SOMBRERO Technical Report

By Over-Defined Limited

Presented to
MATE ROV COMPETITON

Hong Kong

CHIEF EXECUTIVE OFFICER
MAK Ka To Grade 11

ELECTRONIC MANAGER
GAO Yi Grade 11

SOFTWARE MANAGER
CHUNG Toi Lam Grade 10

MECHANICAL MANAGER
YEUNG Shing Kit Grade 9

ELECTRONIC ENGINEERS
LAW Pak Yin Grade 9
HUANG Kaijia Grade 9
HE Chi Yuen Grade 9
WONG Sum Lok Brian Grade 9
CHU Siu Hang Grade 8
WU Tsz Wah Grade 8

MECHANICAL ENGINEERS
LEUNG Hok Him Grade 9
LAM Chun Ho Grade 9
CHEUNG Ka Kit Grade 9
LAM Ming Hon Grade 8
WU Tsz Shing Grade 8

SOFTWARE ENGINEERS
YEUNG Sheung Lam Grade 9
YAN Yongzhe Grade 9
PANG Bo Grade 9
LAW Chak Him Grade 9
KONG Yeuk Nam Clinton Grade 8
LAU Evan Grade 8

SUPERVISED BY
Mr. HUI Shek Hin, Mr. HUNG Kam Fai, Mr TSE Man Lok

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Fig. 1 Company Photo

Front Row From Left to Right :
LAW Chak Him, CHUNG Toi Lam,
YEUNG Shing Kit, MAK Ka TO, GAO Yi,
PANG Bo, WONG Sum Lok Bria n

Back Row From Left to Right :
WU Tsz Wah, LAM Ming Hon, WU Tsz Shing,
CHU Siu Hang, LAU Evan, LAM Chun Ho,
HE Chi Yuen, KONG Yeuk Nam Clinton,
LEUNG Hok Him. LAW Pak Yin,
HUANG Kaijia, CHEUNG Ka Kit,
YEUNG Sheung Lam, YAN Yongzhe

Over-Defined

I. Abstract

Over-Defined is a company of twenty-one dedicated students who are passionate about underwater remotely operated vehicles (ROV). Working collaboratively across mechanical, electrical, and software divisions, Over-Defined is proud to introduce our ROV, Sombrero. It is designed to embrace environmental, social, and governance (ESG) efforts to create a sustainable future on our ocean.

To accomplish this task, Sombrero has been equipped with mission-specific manipulators to address the challenges of climate change, promote the use of renewable energy, closely monitor ocean health and work to heal and protect our aquatic health. Sombrero was constructed using hand tools, custom-made microelectronics, and advanced communication protocols under strict safety measures and careful project management. With months of quality control and prototyping, we have established Sombrero as the most suitable ROV to fulfill the request of the proposal released by MATE ROV and the global community.

This technical document will describe the design, process of development, and construction methods used to establish Sombrero as a leading technology to create a sustainable future for the ocean.

II. Project Management

Company Structure, Planning, and Procedures:

Our company is formed with members that are skilled in several aspects. Having a good understanding of the robotics system and electricity, with prior experience in ROV and land robotics (Mini Robocon), each member is separated into 3 teams as listed below and assigned with suitable duties.

- Mechanical Team
- Software Team
- Electrical Team

The figure below shows our team's makeup:

All Engineers

- Completing Documentation
- Brainstorming Ideas for ROV design and completing construction.

Mechanical Engineers

- Designing the ROV using SOLIDWORKS
- Building the ROV frame and adding additional features
- Preparing tether and strain relief
- Designing several mounts and thruster guards
- Designing controller frame

Electrical Engineers

- Building ROV circuit boards and connecting wires
- Assisted in assembling the ROV
- Designing the wiring pin sheet
- Designing ROV controller

Software Engineers

- Programming the ROV thrusters with Arduino and C++
- Programming the servos
- Programming wired and wireless communication with Arduino
- Assisted in assembling the ROV

The chief executive officer (CEO) is the highest-ranking executive in the company. It is responsible for managing operations and resources, leading the organisation toward achieving its goals and objectives. Three department managers assist the CEO in managing engineers by taking responsibility and setting tasks for the engineers in their own department. Frequent communication happens between every member of the company which helps every member to learn and improve as one.

III. Design Rationale

A. Design Evolution

We had paid close attention to the technological development and robot design of the ROV in question. We worked hard to design our robot and were successful in removing unnecessary parts, resulting in a lightweight ROV for continuous operation.

After reviewing the aims of earlier competitors' ROV designs, our engineers started the design process by selecting our ROV's objectives. Following great consideration, we decided on the following goals: We develop our problem-solving skills and gain experience in the ROV competition.

B. Innovation

Our team opted for SOLIDWORKS as the tool to design a versatile claw with enhanced flexibility. With the aim of streamlining the controller's tasks, we focused on creating a claw that could adapt to a range of functions. During the design process, we made numerous adjustments to perfect the claw's functionality for the ROV to excel in the competition. Multiple versions were crafted to accommodate incremental changes in pursuit of the optimal state for the claw.

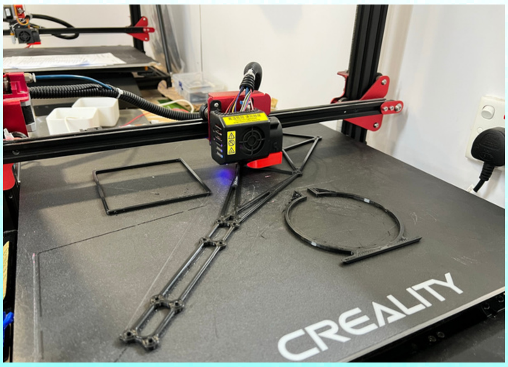


Fig.2
3D printing

The majority of our ROV's components have been fabricated using 3D printing techniques, and the fillet function in SOLIDWORKS has been utilized to ensure that there are no sharp edges present.

We used tough PLA instead of traditional PLA or ABS as our printing material. First, Tough PLA weighs light ,and offers greater durability and strength compared to traditional PLA, and is more reliable than ABS for larger prints, which in turn minimizes the likelihood of our components cracking, breaking, or warping.

Secondly, Tough PLA is recyclable, which makes it an environmentally friendly option for those looking to reduce their carbon footprint. Tough PLA can also achieve complex geometries, it can produce high-quality parts with high accuracy and precision.

C. Problem Solving

Our team sets tasks by making a Gantt chart, where all the tasks and processes are clearly listed. All members are required to record their process by filling out a process log. If a member is absent, the log can allow other members to keep track of the task and handle it, saving more time and doing our work efficiently.

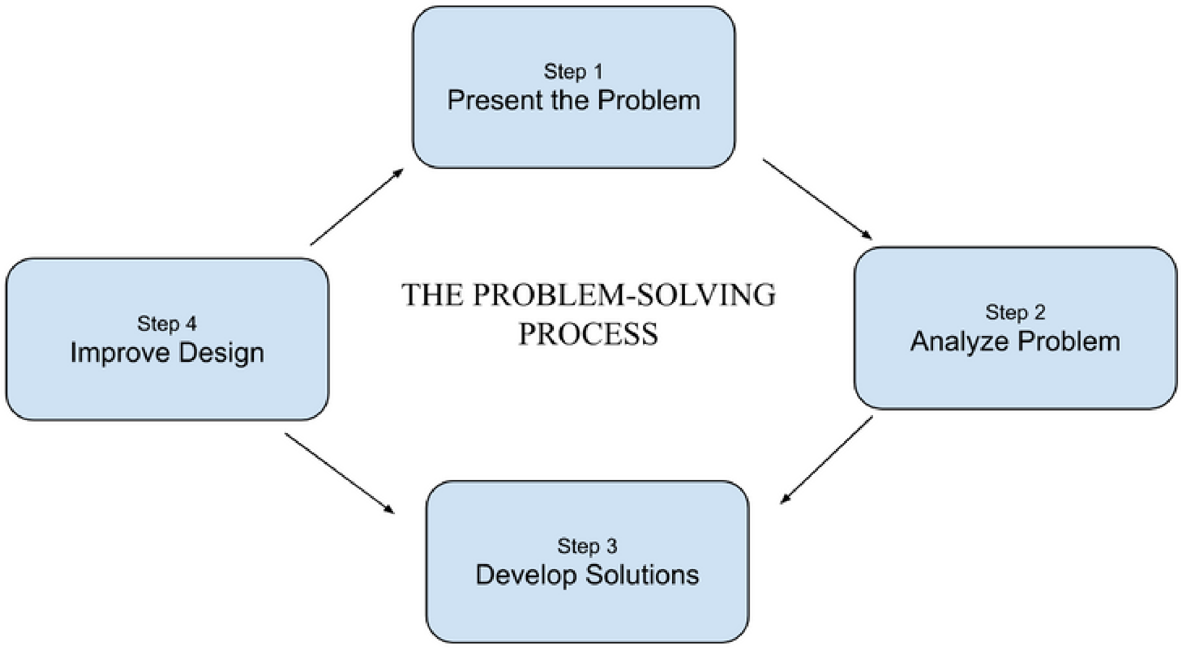
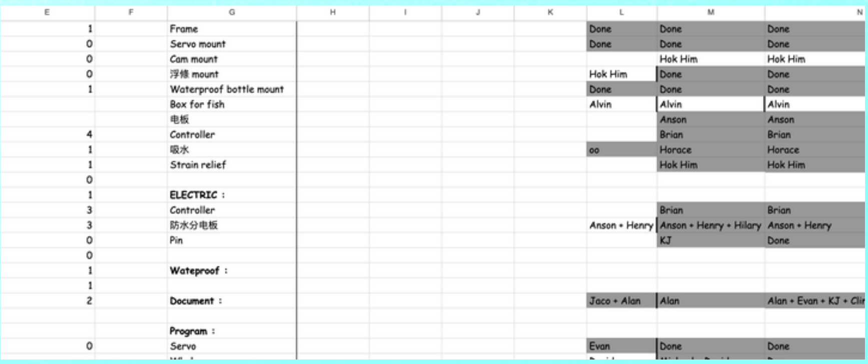


Fig. 3
Problem-Solving Chart

Furthermore, meetings in the lab and online can allow us to solve day-to-day operational challenges, for example, CAD, 3D printing, programming, and electric wiring challenges.



E	F	G	H	I	J	K	L	M	N
1		Frame					Done	Done	Done
0		Servo mount					Done	Done	Done
0		Cam mount						Hok Him	Hok Him
0		浮條 mount					Hok Him	Done	Done
1		Waterproof bottle mount					Done	Done	Done
		Box for fish					Alvin	Alvin	Alvin
		电板						Anson	Anson
4		Controller						Brian	Brian
1		吸水					oo	Horace	Horace
1		Strain relief						Hok Him	Hok Him
0									
1		ELECTRIC :							
3		Controller						Brian	Brian
3		防水分电板					Anson + Henry	Anson + Henry + Hilary	Anson + Henry
0		Pin						KJ	Done
0									
1		Wateproof :							
1									
2		Document :					Jaco + Alan	Alan	Alan + Evan + KJ + Cli
		Program :							
0		Servo					Evan	Done	Done

Fig. 4
Gannt Chart

Fig. 5
Teammates having a meeting in lab

D. Vehicle Core System

i. Mechanical

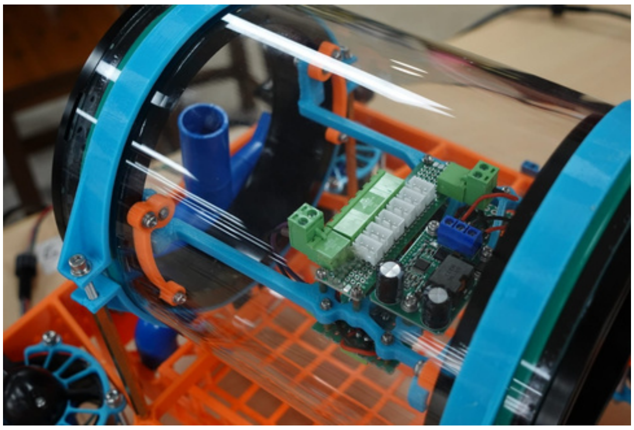


Fig. 6 Bird's-eye view of Sombrero

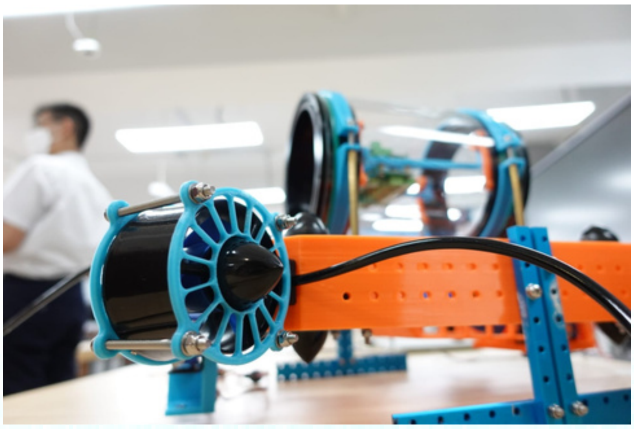


Fig. 7 Side view of Sombrero

Frame

Our company evaluated multiple materials and their costs/benefits before selecting Polylactic Acid (PLA) to 3D print the ROV frame. PLA was chosen due to its durability, functionality, and ability to be 3D printed into customizable designs.

To minimize weight while maximizing maneuverability, a single-layer ROV frame was constructed instead of a multi-layer design. This single, lightweight yet rigid layer improves maneuverability and controllability. The operator experiences an intuitive, facile control of the ROV, able to navigate and manipulate it with greater ease, dexterity, and finesse. Simultaneously, the ROV's handling and stability are optimized for performing various underwater tasks.

Bouyancy

For trim and buoyancy, we incorporated floatation aids (pool noodles) and ballast (weights).

Buoyancy control via floatation (pool noodles) and ballast (weights) tunes neutral buoyancy, where the ROV’s buoyancy matches its weight. In this state, the ROV is neutrally buoyant, static in water, and requires minimal propulsion to maintain position. From here, subtle control inputs induce translational movements and rotational manoeuvres.

Fig. 8
Pool noodles and weights of Sombrero

Claw

Our team first used aluminum hooks to design the claw, but our teams found that the claw had less resilience and flexibility in completing the tasks. Therefore, we decided to use SOLIDWORKS to design two multi-functional claws to increase their flexibility. To make the tasks much easier and better for the controller to do the tasks, our team decided to make a horizontal claw and a vertical claw. Lots of adjustments were made while designing the robot, we made a total of 13 versions because of some little adjustments to make the claw the best state for the ROV to participate in the competition.

The string holder in our claw is able to complete tasks such as remove biofouling from the foundation and collect a water sample from above the coral head.

The crossing hook can do tasks such as lifting the container and returning the container to the surface, side of the pool.

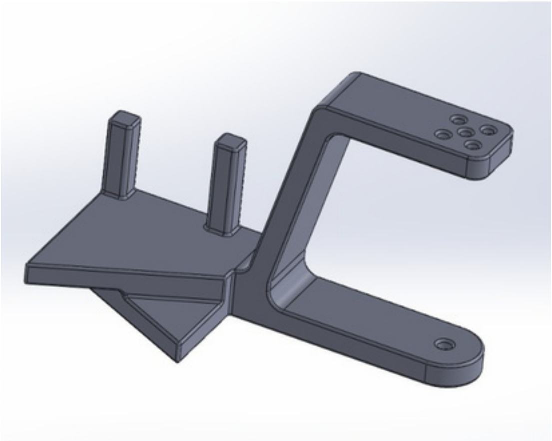


Fig. 9
Multifunctional claw

Thruster

Using a total of 8 thrusters provides more power for the ROV, allowing it to move faster in both vertical and horizontal directions. The additional thrusters also help provide better balance and stability, preventing the ROV from flipping over.
With increased speed and maneuverability, the ROV can complete tasks in less time. By reducing the travel time between starting points and objectives, the ROV can accomplish more tasks efficiently.

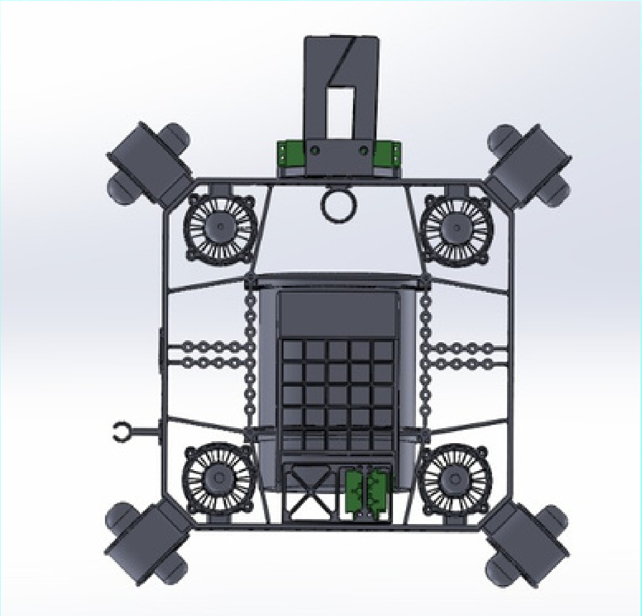


Fig. 10
Thruster positioning of Sombrero

Power Distribution

A distribution board is used to distribute the 12V to feed the thruster and the buck converter, which converts 12V to 5V and distributes the 12V to provide the camera, Arduino, and controller. A 15V fuse is used to prevent the machine from being damaged when the boards are operating under different currents.

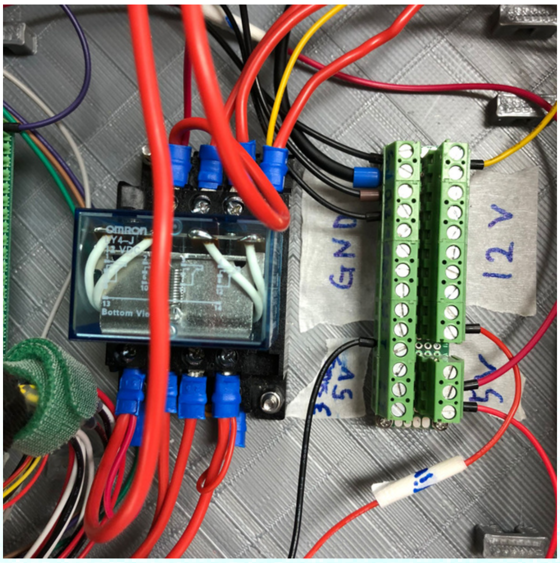


Fig. 11 Power distribution of Sombrero

Wiring

Our electrical wiring designs for the ROV are based on a system integration diagram (SID), which closely resembles our previous ROV wiring designs. The SID is a crucial element in our ROV as it enables us to plan our wiring in a neat and organized manner. Its purpose is to clearly indicate the power source and distribution components through appropriate wiring, cabling, and circuitry, making it easier for our team members to wire the ROV. We follow voltage compatibility standards to prevent any potential issues that may arise.

Electric boards

Our ROV system comprises several integral components designed to facilitate efficient and reliable operation. One such component is the soldered plain electric hole boards that ensure clear power distribution to various components in both the ROV and controller. These boards also function as a signal routing system, allowing analog and digital signals from thrusters, servos, joysticks, and other components to be routed through them. Proper shielding is provided to prevent crosstalk or noise, which can also work for short-circuit protection and overvoltage protection. Control signals for thrusters and servos are also routed through these circuit boards.

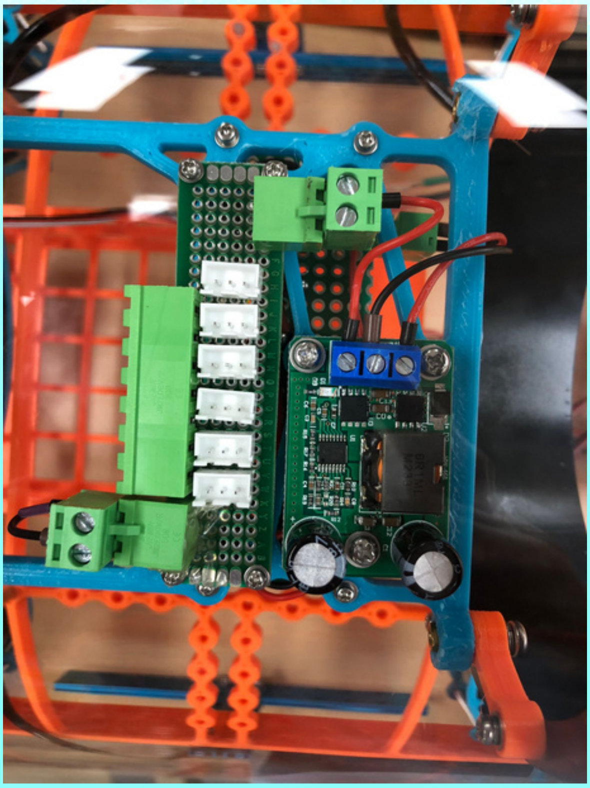


Fig. 12
Electrical boards of Sombrero

Camera

Our ROV is also equipped with three cameras, aimed towards the front, the claw, and the bottom respectively , providing the operator with a clear view of their surroundings while manoeuvring the ROV. By following the Serial Digital Interface (SDI) standard, the video can be displayed with high-quality resolution and clarity on a four-square grid screen. Three squares display the video while one square remains blank.

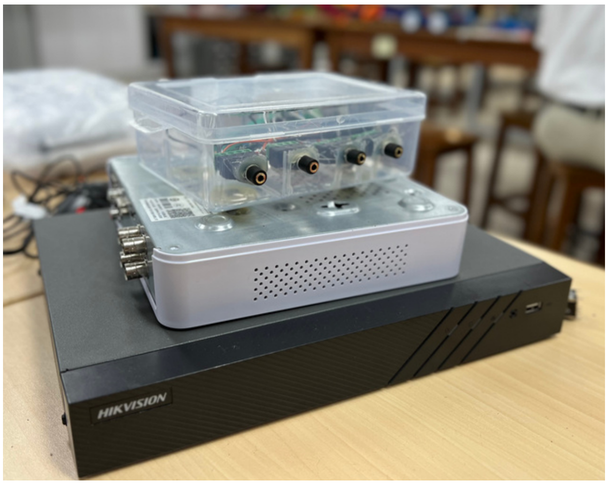


Fig. 13
Video system

Controller

Another vital component is the controller, featuring two joysticks used by the operator to send analog commands interpreted by the controller. The controller also includes a potentiometer for controlling servos, switches to control other components, buttons to operate auxiliary functions, and an emergency button that halts the entire circuit. A start button is present to initiate the ROV.

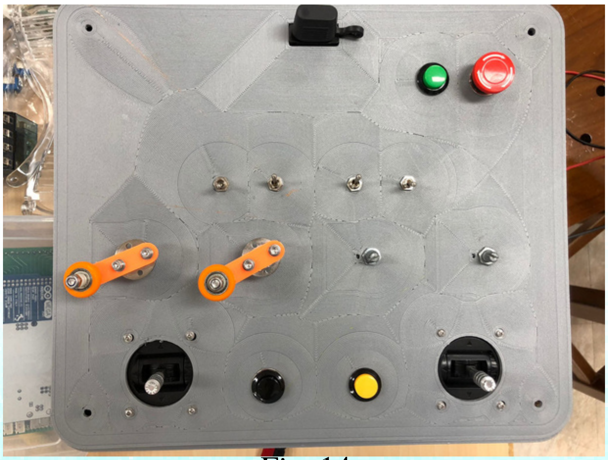


Fig. 14
Controller box of Sombrero

Tether

The tether for our ROV comprises three parts: power, SDI camera signal, and component signal (for components within the ROV). It contains two power cables, a positive and negative power cable, three SDI signal cables, and 11 component signal cables in total.

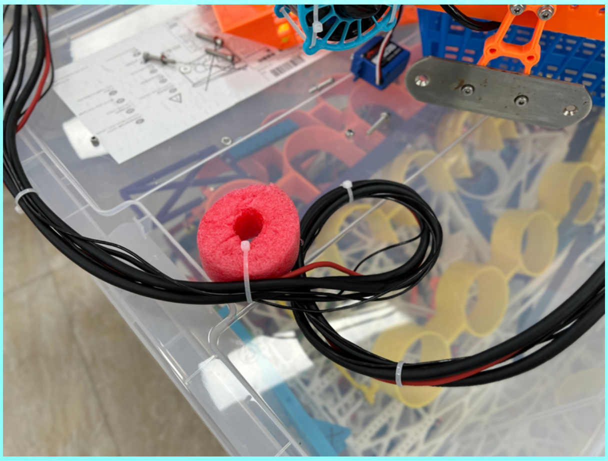


Fig. 15
Tether with Float

iii. Software

Control System

Our goal in developing software was to create a dependable control system for our ROV, Sombrero. To accomplish this, we opted to use the Arduino MEGA platform and programmed it in C/C++. We devised mathematical formulas and scenarios to translate joystick values into thruster speeds, while also mapping potentiometer readings to specific servo angles to control the claw's movements.

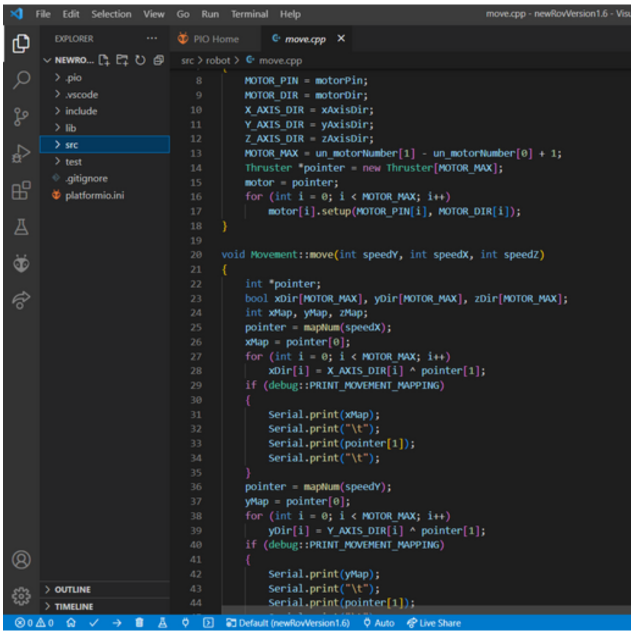


Fig. 16

Small part of our coding

Wireless Communication

For the wireless communication component, a pair of Arduino Nanos are utilized for both transmitting and receiving. The transmitter and receiver models employed are both nRF24L01. The transmitter Nano is connected to a transmitter module with an onboard antenna, which provides a superior transmission range, and it utilizes a 2.4GHz frequency for communication with the receiver. Additionally, the transmitter Nano is outfitted with a DS1302 Real Time Clock (RTC) module, which supplies the current time to the transmitter and transmits it to the receiver. The receiver Nano receives the time signal and displays it on an LCD screen, along with the company name and the UTC time acquired from the Nano.

Automatic Stabilization

Initially, our team planned to integrate a gyro to enable automatic stabilization of the ROV via PID. However, during prototype testing, we discovered that Serial communication was not practical over long distances. We also considered employing a sonar sensor for automatic positioning, but it turned out to be too expensive to purchase. As a result, we had to abandon the idea of utilizing PID with gyros and Sonar sensors.

E. Mission Specific Tasks

i. Task 1 : Marine Renewable Energy

Claws

In order to carry and transport props for specific missions, our team decided to design a pair of reliable and multi-functional claws with Servos and complete the task manually. In the beginning, our team used aluminium hooks for the claw design, but we found that the claw had less resilience and flexibility in completing the task.

Therefore, we decided to use SOLIDWORKS to design two multi-functional triangular claws with poles to increase their flexibility. The triangular claws are responsible for manipulating objects such as the solar panel, and the poles are used to remove the biofouling. To make the tasks easier to accomplish, lots of adjustments were made while designing the robot, we modified the designs for a number of times in order to allow the claw to be in the best state for the Sombrero.

Fig. 17
Some of the old versions of the claw

ii. Task 2: Healthy Environments from the Mountains to the Sea

Lifting Mechanism

To lift the heavy container from the bottom of the reservoir, additional lift was required with the thrusters. Various options were considered, such as a parachute-type or cylindrical-type lift bag that could be automatically deployed after being engaged. However, after careful consideration, it was decided to use a water-sealed bag with a manual pump and a long tube. Once the container was collected with the claws, air was pumped into the bag onshore using a manual pump, causing the bag to inflate and provide additional lift. This approach was deemed the simplest and most reliable solution for the task at hand, as it allowed for greater control and flexibility during the lifting process. By using a water-sealed bag with a manual pump, the necessary lift was generated without the need for additional complex mechanisms or automation. In short, this approach ensured the safe and efficient retrieval of the heavy container from the bottom of the reservoir.

Fry releasing Mechanism

The releasing mechanism that has been implemented to facilitate the underwater retrieval and release of fry is powered by servos. These servos are responsible for opening the tray and releasing the fry into their new environment. The use of servos in this mechanism allows for precise control and reliable operation, making it an ideal solution for this task. The HD camera that has been installed next to it also helps in monitoring the opening of the box by providing a clear view of the process.

Overall, the combination of the releasing mechanism and the HD camera ensures the safe and efficient release of the fry, without causing any harm to them or their environment.

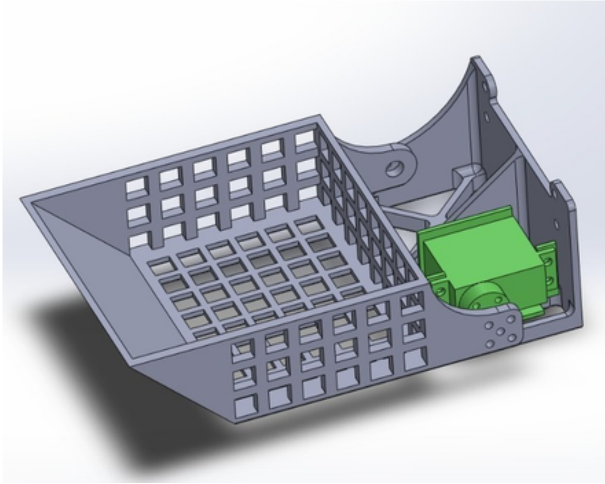


Fig. 18
CAD rendered photo of Fry Releasing Mechanism

Hawk

We have equipped our ROV with a 3D-printed hawk to assist us in carrying the heavy container during tasks. It prevents the container from falling out during the transport process. The use of 3D printing ensures that our hawk does not possess any sharp edges, unlike the conventional hawks available in the market.

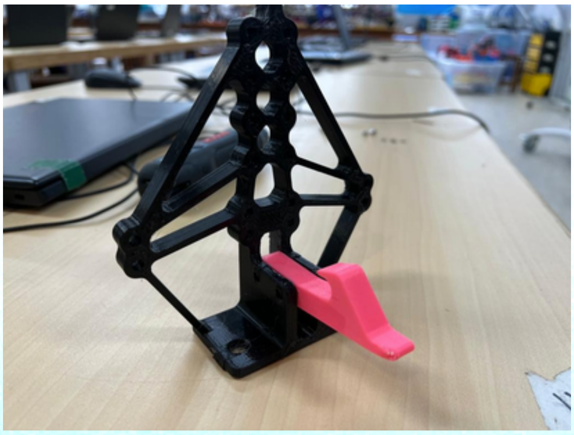


Fig. 19
3D-Printed Hawk(In Pink)

Pumping Mechanism

Our company has developed a new pumping mechanism that has been installed on Sombrero. This mechanism involves inserting a needle filled with probiotics into a container, which is then pumped with water using a syringe driven by servos. To ensure accuracy and precision, we have incorporated a camera into the mechanism for positioning. Our design is based on proven mechanisms used in various industries, such as the medical and agricultural sectors, where precise dosages are crucial.

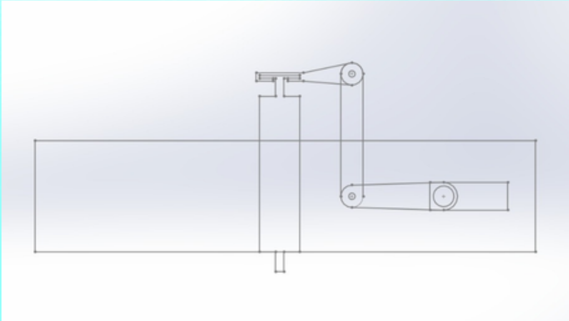


Fig. 20
Draft of Pumping Mechanism

iii. Task 3: Antarctica Then and Now - Endurance22 and MATE Floats!

Wireless Communication

In order to allow the float to communicate with the mission station, a pair of Arduino Nanos are utilised for both transmitting and receiving data, installed on the float and the controller at the mission station. The transmitter and receiver models employed are both nRF24L01. The transmitter Nano is connected to a transmitter module with an onboard antenna, which provides a superior transmission range, and it utilises a 2.4GHz frequency for communication with the receiver. Additionally, the transmitter Nano is outfitted with a DS1302 Real Time Clock (RTC) module, which supplies the current time to the transmitter and transmits it to the receiver. The receiver Nano receives the time signal and displays it on a LCD screen at the mission station, along with the company name, and the UTC time acquired from the Nano.

Vertical Profiling

Initially, our team planned to complete the vertical profiling with a buoyancy engine. However, we had to abandon the design due to technical difficulties. We utilised dual thrusters with a total maximum thrust of 19.62N to perform vertical profiles autonomously for specific duration. The system uses hall sensors to start the vertical profiling with a magnet and switches.

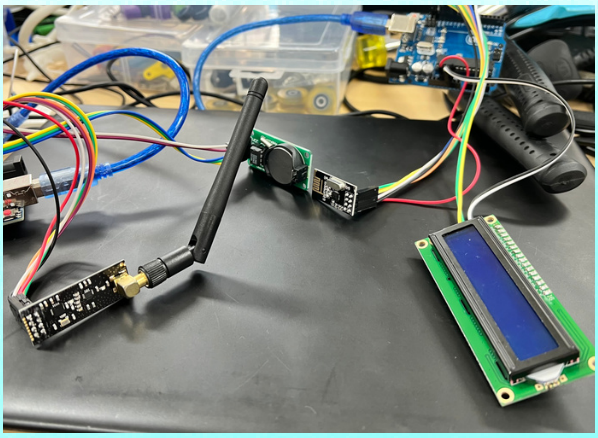


Fig. 21
A pair of Arduino Nanos

Fig. 22
CAD Rendered Photo of Vertical Profiling Float

F. Payload Tools

Our team initially opted to create a variety of claws to accommodate various jobs. We later learned that doing such a thing would raise the budget needed for cameras and could be inconvenient for the person in charge of the robot. As a result, after consulting with the team, our organization created a multi-functional hook that could do the majority of CAD tasks.

The water pipe replacement or the buoyancy module can be held and carried in the rectangle region which we designed before.

The hydrophone can be carried by the string holder while clamped. It can be recovered to assess the data. Algal and encrusting marine vegetation can be removed with our crossing hooks.

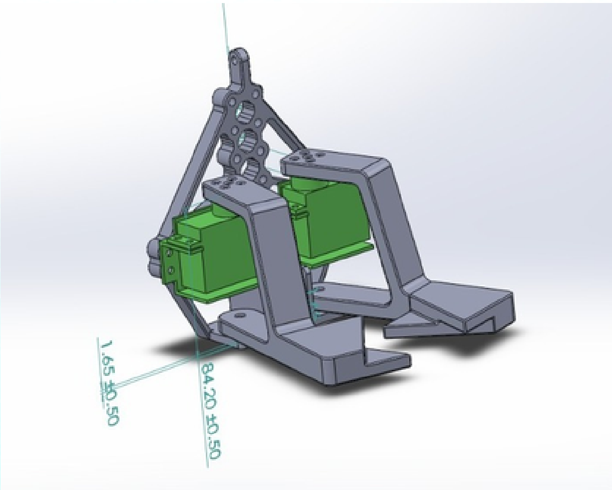


Fig. 23
CAD rendered photo of Claw Mechanism

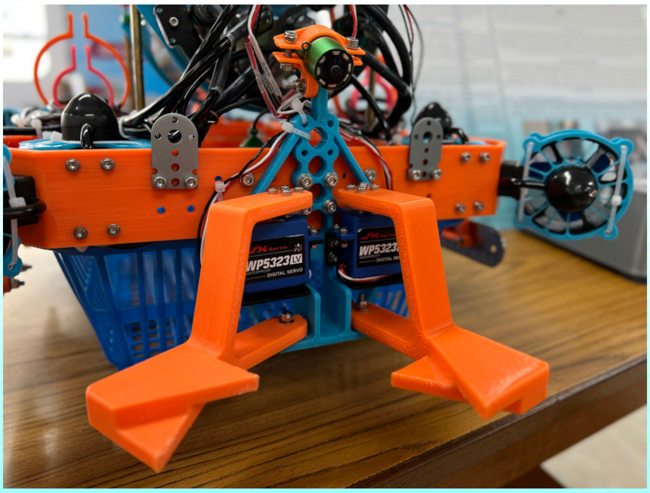


Fig. 24
Assembled Claw Mechanism

G. Build vs Buy

While we have the capability to improve our ROV, we must establish a budget to avoid lacking sufficient funds to purchase other materials for our ROV and spending too much money on our ROV. For instance, if we acquire materials, we may lack enough cash to buy other necessary items like servos, bearings, etc.

Consequently, our team has issued a reminder for ourselves to try not to lose the materials we currently possess, as well as prevent going over budget. To keep this reminder in mind, we would store materials in boxes and use labels to identify items in case we mix them up. Additionally, our classroom has a notice that reminds us not to misplace things and go over budget. This reminder has helped us become more responsible for caring for supplies and maintaining a tidy environment instead of a messy area to avoid losing components.

In summary, though we can improve our ROV's capabilities, we must establish a fiscal limit to ensure we have enough funding for other ROV materials and do not spend too much on enhancements.

H. Testing Protocol

To enhance the speed and efficiency of our ROV, our team established a procedure to test the ROV for any errors or defects after its construction. If any breakdowns or water leakages occurred during the process, we would immediately halt the protocol and promptly fix the issue to prevent further damage. This protocol has enabled us to improve and advance our ROV, leading us to achieve our goal more quickly than in previous builds.

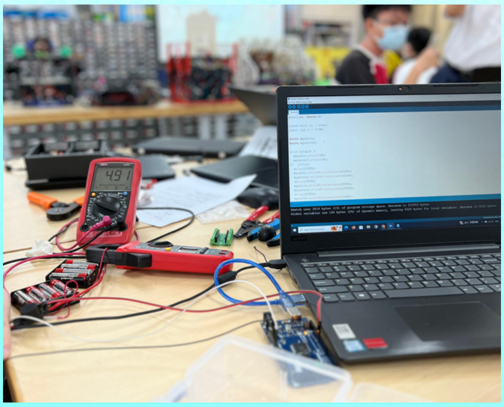
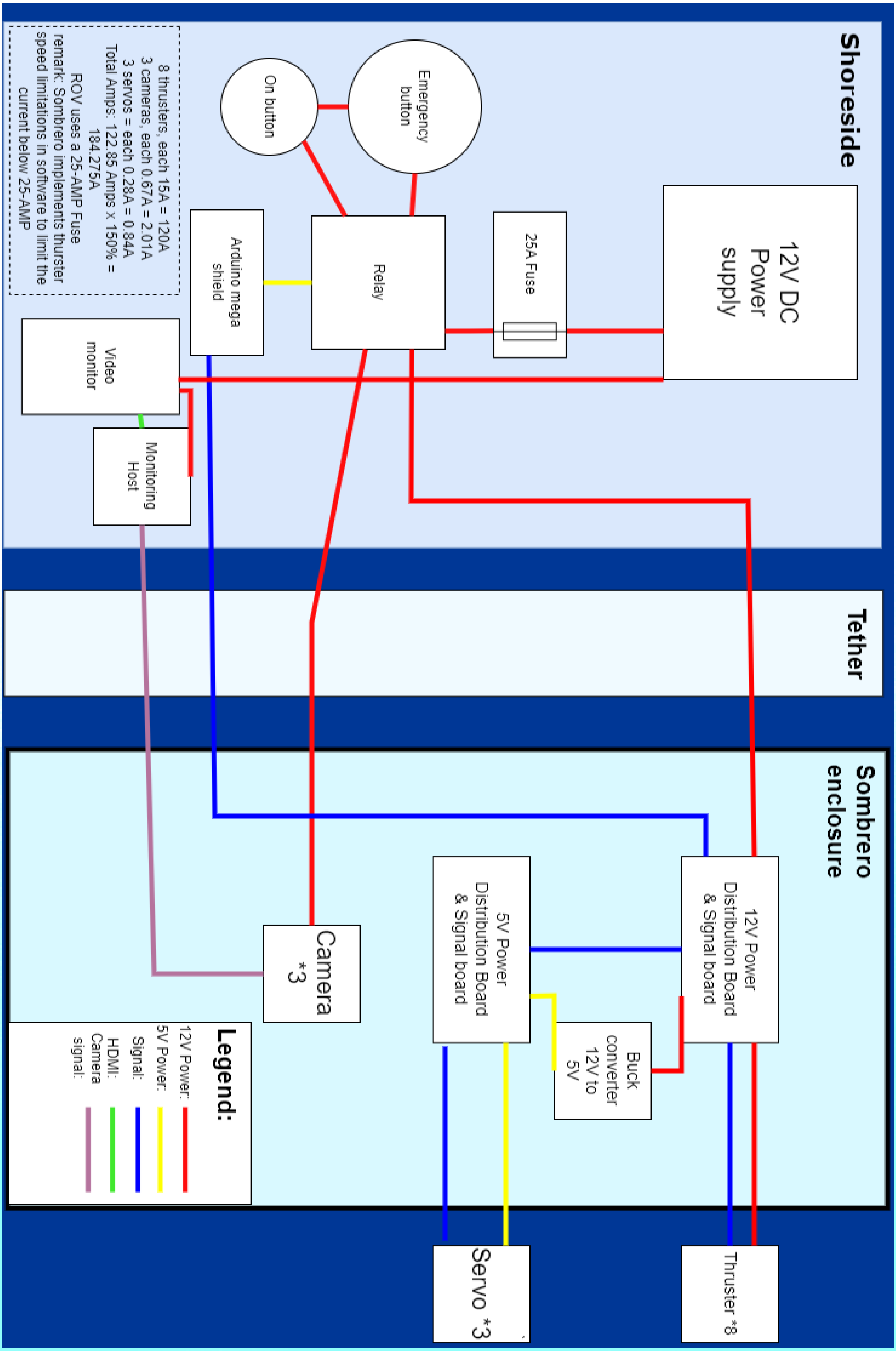


Fig. 25
Testing with Arduino

During our testing protocol, we meticulously inspect the ROV for any signs of water leakage or surface damage. If the ROV passes these checks, we proceed with testing by performing basic tasks such as utilizing the ROV claws to retrieve objects, testing the maximum distance the ROV can travel before losing signal, and checking for any damages or minor water leaks.

IV. System Interconnection Diagram



V. Safety

i. Philosophy

Safety is of the utmost importance in any ROV project. To maintain a safe working environment, Over-Defined Ltd implemented rigorous safety policies across different aspects of different developments. Over-Defined Ltd ensures that all employees gain sufficient knowledge and skills to prevent accidents while conducting work.

ii. Equipment and Laboratory Safety

To make sure that our ROV is as secure as possible, Over-Defined Ltd uses additional safety measures. As a relatively new team, we've realized that maintaining a productive working environment requires us to be highly conscious of our surroundings.

For storage, matching labels are used to maintain a clean workplace and prevent inadvertent harm to instruments or users. After use, all of the tools, desks, and equipment must be cleaned. All employees are required to have training where they learn how to use the tools and equipment in the laboratory safely and correctly. To minimise the occurrence of accidents, ensuring clean working conditions and safety protections are essential. To uphold these standards, regular cleaning and maintenance are required, and employees must strictly adhere to wearing safety goggles, gloves, and masks while operating with hazardous or poisonous equipment. Additionally, all laboratory equipment is labelled and stored on shelves, and employees can easily locate different components through a spreadsheet. Overall, these measures are critical to ensuring a safe and productive laboratory environment for everyone involved.

Fig. 26
Safety practices by team member

iii. Mechanical Safety Features

The main goal of introducing mechanical safety measures is to protect our ROV from harm. To accomplish this, our company has installed strain relief features on both the ROV and its tether to prevent the controller from becoming dislodged and the cables from pulling the ROV. We have also utilised fillets in SOLIDWORKS to smoothen the corners and edges of our 3D prints, ensuring that the ROV does not have any hazardous edges. Moreover, we have developed thruster protectors that reduce the potential damage to the ROV's thrusters. It significantly decreases the chances of the ROV encountering any damage.

iv. Electronic Safety Features

To guarantee the immediate cutoff of our ROV's power supply when needed, our company has incorporated a 25A fuse and an emergency button that is linked to a normally closed 2A relay. When the emergency button is engaged, the relay opens, preventing the ROV from moving even if the emergency button is disengaged. To further aid our team in debugging, we have utilized wire labeling in our setup. Moreover, our monitor is powered by 120VAC and the SDI camera multiplexer is equipped with a 120VAC to DC supply. AC supplies are properly labeled and separated from DC. These measures ensure the safety and reliability of our ROV's power supply, allowing for efficient and secure operations.

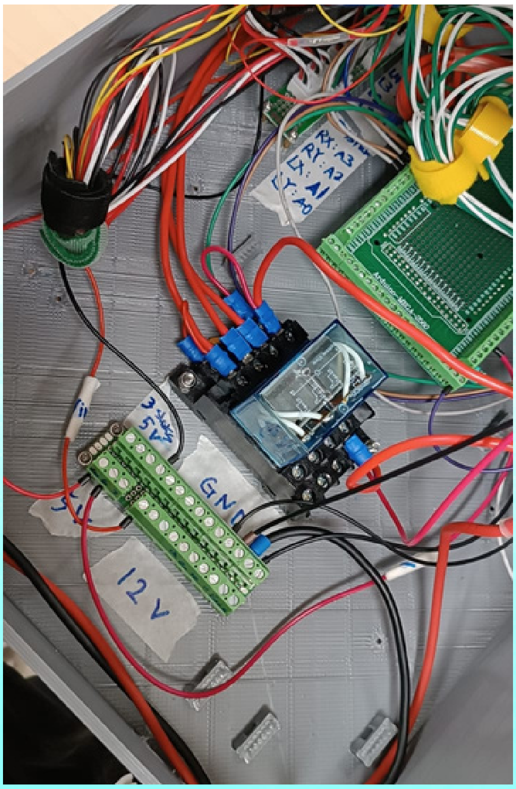


Fig. 27
Wiring with clear labels

VI. Testing and Troubleshooting

We placed the robot for testing in a big water-filled container.

We started testing with the thrusters and our first version of the ROV to let our software engineers become more familiar with programming ideas and techniques for operating the ROV. If we find a new issue, the software will be changed immediately.

We improvised the program and the frame with minor tweaks until the robot was ready to compete with the others. We run into problems with the robot despite our efforts to enhance it. If there is an issue, we would take notes of it and try to solve it in various ways.

We will always ask our teachers for help if we cannot find a solution on our own.

After perfecting the frame design for the final product, we take photos of the robot for the poster.

Fig. 28
Company Member Troubleshooting

VII. Budget and Costs Projection

The majority of our budget is allocated to electronics and mechanical parts. For electronics, most of the budget was spent on purchasing cables, tethers, digital cameras, and a waterproof case. For the hardware, most of the cost was spent on the construction and manufacturing of our ROV's frame, the rest of the budget was spent on buying tools and materials including servos, thrusters, and 3D-printing materials.

Over-defined has developed a comprehensive budget plan and conducted a thorough review of previous materials to promote efficient budgeting and sustainable use of resources. We have also explored the possibility of reusing tools and materials through proper maintenance and updates. After summarizing, HKD11703 was spent for Over-Defined as development, which is within the budget of HKD12000. The budget projections and cost breakdown of Sombrero are attached in Appendix A and Appendix B.

VIII. Challenges

Throughout the development process of our ROV, various complex challenges arose requiring substantial time, resources and effort to overcome. Weight management and maintaining proper buoyancy were crucial hurdles, necessitating numerous iterations, investments in higher strength materials, and rigorous testing to achieve the ideal balance.

Cable management also presented difficulties, necessitating clear labelling, organising, and routing of all wires and tethers to guarantee safety, prevent tangles or damage, and facilitate troubleshooting.

Ensuring a robust yet reconfigurable design, powering the system efficiently, developing intuitive controls and high visibility, controlling costs, adapting to diverse environments, improving reliability and meeting regulations simultaneously introduced conflicts that demanded innovative solutions.

Numerous imposing obstacles stood in the path, threatening to derail progress at every turn. Yet determination could not be quelled, and perseverance against difficulties did not cease. Slowly but steadily, solutions emerged through diligent problem-solving.

IX. Lesson Learnt

Over the year, our company has had many opportunities to learn and grow. One of the most significant areas of growth has been in the development of our team, and the importance of working together efficiently to achieve our goals. We have learned that when we work as a cohesive unit, we are able to accomplish much more than we could as individuals.

Time management is another area that we have focused on and improved throughout the year. We have learned the value of planning and prioritizing our tasks, and how to make the most of the time we have available. By managing our time effectively, we have been able to meet our deadlines and deliver high-quality work to our clients.

Problem-solving is a third area where we have gained valuable knowledge. We have learned to approach challenges with a positive attitude and to think creatively to find solutions. By working through problems together, we have been able to overcome obstacles and achieve our objectives.

Overall, the lessons we have learned this year in teamwork, time management, and problem-solving have been invaluable. By focusing on these areas, we have been able to improve our efficiency, productivity, and success as a company.

Fig. 29
Teammates teaching each other

X. Future Improvements

As part of our ongoing efforts to improve the capabilities and reliability of our system, we have identified several areas where upgrades to our software and hardware can have a significant impact. One of the key areas we are focusing on is the stability of our system during operation. To address this, we plan to incorporate a gyro into our system, which will provide improved stabilization and enable auto-stabilization to keep our system steady and ensure accurate data collection.

Another important area where we plan to make upgrades is in communication between the controller and the ROV. By incorporating Ethernet connectivity, we can establish a more seamless and reliable connection between the two components, enabling faster and more efficient data transfer. This will also allow us to implement more advanced control features, such as remote operation and real-time monitoring of the ROV's performance.

Overall, we believe that these upgrades will significantly enhance the performance and capabilities of our system, enabling us to continue to deliver high-quality results to our clients and advance our research in underwater exploration and monitoring.

XI. Acknowledgements

Over-defined are incredibly grateful for the support of the following organizations and individuals who have contributed to the development of Sombrero:

Fukien Secondary School — for the continuous support, sponsorship and resources

HUNG Kam Fai and TSE Man Lok — our supervisors, for their consistent guidance in technical and non-technical aspects

HUI Shek Hin — our mentor, for his guidance and technical help throughout the development of Sombrero

MATE Center — for organizing the 2023 MATE World Championship, providing a platform for the community to learn about marine technology, and promoting STEM education around the world by solving real life problems

The Institution of Engineering and Technology, Hong Kong (IET HK) — for organizing the 18th IET/MATE Hong Kong Regional of the MATE ROV Competition and educating the Hong Kong public on marine technology

XII. Appendix

A. Proposed Budget

Category	Description/Example	Budget(HKD)
School Funding	From Fukien Secondary School	12000
Total Income		12000
Research and Development	Mechanical	950
	Electronics	750
	Software	750
Mechanical Development	ROV Frame	750
	Thrusters	3000
	Cameras	1000
	Sensor	750
	Electronics	750
Control Box	Waterproof Box	2000
	Electronical parts	400
Mechanical Development	Waterproof Cylinder Box	900
Total Expenses		12000

B. Cost Projection

Category	Type	Description/Example	Budget(HKD)
Hardware Components	Reused	Thruster (10pcs)	2590
	Purchased	Communication Sensors	123
	Reused	Tether	204
	Reused	Camera (4pcs)	752
	Reused	3D printed ROV frame	750
	Reused	Wires	588
	Purchased	Servos	806
	Reused	Waterproof cabin	1864
	Purchased	32-75 inch screen	3180
	Purchased	DVR monitoring host	269
Hardware Components Sub-Total [1]			11126
Control Box Components	Reused	Joystick	150
	Reused	Emergency Button	27
	Reused	Electric Wires	400
Control Box Components Sub-Total [2]			577
Total Cost of Sombrero			11703

From above, total expenditure is within budget for this fiscal year.