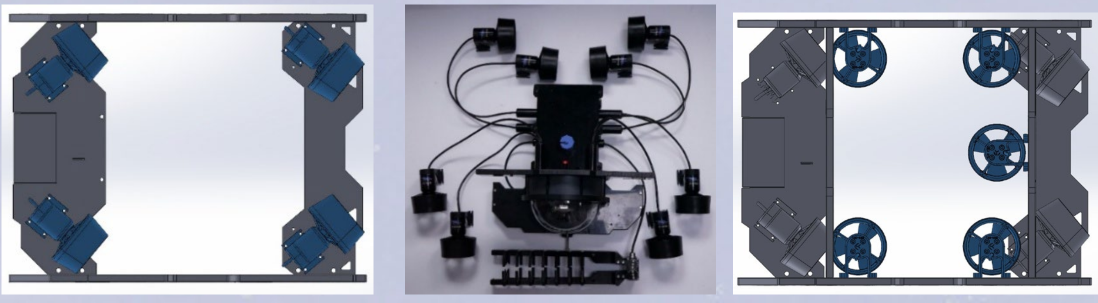


Figure 12: Thruster layout

The "Pozhen" underwater robot features an optimized 8-thruster configuration, consisting of 4 horizontal and 4 vertical thrusters, enabling full-range motion control through a scientifically designed spatial layout. The horizontal thrusters are arranged at 45° angles and evenly distributed at the four corners of the baseplate. This layout increases lateral thrust by approximately 25% compared to traditional cross arrangements while providing more balanced turning torque. Through vector synthesis, the robot can perform precise forward, backward, lateral, and rotational movements, making it particularly suitable for delicate operations in complex environments. The 45° installation angle of the horizontal thrusters was determined as the optimal value through fluid dynamics simulations and practical testing, maximizing combined thrust while minimizing interference from turbulent flows.

The vertical thrusters are symmetrically mounted on both sides of the electronics compartment, controlling the robot's ascent, descent, and pitch movements. The four-point support installation significantly enhances stability in the vertical plane, maintaining basic functionality even if one thruster fails. Each vertical thruster provides a maximum thrust of 3.5 kgf, delivering a thrust-to-weight ratio of over 1.5 at full load, ensuring the robot can quickly ascend or descend while carrying mission-required tools.

The selected thrusters are based on a comprehensive evaluation of performance, energy efficiency, and cost. Each thruster consumes approximately 4A at 12V, providing 3.5kgf thrust, with a thrust-to-power ratio superior to similar products on the market. The thrusters' waterproof design employs a multi-seal system, ensuring stable operation at depths of up to 4 meters. The propulsion system's energy management is meticulously optimized, with electronic speed controllers (ESCs) enabling precise thruster control. The control algorithm integrates PID tuning and acceleration limits, ensuring responsive sensitivity while avoiding sudden power spikes, thereby extending battery life and improving system stability.

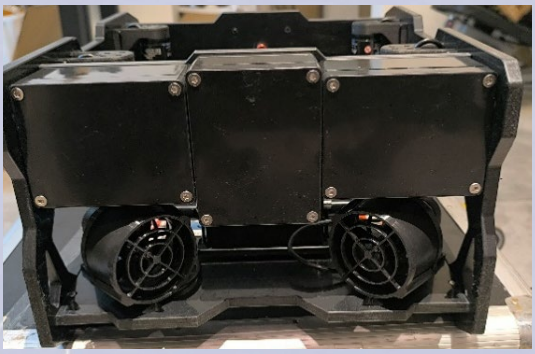
Additionally, the main frame and electronics compartment of the "Pozhen" underwater robot are equipped with two spare quick-detach thruster mounting ports. In the event of temporary damage to one or two thrusters, replacements can be installed promptly without time-consuming repairs, ensuring all degrees of freedom in underwater motion and maintaining the robot's flexibility.

Figure 12 Thruster

3. 8 Buoyancy and Ballast

The "Pozhen" underwater robot employs a precision buoyancy control system to ensure stable and controllable operations in underwater environments. The buoyancy compartment is a core component of the main structure, located between the vertical partitions at the rear of the robot. This position was chosen based on weight distribution analysis, effectively balancing the weight of the front electronics compartment and actuators. Its main structure consists of a custom plastic sealed box using fluorine rubber rings seals.

The buoyancy compartment features a modular and adjustable design, allowing precise buoyancy adjustments by adding or removing ballast materials. This enables quick adaptation to different environments based on water properties (freshwater or seawater). Operators can fine-tune the center of gravity before missions according to the payload, achieving precise buoyancy control within ±0.2kg.



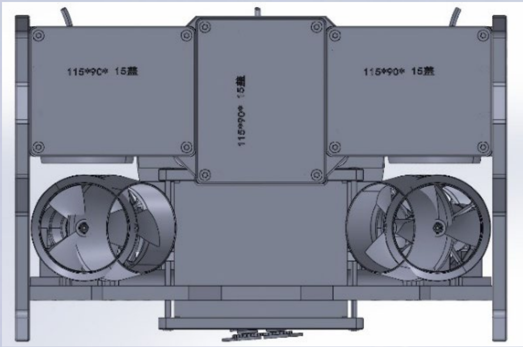
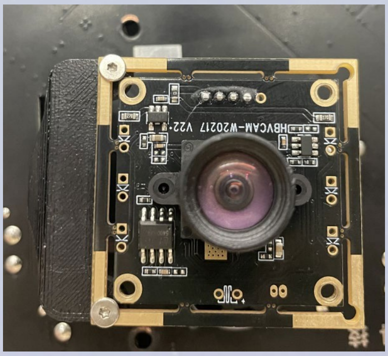


Figure 13: Buoyancy adjustment cabin

3.9 Payload and Tools

The "Pozhen" robot features a low-light Ethernet camera with an OV9732 sensor, delivering 720p/30fps video for clear underwater imaging. Positioned at the front behind a hemispherical acrylic dome, the camera offers unobstructed forward and downward views, ideal for mission tasks.

Mounted on an "L" -shaped bracket with a servo gimbal, the camera tilts ±30° for flexible viewing. To solve past fogging issues, a small turbine fan directs airflow to the dome, preventing condensation during dives. Ethernet transmission ensures sharper, more reliable video than older analog setups.



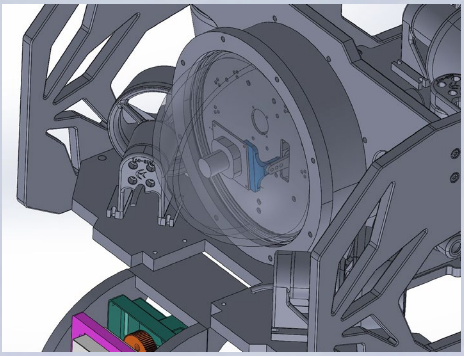


Figure 14: Camera Module **Figure 15: Camera Control Structure**

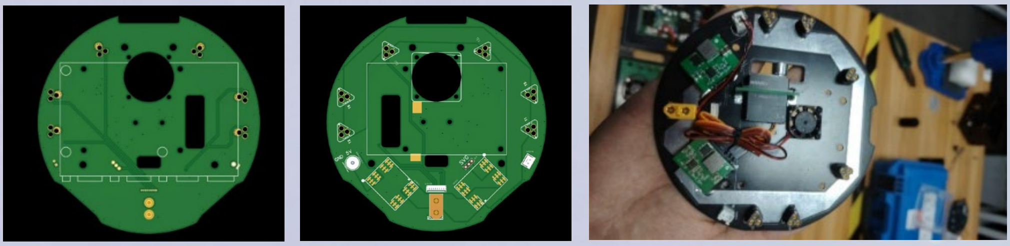


Figure 16: Camera Control Board: Top Side Design

To meet the specific mission requirements of this competition, the "Pozhen" underwater robot is equipped with a specially designed actuator system. The actuators are mounted on the front lower side of the robot using a quick-detach mechanism. These actuators can replace the structure highlighted by the red circle in Figure 17 through the quick-detach mechanism. We have prepared different actuators for various tasks, including a gripping mechanism, a syringe mechanism, and a tilted fixing mechanism, each tailored to address specific mission needs.

The gripper mechanism, designed for object retrieval, features a two-claw parallel configuration with elongated claws and evenly spaced curved teeth. Through task analysis and gripping experiments, we found that this structure offers the highest versatility.

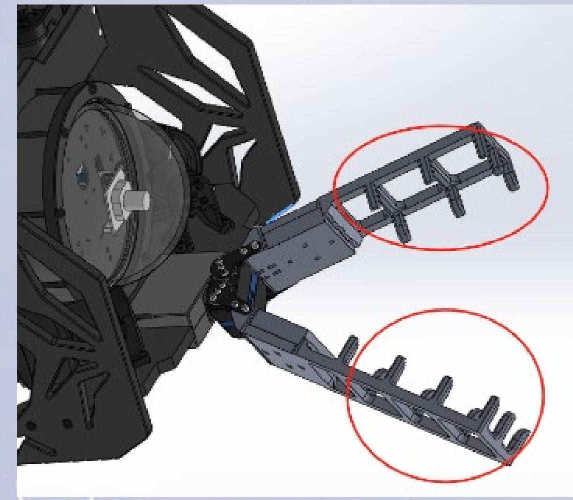


Figure 17: Modal of the quick-release claw

To ensure our operational interface supports live streaming, we have specifically designed the ground station to include an HDMI port, conveniently placed alongside an Anderson connector. This arrangement allows competition officials to easily and clearly inspect and output our video feed, ensuring seamless monitoring and broadcasting during the event.

Figure 18: HDMI port

The "Pozhen" underwater robot is equipped with a carefully selected sensor system, providing essential environmental perception capabilities for mission execution. Core sensors include the MS5837 pressure sensor and a 9-axis IMU (Inertial Measurement Unit).

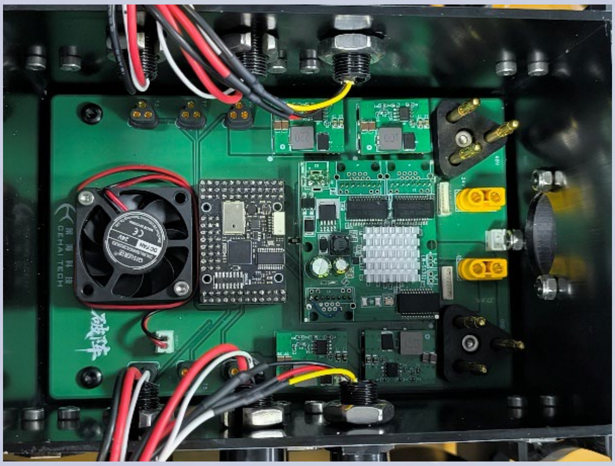


Figure 19: Sensor board

3. 10 Build vs. Buy, New vs. Used

The development of the "Pozhen" robot reflects a strategic balance between in-house development and off-the-shelf solutions, as well as new purchases versus reuse—maximizing performance, cost-efficiency, and resource use within budget.

For propulsion, the team chose commercial thrusters for their reliability and shorter lead time, despite higher unit costs. In contrast, the power management circuit was developed in-house, reducing cost and allowing tailored functionality.

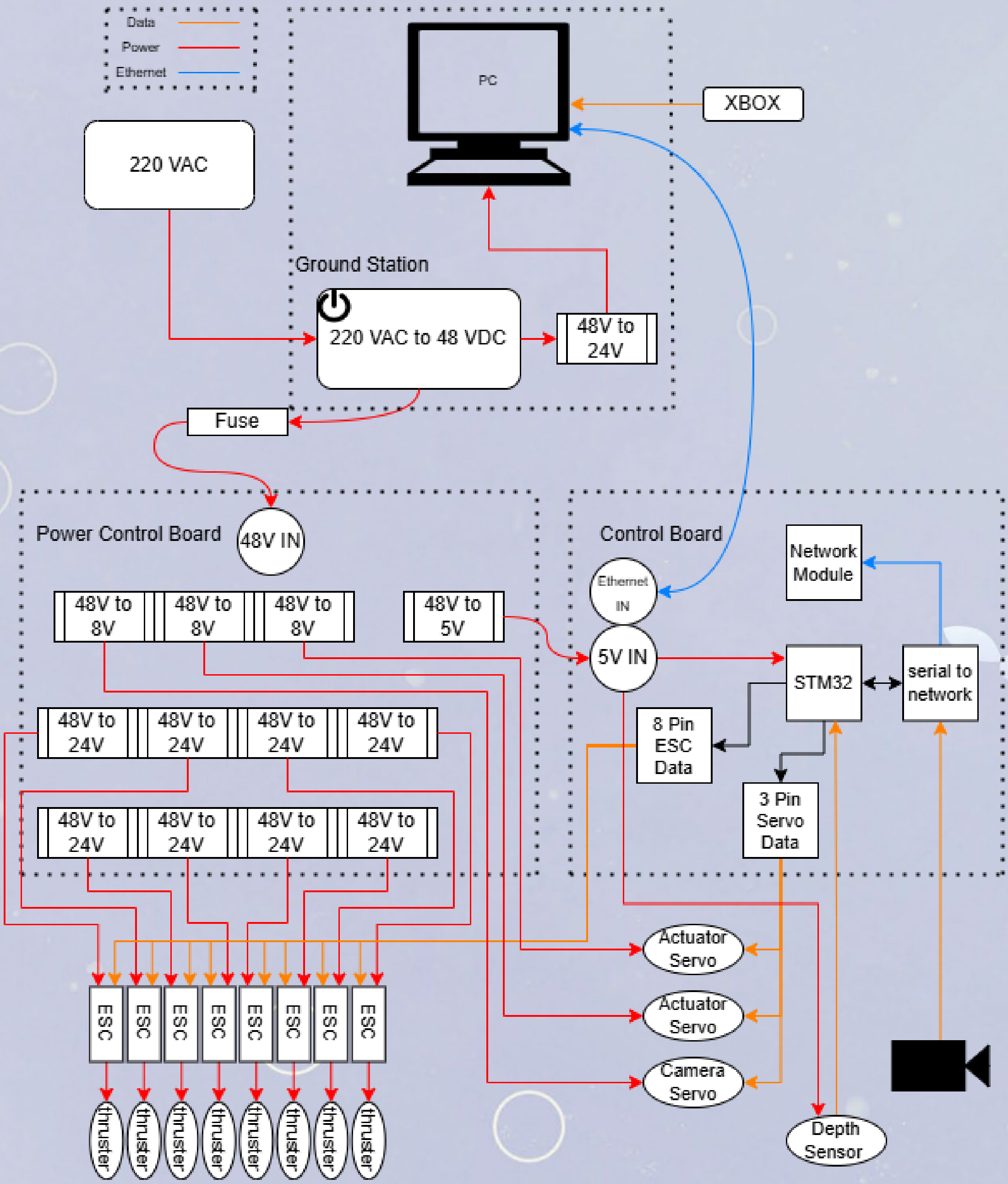
Mechanically, core parts like the baseplate and side panels were custom-designed and manufactured, while standard connectors and fasteners were purchased. This hybrid approach ensured quality where it mattered while saving cost and time elsewhere.

The software system built on QGroundControl allowed fast, low-cost customization. Mature control code from the previous generation was reused and refined, focusing limited manpower on key updates.

The team also selectively reused reliable sensors and components, while upgrading propulsion, control circuits, and actuators. This reuse strategy minimized cost, debugging time, and learning curves.

Throughout development, the team prioritized critical performance areas—such as the new mechanical claw—while leaving proven systems like communications largely unchanged. This approach delivered a high-performing, reliable robot within tight budget and time limits.

4 System Integration Diagram (SID)



5 Safety

5. 1 Safety Philosophy

Safety is prioritized in DragonLeap. Our company aims to provide a safe atmosphere for every employee to work. To achieve this goal, we not only consider our workspace as a clean, well-equipped place but also train everyone safe issues. To a certain degree, we can minimize the risks of injury to our members as well as the logistics of the vehicle and our company properties.

At the same time, in order to fully ensure our safety, our company designed different protocols for our employees to follow. The following will be more details

5. 2 Safety Standards

The ROV adheres to safety standards outlined by the MATE competition, with comprehensive safety measures integrated into both its mechanical and electrical components. Anderson connectors are employed for secure electrical connections, while pressure relief valves prevent over-pressurization. Fuses safeguard the electrical system, preventing overloads, and leak sensors swiftly detect and address any leaks to prevent flooding. An anti-tension mechanism prevents excessive strain on cables, and protective panels shield critical components from damage and harsh conditions. These safety features ensure both the safety of personnel and the durability of the equipment, especially in challenging underwater environments.

5. 3 Safety Features

As required by the MATE Organization, a suitable sized fuse is connected 30cm from the Anderson Power-pole connectors. Strain-relief is applied to the tether on both ends to prevent strain on the connectors and to ensure uninterrupted connections. Shrouds cover the thrusters' intake and exhaust without disrupting flow. Kill-switches are present on the main power supply unit on the TCU. Power terminals are fused to provide overcurrent protection. Moreover, fuses are strategically placed on the power boards for quick debugging and replacement. The electronics housing, thrusters, and cameras are waterproofed to prevent short circuits or exposing personnel to any danger.

Warning labels exist on the thrusters and electronics housing. The camera compartment is physically isolated from the electronics housing with the use of O-rings. Traffic area the clear acrylic plate housing of the cameras allows us for visual inspection in case of any leaks by searching for water droplets.

As for our workspace:

- All dangerous equipment and hazardous components like electrical panel and xenon jars are labelled with eye-catching labels which are noticeable to any users.
- No sharp edges are exposed during the main frame construction and other hardware components' manufacturing.
- A kill box, containing a fuse and a kil switch, can shut off the system immediately in case of emergency or any abnormal operation situation. Fire extinguishers are always nearby in case of dangerous situations.
- Compliant with MATE competition requirements, the thrusters are designed with guards less than 8mm to ensure fingers cannot be drawn in from any angle.

Figure 20 (left) Warning Label, (mid) Safety glasses, (right) Thrusters guards

*The Job Safety Analize is provided in another pdf file.

5. 4 Safety Procedures

Construction Checklist

☐ Ensure the robot's casing is intact without cracks or signs of water leakage.

☐ Test power systems, including main switches and fuses.

☐ Inspect propellers for proper operation. Ensure the robot's buoyancy and stability.

☐ Employees are required to wear closed-toed, non-slipped shoes while working on the deck.

☐ Check around the canvas for leaks caused by damage. Use waterproof tape to fill the gap if there has a damage.

☐ Regularly check emergency kits (including fire extinguishers and first-aid kits) to ensure they are fully stocked and functional.

☐ Check that sensors and cameras are clean and unobstructed for clear visibility and sensing capability.

Operational Safety Checklist

☐ Ensure that all members have proper PPE and attire.

☐ If water is detected in the pressure hold, the power must be cut immediately (via main control or kill switch on control box).

☐ Team members are required to wear rubber gloves.

☐ The control box must be fixed on a level, stable table and supervised by a specialized person.

☐ Make sure all team members know the location of the tether.

☐ Avoid overexertion by moving in teams if needed.

☐ Pressure hold must be completely sealed at all times in-water.

☐ Use good quality anti-leakage water pump and keep the water pump grounded.

☐ All team members are trained on proper deck operations.

☐ Ensure battery and power supply are completely dry and away from the poolside.

☐ Ensure power has been cut/turned off before handling the ROV.

6 Critical Analysis

6.1 Testing methods

This year marks the second year of our team's participation in the MATE competition. Compared to last year, our team operates more maturely and plans more meticulously. At the same time, as our robot has become more complex, we have encountered more challenges, and the testing and debugging processes have become more intricate. Our team's approach to problem-solving has also become more diversified.

Since the school pool is temporarily unavailable to the robotics association, we independently designed and constructed a 5 x 3 x 1.5m pool supported by a solid iron structure for robot testing. We installed ladders, tables, and power sources around the pool to assist in testing the robot. Additionally, we divided the robot testing process into three steps: waterproof performance testing, robot motion endurance testing, Timed mission testing.

Waterproof Performance Testing:

We designed specialized plug sockets for airtightness testing on the robot's electronic compartment frame and the bottom of the buoy. First, we used an airtight gun to extract internal air to 5 kPa and maintained the pressure for 5 minutes to complete the preliminary airtightness test. Then, we conducted high-pressure testing at a depth 2 meters deeper than the normal competition depth to ensure the robot remains watertight.

Figure 21 Waterproof test

Robot Motion Endurance Testing:

We continuously operated the robot in the pool for 30 minutes, testing its ability to move forward, backward, left, right, yaw, and roll from multiple angles. This ensured that each motor functioned correctly. Simultaneously, we used the QGC open-source platform to automatically collect data on various aspects of the robot, such as speed, angle, and depth stability, to guarantee its sustained performance.

Figure 22 Motion test

Timed Mission Testing:

To better meet the competition's requirements, we conducted daily timed mission completion tests for the operations team. Within 15 minutes, we evaluated the team's performance and coordination. When issues arose, such as the robot's claw getting entangled in a cable or a thruster getting stuck, we

Figure 23 Timed mission test

were able to address them promptly.

6. 2 Troubleshooting

At DragonLeap, our troubleshooting strategies are built on a structured, data-driven approach for efficient problem resolution. We begin with root cause analysis using tools like fishbone diagrams and the "5 Whys" method. For example, when inconsistent thruster performance arose, we traced it to PID tuning and power supply instability.

We validate solutions through rapid prototyping and iterative testing. For a buoyancy compartment sealing issue, we tested O-rings, silicone gaskets, and epoxy under simulated 10-meter pressure, ultimately choosing O-rings for their 100% success rate.

Data is central to our process. Real-time telemetry and historical logs help identify anomalies. Diagnosing communication latency between the STM32H743 and QGroundControl, we switched from UART to Ethernet, reducing latency by 60%.

Collaboration is key. Cross-functional teams brainstorm solutions, such as developing an automated thruster calibration script, cutting calibration time by 40%.

All processes and outcomes are documented in a centralized knowledge base for future reference, ensuring quick issue resolution and minimal downtime.

7 Accounting

7.1 Budget

Category	Items	Amount	Unit Price (USD)	Type	Total Price(USD)
Hardware and circuitry	48V Battery	3	$47.74	reused	$143.22
	PCB Board Printing(include MCU)	8	$27.69	purchase	$221.52
	Switch	2	$0.70	purchase	$1.40
	9Vto12V DC - DC Module	5	$1.47	purchase	$7.35
	Wire	10	$4.12	reused	$41.20
	U Type Terminal Wires	20	$1.68	purchase	$33.60
	XH6 Terminal Wires	30	$1.54	purchase	$46.20
	Dupont Terminal Wires	30	$0.84	purchase	$25.20
	Flight Control Board	10	$56.00	purchase	$560.00
	Portable Monitor	2	$54.84	purchase	$109.68
	Camera	4	$74.20	reused	$296.80
	Servo Controller	8	$157.92	purchase	$1,263.36
	Raspberry Pi 4B	3	$25.06	purchase	$75.18
	Mini PC	4	$157.92	purchase	$631.68
	Power Carrier Module	2	$87.51	purchase	$175.02
	Stress Relief Components	2	$4.90	reused	$9.80
	Servo	8	$22.40	purchase	$179.20
	Microwater pump	10	$2.66	reused	$26.60
	Vertical Profiling Float Battery	2	$0.17	purchase	$0.34
	Vertical Profiling Float Battery Box	2	$0.84	purchase	$1.68
	Underwater Lighting	4	$76.16	reused	$304.64
Mechanical and assembly	RCV Frame 3D Printing	10	$94.72	purchase	$947.20
	Ground Station Box	2	$18.25	reused	$36.50
	Counterweight Block	10	$4.13	purchase	$41.30
	Vertical Profiling 3D Printing	5	$21.01	purchase	$105.05
	Cehai Thruster	10	$110.00	purchase	$1,100.00
	MOI - P75 - 170ESC Thrusters	6	$93.66	reused	$561.96
	Power Steering Servo	5	$77.00	purchase	$385.00
	Power Tether Cable	20	$2.93	purchase	$58.60
	Signal Tether Cable	20	$12.64	purchase	$252.80
	Cable Connection(or Power)	10	$3.58	purchase	$35.80
	Cable Connection(or Signal)	10	$3.58	purchase	$35.80
	M10 Nylon Bolt	10	$0.50	purchase	$5.00
	Waterproof glue	2	$20.16	reused	$40.32
	Servo screws	2	$3.22	purchase	$6.44
software and testing	Waterpool	2	$600.00	purchase	$1,200.00
	Ladder	1	$42.00	reused	$42.00
	Props	30	$2.80	purchase	$84.00
	Software Fees	1	$4.20	purchase	$4.20
Team development and traveling	Team Building	1	$300.00	purchase	$300.00
	Accommodation	10	$56.00	purchase	$560.00
	Transportation	5	$182.00	purchase	$910.00
	Competition Fees	1	$1,540.00	purchase	$1,540.00
Total Cost					$12,405.64

7.2 Cost Accounting

Budget estimation is one of the initial responsibilities for company. Due to limited funds, we need to figure out the most effective way to utilize our resources without wastage. And every department's procurement undergoes scrutiny. Only when it's determined that the items are truly necessary do they get added to the purchasing list for procurement. This approach significantly reduces our production costs.

Based on the experience from the past competition, some of the essential components will be reused, such as the Cehai thrusters and controller, Anderson connector and our ground stations.

All the blueprints used for 3D printing and PCB fabrication are designed in-house. However, since our laboratory lacks the equipment for 3D printing and PCB fabrication, this part is outsourced to manufacturers for production. The selection and procurement of other modules are based on task requirements.

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