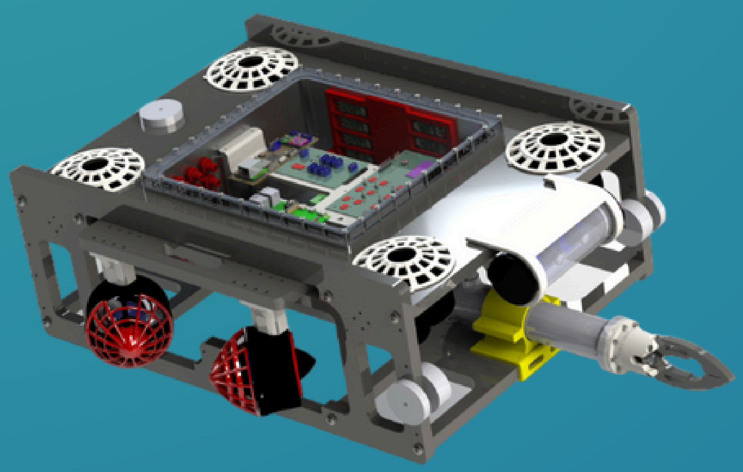
PoliTOcean

MATE ROV COMPETITION

Technical Report 2023/24

Team PoliTOcean



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Abstract

PoliTOcean consists of **sixty multicultural** students who are passionate about underwater robotics and ocean preservation.

The company has **improved the previous Remotely Operated Vehicle** (ROV) prototype '**EVA**' in order to create a reliable product with a high engineering impact.

Extensive collaboration between mechanical and electronic division has yielded a compact and elegant ROV with a simplified and reliable arm in situations that require timely intervention. The software division also experimented with ROV simulation and sensor filtering for research and development of new solutions.

With the combined efforts of PoliTOcean's members over thousands of man-hours of planning, development, testing and with its modular frame, expandable electronics, and extensible software platform, EVA is purpose-built to dynamically respond to the ever-changing global environmental challenges.

In this technical document, we outline the design and development journey of our ROV, highlighting how EVA proficiently tackles a diverse range of real-world tasks.

1 - All the 60 Team PoliTOcean students members

PoliTOcean

Teamwork

Briefly Overview

Our team, PoliTOcean, is a unique **mixture** of talented individuals from Politecnico di Torino, consisting of engineering and design students who are **passionate** about creating underwater robotics and ROVs, all driven by a common goal: **to create something to be proud of**.

Vision, Mission an Values

Our vision is to become a pole of excellence for ROV ideation among students **in Italy**, aligning with our mission of raising awareness about **underwater pollution**. We aim to inspire the **younger generation** of high school and university students to actively engage in addressing this social issue and utilize our **skills** to contribute to a better world. In our work environment, we uphold strong values such as passion, diligence, and mutual respect, which serve as the cornerstone of our endeavors.

Company Organization

Our organizational structure has **evolved** into a divisional model to align with the modularity of our product. We now operate across four distinct divisions led by a Team Leader and a General Manager : MATE ROV, R&D , Growth and Operations and Communication.
Each division focuses on specific **tasks** and **objectives** tailored to its area of expertise.

The **MATE ROV division** is dedicated solely to tasks and competitions related to the MATE ROV project. Here, our team members channel their efforts into optimizing performance and achieving success in competitions.

In the **R&D projects division**, we collaborate with **external firms and associations** to explore new materials and technologies. This division serves as a **hub for innovation**, fostering partnerships that drive progress in underwater robotics.

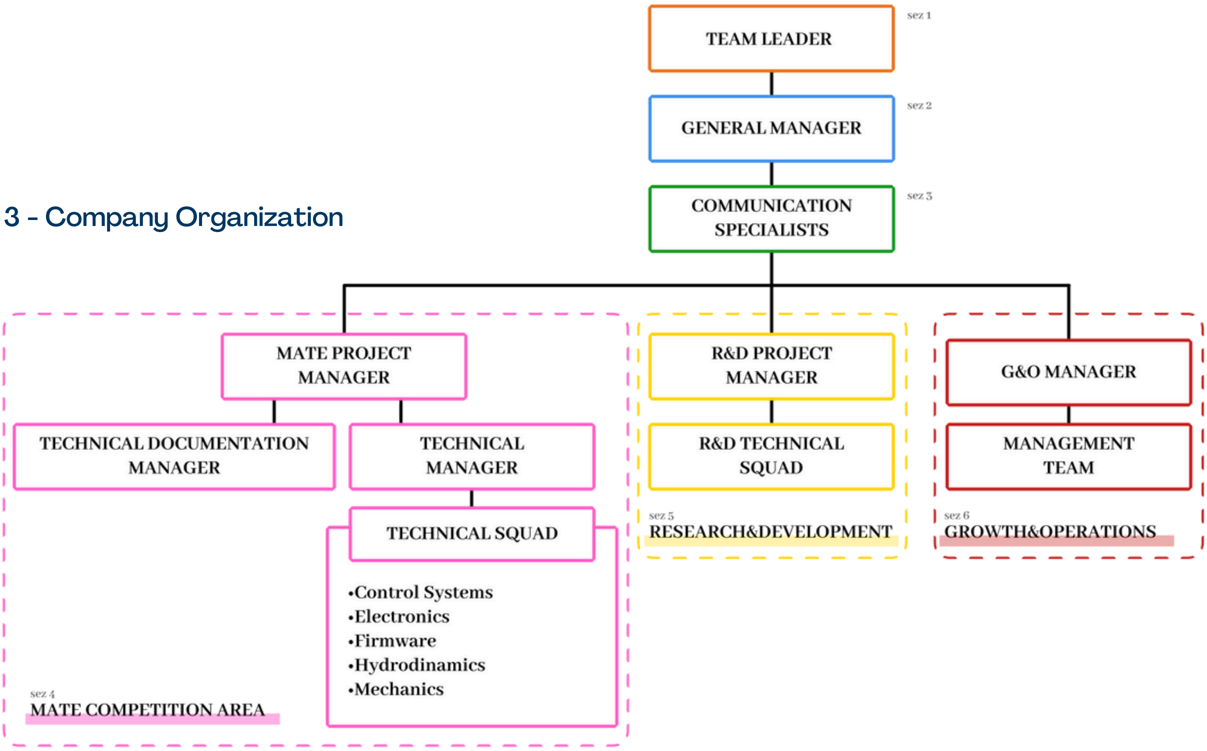
2 - PoliTOcean at Maker Faire 2023 in Rome

PoliTOcean

The **Growth and Operations** division oversees all operational aspects of our team. From managing **purchases** and **warehouse logistics** to **cultivating experiences** and **securing sponsorships**, this division ensures the smooth functioning and expansion of our team over time.

Communication remains a crucial aspect of our organization, spearheaded by our dedicated communications team. Through social media and design initiatives, we continue to **engage with our audience** and promote our mission.

3 - Company Organization



Goal Setting and Tasks Management

At the **beginning of each year**, we establish our team goals and devise a strategy to achieve them.

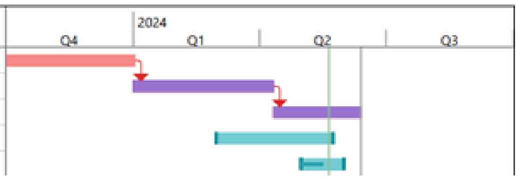
These overarching objectives are then tailored to each department, with a comprehensive **Gantt Chart** outlining **key milestones** to guide our progress throughout the year.

To manage specific tasks, we employ a **Kanban system**, allocating responsibilities to team members accordingly. Task prioritization is facilitated by the Eisenhower Matrix, ensuring optimal time and resource utilization. Weekly departmental meetings are convened to monitor **workflow** and address any bottlenecks.

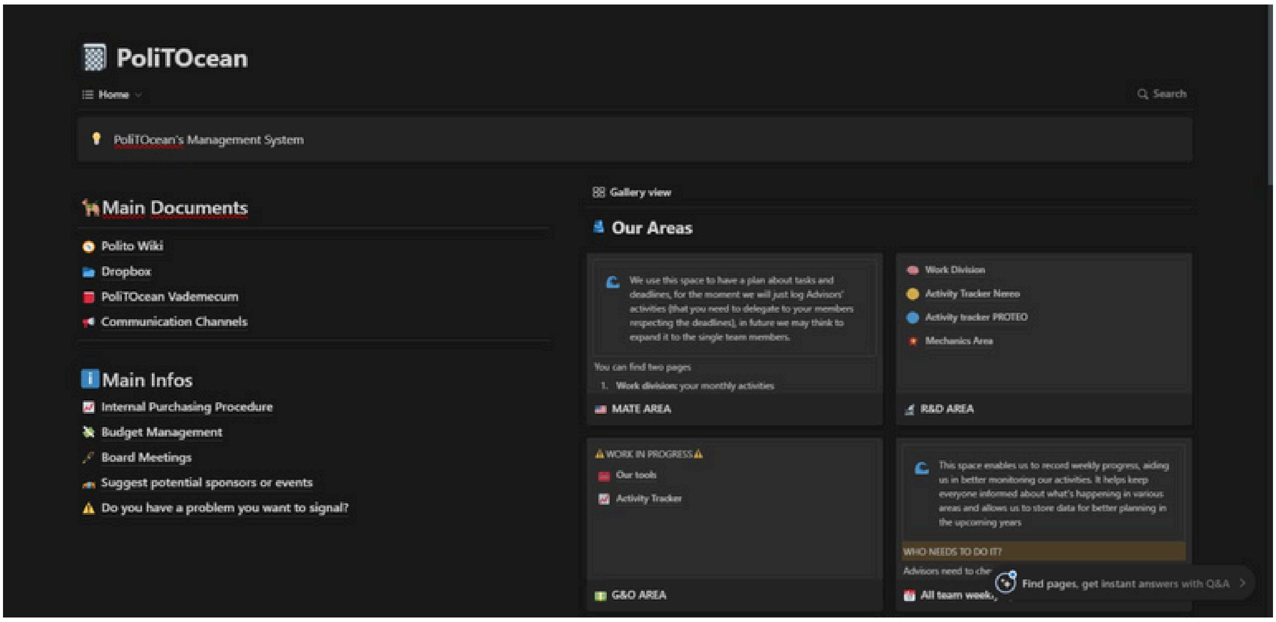
For **seamless collaboration**, we utilize Dropbox for document storage and real-time collaboration. Our new software, Notion, replaces Monday.com and serves as a versatile platform for creating customizable activity schedules, including **Gantt Charts and Kanban boards**.

Monthly all-team meetings provide a forum for progress updates and **cross-departmental communication**, ensuring alignment with our collective objectives. This structured approach enables us to maintain a proactive stance in our work and uphold our commitment to excellence.

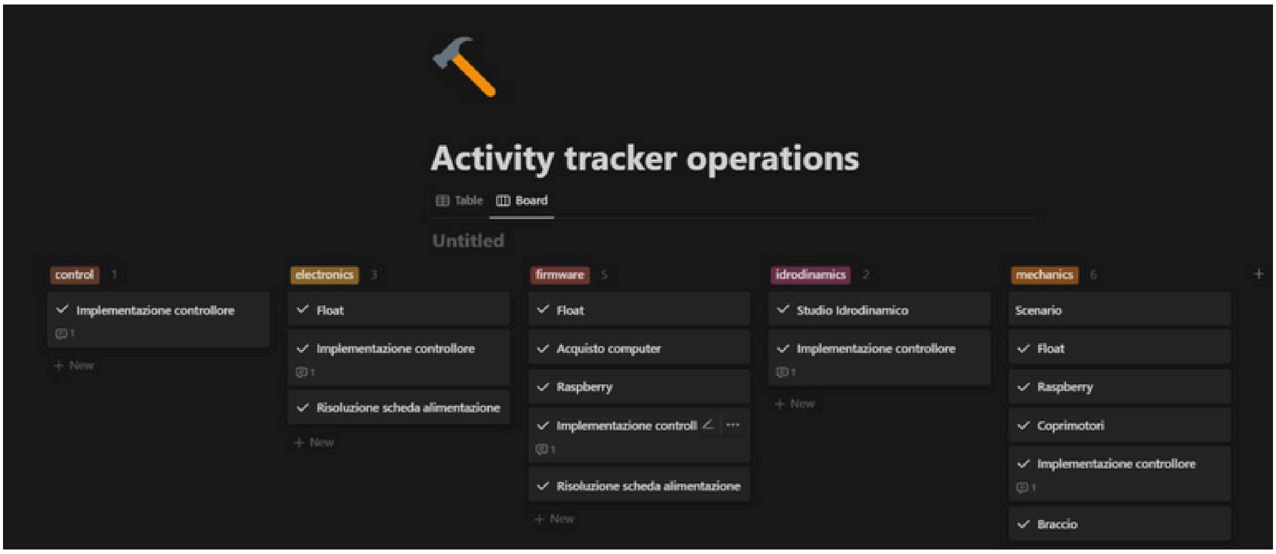
ID	Task Mode	Task Name	Duration	Start	Finish
1		Maintenance Operations	67 days	Sun 01/10/23	Mon 01/01/24
2		Specific Tasks Training	73 days	Mon 01/01/24	Wed 10/04/24
3		Pool Training	45 days	Thu 11/04/24	Wed 12/06/24
4		MATE ROV Documents	60 days	Fri 01/03/24	Thu 23/05/24
5		Engineering Presentation	23 days	Wed 01/05/24	Fri 31/05/24



4 - Gantt Chart for outlining key milestones and improving the workflow.



5 - Internal Management System on Notion



6 - Activity Tracker on Notion

Design Rationale

EVA is our latest designed ROV. The **starting point** was identifying the necessary sistems and looking for a structure that could accommodate them all. The **chassis**, made of HDPE, is a compromise of lightness and performance achieved through topological optimization techniques. The choice to mount 8 motors makes all degrees of freedom available to us and at the same time allows effective and **refined operation of the controller** to regulate stability.

To interact with the environment we chose a **centered arm** equipped with rotating grippers. It is a simple, effective, lightweight and **easy to control** solution. 3 cameras, 2 front and 1 bottom, allow you to properly visualize your surroundigs and carry out any activities involving graphic shots.
The heart of EVA, inserted **centrally** in the frame, is the rectangular pod made by CNC in metal.
The position **balances** the structure and the type of material allows us to have optimal thermal relief of the boards.

This construction solution was the result of a long work of improvement and choice of the best solutions, in order to create a product that is not only high-performing and reliable but it also has a simple operating logic.

7 - Front-side and back-side ROV.

Design Evolution

When embarking on the **design** of a new ROV, the company's primary objective is to create a product that excels in **reliability** and **performance**.

Engineers leverage insights from **previous prototypes**, meticulously analyzing their strengths and weaknesses to optimize past experiences and address any identified shortcomings.

EVA is the culmination of nearly two years and a half of **study** and represents a remotely piloted vehicle specifically tailored for recovery and repair missions. The current version incorporates numerous improvements over its predecessors.

This year we focused on improving the whole system of the ROV to make it more efficient, reliable and cheap to produce, we achieved this by optimizing the electronic design in the rov, eliminating unnecessary pcbs to simplify the system and changing the power board for a new one enabling our new iteration of Eva to be simpler to assemble and to do maintenance on while maintaining the same capabilities of the previous iteration.

Frame

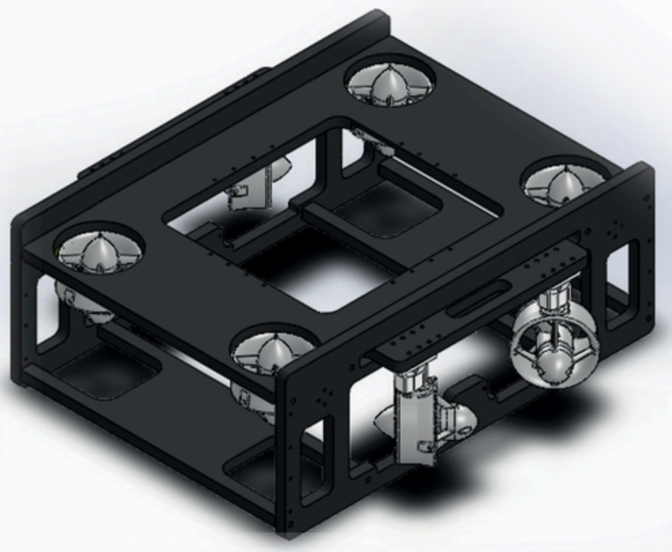
Eva's frame has been designed to obtain a stable and robust structure. The design of the various components was done in Solidworks (*6).

This allowed us to perform several **FEM simulations** to choose the material that met our requirements, minimized disturbances in the thruster's flow, and reduced the weight of the structure. After testing with different materials, we found that HDPE was the best solution.

Although it has **lower tensile strength** than materials like PVC or nylon, HDPE has a lower water absorption rate, a large strength-to-density ratio, and a significantly lower cost.

The frame was made by machine due to the material's ease of processing. The **structure** consists of five parts: an upper panel, two side panels, and two lower panels. These were then connected to each other by screws (M6) and threaded inserts.

The overall footprint is **565 mm long**, **498 mm wide**, and **220 mm high**, with each panel being 15mm thick to maintain frame integrity, the complete ROV has a weight of **18.20kg**.



8 - Frame of the ROV

Electronic Housing

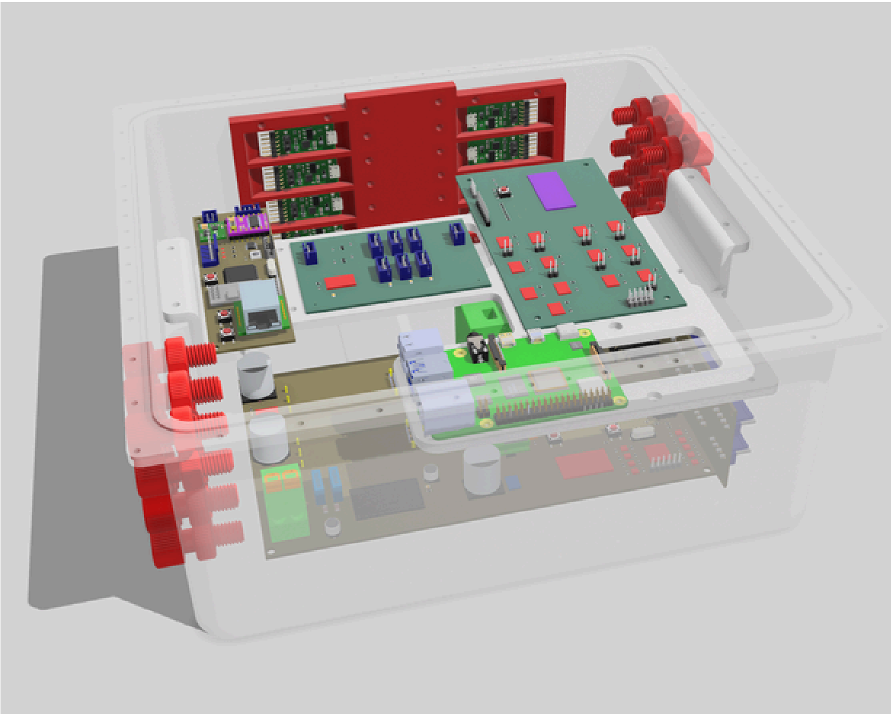
EVA's electronic housing consists of a box-shaped enclosure (260x280x110mm) made of 7075 T651 aluminum alloy milled into shape. It has 24 holes placed symmetrically on the front and rear, divided into two groups of 12.

The **holes** are equipped with M10 penetrators that allow cables to pass from the box to the utilities, including thrusters, cameras, and the power source.

The upper closure of the box is made of a flange and a **15 mm-thick plexiglass panel**, with 56 and 40 M3 holes respectively. The flange is used to seal the box to the chassis through 16 M3 screws, while the panel is attached to the box through 40 M3 holes.

Aluminum 7075 was chosen for its high mechanical properties and ability to dissipate heat generated by electronic boards' operation. The inner bottom of the box has tappings suitable to house **M2 screws** for the two largest electronic boards, while a PLA support with M2 holes is available for positioning the other three boards.

Compared to previous models of circular boxes, the **simple and functional design** allows easy installation, maneuverability, and replacement of any damaged parts, as well as better internal cable management.
The box and closure in **plexiglass** have been designed to ensure safe handling through the joint of the edges.



9 - Electronic Housing

Propulsion

EVA is equipped with 8 **T200 Blue Robotics thrusters** made from tough polycarbonate plastic and marine grade 316 stainless steel. In order to **achieve a stable motion and control** four thrusters (2 clockwise, 2 counterclockwise) are set in the corners (for Z DOF) and the others four (2 clockwise, 2 counterclockwise) on the sides with a 45° angle inclination (for XY DOF).

The T200 are the most efficient, powerful and best value for money thrusters from Blue Robotics.

Voltage usage is set at 12 V for two different reasons:
1. From 48 V power supply to 12 V usage we have a 92% conversion efficiency
2. For our thrust requirements (2.9 kgf) 12 V is the most efficient voltage/power ratio

Buoyancy

Our goal in designing the ROV is to achieve a nearly **neutral buoyancy state**. In this condition, there are two advantages.
The ROV, being nearly neutral, still **remains positive**, so in the event of malfunction shutdown, there is no need to apply a pulling force via the umbilical to recover the vehicle.
The second advantage is the **attainment of lower power required** by the motors to stabilize the ROV at the desired depth, reducing the likelihood of overheating of electronic components.

Topside Control Unit

This year we decided to use a PC instead of a control unit built by us.
This decision was taken in order to ensure the safety of the pilot and to ease the usage of the control system. The ROV is remotely controlled by an xbox controller connected to the PC via an USB and it sends and receives information via ethernet cable.

10 - Personal Computer and joystick

Electronic Systems

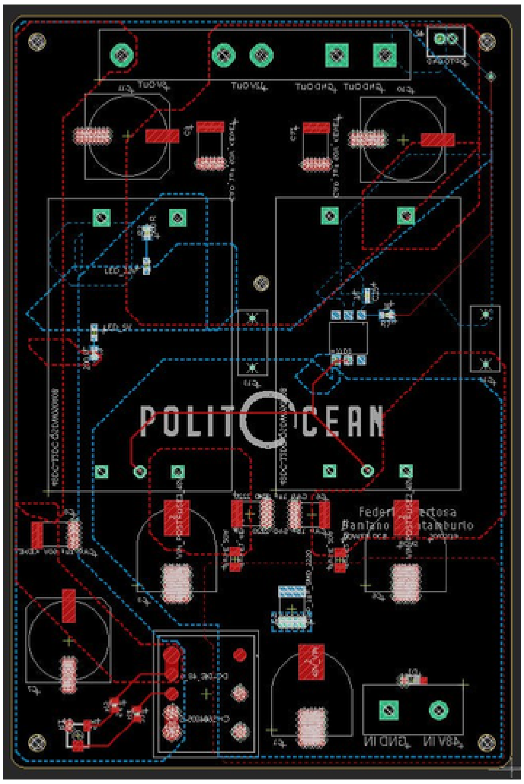
Power Distribution

EVA is powered with a **48V/30A supply** from shoreside. Before reaching the overall electronics, the input power is processed by a custom power PCB, on which are placed **2 QSDW050A0B Barracuda III Series 48V-12V DC-DC converters** working in parallel, providing both up to 600W. In addition, there is also a 48V-5V DC-DC converter.

This **conversion step** is necessary because EVA's electronics needs 5V supply for Raspberry Pi 4 and the 12V to power on the thrusters/actuators. Our engineers designed the power distribution system to tackle the heat dissipation that leads to extremely high temperatures in electronics enclosure. An increase in temperature means a reduction in efficiency, therefore, to maximize performance is indispensable an effective **heat dissipation**.

For this reason, the **power PCB is housed at the bottom of the electronics case**. In addition, DC-DC converters were chosen because of their built-in dissipation plates, which are directly touching the aluminium box.

Being **the aluminium case directly in contact with the water**, it provides a thermal exchange with the external environment that leads to a decrease in temperature of 60% with respect to other solutions evaluated (for example use a commercial acrylic tube as electronic housing). In this way, the thrusters can absorb all the delivered power, making the ROV more reliable.

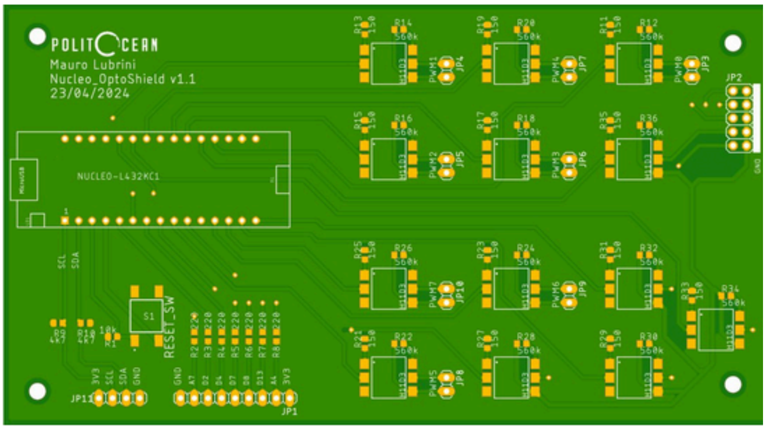


11 - Power Distribution Board

Printed Circuit Board

Our electronic engineers designed EVA's electronic system paying special attention to operational stability and space optimization and serviceability. All the electronic boards are mounted in the Electronic Box (EB). The thinking-core of the ROV is the Raspberry Pi 4 where all the logic and the computation modules responsible for balancing, motion and diagnostics of the machine are implemented. Other main roles of Raspberry are the video streaming flow elaboration, hosting the MQTT broker and the communication with the ESC controller PCB.

Description of the modules: Power PCB: previously described. ESC controller PCB: To interface the Raspberry with the thrusters and the arm PCB, we decided to insert in this board a Nucleo to generate the PWM signals needed to control the ESC of the thrusters and the PWM/Digital signals to control the arm movements. For this purpose we designed a shield for the Nucleo with electrically decoupled outputs. The Nucleo is powered by a 5V voltage coming from the micro USB connection. The supply of the PCB is then taken directly from the Nucleo through the +3V3 and GND pin.

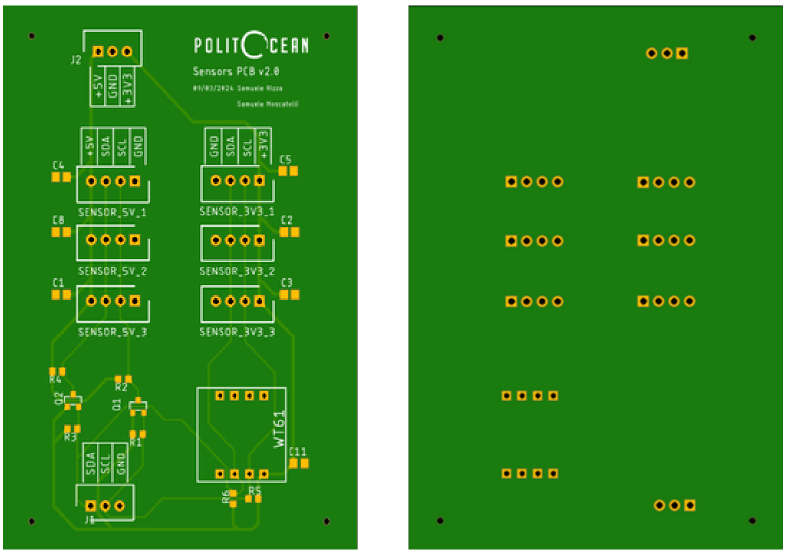


12 - ESC controller PCB

We focused on **making the system the most robust and reliable possible**, so we spent a lot of efforts to decouple the low voltage control electronics from the high voltage one in order to avoid any possible ground loop or any inducted noise currents which could lead to failures in the system. In order to **implement this features** we adopted 13 optocouplers which allows to separate the low voltage signals (+3.3V) generated by the Nucleo from the high voltage (+12V) used to power the thrusters and the servos of the arm.

Sensor Interface

This board is in charge of Eva's sensors interface; It's provided with a WT61 IMU that can manage up to six ports with a I2C-type protocol communication. All the components on this board are powered by either 5V or 3.3V that we provide from the outside on the dedicated supply connector, thus we can power up and communicate with 3 sensors that work with 5V and 3 with 3.3V.



13 - Sensor Interface Board

Looking closely at the design you can see that we drew only the 5V and 3V3 lines cause the GND is a plane on the board. We have also used some little capacitor near all the connectors to protect them from possible supply ripple.

Features of the Board

The PCB implements:

- A Nucleo LK324KC used to generate the PWM signals which are used to control the 8 thrusters, and the control signals used to pilot the arm.
- 8 optocouplers with a 2 pin output connector used to send the PWM signal to the 8 thrusters.
- 5 optocouplers used to send signal to the arm controller.
- 8 digital I/O pins and one I2C port.
- ESC wiring: 8 BlueRobotics' BasicESCs that drive the thrusters are wired to the ESC controller PCB via connectors through which they receive PWM signals. They are secured inside a mechanical support
- attached on the side of the EB, that facilitates heat dissipation and maintenance.

Arm PCB:

This board, represents the hardware control for the ROV's arm. It is responsible for controlling the wrist, and the claw of our robotic manipulator. Its main components are:

1. Two motor drivers (DRV8825 and MAX14870) used to control properly the wrist and the claw movement.
2. A 10 pin connector that allow the communication between the drivers and the Nucleo board.
3. The supply of 12V is provided by an external source and on the board there is a linear DC-DC converter for the generation of 3.3V. When the board is correctly connected to the ROV power, a red LED turns on.

Tether

The **tether** from the surface is composed by a 48V supply cable put together with an Ethernet cable using a protection sleeve, in order to reach an optimal tether management.

The **power cable** was chosen looking for an adequate copper size, while for the data cable the data transmission rate was essential. The **former** has a copper size of 2.5mm that guarantees a proper power transmission, and the latter is an Ethernet cable Cat6E, which allows data transmission up to 1Gbit/s.

14 - Bottom side strain relief

Cameras

There are **three USB cameras** connected to the Raspberry: the first one facing the arm, the second one facing the front in order to have a good view of all the space in which Eva is moving, the last one on the bottom to control the vertical movement. Cameras are managed by a Motion server.

Software Systems

The **main programming languages** used to code EVA's firmware and software are **C/C++** and **Python**. Excellent code maintenance as well as fast prototyping and development are guaranteed by code modularity and object-oriented programming.

EVA's main **firmware** and **software** run on a Raspberry PI 4 while the code behind the robotic arm and the thrusters lies in a STM NUCLEO board.

Such choice grants **better flexibility** and reliability to our project. Both the communication among boards and with the user interface, rely on MQTT, with the Raspberry acting as the broker.

Such **communication protocol** was chosen for its reliability and noise resistance. This system allows us to integrate an arbitrary number of boards with a plug and play solution. The **GUI allows the operator to easily control the ROV through our PC**, making it possible to both visualize specific data concerning the ROV along graphs updated in real time. As far as the float is concerned, an additional interface was added to the GUI with all its available functionalities and status.

Raspberry PI 4

The **Raspberry PI 4** hosts the MQTT broker, this communication protocol is used to communicate with the control station while guaranteeing a good compromise of speed and efficiency. The protocol is organized in various topics, which can be mainly divided into command and status one, used for debugging reasons.
The Raspberry receives commands from the **GUI**, it elaborates control data and calculates the correct data to send to the STM Nucleo that controls the motors and the arm.
The **code for the controller** is also located in the Raspberry.
The Raspberry also controls multiple **usb cameras**, a script streams the cameras to the GUI.

STM Nucleo Board

The **Nucleo L432KC** is a development board which mounts an STML432KCU6U microcontroller. The Nucleo board controls the thrusters and the components of the art, the wrist and the claw, based on the commands received from the Raspberry by serial connection.

Board Communication

Two different communication protocols were chosen to better adapt to each board.
the sensor board communicate with the Raspberry using the I2C protocol, while for the STM Nucleo its used serial protocol.

Sensor Board

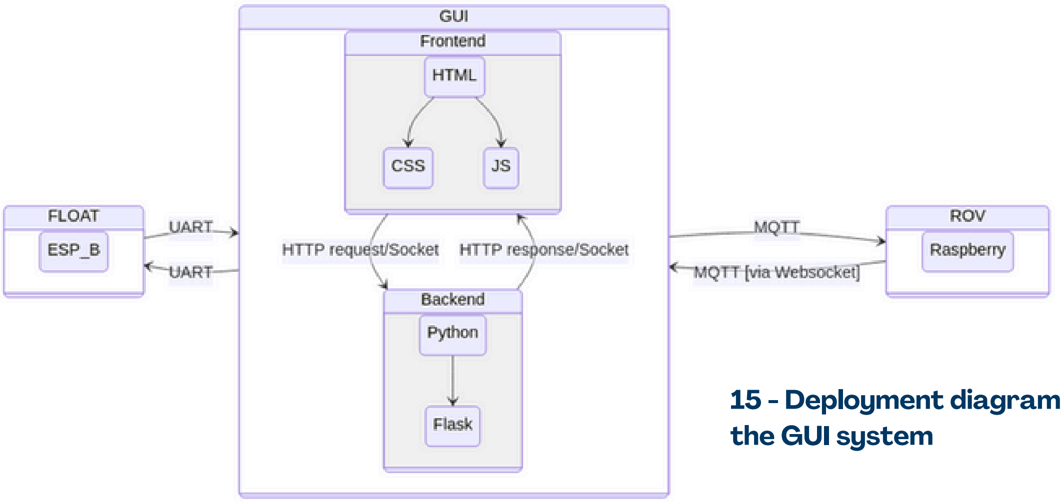
The **sensor board** mounts an IMU (Inertial measurement unit), a Bar02 pressure sensor and an internal temperature sensor. The board is connected to the Raspberry with the I2C communication protocol. This component is essential for the controller to work properly, providing depth and angular accelerations.

GUI (Graphical User Interface)

The Graphical User Interface (**GUI**) is used by the operator to remotely control the ROV and the FLOAT.

It was **developed in Python** using the **Flask framework**, which handles HTTP requests, socket connections, MQTT communications and many utilities related to the ROV, as a cross-platform desktop web application. The frontend is built with HTML, CSS, and JavaScript.

The GUI is divided into several sections (ROV, Float, PID, etc.). The one concerning the ROV is split into two sides: on the left, there is the cameras section. On the right side, there is a designated area for displaying plots of sensor data, joystick inputs, and more.



15 - Deployment diagram of the GUI system

Control Station

This year we decided to use a PC instead of a control unit built by us as previously said. The laptop runs Linux Ubuntu operating system in order to improve the efficiency and the communication with the ROV and the FLOAT.

16 - PC as a Control Station

Control Systems

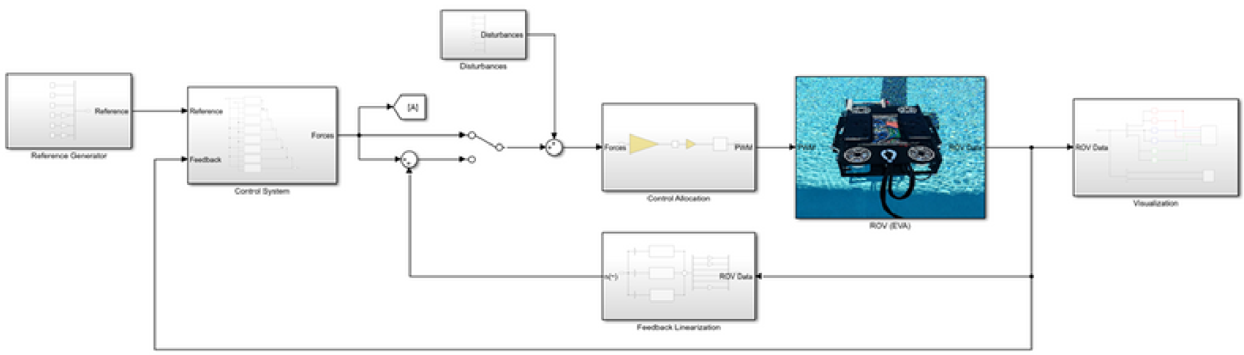
The ROV is designed to be positively buoyant, and as it must manipulate various objects, it is continuously subjected to disturbances that alter its attitude.

Therefore, to successfully carry out operations, the presence of a control system capable of maintaining the ROV at the desired depth and with a stable attitude is crucial. It must also be capable of counteracting disturbances.

That's why we developed different kinds of **control systems** that automatically command the thrust and stabilize EVA to the desired depth and attitude.
So, we control heave, roll, and pitch dynamics, and as feedback, we use measurements from the **IMU** that has an integrated Kalman Filter that can directly provide roll and pitch values, in addition to linear accelerations and angular velocities, and a **barometer**.
We developed different **mathematical models in MATLAB/Simulink**. One is a high-fidelity model used for simulation purposes since it accurately describes the dynamic behaviour of our ROV.
The other models are control-oriented and describe simplified dynamics of the ROV.

They are useful because they are linear models that can be expressed in state space and transfer function form, making them directly applicable for controller design.

Thanks to these models, we developed different controllers. The first was a simple manual tuning of PID, but then we designed some controllers with a 2-DOF pole placement technique based on Diophantine equations, a Linear Quadratic Regulator (LQR), a Sliding Mode Controller, and a Model Predictive Control.
At the end we ended up with the following **simulator**:



17 - Simulator

As depicted in the picture, the simulator consists of seven blocks: Reference Generator, Control System, Control Allocation, ROV (EVA), Disturbances, Feedback Linearization, and Visualization. The Reference Generator block provides the references to be tracked.

The Control system block uses the reference and the **feedback** to generate the Force signals; inside this block, we can switch from one controller to another of those cited above. The **Control Allocation** uses such forces and converts them into a PWM signal thanks to the pseudo-inverse of the **Thrust Configuration Matrix** (TCM) and the lookup table of T200 thrust of Blue Robotics that maps thrust to PWM.

The **Disturbances** block is used to simulate disturbances in the dynamics. Feedback linearization is useful for Sliding Mode Control and compensates for nonlinearity in the control loop.

The **ROV** (**EVA**) block contains the dynamics of our system (high-fidelity model), which is divided into two parts: kinematics, which deals only with the geometrical aspects of motion, and kinetics, which analyze the forces causing the motion.

The equations that describe the dynamics are the following:

$$\dot{\boldsymbol{\eta}} = \boldsymbol{J}_{\Theta}(\boldsymbol{\eta})\boldsymbol{\nu}$$

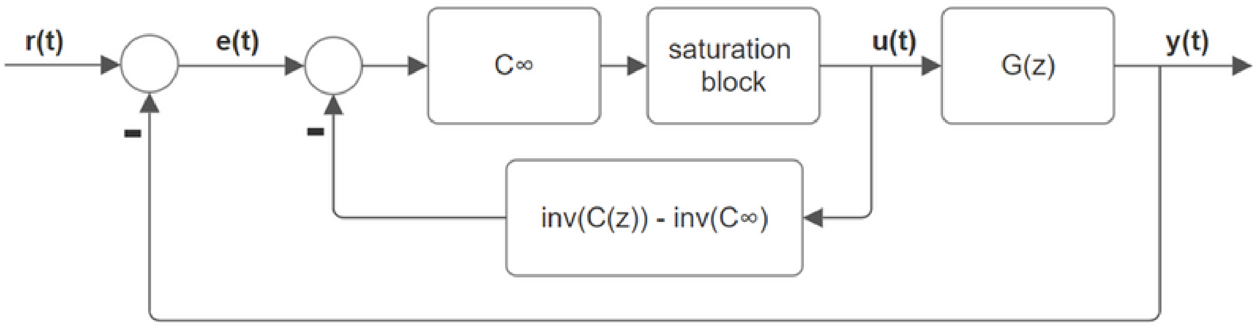
$$\boldsymbol{M}\dot{\boldsymbol{\nu}} + \boldsymbol{C}(\boldsymbol{\nu})\boldsymbol{\nu} + \boldsymbol{D}(\boldsymbol{\nu})\boldsymbol{\nu} + \boldsymbol{g}(\boldsymbol{\eta}) = \boldsymbol{\tau}$$

The first equation is the kinematics term where η is the pose in the fixed frame, ν is velocity vector in the mobile frame and $J(\eta)$ is the Jacobian matrix that convert the kinematics variables from the mobile to the fixed frame. The second equation is the dynamics term where M is the mass matrix composed by the sum of the rigid body mass matrix and the added mass matrix, $C(\nu)$ is the Coriolis and Centripetal matrix, $D(\nu)$ is the damping matrix, $g(\eta)$ is the vector of the hydrostatic forces and moments and τ is the vector of the external forces and moments.

The control system used for the competition strikes a **good balance between performance and complexity**. This is why the control system for EVA is based on three 2-DOF pole placement controllers for heave, roll, and pitch, which are derived from **Diophantine equations**.

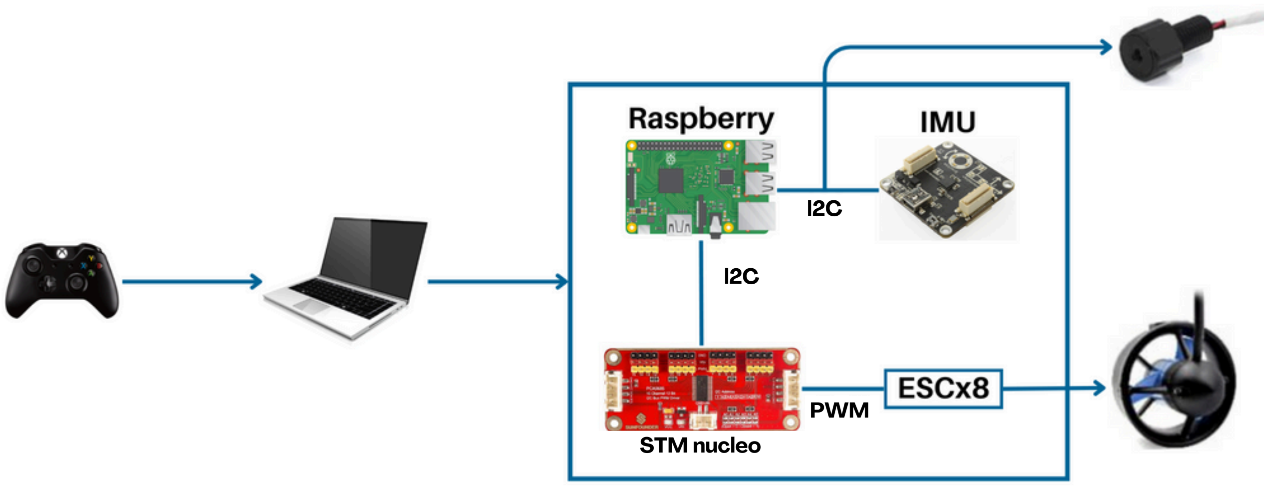
Since real actuators have limited authority, it is crucial to consider this aspect, as neglecting it can lead to significant performance degradation. A common issue when an input reaches its saturation limit is that, if the controller includes an integrator, it may continue integrating despite the input constraint.

As a result, the integrator's state may escalate to an undesirable level, leading to suboptimal transient performance. This problem, known as wind-up, can be addressed by employing the following **anti wind-up** control structure:



18 - Anti wind-up structure

At the end, the controller and the control allocation were translated in a C++ function, and it was flashed inside Raspberry that send PWM values to the STM Nucleo Board that generate PWM signals for the ESC of our thrusts. A Control oriented SID is reported in the next schematic.



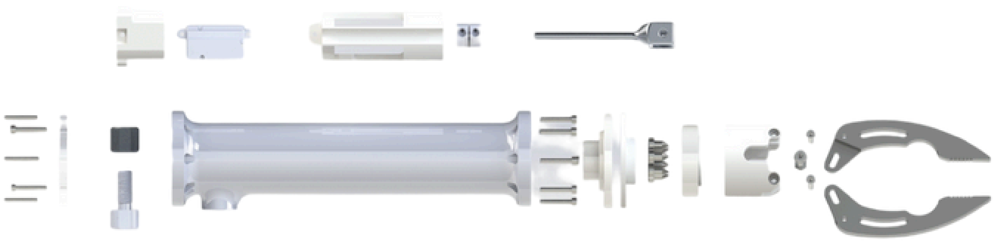
19 - Control oriented SID

Payload Tools

Working Principle

Our **multi-functional manipulator** is an **electronic robotic** arm designed to have one degree of freedom.
It is designed in such a way to adapt to structures and parts of previous models, with the addition of **improvements** regarding materials and operation.

It allows us to pick up several types of objects of varying shapes and sizes thanks to the use of grasping jaws.
Our arm, excluding the hand, has a total length of 22 cm and protrudes from the ROV for about 13 cm, and it weighs only 480g.
The manipulator is composed of three very different systems, interconnected in such a way as to make the ROV optimal. These two systems are called MANO and BRACCIO.



20 - EVA Manipulator

Mano

The **MANO compartment** includes a **3-hinge mechanism** (2 fixed hinges, 1 movable).
This choice was made to **optimize and simplify the assembly method**, and to reduce the number of components at risk of breaking. This mechanism binds 2 jaws, made by 3D printing in metal, to allow only the opening and closing movement, using only the simple motion of a shaft made of **ERGAL Al 7075-T6**. It is machined with multi-axis machines and connected to a linear actuator (pq12-etc...). The structure that holds the clamps is called the **POLSO mechanism** and consists of a set of fifth wheel couplings created by **3D filament printing** (ALFAPRO material). Thanks to a **NEMA8 motor**, it allows the rotation of the wrist.

21 -Eva gripper

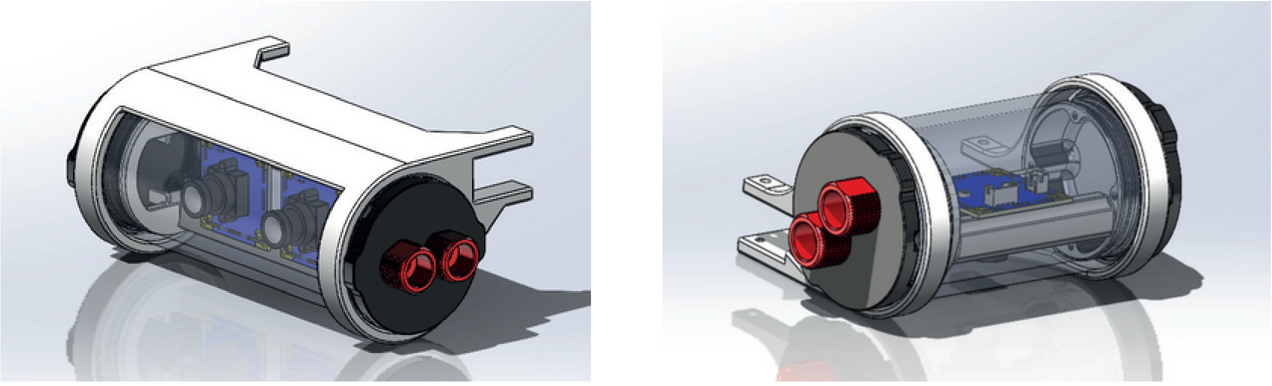
Braccio

The **BRACCIO system** consists of a **tubular design 3D printed in resin** (VisiJet Armor M2G-CL MJP). This type of printing has enabled us to obtain a solid and resistant body with a **high surface definition** that allows, thanks to the use of gaskets and o-rings, an excellent seal. Each **internal component** of the forearm has been designed in such a way that it **can be removed quickly and easily**, compared to previous models. The forearm contains within it all the motors, which, by means of a connecting joint, allows the correct functioning of the MANO compartment (mainly the NEMA8 and the linear actuator).

22 - EVA Manipulator

Camera compartments

The cameras are fixed inside by internal supports consisting of two non-rotating suspended rods. Due to the unfavorable position of the screws on the tube, the internal supports have notches to allow the use of offset head screws. The tubes containing the cameras are fixed to the ROV through external supports that are cut in half to make realization easier. Both internal and external supports are built using 3D printing with Alpha Pro filament supplied by Filoalfa



23 & 24 - Front (left) and rear (right) cameras

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Build vs Buy, New vs Used

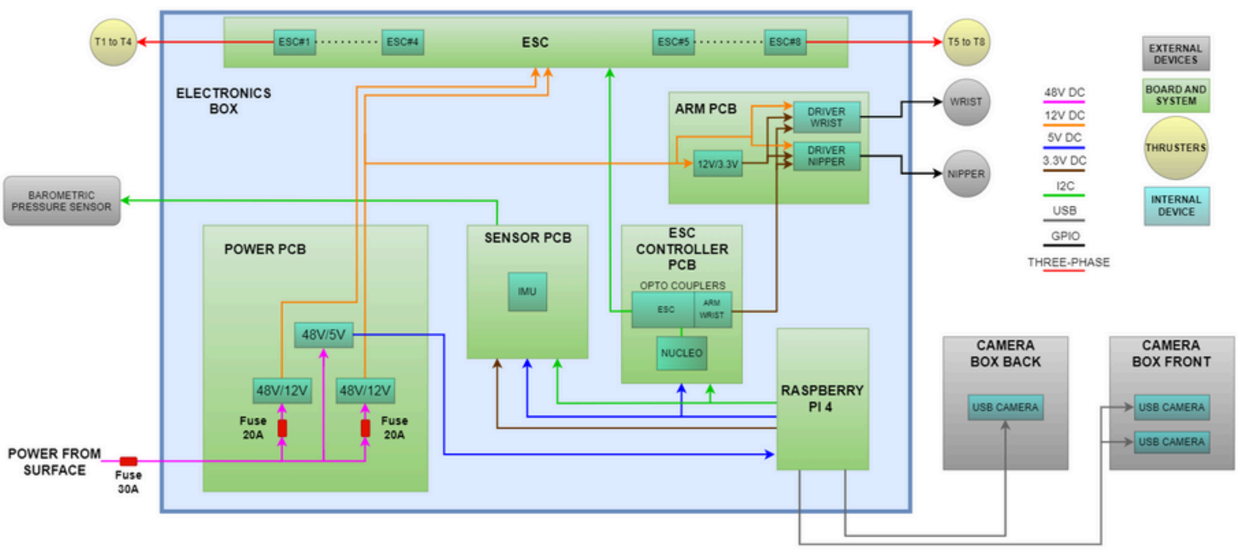
In comparison to last year, the same Eva manipulator has been used, albeit with appropriate modifications. Specifically, **we transitioned from 2 degrees of freedom to 1**, with the sole permitted movement being the rotation of the mano. By reducing the degrees of freedom, we have removed the previous year support system called spalla, opting for a fixed support.

Additionally, the design of the motor covers has been **altered** to enhance durability and improve hydrodynamics, while still maintaining safety standards.

Furthermore, our focus shifted in developing and improving the control system. In last year competition there was only a manual tuned PID for heave dynamics. This year we spent a lot of effort in improving performances.

We developed an improved version of our simulator to test control laws in **MATLAB/Simulink**. Then, instead of PID, we designed a more sophisticated controller like a 2DOF Pole Placement Control based on Diophantine equation, a LQR, a Sliding Mode Control and a Model Predictive Control. All these control techniques have been developed for heave, roll, and pitch dynamics, and the design has been made to compensate for various types of disturbances. Moreover, we have focused our attention on developing **anti-windup techniques**.

SID



25 - SID

Safety

Company Safety Philosophy

At PoliTOcean, we strongly believe that a safe work environment is an essential requirement for the success and realization of a project.

It is our responsibility to ensure a safe work environment that prioritizes the protection of people and the surrounding environment.

However, we recognize that employees must also collaborate to prevent accidents. To this end, we have chosen to implement mandatory training, safety procedures, and safety protocols

Laboratory Protocols

Working in a laboratory requires adherence to specific safety protocols to ensure a safe work environment. When it comes to assembling electronic equipment, employees are required to wear special gloves and eye protection and to turn on the chemical ventilation system, which is located near each workstation.

Over time, we have developed an electrical safety protocol to prevent electrocution and overheating of devices. For mechanical processes, a specific dress code is mandatory, which includes the use of a suit, goggles, and gloves. In case hazardous materials are being handled, adequate ventilation must be ensured.

All these procedures listed so far are included in PoliTOcean's Safety Data Sheet, which is accessible to all employees. We remind you that the SDS is just an additional tool that complements mandatory training for all new employees

Vehicle Safety Features

An important safety feature present in EVA is the ability to remotely turn on and off the 12V output, which powers all the propellers and actuators of the ROV. This has been achieved thanks to the use of an optocoupler, a component capable of ensuring galvanic isolation.

Operational and Safety Checklists

Safety protocols and checklists are diligently followed before, during, and after operations. Employees are required to follow specific procedures for the launch, recovery, and water safety of the ROV.

Troubleshooting and Testing Techniques

Testing is a fundamental part of the development of the ROV as it helps to identify any problems that may have been overlooked.

PoliTOcean's workflow involves testing each individual component through dry testing before assembling and evaluating the ROV as a whole.

For the Mechanical Area, each piece is subjected to FEM analysis to verify its behavior under stress. In the Electronics Area, the preliminary step involves examining each individual PCB through a multimeter to ensure correct soldering and assembly.

Once the cards are confirmed to be functioning properly, they can be placed in the ROV. To ensure the integrity of the ROV, it is necessary to verify any loss of insulation that may be harmful to it before testing it in water conditions.

Attention must be paid to the penetrators through which the cables connecting the electronic parts to the ROV pass. To inspect these, the company has developed a system using a pressure pump with a pressure gauge and an acrylic tube inserted into one of the penetrators. Once all the necessary steps have been successfully completed, testing in water can begin, during which any problems at the firmware level are verified. If any issues are encountered while piloting the ROV, developers attempt to find solutions. When the ROV performs all assigned tasks correctly, testing ends.

Accounting

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Politocean estimates the cost of the project and the expenses done at the start of the year to manage its budget.

For the year 2024, our expense table was heavily reduced due to recycling of the 2023 ROV. With this decision our team decided to use the budget mainly for representation missions and fixes.

Our income source is heavily given by Polytechnic University of Turin, in addition to that our sponsors' support is very important to us when it comes to material donations.

All of our purchases first must be recognized firstly by the General Manager and then finally approved by the Team Leader, and then are processed by the internal division Growth & Operation. Our expenses are regularly being checked to ensure that they match with our stock records.

Expenses	Type	Budget	Cost	Balance
ROV Production				
Materials	Purchased	6.000,00 €	5.437,52 €	562,48 €
3D Printing	Purchased	2.000,00 €	1.345,33 €	654,67 €
IT equipment	Purchased	1.500,00 €	987,00 €	513,00 €
ROV Total		9.500,00 €	7.769,85 €	1.730,15 €
Operation Expenses				0,00 €
Accomodition	Purchased	7.000,00 €	7.563,79 €	-563,79 €
MATE ROV Entrance Fee	Purchased	400,00 €	400,00 €	0,00 €
Transportation of ROV	Purchased	3.500,00 €	2.267,00 €	1.233,00 €
Operation Total		10.900,00 €	10.230,79 €	669,21 €
Total Expenses		20.400,00 €	18.000,64 €	2.399,36 €

26 - Project Cost detailed Excel Scheet

Aknowledgements

A plunge of gratitude to those who have illuminated our path in the ocean of the MATE ROV Competition and underwater robotics!

A special thank to the MATE ROV Competition for offering us this incredible adventure in the underwater world of growth and competition. Your commitment to encouraging innovation and sustainability education is the current that guides us towards the future.

Immense gratitude to the Politecnico di Torino for their generous financial support, their contribution was essential in bringing our project to the surface.

A special thanks goes to Professor Sansoè, our mentor, for his constant support in every aspect. Whether it's technical suggestions or words of encouragement, he always backs us up and keeps our motivation high.

A warm thank you to the Department of Electronics, for their logistical and technical support.

We would love to thank other amazing companies that have collaborated with us: Abel Company, Altair, Dewesoft, Officine Massola and Notion.

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