# Federal University of Santa Catarina's Terra Competition team: Design, Strategy and Implementation of the Yvy AUV

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***Abstract*: Yvy is Terra Competition team's AUV for the AUVSI Robosub 2025 competition. It is the first year that the team will participate in person. The AUV was designed to be robust and a stable ground to improve for the next competitions. It is mainly designed to be capable of completing the movement tasks.**

## 1. Competition Strategy

For this project, the team's main goal is to build a vehicle that serves as ground for the next generation of members to learn and be able to improve for the years that will come. For this specific competition, our goal is to complete all movement tasks, as it marks our first on-site participation with a newly built vehicle. Always with the thought that our top priority is to learn and build knowledge to put into practice the theory that is seen in different courses.

The Terra Competition Team's prior engagement in RoboSub was limited to online participation, leveraging a 3D model of the BlueRov from BlueRobotics for task simulation. This year marks a pivotal shift to an in-person competition, requiring the design, fabrication, and deployment of a custom AUV. This transition fundamentally alters the engineering challenges and strategic considerations for the team.

The choice of which tasks to complete in this year was based on their complexity. The first working part of an AUV must be its movement, without this, it is unable to complete any other task. That's the reason for the team's choice to explore first the tasks that involve only movement and, if possible, tasks that do not involve movable parts such as the task 3: Ocean Cleanup that could, in theory, be done by pushing the objects to the baskets.

## 2. Design Strategy

The team comprises four main sectors: Mechanics, Embedded Systems, Marketing, and Administrative. The Embedded Systems sector is further divided into Electronics and Software. Each sector's responsibilities and contributions to this project are defined below.

### *A. Mechanics*

This sector is responsible for the structural integrity, thermal management and both solid and liquid simulation.

The AUV's structural components are crafted from 4.75mm aluminum plates, designed for robustness and reusability. These plates feature openings to facilitate water flow from the thrusters and provide convenient holding points for the AUV.

Aluminum 5083 was selected as the structure material primarily because of its cost-effectiveness, strength and reliability, often used in the naval industry due to its high corrosion resistance which converges to the idea for this vehicle that it should be robust and reliable.

The watertight cases are constructed from two aluminum tubes. The larger tube, with an internal diameter of 160mm and a length of 360mm, houses all electronic components listed in item B. The smaller tube, measuring 125mm in internal diameter and 220mm in length, is dedicated solely to the battery. Both tubes feature eight flanges, with four on each end.

The caps' design draws inspiration from a combination of two BlueRobotics products: the O-ring flanges and the end caps. The tubes and caps are connected using four M5 screws and nuts, fastened through the flanges of each component.

Piston O-rings, designed to withstand depths of up to 30 meters, are used for sealing in accordance with ISO 3601. The Laboratory of Underwater Technology (LaSub), located at the same university as our team, generously provided a spreadsheet for calculating the appropriate O-ring dimensions based on specific usage conditions. We extend our sincere gratitude to Arthur Sena Marques and LaSub for their invaluable assistance.

A simplified CAD with the minimal components of the structure can be seen on figure 1.

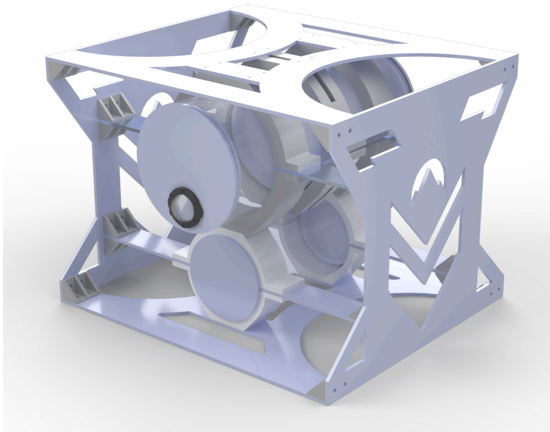


**Figure 1:** Simplified Yvy’s CAD with the essential structure.

The inherent thermal properties of the structural materials effectively mitigated any potential issues related to thermal management. This deliberate selection demonstrated that a purely passive cooling approach was not only feasible but also entirely sufficient to dissipate the generated heat efficiently. The system's intrinsic ability to conduct and radiate heat showed that there was no need for active cooling mechanisms, simplifying the design and reducing potential points of failure.

On the inside, a modular electronic tray, based on the BlueRobotics Enclosure rails, was made to secure the electronics components in place. The tray is 3D printed with Acrylonitrile Butadiene Styrene, ABS for short, put together by M3 screws and bolts. A 3D render of the pieces can be seen on figure 2 assembled with some of the electronics.

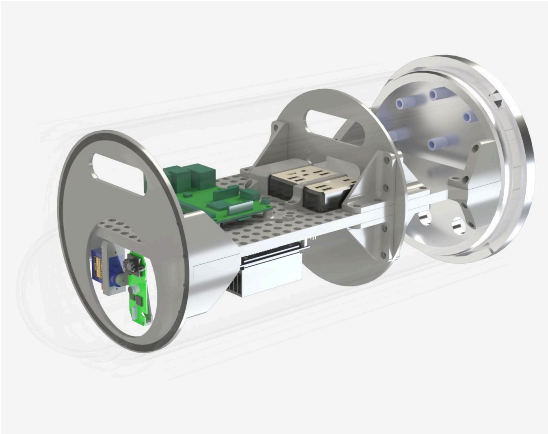


Figure 2: Electronics tray 3D render with four of the electronics components.

For the wiring between the outside and the inside, potted cable penetrators were created, based on the BlueRobotics Potted Cable Penetrator, with axial O-rings in accordance with ISO 3601 for sealing.

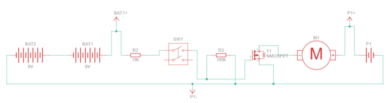
*B. Embedded Systems: Electronics*

This sector is tasked with establishing all electronic component connections, selecting appropriate components for specific functions, and integrating power electronics. This includes linking ESCs to motors, the kill switch, and the board's power supply.

This year's battery features an 11.1 Volt (3S Li-po) capacity of 6 AH Li-po battery. To power the 5 Volt electronic components, three LM2596 tension regulators, each providing a maximum output of 3A, are used. These are sufficient to supply all processing units. The system's electronic components include a 2GB Jetson Nano developer kit, a Raspberry Pi 3B+, a Pixhawk (provided by a professor), a custom STM32G4 board, a Logitech C270 camera, and six generic ESCs. The specific use of each listed item will be detailed later.

Due to its conductivity, the aluminum cases are connected to ground to capture the leakage currents created by the variation of the magnetic fields that might appear inside the cases.

The kill switch circuit implemented was designed to cut off power to all ESCs and, consequently, to all motors in case of an emergency. It utilizes an N-channel MOSFET operating as a low-side switch, placed between the negative side of the ESCs and the ground of the main power supply battery. The gate of the transistor is driven by two 9 V batteries connected in series, providing an 18 V control voltage. A 10 kΩ current-limiting resistor is placed in series with the gate, and the normally closed button is also connected in series with the batteries. Additionally, a 100 kΩ pull-down resistor is connected between the gate and the source of the MOSFET to ensure proper discharge of the gate when the button is pressed. Under normal conditions, the button remains closed, allowing the gate to be pulled high and the MOSFET to conduct, enabling current flow to the ESCs and motors. In the event of an emergency, pressing the button opens the circuit, disconnects the gate voltage, and causes the MOSFET to stop conducting, effectively cutting power to the propulsion system. The circuit schematic can be seen below on figure 3.



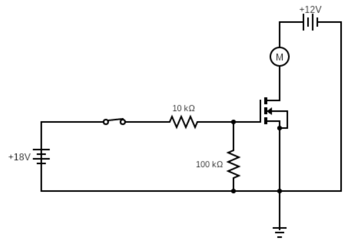



Figure 3: Electrical design of kill-switch.

*B. Embedded Systems: Software*

Programming within this sector is split into two distinct levels: high-level and low-level. High-level programming encompasses the communication between the Jetson and Raspberry, computer vision, the AUV's state machine and the configuration of the simulator. Low-level programming, on the other hand, focuses on the Raspberry's connection with the Pixhawk and ESCs.

*B. Embedded Systems: High level*

For data exchange between the Jetson Nano and the Raspberry Pi, a TCP/IP protocol has been implemented. The Jetson Nano, connected to the camera and serving as the central processing unit for the computer vision, initiates the communication by establishing a dedicated TCP socket. This socket acts as a continuous connection. Upon establishing this connection, the Jetson Nano codifies the information into a structured JSON format, this one was chosen for its human-readable structure, lightweight nature, and widespread compatibility. The data encoded in JSON includes seven values: the upper corner (x, y) coordinates of the detection box, the lower corner (x, y) coordinates, the confidente of the detection, the class identification number, the class name and the information of which camera is detecting, this last one not being implemented due to only having one camera. The Jetson Nano codes were written in Python. This choice was made due to Python's user-friendly interface. Although Python is slower than compiled languages, this proved not to be an issue.

The Raspberry Pi, acting as the main controller or actuator, actively accesses this information through the established TCP socket. Upon receiving the JSON-encoded data stream, the Raspberry Pi decodes the information. This communication mechanism allows for real-time data synchronization and control, enabling the Jetson Nano to operate only for the computer vision processing and the Raspberry Pi to execute the decision making and movement work based on the received instructions. The code currently running on the Raspberry Pi is written in C++. This decision was made because the team experienced slow performance with other languages.

The boards operate in headless mode. Code uploads are performed via Ethernet using a hub and the Secure Shell (SSH) protocol.

*B. Embedded Systems: Low level*

Inertial measurements are taken using the Pixhawk 2.4 board, which connects directly to the Raspberry Pi via Mavlink, which uses Universal Asynchronous Receiver/Transmitter (UART) as base. Data collected from this board includes angular and linear acceleration across all three axes.

The team utilizes a custom board equipped with an STM32G4 microprocessor. This board features four Analog to Digital Converters (ADCs), each connected to one of four H2a hydrophones from Aquarian Audio Products. These hydrophones were generously lent to the team for this competition by Professor Nuno Cruz from the Institute of Systems and Computer Engineering, Technology and Science (INESC-TEC) at the Faculty of Engineering of the University of Porto (FEUP).

A Sallen-Key multiple-feedback band-pass filter is employed to process the data according to the team's competition handbook. This filter's band encompasses all pinger frequencies. The team extends its immense gratitude to Gabriel Madeira, who joined the team and provided invaluable assistance with hydrophone utilization and data processing—an area in which the team previously lacked expertise.

## 3. Acknowledgements

Terra Competition extends its gratitude to all who have supported us. We especially thank the LaSub team for their invaluable knowledge and tools, which were instrumental in the vehicle's construction. Our appreciation also goes to the Laboratory of Fluid-Structure Interaction and Professor André Fujarra for generously providing space for water testing. We are immensely thankful to our sponsor, Connor Solutions & Services LTDA, whose significant contribution helped us build the vehicle. Finally, we acknowledge Solidworks for providing their cutting-edge CAD technology free of charge through their student team sponsorship program. We'd like to thank Santa Catarina Education and Engineering Foundation (FEESC) for providing almost the entirety of the registration fee, which enabled us to start the process to compete this year.

Terra Competition would like to explicitly thank the Robonation team for their understanding regarding the challenges encountered. Special thanks are due to Alison Young for her invaluable assistance throughout our steps until now.

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