# D.5.2.4. Specification and scenario of the demonstration 1

InnovaMare project

Blue technology - Developing innovative technologies for sustainability of Adriatic Sea

WP5 – Cooperation in innovation on robotic and sensors solution (TT) – pilot actions

## Project References

**Call for proposal 2019 Strategic – InnovaMare**
**Project number:** 10248782
**Work package:** WP5 Cooperation in innovation on robotic and sensors solution (TT) – pilot actions
**Activity title:** A2 Pilot I. - creating a prototype that is innovative robotic solution
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# Contents

# INTRODUCTION

The Adriatic Sea is one of the crucial industrial and touristic sites of the north east Mediterranean Sea and mitigate the anthropogenic impact on this area is crucial to protect the health of the ecosystems and of the people that leave by it. One of the main aims of InnovaMare Project is the monitoring of the health of the Adriatic Sea via an innovative robotic system and, specifically, the goal of WP5 is to put into practice the collaboration among the partners on robotics solutions to be used for the sustainability of the Adriatic Sea.

To achieve this goal, two different scenarios were identified in different environmental conditions, specifically Scenario 1 was designed for the Venice Lagoon.

The Venice Lagoon is the largest Mediterranean lagoon and the strong anthropogenic presence adds to its environmental characteristics, typical of transitional areas. Indeed, the characteristics of the lagoon in terms of strong horizontal density gradients, high turbidity, strong hydrodynamics in single events, high biological productivity, etc ... can lead to different types of monitoring problems such as problems for buoyancy-based systems, difficulty in reaching certain areas and time-consuming monitoring, problems with optical systems, encrustations and difficulties in detecting certain types of objects. Furthermore, the presence of anthropogenic activities such as

- tourism: 10 million tourists every year
- industrial activities, in particular chemical activities, in the industrial center of Porto Marghera (since 1920), one of the largest coastal industrial areas in Europe
- fishing and aquaculture
- agricultural activity in the catchment area but also within the lagoon of the Island of Sant'Erasmo

leads to the traffic problem and consequently to the problem of avoiding obstacles by autonomous vehicles for monitoring.

This particular situation makes the lagoon a perfect test bed for some problems related to the use of marine robotics both on the surface and underwater.

# GENERAL SCENARIO DESCRIPTION

The main aim is to apply the technologies developed within InnovaMare project in a transitional environment, testing also the interaction possibilities between the different technical solutions.

In order to perform the testing activities, the Scenario will be divided in two phases

Phase 1 - 23rd – 27th of May 2022

Testing of SWAMP platform navigation, control, data visualization, communication

Phase 2 - 20th – 24th of June 2022

Test of ROX and SUNA integration on SWAMP, data acquisition, communication and visualization.
Test of R2Sonic MBES integration on SWAMP, data acquisition, communication and visualization.
Test of buoy, sensor units and integration of SWAMP within the buoy monitoring system.

# GOALS OF DEMONSTRATION

The demonstration has different goals, the correct implementation of the USV SWAMP in terms of navigation and communication and autonomous control, the correct integration of the different sensors on this platform, the correct acquisition and visualization of data. Moreover, one of the demonstration goals is also testing and demonstrating the integration of SWAMP as a module within the Buoy monitoring system, displaying its navigation and sensor data on the visualisation dashboard, together with the deployed buoy and sensor units. A goal is also testing the data acquisition and dynamic communication between the SWAMP and buoy systems in the challenging marine environment of the Venice lagoon.

# EQUIPMENT TO BE USED

## SWAMP ASV

*Characteristics*

SWAMP - Shallow Water Autonomous Multipurpose Platform (fig. 1) - is a portable, modular Unmanned Surface Vehicle (USV), designed and built by CNR-INM Genoa research group. It is a catamaran, equipped with four azimuth Pump-Jet thrusters, all contained within the hulls, and designed specifically for SWAMP. The hulls are made of a soft-foam lightweight material, each hull hosts a propelling and control unit (MINION).
The design of SWAMP ensures high modularity and floatability, rendering the vehicle adaptable to the mission and user requirements. The physical modularity is reproduced also in the software architecture. Moreover, the hulls are fully independent, each of them includes its control, guidance, power, propulsion, navigation and communication systems. SWAMP has an onboard Wi-Fi communication network, that enables communication among every single element, other than between the two hulls. This design renders SWAMP a completely modular vehicle that can be dismounted and transported, and then remounted in various possible configurations.
SWAMP ASV allows for extremely shallow water navigation, disclosing unprecedented data in a hostile navigation environment.

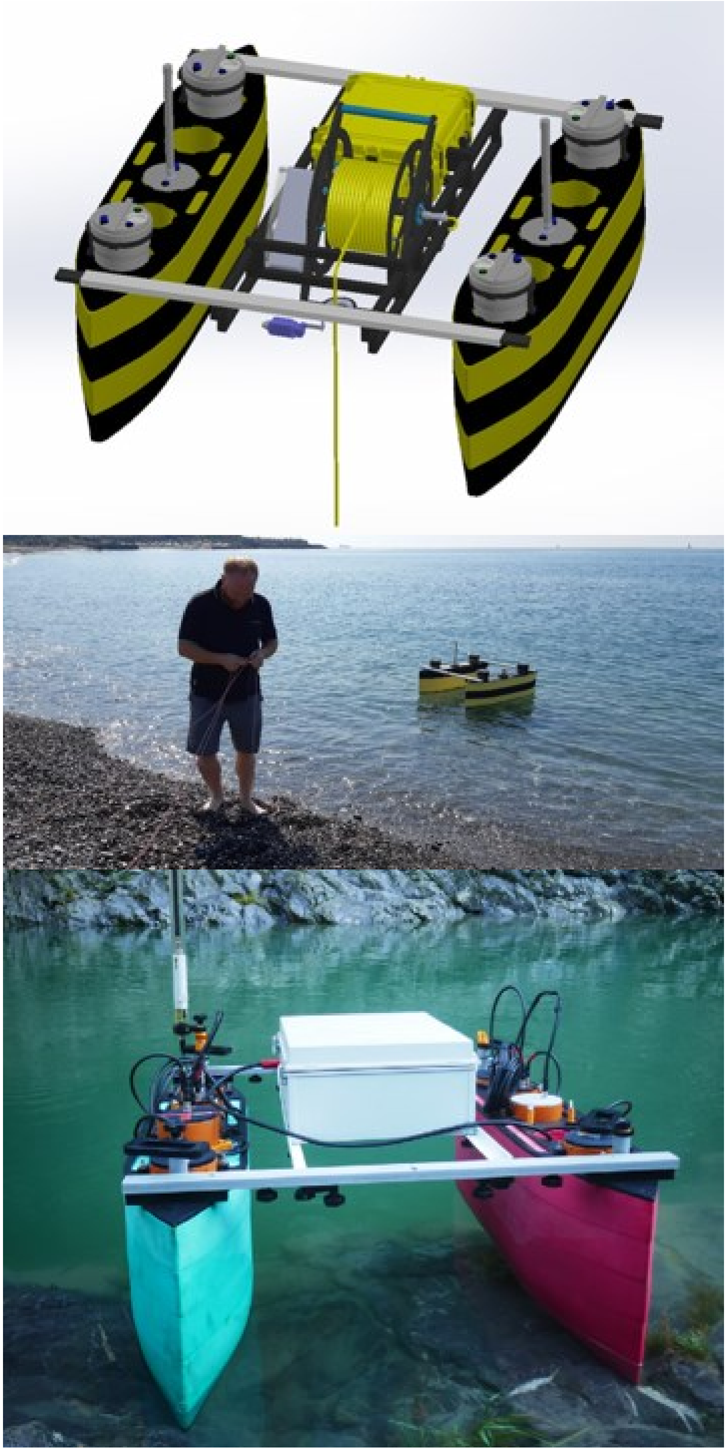

Fig.1 SWAMP in a river (bottom) and sea (top) deployment

*Hardware*

SWAMP is a 1.23 m long fully electric catamaran with a design width of 1.1 m; the width is variable between 0.7 m and 1.25 m. The hull height is 0.4 m; the whole vehicle, including the antennas and the structure connecting the two hulls, is approximately 1m high (fig.2). SWAMP unloaded and dry weight is 38 kg with a draught of 0.1 m. The standard maximum payload is 20 kg, resulting in a maximum design draft of 0.14 m. SWAMP's buoyancy reserve allows for load up to 60 kg with a draught of 0.22 m. The shape of the hull is inspired by the Wigley series; it is symmetrical bow-stern and it has a flat bottom. The longitudinal buoyancy centre is located in the middle of the hull. The following figure shows the main dimensions of the Catamaran.

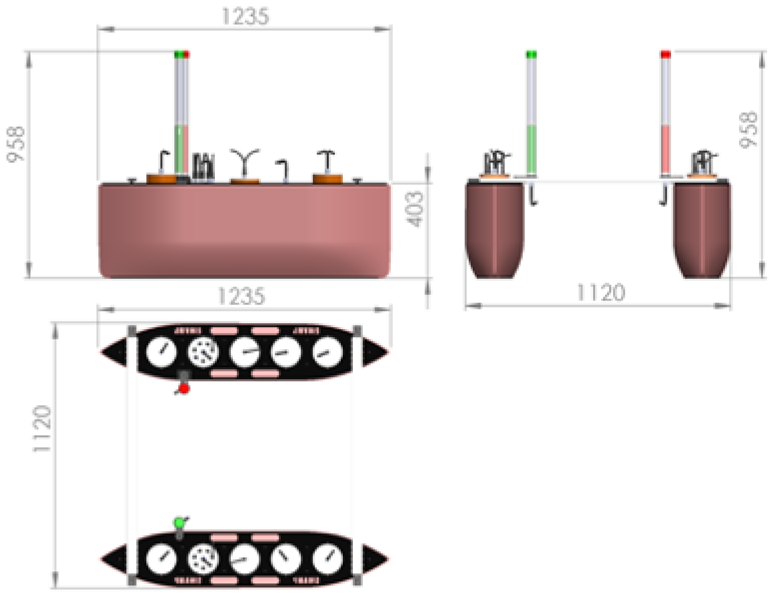

Fig.2: SWAMP dimensions

SWAMP is made of a lightweight, soft and flexible structure. The structure is made of layers of soft PE foam with closed cells, HDPE plates and tie-rods and pultruded rods. This design makes of SWAMP a completely unsinkable vehicle.
The maximum speed of SWAMP in deep water is 1.45 m/s, while the speed in extremely shallow water, up to 200 mm, is reduced to 0.9 m/s due to the peculiar hydrodynamic effects that occur in shallow water.
SWAMP is equipped with an intelligent winch kit with a communication cable for the management of underwater sensors and tools. It also equipped with A GPS-RTK kit for highly accurate positioning in the range of centimetres.
In the newest version of SWAMP there is the least possible wiring, which has been reduced to just the power connections made with IP69k connectors and wiring.
Four azimuth thrusters give SWAMP the controllability that is required for high quality surveys.
The Propelling and Control Units - MINION - encompass two actuators per monohull based on azimuth thrusters pump-Jet and with brushless motors, their controllers, control and power electronics.
Each Pumpjet Thruster produces 12.25 N at 1200 RPM and a Power consumption of 90 W.
Maximum speed of SWAMP in infinite depth waters is 1.6 m/s, while the speed in extremely shallow waters down to 200 mm is reduced to 1 m/s due to the peculiar hydrodynamic effects occurring in shallow water.
The propulsion modules are illustrated below in FIg. 3.

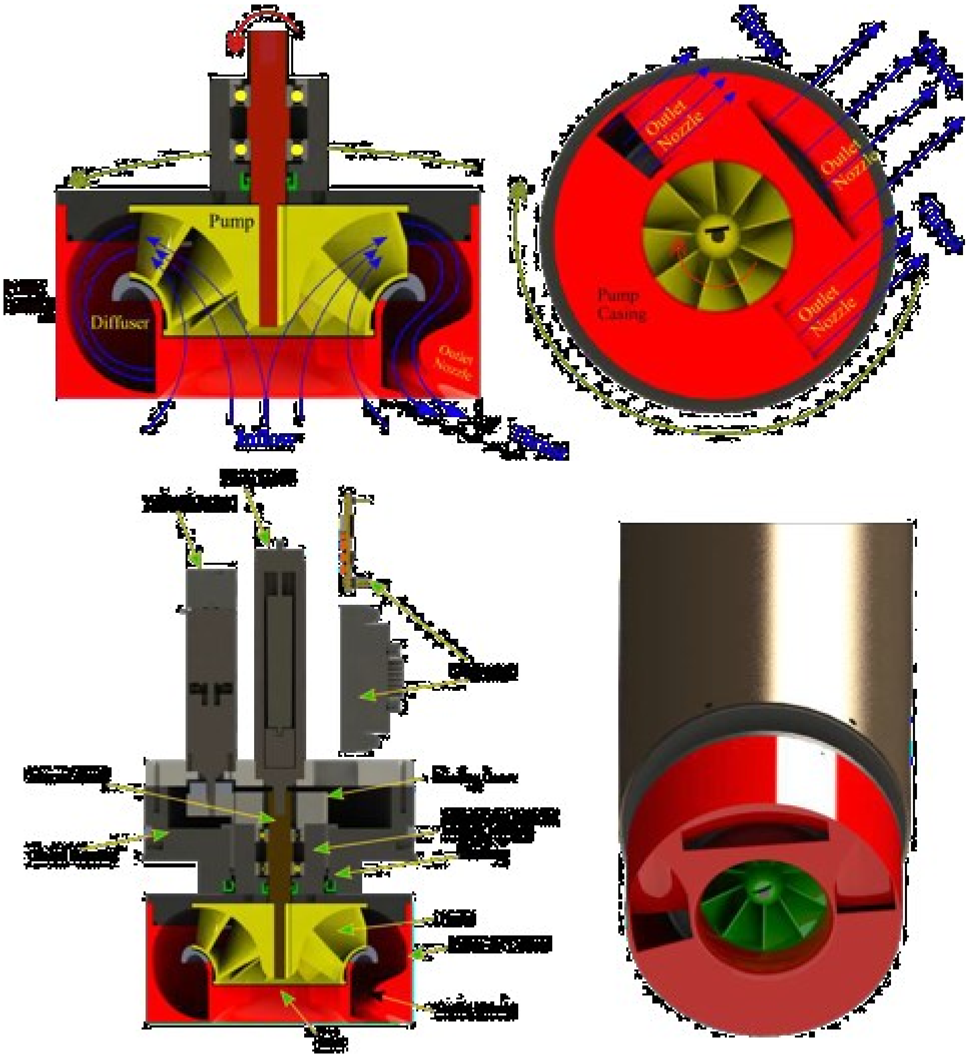


Fig.3: SWAMP Pump-jet schematics

In the new version of SWAMP, the propulsion unit has an optimised temperature management. The innovative motor-propeller coupling is magnetic, hence shaft free.
The battery is integrated in the MINION, it is rechargeable and each propulsion unit has its own battery.
Each MINION is equipped with an electronic interface PCB, which enables control and renders each minion an independent computer. Under this aspect the minion could be an independent vehicle. Inside the MINION there is a GPS and a IMU to ensure localisation and motion performance monitoring.
The Wi-Fi module (i.e. on board access point) mirrors the independency and modularity that figures in the mechanical parts of the MINION. In fact, the WI-FI module has its own battery and can be used to communicate with the particular MINION, moreover it also allows for connection with and among the other modules.

*Software*
SWAMP's software architecture is based on standard commercial components. The basic NGC package of each hull consists of an IMU and a GPS. The communication module for each hull which

provides a communication facility for both its own hull and the other hull's modules. The communication module is a Pilot station Wi-Fi radio (with Omnidirectional antennas for pilot station and Vehicle Wi-Fi radio that can work both in AP (Access Point) mode and in SA (Station Adapter). When the two hulls are physically connected, one of the two computing modules can become the master and the other one can become the slave.
The computing module is based on a Raspberry Pi 3.0 SBC, model B, with Raspbian OS operating system. The software of the control system of each individual hull can be loaded and executed on the computing module. Inside the case of the computational module there are also the basic navigation sensors constituted by an IMU and a GPS.
The basic idea is to have a vehicle made up of N modules (control modules, actuators, sensors, etc.) that communicate via a Wi-Fi connection using the 192.168.29.0 network.
Command packets sent to AM modules are ASCII strings derived from the C programming language.
The commands are sent over a datagram network connection.
All the commands developed for the SWAMP architecture can be used from a computer connected to the network. Commands can be sent from a C program, Matlab, Simulink or other programming tools in a simple way. A customized computer application, developed within the Qt framework, is also available to send commands to the vehicle using a graphical interface and to show the received telemetry as well as the position and movements of the vehicle on a satellite map.

For the purpose of testing sensor integration, an additional single board computer was located on board hosting Windows and Ubuntu in a dual boot configuration. Such computer is accessible remotely through the SWAMP WIFI network. All sensors are connected to it, where the programs to handle and visualize the incoming data are installed.

*Mode of operation/Standard Operation Procedure*
SWAMP is controlled remotely by a human operator, who connects to the onboard access point and guides the vehicle.

## SENSORS on SWAMP Platform

During this Scenario SWAMP will carry different payloads. The first configuration will have the ROX and SUNA sensors, while the second will have the MBES R2Sonic (see D 5.2.3 for references on sensors description).

## Buoys

As part of the platforms offered by FER, innovative smart marine buoys for long-term operation and persistent deployment in marine environments are being developed. The concept of smart buoy can be explored in different perspectives and in the following we will present three distinct configurations. It explores wind and solar energy harvesting methods, anchoring solutions, and a variety of communication methods, including a LoRaWAN (Long Range Wide Area Network) connection for long-range connectivity in the desired Internet of Things (IoT)/Smart City context. The buoy can operate as a remote marine platform performing water quality measurements, as well as a relay for an extended underwater sensor network. Algorithms based on the buoy's inertial measurements can be used to estimate and report on wave height and sea state, and image processing algorithms can be used to implement video monitoring and potential intrusion detection using the buoy's camera for instance for archaeological sites (as mentioned in the Use cases section). The three configurations of the smart buoy concept are described below.

The first configuration features a static buoy gathering, analysing, and storing measurements of various environmental values (for both water and air) using built-in sensors while ensuring long-term autonomy of up to several months by employing energy consumption optimisation algorithms as well as renewable energy sources. Communication-wise, the buoy represents a node in a smart city network with real-time remote access (see Fig. 4). This configuration best embodies the system's application in tourism-heavy areas, providing continuous remote access to water quality, sea state, beach, harbour, and waterway data.

Fig. 4 The first configuration with a static buoy.

The second configuration expands upon the first by adding support for an extended network of seabed-mounted sensors and devices such as cameras and sonars, providing two-way remote access to them for expanding an IoT approach into an Internet of Underwater Things (IoUT) approach (Fig. 5). This configuration is of particular relevance to marine archaeology-related applications of surveillance and protection of culturally significant underwater sites such as shipwrecks, while also being appropriate for sites of biological and ecological significance such as coral reefs.

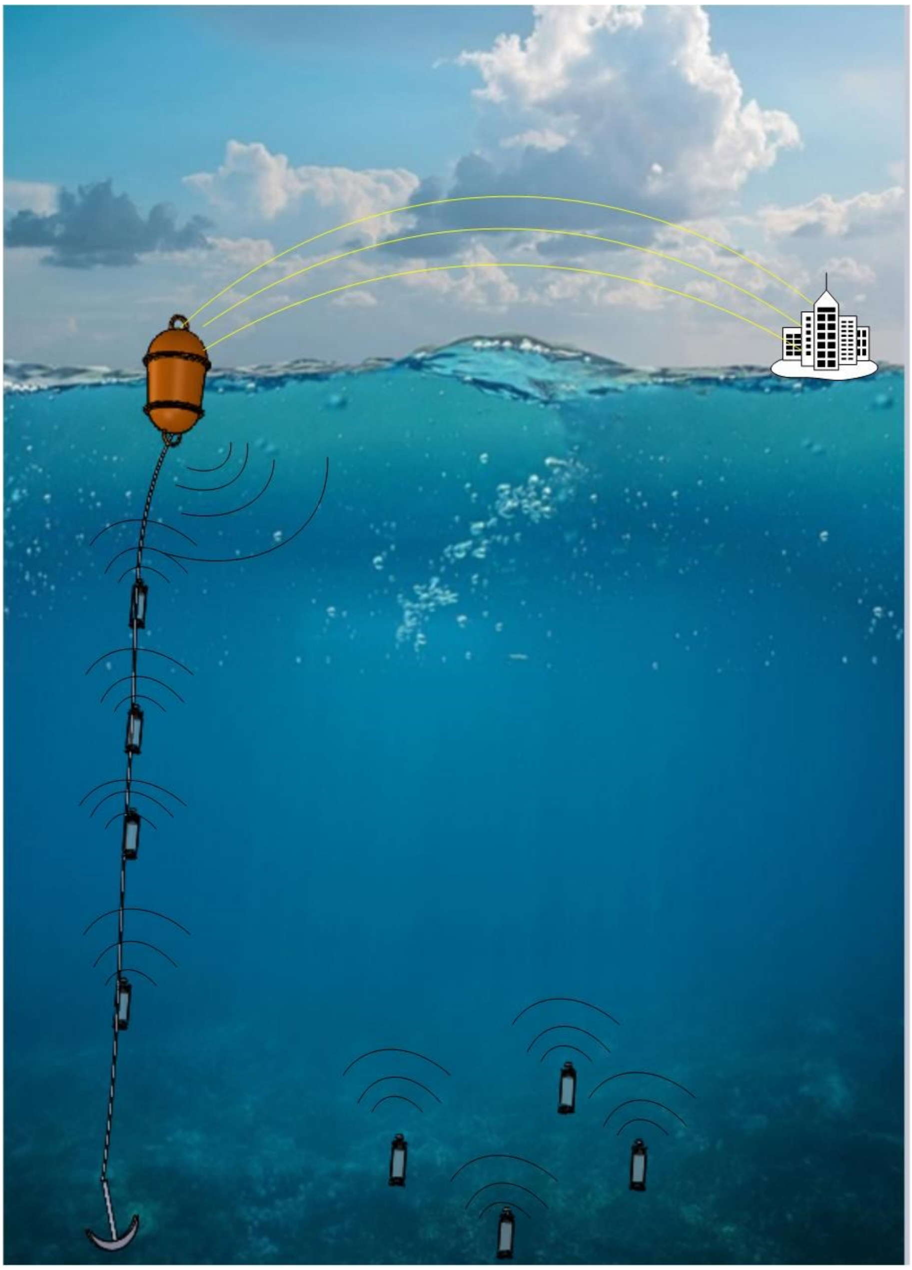

Fig. 5 Static buoy and sensor node concept realised as underwater acoustic sensor network.

The third and final configuration is a mobile, dynamic buoy, an ASV, uniting the IoT approach of the previous configurations with significantly enhanced movement and control capabilities which enable the coverage of a wider measurement area for pollution detection, while optimising energy use in order to maintain long-term operation. This configuration emphasises the system's capability to detect and map ecologically threatening phenomena such as oil spills and its ability to raise appropriate alarms over long distances.

## Hardware modules

The static buoy contains a GPS unit in order to accurately report its location. Mounted on the top of its hull is an IR-CUT B camera capable of both day and night operation, making a video feed possible, as well as offering potential intrusion detection functionalities in use-cases such as deployment near archaeological or aquacultural sites. The buoy is currently equipped with a RTD temperature probe

- Atlas Scientific PT-1000 for water temperature monitoring. The first developed static buoy concept is shown in Fig. 6.

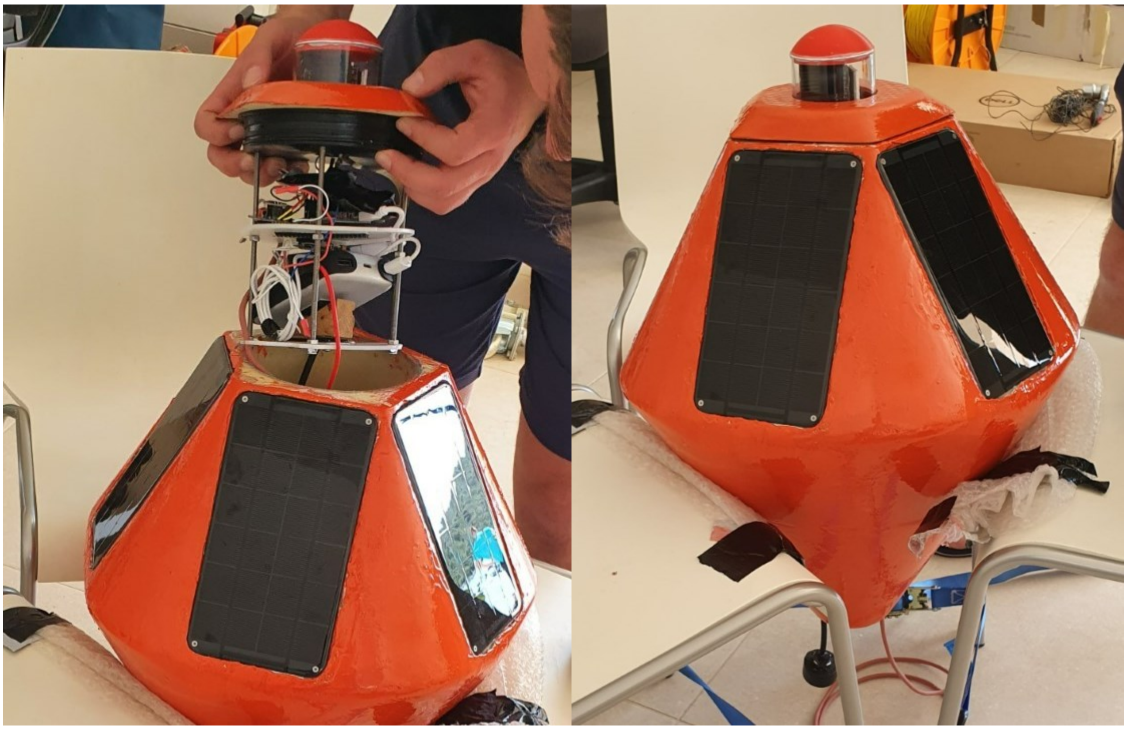

Fig. 6 First prototype buoy prepared for deployment.

In addition to a camera and a standard pressure-temperature sensor, when operating as a remote marine platform performing water quality measurements, the buoy uses existing in-situ sensors such as those for detecting oil, chlorophyll, green algae, and rhodamine; sensors for measuring water turbidity and conductivity (salinity); as well as Coloured Dissolved Organic Matter (CDOM). For this purpose, Turner Designs' Cyclops-7F sensors are being integrated into the buoy system.

Chosen communication methods for the buoy system include WiFi for shortest-range communication, LTE Cat-M1/NB-IoT/EGPRS modem for primary data reporting when far away from any access points, LoRa for low-bandwidth and low-frequency long-distance reporting of small data packets, and acoustic communication between the surface unit and the underwater network using well-tested miniature acoustic nanomodems, the use of which in an underwater acoustic sensor network was established.

Each buoy contains Li-ion batteries and is equipped with solar panels to increase its autonomy (5 panels of 6V/3.5W per buoy unit). It also uses electronic power boards to control power usage and put its various components into a low-powered sleep mode or turn them on and off completely, ensuring long-term autonomy. Experiments with a wind generator are planned for the third, mobile buoy configuration.

As mentioned above, in the second configuration, the buoy can be paired with underwater sensor nodes. These can be attached to a static buoy's mooring line, or deployed on the seabed in the area surrounding a buoy as in-situ sensors, acting as an extension of the buoy system. In both variants the sensor nodes communicate with the buoy acoustically. The design of a sensor node with two optical sensors for water quality measurement is shown in Fig. 7. The main node housing consists of a plexiglass tube with two end caps forming a watertight enclosure. The top cap of the node contains cable penetrators for submersible sensors mounted on the outside, a vent for pressure equalisation, a power switch for activation and deactivation without the need for opening the enclosure, and an acoustic nanomodem transducer.

The sensor nodes currently contain a Maxim Integrated DS18B20 temperature probe, Atlas Scientific conductivity probes K 10 (for salt water) and K1.0 (for brackish water), an Atlas Scientific dissolved oxygen probe, and a Turner Cyclops-7F submersible fluorometer for chlorophyll in vivo (blue excitation). A TE Connectivity MS5837-30BA pressure sensor is used for depth measurement.

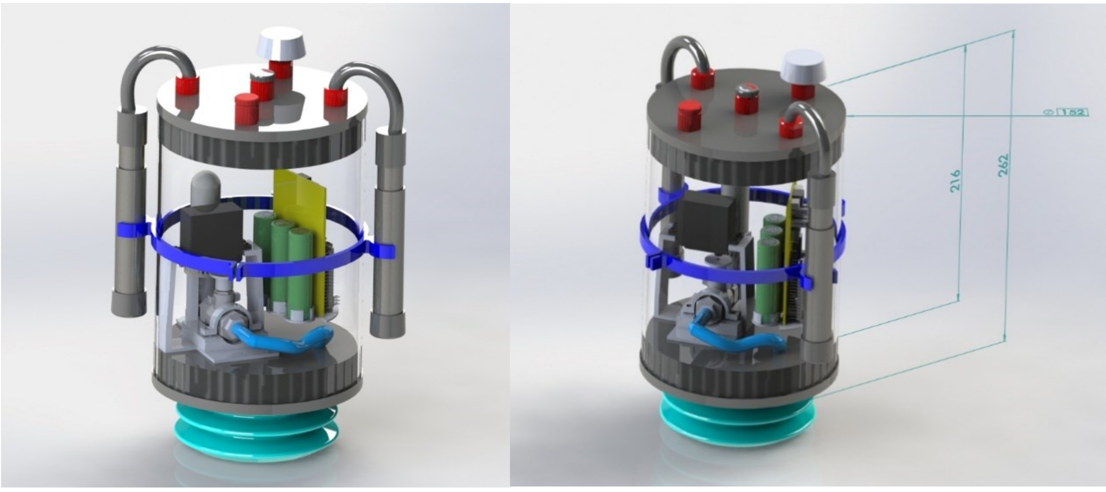

Fig. 7 Sensor node design with dual optical Cyclops-7Fsensors mounted.

Fig. 8 Sensor units ready for deployment.

## Software modules

The main on-board computer used in the buoy is a Raspberry Pi running Ubuntu with Robot Operating System (ROS). Both a low-power version using a Rasberry Pi Zero and a high-capability version using a Raspberry Pi 4 are being tested. The sensor nodes use an Arduino Micro as their main board.

The currently envisioned operation cycle of the buoy system is shown in Fig. 9 and includes the buoy waking up from its own sleep mode on a preset fixed timer interval, sampling environmental data using its own sensors, then starting acoustic interrogation of all deployed sensor nodes. Each sensor node is awakened from its low-power mode by the acoustic ping, then samples data from its own sensors and sends the readings in an acoustic response to the buoy's ping using a predefined payload format. This communication is done in the node's own designated timeslot, ensuring no acoustic channel interference happens. Once the buoy replies with a reception acknowledgment, the sensor node goes back to sleep. The buoy, once it has collected all the sensor node data (or any of the sensor nodes reach a predefined time-out without response), sends its data to the IoT cloud in an appropriately formatted message, where it is displayed on a dashboard for users to see, track, and react to accordingly (for instance, if any alarms are raised).

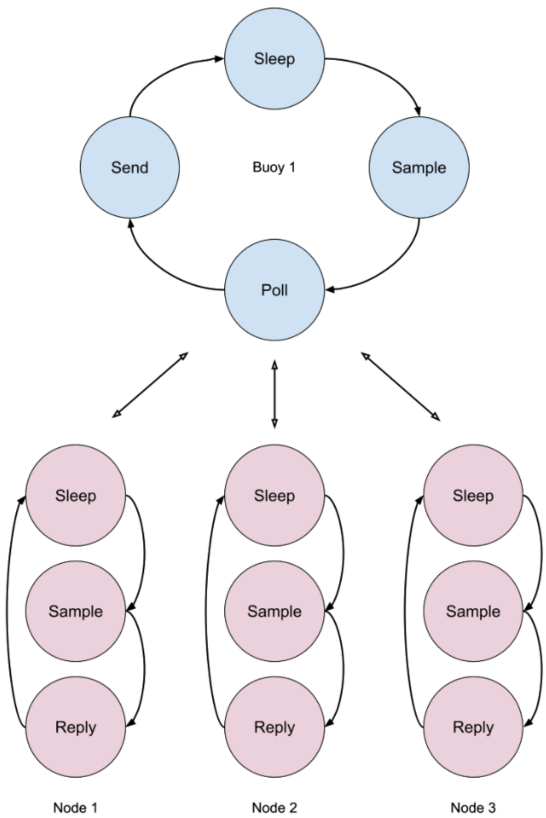


Fig. 9 Buoy and sensor nodes standard operation mode.

The buoy also serves as an acoustic relay to the sensor nodes, whose surfacing is triggered from the buoy. This can be a unicast intended for retrieval of a single node, or a broadcast when retrieving the entire underwater sensor network is required.

In terms of IoT, an open-source IoT platform called ThingsBoard was chosen for data collection, processing, visualization, and device management (Fig. 10). The service is hosted on a server in Zagreb, and a dashboard was configured with appropriate widgets to display desired measurements for various experiments. Due to the innate modularity of the system, the buoy can also serve as a relay for other vehicles connected to the same WiFi network and forward their position, battery state, and other data to be displayed on the dashboard.

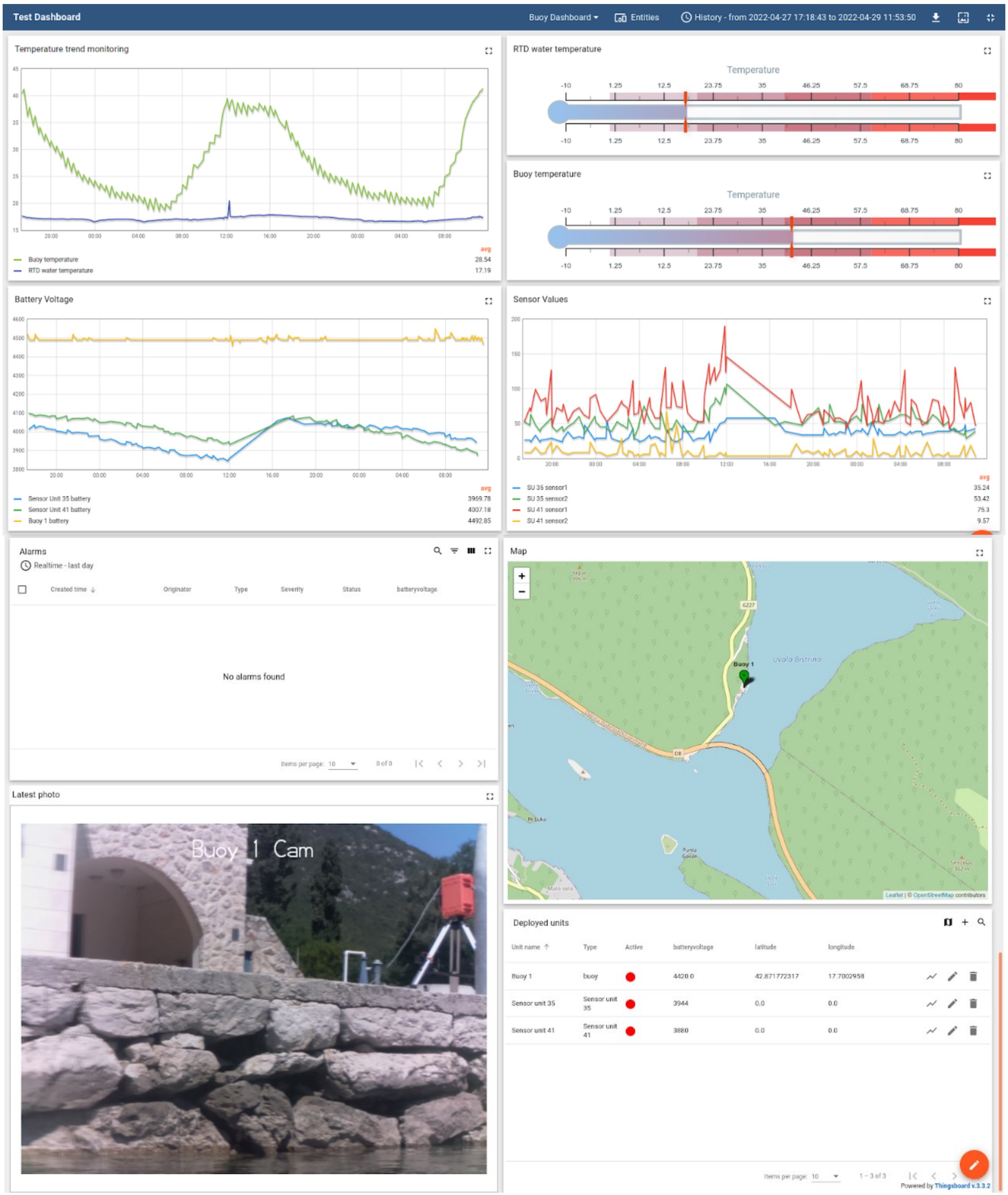


Fig. 10 ThingsBoard IoT dashboard showing proof-of-concept for experimental data.

As the main objective of the trials is to demonstrate the possibilities of cooperation in innovation on robotic and sensor solutions, this modularity and relay function is highly relevant. This is also an example of the third system configuration planned - that with an ASV integrated in operations. Thus, the LABUST Multifunctional Smart Buoy unit and the CNR catamaran-like surface vehicle SWAMP are integrated into a single environmental monitoring and surveying system.

The vehicles communicate via WiFi, with the buoy serving as a relay hosting an UDP listener. Once packets of telemetry and/or sensor data are received from SWAMP, data collected by both the buoy and SWAMP is sent to an online IoT dashboard which has SWAMP included as a device, providing real-time access to the status of the catamaran as it goes about an algae mapping mission. For the first trials, the data sent from SWAMP is its latitude/longitude GPS position, its heading, its on-board temperature, and the voltage state of its batteries. The buoy itself provides its own GPS position, on-board and in-water temperatures to compare.

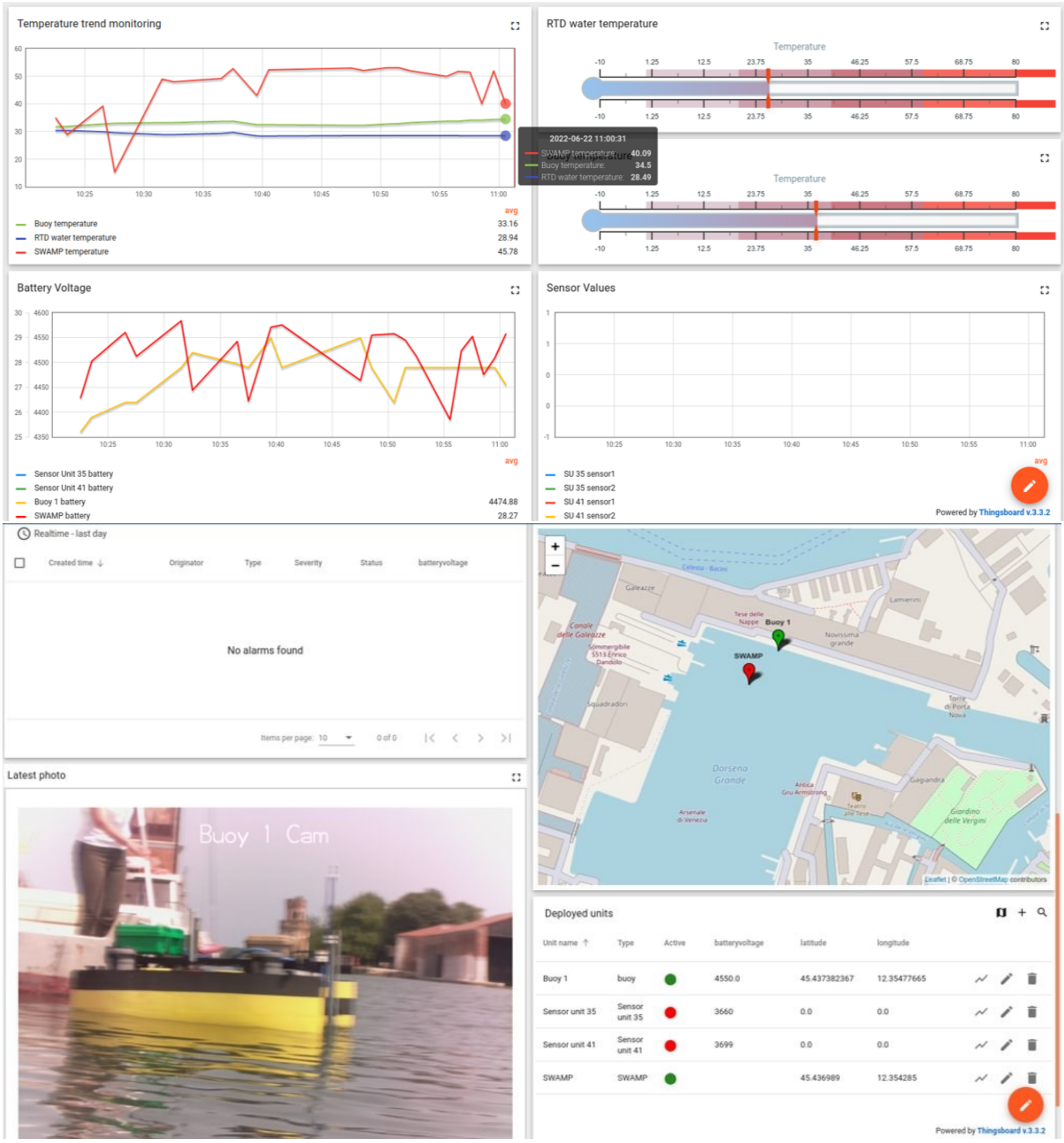


Fig. 11 ThingsBoard IoT dashboard showing SWAMP being integrated in monitoring system.

The trials taking place in the challenging marine environment of the Venice Lagoon also serve as an excellent logistics challenge, offering opportunities to test and practice buoy deployment, retrieval, and mooring options in a variety of conditions, as well as a stress test for the buoy.

# PARTICIPANTS

Participating partners are UNIZG-FER and CNR.

# PARTICIPANTS RESPONSIBILITIES

CNR will be the host partner and will be responsible for

- Logistic
- Equipment storage
- Boats and vessels necessary for deployment
- Internet access
- Workspace
- SWAMP and sensors operations (ROX, MBES R2Sonic)

UNIZG-FER will be responsible for

- Buoys equipment operations
- to bring the buoys equipment to the Venice P.le Roma location,
- taking care of this equipment for all the duration of the scenario.

OGS will be responsible for
SUNA V2 operations

# OPERATING AREA REQUIREMENTS

The operations will be carried out in two different areas of the Venice Lagoon (Fig. 14):

- Area 1: Arsenale Basin, test of SWAMP navigation and R2Sonic MBES and Buoys communications
- Area 2: Test areas for ROX and SUNA acquisitions on SWAMP USV and Buoy communications in the lagoon field.

Fig. 14 Testing area for the operations in the Venice Lagoon

Vessels

- LITUS cabin cruiser 9 m, 10 people (2 drivers + 8 researchers) equipped with winch and small beach for lowering the tools
- ARETUSA, 7 m, 6 people including 1 driver (if they fix the damage to the engine)
- Boston Whaler 5 m, 4 people including 1 driver

# EVENTS SET-UP

## Scenario Agenda: MAY 23-27 2022

**May 23**-CNR - INM Team arrival in the morning, briefing and preparation of instrumentation and dry test
**May 24**-Basic SWAMP test operation and identification, navigation, guidance and control tests.
**May 25**-Basic SWAMP test operation and identification, basic navigation, driving and control
**May 26-27** - Basic test of SWAMP, Electrical-mechanical-hydrodynamic Integration

## Scenario Agenda: JUNE 20-24 2022

**June 20 :** (Activity at the ISMAR institute- Arsenale - Area 1 Fig 14)

8:00-13:00

- CNR- INM Team and UNIZG-FER colleagues' arrival
- briefing
- preparation and verification in the Arsenal basin, in front of ISMAR, to fine-tune the instrumentation and verify that everything works.

14:00-18:00

- Equipment and buoys preparation
- ISMAR and FER equipment setting evaluation for the next days

**June 21 :** (Activity at the ISMAR institute- Arsenale - Area 1 Fig 14)
9:00-16:30

Data acquisition and dynamic communication test between SWAMP and FER buoys from the following sensors: SWAMP battery status, ROX, and SUNA.

16: 30-18: 00

Check of the acquired data of the day and evaluation of any settings to be changed
OGS colleagues' arrival

**June 22 :** (ROX and SUNA testing, Buoys and SWAMP, Area 2, Fig 14)
9:00 Departure from Arsenale and Transfer to Area 2
10:30 -12:30 acquisitions with the ROX and SUNA
13:00 lunch

14:00 16:00 Test between SWAMP and FER buoys in the Lagoon
16:30 Return to Arsenale and FER departure
16:30 - 18:00 MBES Calibration

**June 23 :** (Data acquisition test on marine litter by MBES)
7:00 departure from Arsenale
8:00-10:00 MBES survey
15:00 Return to Arsenale
16: 30-18: 00 Check of the acquired data of the day and evaluation of any settings to be changed

**June 24 :** (Activity at the ISMAR institute -Arsenale - point A)
debriefing on the data collected and definition of the next steps also on the GIS and FAIR part

## TESTS

Here the different specific tests are listed, basic tests and then cooperative scenarios.

Preliminary testing

SWAMP will be tested in the surroundings of CNR-ISMAR headquarters in Venice during the week 23-27 May. During the tests a division of the CNR-INM research group will perform SWAMP ASV identification, a second phase of these tests, from 20-24 of June, will focus on sensor integration and data communication, in collaboration with other partners of the project.

SWAMP tests

- switching on
- verification of wifi communication
- MINIONS software update
- Correct GPS positioning
- maximum operating distance of wifi communication
- navigation and guidance (auto heading, set and go home if connection is lost,go to point, etc.), functionality, identification, communication, control, (test in Genoa will be present for final tests in September), telemetry.
- Test of a new HCI interface to control navigation and guidance of SWAMP.

MBES R2Sonic

- switching on,
- GPS calibration
- interface software (QINSY) display
- correct acquisition,
- Check the quality of the data in real time (software onair and QINSY) and in post processing
- Check remote access to the computer that handle the sensor's data located on board.

ROX

- set up
- ignition
- correct acquisition, display of the data
- acquisition test during movement and/or stationary
- Acquisition test by placing the sensor either on the bow or stern of the vehicle
- Check remote access to the computer that handle the sensor's data located on board.

SUNA V2

- power on
- correct acquisition (interface software display of real time data)
- Check remote access to the computer that handle the sensor's data located on board

Buoy tests

- Setup of network base station, connection buoy and SWAMP to same network (either base station or SWAMP access point)

- General system/connection check upon arrival, battery check (disable sleep intervals, make sure all is charged)
- Maximum operating distance of WIFI communication (+ internet access)
- UDP node with JSON packets, check SWAMP -> buoy comms
- Integrate dashboard widget for SWAMP, add SWAMP as agent
- Full data collection test - sensor units and SWAMP send to buoy; buoy sends to dashboard for data display

# HEALTH AND SAFETY

All the participants were equipped with PPE and covered by proper insurance.

# CONCLUSIONS

This report describes in detail the foreseen scenario to test the platforms developed and used by InnovaMare Project partners and the related sensors. This scenario was designed in the Venice Lagoon in order to offer a challenging environment to test the different capabilities and functionalities of platform and sensors. The work in Activity 5.2 was extended until the end of November in order test properly the sensors and acquire good datasets. In order to design this scenario a series of regular meetings have taken place among partners, looking at the different possibilities of collaboration. A showcase of the platforms and sensors is also foreseen at the upcoming Breaking the Surface 2022 workshop.

# GLOSSARY

**AP** Access Point
**ASV**: Autonomous Surface Vehicle
**Benthic zone**: is the ecological region at the lowest level of a body of water such as an ocean, lake, or stream, including the sediment surface and some sub-surface layers.
**CDOM** Coloured Dissolved Organic Matter
**CRI** Color Rendering Index
**DDNS** Dynamic Domain Name System
**EPA**: Environmental Protection Agency
**GES MSFD**: Good Environmental Status descriptors of Marine Strategy Framework Directive
**GIS**: geographic information system
**GNSS**: Global Navigation Satellite System
**GPS**: Global Positioning System
**GUI** Graphical User Interface
**IMU** Inertial Measurement Unit
**IMC** Inter-Module Communication

**IoT** Internet of Things
**IoUT** Internet of Underwater Things
**LABUST** Laboratory for Underwater Systems
**LL** Living Lab
**LoRaWAN** Long Range Wide Area Network
**LTE** Long Term Evolution
**MBES**: MultiBeam EchoSounder
**MPA**: Marine Protected Area
**MQTT** Message Queuing Telemetry Transport
**NGC** Navigation, Guidance and Control
**Ortophoto**: is an aerial photograph or satellite imagery geometrically corrected ("orthorectified") such that the scale is uniform: the photo or image follows a given map projection.
**PTZ** Pan-Tilt-Zoom
**ROV**: Remote Operated Vehicle
**RTK Real Time Kinematic**
**RTSP** Real Time Streaming Protocol
**SA** Station Adapter
**SBP** Sub Bottom Profiler
**SDK** Software Development Kit
**SV**: Surface Vehicle
**SWAMP**: Shallow Water Autonomous Multipurpose Platform
**TMS** Tether Management System
**UNESCO** United Nations Educational, Scientific and Cultural Organization
**USBL** Ultra-Short BaseLine