# 2022 RobotX WAM-V Application

Pontificia Universidad Católica de Chile

School of Engineering





Contact Information:

**Giancarlo Troni, PhD**
Assistant Professor
Department of Mechanical Engineering
Pontificia Universidad Católica de Chile

e-mail: gtroni@ing.puc.cl
Campus Address: Vicuña Mackenna 4860, Macul, Santiago, Chile
Phone number: +56 2 2354 4229
www.ing.uc.cl
https://compas.ing.uc.cl/

# 1. Our Technical Approach

The main approach considers implementing our working autonomy system methods for our marine robots into de WAM-V and the drone. This consists of our estimation algorithms, 6 DOF control, and vision and navigation instrumentation. The following section details each part of our solution: from the general system integration to detail the WAM-V integration, the drone challenges, and finally our software and algorithm implementation.

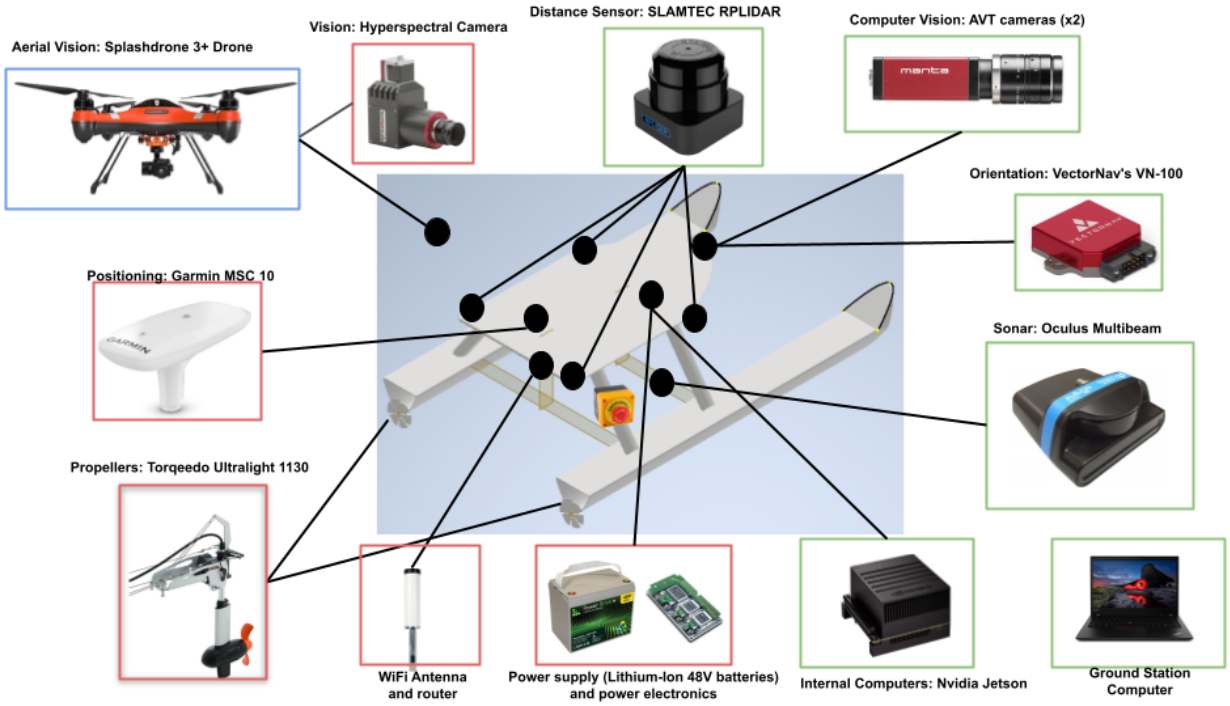



Figure 1: Devices diagram showing the mounting position and the particular device used (in green devices that we already have, in blue devices that we have but need major adaptations, and in red devices to be purchased)

## 1.1. WAM-V

The systems will be mounted on a bolted skid, specially designed and constructed for this purpose. Our team has the expertise in constructing the remotely operated vehicle's (ROV) frame and chassis, with the integration of instrumentation, actuators, and subsystems. The team also considers the design and integration of the propulsion and maneuver system.

Our team has experience with marine systems, including the ROV integration and power supply. We have designed and built from the ground up the power and control electronics, and propulsion systems of our in-house ROV. The hardware level of the communication is implemented over ethernet to provide robustness and interchangeability of components. Due to our experience with these systems, we plan to use them in this solution. We plan to use a twin Torqeedo Ultralight 1103 AC supplied by a bank of lithium-ion batteries for propulsion. The processing units on both platforms will be multiple Nvidia Jetson Xavier and Nano due to our

experience with them, their machine vision capabilities, and overall computing power. For the communication between the UAV and WAM-V, we intend to use WiFi.

## 1.2. Drone

The drone includes three main challenges: (1) navigation and control, (2) obstacle avoidance, and (3) the manipulation of the objects. We have experience with navigation and control. The challenge is the design of the gripper and detection system. Several prototypes will be developed at an early stage and test them. The objective is to achieve a gripper that is as accurate and light as possible and integrate it into the drone. The detection system will be based on vision with an onboard hyperspectral camera and detection algorithm, trained on campus to increase its accuracy.

## 1.3. Software

In CoMPAS we have worked on multiple projects, most of them use LCM for communication, although we have also used ROS. Some of the projects we have worked on that have some overlap with the operation and development of WAM-V. This includes a complete repository for the operation of our ROV, which considers navigation, sensors, viewing, and simulation modules. Most of this software can be adapted for the operation of the WAM-V according to the chart in figure 2:

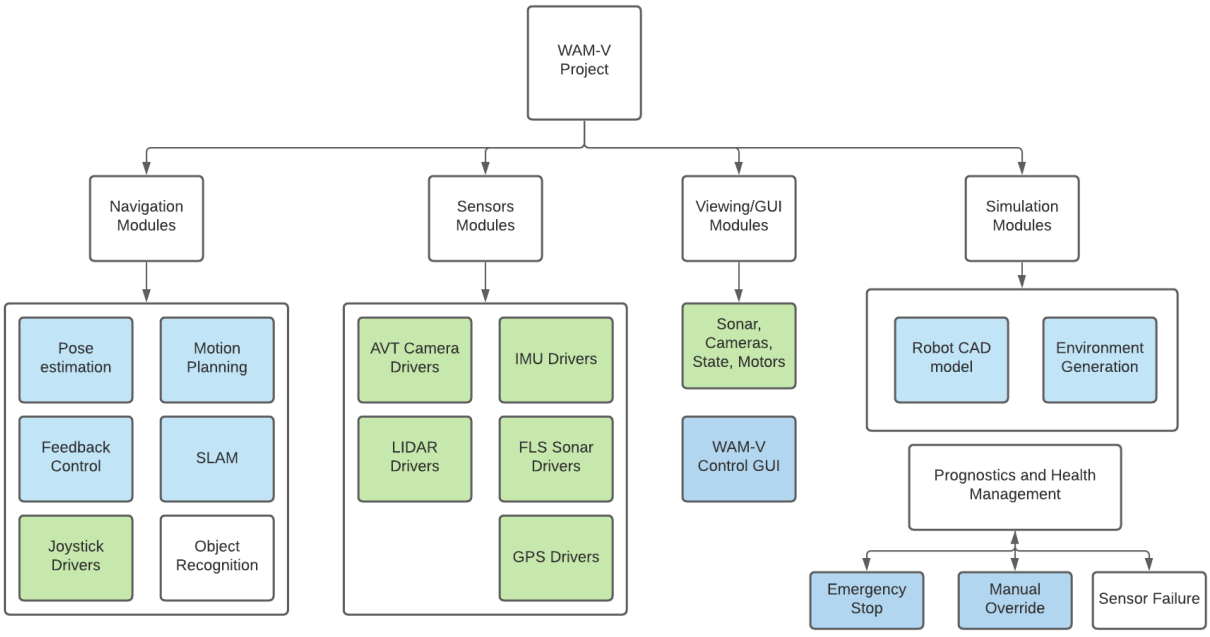



Figure 2: Software modules (in green, software that is already in operation and needs minor adaptations; in blue, software that needs major adaptations for its use in the WAM-V).

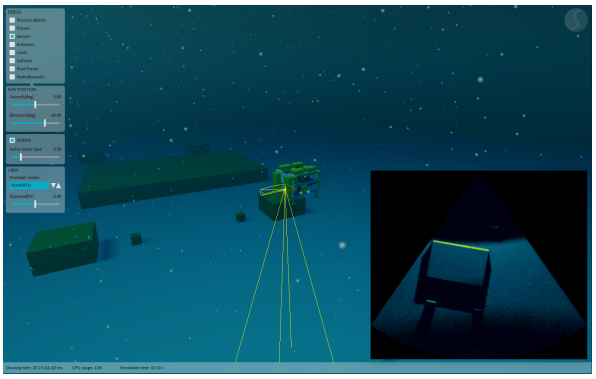


Figure 3: Our in-house simulation architecture for underwater robots that we are planning to adapt for RobotX based on current simulation environments.

## 1.4. Our Road Map to RobotX

Our tentative plan to achieve the goals outlined in the "2022 Maritime RobotX Challenge Task Ideas" document is described by the following chart:

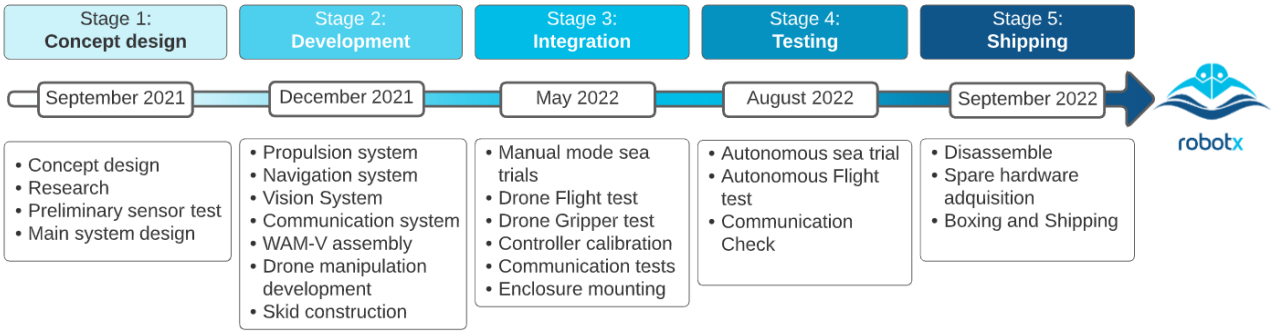



Figure 4: Planning chart

The planning of the project is based upon the arrival of the WAM-V. Before its arrival, research and conceptual designs will be done to develop the complementary systems that will be mounted on the vehicle. The drone challenge goes on a parallel stream, which leads to the integration in middle 2022.

# 2. Our Team and Relevant Experience

Our team is composed of a large group of people from the School of Engineering at the Pontificia Universidad Católica de Chile. The team is led by the Control, Modeling, Perception for Autonomous-Systems (CoMPAS) research laboratory, specializing in marine robotics. The director of the laboratory is the mechanical engineering professor Giancarlo Troni, who has over a decade of experience working on underwater mapping and state estimation. The laboratory is composed of Ph.D, master, and undergraduate students and few research engineers. Other research laboratories will support the team in specific tasks such as in Electrical Engineering (related with robot manipulation, sensor integration, and drone control) and Computer Science (machine learning and computer vision) and members of the Major in Robotics Engineering. We already have more than 30 students interested to participate. The Pontificia Universidad Católica de Chile is ranked first in Chile and first in Latin America by QS World University Ranking. It attracts the best students in the country and is also a very active research institution.

# 3. Our Facilities and Testing Places

We count on several laboratory facilities to develop different parts of the project. We have developed robots for underwater, agriculture, mining, and inventory in-store survey systems among the different research laboratories. Among all spaces, in different departments in the school of engineering, we have the tools required to work with electronics and small to medium mechanical fittings. For bigger work, we access a fully equipped workshop.

For small-scale testing in water, we built a tank (which will be used to test individual subsystems). The integration of systems can be tested in the swimming pool located on campus. For preliminary testing, we have access to Laguna Caren, in Santiago. The final testing and tuning can be done in the pools at San Alfonso del Mar, Algarrobo, or other facilities from the university Coastal Marine Research Station, that could provide us with an environment similar to the challenge venue.

Figure 5: Our Research Facilities and the Mechanical Engineering Workshop Facilities

Campus Pool

In Town Test Facility
(Laguna Caren)

PUC Coastal Marine
Research Station

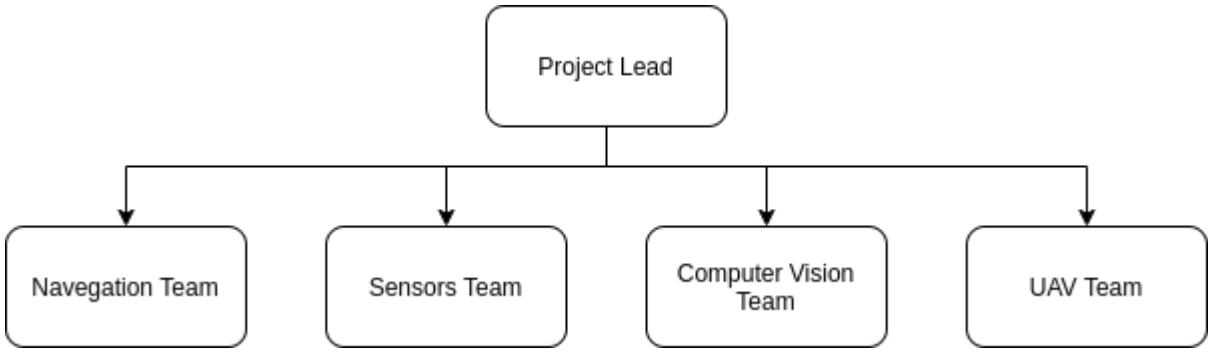
# 4. Our Sponsorships and Partnerships

| | | |
|---|---|---|
| Pontificia Universidad Católica<br>Office of Research (VRI) | +56 2 2354 9263 | rcevallos@uc.cl |
| Pontificia Universidad Católica<br>School of Engineering | +56 2 2354 9528 | jpkuzmic@ing.puc.cl |
| Chilean Navy (INNOVAPOLINAV) | - | jmaldonador@gmail.com |
| ONR-Chile | +56 2 2330 3154 | onrg.santiago@mail.mil |
| Puerto Ventanas | +56 2  2837 2900 | pventanas@pvsa.cl |
| Minera Coyahuasi | +56 2 2362 6730 | bernarditafernandez@collahuasi.cl |

# 5. Our Management

A recruitment process inside the school of engineering and its faculties will be done before the beginning of the project, to create a strong group of undergrad, master, and Ph.D. students. Currently, over 30 undergrad students have expressed interest and the members of multiple robotics research labs have their research aligned with the problems tackled in this project.

Our division of labor scheme consists of small groups of undergrad students working with a grad student to achieve a limited goal within a project, when this goal is reached the group is assigned a new task or disbanded and integrated into the new group. Within this group is a marketing and funding group with the purpose of raise funds from different institutions with interests in the technological developments of this project.



# 6. Our Cost Estimation

We estimate the project cost (from items that we are missing):

| | |
|---|---|
| Hyperspectral camera (incl. import duties) | $ 60.000 |
| WAM-V propulsion (incl. import duties) | $ 14.000 |
| Instruments and mountings for WAM-V | $ 15.000 |
| Transport of WAM-V | $ 7.500 |
| Team transportation | $ 15.000 |
| Total (USD) | $ 111.500 |

Some instruments we currently have available are estimated at around $30.000, we also have access to a UAV.

# 7. Summary

We have explored a first high-level analysis of the challenge in addition to the opportunities for our research groups. Working collaboratively, we have a first draft that we hope we will continue to improve to not only be able to compete but also to be competitive. We expect to get more attention if we are awarded the WAM-V allowing us to increase the numbers of sponsors and partners to even be able to have a better solution. We have many years of experience in different related domains, such as underwater, agriculture, mining, and other autonomous robotics systems, which we hope that we can show in this challenge.

We are very excited to be part of RobotX in Sydney in 2022. We are not only representing the best of several engineering groups in the School of Engineering and in Chile, a country with a large coastline, but also what we can do in Latin America in the area. We look to inspire other groups in the country and the region to follow this kind of challenge to have a larger impact on the R&D in ocean engineering in the region. With your support, we can make a difference in this area for many new generations of engineers.