Report on the functional tests at sea of the second generation

Activity 3.3 - Piloting of the UUV
WP3 - Implementation of the Drone-enabled Monitoring System

SUSHI DROP project (ID 10046731)

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Abstract

WP3 is focused on the definition of requirements, procurement, and validation at sea of a drone, i.e. an Unmanned Underwater Vehicle (UUV) for acoustic and optical characterization of the marine ecosystem at different degrees od resolution. This WP comprehends the functional tests at sea of the second generation of UUV performed during the Italian missions. These tests involve the implementation of new scripts to provide fully interaction between subsystems, implementation of the USBL subsystem and Multibeam into the drone, and the tests on the manoeuvres to be performed during the different surveys, depending on the scientific payload used and the environment itself.

Overview

This deliverable describes all the functional tests carried out to improve the vehicle capability and scientific data quality. These tests are fundamental to check if the new the new software and hardware implementations have been implemented correctly and have increased the quality of scientific data.

This report is organized as follow:

1. Functional Tests of Positioning System: report on the software and hardware implementation meant to improve the accuracy of the position data.
2. Sea Mission Tests: validation of the new software and hardware implementations with sea trials.

Functional tests of Positioning System

In order to improve the position data of Blucy during dead reckoning navigation, it is necessary to implement on the system a new subsystem (USBL [1]) and a new software that allows to connect all the subsystems dedicated to navigation.

These activities provide for the accomplishment of the following objectives:

- Know and visualize on screen the position of the drone during the missions: thanks to the installation of the USBL system and its control software installed on the RS (SiNAPS 2 [2]), it is possible to know the position of the drone with respect to the surface vessel during the dead reckoning navigation.
- Improved position data estimation for better geo-referencing of scientific data and for autopilots: all navigation subsystems are in communication with each other, increasing the accuracy of position estimation (2D position, depth, altitude, attitude angles, 3D speed).
- Telemetry data management for data processing software, i.e. QPS suite [3] (Qinsy [4], Qimera [5], Fledermaus [6]) and Meshroom [7]: Creation of Survey Log for georeferencing the acquired data.
- QPS software suite setup for MBES management and control.

This activity is articulated in the following activities:

1. Installation and interfacing of the USBL system with RS and configuration of the SiNAPS 2 mapping software.
2. Software development for:
    a. Communication between subsystem: MBES, FOG, AHRS, miniSVS-P, MiniCT, USBL, Altitude.
    b. Telemetry data management for data processing.
3. Setup QPS suite for MBES management and control

Setup USBL System

In order to know the position of Blucy during the missions, the USBL system is implemented to reduce the inaccuracy of the position data generated by the FOG. This subsystem is also useful during the navigation phase itself as the pilot is able to visualize, using the SiNAPS 2 software on RS, the position of Blucy with respect to the surface vessel.

The following steps were followed for the installation and implementation of the subsystem:

- Installation and securing of the USBL system on board surface vessel
- SiNAPS 2 software installation on RS and USBL connection to RS Modem
- Measurement of offsets between USBL, Vessel GPS, and Vessel CoG
- Surface vessel model editing on SiNAPS 2
- Communication channel configuration between Vessel Transponder and Blucy Transponder
- Calibration of the USBL system following the guidelines in the manual [2]
- USBL user profile creation (Frequency, Input Length, Power Transmitted)

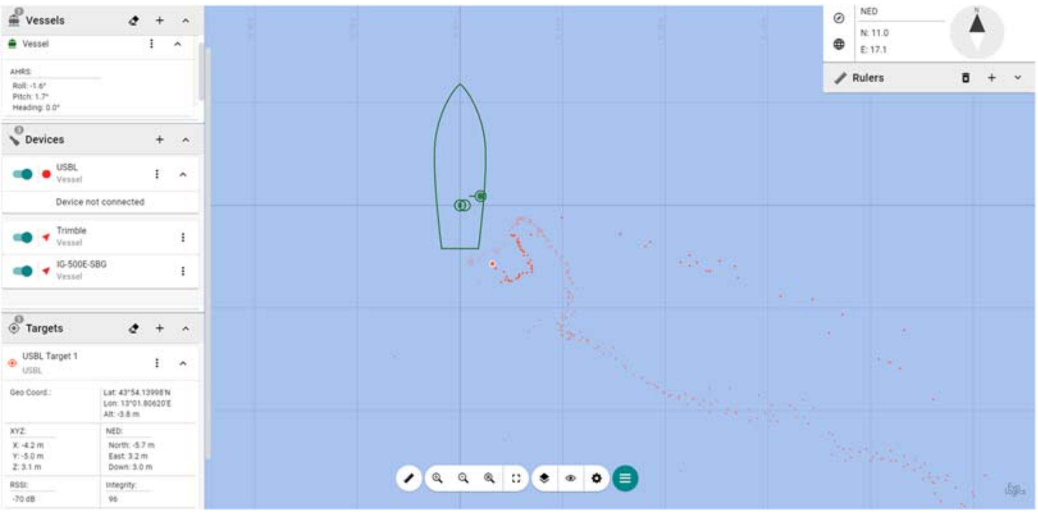


FIGURE 1 SiNAPS 2 ON RS

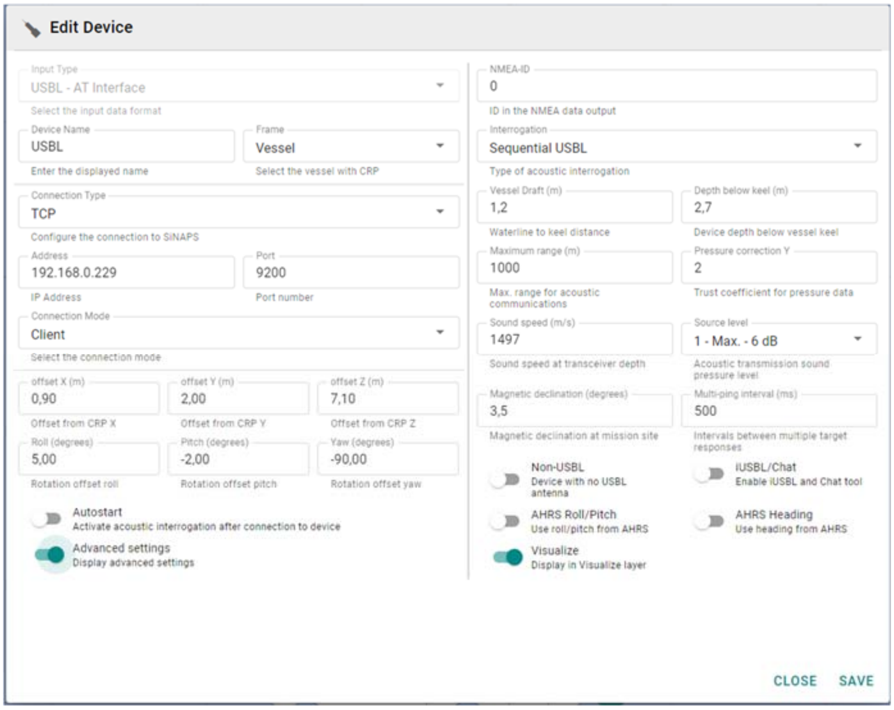
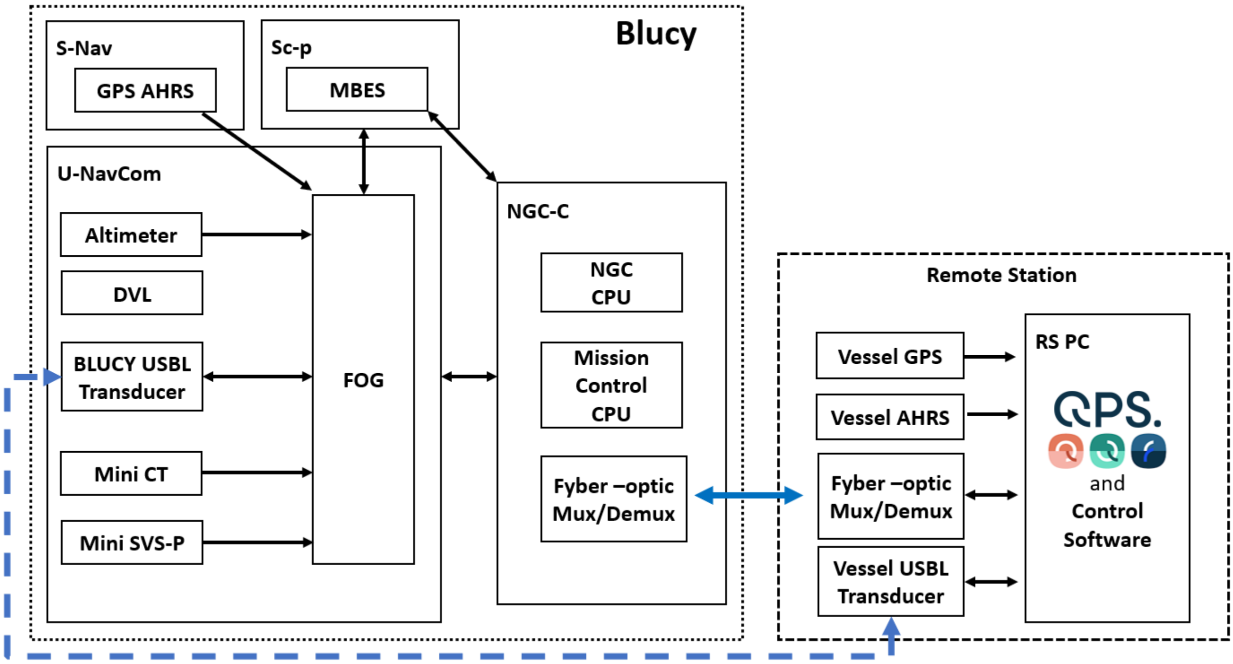


FIGURE 2 SINAPS 2 USBL SETTINGS

Software Development

In order to improve the estimation of Blucy's position variables, it is necessary to connect the various navigation subsystems. To do this, scripts were written in Python language, which allowed to obtain the architecture shown in the



Blucy
S-Nav
GPS AHRS
Sc-p
MBES
U-NavCom
Altimeter
DVL
BLUCY USBL Transducer
Mini CT
Mini SVS-P
FOG
NGC-C
NGC CPU
Mission Control CPU
Fyber –optic Mux/Demux
Remote Station
Vessel GPS
Vessel AHRS
Fyber –optic Mux/Demux
Vessel USBL Transducer
RS PC
QPS.
and
Control Software

Figure **3**.

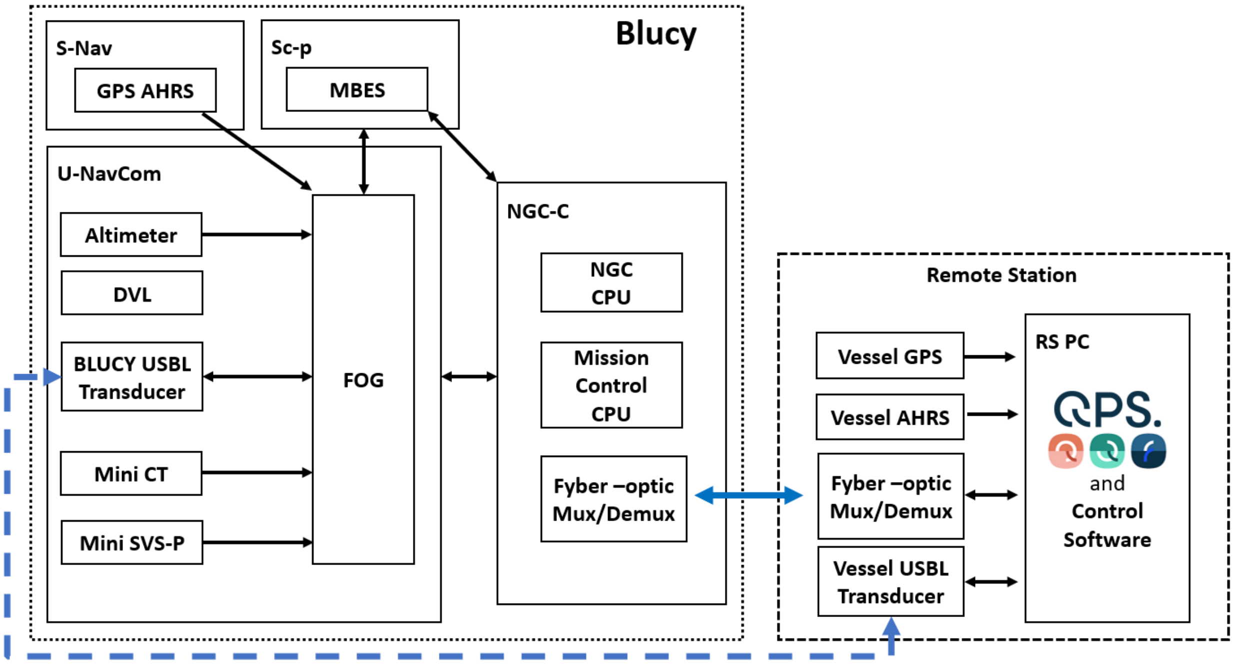


FIGURE 3 SOFTWARE DEVELOPMENT ARCHITECTURE

The result of executing these scripts results in enhanced estimation of position parameters during dead reckoning navigation, as each subsystem has access to all state variables of the drone.

Each subsystem has its own specific real-time script to receive data from the other navigation sensors. The workflow is as follows:

- Data subscription request
- Data packaging according to sensor compatible format (NMEA standard or specific sensor format)
- Send data using UDP protocol to subsystem

The procedure for the management of the telemetry data packet involved the writing of scripts to forward the data generated by all the navigation subsystems both to the RS, via optical fiber, and to the Mission Control CPU, via Blucy's internal LAN. The architecture of these scripts is similar to the architecture of the scripts for communication, with the exception that the data generated by the different sensors are ready to be sent.

Setup QPS suite: Qinsy

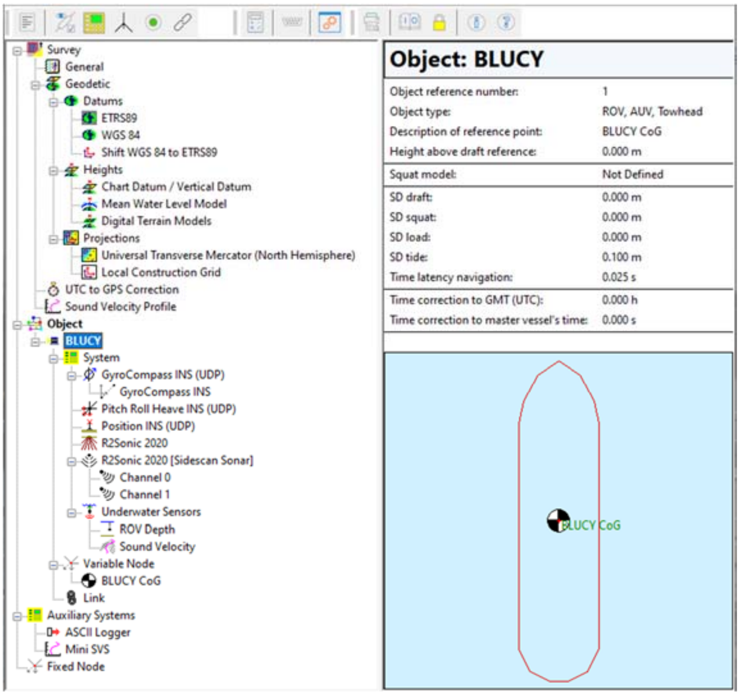


FIGURE 4 QPS PROJECT SETUP OF DIGITAL TWINS OF BLUCY

The QPS suite software is composed of three programs (Qinsy, Qimera, Fledermaus) necessary for the management and analysis of data coming from the MBES. In this phase is presented the setup procedure of Qinsy software for survey planning, acquisition and real-time hydrographic data processing.

The following steps have been followed for this activity:

- Installation of Qinsy on RS
- Project Setup: creation of the digital twins of the Surface Vessel and Blucy
  - Surface Vessel
    - GPS Sensor
    - INS Sensor
    - Vessel USBL Transponder
  - Setup of Blucy Digital Twin:
    - AHRS

  - FOG
  - Blucy USBL Transponder
  - DVL
  - Altitude
  - Mini-SVS
  - Mini-CT
  - MBES
- Communication tests: control data reception from sensors and subsystems
- Creation of database template for Bathymetric, TruePix, Snippets and WaterColumn data
- Tests on MBES control software in Qinsy
- Creation of MBES Mission Profiles: impulse length, frequency, power, gain, dead zone based on different mission scenarios
- Tests of MBES Mission Profiles during sea missions
- Creation of Mission Displays
- Test of data acquisition during sea missions

Sea Mission tests

In order to validate Blucy's capabilities in different mission scenarios, navigation tests were performed in ROV mode with autopilots engaged. Mission tests at sea have increased the level of knowledge of the drone's capabilities to acquire data and navigate in different operational scenarios. These tests have been carried out during missions in Italian waters (Pedaso, Ortona, Fano).

Mainly two types of tests have been performed: MBES Survey and Close Seabed inspection.

Regarding MBES Survey, the following activities have been carried out:

- Calibration of USBL System
- Capability of Blucy to follow Parallel trajectory for MBES overlap
- Tests on optimal MBES setting depending on seabed type and underwater condition (salinity, temperature, depth, sound Velocity)
- Tests on optimal Qinsy setting for MBES acquisition
- Tests on MBES capability

For close seabed inspection the following tests were performed:

- Blucy maneuverability during vertical cliff survey
- Blucy capability in monitoring vertical cliff with optical scientific sensors (BottomCam, PilotCam)

- Blucy maneuverability during shallow water surveillance
- Blucy capability in monitoring seabed in shallow and deep water
- Tests on minimum and maximum altitude of data acquisition with BottomCam (Turbidity, color temperature, light conditions)
- Blucy capability in monitoring mussel farming implant

All these tests have allowed to define Blucy operational scenarios and improve its capability acting on optimization of scientific payloads settings.

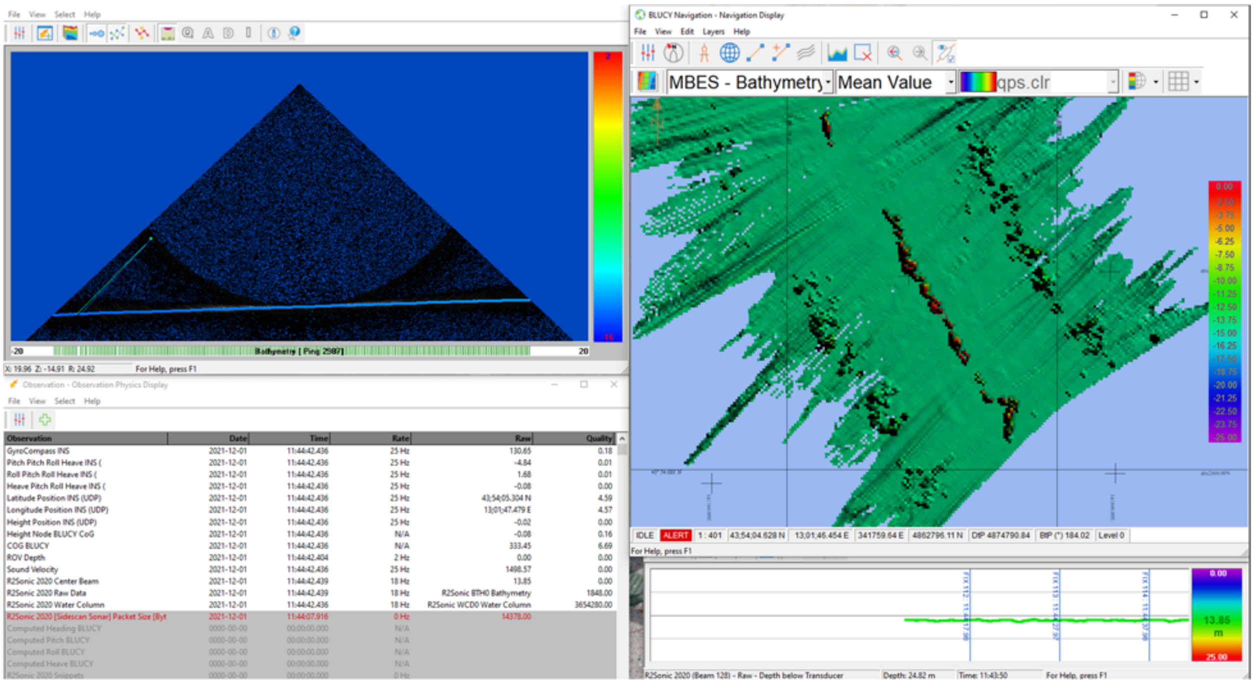


FIGURE 5 QINSY MBES ACQUISITION DURING MISSION

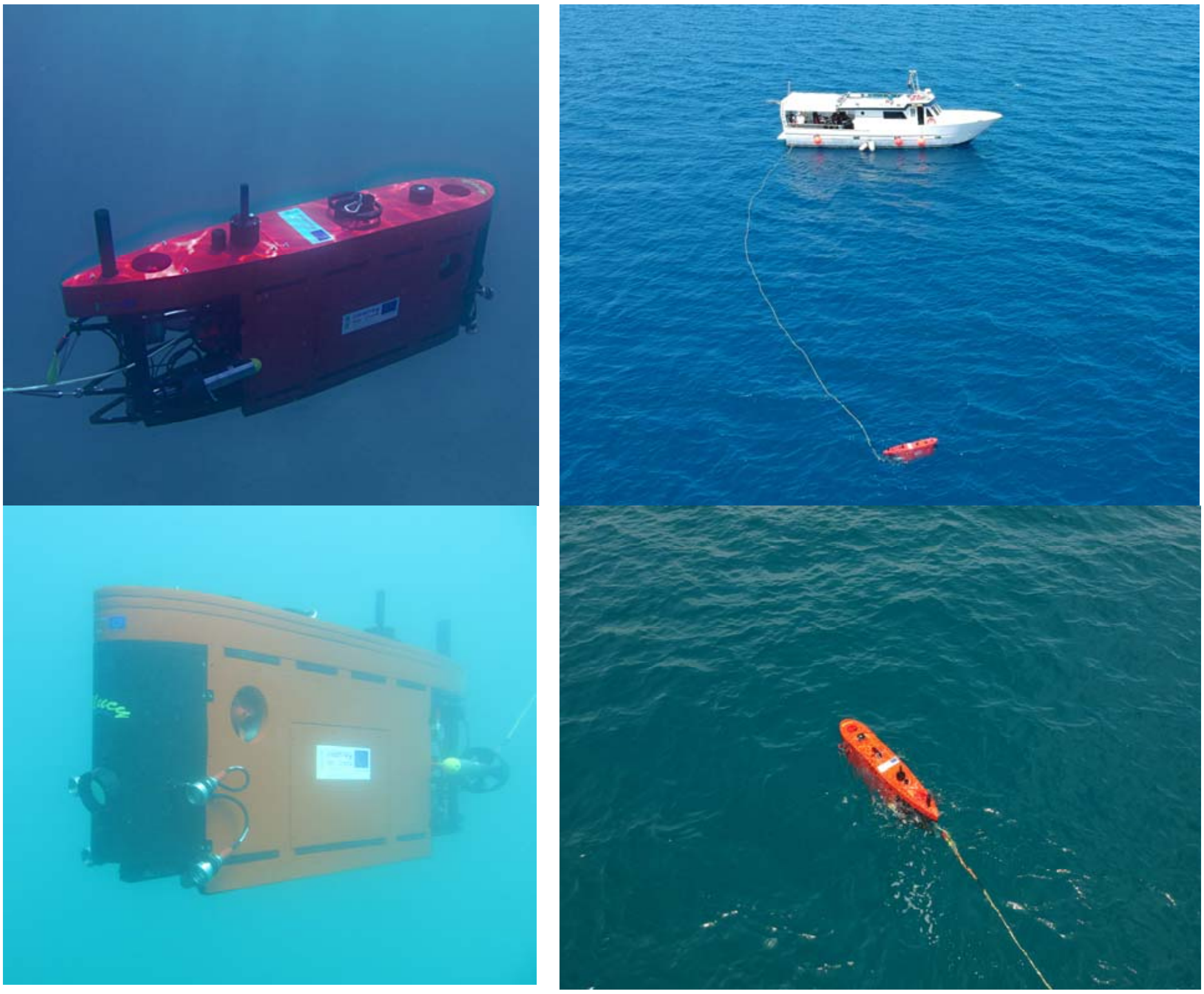


FIGURE 6 BLUCY DURING MISSIONS IN ITALIAN WATERS

Abbreviations

The following abbreviations are used in this deliverable:

AHRS	Attitude and Heading Reference System
AUV	Autonomous Underwater Vehicle
DEM	Digital Elevation Model
DT	Digital Twin
DVL	Doppler Velocity Log
EKF	Extended Kalman Filter
FDI	Fault Detection and Isolation
FOG	Fiber Optic Gyroscope
FOV	Field of View
GNSS	Global Navigation Satellite System
GSD	Ground Sample Distance
INS	Inertial Navigation System
MBES	Multibeam Echosounder
NGC	Navigation, Guidance and Control
ROV	Remotely Operated Vehicle
RS	Remote Station
SFM	Structure from Motion
USBL	Ultra-Short Baseline
UUV	Unmanned Underwater Vehicle
GIS	Geographic Information System
CoG	Centre of Gravity
NMEA	National Marine Electronic Association
UDP	User Data Protocol

References

[1] Evologic USBL S2C R 18/34 https://evologics.de/acoustic-modem/18-34/usbl-serie

[2] SiNAPS 2 https://evologics.de/sinaps

[3] QPS Suite https://qps.nl/

[4] QPS – Qinsy 9 https://www.qps.nl/qinsy/

[5] QPS – Qimera https://www.qps.nl/qimera/

[6] QPS – Fledermaus https://www.qps.nl/fledermaus/

[7] AliceVision Meshroom https://alicevision.org/

Acknowledgement

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