

NET4mPLASTIC PROJECT

WP5 – Act. 5.2 Development of the UAV/marine drone for data acquisition

D 5.2.6

Marine OBU and Drone User Manual

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Acronyms / Abbreviations

ACRONYM	DEFINITION
CT	Conductivity and Temperature
EWS	Early Warning System
GNSS	Global Navigation Satellite 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 WP5 deals with the design implementation 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 activities planned for WP5 are the following:

- development of the EWS - Early Warning System data center platform and integration with the transport model (WP4)
- development of the UAV/marine drone for real-time data acquisition
- testing and calibration
- business simulation for testing the solution with real users –
- final assessment of the solution, including a CBA—cost benefit analysis and the preparation of the business plan.

The main expected output will be:

- EWS integrated platform, implemented and tested
- Training for the required personnel and users - Assessment of the platform.

The required main software modules of the EWS platform will be:

- MP Transport model, providing data with distribution and concentration,
- MP WebGIS platform, for: a) Display MP data (historical, actual forecast, 24-72h forecast) b) Early warning provision, based on the transport model c) Data entry, recording & replay
- MP DB, the DB for collecting data
- A mobile APP, for starting/closing the field activities and for data reporting
- Firmware for marine remote units - Integration with external system, for meteo/other data

The coordinator will be Hydra Solutions. The EWS SW platform will be developed by Hydra Solutions, with the support of Marche Region for the transport model, and Prosoft for localization, the ICT

implementation, the integrated testing, training and support for maintenance activities. UNITS will coordinate the assessment of the platform. The other partners involved will give contribution for data entry, as target user, and for preparation of the required documentation. The user target group will be based on the main project partners, institution, regions and councils. They will be involved in the design stage for collecting the main needs, for testing and user training of the solution. The target group will be required to use the system during the business simulation, and provide feedback.

The expected reports within WP5 are the following:

- D 5.1.4 –Hardware and Network Integration Report (Report): this deliverable will provide a report with details on integration of the network and other hardware required for the system;
- D 5.1.5 –Test procedures and reporting (Report): this deliverable will provide the procedures for testing the data centre and the integrated solution in the test bed environment, and the reporting of the tests done to assure the quality of the solution provided;
- D 5.1.6 –Hardware & Network Maintenance Manual (Document); this deliverable will provide the manual for the maintenance of the hardware and the network of the system;
- D 5.1.7 –Software User and Maintenance Manual (Document); this deliverable will provide the manual for the maintenance of the software and the User manual for the operators
- D 5.2.4 – Marine OBU / Drone Test Procedure and Report (Document): this deliverable will provide the procedures for testing the drones and the OBU, and the reporting of the tests done to assure the quality of the solution provided;
- D 5.2.5 –Marine OBU / Drone Maintenance Manual (Document); this deliverable will provide the manual for the maintenance of the Drone and OBU;
- D 5.2.6 – Marine OBU / Drone User Manual (Document); this deliverable will provide the User manual for the operators;
- D 5.3.1 – Data Centre Hardware and Network Facility implemented (Hardware, report), in this deliverable is relevant to the implementation of the data centre for the integrated solution, hardware and the network facility, and the preparation of the AS BUILT document describing the data centre facility;
- D 5.3.2 – Remote Units and Data Centre Communication Test Procedure and Report (Document); this deliverable will provide the procedures for testing the communication integration between remote units and the data centre, and the relevant reporting of the tests done to assure the quality of the solution provided;
- D 5.3.3 – Data Centre Test Procedure and Report (Document): this deliverable will provide the procedures for testing the features of the solution provide in the data centre, and the relevant reporting of the tests done to assure the quality of the solution provided, that will be done in cooperation with the main stakeholders;
- D 5.3.4 – Integrated System Final Test Procedure and Report (Document): this deliverable will provide the procedures for the integrated test cases testing the integrated solution, and the relevant reporting of the tests done to assure the quality of the solution provided, that will be done in cooperation with the main stakeholders.
- D 5.4.1 – Training documentation (document): this deliverable is relevant to the implementation of the required documentation for performing training to the personnel involved in the business simulation (as defined in the WP3.3 and the design of the solution);

- D 5.4.2 – Training assessment (report): this deliverable is relevant to the implementation of the training to be done for the personnel involved in the business simulation, with a reporting on evaluation of the training;
- D 5.4.4 – Questionnaire for platform assessment (report) this deliverable is relevant to the preparation of a questionnaire for evaluation of the platform from the user point of view involved in the business simulation;
- D 5.4.5 –Cost Benefits Analysis – CBA of the platform (Document); this deliverable will provide a final document with lessons learnt during the real use of the platform, an evaluation of the benefits of the platform, and costs for full exploitation of the solution, including the future recommendations on potential improvement, and including a business plan for a full implementation of the platform.

1.2 Purpose of the report

This document is the **deliverable D.5.2.6 – Marine OBU-Drone User Manual**: it provides the manual for the operators to use the OBU and Drone during missions at sea and for the data download and processing.

This deliverable is within the activity 5.2 of the Net4mPlastic project – Development of the UAV/marine drone for data acquisition. This activity shall have as input the deliverables of WP3.3 relevant to the design of the solution to proceed with the execution of the following tasks:

- procurement and Integration of the autonomous electrical power supply system for the instruments payload;
- identification of the most suitable sensors for the detection of the MP;
- design, integration and test of a drone/OBU suitable for these innovative sensors;
- procurement and Integration of the electronic Data Acquisition and Communication System (DACS) relied on wireless technology;
- development and implementation of the firmware for DACS to get scientific instrumentation;
- data and system diagnostic sensors data (technical data);
- development and implementation of the deck control unit for navigation and data acquisition with related software interface (HMI);
- laboratory Integration Test;
- sea trials Test.

The coordinator will be Hydra Solutions, in cooperation with Prosoft, UNIFE, Marche Region. The purpose of this document is summarised as follows:

- Configuration of Drone and OBU to prepare the units for a mission at sea.
- Use of the units during the mission at sea.
- Deployment and Recovery tasks with related data download.

1.3 Reference documentation

No	Title	Rif/Report N.	Published 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]	D 5.1.4 –Hardware and Network Integration Report (Report)	HYD514-REP-001.0	ACT5.1 – Net4Mplastic
[R3]	D 5.1.5 – Test Procedures & Reporting Report	HYD515-PRO-001.0	ACT5.1 – Net4Mplastic
[R4]	D 5.1.6 –Hardware & Network Maintenance Manual	HYD516-MAN-001.0	ACT5.1 – Net4Mplastic
[R5]	D 5.1.7 –Software User and Maintenance Manual	HYD517-MAN-001.0	ACT5.1 – Net4Mplastic
[R6]	D.5.2.4 – Marine OBU-Drone Test Procedure and Report	HYD524-PRO-001.0	ACT5.2 – Net4Mplastic
[R7]	D.5.2.5 –Marine OBU-Drone Maintenance Manual	HYD525-MAN-001.0	ACT5.2 – Net4Mplastic
[R8]	D 3.3.1 – EWS Requirements definitions based on the stakeholders and users’ needs, through questionnaires and specific meeting	HYD331-SPE-001.0	ACT3.3 – Net4Mplastic
[R9]	D 3.3.2 – EWS Hardware Architecture and network design (central Data Centre Hardware Architecture Client/Server, Data network architecture and related communication segments)	HYD332-SPE-001.0	ACT3.3 – Net4Mplastic
[R10]	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	HYD333-SPE-001.0	ACT3.3 – Net4Mplastic

[R11]	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).	HYD334-SPE-001.0	ACT3.3 – Net4Mplastic
[R12]	D 3.3.5 - Report and database provision with all the collected data	HYD335-SPE-001.0	ACT3.3 – Net4Mplastic

2 OBU USER MANUAL

This section deals with the description of all tasks to be carried out for the preparation, utilization and recovery of the OBU for the execution of a mission at sea.

The first paragraph is dedicated to the description of the OBU hardware and software architecture to better understand how to use the device in a mission at sea. The second paragraph describes the devices connected to the OBU and how to use them. The final paragraph describes the preparation of the system and the download of the data at the end of the mission.

2.1 OBU Hardware and Software Architecture

The OBU is depicted in the picture below where the following parts can be identified:

- OBU-Box integrating the Datalogger, a rechargeable battery pack and a power supply (AC/DC converter) useful in case of availability of power socket on board of the boat;
- CT sensor;
- GNSS receiver;
- Battery Charger.



Figure 2.1 – OBU Parts

The internal interconnection diagram of the OBU-Box is the following

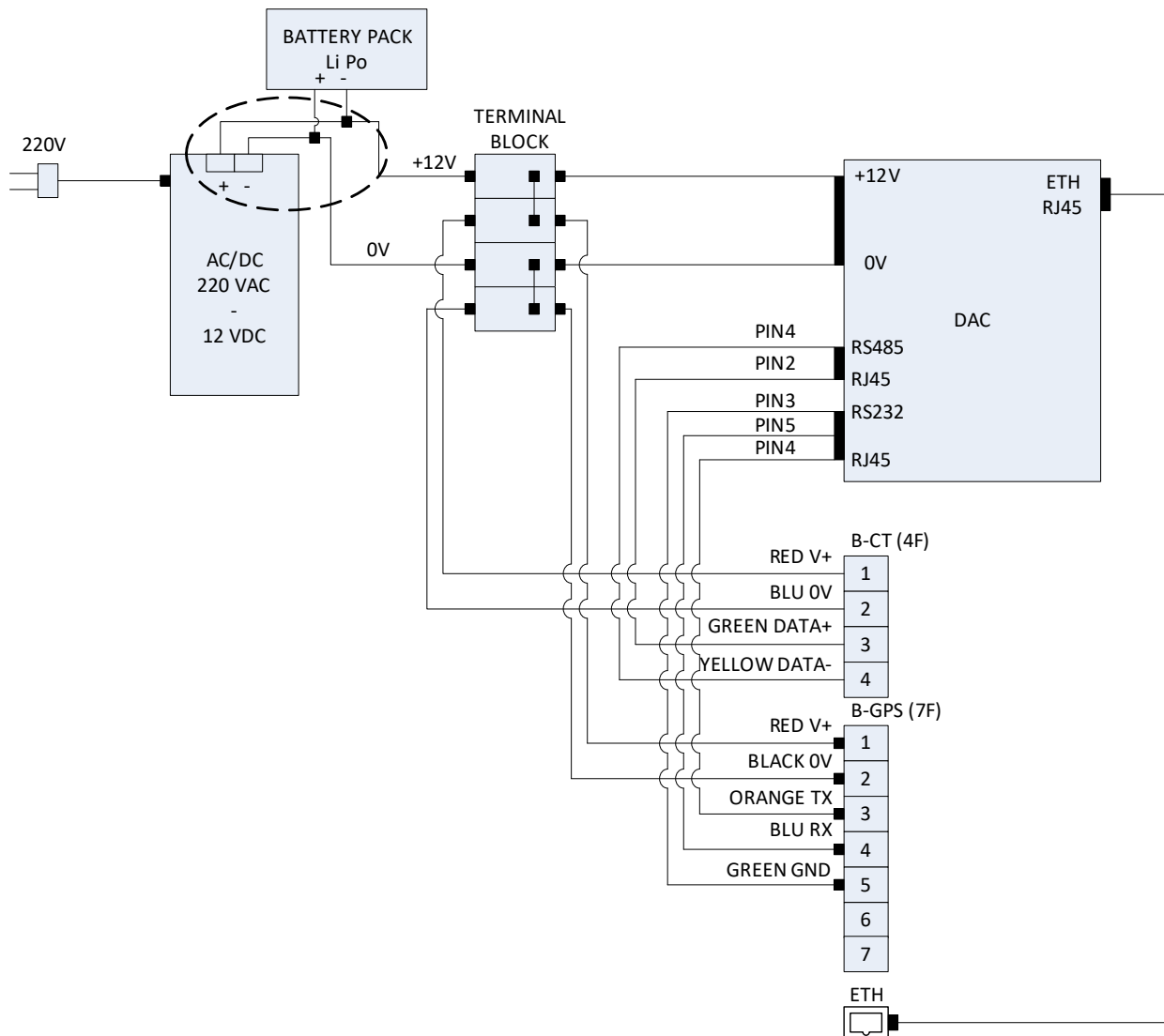


Figure 2.2 – OBU Interconnection Diagram

where there are the Datalogger Matrix-518 which detailed manual is reported in *ANNEX DAC*, the rechargeable battery, the power supply (alternative to the battery) and the connectors for CT and GNSS sensors. The technical sheets of the battery and of the connectors are respectively reported in *ANNEX BAT* and *ANNEX CON*.

The software implemented in the Datalogger is an acquisition loop that collects data from the GNSS receiver and the CT sensor every 3 seconds. At Datalogger power-ON there is a delay of 1min waiting for correct time and position from the GNSS receiver that provides the data-position to tag the mission data.

2.2 Manuals of CT and GNSS

The default configuration of OBU adopted for the mission includes

- CT sensor
- GNSS receiver with antenna

The main sensor is the LISST-Holo2 whose manual is reported in the section dedicated to the Drone. It can also be considered part of OBU because it can be fixed outboard of a boat, anyway it is equipped with own internal battery pack and datalogger of holograms thus it is not necessary to connect LISST-HOLO2 to the OBU-Box.

2.2.1 CT sensor Manual

The CT Manual is reported in *ANNEX CT* of the present document. This sensor C4E measuring temperature, conductivity and salinity of the sea water, has to be fixed outboard of the boat at about 50cm below the sea surface to be always totally submerged during the mission. Before to put the instrument at sea it is necessary removing its protective cap and to insert the connector in the OBU-Case to get power and data link.



Figure 2.3 - CT Sensor

2.2.2 GNSS Manual

Technical details of GNSS receiver acquired by OBU Datalogger are reported in *ANNEX GNSS1* and *ANNEX GNSS2* describing the data format produced and the electrical schematic. The GNSS receiver is powered directly by the internal battery of the OBU and acquired by the OBU Datalogger to get the time and position of the ship during the mission.

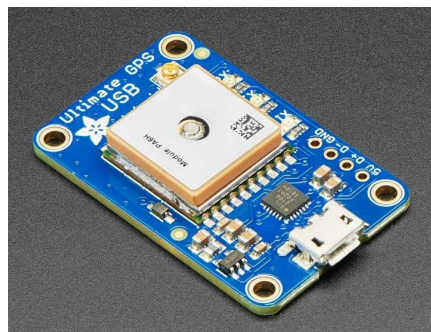


Figure 2.4 - GNSS Sensor

The data are acquired in GPRMC format detailed here below:

RMC Data Format

Name	Example	Units	Description
Message ID	\$GPRMC		RMC protocol header
UTC Time	161229.487		hhmmss.sss
Status ¹	A		A=data valid or V=data not valid
Latitude	3723.2475		ddmm.mmmm
N/S Indicator	N		N=north or S=south
Longitude	12158.3416		dddmm.mmmm
E/W Indicator	W		E=east or W=west
Speed Over Ground	0.13	knots	
Course Over Ground	309.62	degrees	True
Date	120598		ddmmyy
Magnetic Variation ²		degrees	E=east or W=west
<i>Mode</i>	<i>A</i>		<i>A=Autonomous, D=DGPS, E=DR</i>
Checksum	*10		
<CR> <LF>			End of message termination

1. A valid status is derived from the SiRF Binary M.I.D 2 position mode 1. See the *SiRF Binary Protocol Reference Manual*.

2. SiRF Technology Inc. does not support magnetic declination. All "course over ground" data are geodetic WGS84 directions.

The GNSS receiver needs about 1min after power on to provide correct time and position to the OBU-Datalogger thus it is always necessary to connect the GNSS receiver to the OBU-Box before powering ON the OBU-Box in order to have all collected data (CT and additional sensors data) correctly tagged with time and position since the beginning of the mission.

2.3 Preparation and Data Download

The preparation of the OBU for the mission is very simple: it is sufficient

- to fix the OBU-Box on board of the boat;
- to connect the GNSS receiver to the OBU-Box and to fix the GNSS receiver on top of the boat in a place to see the sky;
- to connect the CT to the OBU-Box and to put the CT in water after removal of the protective cap;

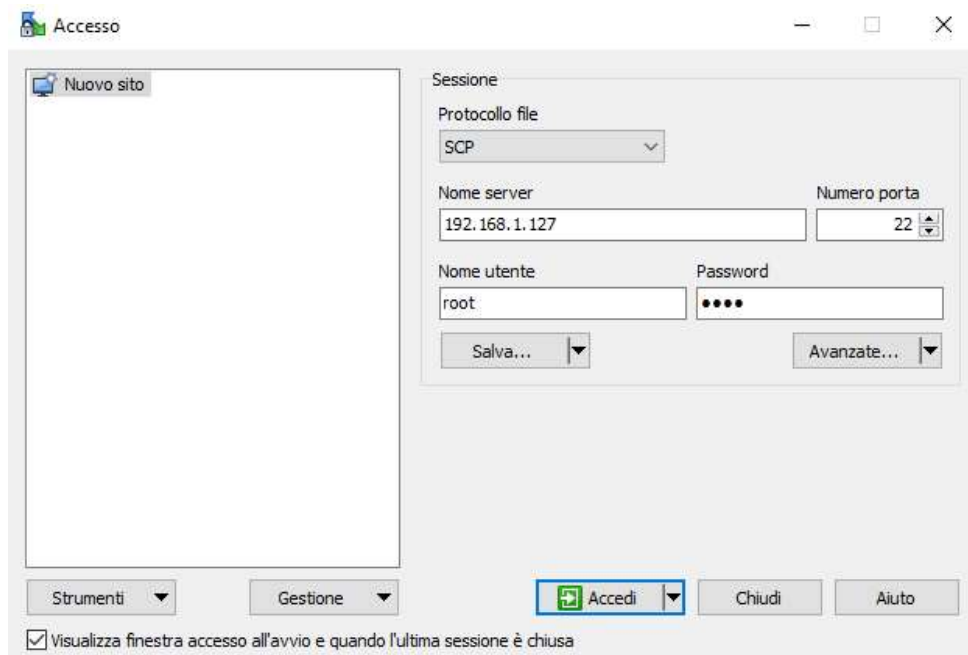
- to power the OBU-Box connecting the internal battery or the external power supply cable to the boat power socket.

After power-ON the OBU is ready for the mission and the boat can start the navigation.

At the end of the mission it is sufficient to recover CT and GNSS receiver, to power-OFF the OBU-Box and to disconnect CT and GNSS cables from OBU-Box.

All CT data logged inside the OBU are GMT time and GNSS position tagged thus they can be downloaded at the end of the mission in office. Anyway it is suggested to get a look at the data inside the OBU datalogger also during the mission.

The OBU datalogger has IP address 192.168.1.127 thus it is necessary to set the notebook PC with the IP 192.168.1.100 (netmask 255.255.255.0) to get access to the data using WINSCP application (<https://winscp.net/eng/download.php>) in modality SCP. As indicated in the following picture set the server IP **192.168.1.127** and insert the username and password **root, root** to get access to the OBU datalogger as shown in this picture.



In the following window on the right side move from the root to the folder /media/mmc/datames to see the files **YYMMDDhhmmss.dat** and **YYMMDDhhmmss.gps** and drag and drop them on the left side in the PC hard drive. They are small files easy to be transferred also via email. The name of the files is the GMT date and time of switch on of the OBU on board of boat B. No necessary to delete the files from the OBU datalogger as the storage autonomy is very big compared with the files sizes. .DAT and .GPS files can be open with EXCEL as they are CSV test files.

This is a sample of **.dat** file

```
DATE_TIME, LAT, LON, TW [ ° C ] , CW [mS/cm] , SW [ppt]
```

29/10/21T08:48:42,+43.485952,+016.486000,+19.0,053.0,34.9
29/10/21T08:48:45,+43.485952,+016.486000,+19.0,053.0,34.9
29/10/21T08:48:48,+43.485952,+016.486000,+19.0,053.0,34.9
29/10/21T08:48:51,+43.485952,+016.486000,+19.0,053.0,34.9
29/10/21T08:48:54,+43.485952,+016.486000,+19.0,053.0,34.9
29/10/21T08:48:57,+43.485952,+016.486000,+19.0,053.0,34.9
29/10/21T08:49:00,+43.485952,+016.486000,+19.0,053.0,34.9

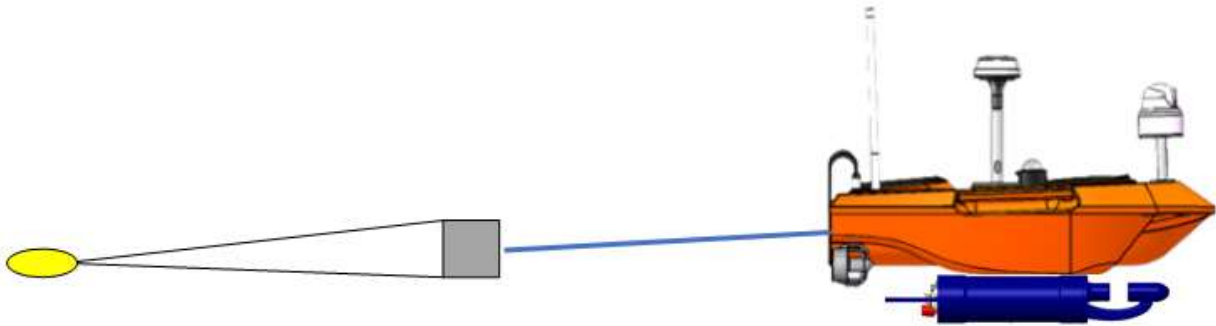
And this a sample of .gps file

```
HEADER, TIME, VALIDITY, LAT, NorS, LON, EorW, SOG[knot], COG[deg], DATE, MAG_VA[deg], EorW, MODE*CHK
$GPRMC, 084840.000, A, 4329.1578, N, 01629.1605, E, 0.02, 346.91, 291021, , , , D*60
$GPRMC, 084843.000, A, 4329.1578, N, 01629.1605, E, 0.03, 36.61, 291021, , , , D*59
$GPRMC, 084846.000, A, 4329.1578, N, 01629.1605, E, 0.10, 331.93, 291021, , , , D*67
$GPRMC, 084849.000, A, 4329.1578, N, 01629.1605, E, 0.08, 312.95, 291021, , , , D*66
$GPRMC, 084852.000, A, 4329.1578, N, 01629.1605, E, 0.09, 314.16, 291021, , , , D*60
$GPRMC, 084855.000, A, 4329.1578, N, 01629.1605, E, 0.19, 347.97, 291021, , , , D*69
```


3 DRONE SYSTEM MANUAL

3.1 System Layout

The system layout adopted for the mission is depicted in the following pictures



where the following parts can be identified:

- Drone to get a Lagrangian monitoring node;
- LISST HOLO2 fixed on the bottom of the drone hull;
- Mini Manta fixed to the stern of the drone with a wire rope of about 3m length

The drone is manually controlled with this console through a WiFi link with a control range up to 1km in open air.



The drone is the Model USV-M1100 characterised by the following main features:

- Weight 20kg
- Sizes 1100x560x800mm
- Max spees 5m/s = 10knot
- Typical speed di 2m/s = 4knot
- Autonomy 4h
- Remote control up to 1km via WiFi and 10km via radio link UHF



3.2 Drone Manual

The Drone Manual is reported in *ANNEX D* of the present document where it is possible to manage the Drone in two different modalities:

- A. Short range control using the deck unit directly connected via WiFi with the drone to control its speed and direction up to a distance of 1km in open area;

- B. Long range control using a radio link unit or LTE link to control the drone from a distance up to 10km through a software with a programmed route.

Currently the modality B is not allowed by the coast guards in Italy and Croatia for safety reasons thus for the execution of the missions only the modality A is allowed controlling the drone from a boat following the drone at a distance of few tens of meters at a maximum speed of 2knots.

For the execution of a mission the following tasks shall be carried out:

- a) The day before the mission recharge the drone battery with related battery charger.
- b) Fix the LISST-HOLO2 under the drone with dedicated clamp.
- c) Switch ON the drone and related console and test correct pairing in air activating the thrusters. The drone is switched ON with related switch SW indicated in this picture whereas to switch ON the console it is necessary to push and release the button indicated with the arrow a first time and after to keep the same button pressed waiting for the 4 LEDs ON. **NOTE: before to switch on the console check that the front selectors are set on Unlock (left) and Manual (right).**



Joystick on the left allows to command the drone to go forth and back whereas joystick on the right allows the drone to turn. The person controlling the drone shall keep the console tied with a safety string to the pants or jacket.

- d) Deploy the drone in water and also the manta and connect the manta to the drone with dedicated wire rope.
- e) Move the boat and with the console keep the drone parallel to the boat at about 5-10m from the boat avoiding collision
- f) At the end of the transept recover the drone onboard and move the magnetic switch to 0 taking note of time of this event and related GNSS position. In order to avoid to recover and to deploy the drone it is possible to carry out consecutive transepts (maximum 3-4 transepts of 15-20min) recovering only the manta bottle but it is recommended to take note of the time of beginning and end of each transept.

3.3 LISST-HOLO2 Manual

The LISST-HOLO2 Manual is reported in *ANNEX H* of the present document, where all details related to the preparation for the mission, execution of the mission and data download and processing are detailed. The present section summarize the main aspects related to the data download and processing adopted for the detection of Microplastics at sea.

3.3.1 HOLO2 Data Download

To download the data from the HOLO2 sensor it is necessary

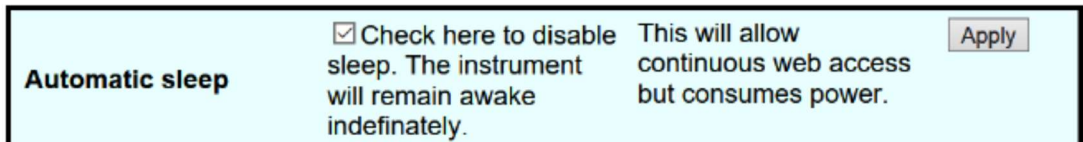
- a. to connect the ethernet cable from the sensor to a notebook PC with ethernet interface (IP address 192.168.0.1/24) and with installed an FTP client (e.g. Filezilla).



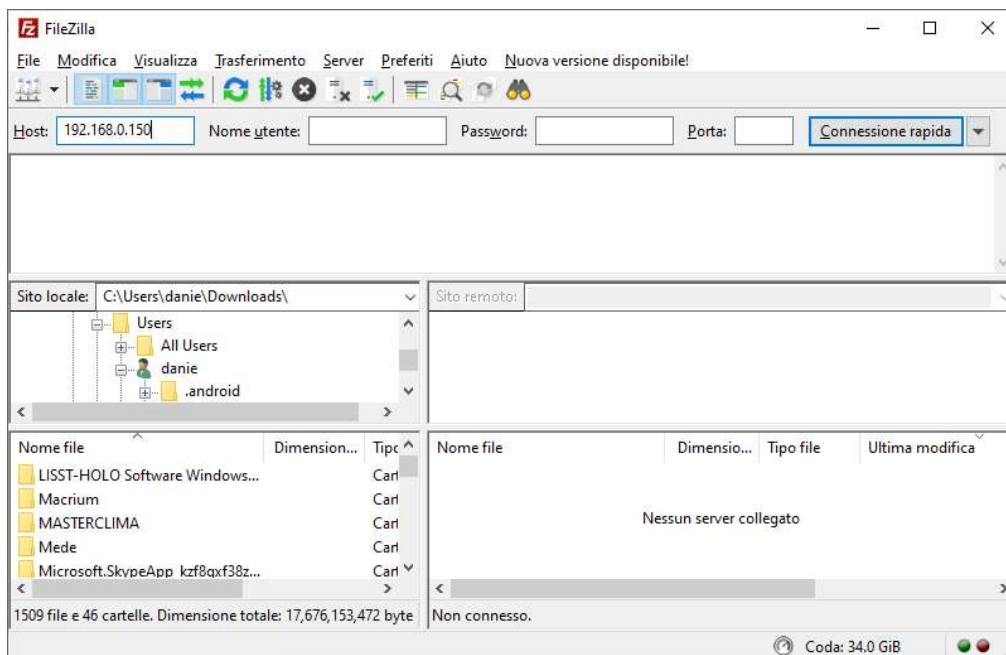
- b. Move the magnetic switch of HOLO2 from 0 to 1 for 1 second and immediately back to 0. After about 1 minute it is possible from the PC to get access to the web server interface of the sensor using a web browser with URL 192.168.0.150. The following page is displayed



- c. Go to the **Tools** page and disable the automatic sleep to keep the sensor awoken during the data transfer.



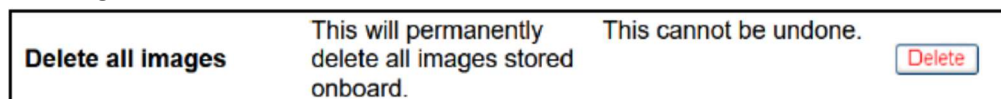
- d. Open Filezilla ftp client, insert the IP 192.168.0.150 and no need to specify a host thus you can push directly the button "Quick Connection"



- e. On the right side of the window above there will be the folder **images**: drag and drop it to the left side. It is suggested to select as destination folder on the left side an external SSD in order to allow an easy data transfer among the project partners. With an acquisition rate of 20fps the time to transfer the holograms collected in 15mins is about 30-40mins. At the end of the transfer rename the folder images on the left side with a name associated to the transept: e.g. Rijeka_Transept_1 and inside the folder create a **readme.txt** file where to write date and time of begin and end of the transept:

```
BEGIN 25/10/21 09:23:12
END 25/10/21 09:52:24
```

- f. At the end of the data transfer you can delete all the HOLO2 internal images with the following command



- g. Before disconnecting PC from HOLO2 you can put the HOLO2 to sleep after 10min as indicated in this picture

Automatic sleep	<input checked="" type="checkbox"/> Check here to disable sleep. The instrument will remain awake indefinitely.	This will allow continuous web access but consumes power.	<input type="button" value="Apply"/>
------------------------	---	---	--------------------------------------

The processing of the holograms will be done in the office in the afternoon/evening at the end of the mission. It consists of the following step:

STEP1 – To see rapidly with the application **OpenSeelt_v0.47.16.4** in browse modality all acquired holograms and take note only of the ones with presence of particles. In particular select a clean holograms without particles to be used as background during the batch processing.

STEP2 – To start the batch processing and wait for result generation only for the subset of holograms selected in STEP1.

For a transept of 15-20min at 20fps, STEP1 takes about 1-1.5hours and STEP2 another hour for a total processing time of about 2-3 hours to get MP concentration results and image of detected particles with size classification.

3.4 Mini-Manta Manual

The Mini-Manta Manual is reported in *ANNEX MAN* of the present document.

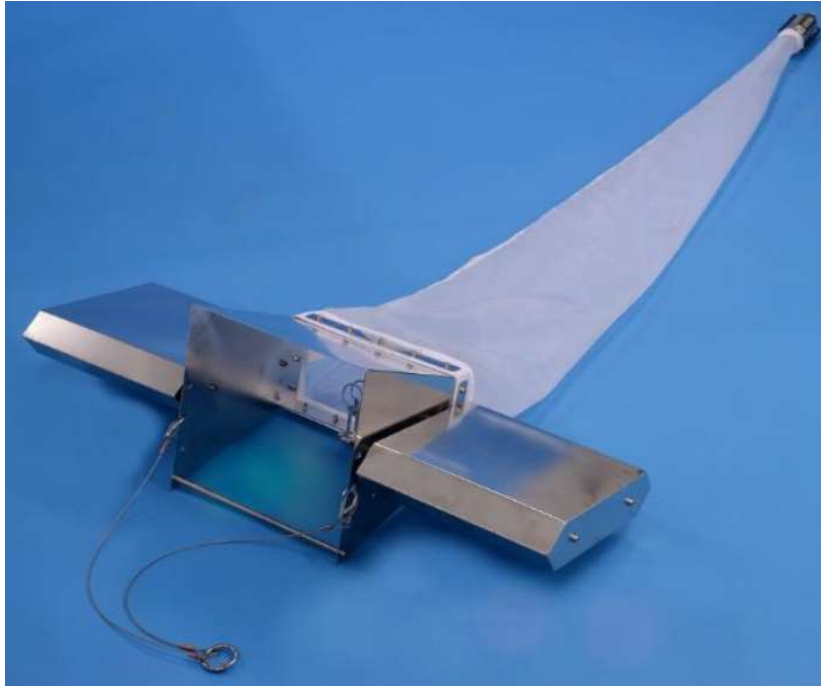


Figure 3.X – Mini Manta

It is a manta with 300micron net, mouth 30x15cm and flow sensor with flow coefficient 13.5 litre per revolutions. Before a mission it is necessary to sign the initial and final counter of the flow sensor to calculate the water volume passed through the net during the mission. During a mission the manta is connected to the Drone with a dedicated wire rope. At the end of the mission the content of the collecting bottle at the end of the net is removed and transferred to a dedicated sample bottle. After each mission the net and the collecting bottle have to be cleaned with fresh water.