NET4mPLASTIC PROJECT

WP3 – Act. 3.3 Study and Design of the Integrated Platform's structure associated with early warning system

D 3.3.4

EWS Hardware and other software Components Specifications design

March, 2020 - Version 1.2

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Acronyms / Abbreviations

ACRONYM	DEFINITION
ADCP	Acoustic Doppler Current Profiler
CTD	Conductivity Termerature and Depth sensors
EWS	Early Warning System
MP	Microplastic
OBU	On board Unit
PP	Project Plan
PT	Project team
TC	Technical task coordinator
TGS-ML	Technical Subgroup on Marine litter, European Union expert group On marine litter
TM	Task Manager
UML	Unified Modelling Language
WP	Workpackage

1 Introduction

1.1 Background of the project

The main goal of the NET4mPLASTIC project is to achieve an efficient monitoring system for plastic and MP distribution along the Croatian and Italian coastal and marine areas in order to improve the environmental coastal and marine sea quality conditions.

According to doc R1, the Act 3.3 deals with the study and design of the EWS - Early Warning System including:

- a control centre, based on system hardware and network (Prosoft), and a EWS application (Hydra Solutions) integrated with the transport model and external systems (such as the oceanographic model - (Marche Region);
- Integrated Marine Drone, for collection of MP - microplastic, and geolocalized water indicators on the route (Hydra Solutions);
- Integrated Marine OBU, a unit to be installed on board of ships for improved MP collection with geolocalized water indicators on the route (Hydra Solutions).

The design shall be carried out with the modern system engineering approach based on UML - Unified Modelling Language (Hydra Solutions). UNITS and RERA SD will provide data for the first set up of the platform related to MP. Based on this WP, the transport model will be developed in WP4. The development of the EWS platform integrated with the transport model will be done in WP5.
The expected deliverable are the following:

- D 3.3.1 – EWS Requirements definitions based on the stakeholders and users' needs, through questionnaires and specific meeting
- D 3.3.2 – EWS Hardware Architecture and network design (central Data Centre Hardware Architecture Client/Server, Data network architecture and related communication segments)
- D 3.3.3 – EWS Software Architecture design (data modelling software, GIS applications, early warning detection software, etc.), the Relational Database to manage all collected data with related meta data, the communication Front-End for web remote access, the Data Centre Software Interfaces for users
- D 3.3.4 – EWS Hardware and other software Components Specifications design (Integrated Marine Drone and Marine OBU, with details of required components (hardware and firmware), firmware and other software components (mobile apps for managing the drones and for remote mobile activities).
- D 3.3.5 - Report and database provision with all the collected data

1.2 Purpose of the report

This document is the deliverable **D.3.3.4 - EWS Hardware and other software Components Specifications design**, based on the EWS requirement definition report [R2], and the deliverable D.3.3.2 - EWS Hardware Architecture and network design, to describe the software architecute design, within the activity 3.3 of

the **Net4mPlastic project - New Technologies for Macro and Microplastic Detection and Analysis in the Adriatic Basin.**

The purpose of this document is summarized as follows:

- Description of the main hardware components, Integrated Marine Drone and Marine OBU, with details of required components (hardware and firmware);
- Description of the firmware on board the drone and other software components (mobile apps for managing the drones and for remote mobile activities).

Reference documentation

No	Title	Rif/Report N.	Pubblished by
[R1]	**APPLICATION FORM - NET4mPLASTIC Project - New Technologies for macro and Microplastic Detection and Analysis in the Adriatic Basin** 2014 - 2020 Interreg V-A Italy - Croatia CBC Programme Call for proposal 2017 Standard - NET4mPLASTIC Priority Axis:Environment and cultural heritage	Application ID: 10046722, dated 30/06/2017	Lead applicant: UNIVERSITY OF FERRARA
[R2]	**EWS requirements definition**	HYD001-SPE-001.0	ACT3.3 – Net4Mplastic
[R3]	**EWS hardware architecture and network design**	HYD002-SPE-001.0	ACT3.3 – Net4Mplastic

2 Control center

2.1 Introduction

This chapter provides an overview of the hardware and software needed for the control center, hardware and software to be procured in accordance with the requirements defined in "D 3.3.1 EWS requirements definition" and D 3.3.2. Hardware architecture and network design".
In addition to the functional requirements defined in the EWS requirements definition, the characteristics of hardware and network equipment must also meet the following additional criteria for the long-term viability of the project:

- reliability - which is ensured through procurement from reputable manufacturers and whose products quality is confirmed in the market;
- 36-month manufacturer's on-site warranty for the equipment;
- minimum 5-year service life, preferably 7 years in which spare parts are available;
- equipment should support the latest versions of software (operation system, database software, network and security software) available on the market

The following list of EWS control center equipment with operation systems are essential and represents the minimum required for the development, operation and management of the EWS:

ITEM	QTY	DESCRIPTION	FUNCTION
1	2	Server	Infrastructure, Database, Web, Testing & Development
2	2	Networking, security and integration	Connectivity and reliability
3	2	Workstation	Management, Development, Testing
4	2	Tablet	Development, Evaluation, Testing
5	2	Smartphone	Development, Evaluation, Testing

Additional (optional) products are needed if they cannot be provided by EWS CC hosting partner:

- two Firewall/router with software
- Backup software
- Antivirus/Antimalware software

Project partners hosting the EWS Control Center should ensure that the following prerequisites are met for EWS servers location and operation:

- a server room that meets all general and specific standards for this purpose with adequate capacity to host EWS Control Centre equipment such as space requirements, enclosures, cooling system, fire protection, power supply, UPS, alarm and security,
- Internet access with adequate speed and throughput (100 Mbps minimum)
- at least four 10 GB switching network connection ports available per physical server (or one for any virtual server) per location

- VPN connectivity and remote access solution to EWS equipment at both location.

In the next paragraphs hardware devices are identified for a on-premise server solution. Anyway in the prodrement phase the cost advantages of the cloud server solution.

2.2 Servers

Servers are the cornerstone of the EWS hardware architecture. To allow for high availability of EWS, two physical servers of the same configuration are provided at two locations. Their configuration must meet at least the following specification or specification of equal value.

COMP 1: Servers Main Feature and Specifications

Option	Selection	Quantity
Base	PowerEdge R540 Server	1
Trusted Platform Module (TPM)	Trusted Platform Module 2.0	1
Chassis	3.5" Chassis with up to 8 Hot Plug Hard Drives	1
Processor	Intel Xeon Silver 4214 2.2G, 12C/24T, 9.6GT/s, 16.5M Cache, Turbo, HT (85W) DDR4-2400	1
Additional Processor	Intel® Xeon® Silver 4214 2.2G, 12C/24T, 9.6GT/s, 16.5M Cache, Turbo, HT (85W) DDR4-2400	1
PCIe Riser	1xFH, 4xLP, 2CPU	1
Processor Thermal Configuration	Heat Sink already included	1
Memory DIMM Type and Speed	2666MT/s RDIMMs	1
Memory Configuration Type	Performance Optimized	1
Memory	16GB RDIMM, 2666MT/s, Dual Rank	4
RAID	C4, RAID 5 for 3 or more HDDs or SSDs (Matching Type/Speed/Capacity)	1
RAID/Internal Storage Controllers	PERC H730P RAID Controller, 2GB NV Cache, Adapter, Low Profile	1
Hard Drive	1.92TB SSD SAS Mix Use 12Gbps 512n 2.5in Hot-plug Drive,3.5in HYB CARR, PX05SV,3 DWPD,10512 TBW	5
Operating System	Windows Server® 2019 Standard,16CORE,FI,No Med,No CAL, Multi Language	1
OS Media Kits	Windows Server 2019 Standard,16CORE,Digitally Fulfilled Recovery Image, Multi Language	1
OS Media Kits	Windows Server® 2019 Standard,No Media,WS2016 Std Downgrade DF and DVD Media,Multi Lang	1
Client Access Licenses	10-pack of Windows Server 2019/2016 User CALs (Standard or Datacenter)	1
Client Access Licenses	5-pack of Windows Server 2019 Remote Desktop Services, User	1
Additional Virtual Machines for Windows Sever	WS2019, Additional 2Virtual Machines,2 Processor with 12CORES each	2
Embedded Systems Management	iDRAC9 Basic	1
Embedded Systems Management	Dell EMC OpenManage Integration for ServiceNow for iDRAC9	1
Group Manager	iDRAC Group Manager, Disabled	1
Password	iDRAC,Factory Generated Password	1

iDRAC Systems Management Options	Static IP	1
Additional Network Cards	On-Board Broadcom 5720 Dual Port 1Gb LOM	1
Additional Network Cards	Intel X550 Dual Port 10GbE BASE-T Adapter, PCIe Low Profile	2
Internal Optical Drive	No Internal Optical Drive for 8 HDD Chassis	1
Power Supply	Dual, Hot-plug, Redundant Power Supply (1+1), 750W	1
Power Cords	Power Cord 250V	2
Power Management BIOS Settings	Performance BIOS Setting	1
Advanced System Configurations	UEFI BIOS Boot Mode with GPT Partition	1
Rack Rails	ReadyRails™ Sliding Rails Without Cable Management Arm	1
Server Accessories	Keyboard and Optical Mouse, USB, Black, English	1
iDRAC Service Module	iDRAC Service Module (ISM), Pre-Installed in OS	1
Support & Services		
Warranty	Basic Next Business Day 36 Months, 36 Month(s)	1
Database		
Microsoft SQL	Microsoft SQL Server 2017 Standard, 4 CORE, OEM, NFI with SQL2014/2016 DWGD Media	1

2.3 Database server

According to the EWS software architecture, all collected data will be stored in a relational database. Standard relational databases enable users to manage predefined data relationships across multiple databases. The main advantage of relational databases is that they enable users to easily categorize and store data that can later be queried and filtered to extract specific information for reports. Relational databases are also easy to extend and aren't reliant on physical organization. After the original database creation, a new data category can be added without all existing applications being modified.
There are other relational database advantages as:

- Accuracy - Data is stored just once, eliminating data duplication.
- Flexibility - Complex queries are easy for users to carry out.
- Collaboration - Multiple users can access the same database.
- Trust - Relational database models are mature and well-understood.
- Security - Data in tables within a RDBMS can be limited to allow access by only particular users.

Among several relational database management systems (RDBMS) options, MySQL and MS SQL Server which are widely used enterprise database systems have been taken to account to best suite project needs. MySQL is an open source RDBMS, whereas SQL Server is a Microsoft product. The major differences between MySQL and MS SQL Server were discussed regarding to:

- Supported Platforms – both supports major platforms, MS SQL is natively written for Windows
- Supported Programming Languages – both support Java, PHP, C++, Python, Ruby, Visual Basic, MySQL support additional programming languages
- Storage Engine - The multiple storage engine support makes MySQL more flexible than MS SQL Server

- Filtering – MS SQL has the possibility of row-based filtering option and storing data inseparate distribution database
- Backup - Unlike MySQL, SQL Server does not block the database while backing up data
- Option to Stop Query Execution - MySQL does not allow users to kill or cancel a query when it is running, whilest SQL Server programmers can truncate a database query during execution without killing the entire process.
- Security – MySQL allows the database files to be accessed and manipulated by other processes at runtime, SQL Server does not allow any process to access or manipulate its database files or binaries
- Editions – MySQL comes as Community Sever (Free) or MySQL Enterprise Server (many proprietarity features), MS SQL Server has enterprise, standard, web, workgroup, or express edition
- As a Software Stack Component - MySQL is designed with features complement the needs of modern web applications (LAMP), MS SQL can integrate with a variety of proprietary and open source technologies.

Because of the benefits of filtering, backup, security, and the ability to stop query execution, MS SQL was selected. As the MS SQL Express edition has limitations, of which a capacity limitation of 10GB is significant for our project, following RDBMS was chosen that meets the needs of the project:
CCSW04 - MS SQL Server 2019 Standard Edition

2.4 Workstation

For EWS software solution development, testing and management two workstations that fulfill criteria enlisted in chapter 2.1, are needed. Their configuration must meet at least the following specification or specification of equal value.
CCHW05 - Workstation specifications:

- CPU: Intel Core procesor i5-8500T 2.1GHz, 9MB Smart Cache, 6 Cores
- RAM: 8GB (1x8) 2666MHz DDR4 memorije
- DISK: 256GB Solid State Drive
- Graphics: nVidia GeForce 4GB or integrated
- Network: Gigabit network adapter (10/100/1000Mbps)
- USB or wirelles keyboard and mouse
- Screen: 23.8" IPS Full HD 1920 x 1080 (Touchscreen)
- Microsoft Windows 10 Pro 64-bit
- Chases: All-in-One or Tower

2.5 Other components

2.5.1 Tablet

For EWS software solution development and field testing two tablets that fulfill criteria enlisted in chapter 2.1, are needed. Their configuration must meet at least the following or equivalent specification.

CCHW07 - Tablet specifications:

- CPU: Qualcomm 2.0GHz Quad Core
- Memory: 4GB RAM- - 64GB eMMC
- Screen: 10.1" IPS FUll HD multi-touch
- Rezolution: 1920 x 1200
- Operation System: Android 5.1
- Camera: 5MPfront, 8MP back
- Data: - WiFi a/b/g/n - Bluetooth - USB Type-C
- Warranty: 24 month

2.5.2 Mobile phone

For EWS software solution development and field testing two smartphones that fulfill criteria enlisted in chapter 2.1, are needed. Their configuration must meet at least the following or equivalent specification.

CCHW07 - Mobile phone specifications:

- CPU: Octa-core (2x1.8 GHz Cortex-A73 & 6x1.6 GHz Cortex-A53)
- Operating system: Android 9.0
- Screen: 6.4"
- Memory: 4GB RAM, 64GB
- Network: GSM / HSPA / LTE
- Camera: Back: - 20 MP, front: 8 MP
- Connectivity: Wi-Fi 802.11 a/b/g/n/ac, Bluetooth 5.0, USB Tip-C
- Location: A-GPS, GLONASS, BDS
- Senzors: Akcelerometar, Senzor blizine, Compass
- Warranty: 24 month

Note on 2.5.3 to 2.5.7

We have prepared an additional Questionnaire for Marche Region outlining all the prerequisites that must be met to accommodate the equipment required for the EWS Control Center. In this way we would get information about any additional equipment needs such as server cabinet, UPS, router ...

A draft of the questionnaire is Annex of the present document.

2.5.3 Server enclosure

A fully equipped server cabinet is an option if the project partner hosting the EWS Control Center does not have a proper server cabinet or there is insufficient space in the existing server cabinet. The server cabinet must have sufficient space to accommodate the server and its accessories including the sufficient power outlets and uninteruptible power supply unit (UPS).

2.5.4 Communication equipment

Communication, connectivity and security is a must in these days. To satisfy all project needs the communication between the sites, between sites and remote developers and remote users have to be fullfiled.

The communication prerequisites and hardware are:

- Internet connection of minimum throughput of 100 Mbps per site.
- Firewall/Router appliance (eq. Fortigate FG50E or similar) with AntiVirus, AntiSpam, IPS, Web Filtering, WAF, APPC and IPSEC/SSL VPN options have to be provided on both sites.
- Switching device to connect all the site equipment (SG350X-24-K9-EUCisco SG350X-24 24-port Gigabit Stackable Switch or similar) per site

2.5.5 Backup software and Antivirus/Antimalware software

To avoid data lost or a system downtime an adequate Backup software and Antivirus/Antimalware SW to implement a defined backup plan of all servers, data and configuration in case of any type of disaster is a good practice.

Suggested Backup SW is Veeam Backup& Recovery 9.5 - min. 5 license per site.

Suggested Antivirus SW is ESET NOD Antivirus for Servers, Workstations and Mobile devices.

Suggested Antimalware SW – MalwareBytes 1.8 or later Version.

3 Integrated Marine Drone

3.1 Introduction

This chapter provides an overview of the integrated Marine Drone design, with description of the components to be integrated.

3.2 Hardware Architecture

The drone is composed of an off-the shelf autonomous marine veichle equipped with its own power supply, propulsion and navigation system with a remote control unit.

The hardware architecture of the drone is depicted in the following picture where the following parts and devices can be identified:

- Drone hull with related propulsion and navigation system;
- Autonomous power supply composed of a rechargeable battery;
- Data Acquisition Unit with custom software modules;
- Communication subsystems;
- Instrumentation for acquisition of chemical/physical properties of the water and some innovative instrumentation aimed at the qualitative/quantitative detection of microplastic at sea.

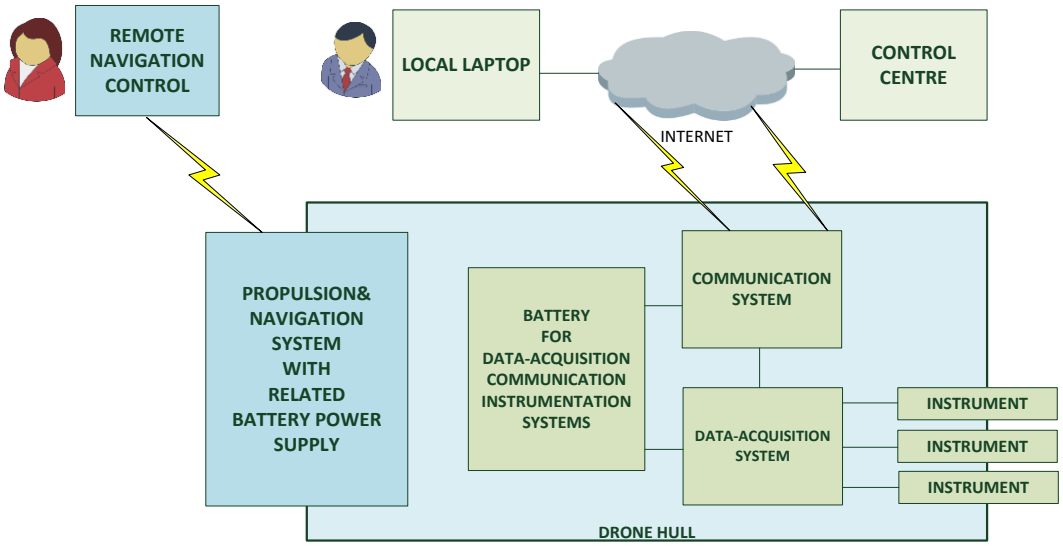


Fig. 3.1 – Drone Hardware Architecture

3.3 Software Architecture

The software modules for the managmenet of the drone are illustrated in the following deployment diagram.

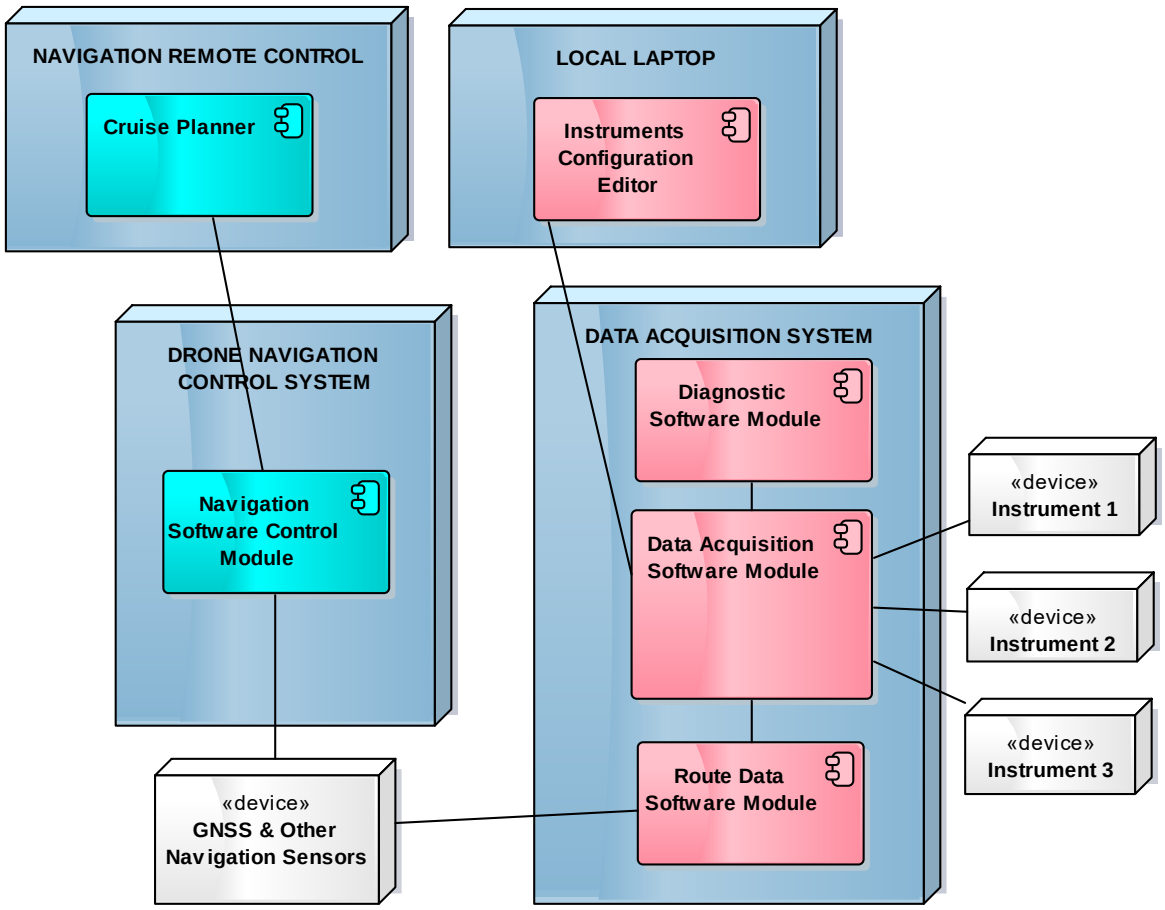


Fig. 3.2 – Drone Software Deployment Diagram

The *Cruise Planner Software Module* running in the Remote Control Unit of the drone, allows to define the cruise path like a set of waypoints with related cruise speed.

Th *Navigation Software Control Module* implemented in the hardware of the drone dedicated to the control of the propulsion and steering devices and the acquisition of position, attitude and speed data, allows to maintain the drone within the planned cuise path with the planned navigation speed.

The *Instruments Configuration Software Modules* is a set of software modules to enable/disable the instruments for a specific cruise and to set related parameters (data rate, calibration parameters, etc.).

The *Data Acquistion Software Module* that allows acquiring the instrumentation dedicated to the collection of physical/chemical parameters and other parameters useful for the detection of microplastic concentration. This module stores all raw data collected in hourly files in TXT or binary format readable with the specific software tools of the instruments.

The *Route Data Software Module* that for each cruise store in dedicated files the GNSS position (in WGS84 or UTM coordinate system) with related time tag. In case of significant deviation of the drone (10-20m) from the planned route, an alarm message shall be generated and sent to the user with the drone remote control.
The *Diagnostic Software Module* that collect the following diagnostic parmeters in hourly files with data rate of at lest one data per minute:

- Power supply voltage in volt with a resolution of at lease 0.1Volt.
- Power supply current with a resolution of at least 1mA.
- Internal Temperature of Data Acquisition System with resolution of at least 0.1°C.
- Alarm of water intrusion in the Datalogger protection case.

This software module is important to check the corret operation of the Data Acquisition System and to validate the scientific instrumentation data.

3.4 Drone Subsystems

This paragraph deals with the description of the subsystems of the drone that are:

- The Hull with Navigation and Propulsion subsystem
- The Power supply subsystem for the Data Acquisition System
- Data Acquisition subsystem
- Communication subsystem
- Instrumentation subsystem

Each subsystem is detailed in the following subparagraphs.

3.4.1 Hull with Navigation and Propulsion Subsystem

Several type of hulls are available but for the specific application characterized by short range monitoring cruises (few nautical miles) the hull is catamaran shape that is an open frame that allowa a flexible and easy integration of monitoring instrumentation such as CTD or ADCP or other probes to be in water at about 1m of water depth.

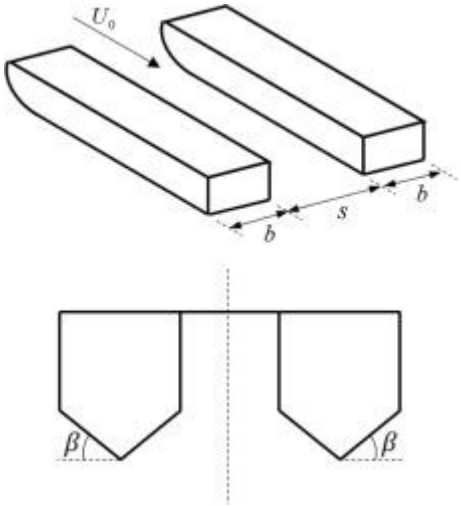


Fig. 3.3 – Catamaran shape

In the market are available several models able to host different instrumentation and with different performances. For the specific application aimed at the qualitative and quantitative monitoring of the microplastic concentration, the models shown in this picture can be used: their typical size suitable for the transportation is about 2m length for 1m large with a maximum weigth of 150kg

Main Features

- Length 1.8m
- Autonomy of 6hours at 2knots
- 24cm Moon pool for instrmentation
- Industrial PC to manage instrumentation payload
- Autopilot with remote control via modem 4G including mission planning software

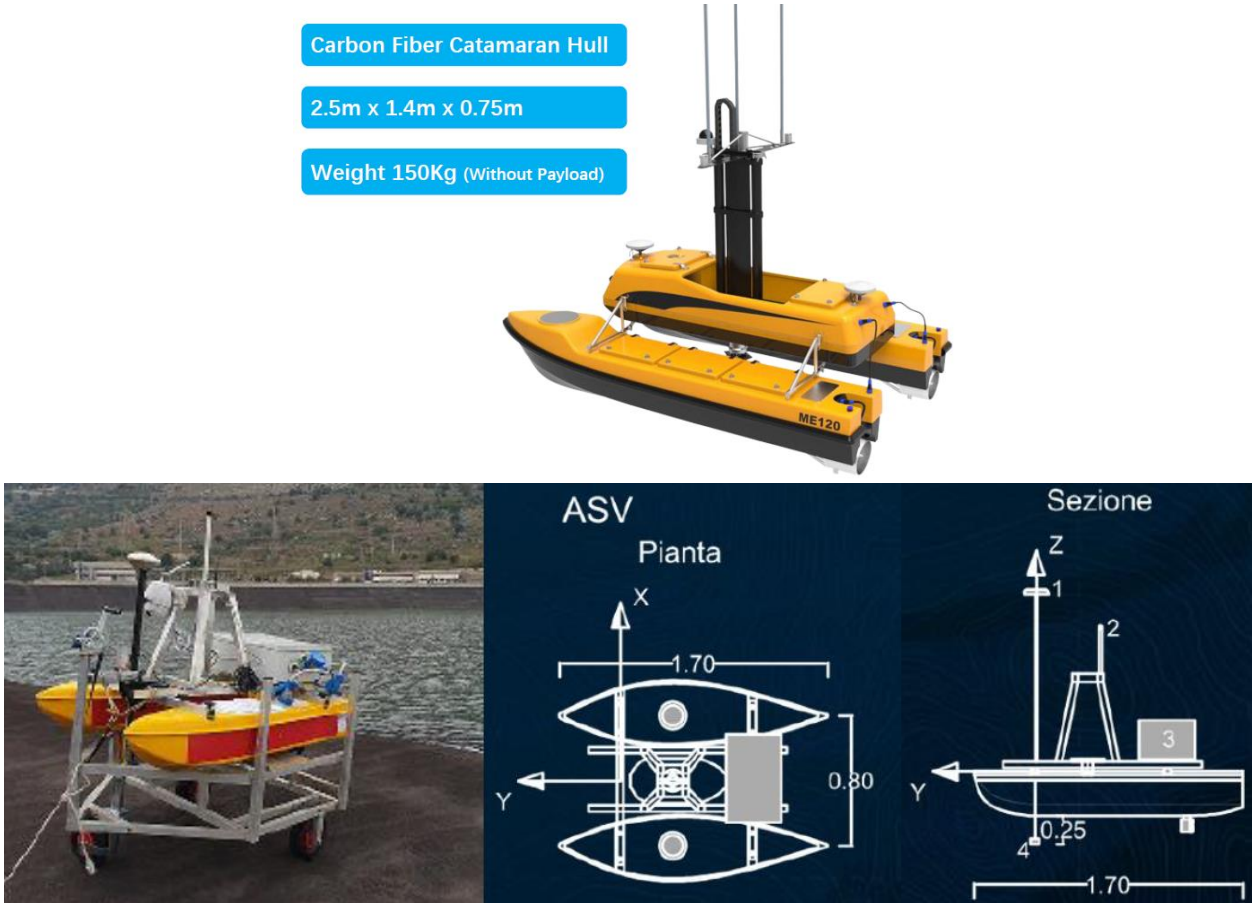


Fig. 3.4 – Suitable Catamarans

All these autonomous veichles have their own propulsion system relied on electrical propellers (thrusters) and an integrated navigation system with GPS, speed, heading, pitch and roll sensors that allows to follow a planned route at planned speeds.

The catamaran hull allows a good stability of the system during the navigation, anyway it is pointed out that these vechiles shall be used with good meteo-marine conditions characterized by wind speed lower than 2-3knot, sea current lower than 0.5m/s and significant wave lower than 30cm.

3.4.2 Power Supply Subsystem

The power supply subsystem is composed of a custom rechargeable Lithium battery pack with a nominal voltage of 14-15VDC to be able to supply all electronic devices (Data Acquisition System, Communication devices) and the scientific instrumentation. The propulsion and navigation system of the drone shall have an independent battery pack for reliability purpose.

The typical power consumption of the payload is summarized in the following table

Id	Payload	Typical Power Consumption [W]	Typical current at 14VDC [mA]	Requested [Ah] for a cruise of 8 hours

1	Data Acquistion Unit	8	570	4.56
2	Data Communicaion System (long range)	5	357	2.86
3	CTD with Dissolved Oxygen and Turbidity sensor	0.5	36	0.29
4	ADCP	0.7	50	0.4
5	Additional sensors	3	214	1.7
			Total capacity	***9.81 Ah***

Considering a safety factor of 30-50% we can consider a battery with a capacity of about 15Ah@14V that can be orderd by a custom battery integrator. This battery looks like the one in the following picture with a weight of about 2kg and maximum size about 200x100x60

Fig. 3.5 - Rechargeable Lithium battery pack

The battery will be integrated in a water proof case integrating also the circuit to recharge the battery: the case shall be equipped with a safety vent valve to avoid internal overpressure and with two external connectors: one for the battery charging and one to connect the Data Acquisition Unit as illustrated in this drawing.

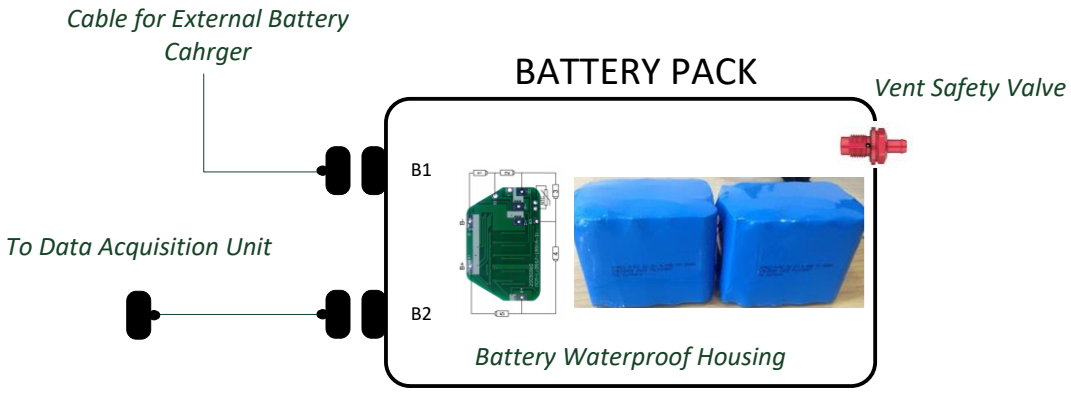


Fig. 3.6 - Battery Housing

3.4.3 Data Acquisition Subsystem

The Data Acquisition System is composed of a fanless PC with solid state disk integrated in a waterproof case with electronic devices to condition the battery voltage for the instrumentation and to monitor internal status (temperature, current and voltage). The husing is composed of an IP67 plastic box like the one shown in this picture

Fig. 3.7 - Data Acquisition System Housing

This box is the mode Peli Case 1400 which datasheet is annexed to the present document.

The cables and connectors will be Seaconn, Subconn or Buccaneer that are the main brands suitable for marine applications in shallowaters.

The fanless PC adopted will be the RCO-1000 series or equivalent with WIN10 Operative System and with the following hardware interfaces:

- 6 serial ports configurable as RS232 or RS422 or RS485
- 4 USB ports
- 2 ethernet ports
- 4G Modem with double SIM card
- WiFi interface
- 4 Digital I/O and 4 analogue inputs

This fanless PC has the sizes 170x150x90cm, a weight of 1.1kg and power consumption of about 8W.

Fig. 3.8 - RCO-1030 Fanless PC

3.4.4 Communication Subsystem

The communication subsystem is composed of the following communication segments:

A. A dedicated long range wireless communication segment for the remote navigation control;
B. A short range wirless communication link (WiFi) for configuration and test purposes;
C. A long range wirless communication link (modem 4G) for data transfer to the EWS Control Centre;
D. An emergency data link composed by an Iridium beacon able to provide the dorne position in case of fault or temporary black-out of the previous long range data links.

Data link A is provided with the drone hull, propulsion and navigation systems and remote control unit. It is usually an UHF radio link using a free frequency or also a 4G modem.
The link B is integrated in the Data Acquisition Unit as described in the sub-paragraph 3.4.3 and it is a standard WiFi link 802.11 operating at the frequencies 2.4 and 5.3GHz.
The long range communication link is implemented by a modem 4G integrated in the fanless PC described in the sub-paragraph 3.4.3.
As for the emergency data link, it is composed by an autonomous self powered unit integrating Iridium satellite modem and GNSS receiver to provide the drone position in case of loss of the others data links. For the specific purpose it is identified the model XEOS Rover that it is an independently powered, self-contained satellite transceiver designed to track buoys or autonomous vehicles on the surface. Things don't always follow plan, so the Rover features independent dual GPS and Iridium patch antennas, so that in the event the surface expression is flipped over, the unit will continue to record its position and transmit it back to you. Packaged in a ruggedized, UV protected, marine grade housing, the Rover makes use of the low power, real-time Iridium satellite constellation and GPS to reliably transmit the buoy's position automatically or on demand at any time. Main features are

- Surface buoy tracking
- 1055g in air, 378g in water
- Waterproof to 100m
- Iridium Communications
- Bluetooth Low Energy (BTLE)
- 18 AA-cell Alkaline batteries
- Deployment time: 1096 days at the surface (once a day SOH message, checking its position every 3 hours within the watch circle)
- Two antennas at the top and bottom allow the unit to collect and transmit data even if it is capsized
- Command & Control App

Fig. 3.9 - XEOS Rover Beacon

3.4.5 Instrumentation Subsystem

As indicated in the system requirements document, the instrumentation suggested by the stakeholders is manily composed of a multiparametric probe inclusign CTD with dissolved Oxygen and Trubidity sensors, ad an ADCP to get the local current profile.

A suitable option can be the introduction of a small winch to have the possibility to collect the multiparametric probe parameters along the water column: this option will be evaluated in the integration phase because it is risky for an autonomous veichle to have a tethered instrument; this implementation need also an echo sounder in the multiparametric probe and a reliable control system for the winch.

The ADCP is an instrument relied on the acoustic Doppler effect to measure accurately the current speed along the water column. Taking into account the maximum water depth of the Croatian side, it is sufficient to use and ADPC with a range of about 100m. To measure the current profile with the drone moving along its route, it is necessary to adopt an instrument wit the bottom tracking options that allow in real time to introduce the correction due to the drone speed respect to the sea water. This option is expensive thus for the purposes of the project it is sufficient to define along the route some waypoints where the drone can stop moving to allow the ADCP to get an accurate current profile.

After a research in the market, a cost effective solution suitable for the project purpose is the multiparametric probe reported in this picture. It is the model Valeport Midas, anyway also other equivalent products are available in the market.

Fig.3.10 - CTD Probe with Dissolved Oxygen and Turbidity Sensors

Main features of the identified probe are summaried in the following table.

Sensor	Range	Accuracy	Resolution
Conductivity	0 – 80mS/cm	+/-0.01mS/cm	0.002mS/cm
Temperature	-5 - +35°C	+/-0.005°C	0.002°C
Pressure	Up to 600Bar	+/-0.01%	0.001%
Turbidity	0 – 2000FTU	+/-2%	0.002%
DO	0 – 16ml/l	+/-0.07ml/l	0.017ml/l

Also for the ADCP it has been identified the light model Acquadopp 400kHz in the picture able to measure the current on a water column up to 90m of water depth.

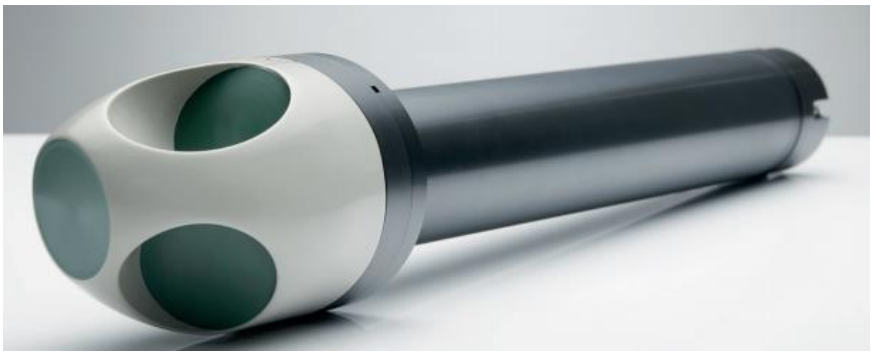


Fig. 3.11 - Acoustic Doppler Current Profiler (ADCP)

Both instruments are low power demanding and can be easily managed by the Data Acquisition system through USB or RS232 serial links.
In addition to the multiparametric probe and the current profiler, some innovative instruments are suggested, anyway they are expensive and thus their integration in the drone or onboard unit will be avaluated in the procurement phase.
Some innovative instruments are the following:

- LISST-Holo2 relied on holograms capture;
- RAMAN spectrometry.

It is undelined that in the latest years the market produced a lot of innovative solutions aimed at the detection and classification in real time or near real time of the microplastic at sea or in the sediments but they have to be tested and validated with a significant number of campaigns at sea to verify their reliability.

LISST-Holo2

The LISST-Holo2, introduced in 2017, stores holograms for study of flocs, plankton, and other particles in water. It is an advanced successor to the original LISST-Holo. This new version is the world's fastest, capturing holograms at 20Hz, [vs.0.2Hz for the original LISST-Holo]. The same original housing now includes a rechargeable battery and 237 GB of data memory. Processing speed per unit water volume imaged is faster than the competition. A unique new feature ranks thousands of holograms based on richness of imagery – a Sequoia innovation for fast overview of a collection of holograms.

Fig. 3.12 - LISST-Holo2 Probe

The main specifications of this instrument are summarized herebelow:

Parameters Measured

- 2MB Hologram containing the interference pattern of all particles in the laser beam
- Depth
- Temperature
- Time-stamp on each hologram
- Parameters derived upon hologram processing
- Reconstructed in-focus images of particles in laser beam.
- Particle Size Distribution (PSD)
- Standard Deviation of PSD
- Particle Area Concentration
- Mean and Median particle size
- 5 seconds processing time per 1 cm^3 volume imaged, in MATLAB (typical, @ 2.2 GHz PC)

Particle Size Distribution and concentration range

- ~25-2500µm size range
- Beam attenuation values between 0 and 4 m^{-1}
- Maximum concentration between 0 and 50 mg/l, depending on grain size.

Technology

- Solid state laser diode @ 658 nm, 8 mW
- 4.4µm pixel size digital camera, 1600 x 1200 pixels
- 2 MB hologram size
- Hologram capture rate programmable up to 20 Hz continuous;

- Optical path length 50 mm standard; Path reduction modules available for high-concentration environments.
- All particles in focus in optical path.
- Sampling volume per hologram 1.5 cm
- Volume sampled per second at 20Hz sample rate: 30 cm^3
- Maximum current velocity/CTD speed during deployment: 2 m/s

Software

- Holo Batch: Automated image reconstruction and particle segmentation
- Holo Detail: Hologram sorting by richness of information content, and detailed reconstructed image examination.

Mechanical and Electrical

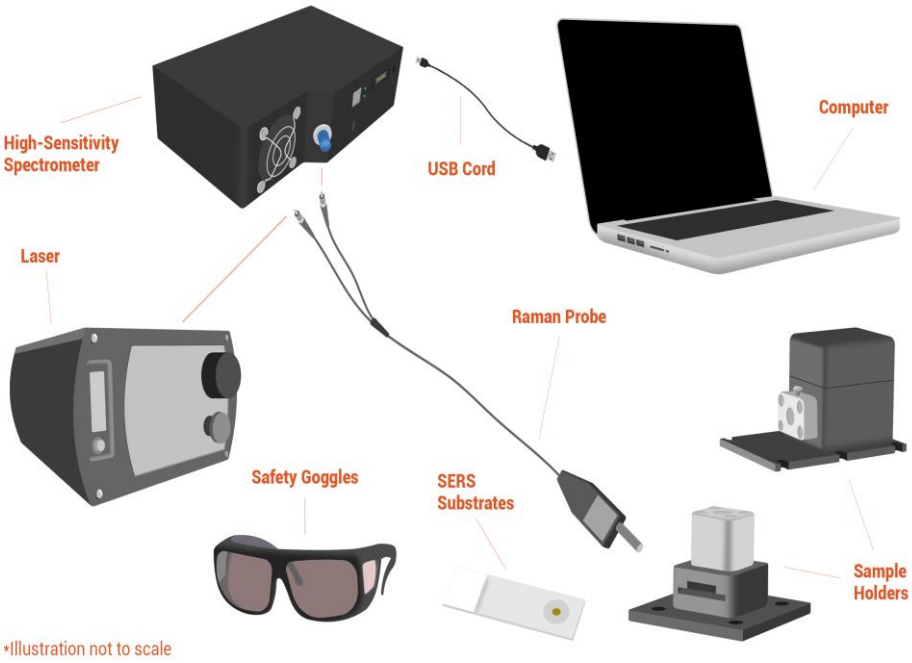
- Dimensions: 13.3 cm × 76.7 cm (5.25" × 30.21") [Ø × L]
- Weight: 7.2 kg (15.8 lbs) in air; 1.0 kg (2.2 lbs) in water
- 600 m depth rating
- 237 GB internal solid state drive
- Internal Battery life: at least 12 hours of continuous use.
- External power input: 18VDC nominal, 12-24VDC
- Power drain: 200µA / 700mA / 800mA / 800mA (sleeping / idling / laser on / laser + camera on)

Modular Raman

Fig. 3.13 - Raman QEPro

The QE *Pro* is a high sensitivity spectrometer with low stray light performance. It is ideal for a wide range of low light level applications such as fluorescence, DNA sequencing and Raman analysis.

The sensitivity and large dynamic range of the QE *Pro* combine to make it the highest-performance modular spectrometer in its class. Key features include advanced optoelectronics and thermoelectric cooling to provide thermal stability, and onboard spectral buffering to ensure data integrity at high collection rates.



Details

Take advantage of Ocean Insight application-ready systems – spectrometer, laser, accessories and software – for Raman measurements. These bundles have all the components necessary for probe-based Raman measurements.

Packages are available for Raman excitation wavelengths of 532 nm, 638 nm, 785 nm and 1064 nm. Designed to operate as a system, the components in these packages mate seamlessly to get you started taking Raman spectra more quickly. All bundles come with software and the appropriate laser safety glasses.

Fig.3.14 - Raman System QEPro

4 Marine OBU

4.1 Introduction

The Marine OBU shall be used in two specific use cases:

- for fixed installation in specific Eulerian node (Close to mouths of rivers, close to fields of mythiculture that absorb and release microplastic with the tide current);

- during surveys with boats normally used for MP data collection with Manta, to collect more information.

The solution identified is to use the Marine drone as described in the previous chapter, for all the use case mentioned. For description of each component refer to the previous chapter.
In the OBU, the Data Acquistion Unit and related instrumentation with the interconnection cables, will be integrated in a custom light metal frame like the following

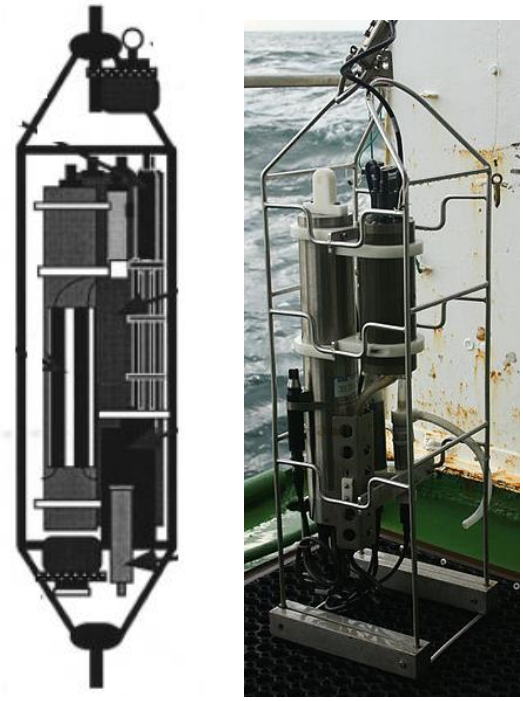


Fig.4.1 - Custom light frame of OBU

The OBU can be supplied directly from the electrical power source on board of the boat and its Data Acquistion Unit can be connected via WiFi with the Laptop or tablet of the user on board of the boat.

4.2 Other components

Other useful components that can be installed on board of the marine drone can be the following:

- A Manta
- A Digtial Camera

The manta is composed of a light Alluminium frame with attached a net to filter the seawater. It can be fixed to the drone or to a boat to capture microplastic debris along the navigation path. It is equipped with a flow meter to measure the whole volume of water passed through the net to allow the estimation of the microplastic concentration in the monitored area. Typical sizes of the net is

- Mouth opening 30 x 15 cm
- length of net bag 200 cm
- Mesh size 300 microns

Fig.4.2 - Manta Net with volumetric sensor

Another useful instrument to get the local context conditions can be a self-recording digital camera that is currently a low cost component easy to handle by a datalogger to extract useful pictures and short vides with good resolutions.
Some sampled of digital cameras that could be used are reported in the following picture

Fig.4.3 - Digital Cameras suitable for marine environment

5 Other hardware and software components

5.1 Software application for smartphone for managing the drones

The availability of a 4G link on board of the drone, makes it possible the Internet connection of the Data Acquisition Unit of the drone thus it is possible to develop an APP for the direct control of the drone Data Acquisition System and also for its navigation. The layout of the APP could be like the one shonw herebelow where the route of the drone is shonw on google map and also a the image of a camera on board of the drone is shonw in real time to the user. Under the image of the camera it is possible to insert some tabs for the selection of some instrumentation data to be displayed in real time in table or plot format.

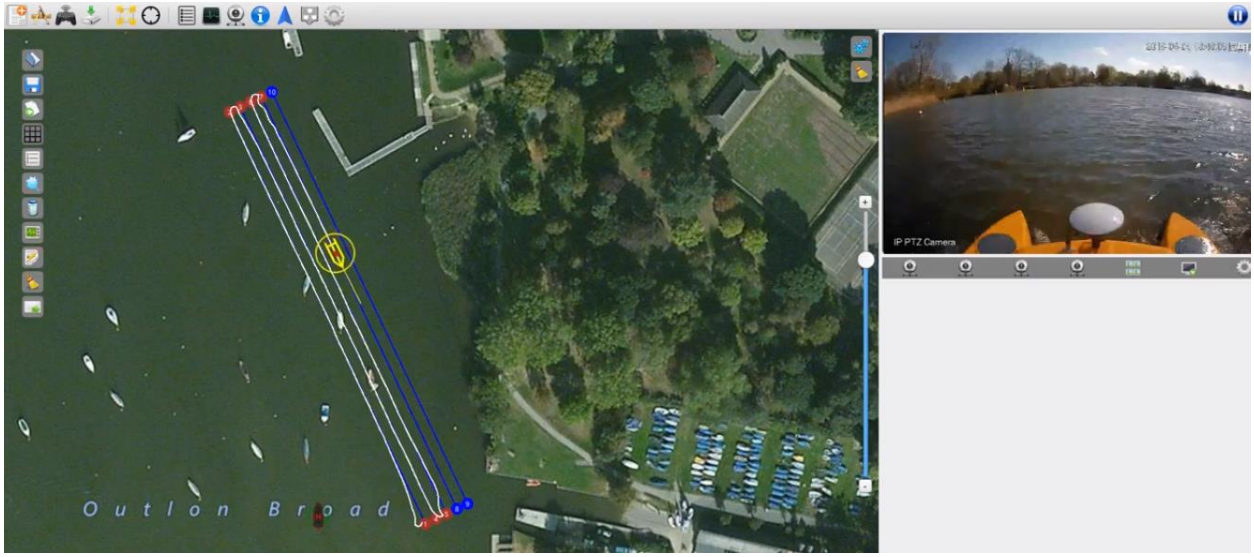


Fig.5.1 - Layout of an APP for smartphone for remote control of the drone

5.2 Software application for smartphone for Macroplastic data reporting

For the collection of macroplastic information it is possible to use the ML—REPAIR APP described in this paragraph. This APP after a preliminary registration of the credantials, allows

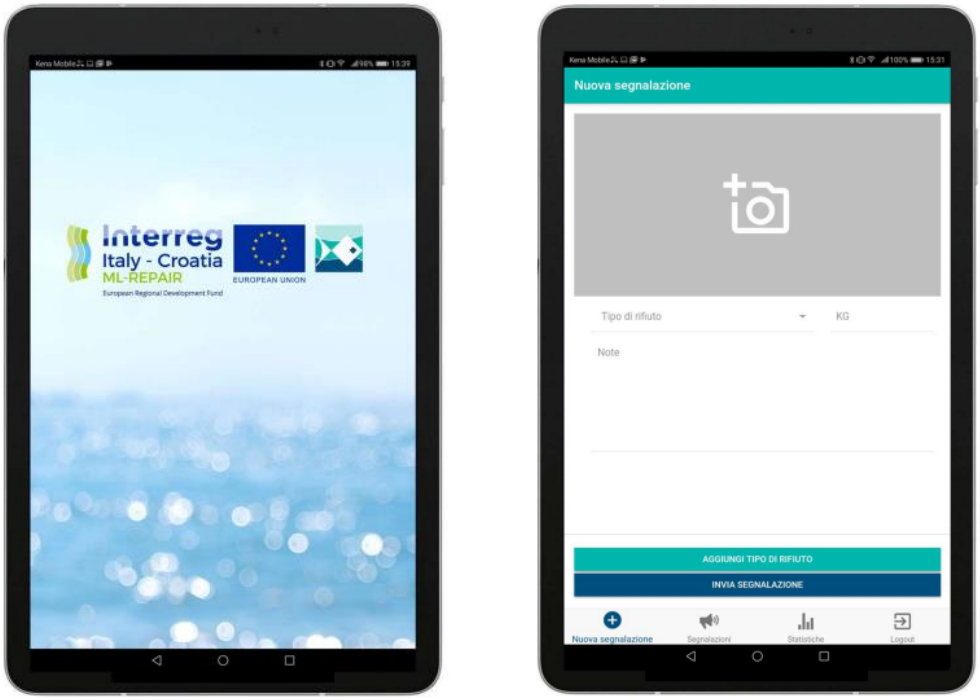


Fig.5.2- Splash screen and panel to get picture of macroplastic

Fig.5.3 - Interfaces to get and validate the picture

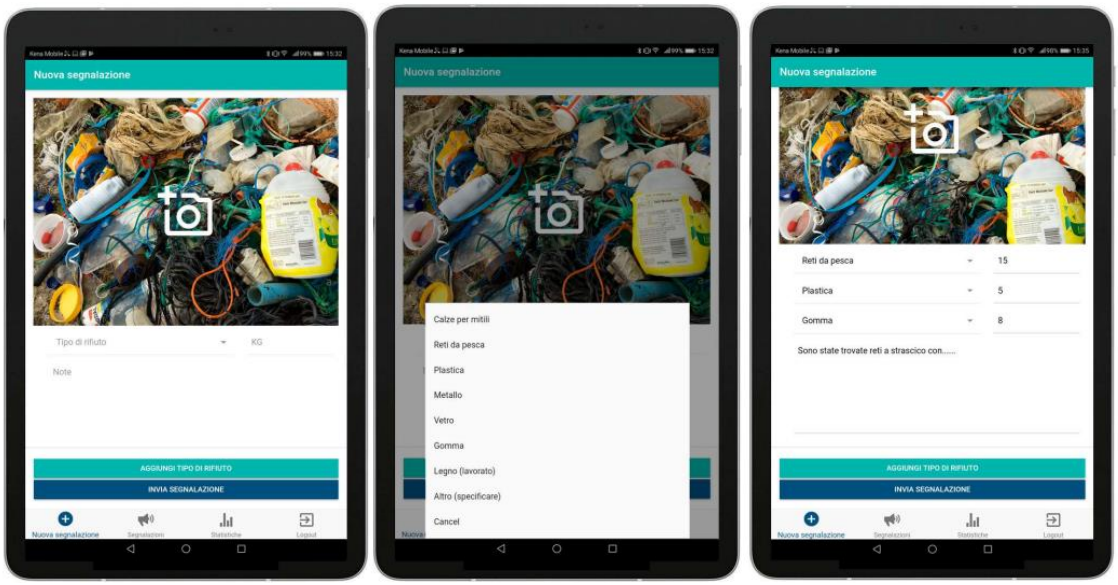


Fig. 5.4 - Interfaces to insert the following informations:

- *Type of macroplastic identified*
- *Weight and sizes*

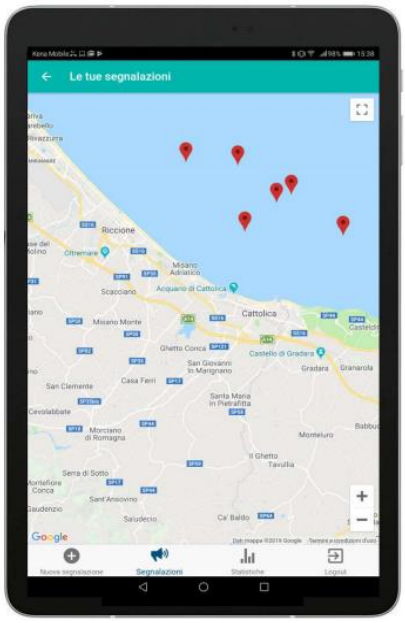


Fig. 5.5 - Interface showing all macroplastic sites notified