# Blue Lobster

## 2025 Technical Paper

**One Degree North, Singapore American School (Singapore)**

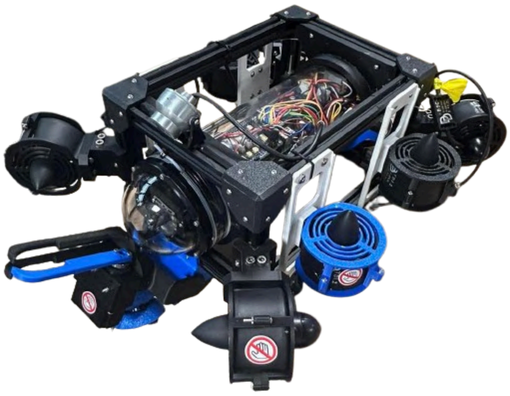

Fig. 1 Blue Lobster ROV

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# Abstract

Singapore American School's One Degree North (ODN) presents the second iteration of the Blue Lobster remotely-operated vehicle (ROV). Through extensive research and development (R&D) work, Blue Lobster ROV was designed with modularity, safety, and reliability in mind. It features a frame constructed out of aluminum T-slot extrusions, easily detachable and replaceable thruster mounts, a claw purposefully designed and optimized for the 2025 mission task set, and a fuse box within the electronics enclosure to protect components, among many others. Pushing the boundaries of technology in marine applications, enabling faster and more efficient exploration, maintenance, and data collection of underwater environments. Besides ensuring reliability, R&D work on Blue Lobster ROV has also resulted in experimentation with newer designs and systems to improve overall efficiency and minimize costs.

# Team Management

## Overview

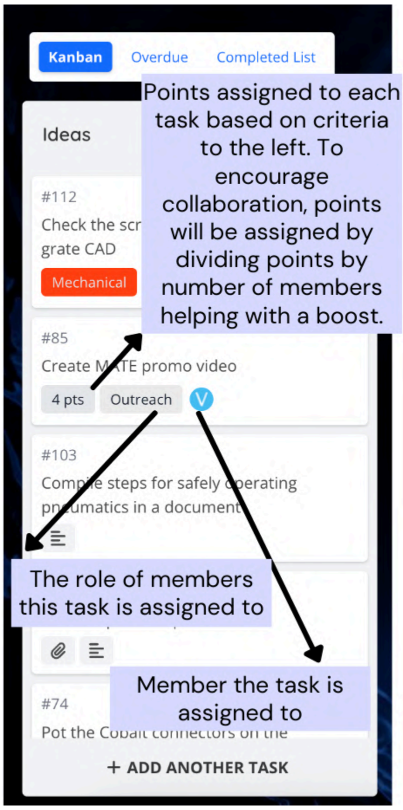
After experiencing issues stemming from disorganized team management and mentorship in the preceding year, Blue Lobster focused on boosting team organization and the member training program by switching to an improved communication platform, introducing task management software, and improving the training curriculum. Furthermore, concerns surrounding the inexperience of future driving teams have resulted in the implementation of a secondary driving team, whose members shadow the primary driving team to gain experience and serve as backups.

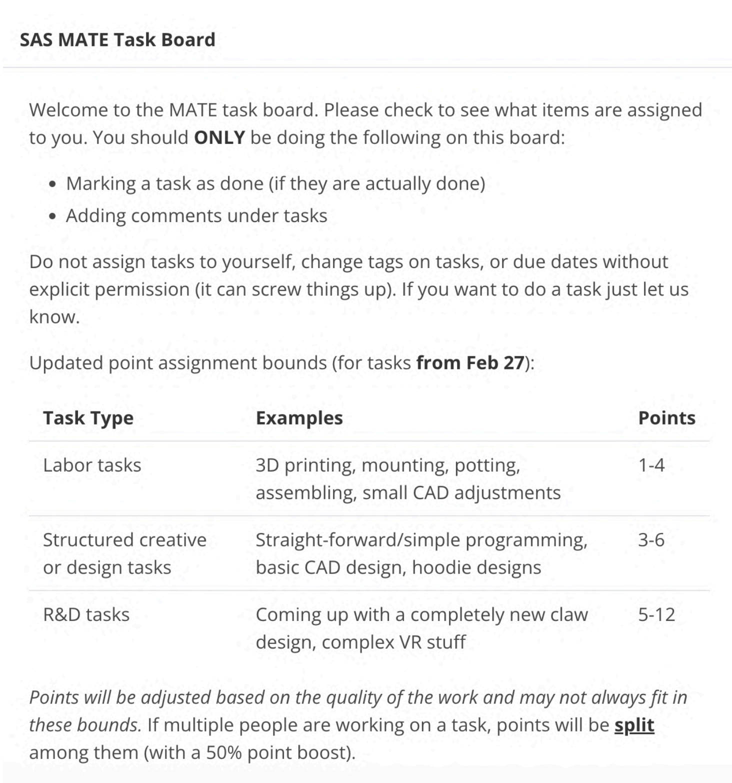
## Team Structure and Communication

In previous years, team members had trouble using the Mattermost ecosystem, our primary communication platform and task management software. This reduced communication and led to delays. To improve, Blue Lobster made multiple changes to its organizational system.

The first change was the switch in communication from Mattermost to Google Chat, which is easily accessible through a member's school Google account. This led to increased communication within the team, which is essential to maximizing productivity.

Second, besides communication, Mattermost offered a Kanban board feature (Mattermost Boards), allowing the team to keep track of rapidly changing tasks through a form of Agile Project Management (APM) (Drumond, 2021). Although this allowed members always to know what tasks they should be working on, the current technology implementation would lead to unnecessary delays in the development schedule when a member fails to complete their work promptly. This year, the team switched to a self-hosted, open-source Kanban board software called Vikunja for project management. Compared to Mattermost Boards, this software enables webhooks to track task changes. These were used alongside the labels feature to assign and reward members “points” based on their contributions to the team, incentivizing members to select and complete tasks on time. This was created to encourage R&D, while still completing more laborious tasks. Based on the points, we created a scoreboard to gamify task completion (to the right).



**SAS MATE Task Board**

Welcome to the MATE task board. Please check to see what items are assigned to you. You should **ONLY** be doing the following on this board:

- Marking a task as done (if they are actually done)
- Adding comments under tasks

Do not assign tasks to yourself, change tags on tasks, or due dates without explicit permission (it can screw things up). If you want to do a task just let us know.

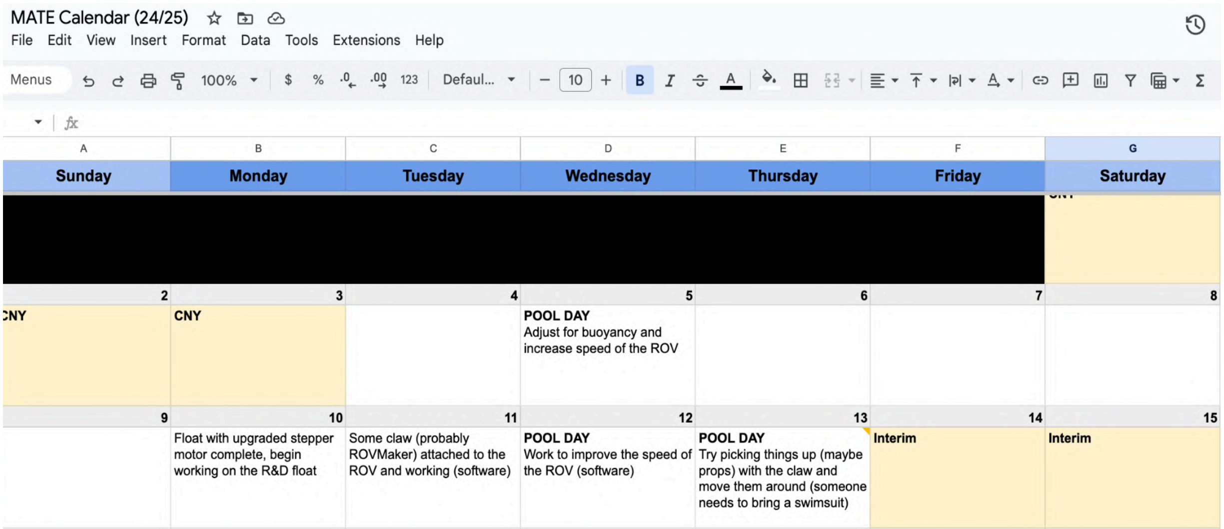
Updated point assignment bounds (for tasks **from Feb 27**):

| Task Type | Examples | Points |
|---|---|---|
| Labor tasks | 3D printing, mounting, potting, assembling, small CAD adjustments | 1-4 |
| Structured creative or design tasks | Straight-forward/simple programming, basic CAD design, hoodie designs | 3-6 |
| R&D tasks | Coming up with a completely new claw design, complex VR stuff | 5-12 |

*Points will be adjusted based on the quality of the work and may not always fit in these bounds.* If multiple people are working on a task, points will be **split** among them (with a 50% point boost).

*Fig. 2 and 3 - Image of task board (left) and details of how points are assigned for each type of task (right)*

In addition to these components, captains established role-specific officer group chats and regularly coordinated meetings with officers to discuss plans and deadlines, ensuring the team was on track. Moreover, calendars allowed members to see key dates to pace themselves properly.


MATE Calendar (24/25)

| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
|---|---|---|---|---|---|---|
| [redacted] | | | | | | |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| CNY | CNY | | POOL DAY Adjust for buoyancy and increase speed of the ROV | | | |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | Float with upgraded stepper motor complete, begin working on the R&D float | Some claw (probably ROVMaker) attached to the ROV and working (software) | POOL DAY Work to improve the speed of the ROV (software) | POOL DAY Try picking things up (maybe props) with the claw and move them around (someone needs to bring a swimsuit) | Interim | Interim |

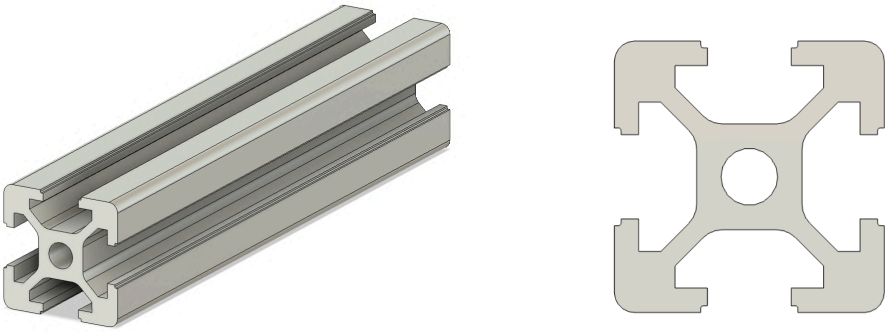
*Fig. 4 - Image of MATE schedule*

# Design Rationale

## Engineering Design Rationale

Blue Lobster ROV was designed to optimally execute the tasks outlined in the MATE competition manual. The design goals included ensuring modularity for future upgrades and optimizing task execution.

To allow for easier upgrades in the future, the company selected aluminum T-slot extrusions for the frame. These extrusions enabled Blue Lobster to easily attach and detach components, such as claw prototypes and thrusters, using T-nuts, satisfying the goal of modular design.



Figs. 5 and 6 - Diagonal view and cross section of aluminum T-slot extrusion

Subsequent designs of Blue Lobster aimed to optimize task execution by increasing the ROV's speed and precision. First, the company modified the thruster configuration to include two additional vertical thrusters, increasing the speed and degrees of freedom (DOF) to enable more precise control. To increase speed, Blue Lobster aimed to minimize the size of the frame to reduce the impact of drag on the surface of the ROV. Furthermore, the company modified the grippers on the claw to include rubber bands to increase grip, which is necessary in task 2.1, where rubber bands increase grip on the U-bolt and thermistors, minimizing mission execution time.

## Frame

Blue Lobster's choice to use aluminum extrusions to construct the frame of the ROV was based on the need for modularity. Compared to other frame designs, aluminum T-slot extrusions have significant modular benefits, allowing components such as thrusters to be easily adjusted when paired with T-nuts. If PVC or another type of frame were used, Blue Lobster would have to drill or damage the material in some way, limiting Blue Lobster's ability to adjust the design rapidly. Blue Lobster created custom corner pieces to connect the aluminum extrusions using computer-aided design (CAD) and 3D printed them out of polylactic acid (PLA). These custom corner pieces were for their durability, cost-effectiveness, and simplicity during assembly.

| Frame | Weight | Cost | Durability | Modularity |
|---|---|---|---|---|
| PVC | Very light | Low | Low | Low (drilling) |
| Carbon fiber | Extremely light | Very high | Medium (brittle) | Very low (hard to modify) |
| Aluminum extrusion | Light | Moderate | High | High |

*Fig. 7 - Comparison matrix of frame materials based on weight, cost, durability, and modularity.*

## Propulsion

The ROV's main propulsion consists of 8 Diamond Dynamics TD1.2 Thrusters arranged in four vertical and four horizontal positions. The horizontal thrusters were mounted at a 45° angle on each frame corner, allowing the ROV to surge, sway, and yaw. Two vertical thrusters on either side of the frame also enable the ROV to heave, pitch, and roll.

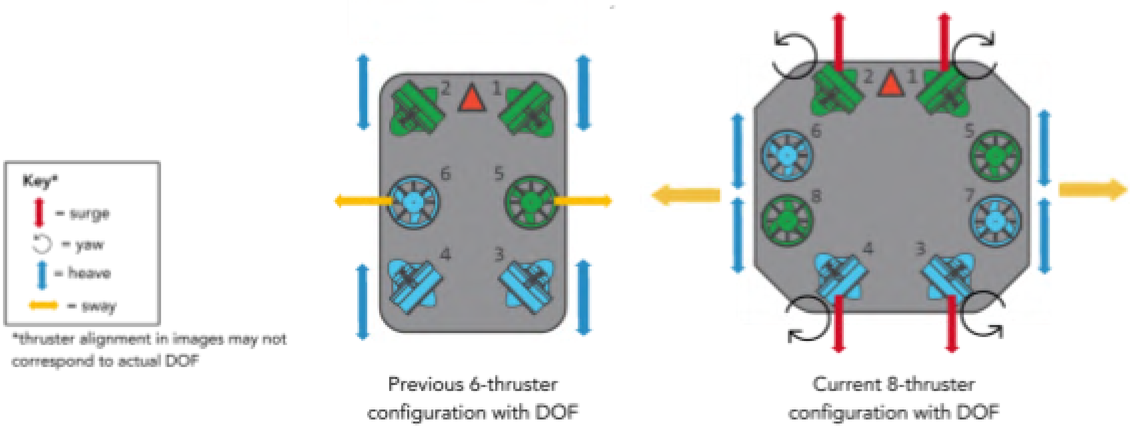



*Fig. 8 - Demonstrating the degrees of motion permitted by 6-thruster layout versus 8-thruster layout*

Diamond Dynamics TD1.2 Thrusters were selected for their power and waterproofed integrated electronic speed controllers (ESC). This allows straightforward installation without external waterproofing and saves space within the enclosure.

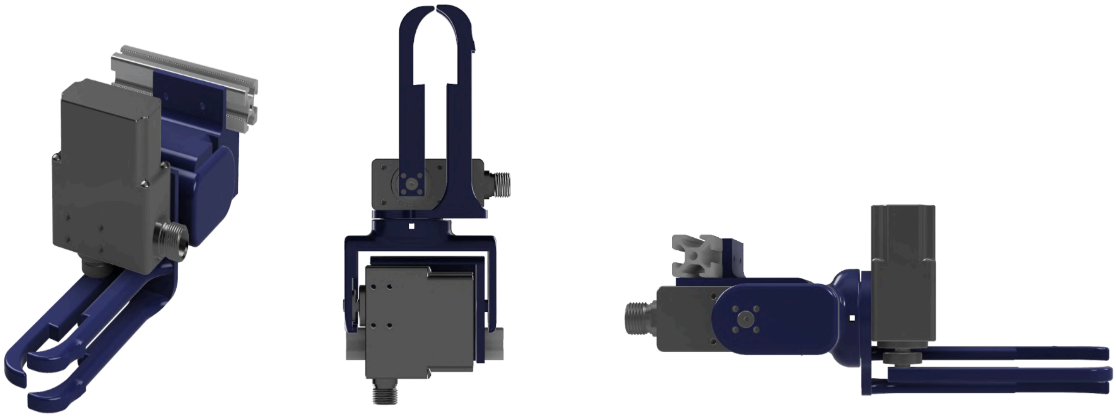
A primary concern of Blue Lobster was the tradeoff between speed and power. Drawing more power for the thrusters results in less that can be diverted to other electronics, and the thrusters would also increase drag. Although utilizing more thrusters draws significantly more current from the power supply, time is a crucial constraint when executing tasks, such as visually inspecting the base structure for corrosion and quickly rising and descending for the thermistor. The company decided to utilize eight thrusters instead of six, prioritizing the significant increase in speed over the current conservation.

## Claw

Blue Lobster's claw was designed with the mission tasks in mind, minimizing task execution time while considering cost and power consumption. For the task that requires installing the pCO2 sensor into the spotter buoy in task 1, active pitch control is required to position the gripper properly.

The claw consists of two primary components: 3D-printed claw fingers and a chassis designed using CAD, with two DSSERVO DS3225MG 25 KG servos enclosed in the Blue Trail Engineering SER 2000 housing. The servos are only splash-resistant by themselves. To increase their IP rating, it was waterproofed within the SER 2000 housing, which features a durable acetal waterproof case rated for depths of up to 200 meters.

The claw design features a three-finger layered design, implemented after testing that revealed significant issues with the previous two-finger configuration when completing tasks involving interactions with ropes and more fine components, like in the resistor task. The two-finger design did not maintain a secure hold when interacting with props such as the hydrophone, which involved gripping spindly objects. To address this, the claw was redesigned with three fingers, allowing for more stable gripping of PVC pipes, hooks, and rope. In addition to the shape of the claw, rubber bands were added to increase friction and improve grip following repeated issues with effectively gripping specific props underwater. The thermistor, in particular, would often slip out of the existing claw's grip. As a result, props that were previously difficult or impossible to hold could now be maneuvered with greater ease and reliability.



*Figs. 9, 10, and 11 - Top and side views of the finalized claw*

Although some tasks require different claw roll orientations (horizontal or vertical), active adjustment is unnecessary. Because of this, Blue Lobster could reduce the number of servos required to two degrees of freedom and create a manually adjustable system to quickly change the claw's roll orientation on the surface.

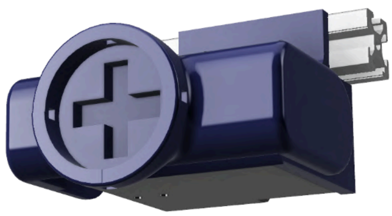


*Fig. 12 - System for manually adjusting the roll orientation of the claw*

## Buoyancy and Ballast

Different materials are strategically positioned across the ROV to achieve neutral buoyancy in all depths, reducing the thrusters' workload. Achieving neutral buoyancy allows the ROV to hover in place, minimizing the workload on thrusters required to maintain depth. Polyurethane foam blocks are positioned on top, and iron weights are on the bottom of the frame to increase stability (center of drag below the center of mass). Sections of pool noodles are fixed onto the tether to achieve neutral buoyancy and prevent it from dragging on the pool floor.

| | |
|---|---|
| Mass | $5.350\ kg$ |
| Volume | $0.0036\ m^3$ |
| Density | $1490\ kg/m^3$ |

*Fig. 13 - Mass, density, and volume of ROV used for buoyancy calculations*

$$F_b = pVg == 1490\ \frac{kg}{m^3} * \ 0.0036\ L\ * \ 9.81\ kg\ = \ 52.62N$$
$$F_g = mg\ = 9.81\ kg\ \times\ 5.350\ \frac{m}{s^2} = 52.4835\ N$$
$$F_b \approx F_g$$

***(Therefore, the ROV has relatively neutral buoyancy)***

# Control and Electrical System Design Rationale

Blue Lobster's control and electrical system layout was designed by iterating upon previous years' designs and incorporating newer components to enhance the modularity of its design. Key upgrades include centering Blue Lobster's systems communications around a Blue Robotics Navigator board—a flight controller to which the ESCs, sensors, and servos are wired—and a 3D-printed internal mounting plate. The Navigator board allowed for controlling the ROV using BlueOS, a web interface that supports the operation of various types of marine vehicles, including ROVs. Specifically, BlueOS allowed for the control of components, including the ROV's sensors, thrusters, and servos. This system improved on last year's ROV by increasing software development speed and, as a result, improving the team's overall efficiency.

## Layout and Modularity

In prior years, little attention was paid to the wiring layout inside our waterproof enclosure, leading to delays in troubleshooting during runs and potential safety concerns.

The electronics enclosure is a 110mm x 300mm BR-100895 by Blue Robotics, which is rated to depths of up to 135 meters. The enclosure consists of a tube, dome, end cap, and two O-ring flanges to interface with the tube. This year, the team implemented a custom 3D-printed electronics plate within the enclosure to mount the Raspberry Pi, fuse box, and other components in a neat and organized manner. This minimizes clutter, reduces the risk of short circuits, and quickens troubleshooting. When designing the 3D printed plate, careful consideration was given to positioning the fuse box and Raspberry Pi to ensure the wiring was less cluttered. The custom plate also allowed for easy upgrades to the design and featured a more compact layout, resulting in reduced time needed to iterate and test prototypes. Blue Lobsters' prioritization of modularity also led the team to choose components that could be easily swapped, such as the standard fuse box and customized board. While some components like the Raspberry Pi were reused from last year's ROV to reduce costs, the internal design differed significantly in layout, as detailed above.

## Power System

The Blue Lobster ROV is connected to the control station via a 15-meter-long tether consisting of one shielded, weatherproof Cat 6 Ethernet cable for communication to limit the effect of electromagnetic interference (EMI) on the signal and two 8 AWG power cables. The gauge and length of the tether were selected to minimize drag underwater and ensure the voltage drop was not too significant. Given the power supply of 14.6V at 25A, the tether configuration would result in a 10.3% voltage drop to 13.09V, greater than the minimum 12V required to operate Blue Lobster ROV.

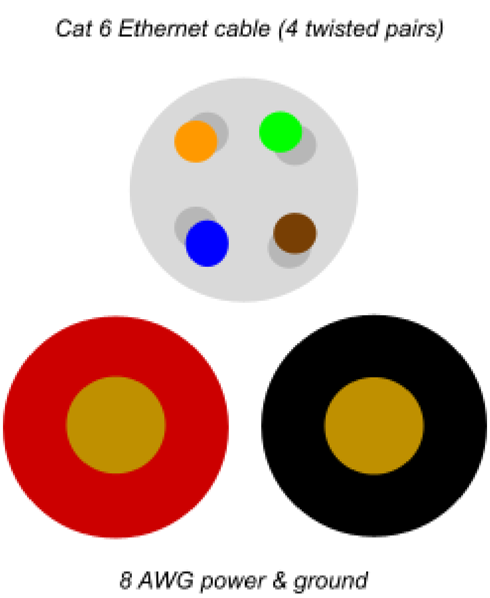



*Fig. 14 - Diagram of tether cross-sections*

Given the 12V 25A power supply, the software limiting reduced the thrusters' maximum current draw. This prevents the system from drawing too much current, which could damage components and present potential safety hazards. Fuse amperage was chosen by running the ROV underwater at maximum forward and down thrust and selecting the next highest fuse available.

| **Fuse** | |
|---|---|
| Full Load Amperage (FLA) | 20.88A |
| Selected Fuse Size | 25A |

*Fig. 15 - Full Load Amperage (FLA) and selected fuse size*

## Tether Management

Two team members handle tether management to ensure smooth deployment and efficiency. One tether manager stands closest to the pool to ensure the ROV has enough slack to move around freely. The secondary tether manager is positioned closer to the control station to feed the tether to the primary tether manager and monitor the remaining length. Blue Lobster keeps the tether wrapped around a spool behind the secondary tether manager when unused. Before a run, the necessary tether is unspooled from the spool by the secondary tether manager and then rewound after the run. This helps maintain organization and minimizes the risk of damaging the tether.

To optimize the ROV’s performance when deployed, Blue Lobster accounted for the strength, efficiency, and durability of the tether chosen. The tether must be strong enough to resist tension during retrieval and maneuvering. The communication and power cables Blue Lobster chose, 2×8 AWG for power and a durable, waterproof, Cat6 Ethernet cable for data, withstood this mechanical stress without dropping packets, which is crucial to maintain continuous operation during missions. Additionally, the tether needed to be lightweight to resist drag underwater, which would decrease the propulsion efficiency of our thrusters and hinder the ROV's movement. Blue Lobster purposefully reused the tether from last year, which proved to be lightweight and durable with internal strain relief. To make the tether more neutrally buoyant, Blue Lobster cut pool noodles and attached them to sections of the tether in intervals, securing them with zip ties.

## Control System Software

Blue Lobster’s control system software runs on two surface laptops and a Raspberry Pi 4. The first laptop operates BlueOS’ cockpit web interface, which the main driver uses to control the ROV. The second laptop executes auxiliary, sometimes resource-intensive tasks, such as generating a 3D model of the shipwreck using photogrammetry and rendering the photosphere. This decision was implemented after observing that using two laptops improves the efficiency of task execution, as the main driver no longer needs to handle auxiliary tasks and can focus on controlling the ROV. The Raspberry Pi runs BlueOS and receives signals from both laptops and directly controls functions such as thruster and servo movements, PID control, camera streaming, and $I^2C$ data exchanges with other systems in the ROV, such as the depth and temperature sensors.

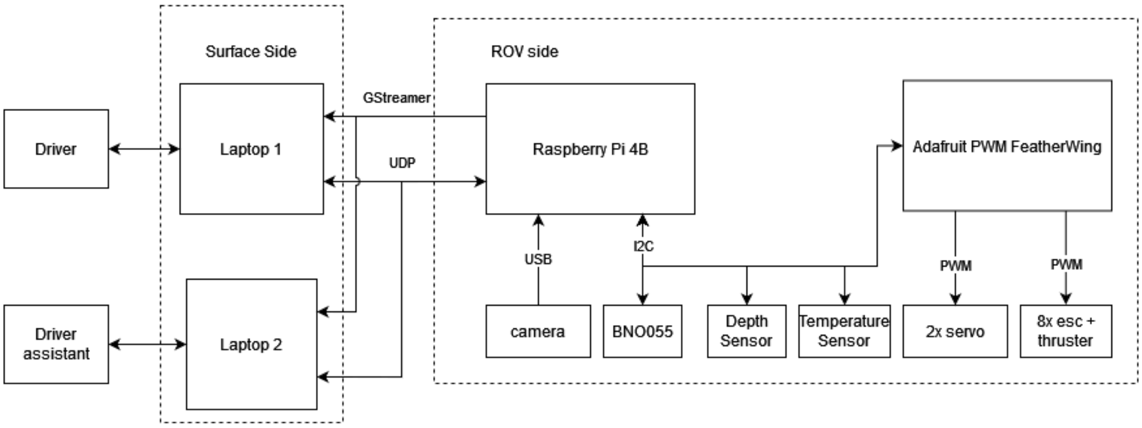



*Fig. 16 and 17 - Dual-laptop setup (top) and diagram of software layout and sensor communication (bottom)*

## Payload and Tools

To complete the 2025 mission tasks effectively, including identifying corrosion on the submerged infrastructure, deployment of components at specific depths, and retrieving thermistors from the base of the pool, Blue Lobster selected sensors and tools to address these tasks.

In previous years, Blue Lobster used one camera for an ROV. However, only having one camera limited the ROV's field of view. With two cameras, the driver could focus on claw and movement-related tasks without repositioning the ROV. As such, Blue Lobster decided to include two cameras in our ROV.

The first camera, a non-waterproof USBFHD06H USB camera, is mounted inside the enclosure and positioned parallel to the side of the ROV frame. This allows us to get a larger view of the surrounding environment, which is useful for navigating and photogrammetry.

Blue Lobster also mounted a more expensive waterproof IP69K exploreHD 3.0 FHD camera by DWE, aimed at a 40-degree angle of depression. Despite the price, the benefits gained from the camera's quality significantly outweighed its cost. Its high definition (HD) fisheye lens increased the driver's field of vision while critically improving the video quality. This is especially important for the claw, as the driver requires a clear view of the claw to see what they are picking up.

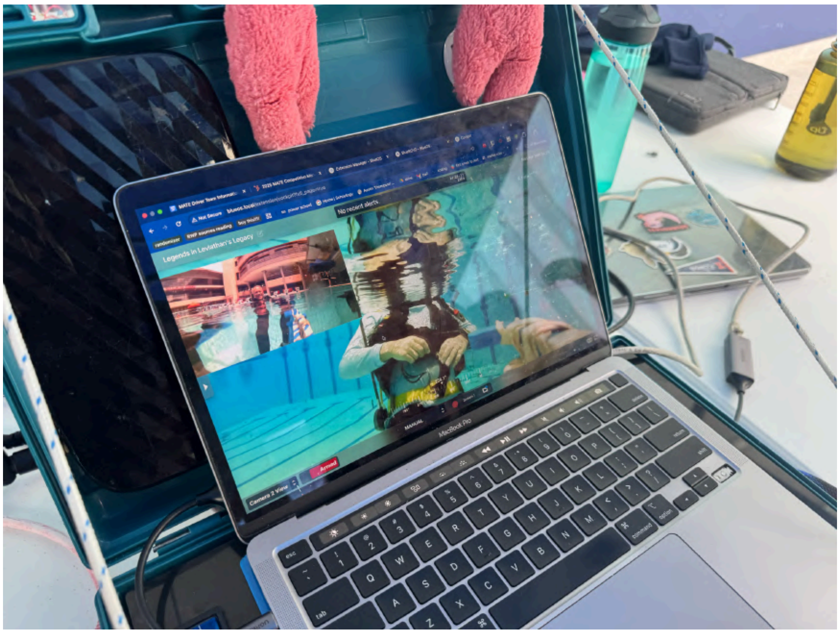


*Fig. 18 - Camera feed from the ROV*

Additionally, to navigate the field more effectively, Blue Lobster implemented PID, a closed-loop feedback control mechanism, by equipping the ROV with the Blue Robotics Bar30 depth sensor and the Bosch BMI088 Inertial Measurement Unit (IMU) located on the Blue Robotics Navigator Board. The depth sensor allowed the ROV to monitor its relative position vertically to the pool floor, enhancing the performance of the ROV in depth-dependent tasks, such as locating the submerged thermistor and positioning near corrosion targets without disturbing the structure, by providing more feedback. The BMI088 IMU enabled precise orientation and stabilization tracking, allowing the ROV to maintain a steady position during visual inspection tasks, such as photogrammetry.

To collect the water sample for task 1, a modified syringe is secured to the claw in the horizontal orientation.

## Cameras and Imaging

Because the driver cannot physically view the ROV while it is active, having low-latency and reliable cameras is essential to ensuring the driver can effectively complete tasks.

Blue Lobster used the DWE exploreHD 3.0, a high-definition underwater camera with an IP69K rating. This rating guarantees protection against high-pressure water jets (80-100 Bar @ 14- 16L/min) from nozzles positioned just 0.15m away, even at temperatures up to 80ºC, making the camera incredibly robust and highly water-resistant (Madhu, 2024). The camera also uses a high-quality 1/2.9″ Sony Exmor™ CMOS sensor for low-light and accurate color operation, which is just as necessary since underwater environments can change quickly, requiring quick auto-stabilizing focus and sharp resolution. In addition, both cameras use H.264 compression for low latency and high-quality streaming at wide angles, ensuring that the operator always has the best quality view possible.

Blue Lobster's imaging system begins by receiving the video stream in a UDP format, which is then decoded using GStreamer. Blue Lobster can process the video data efficiently before displaying it in the auxiliary software.

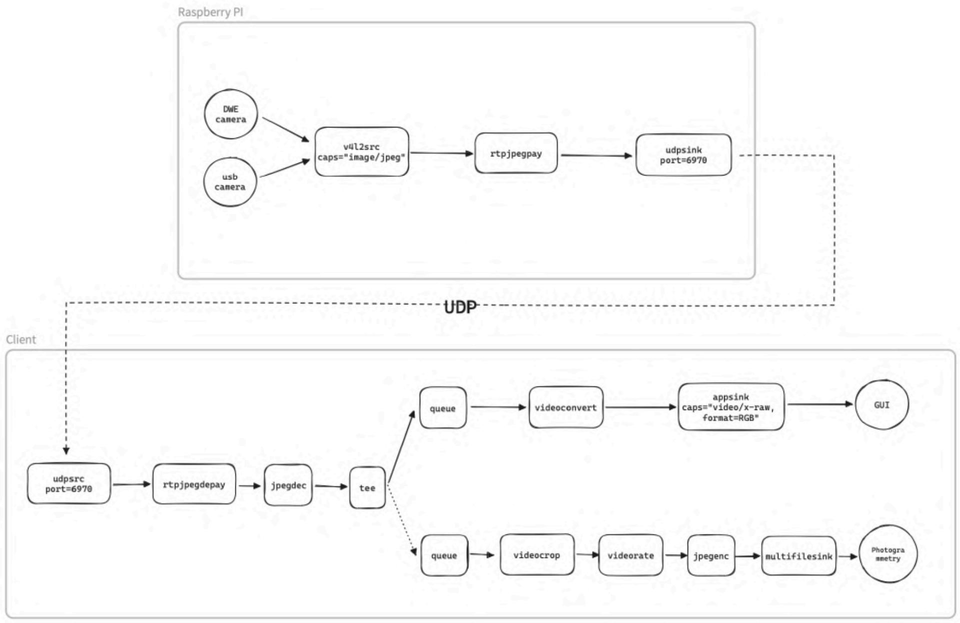



*Fig. 19 - Diagram of the camera in the client data pipeline*

# Testing and Troubleshooting

Blue Lobster looks for simple yet effective changes to troubleshoot issues. Blue Lobster implemented a structured brainstorming and evaluation protocol that facilitated subteam communication. During our weekly meetings, members, officers, and captains would discuss updates from their specific subteams and issues they faced, sometimes demonstrating the issue through a drawing on paper or an online diagram, ensuring to reference mission specifications and experiences in prior years. Some of the proposed ideas, like redesigning the claw, control station, and altering the size of the ROV, were decided upon after implementing a trade matrix referenced throughout this paper, considering functionality, cost, and user friendliness. If a specific design project were approved, particular members from subteams would be assigned a task related to brainstorming and executing it using the Vikunja project board. This allowed Blue Lobster to iterate effectively and avoid repeating mistakes during prototyping.

For example, when testing the ROV in the pool, the team found that the ROV was too slow to compete, at between 0.1 and 0.2 meters per second. First, the software team changed the parameters of the thrusters, and another test run showed that this increased the speed more, but not enough. Further inspection revealed that the primary cause of the lack of speed was the size and weight of the ROV, so Blue Lobster cut down aluminum extrusions to decrease drag. The frame's width and height were reduced from 0.27m to 0.22m and 0.22m to 0.17m, respectively. Subsequent test runs revealed that this change made propulsion easier, increasing maximum velocity by roughly double. This improvement allows tasks to be completed quicker, like inspecting a base structure to identify underwater corrosion. It also assists in moving on to the next task more efficiently. Through this troubleshooting process, Blue Lobster improved the ROV through repeated testing and iterative optimization.

# Waterproofing

## Research

To ensure our waterproofing methods are reliable and cost-effective, Blue Lobster researched and compared different products to find the best fit for our needs. Waterproofing requires several products: an enclosure for all the electronics, O-rings, and a potted penetrator.

Blue Lobster researched several potential solutions for the enclosure and narrowed them down to a few options, including BlueRobotics' 4″ enclosure, ROVMaker Underwater Electronic Enclosure, and RS Electronics' Bopla Bocube. Blue Lobster first ruled out the Bopla Bocube because it lacked sufficient waterproofing for our needs. Next, Blue Lobster ruled out ROVMaker's Underwater Electronic Enclosure because it did not have a locking cord. Reducing the chance of it coming loose or popping off is crucial to enhance reliability. Ultimately, Blue Lobster selected BlueRobotics' 4-inch enclosure due to its reliability and additional safety features, such as the locking cord.

Blue Lobster chose Molykote 111 by DuPont for the O-ring lubricant because of its strong water, heat, and chemical resistance. Although incompatible with a few types of elastomers, it is fully compatible with the O-rings being used on the ROV, so this was not a significant concern. It was priced at 60 SGD per 150g tube, which fitted within the budget.

For adhesives, Blue Lobster selected Loctite Marine Epoxy, a reputable brand that has performed well in previous years. Several other kinds of epoxy were tested, but they all had various issues, whereas Loctite remained consistently reliable for Blue Lobster's needs.

| Waterproofing Techniques | Cost (USD) | Accessibility | Modularity | Reliability |
|---|---|---|---|---|
| WetLink Penetrator | $10.00 | High | Moderate | High |
| Potted Cable Gland | $3.50 | Moderate | Low | High |

*Fig. 20 - Comparative analysis of frame materials—PVC, carbon fiber, and aluminum extrusion—evaluated by weight, cost, durability, and modularity*

Blue Lobster primarily relied on potted cable glands for wires entering and exiting the enclosure due to their reliability and ability to accommodate different wire sizes. They are also cost-effective and were potted with epoxy on the outside, while Molykote 111 was applied to the O-rings in-house.

However, Blue Lobster could not apply epoxy to the power tether cables as it did not bond properly because of the material of the wire's insulator. As a result, another solution was needed. Despite its cost, the Blue Robotics WetLink Penetrator was ultimately chosen because, compared to potted penetrators, WetLinks rely on a compression seal to prevent water ingress. As such, it is compatible with our power cables. Moreover, Blue Lobster had several WetLink penetrators of the correct diameter left over from previous years.

# Build vs. Buy, New vs. Used

With sustainability and cost-efficiency at the forefront of operations, Blue Lobster reused parts from previous seasons' ROVs, as long as these parts remained undamaged. For example, the aluminum extrusions on this year's ROV frame have been dismantled, modified, and reused from last year's ROV. However, design improvements from previous years have rendered some parts incompatible for reuse, such as the new claw and thruster mounts. Additionally, Blue Lobster sought to explore new ideas and experiment with different approaches. In such instances, Blue Lobster creates parts and components in-house through 3D printing and cutting parts in the school's robotics lab. For instance, Blue Lobster recycled an old toolbox in our robotics lab to create our control station. Custom parts also allowed Blue Lobster to cut down on expensive manufacturing/delivery costs and maintain a sustainable carbon footprint. While Blue Lobster aims to manufacture as many parts as possible, crucial parts or parts beyond the scope of Blue Lobster's manufacturing capabilities need to be purchased from reputable suppliers to ensure reliability and quality for maximum ROV performance, such as DeepWater Exploration and Diamond Dynamics.

## Innovations for Cost-Effective Functionality

Blue Lobster prioritized balancing the tradeoffs between developing innovations that strengthened the ROV's performance while minimizing costs. Instead of repurchasing new aluminum extrusions, the team disassembled last year's ROV and redesigned the frame using the same aluminum extrusion components. These extrusions were then cut and reassembled into a lighter, smaller frame to improve speed when deployed with no additional cost. Additionally, leftover WetLink penetrators from previous years are used for waterproof tether seals, eliminating the need to purchase more epoxy and new cable glands.

To reduce environmental impact and material costs, the team repurposed an old toolbox to create a durable and portable control station, eliminating the need to buy a premade casing. This allowed for full internal customization, safe wiring, and emergency stop features, demonstrating Blue Lobster's dedication to developing cost-effective innovations.

# Safety

## Overview

Safety is an important aspect that Blue Lobster takes very seriously during the construction and operation of the ROV because it protects both the robot and the team. Blue Lobster has been focusing on several important safety features.

When working in the lab, proper protection is always used without any exceptions. While in the lab, safety goggles are worn to protect the eyes, and standard DIN EN 352 ear protection is used when working with loud tools to prevent hearing damage (UVEX, n.d.).

MATE requires thruster guards to stop fingers, cables, or debris from entangling in the propellers. The propeller's force can cause injuries or damage to the thruster if something gets caught in it. Blue Lobster also utilizes an emergency stop switch built into the control station that can immediately cut the power to the entire ROV in an emergency. In addition, if too much current flows through the circuit, the 25A fuse required by MATE will blow and cut the power before anything can overheat or get damaged.

Although mission tasks such as the floating solar panel array are simulated, the Blue Lobster approached every task with the same rigor as in the real world. Special caution was taken to inspect all electrical connections before the run and ensure cables and other components remained strain-relieved so no damage could occur to the ROV or environment during this task.

In addition to the requirements implemented by MATE, Blue Lobster also took the initiative to add additional safety features. One such implementation included an integrated fuse box within the underwater enclosure, where each component connected had a fuse based on its power draw under peak conditions. Additionally, distinct polarized connectors for thruster signal, thruster power, and tether power were incorporated into the enclosure to physically prevent human error that could result in injury or damage to the ROV and its components.

All safety protocols are reviewed during mandatory driver team meetings before pool testing, and roles are assigned to ensure compliance with safety standards. The team captains organized weekly meetings for driver team members to review roles and expectations, mandating that every member review the task list and familiarize themselves with it to prevent accidents during deployment from miscommunication. The roles are as follows:

| Role | Primary Team | Secondary Team |
|---|---|---|
| Driver | Austin | Angie |
| Auxiliary driver | Sid | Rebecca |
| Coordinator | Krishna | Aarya |
| Tether manager | Vyju | Jinoo |
| Loader | Nick | Caleb |
| Float manager | Kaito | Veehaan |
| Float controller | Max | N/A |

*Fig. 21 - Assigned roles for secondary and primary driver teams*

## Safety Procedure Checklist

The following checklists are followed before and after every deployment to ensure personnel and equipment safety.

### Construction

| | |
|---|---|
| | All tools and materials are gathered and in good working order. |
| | All thrusters are properly mounted. |
| | No exposed connections |
| | Organized internal wiring |
| | The enclosure is properly sealed with the locking cord and vent plug. |

*Fig. 22 - Construction Safety Checklist*

### Disassembly

| | |
|---|---|
| | Power has been turned off. |
| | Open the enclosure while applying minimal strain to the wires. |

| | |
|---|---|
| | Remove external sensors or tools and store them in protective cases. |
| | Examine structural components for wear or damage and note any necessary repairs. |

*Fig. 23 - Disassembly Safety Checklist*

## Driving

| | |
|---|---|
| **Setup** | Ensure that the power is on before driving. |
| | Check that the strain relief is secure. |
| | Inspect the thrusters and verify no blockage of operation. |
| | Confirm that all power connections are functional and unspool the tether. |
| | Set up the control station, making sure cameras are operational. |
| | During the run, tether managers ensure that the tether is untangled. |
| | After the run, ensure that the ROV is dried before being transported. |
| | Inspect the ROV's structure to ensure no exposed metal or protrusions that could damage the shipwreck model. |
| **Task 2** | First, verify that all electrical connections for the floating solar panel array and onboard systems are properly secured. |
| | Check that the hydrophone and its release mechanism are free from obstructions and that strain relief on the cables is intact. |
| | Confirm that the control station and onboard cameras are operational to monitor the task area continuously. |
| **Float Task** | Power down the float's buoyancy engine circuitry before detaching or reconfiguring float components. |
| | Ensure the float's pressure sensor is calibrated, and the transmitted data is monitored at the control station. |

*Fig. 24 - Driving Safety Checklist*

# Accounting

| (All prices in USD) | Method | Quantity | Budgeted | Actual | Running |
|---|---|---|---|---|---|
| **Mechanical** | | | | | |
| Blue Robotics 4" enclosure (set) | Purchased | 1 | $1,500 | $344.00 | **$344.00** |
| BlueRobotics WetLink penetrators | Re-used | 3 | | $ - | **$344.00** |
| Diamond Dynamic TD1.2 thrusters | Purchased | 8 | | $746.88 | **$1,090.88** |
| Blue Trail SER-20XX Servo | Purchased | 2 | | $430.00 | **$1520.88** |
| DSServo | Re-used | 2 | | $ - | **$1520.88** |
| Aluminum Extrusions | Re-used | 1 | | $ - | **$1520.88** |
| Control Station Box | Re-used | 1 | | $ - | **$1520.88** |
| **Electronics** | | | | | |
| DWE exploreHD 3.0 | Re-used | 1 | $1,000 | $ - | **$1520.88** |
| Blue Robotics Low-Light USB Camera | Purchased | 1 | | $99.00 | **$1,619.03** |
| Blue Robotics Navigator Board | Purchased | 1 | | $539.00- | **$2,158.88** |
| Blue Robotics Depth Sensor | Re-used | 1 | | $ - | **$2,158.88** |
| Blue Robotics Temperature Sensor | Re-used | 1 | | $ - | **$2,158.88** |
| Power Tether | Purchased | 2 | | $42.19 | **$2,201.07** |
| Ethernet Tether | Re-used | 1 | | $ - | **$2,201.07** |
| Fuse Box | Purchased | 1 | | $8.22 | **$2,209.29** |
| Raspberry Pi 4 Model B | Re-used | 1 | | $ - | **$2,209.29** |
| Control Station Power Distribution | Re-used | 1 | | $ - | **$2,209.29** |
| Router | Re-used | 1 | | $ - | **$2,209.29** |
| Laptop | Re-used | 2 | | $ - | **$2,209.29** |
| **Other** | | | | | |
| Travel expenses | | 11 | $30,000 | $26422 | **$28,631.29** |
| Singapore American School Covered | | | -$2,500 | -$1,944.29 | **$26,422** |
| **Total** **(Including Funds Covered By School)** | | | | | **$26422** |

# Acknowledgments

The One Degree North MATE team sincerely thanks Marine Advanced Technology Education II for allowing us to evolve as engineers as we construct and engage in the MATE ROV competition program.

*Fig. 25 - MATE II logo*

Additionally, we extend our heartfelt appreciation to the Singapore American School for generously providing us with the financial support, resources, and workspace necessary to participate in this competition.

*Fig. 26 - Singapore American School logo*

Finally, we wish to convey a special acknowledgment to our club sponsors, Paul Booth and James Harvey, along with Simone Torreon, for their unwavering support and invaluable mentorship throughout our journey, guiding us through triumphs and challenges.

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# Appendix

## Appendix 1 - SID