



國立高雄科技大學
National Kaohsiung University of
Science and Technology

NKUST

2026
ROV Team

Technical Documentation



Kaohsiung, Taiwan

ROV 後勁
HouJing

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Abstract

NKUST ROV Team, named after the National Kaohsiung University of Science and Technology, was established to participate in the **MATE Remotely Operated Vehicle (ROV)** Competition. The team brings together students from diverse academic backgrounds who share a passion for underwater exploration. We are proud to present the **HouJing**, a **ROV** specifically designed and built to meet the mission requirements outlined in the **MATE ROV Request for Proposal (RFP)**, including observation, data collection, and identification tasks.

The design philosophy of HouJing emphasizes stability, reliability, and maintainability. To support the successful completion of mission tasks, the HouJing and its associated tools were designed and developed in-house by the NKUST ROV Team. The team is committed to continuous improvement and innovation. Although this report captures only part of that ongoing journey, it provides a comprehensive introduction to the design and development of HouJing, which will be presented in detail in the following technical documentation.



NKUST company



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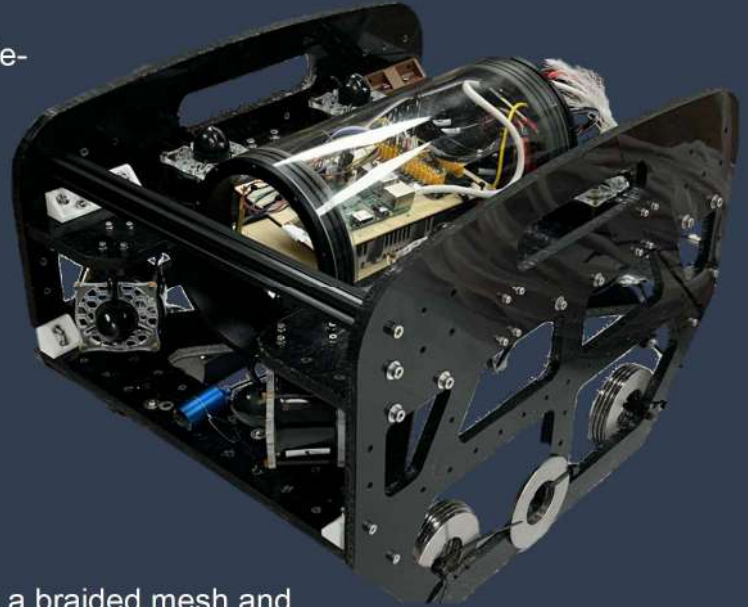
Finally, we would like to express our deepest appreciation to Dr. Chieh-Wei Hsu for his continuous guidance and support.



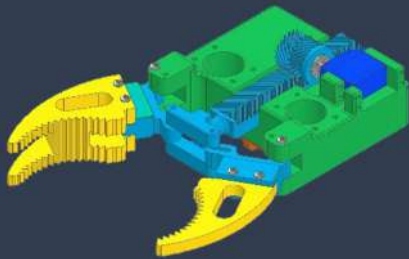
NKUST ROV TEAM

HouJing employs a PE structure and an adjustable buoyancy system to multi-degree-of-freedom thruster configuration provides omnidirectional mobility, enhancing underwater maneuverability and operational precision.

The front end is equipped with a single-axis mechanical gripper featuring a curved tip design to enhance automatic target alignment capabilities. It also integrates an electronic protection mechanism to prevent motor overload, thereby improving the stability of underwater operations.



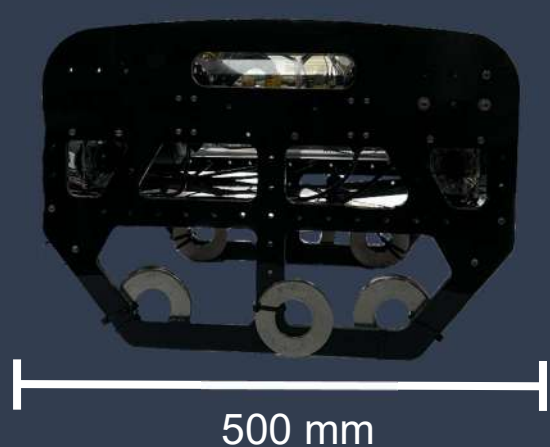
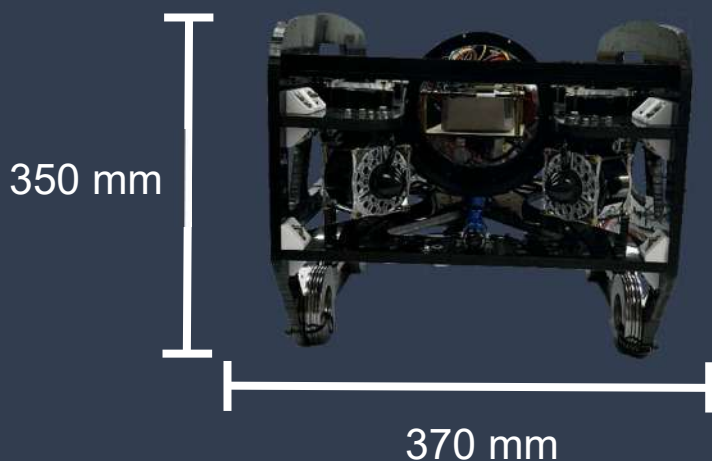
The exterior of the cable incorporates a braided mesh and buoyancy material to reduce the risk of dragging and entanglement.



Gripper



Camera



Design Philosophy

Engineering Design

Philosophy

The NKUST design prioritizes stability and maneuverability, aiming to enhance the reliability and control precision of underwater missions.

In terms of mechanical design, the frame system is primarily constructed from polyethylene (PE), selected for its advantageous material properties. By utilizing its density close to that of water (approximately 0.95 g/cm^3), the structure achieves near-neutral buoyancy. This effectively reduces the requirement for additional buoyancy materials while enabling structural lightweighting, thereby improving the thrust-to-weight ratio and enhancing maneuverability during underwater operations.

Furthermore, the system adopts a functional zoning architecture, separating the propulsion system, control system, and mission modules to improve system integration and maintenance efficiency. Combined with the excellent impact resistance and wear resistance of PE, the structure maintains durability under underwater collision conditions. This integrated design approach enables HouJing to withstand external stresses while achieving stable, precise, and efficient task execution.



Figure 1. Conceptual 3D design of
HouJing

Vehicle Structure

The structural design of HouJing is primarily composed of two key aspects: geometric configuration and material selection.

In terms of geometric design, HouJing measures $370 \text{ mm} \times 350 \text{ mm} \times 500 \text{ mm}$ ($W \times H \times L$) with a total weight of 12.8 kg, successfully meeting the competition's lightweight scoring threshold. Its rectangular frame configuration facilitates the symmetrical arrangement of thrusters, sensors, and robotic manipulators, contributing to balanced mass distribution and improved stability during underwater operations.



Figure 2. HouJing Framework

Additionally, to further improve overall structural rigidity, aluminum extrusions were incorporated into the main frame as reinforcing elements, ensuring the vehicle maintains excellent structural stability when subjected to external forces or performing mission operations.



Figure 3. Aluminum Extrusion

Regarding material selection, the team initially considered using carbon fiber panels as the primary structural material; however, these are relatively expensive and lack sufficient impact toughness. After comprehensive evaluation, PE was ultimately selected as the primary material. PE possesses excellent impact toughness, and with a density of approximately 0.95 g/cm^3 —close to that of water—it enables the structure to achieve near-neutral buoyancy. This facilitates subsequent overall buoyancy adjustment and stable system control.

Software System

The NKUST has developed Abyss-OS 2.0, a fully custom, three-tier distributed software architecture spanning the ROV vehicle, an intermediate ground control server, and an operator laptop.

The vehicle layer runs on a Raspberry Pi 5, handling all real-time hardware interactions, including a 50 Hz sensor-fusion pipeline utilizing an MPU9250 IMU, MS5837-30BA depth sensor, and ADS1115 ADC. Attitude estimation employs a complementary filter for pitch and roll, while yaw is derived from a tilt-compensated magnetometer. For propulsion, the system executes 50 Hz closed-loop thruster control driven via a PCA9685 module.



Figure 4. ROV Maker V0.3 IMU

To minimize latency, communication utilizes the UDP protocol—50 Hz for control packets and 20 Hz for telemetry—ensuring missed packets do not cause stale queued commands. The control system features runtime-configurable thruster mixing matrices (H_MIX and V_MIX) loaded from a central JSON configuration file, allowing for immediate thrust allocation adjustments without altering the source code. Furthermore, the software incorporates a resilient fault-tolerance framework, including a UDP timeout watchdog, an overcurrent limiter, and a sensor degraded mode that maintains

partial operation even if initializing sensors fail. Additional advanced flight features include PID depth hold, proportional heading hold, deadzone filtering, and four distinct thrust control modes.

Buoyancy System

HouJing buoyancy system is designed to achieve neutral buoyancy and excellent static stability. HouJing views buoyancy configuration as key to enhancing mission efficiency, thereby improving underwater operational efficiency and control precision.

Structurally, the main frame is constructed from PE material, whose density is very close to that of water, giving the frame the advantage of “built-in buoyancy.” This not only significantly reduces the volume required for additional buoyancy materials but also lowers the ROV’s frontal area and underwater drag, thereby improving the responsiveness of vertical movement.

To accommodate varying aquatic environments (such as differences in freshwater and seawater density) and changes in the ROV’s payload weight, the system incorporates a sliding ballast compensation mechanism. By moving stainless steel ballast blocks along the frame’s guide rails, the ROV’s buoyancy can be precisely adjusted to maintain a stable attitude.

Additionally, the HouJing system

features a fail-safe design. In the event of a power system malfunction, the ROV will slowly ascend to facilitate recovery and minimize the risk of loss. Furthermore, during operations, it can maintain a constant depth with extremely low power consumption, achieving both energy efficiency and stable control.

Propulsion System

The propulsion system utilizes a 2216-type brushless motor, selected primarily for its compact size, light weight and relatively low cost, which make it well-suited to the space constraints and budgetary limitations of this ROV. Furthermore, the 2216 motor is equipped with an electronic speed controller (ESC) for control purposes, providing the system with excellent adjustability in terms of thrust regulation and speed control.

Since the thrust of a single 2216 thruster is relatively lower compared to dedicated underwater thrusters, HouJing employs a configuration of eight thrusters to ensure sufficient thrust and stability during underwater operations, thereby enhancing overall output capacity and control precision.

In terms of configuration design, this system features: four thrusters arranged in the horizontal plane (X-Y), responsible for forward, reverse, lateral movement, and yaw control; and four thrusters arranged in the vertical plane

(Z-axis), responsible for ascent, descent, and attitude stabilization.

The horizontal thrusters are mounted at an approximate 45-degree angle, allowing each thruster to provide both forward and lateral thrust components simultaneously, thereby enhancing maneuverability and enabling omnidirectional movement.

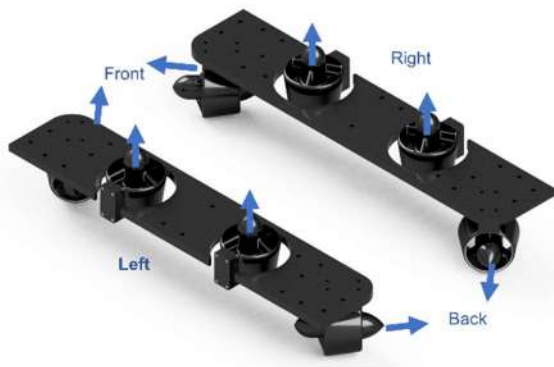


Figure 5. Configuration of thrusters

The four vertical thrusters are primarily used to improve attitude stability. During precision maneuvers (such as grasping and docking), the system can use differential thrust to correct roll and pitch, keeping the vehicle stable.

This system controls 2216 brushless motors via ESCs, using standard PWM (Pulse Width Modulation) signals with the following parameter settings:

- PWM frequency: approximately 50 Hz (corresponding to standard RC ESC control specifications)
- Pulse width range: approximately 1100–1900 μ s
 - 1500 μ s: Neutral (stop)

- 1500 μ s: Forward thrust
- <1500 μ s: Reverse thrust

To enhance control stability, this system uses the PCA9685 to generate a hardware PWM signal. Compared to software PWM, this reduces signal jitter and improves output accuracy.

Additionally, ESC calibration is performed during system initialization to ensure that the PWM signal range corresponds accurately to the actual propeller output, thereby preventing thrust asymmetry and control deviation issues.

To comply with competition safety regulations, this system is equipped with motor guards on each propeller to prevent contact between personnel and foreign objects and the propeller blades. The guards feature a honeycomb structure that provides protection while maintaining water flow efficiency and reducing the risk of foreign objects becoming lodged. Furthermore, the modular design facilitates disassembly and maintenance.

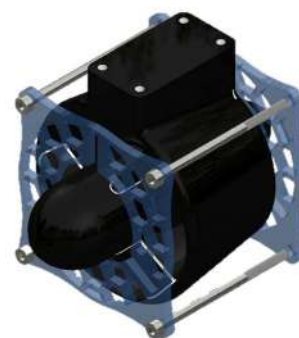


Figure 6 : Motor shroud

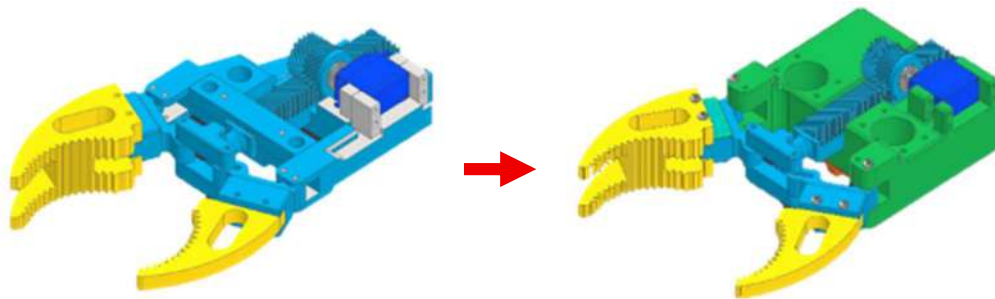


Figure 7. Gripper Optimization

Gripper design

For the object manipulation tasks in this year's competition, the NKUST team adopted a "minimalist engineering" design philosophy and developed a highly reliable, mission-specific gripper system tailored for underwater operations.

To reduce system complexity and enhance operational stability, the gripper was designed as a single-axis actuation mechanism, thereby minimizing potential failure points through a simplified component configuration.

In terms of manufacturing and material selection, the main body of the gripper was fabricated using PETG filament via 3D printing, providing sufficient structural strength and impact resistance. Furthermore, to address the critical challenge of coral grasping, the gripper geometry was specifically optimized. The tip was designed with a curved profile, and the opening width was matched to the diameter of the

target object to increase contact area and improve gripping stability.

Additionally, this geometric configuration offers a degree of passive self-alignment, enabling operators to effectively complete grasping tasks even under conditions of limited visibility.

Camera System

To enhance image stability and recognition efficiency during underwater missions, the system integrates carefully selected camera hardware with machine vision algorithms into a low-latency visual network. The team adopted HORUS-T20 USB waterproof camera modules, whose integrated design eliminates common issues like water ingress, fogging, and optical distortion. Direct USB transmission bypasses network switching equipment, reducing the system's footprint, power consumption, and transmission latency.

To optimize operational efficiency and full-range monitoring, the system

implements a "Three-Angle Camera Layout" for synchronized multi-camera streaming. This configuration includes a primary forward-facing camera for the pilot's view, a secondary auxiliary camera mounted on the upper for manipulator and docking observations, and a third camera on the bottom specifically designed for image recognition and target detection tasks.

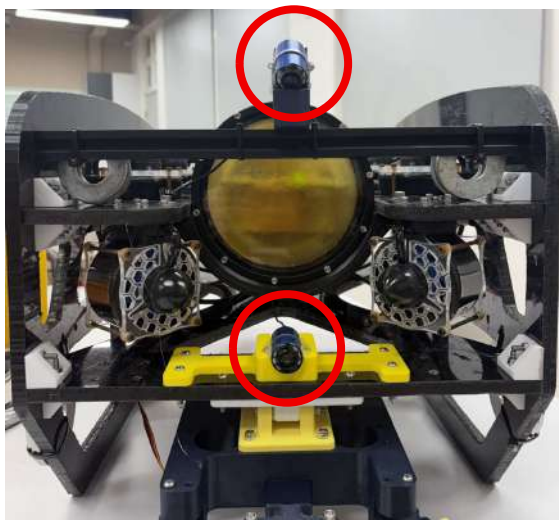


Figure 8 : Front-facing camera

Departing from traditional HTTP multipart/MJPEG protocols, Abyss-OS 2.0 streams JPEG frames from each camera as binary data via WebSockets. The central FastAPI server instantly fans out multi-channel video frames to all connected browser clients, minimizing transmission latency. To prevent blank startup screens, the system caches the last frame of each camera in memory to send immediately upon new connections. Video JPEG quality is optimized at 50% to strike an ideal balance between bandwidth

consumption and visual clarity.

The image processing framework employs a dual-model design with conditional sequential processing, primarily focusing on real-time recognition of the bottom camera feed. Under normal conditions, video is transmitted directly to the operator. When low visibility triggers the enhancement mode, the bottom feed is first enhanced via FUnIE-GAN and then processed by a YOLO model for object recognition. To maintain a stable frame rate, an on-demand trigger mechanism executes recognition tasks only when specified by the operator. Under challenging underwater conditions, the system appropriately lowers the confidence threshold and adjusts parameters to improve detection rates.

For user interface support, the system adheres to a minimalist principle, displaying only essential data. When recognition is triggered, different targets identified from the bottom camera are marked with distinct colors for quick interpretation, and the system automatically logs video frames and recognition results.

Cable

In designing the interconnectivity between the surface control station and the ROV, the NKUST team integrated system requirements with practical field experience to execute multiple

iterations of the tether configuration. This process ensured an optimal balance between power transmission stability, signal integrity, and operational agility.

The initial design scheme incorporated five discrete tethers: a 48V power cable, a PoE camera communication link (RJ45), a control signal cable (RJ45), and a dedicated underwater camera signal line (4P). However, following systematic evaluations of the architecture, the PoE communication design was phased out. The final configuration was consolidated into a 48V power cable, one control signal cable (RJ45), and three independent underwater camera signal cables (4P).

For the 48V power delivery, the team initially proposed a 10 AWG neutral-buoyancy cable to refine underwater performance. Nevertheless, considering budget constraints, physical dimensions, and procurement timelines, this option was ultimately bypassed. A comparative evaluation was conducted between a unified dual-core power cable and separate conductor pairs. Given that the rigid outer sheath of dual-core cables significantly restricts the ROV's range of motion, the final solution adopted two 15-meter 10 AWG copper wires. This approach successfully maintains high conductivity while enhancing overall mechanical flexibility.

Regarding cable management and protection, all conductors are encased within a uniform braided sleeve, replacing conventional cable tie methods. This integrated design effectively mitigates the risk of entanglement with the environment during subsea or pier-side operations, thereby augmenting system survivability. Additionally, strategic buoyancy modules are attached to the tether's exterior to neutralize the impact of cable weight on maneuverability, ensuring stable and precise vehicle control.

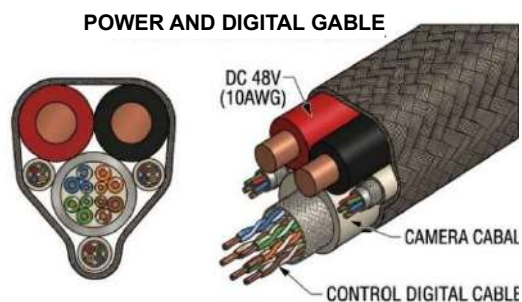


Figure 9. Cable

Control Box

This year's control cabinet architecture builds on previous field experience, focusing on structural simplification and enhanced system reliability. The layout implements a strategy of vertical layering and horizontal zoning to effectively isolate sensitive signal processing from high-power distribution. This spatial arrangement ensures superior electromagnetic compatibility

(EMC) and operational stability during demanding underwater missions.

Regarding the electrical safety framework, a 30A circuit protection fuse is integrated at the 48V power output interface. To maintain strict compliance with competition safety protocols, the fuse is positioned within 30 centimeters of the power source. This ensures that any overcurrent anomalies are mitigated at the source, shielding downstream avionics and sensitive electronic components from potential damage.



Figure 10. 30A Fuse

The upper console assembly features a 24-inch high-resolution display as the primary operator interface. It supports simultaneous multi-channel feeds from one main and two auxiliary cameras, providing a comprehensive, zero-blind-spot visualization. This configuration allows for precise monitoring of the ROV's spatial orientation and status, even when navigating through complex or low-visibility aquatic environments.

The lower-left quadrant houses the integrated power and data distribution compartment, managing system supply

and external tether connections. This bay includes the 48V DC main power bus, a master power toggle, and a hardware-integrated emergency stop (E-Stop) mechanism for instantaneous shutdown. This safety-critical interface significantly bolsters the overall protection of the mission-critical hardware during deployment.

For data communication, standardized RJ45 interfaces establish robust links between the ROV terminal and the surface command station. The power system supports a universal 110V–220V AC input, resolving regional plug compatibility issues and streamlining field logistics. This universal design ensures the system is ready for rapid deployment with a single standard cable, regardless of the local power infrastructure.

The lower-right quadrant integrates the system's core computational hub, including a network router for IP management, an industrial PC for control software, and dedicated power adapters for peripherals. To ensure resilience in harsh maritime conditions, a quick-release acrylic shield covers the equipment on the right side. This transparent design allows real-time status monitoring while providing an effective barrier against water ingress, significantly extending the system's Mean Time Between Failures (MTBF).



Figure 11 : Control Box

User Interface

The system's User Interface has been completely redesigned into a browser-based Ground Control Station (GCS), effectively decoupling physical hardware inputs from the display interface. Following a stepwise integration and verification approach, a FastAPI application serves as the central message broker and web host, supporting multiple simultaneous browser clients for collaborative monitoring.

During the input validation phase, the system verified that control signals from the Xbox Controller were correctly acquired and transmitted. To ensure operational resilience, joystick hotplugging was thoroughly tested to allow seamless controller reconnection during missions, alongside an integrated keyboard backup control mechanism to maintain maneuverability in the event of primary gamepad failure.

Subsequently, data integration was validated using bidirectional WebSockets to push 60 Hz telemetry packets and configuration bundles to the browser in real-time. A key advantage of this architecture is its advanced configuration management; all tunable parameters are stored centrally and can be edited dynamically at runtime via the web UI without restarting any processes. Finally, advanced UI features were integrated and evaluated, including a built-in record and replay functionality that utilizes a 3600-frame circular buffer (60 fps for 60 seconds) of control sequences for mission rehearsal and fault analysis.

Furthermore, version control was managed via Git to optimize development efficiency. While the web-based rendering adds minor computational overhead to the station platform, this integrated framework drastically improves debugging efficiency, module verification, and multi-operator coordination.



Figure 12 : User Interface

Non-ROV Device (Float)

The vertical profiling Float developed by NKUST is fully compliant with the competition's dimensional constraints. The main body adopts a sealed acrylic pressure hull integrated with an O-ring sealing structure, ensuring excellent watertight integrity and maintaining structural stability under underwater operating conditions. Additionally, U-bolts are installed on the exterior to facilitate efficient retrieval and handling by the ROV during mission operations.

The Float engine is designed based on a piston-driven displacement mechanism, where a motor actuates the piston to precisely regulate internal volume, thereby controlling Float and enabling stable and controlled vertical ascent and descent within the water column. The system is powered by an independent 12V power supply module and incorporates protective components, including a fuse and a pressure relief mechanism, to enhance overall operational safety and system reliability under varying pressure conditions.

At the core of the system, an ESP32 microcontroller is employed to handle control tasks, integrating seamlessly with a pressure sensor to achieve accurate depth measurement, closed-loop control, and real-time data logging. Upon completion of the mission, the recorded data is transmitted wirelessly

to the shore-based station, allowing for further analysis, performance evaluation, and mission verification.



Figure 13. Float



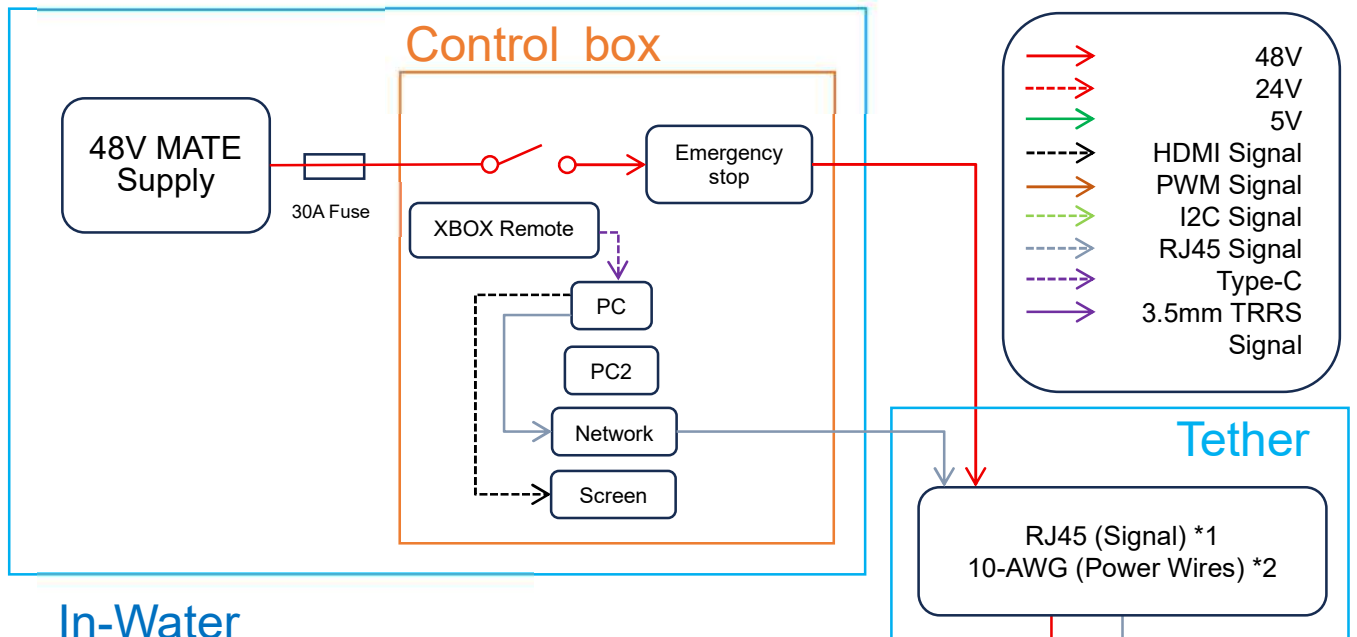
Figure 14. Battery and Fuse

System Integration Diagram (SID)

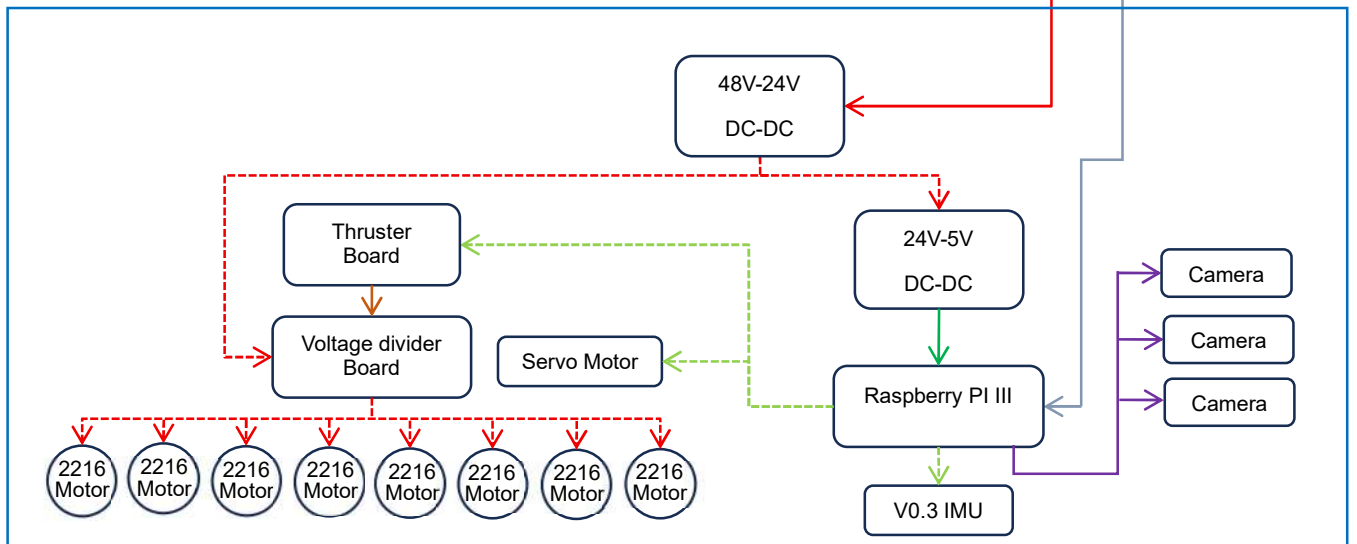
HouJing Electrical SID



Surface



In-Water



ROV Full Load Amps (FLA) in water = 27A
Fuse size selected based upon FLA = 30A

Critical Analysis

Test Method

To ensure the ROV's high reliability and mission capability at the competition site, NKUST adopted a tiered testing approach, conducting step-by-step validation from individual components to the entire system.

Static buoyancy tests were conducted to evaluate the performance of the buoyancy system. By leveraging the near-neutral buoyancy characteristics of the PE frame, the team fine-tuned the sliding counterweights and verified that the vehicle exhibits self-righting capability.

For dynamic mission simulations, the team constructed a full-scale obstacle model to assess the gripping stability and alignment capability of the claw design. Simulated collision tests further demonstrated the excellent impact resistance of the PE material. In addition, the team regularly performs hands-on training in a test pool to recreate a range of competition scenarios, thereby enhancing operational proficiency and adaptability.

This validation process, integrating rigorous hardware testing with software control refinement, ensures that the ROV is capable of delivering stable and efficient performance under demanding competition conditions.



Figure 15. ROV testing in diving center

Troubleshooting Strategies

During the system development process, the team adopted a systematic fault analysis process for troubleshooting. This process included fault identification, hypothesis formulation, testing and verification, and result confirmation, with the aim of enhancing system reliability and debugging efficiency.

Regarding network communication, we initially encountered an issue where the host computer could not connect to the Raspberry Pi 3. After analysis, it was determined that the cause was the lack of a stable local area network (LAN) infrastructure, and the devices were unable to obtain valid IPv4 addresses. To address this, the team deployed a router to establish a LAN and used DHCP to assign IP addresses, while also configuring static IP addresses to ensure stable device connectivity. This allowed the host computer to establish

a stable remote connection via VNC, successfully resolving the communication issue.

During propulsion system testing, the propellers intermittently stopped operating. During discussions regarding this issue, several potential causes were proposed, including voltage instability, poor PWM signal quality, and communication latency. To identify the root cause, our team conducted multiple tests, including replacing the power supply module and comparing different PWM output methods.

Test results indicated that the issue primarily stemmed from instability in the software-generated PWM signal, which caused abnormal signal reception by the ESC. To address this, the system was upgraded with a PCA9685 hardware PWM control module. Its independent clock and stable signal output effectively reduced signal jitter and improved control accuracy.

Following the implementation of hardware PWM, the propeller's operational stability improved significantly, system latency decreased, and overall operational reliability was enhanced.

This troubleshooting experience demonstrates that, in multi-system

integration, signal stability and system architecture design are critical factors affecting overall performance. Future designs will prioritize stability at the hardware level to mitigate system risks.

Safety

At NKUST, safety is at the heart of our operations. We maintain strict safety standards to ensure the safety of our engineers during construction, deployment, and operation.

Personnel Safety

To ensure the safety of team members during system construction and testing, the NKUST requires all members to complete mandatory safety and equipment operation training before entering the laboratory. The training covers the proper use of hand tools, welding equipment, and power tools to reduce the risk of cuts, burns, and electric shock.

In addition, the team has established basic emergency response procedures, including power disconnection protocols in the event of equipment malfunctions, procedures for halting propulsion system operations, and personnel evacuation protocols. These measures ensure a rapid response to unexpected incidents and enhance overall operational safety.



Figure 16 : First aid kit

Equipment Safety

To ensure the safety of personnel and equipment, the NKUST has implemented basic safety management measures during operations.

Regarding the handling of materials and equipment, engineers must wear personal protective equipment (PPE), including gloves and eye protection, when using epoxy resin and power tools to reduce the risk of chemical exposure and mechanical injury. Relevant safety equipment is issued to members upon joining the team, and its use is required at all times during operations.

Regarding equipment maintenance, the team conducts regular inspections and maintenance of construction tools. Monthly assessments are performed to evaluate tools for corrosion, damage, and functional status, and any defective equipment is repaired or replaced. This measure reduces operational risks caused by tool failure and enhances overall operational safety and equipment reliability.



Figure 17 : CEO Adjusts Epoxy

Operational Safety

This system employs standardized operating procedures and safety inspection mechanisms to mitigate potential risks during ROV operations. Prior to operations, tasks are assigned and system checks are conducted, including verification of power supply, communication, and thruster status, to ensure the equipment can be safely activated.

During deployment and operation, a two-person operation mechanism is implemented, with one operator responsible for controlling the system and the other for environmental monitoring and safety verification. Initial testing is conducted in low-power mode to prevent risks caused by equipment malfunctions. System status is continuously monitored during operation. In the event of an anomaly,

emergency stop procedures are immediately executed and power is cut off.

After the operation concludes, the system must be shut down in accordance with standard procedures, followed by equipment inspection and documentation to ensure the system remains in good working order and to facilitate subsequent maintenance and troubleshooting.

Safety Procedures

To mitigate potential risks during construction and deployment, the NKUST has established a safety inspection mechanism. The safety officer conducts pre-operation checks based on a safety checklist to ensure that personnel operations and equipment conditions comply with safety regulations.

Project Management

Company Structure

NKUST is a student team dedicated to the development and engineering integration of underwater robotic systems. The team focuses on participating in the MATE ROV Competition and undertaking diverse underwater mission challenges. Team members come from various disciplines, including mechanical, electrical, electronic, and computer engineering. Through interdisciplinary collaboration,

the team achieves the development of highly integrated underwater vehicles.

The team's core development philosophy is "independent design, system integration, and stability and reliability." It possesses comprehensive R&D capabilities spanning mechanical design, power systems, communication architectures, and software control. In terms of development strategy, the team emphasizes the transfer of technical expertise and continuous innovation, using design iterations and practical validation to continually improve system maturity and mission completion efficiency.

In terms of organizational structure, the team adopts a corporate-style division of labor with clearly defined responsibilities to enhance project execution efficiency. The CEO (Chief Executive Officer) is responsible for overall project planning and decision-making; the CFO (Chief Financial Officer) manages budget control and resource allocation; and the CTO (Chief Technology Officer) sets technical direction and oversees system integration.

At the engineering implementation level, software engineers are responsible for developing the control system, communication architecture, and user interface; hardware engineers handle mechanical design, power systems, and electronic integration; and the



Safety Officer is responsible for establishing safety protocols and managing risks to ensure that the construction and operation processes comply with competition safety requirements.

Through this clear division of roles and cross-disciplinary collaboration mechanism, the team is able to effectively integrate all subsystems, ensuring that the ROV maintains high stability and reliability throughout the design, testing, and competition phases.

Project Timeline

Building on last year experience, NKUST began preparing for the competition early. From September to November, the team focused on recruiting new members. In October, they began brainstorming ideas for structural design and programming, while also starting to build the Float. During this period, they continued to promote STEM education activities; In December, the team began procuring the necessary materials and components. By February, they had completed the mechanical structures, programming, related hardware, and props required for the mission. In March, the team began conducting field tests on the ROV and Float, while drafting technical documents to ensure all specifications met the requirements of the MATE ROV 2026 competition. Please refer to Appendix A for the

project timeline.

Accounting

Building on last year experience and through team collaboration, NKUST has a clearer direction for procurement and material selection this year. With increased funding compared to last year, the team has reassessed and raised the budgets for each department.

NKUST has installed a monitor on the control box to view footage captured by the ROV underwater, while a laptop is used to monitor program operations. This has significantly improved operational convenience and efficiency.

Due to the short preparation time and limited funding last year, the team was unable to purchase necessary equipment. This year, we assessed our needs, compared major equipment options on the market, and allocated a significant portion of the budget to new equipment purchases—such as a tool cart and a 3D printer—to improve efficiency.

The team's funding primarily comes from corporate sponsorships and university grants, while the \$5,000 in travel expenses—covering airfare, accommodation, and daily living costs—is covered by the team members.





School Name:	National Kaohsiung University of Science and Technology	From: September 1 2025
Instructor:	Chieh-Wei Hsu	To: June 30 2026

Available Funds		
Category	Name	Amount (USD)
Sponsorship	Dragon Geosciences Group	\$9,383
Sponsorship	Grand Ark International Co., Ltd	\$6,255
Sponsorship	Office of Marine Science and Technology of National Kaohsiung University of Science and Technology	\$6,255
Sponsorship	Bright Future Homeland Security Co., Ltd.	\$3,127
Sponsorship	Cross College Elite Tech Program of National Kaohsiung University of Science and Technology	\$3,127
Sponsorship	Good House Foundry Co., Ltd.	\$1,897
Total:		\$30,044

Budget Allocation				
Category	Type	Item	Budgeted Value	Projected Cost (USD)
Lab Safety	Purchased	Safety helmets, first aid kits, etc.	\$50	\$50
Tooling & Equipment	Purchased	3D printer, tool cart, wire dryer, soldering iron, etc.	\$2,500	\$2,200
Research & Development	Purchased	PVCs, PCBs, sensors, controllers, manipulators, O-rings, etc.	\$1,500	\$1,000
ROV Surface Station	Purchased	screen, router, main control box, etc.	\$800	\$890
ROV Structure	Purchased	polycarbonate sheets, ballasting, etc.	\$50	\$60
ROV Electronics	Purchased	cameras, power converters, etc.	\$700	\$580
Float	Purchased	O-ring, ballasting, sensor, etc.	\$300	\$250
Team Operations	Purchased	shirts, badges, stickers, etc.	\$500	\$500
Science Initiatives	Purchased	batteries, light-emitting diode, Servo motor, etc.	\$500	\$200
Competition Fees	Purchased	Registration fees for the MATE ROV Competition Hong Kong Regional	\$1,500	\$1,217.88
Total:			\$8,400	\$6,947.88



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Appendix

Appendix A: Project Schedule

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Properties	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Bill of Materials (BOM) creation										
List of purchases										
Preliminary structural design										
Component testing										
Assembly										
Optimization and testing										
Production of display materials										
Hong Kong Regional										
World Championship										

Appendix B: Safety Checklist

ROV Safety Regulations: Construction, Operation, and Emergency Protocols

Construction & Maintenance Safety Phase

Pre-Disassembly

- ☐ [**Power Isolation:** Ensure the ROV body is disconnected from all external power sources.
- ☐ [**Environment Check:** Verify both internal and external components are free of water accumulation or high humidity.
- ☐ [**Personal Protective Equipment (PPE):** Personnel must wear cut-resistant gloves and safety goggles.
- ☐ [**Accountability:** Confirm the disassembly workflow and designate a Lead Personnel to ensure clear oversight.

During Disassembly

- ☐ [**Protocol Adherence:** Proceed strictly according to the pre-planned disassembly sequence.
- ☐ [**Labeling:** All cables and connectors must be labeled prior to removal to prevent cross-connection.
- ☐ [**Handle with Care:** Prohibit pulling, twisting, or forcing the removal of cables and components.
- ☐ [**Direct Contact Prevention:** Avoid bare-hand contact with exposed circuitry or sharp structural edges.
- ☐ [**Inventory Management:** Centralize all removed screws and small parts to prevent loss (FOD prevention).
- ☐ [**Anomaly Response:** If anomalies (unusual odors, overheating, or corrosion) are detected, stop work immediately and report.

Post-Disassembly

- ☐ [**Inventory Audit:** Confirm all disassembled parts are accounted for and free of damage.
- ☐ [**Electronic Preservation:** Store electronic components in a dry, moisture-proof environment.
- ☐ [**Hazard Mitigation:** Properly wrap and label sharp, rotating, or high-risk components.
- ☐ [**Site Remediation:** Clean the workspace post-operation to remove any residual hazardous materials.
- ☐ [**Documentation:** Maintain detailed records of disassembly and maintenance for future traceability.

Startup & Shutdown Safety Phase

Pre-Startup

- ☐ [**Integrity Check:** Confirm all electrical connections, connectors, and fasteners are securely locked.
- ☐ [**Seal Inspection:** Ensure sealing structures (O-rings, hulls) are intact and undamaged.
- ☐ [**Clearance:** Ensure no personnel or foreign objects are near the thrusters.
- ☐ [**Systems Diagnostics:** Verify control, communication, and video telemetry systems are functioning normally.
- ☐ [**Emergency Stop:** Confirm the location and functionality of the Emergency Power Off (EPO) mechanism.

During Startup

- ☐ [**Sequential Power-Up:** Activate power and control systems in sequence to avoid inrush current/voltage spikes.
- ☐ [**Thruster Test:** Conduct thruster tests in low-power mode.
- ☐ [**Safe Distance:** Operators must maintain a safe distance from the ROV.

- ☐ **Immediate Shutdown:** Deactivate the system immediately if abnormal noise or behavior occurs.

Post-Shutdown

- ☐ **Complete De-energization:** Fully shut down the system and unplug all power sources.
 - ☐ **Stasis Verification:** Wait for thrusters and rotating parts to come to a complete stop before approaching.
 - ☐ **Inspection:** Check for overheating, water ingress, or abnormal odors.
 - ☐ **Post-Op Maintenance:** Perform basic cleaning, drying, and final status confirmation.
-

Operational Safety Phase

Pre-Deployment

- ☐ **Mission Briefing:** Ensure all operators are fully briefed on the mission objectives.
- ☐ **Tether Management:** Check cable/tether length to prevent entanglement.
- ☐ **Safety Systems Test:** Test the Emergency Stop and recovery mechanisms.
- ☐ **Environmental Assessment:** Confirm the operating environment is within safe limits (current, visibility, etc.).

Post-Deployment (Launch)

- ☐ **Stabilized Entry:** Slowly lower the ROV into the water in a controlled manner.
- ☐ **Initial Stability Check:** Perform low-speed maneuvers to confirm buoyancy and attitude stability.
- ☐ **Telemetry Monitoring:** Continuously monitor video feeds, communications, and power status.
- ☐ **Abort Protocol:** If anomalies occur, stop diving immediately and initiate recovery.

During Operation

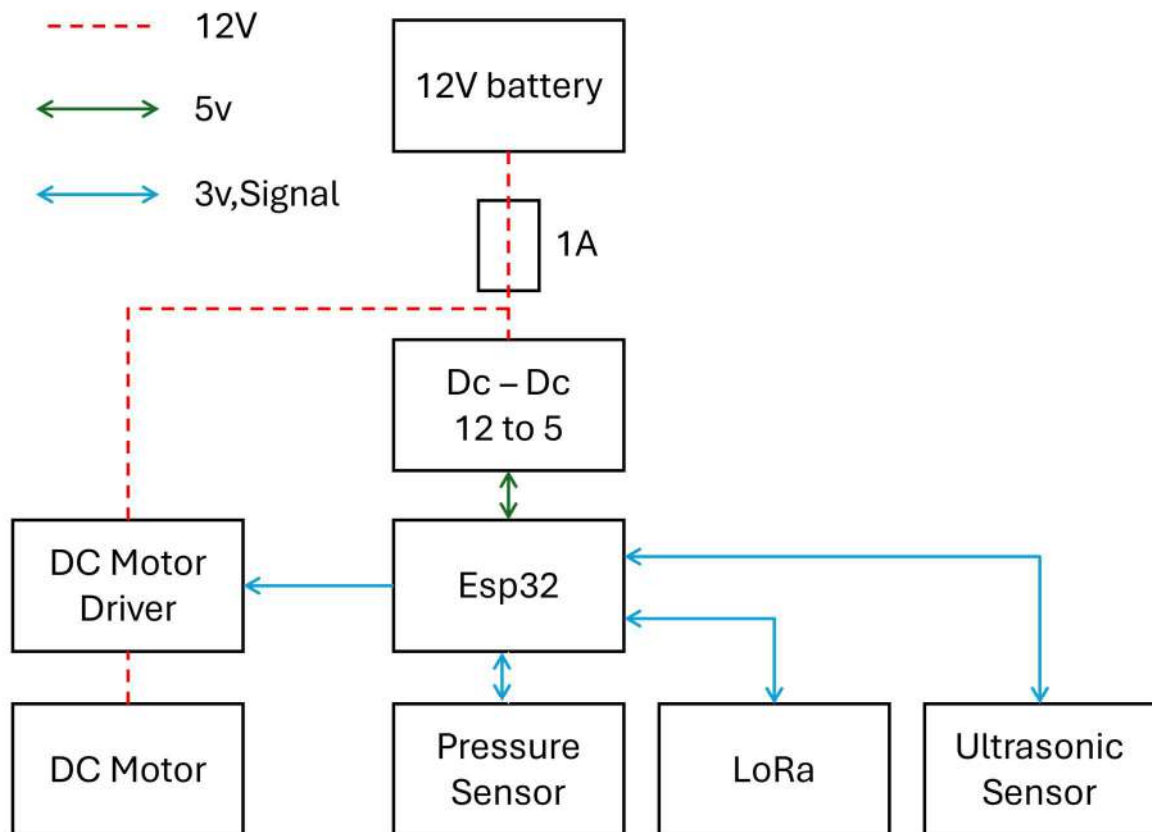
- ☐ **Focused Supervision:** Operators must remain focused at all times; leaving the station unattended is prohibited.
 - ☐ **No Unauthorized Adjustments:** Prohibit any non-essential adjustments or hardware modifications during operation.
 - ☐ **Emergency Recovery:** In the event of communication failure, water ingress, or loss of control, recover the vehicle immediately.
-

Emergency Response & Incident Handling

- ☐ **Redundancy:** The system must be equipped with an Emergency Power Off (EPO) and manual recovery mechanism.
- ☐ **Power Cutoff:** Immediately cut power in case of water ingress, short circuits, or loss of control.
- ☐ **Incident Documentation:** Conduct a thorough post-incident report and root cause analysis (RCA).
- ☐ **Continuous Improvement:** Revise safety regulations and operating procedures based on review findings.

Appendix C: Float SID

System Interconnection Diagram (SID) of Non-ROV Device



FLA Measurements (ELEC-NRD-005)

Waiting Mode (Motors Off) : 0.1 A

Buoyancy Change Mode (Motors On) : 0.7 A