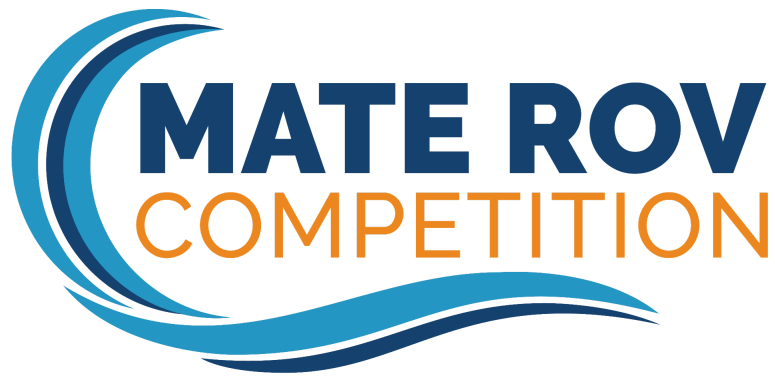




MATE ROV 2026 Explorer Class

Team Snowblast Technical Documentation



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Abstract

Snowblast is a lightweight, modular remotely operated vehicle (ROV) developed for the MATE ROV 2026 Explorer Competition. The vehicle was designed to perform underwater manipulation, observation, sensor handling, and data collection tasks while maintaining stable and efficient underwater operation, as shown in Figure 1.

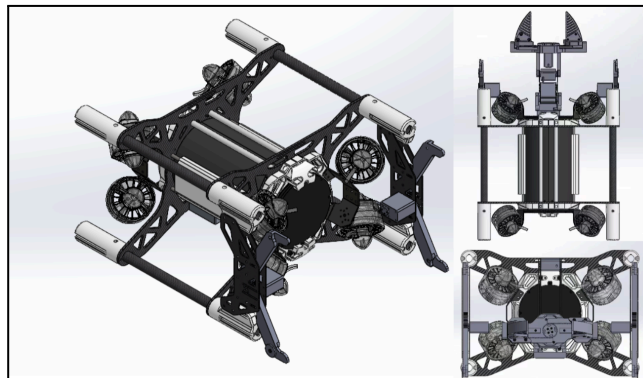


Figure 1. Overall CAD design of the ROV, including isometric, top, and front views.

The ROV uses a carbon fiber and anodized aluminum frame with eight vectored Sublab Z80E thrusters to achieve six degree-of-freedom movement and precise underwater maneuverability. A waterproof electronics system integrates the Jetson Orin NX, flight controller, stereo vision system, sensors, and power management modules to support navigation, image processing, and mission operations. Power line communication through the tether reduces wiring complexity and improves system maintainability.

To address mission-specific tasks, Snowblast includes two side-mounted 1-DOF claws for rapid object interaction and a central 4-axis manipulator for precise alignment, connector handling, and complex underwater operations as shown in Figure 2. All tools use modular mounting structures for rapid replacement and adjustable positioning.

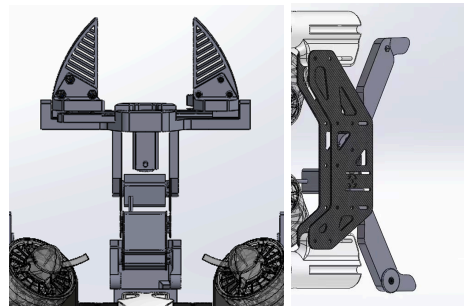


Figure 2. Overall CAD design of the ROV claws, including top and side views.

The project also includes a standalone float system equipped with buoyancy control, pressure sensing, wireless communication, and onboard protection systems for Task 4 operations. Throughout development, the team focused on lightweight construction, modularity, safety, and iterative testing to improve overall vehicle performance and mission reliability.

1. Company Overview

1.1 Company Background

Snowblast is a student engineering team from Worcester Polytechnic Institute participating in the 2026 MATE ROV Competition. The team was formed to design, manufacture, test, and operate a remotely operated vehicle capable of completing complex underwater missions.

Team members are responsible for different areas, including mechanical design, electrical integration, software development, control system design, mission tool

development, testing, documentation, and piloting. This division of responsibilities allows Snowblast to develop the ROV as a complete engineering product rather than simply combining separate components. Each subsystem is tested individually through system testing and reliability testing before being integrated into the main system.

Snowblast's design philosophy is to follow industrial-level engineering standards throughout the development process. The team does not only focus on whether the ROV can complete a single task, but also places strong emphasis on reliability, maintainability, safety, modularity, and repeatable performance. The mechanical structure is designed with strength and maintainability in mind. The electrical system emphasizes clear power distribution, proper fuse protection, waterproofing, and safe cable management. The control and software systems are designed for stable operation, predictable response, and efficient pilot control.

1.2 Project Management

Snowblast manages the ROV project by dividing the work into several major areas, including mechanical design, electrical systems, software and control, mission tools, and testing. Each area has team members responsible for the design, development, testing, and improvement of its corresponding system. This division of work helps improve team efficiency while ensuring that each subsystem is considered as part of the complete ROV system.

During development, the team follows an iterative workflow. First, the team analyzes the mission requirements and identifies the functions that the ROV needs to perform. Then, each subgroup develops design concepts, builds prototypes, and tests its own system independently. After subsystem testing is completed, these components are integrated into the main system and tested again as a complete vehicle. If problems are found during testing, the team analyzes the cause, modifies the design, and repeats the test.

Communication is an important part of Snowblast's project management. Team members regularly discuss project progress, technical issues, design changes, and testing results. Mechanical, electrical, and software-related decisions are evaluated together because a change in one subsystem may affect the entire ROV. For example, a change in the frame structure may affect buoyancy and tool mounting, while a change in the electrical system may affect waterproofing, power distribution, and maintenance.

The team also places strong emphasis on safety and reliability throughout project management. Before components are installed on the ROV, the team checks their mounting, electrical safety, waterproofing, and ease of maintenance. Testing results are used to guide future improvements, and documentation is updated as the design changes. Through this project management approach, Snowblast is able to develop

the ROV in an organized way and ensure that the final system is safe, reliable, and capable of meeting the competition requirements.

2. Mission Requirements

2.1 Mission Overview

For Snowblast, the 2026 mission is not just about completing several underwater tasks. It is a complete engineering project. The team needs to design, manufacture, test, and continuously improve a working ROV system. Our goal is to make Snowblast a safe, reliable, and easy-to-operate ROV that is capable of completing different underwater missions.

To achieve this goal, team members are responsible for different areas, including mechanical design, electrical systems, software, controls, mission tools, testing, documentation, and piloting. Although each part is developed by different members, all subsystems must eventually work together as one complete system. For example, the frame must support the mission tools, the electrical system must provide stable power, the control system must make the ROV easier to operate, and the cameras must give the pilot a clear view of the mission area.

We design the ROV with an industrial engineering mindset. In terms of mission performance, we did not choose to give up or simplify any task; instead, we are committed to completing all mission tasks as fully as possible. We also focus on whether the vehicle can operate repeatedly and consistently, whether it is easy to maintain, and whether it is safe and reliable. Through continuous testing and improvement, Snowblast aims to build a practical underwater robot that reflects teamwork, engineering thinking, and real-world problem-solving ability.

2.2 Task-Based Design Requirements

2.2.1 Object Collection Requirements

Object collection requires the ROV to locate, approach, capture, transport, and release underwater objects in a controlled way. Since the target objects may be small or difficult to align with, the ROV must provide stable low-speed movement and clear visual feedback for the pilot.

To meet this requirement, Snowblast uses front-facing camera feedback, smooth low-speed control, and a simple but reliable collection tool. The manipulator or claw must be easy to operate and strong enough to hold the object securely during movement. This requirement influenced the design of the camera placement, manipulator structure, vehicle stability, and low-speed control response.

2.2.2 Sensor Handling Requirements

Sensor handling requires the ROV to approach, pick up, move, and place underwater sensors accurately. Compared with simple object collection, this task requires more precise alignment because the manipulator must remain steady while interacting with the sensor.

Snowblast addresses this requirement through stable vehicle control, clear camera visibility, and a reliable grabbing tool. Optical flow positioning is used as an assistive feedback source to help estimate small ROV movements relative to the pool bottom or nearby visual features. Since optical flow depends on lighting and visible texture, it is used to support pilot control rather than replace manual operation. This requirement influenced the design of the manipulator, camera system, and low-speed control strategy.

2.2.3 Connector and Cover Operation Requirements

Connector and port cover operations require the ROV to align with small underwater targets and apply controlled pushing, pulling, gripping, or rotating force. These tasks require stable positioning, clear camera feedback, and a manipulator or task tool that can tolerate small alignment errors.

For these operations, Snowblast must maintain a steady position near the mission prop while the pilot aligns the tool with the connector or cover. The tool must engage the target securely without requiring overly complex movements. This requirement influenced the ROV's front camera placement, manipulator mounting position, low-speed control response, and task tool geometry.

2.2.4 Float System Requirements

The float system is an independent non-ROV device that must operate using its own onboard power, controller, sensors, and communication method. Unlike the main ROV, the float cannot rely on tethered power or direct pilot control during operation.

The main requirements for the float system are reliable buoyancy control, safe onboard power distribution, pressure-based depth measurement, and data collection. The float must move vertically in the water without using a thruster, record depth data over time, and provide information for the depth-time graph. These requirements influenced the design of the float's buoyancy engine, waterproof enclosure, battery and fuse system, pressure sensor, and communication method.

2.3 Overall Design Strategy

Snowblast's overall design strategy is to develop the ROV as a complete system rather than a set of separate components. The team focuses on system integration,

practical operation, and repeatable performance. Each subsystem is designed to support the main mission goals while remaining easy to test, maintain, and improve.

2.4 System-Level Design Considerations

2.4.1 Mechanical Design Considerations

To meet the requirements of all mission tasks, Snowblast's mechanical design focuses on structural strength, stability, and ease of maintenance. The frame must support the thrusters, cameras, electronics enclosure, tether connection, and mission tools while keeping the overall structure compact and easy to inspect.

After testing and team discussion, Snowblast selected an eight-thruster vectored layout. Although this layout places higher requirements on the thrusters and flight control system, it allows the ROV to achieve six-degree-of-freedom movement. This gives the vehicle better maneuverability and more precise control during underwater operation.

The team also uses a modular mechanical design. Motors and detection modules use quick-connect structures, so damaged parts or new subsystems can be replaced without changing the main circuit. Mission tools, the manipulator, and mounting brackets are also designed for quick adjustment, testing, and replacement. This makes the ROV easier to improve, maintain, and repair during the development process.

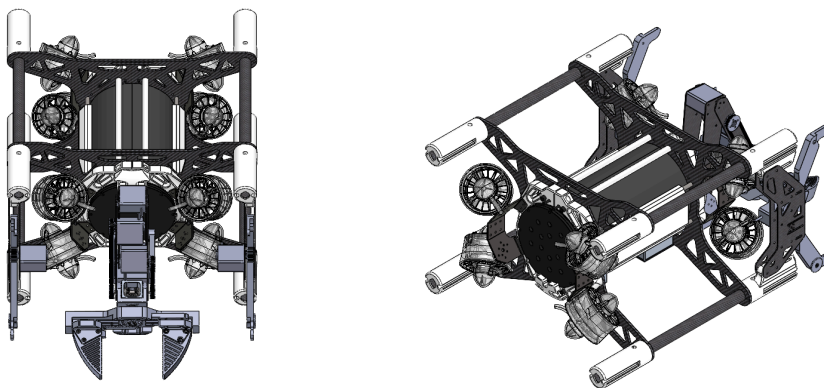


Figure3: Final Mechanical Design

2.4.2 Electrical Design Considerations

Snowblast's electrical design focuses on safety, stable power distribution, waterproofing, and ease of maintenance. The ROV connects to the MATE 48V power supply through the SBS50 Anderson connector, and the Littelfuse fuse is installed on the tether side of the system within the main power path. This ensures

that the vehicle remains protected when operating with the competition power supply.

Inside the ROV, the electrical system follows a modular design. The system is organized into separate modules such as the power module, lower-level controller, and onboard computer. This modular structure allows the team to replace or upgrade individual parts quickly without redesigning the entire electrical system. For example, when the computing power of the Jetson Nano was not sufficient, the team replaced it with a Jetson Orin NX to improve onboard processing performance.

2.4.3 Control System Considerations

Snowblast's control system design focuses on stability, precise movement, and ease of operation. Since the ROV uses an eight-thruster vectored layout, the control system needs to convert pilot input into coordinated thruster outputs. This allows the vehicle to move in multiple directions and achieve six-degree-of-freedom control.

The control system is designed to assist the pilot during complex underwater tasks. With the computing power of the Jetson Orin NX and the optical flow sensor mounted on the ROV, Snowblast can maintain a stable attitude and adjust its movement more accurately in complex underwater environments. The front-facing stereo camera also supports semi-automatic object grabbing by helping the system detect object position and assist with manipulator alignment.

Overall, Snowblast's control system is designed to provide highly stable movement and accurate pilot control. These features help the ROV complete tasks that require precise operation, such as object collection, sensor handling, and connector operation.

3. Mechanical Design

3.1 Frame Design

Snowblast's frame is designed to provide a strong, stable, and serviceable platform for the major ROV systems. The frame supports the thrusters, cameras, electronics enclosure, tether connection, buoyancy materials, and mission tools. Since these components must work together during underwater operation, the frame serves as the main structure that connects and protects the entire vehicle.

3.2 Materials Selection

Snowblast's material selection focuses on strength, weight reduction, corrosion resistance, waterproofing, and manufacturability. The main frame uses carbon fiber

and anodized aluminum alloy instead of the original stainless steel structure, reducing weight while maintaining strength and improving corrosion resistance.

For custom mounts and structural connectors, the team selected PPS-CF after comparing PC, PA6-CF, PPA-CF, and PPS-CF. PPS-CF provides low water absorption, sufficient strength, and fast design iteration through 3D printing. TPU is used for protective covers to reduce sharp edges and improve handling safety.

The waterproof enclosure uses a transparent acrylic tube with aluminum end caps and flange rings. This protects the electronics while allowing visual inspection and organized internal mounting.

3.3 Vehicle Size and Weight

Snowblast has a compact body size of 334 mm × 475 mm × 600 mm and a total weight of approximately 15 kg. When the manipulators are fully deployed, the overall vehicle length can extend to approximately 900–1000 mm depending on the selected tool configuration.

3.4 Thruster Mounting

The thrusters are mounted on anodized aluminum sheet-metal brackets. Aluminum alloy was selected for these mounting parts because it provides better toughness and strength than 3D-printed components. This is important for the thruster mounts because they must withstand vibration, thrust loads, and repeated handling during testing and operation. The anodized surface also improves corrosion resistance and helps prevent rust or long-term water-exposure issues.

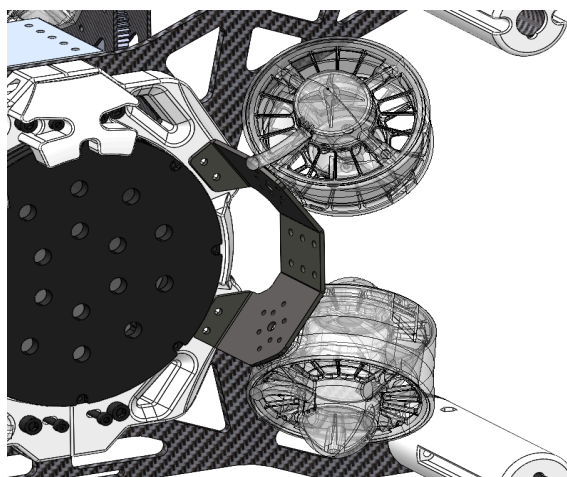


Figure4 : Aluminum Alloy Fixing

3.5 Manipulator and Claw Design

Our ROV uses a dual-manipulator system to handle both simple and complex underwater tasks. The system includes two side-mounted 1-DOF claws and one centrally mounted 4-axis robotic manipulator. All joints and actuators use TD100 waterproof servo motors for compact size, reliable torque output, and simplified control integration.

The two side claws are used for simple and repetitive tasks, such as grabbing handles, pushing objects, and transporting lightweight mission elements. Each claw uses a lightweight linkage mechanism to provide strong gripping force while keeping the structure simple and reliable.

The central 4-axis manipulator is designed for tasks that require higher flexibility and precision. It includes three arm joints and a rotating claw mechanism, allowing multi-angle grasping, object alignment, and operation in confined underwater spaces. The claw is designed to grip objects with different shapes and sizes securely.

All manipulators are mounted on external extension plates for modularity and maintenance. The mounting system allows quick replacement and adjustable positioning, making it easier to test different configurations, maintain the vehicle, and support future upgrades.

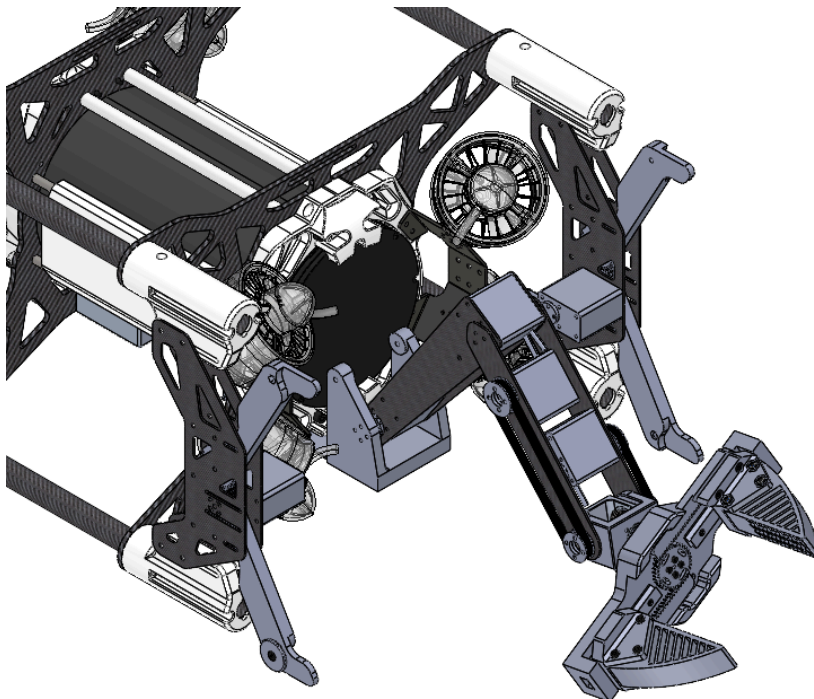


Figure5: Claw Design

4. Propulsion System

4.1 Thruster Selection

Snowblast uses Sublab Z80E thrusters as the main propulsion units. The team selected this model after testing and comparing it with the actual requirements of the ROV. Since Snowblast uses an eight-thruster vectored layout, each thruster must provide stable output, fast response, and reliable performance during repeated underwater operation.

During the selection process, the team first built a thruster test bench to evaluate different models. The main factors considered included thrust performance, control response, energy efficiency, and compatibility with the overall ROV system. Based on the initial specifications, the team compared four thruster models: Sublab Z80E, Sublab Z60E, Blue Robotics T200, and ROVMAKER T60.

After testing, the T200 and T60 were excluded because their control response did not fully meet the requirements of a vectored ROV system. Between the Z60E and Z80E, the Z80E was selected because its larger propeller size provided better energy efficiency and stronger overall propulsion performance. This made it more suitable for Snowblast's eight-thruster configuration.

4.2 Thruster Layout

Snowblast uses an eight-thruster full-vector layout to improve underwater maneuverability, stability, and attitude control. The eight thrusters are symmetrically distributed around the frame and positioned near the front-left, front-right, rear-left, and rear-right areas of the vehicle. In the horizontal direction, the thrusters are mounted at approximately 45 degrees, allowing their thrust to contribute to both forward/backward movement and left/right translation. In the vertical direction, the thrusters are mounted at approximately 35 degrees, allowing part of the thrust to contribute to vertical movement and attitude control. With this angled arrangement, the thrust vectors from all eight motors can be combined to achieve six-degree-of-freedom motion.



Figure6:ROV Frame

4.3 Propeller Guards and Shrouds

Snowblast uses SubLab Z80E thrusters equipped with protective shrouds and weed guards. The weed guard design of the Z80E meets the IP2 finger protection level, meaning that the guard prevents fingers from directly accessing the moving propeller area. These guards also help reduce the risk of foreign objects, ropes, plants, or loose materials entering the propeller area.



Figure7 :Z80E Thruster Structure

5. Electrical System

5.1 Power Input and Distribution

Snowblast uses the MATE 48 VDC supply as the only ROV power source. Power enters through the Anderson SBS50BLU connector and a main Littelfuse fuse installed within 30 cm of the connector. No voltage conversion is performed on the surface; 48 V power is sent through the tether and converted only onboard the ROV.

Inside the ROV, 48 V is converted to 24 V for the Z80E thrusters and high-power devices. Additional onboard converters provide lower voltages for the Jetson Orin NX, flight controller, cameras, sensors, servos, and mission tools. The fuse size is selected based on the measured in-water full-load current.

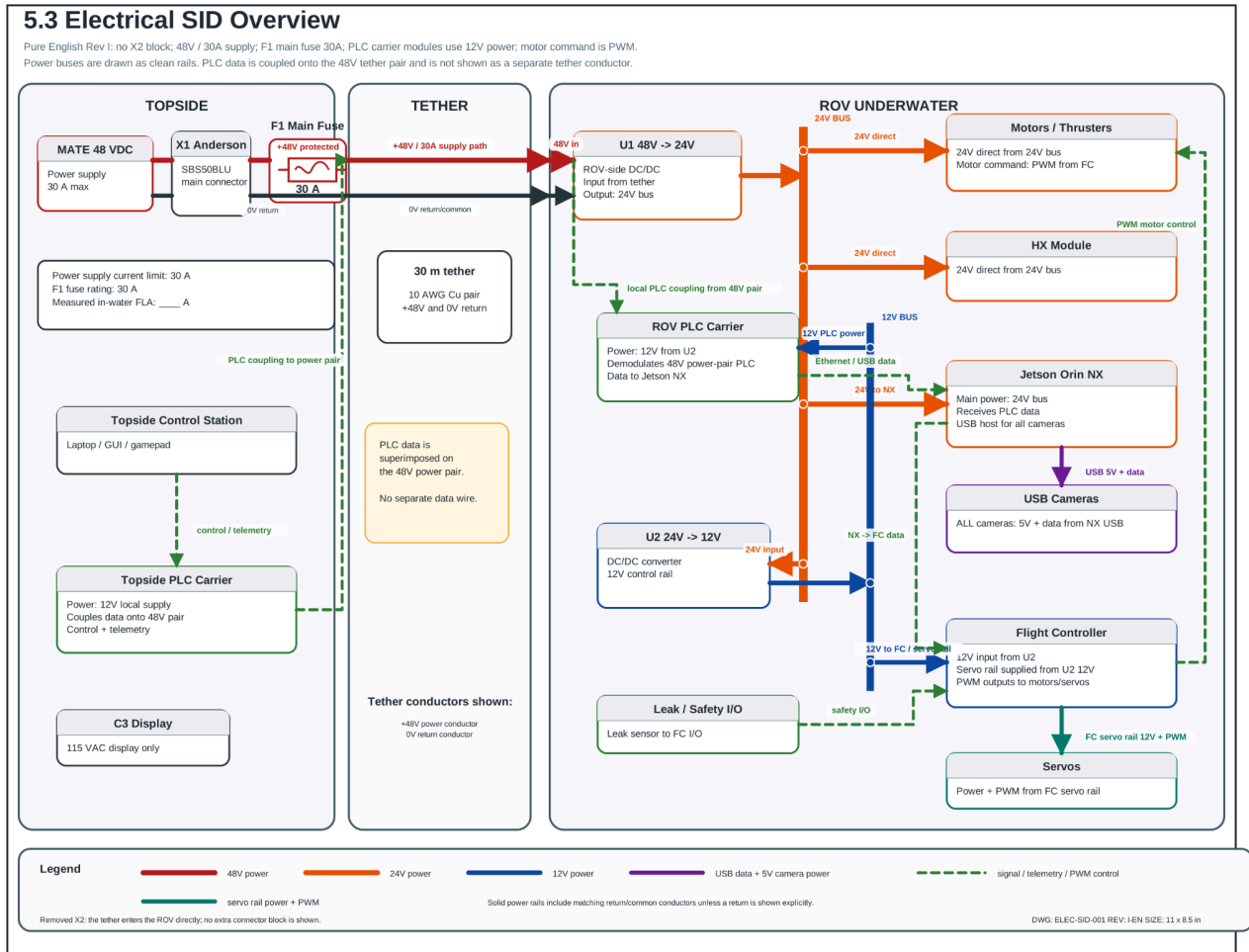
5.2 Electrical Waterproofing

Snowblast's main electronic components are installed inside a waterproof enclosure rated to 50 meters, including the Jetson Orin NX, flight controller, power management modules, and signal distribution hardware. The enclosure uses a transparent acrylic tube, aluminum end caps, sealing flanges, and O-rings, allowing visual inspection while providing a large waterproof safety margin beyond the competition depth.

Selected circuit boards are protected with conformal coating to reduce short-circuit risk if minor moisture enters the enclosure. A leak sensor is installed near the internal flange area, where water intrusion is most likely to occur. If water is detected, the system alerts the team so the ROV can be stopped and recovered immediately.

Cable routing is arranged to avoid sharp bends, loose wiring, and stress on connectors. Before each run, the team checks the O-rings, enclosure seals, cable entry points, waterproof connectors, internal pressure condition, and leak sensor function.

5.3 Electrical SID Overview



6. Control System and Software

6.1 Control Architecture

Snowblast uses a modular layered control architecture that separates upper-level computing, lower-level motion control, sensor feedback, and pilot operation. This structure keeps the system clear, testable, and easy to troubleshoot while supporting both manual control and assisted control functions.

Pilot commands are sent from the topside control station through the tether to the onboard control system. The Jetson Orin NX serves as the upper-level computer and processes camera data, optical flow information, and mission-assistance functions, including visual feedback, object awareness, and semi-automatic object grabbing.

The lower-level controller handles real-time motion control. It receives commands from the Jetson Orin NX or pilot input and converts them into coordinated thruster

outputs. Because Snowblast uses an eight-thruster full-vector layout, the controller must coordinate all thrusters to achieve stable six-degree-of-freedom motion, including translation and attitude adjustment.

Sensor feedback supports stable operation and safety. The optical flow sensor estimates small movements relative to the environment, the camera system provides pilot visibility and target alignment, and the leak sensor improves safety during underwater operation.

6.2 Pilot Input

The pilot input system is designed to make ROV operation more intuitive, precise, and easy to control. Two pilots send commands from the topside control station using controllers and the ground station interface. These commands are transmitted through the tether to the onboard control system, where they are converted into control outputs for the thrusters and mission tools.

The main pilot is responsible for driving the ROV and controlling vehicle movement, including forward/backward motion, left/right translation, up/down movement, yaw, pitch, and roll adjustment. The co-pilot is mainly responsible for controlling the mission tools. The manipulator, camera-related functions, and other task devices can be operated through controller buttons or assigned control channels.

This two-pilot design allows the main pilot to focus on controlling the ROV without being distracted by the manipulator or other intelligent functions. By separating driving and tool operation, Snowblast can achieve more efficient and more precise control during complex underwater tasks.

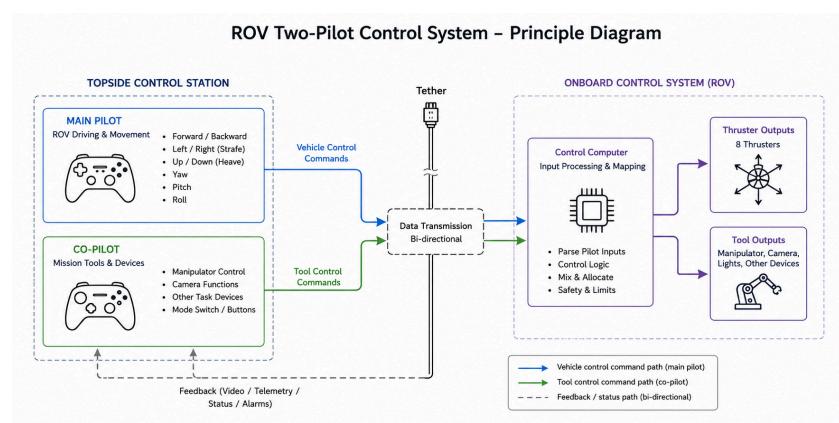


Figure8 : Dual-Control System Diagram

6.3 Thruster Mixing

In the eight-thruster full-vector layout, each thruster is not responsible for only one direction of motion. The thrust generated by a single thruster may affect forward/backward movement, left/right translation, vertical movement, as well as roll, pitch, and yaw attitude control at the same time.

Therefore, the thruster mixing algorithm is very important. Based on each thruster's position, installation angle, and thrust direction, the control system automatically calculates how much force each thruster should output. In this way, all eight thrusters can work together to generate the required combined force and moment, allowing the ROV to move according to the desired command.

The following figure is the thruster mixing matrix calculated by our team.

$$W = \begin{bmatrix} dx1 & dx2 & dx3 & dx4 & dx5 & dx6 & dx7 & dx8 \\ dy1 & dy2 & dy3 & dy4 & dy5 & dy6 & dy7 & dy8 \\ dz1 & dz2 & dz3 & dz4 & dz5 & dz6 & dz7 & dz8 \\ tx1 & tx2 & tx3 & tx4 & tx5 & tx6 & tx7 & tx8 \\ ty1 & ty2 & ty3 & ty4 & ty5 & ty6 & ty7 & ty8 \\ tz1 & tz2 & tz3 & tz4 & tz5 & tz6 & tz7 & tz8 \end{bmatrix}$$

Figure9: Control Allocation Matrix

The matrix describes the thrust or torque contribution of each thruster in different translational and rotational directions. Based on the robot's desired motion state, the controller uses this matrix to calculate the required output force of all eight thrusters, thereby achieving coordinated motion and attitude control of the entire platform.

6.4 Manipulator Control

The manipulator control system is designed to provide stable, precise, and reliable operation during underwater tasks. Snowblast uses a topside synchronizer control method for the manipulator. The control commands for the claw are generated and synchronized mainly from the topside control station, rather than relying entirely on complex underwater control electronics.

The co-pilot inputs the manipulator commands through the topside controller. The topside synchronizer converts the operator's input into the corresponding claw motion signals, which are then transmitted to the ROV through the tether. This allows

the manipulator to respond directly to the operator's commands while keeping the control process simple and easy to manage.

The advantage of using a topside synchronizer is that the control is more direct, stable, and easier to debug. The team can adjust the claw's motion range, response speed, and control logic from the surface side without frequently opening the underwater electronics enclosure. This also improves maintainability, because most control adjustments and troubleshooting work can be completed on the surface.

6.5 Camera and Video System

The camera and video system is divided into two parts: one is a real-time observation camera for ROV driving, and the other is a binocular vision system for task identification and measurement. Currently, it is the independent driving camera that provides the main driving image for the operator; This section focuses on the binocular vision system used for task processing.

The mission vision system uses a binocular camera mounted on the upper part of the ROV and connected to an NVIDIA Jetson Orin NX for local image processing. The current test camera is an ELP-USB3DGS800P binocular camera with a baseline distance of 65 mm, a working resolution of 2560×720 , and a frame rate of 60 fps. The camera is mainly used for mission image acquisition, binocular depth estimation, and subsequent vision algorithm validation. If subsequent testing shows that other cameras perform better in terms of underwater image quality, field of view, or depth accuracy, the system can be replaced after recalibration.

The visual software was written in Python and developed based on OpenCV. Jetson Orin NX was selected as the vision processing platform due to its ability to run local image processing and AI inference tasks on the ROV side, meeting the real-time processing needs of binocular vision and object detection.

The current vision processing pipeline includes: image acquisition, binocular calibration, image correction, disparity calculation, WLS filtering, depth estimation and task-dependent processing. First, the program reads the left and right images from the binocular camera and corrects the lens distortion by the camera calibration parameters. Subsequently, the system performs binocular correction on the left and right images so that the same spatial point lies on the same horizontal line in the left and right images as much as possible. After completing the correction, the program calculates the disparity map between the left and right images and estimates the object depth based on the disparity, the camera focal length, and the 65 mm baseline. Since the original disparity map is easily affected by noise, low-texture regions, illumination changes and edge mismatching, the current system adds Weighted Least Squares (WLS) filtering after disparity calculation. WLS filtering is used to smooth the noise in the disparity map, while retaining the object edge information as much as possible, making the depth map more continuous and stable.

For Task 1.2 Coral Garden Ridge Modelling, the binocular vision system was mainly used for image acquisition, target visibility confirmation, length scaling and height estimation. During the mission, the ROV will slowly move along the coral garden and the binocular camera will collect the left and right image pairs. Jetson Orin NX provides support for 3D modeling and measurement by generating WLS filtered depth information through the OpenCV binocular vision pipeline.

For Task 2.1 Green Crab Recognition, the team trained the YOLO object detection model for identifying invasive European green crabs. The model has been integrated into the existing Jetson Orin NX vision processing pipeline. OpenCV is responsible for the camera input, image preprocessing and visualization of detection results, and the YOLO model is responsible for identifying the green crab target and outputting the detection box, confidence and final number.

7. Tether and Communication

7.1 Tether Design and Power Transmission

We use a 30 m tether with 10 AWG copper power wires to transmit the MATE 48V power supply to the ROV. Since the current passes through both the positive and negative conductors, the total current path length is 60 m. The resistance of 10 AWG copper wire is approximately $0.00328 \Omega/\text{m}$. At the maximum current of 30A, the estimated voltage drop is $30\text{A} \times 0.00328 \Omega/\text{m} \times 60\text{m} = 5.9\text{V}$, so the voltage at the ROV side is approximately $48\text{V} - 5.9\text{V} = 42.1\text{V}$. This result shows that the 10 AWG wire can carry the required 30A current, but it will produce a noticeable voltage drop under full load. Since the ROV uses a 48V-to-24V DC-DC converter onboard, the system can still provide stable power as long as the converter input range supports approximately 42V. To reduce the influence of the tether on ROV movement, we use a custom zero-buoyancy tether designed for ROV applications. This tether has a tensile strength of up to 300 kg and near-zero buoyancy, which helps maintain stable ROV operation underwater.

7.2 Communication and Signal Lines

For communication between the ROV and the topside station, Snowblast uses a power-line carrier communication system. This system allows control signals and system status data to be transmitted through the power line in the tether, reducing the need for additional signal cables.

By using power-line carrier communication, the team can maintain stable transmission of control commands and feedback data while simplifying the tether

structure. This design also supports Snowblast's modular and maintainable system architecture.

After testing, the team found that the 500 m power-line carrier module fully meets the communication requirements of the ROV. Since Snowblast's actual tether length is much shorter than the module's rated range, the system provides a strong communication margin and reliable data transmission during operation.



Figure 10: PLC Data Module

7.3 Strain Relief and Tether Management

Snowblast uses dedicated strain relief points on both the topside and the ROV side. On the ROV side, the tether is secured to the frame using a newly designed 3D-printed locking clamp before it enters the electrical connection area. As a result, pulling forces are transferred to the frame instead of acting directly on the cable connectors. On the topside, the tether is also secured before connecting to the control and power systems, reducing the risk of accidental disconnection or connector damage.

8. Task 1 - 3 Interactive Mission Tasks

8.1 Task1 Seabed 2030 Coral Garden

1. Coral Collection

The ROV uses two side-mounted 1-DOF claws to collect brittle stars and coral samples. The claws are designed with a wide opening and curved gripping surfaces to securely hold lightweight mission props while minimizing damage to fragile coral structures. Rubberized contact pads improve friction underwater and prevent slipping during vehicle movement. The claws are mounted near the front corners of the vehicle, allowing the pilot to approach objects from multiple angles while maintaining camera visibility.

8.2 Task2 Smart Atlantic Alliance

- **Lobster Trap Float Release**

The central 4-axis manipulator is used to rotate and interact with PVC handles and release mechanisms. The L1–L3 joints provide positioning flexibility, while the wrist rotation axis allows precise alignment with the float release handle. The manipulator claw applies controlled rotational force to activate the mechanism without destabilizing the vehicle.

- **Lobster Trap Recovery**

The side claws are used to stabilize and guide the lobster trap during lifting operations. Their simple and robust structure allows reliable gripping of the trap frame while minimizing mechanical complexity.

- **Anchor Recovery Line Attachment**

The 4-axis manipulator is used to align and attach the recovery clip onto the U-bolt structure. Multiple joints allow the manipulator to approach the target from different orientations, improving reliability during underwater alignment tasks.

- **eDNA Sampler Deployment and Recovery**

The manipulator arm is responsible for placing and retrieving the eDNA sampler inside the designated deployment area. The articulated joints allow accurate positioning within confined spaces while maintaining camera visibility. The rotating claw axis improves insertion alignment and connector handling.

- **Observation Station Cleaning**

The manipulator claw rotates the cleaning mechanism by gripping and turning the PVC tee structure. Wrist rotation allows continuous rotational motion without repositioning the entire vehicle.

8.3 Task3 Offshore Energy Platform

- **Bubble Curtain Ring Installation**

The side claws are used to transport and place the lightweight bubble curtain ring around the monopile structure. Their fast actuation and wide gripping area improve handling stability.

- **Micro Pile Pin Removal**

The 4-axis manipulator uses its articulated joints to align with and pull the retaining pin from the micro pile assembly. The rotating claw improves hook alignment during extraction.

- **Power Connector Installation**

The manipulator arm positions and inserts the power connector into the platform receptacle. The L1–L3 joints provide reach and angular adjustment, while the claw rotation axis ensures proper connector orientation during insertion.

9. Pre-Run Safety Checklist

No	Inspection Item	Inspection Content	Passing Standard
1	Power Fuse	Check whether the main power fuse is installed correctly and securely fixed	Fuse is secure with no looseness
2	Strain Relief	Check whether the topside and ROV-side strain relief devices are secure	Fixed securely; pulling force is not applied to cable connectors
3	Sealing Flange	Check whether the enclosure flange, end caps, and O-rings are securely installed	Flange is secure; O-rings are correctly positioned
4	Internal Pressure	Check whether the enclosure internal pressure is maintained at -50 Pa	Pressure is stable with no obvious leakage

5	Thruster Guards	Check whether all thruster guards and weed guards are installed and secure	Guards are complete, secure, and not loose
6	External Devices	Check whether all motors, cameras, and the manipulator are securely mounted	No looseness or risk of detachment
7	Flight Controller Link	Check whether the flight controller connection status is normal	Flight controller is online and communication is normal
8	Device Status	Check whether all cameras, manipulator, and motors are online	All devices respond normally

10. Budget and Cost Accounting

10.1 Funding Sources

Snowblast's funding sources include team-raised funds, discounted component purchases, and donated equipment. Team-raised funds were used for materials, machining, electronics, testing supplies, and general project preparation.

Tianqi ROV97 provided discounted purchasing support for selected components. Hangzhou Extreme Intelligent Control Ocean Engineering Technology Co., Ltd. donated two flight controllers and two pressure sensors, which are recorded in the cost table at fair market value.

10.2 Budget Planning

Snowblast organized the project budget by major subsystems, including propulsion, connectors and sealing, vision, computing and control, sensors and communication, structure and watertight housings, float components, and testing materials. The

budget was used to guide purchasing decisions and compare cost, reliability, and performance during the design process.

The team prioritized safety-critical and mission-critical components, such as thrusters, waterproof connectors, flight controllers, pressure sensors, and onboard computing hardware. Reused parts, discounted purchases, and donated components were used when appropriate to reduce actual spending while maintaining system reliability.

10.3 Cost Accounting Summary

Snowblast records project costs by category, including purchased, reused, discounted, and donated components. Purchased items are recorded by actual paid cost. Reused items and donated items are recorded using fair market value. Discounted items are recorded using the actual paid amount, with discount sources noted when applicable.

The exchange rate used for this draft cost conversion is roughly:

1 USD = ¥6.79 CNY

Project Costing - Snowblast ROV

School/Team Name:	Snowblast		Reporting Period:	2026 Season
Instructor/Sponsor:			Currency:	CNY / USD
Type	Category	Main Items	Estimated Cost (CNY)	Estimated Cost (USD)
Cash donated	Funding	Funded by Snowblast crew	¥80,000.00	\$11,773.00
Purchased	Propulsion System	T60, P75, T200, Z60E, Z80E thrusters	¥22,440.00	\$3,302.00
Purchased	Connectors and Sealing	Waterproof connectors, cable glands, penetrators	¥10,365.16	\$1,525.34
Purchased	Vision System	Stereo cameras and obstacle-avoidance cameras	¥17,995.00	\$2,648.20
Purchased	Computing and Control	Jetson NX, Orin NX carrier boards, switches, Raspberry Pi units	¥19,620.00	\$2,887.34
Purchased	Sensors and Communication	MS5837 pressure sensors, 500 Mbps power-line carrier modules	¥2,835.00	\$417.20
Purchased	Structure and Watertight Housing	Flange rings, aluminum end caps, acrylic sections, M10 plugs, vacuum valves	¥6,605.00	\$972.01
	Estimated Project Value	Major listed ROV subsystems	¥79,860.16	\$11,752.09
Summary				
Total Funding		Funded by Snowblast crew	¥80,000.00	\$11,773.00
Final Balance		Funding minus estimated project value	¥139.84	\$20.91

**Costs are listed as estimated project values for major ROV subsystems. Donated or self-funded items should be recorded at their approximate current market value.*

The budget covers the team's overall testing expenses and the manufacturing costs of two ROV units, including prototype development, component testing, system integration, and final vehicle assembly.

10.4 Discounted and Donated Components

Some components were purchased through discounted channels provided by Tianqi ROV97. These discounted purchases reduced the team's actual spending and allowed the team to allocate more budget to key systems.

Hangzhou Extreme Intelligent Control Ocean Engineering Technology Co., Ltd. donated two flight controllers and two pressure sensors. The flight controllers are used for ROV motion control, thruster signal output, sensor input, and system monitoring. The pressure sensors are used in the float system for depth measurement and depth-time data generation.

All discounted and donated items are included in the detailed cost table with their source, paid cost, or fair market value.

10.5 References

[1] MATE ROV Competition. *2026 RANGER Class Competition Manual — Part 1: Product Demonstration, Task 4.1 MATE Floats Under the Ice!* Used as the main reference for the vertical profiling float task, including the 2.5 m depth hold, 40 cm depth hold, buoyancy-engine requirement, and data-packet verification.

[2] MATE ROV Competition. *2026 RANGER Class Competition Manual — Non-ROV Device Documentation and Electrical Safety Requirements.* Used as the reference for the non-ROV device documentation limit, battery type, fuse placement, full-load current measurement, and pressure-relief design requirements.

[3] TE Connectivity. *MS5837-30BA Water-Resistant Pressure and Temperature Sensor Product Information / Datasheet.* Used as the reference for the MS5837 pressure sensor specifications, I²C interface, 24-bit ADC output, and water-depth measurement application.

[4] Blue Robotics. *BlueRobotics MS5837 Arduino Library and Bar Depth/Pressure Sensor Guide.* Used as a software and implementation reference for reading pressure and calculating depth from the MS5837 sensor.

[5] Arduino. *SD Library Reference.* Used as the reference for SD card data logging, including reading and writing mission data files.