ENVRI^{plus} DELIVERABLE

D3.5

Demonstrating robust data provision – data transmission and near real-time QC – employing a use case in a remote ocean region

WORK PACKAGE 1 – Improving measurement networks: common technological solutions

LEADING BENEFICIARY: UNIHB

Author(s):	Beneficiary/Institution
Christoph Waldmann	UniHB
Robert Huber	UniHB
Sebastian Meckel	UniHB

Accepted by: Helle Pedersen (WP 3 leader)

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ABSTRACT

Most of the environmental RIs involved in EnvriPlus are making use of spatially distributed infrastructures mostly in remote regions of our planet. The operation of the equipment in remote areas requires permanent access via specific communication channels and continuous maintenance of the network. The RIs involved in EnvriPlus have developed ad-hoc solutions that work well in their related network environment. The goal of WP 3 is to encourage cross-fertilization between the different disciplines to improve individual solutions and at the same time ensure that data and information exchange will be facilitated. Furthermore, innovative solutions in regard to implementing necessary network components shall be evaluated. For that purpose, a radical different approach towards implementing a data acquisition and transmission module have been conceived that aims at developing a prototype of an open source system to allow other users to adopt specific concepts or add new ideas on hard- or software implementations.

This report provides a description of the prototype that has been realized and results from first field tests.

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Technical Reviewer -Héléne Leau	Ifremer
RI Reviewer – Helle Pedersen	Université Grenoble Alpes

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PROJECT SUMMARY

ENVRIplus is a Horizon 2020 project bringing together Environmental and Earth System Research Infrastructures, projects and networks together with technical specialist partners to create a more coherent, interdisciplinary and interoperable cluster of Environmental Research Infrastructures across Europe. It is driven by three overarching goals: 1) promoting cross-fertilization between infrastructures, 2) implementing innovative concepts and devices across RIs, and 3) facilitating research and innovation in the field of environment for an increasing number of users outside the RIs.

ENVRIplus aligns its activities to a core strategic plan where sharing multi-disciplinary expertise will be most effective. The project aims to improve Earth observation monitoring systems and strategies, including actions to improve harmonization and innovation, and generate common solutions to many shared information technology and data related challenges. It also seeks to harmonize policies for access and provide strategies for knowledge transfer amongst RIs. ENVRIplus develops guidelines to enhance transdisciplinary use of data and data-products supported by applied use-cases involving RIs from different domains. The project coordinates actions to improve communication and cooperation, addressing Environmental RIs at all levels, from management to end-users, implementing RI-staff exchange programs, generating material for RI personnel, and proposing common strategic developments and actions for enhancing services to users and evaluating the socio-economic impacts.

ENVRIplus is expected to facilitate structuration and improve quality of services offered both within single RIs and at the pan-RI level. It promotes efficient and multi-disciplinary research offering new opportunities to users, new tools to RI managers and new communication strategies for environmental RI communities. The resulting solutions, services and other project outcomes are made available to all environmental RI initiatives, thus contributing to the development of a coherent European RI ecosystem.

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INTRODUCTION

Near-Real-Time (NRT) data transmission on site with several instruments and from site/node to data processing centre is a common feature shared by almost all ENVRI+ RIs. NRT data transmission is also more and more used for rapid quality checking for the benefit of RI operators. SO far, NRT procedures have been left to independent choices of the RIs responding to their specific needs while a common approach to NRT technologies would be extremely useful to coordinate response of RIs in case of environmental crisis.

The work of this task will focus on the use of nongeophysical housekeeping data in measurements systems and sensors for the automation of QC.

- It will first review NRT transmission procedures at RIs, including mapping of NRT quality checking procedures across RIs.
- It will organize best practice workshops on key aspects of remote data transmission, wireless on site, and practices on NRT Quality Assurance checking. This will enable achieving NRT data stream through easy automation of data QC.
- Finally, a demonstration action will be organized to highlight added value and benefits of selected best practices in simulated environmental crisis. Participation of SMEs to the WP will be strongly encouraged

This deliverable deals with the third part of the task (highlighted in bright yellow).

Within Task 3.3 of WP 3 the overall approach was to promote standardization concepts and to move standardisation closer to the actual hardware, i.e. the sensor or instrument. In particular it has been aimed to promote the use of e.g. OGC Sensor Web Enablement (SWE) compliant standards and Semantic Sensor Network Ontology (SSNO) compliant ontologies as early as possible within the data acquisition workflow of the related research infrastructures. Due to manufacturer defined constraints and proprietary sensor hardware as well as software solutions it is however difficult to achieve this without intrusive and potentially harming measures on existing measuring equipment. However, as sensor data commonly is collected, harmonised and transmitted using community or vendor specific acquisition modules we identified this as the optimal point of intervention which would enable a radical shift towards standardised data collection and transmission. Unfortunately, no standards supporting, ready-to-use solution for this concept exists until now.

Therefore, it has been decided to aim to 'materialize' some thoughts and concepts and to develop a **hardware prototype**, which is capable to support standardised data collection and transmission as a proof of concept. A radically Open Source (both software and hardware) sensor data harmonisation and communication module has been built which will transform manufacturer specific, proprietary sensor output signals into standardised formats and will enable data transmission via the recognized ENVRI transmission methods (see ENVRIplus deliverable report 3.3) in an open, standardized way. To support marine domain RIs this module will be provided robustly boxed in order to survive harsh, marine environments. It is expected that this will be a piece of RI key technology in the future.

The work was carried out in close cooperation with a **SME from Spain**, SENSORLAB S.L., http://www.sensorlab.es who has been partner on similar tasks in the past. The actual demonstration mission as described in task 3.3 of the DoA (…*to highlight added value and and benefits of selected best practices*…) will be carried out in the area of Canary Islands where PLOCAN will provide logistic support.

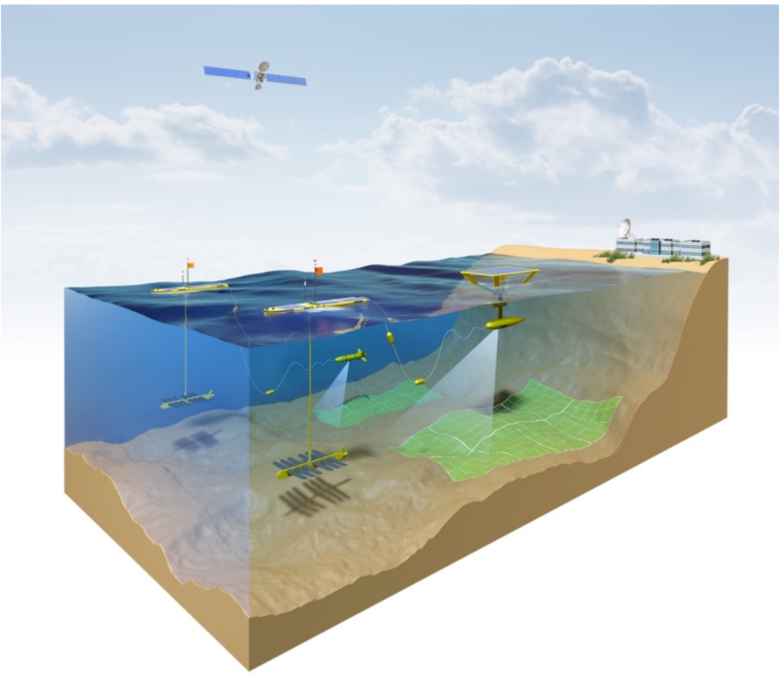


FIGURE 1:ARTIST VIEW OF THE FIELD TEST SCENARIO WHERE A SURFACE DRONE WILL BE DEPLOYED IN A REMOTE OCEAN REGION TO COLLECT ENVIRONMENTAL DATA FROM THE WATER COLUMN AND FROM THE ATMOSPHERE

Description of the Module Concept

Overview on required Functionalities

All environmental observing systems built on in-situ sensors that make use of downstream data acquisition modules that typically fulfills the following tasks:

- Conversion of the incoming signals into a defined and manageable digital data format
- Time stamping of the collected data
- Transfer of those data to a subsequent storage or display module
- Reception of commands for configuring the measuring module and subsequent transfer to the module
- Provision and control of necessary resources like power management, allocation of communication resources, etc.

The open source data acquisition module OpenDAM has been conceived as a system that shall be implemented with off-the-shelf hardware components and open-source software tools that makes extensive use of open-source middleware. As a matter of fact, all information that is needed to build replicas of OpenDAM will be shared with future users with the idea to generate close exchange on future hardware and software implementations.

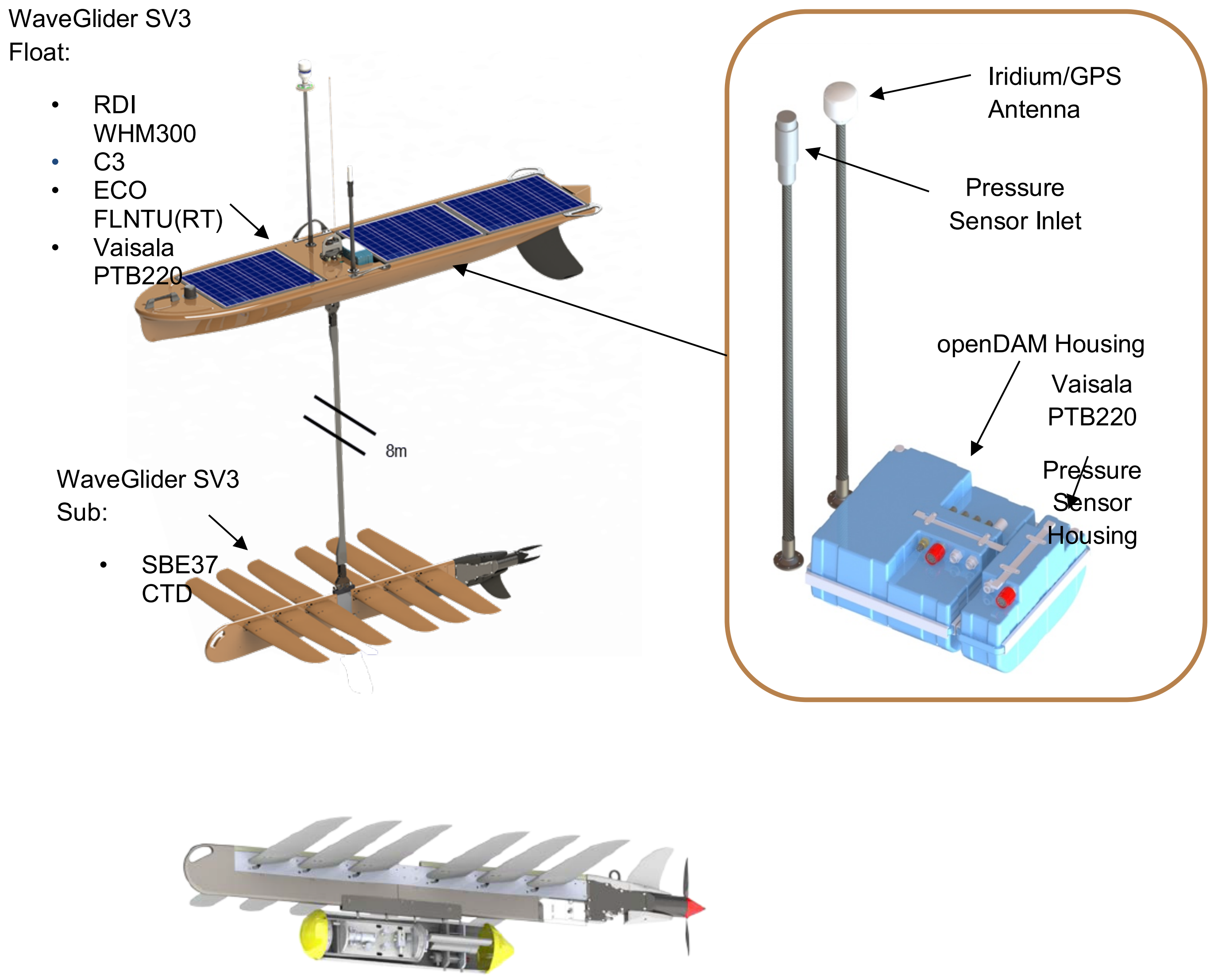


FIGURE 2: THE BASIC OUTLINE OF THE INTEGRATION PROCESS OF THE OCEAN SENSORS THAT WILL BE USED TOGETHER WITH THE OPENDAM MODULE. THE LEFT PANEL SHOWS THE WAVE GLIDER CONSISTING OF A SURFACE ELEMENT, THE FLOAT, AND THE SUBMERGED COMPONENT, THE SUB. BOTH ELEMENTS CAN BE USED FOR SENSOR INTEGRATION. THE RIGHT PANEL SHOWS THE SENSOR SPECIFIC DEVICES THAT WILL BE ADDED TO THE WAVE GLIDER FLOAT WHICH INCLUDES THE OPENDAM SYSTEM. THE LOWER PANEL SHOWS THE CYLINDER THAT IS USED TO CARRY THE SENSORS ON THE SUB.

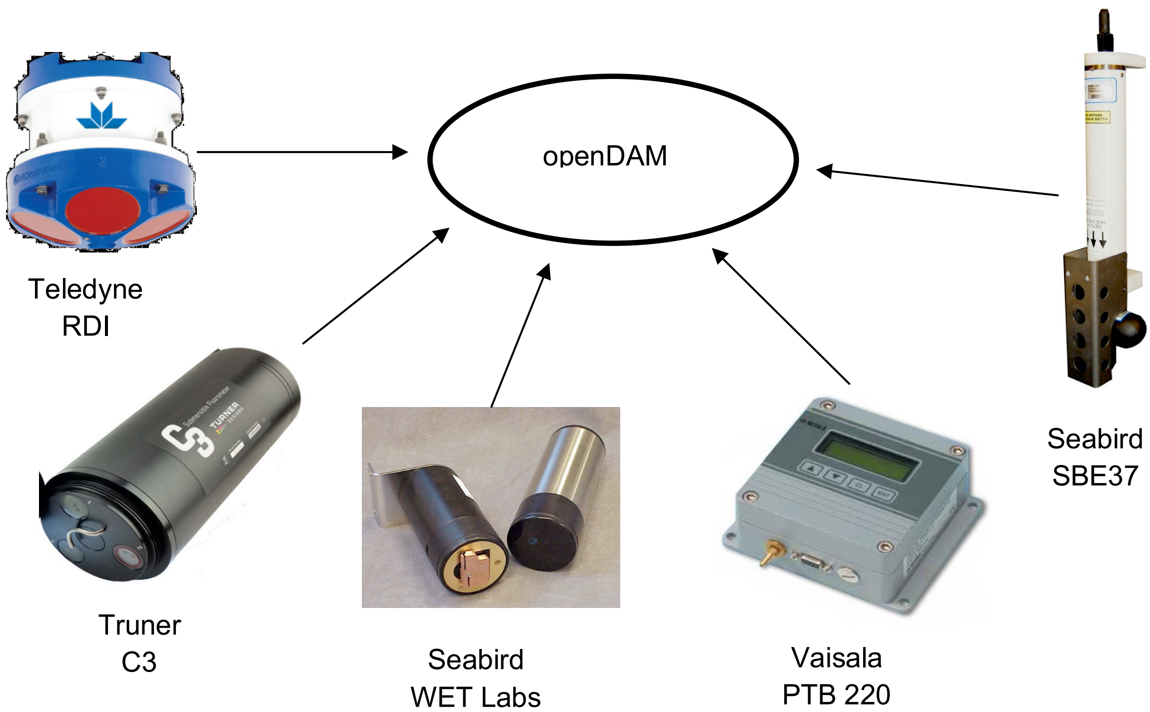
This will only work if OpenDAM proves to be successful and the information on that is disseminated adequately, i.e. on conferences, workshops and publications. It is also considered to link up with activities of other groups to ensure a sustainable use.

To assess and demonstrate the performance of the OpenDAM module the system will be integrated into an ocean surface platform that will be deployed in a remote region off the coast of Northwest Africa. The system that will be used is a commercial product, the Wave Glider by Liquid Robotics [5], that is characterized by a long endurance, typically of the order of months. A set of scientific sensors (see table 1) will be used to observe the seasonality of biogeochemical processes in that region which is massively affected by land-ocean interactions.

TABLE 1: THE OCEAN SENSORS TO BE INTEGRATED INTO THE TEST PLATFORM FOR THE OPENDAM MODULE

Parameter	**Sensors to be integrated**		
	Manufacturer	***Type***	***Location***
CTD&O_2	Seabird	SBE 37-SMPODO MicroCAT C-T (P) Recorder	Sub
Fluorescence and turbidity	WET Labs	ECO FLNTU(RT)	Sub
Current velocity	Teledyne RDI	WH Monitor 300kHz	Float
Fluorescence and turbidity	Turner	C3 Submersible Fluorometer	Sub
Air pressure	Vaisala	PTB220	Float

The choice of sensors had been motivated to have at least have a subset of those sensors that will be used for the EGIM module, the European Generic Instrument Module that has been suggested by the EMSO-ERIC group.



OpenDAM Architecture

In figure 2 the building blocks of the OpenDAM system are displayed. The sensor signals are channeled through the interface board that hosts the data converter and a conversion from the senor specific interfaces typically serial interfaces like RS 232, 422, or 485, to the subsequently used CAN bus. The CAN bus has been chosen as the field bus because it reduces the number of needed cables and typically has low bit error rates. An ethernet interface has not been implemented, yet, but will be added in the future.

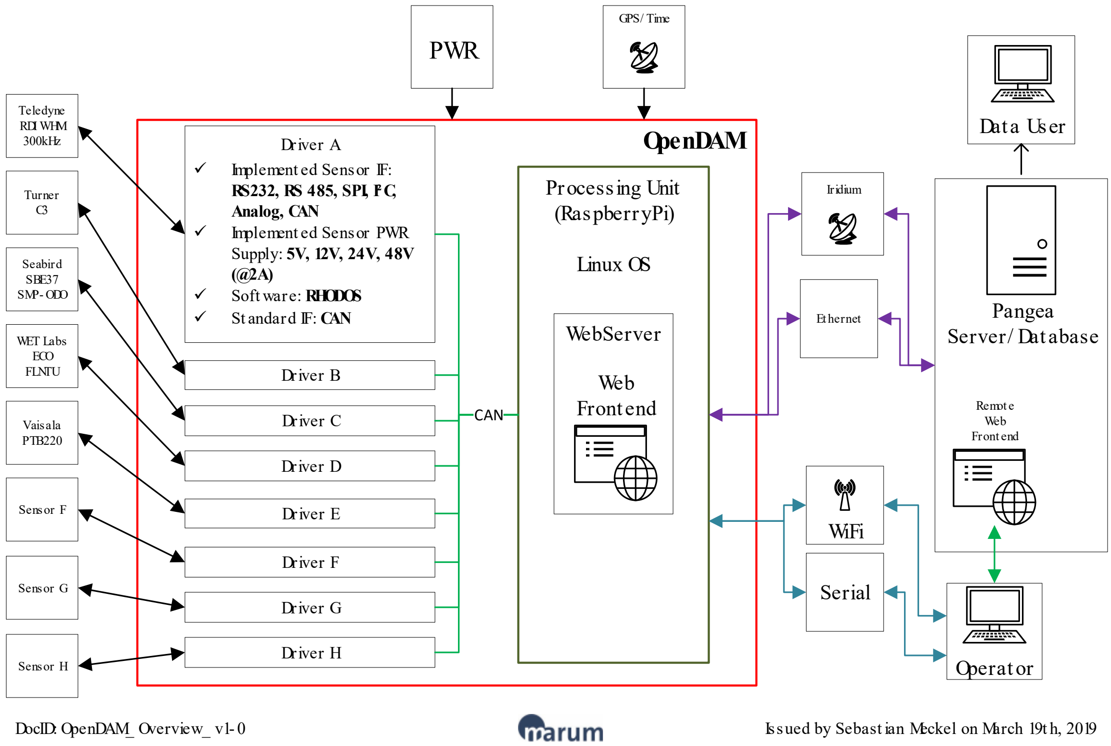


FIGURE 3 THE OPENDAM ARCHITECTURE SHOWING THE END-TO-END VIEW ON THE DATA PROCESSING STEPS STARTING FROM THE INDIVIDUAL SENSOR TO THE FINAL DISSEMINATION BY THE SPATIAL DATA INFRASTRUCTURE PANGAEA

All components that belong to the indicated drivers in figure 3 are implemented with the real-time operating system RODOS developed by DLR and maintained by Universitaet Wuerzburg and the German Space Agency, the DLR. The functions include the conversion of the data protocol, the power control and the CAN gateway management. For the embedded processor a Raspberry module is used that runs LINUX. With a Web Front End all functions of the OpenDAM can be configured and controlled.

The following information is accessible through the OpenDAM Web Server:

- Sensor information
- Sensor data
- Sensor data description
- Sensor configuration
- GPS data
- System data

The sensor information contains a reference to a Universal Unique Identifier, a UUID, of the sensor in operation. For the time being there is no standard approach towards assigning UUIDs to sensor system but quite a bit of work has been already invested into this idea as part of the Research Data Alliance (RDA [8]). It will be of high importance if it comes to making sensor data traceable to quality management routines and to improve the discovery of environmental sensing data.

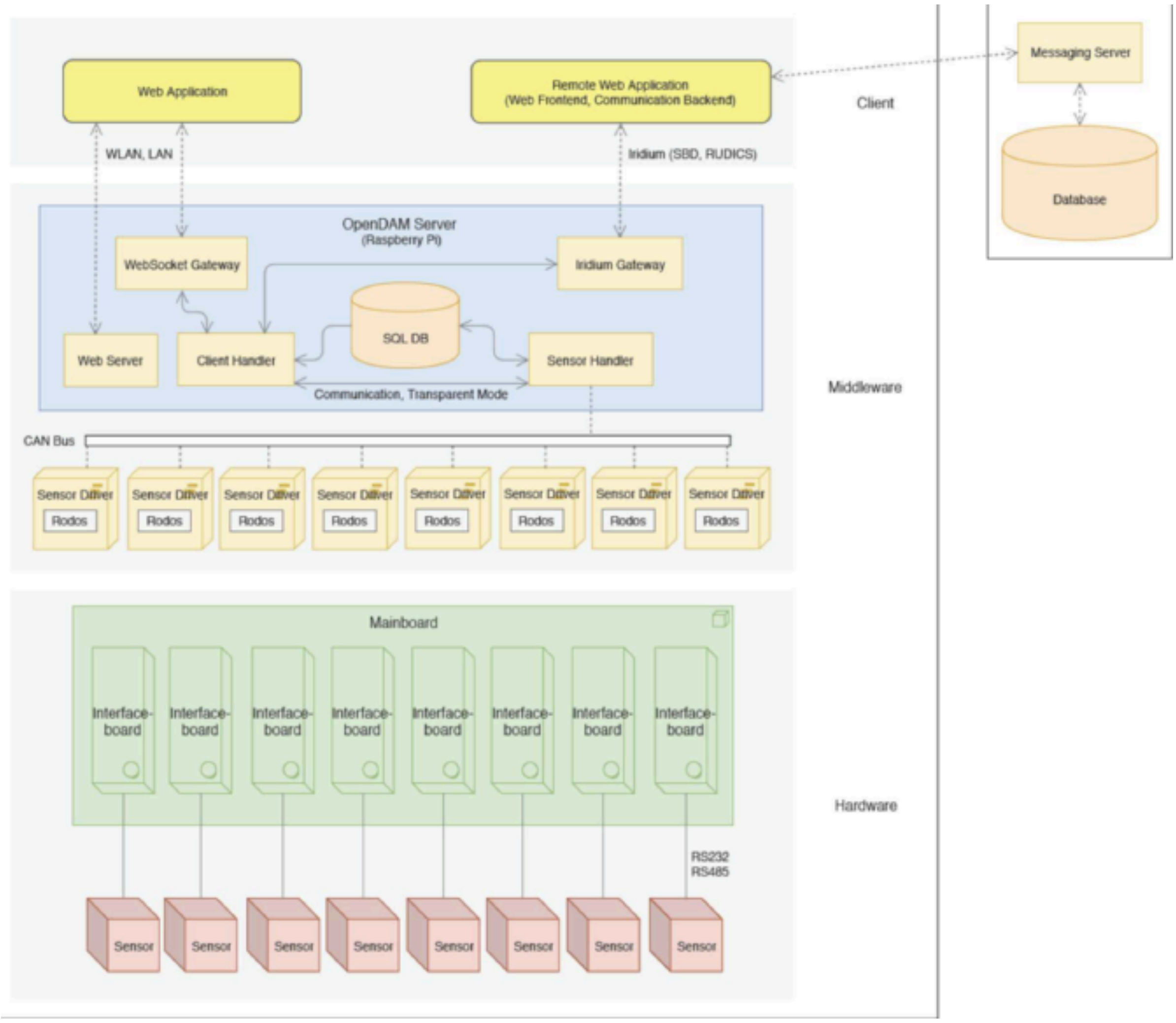


FIGURE 4: THE OPENDAM SOFTWARE ARCHITECTURE

In figure 4 the individual functional blocks of the OpenDAM system is shown. After conversion of the serial output data into a CAN bus protocol an embedded controller implemented on a Raspberry Pi 3 Model B+ is used for the main control functions. The Real-Time operating System (RODOS) running under LINUX is used as a framework for handling incoming data and outgoing commands in a dependable mode. Besides those basic functions the satellite communication via IRIDIUM is handled by the controller and a power management unit allows for controlling individual sensor's duty cycle. All collected data are locally stored so that in case any data gets lost during the transmission process via the satellite link the data can be retrieved after recovery of the Wave Glider.

A Watchdog, a system that permanently checks the status of the power system, prevents data loss when the system runs out of power.

The time tagging of the sensor signals will be done by the logical clock of the embedded processor, which i is daily updated by the GPS time provided by the internal GPS receiver of the OpenDAM system or an external GPS signal. The GPS receiver also delivers the geographical position in case OpenDAM is used on a submerged unit: the latest GPS fix will be stored as reference position.

While testing the instrument either a Wi-Fi or an Ethernet connection to OpenDAM may be used. The actual configuration of the OpenDAM is carried out by a Web Server that can be evoked either by the Wi-Fi/Ethernet or the IRIDIUM communication channel (see figure 4).

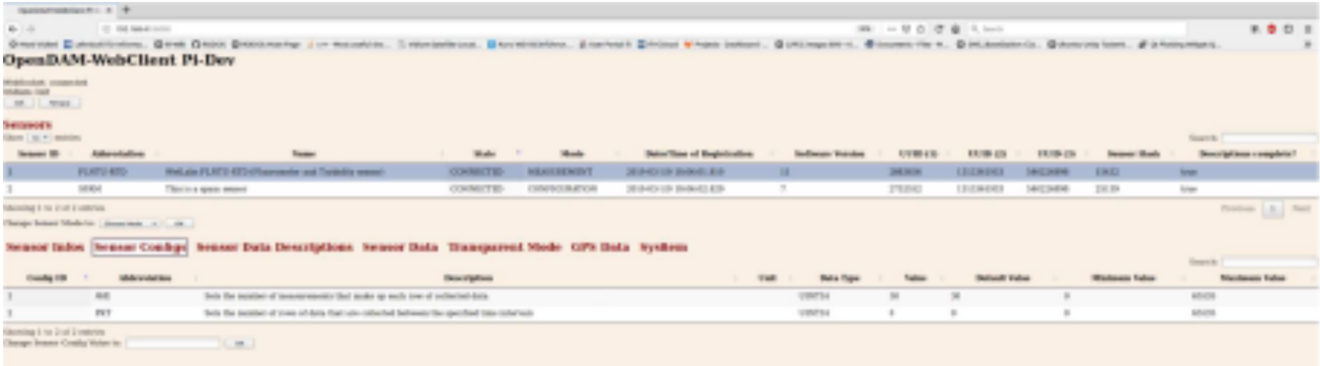


FIGURE 5: IMPLEMENTATION OF THE WEB CLIENT TO CONTROL OPENDAM AND TO CONFIGURE THE OCEAN SENSORS

Figure 5 shows the structure of the Web Client that is used for controlling the OpenDAM system and to configure the sensor collection mode. As mentioned before (page 9) the sensor information contains a reference to a UUID of the sensor in operation. For the time being there is no standard approach towards assigning UUIDs to sensor system but quite a bit of work has been already invested into this idea (RDA). It will be of high importance if it comes to making sensor data traceable to quality management routines and to improve the discovery of environmental sensing data.

The OpenDAM system is currently using the RUDICS service of IRIDIUM that sends all data to a fixed IP address. On the MARUM server a Web client has been set-up to communicate with the Web Server on the OpenDAM system. All incoming sensor data will be stored in the PANGAEA Data Infrastructure that is operated by MARUM. From there the data coming from the air pressure sensor will be transferred to the server of the German Weather Service (DWD server) where it will be fed into the Global Telecommunication System of the World Meteorological Organization.

Standardization considerations

Standardisation of sensor data formats and protocols have been under discussion for almost two decades now. The main driver has been to allow for standardising the data acquisition hardware and software and furthermore allow for the implementation of a plug-and-work system. This is closely connected with the before mentioned UUID for sensor systems and the retrieval of the sensor description as soon as the sensor gets part of the observing system.

Some concepts like the OGC PUCK and the Sensor Web Enablement, SWE, have been implemented in particular application scenarios. The SWE was inserted in the Costof2, proving it is possible to adapt SWE on this type of platform and within the NeXOS project [4] the feasibility has been demonstrated but there are still some issues to be solved fo4 instance in regard to properly describe the sensor deployment and configuration to achieve a broad engagement of users and manufacturers of ocean sensors to adopt this concept. However, if one limits the application of SWE at a higher level of the processing chain where missing information is added to the data string it actually proved to be of high relevance. For OpenDAM we therefore decided to maintain sensor descriptions in the AWI sensor registry which is able to provide SensorML outputs. For sensor data transmission OpenDAM provides a JSON format based on the terminology of the emerging W3C standard Semantic Sensor Network Ontology (SSNO), [1]. Here, the sensor URIs are used to link data to sensor metadata. This concept will be also pursued as part of the OpenDAM activities.

The Open-source concept

The term open source is typically used for software tools that are made freely available, i.e. without license fees [2,3]. In this case the concept is extended to the hardware implementation as well. With the extremely rapid progress in the field of embedded controller systems current hardware can be outdated within a year's timeframe. Therefore, disclosing all elements of the implementation appears to be attractive to allow other users to build on existing knowledge and experience. This stands against standard business models where this type of information is treated as proprietary. The question is whether publicly funded projects shall not better disseminate their results to allow the private sector to focus on other aspects than this definitely needed standard functionality. How detailed the information has to be to let other users benefit from the open-source concept is still an open question. A natural step will be to establish a user community that can discuss and explore alternative solutions. It shall be explored whether existing communities can be leveraged to ensure the continuation of this approach.

First Tests

First tests of the realized systems had been carried out already. All hardware components have been integrated into a standard payload dry box of the Wave Glider. For the air pressure sensor, a separate housing has been chosen to be able to easily replace the system. Due to the high-quality standards of weather observation frequent recalibrations are necessary to ensure the delivery of adequate data.

A particular unknown has been how reliable the IRIDIUM communication link is and how this affects the implemented data acquisition concept. Up to now no major issues had shown up in particular when evoking the Web Server on OpenDAM. In contrast to the Short Bust Data mode (SBD) with delayed data package transfer in transparent mode (RUDICS Service) all incoming sensor data are directly fed into the MARUM Web Client and can be displayed on the client screen. The functionalities of the Power Management Unit and the interaction with the GPS module has been successfully tested as well.

The OpenDAM system together with the listed sensors will in a next step be made ready for field testing within the upcoming months. The deployment will be carried out in the Canary Islands region where during the course of the year a scientific mission is scheduled that will have the Wave Glider operating in a high ocean productivity region close to the Northwest African coast. The first mission will be in parallel with the deployment of the EGIM end of June and another mission is planned for October/November 2019. The vehicle will be deployed from the port od PLOCAN and shall be in operation for several weeks.

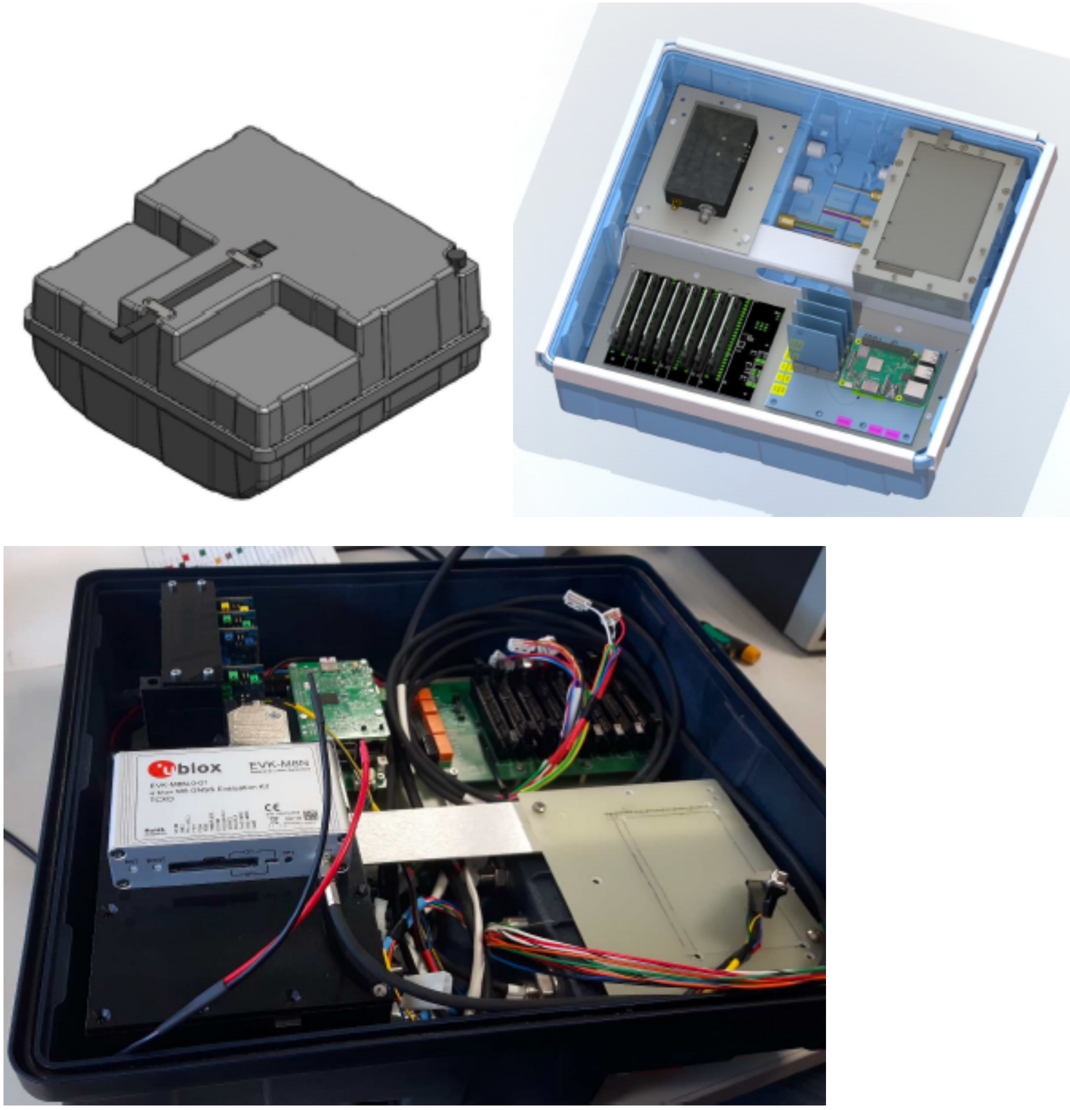


FIGURE 6: PAYLOAD DRY BOX FOR THE WAVE GLIDER – LEFT PANEL CLOSED BOX, LEFT PANEL SHOWING THE DISTRIBUTION OF THE HARDWARE COMPONENTS, LOWER PANEL THE PRACTICAL IMPLEMENTATION

2. CONCLUSIONS

An open-source based concept for a data acquisition and transmission module has been developed and implemented. The concept has been kept generic enough to allow for deployment of the system in different application scenarios, either for oceanic surface platforms or submerged systems where other, m or energy efficient microcontroller systems have to be used. For the moment OpenDAM together with the related sensors, which follow closely the concept of the EGIM within the EMSODEV [6] project, has been built to fit into the Wave Glider of Liquid Robotics but if it comes to the use in for instance a moored sensor suite in 4000 m depth suitable pressure housings can be easily found.

With the concept of open source different pathways can be followed ranging from various hardware implementations to exploring standardization concepts. One of the main drivers for this work actually has been that typically data acquisition modules do not offer all the functionalities that a certain application is calling for and an adaptation is often not possible as proprietary solutions prevent hard- and software changes. In regard to standardization concept the layered architecture appears still to be an adequate approach. It offers enough flexibility to make design changes at different modules. There is an issue with the scalability of this approach as hundreds or thousands of sensors will call for other architectures where subsystems can be grouped.

The openDAM system as it exists right now is a Proof-of Concept for the basic idea of working with open-source hardware and software components. Other areas of application like using the system to collect data at the seafloor or on buoys have been considered as well but due to the limited time and resources could not be implemented. The GPS receiver that is used is good for taking position and time signals while the measuring package is at the surface. For submerged operations the openDAM system will rely on the real-time clock included. In regard to self-powering of openDAM the integrated battery pack is good for several hours. This has been chosen to bridge possible power outages and allow for continuous data recording. With an adequate power pack, the lifetime could be extended significantly. The authors are aware that the RASBERRY PIE is not the most power efficient device for that application but it will work on the Wave Glider vehicle. For future applications other microcontroller systems can be chosen which is actually part openDAM concept.

3. REFERENCES

[1] https://www.w3.org/TR/vocab-ssn/

[2] https://creativecommons.org/licenses/

[3] https://opensource.org/licenses

[4] J. Pearlman, S. Jirka, J. del Rio, E. Delory, L. Frommhold, S. Martinas, T. O'Reilly, "Oceans of Tomorrow sensor interoperability for in-situ ocean monitoring", ***OCEANS 2016***, pp. 1-8, 2016.

[5] https://www.liquid-robotics.com

[6] http://www.emsodev.eu/deliverables.html

[7] https://www.rd-alliance.org/groups/persistent-identification-instruments-wg

Appendix

In the following the individual sensor systems and the core electronic components are listed. All descriptions and specifications are based on the manufacturer’s descriptions

1.1.1 Teledyne RDI Workhorse Monitor 300 kHz

Figure 7: Teledyne RDI Workhorse Monitor [1]

The MONITOR is Teledyne RD Instruments' most popular direct-reading Acoustic Doppler Current Profiler (ADCP). The unit is typically bottom frame-mounted and hard-wired to shore to provide real-time monitoring of coastal currents.

The Monitor's high data accuracy and reliability make it a favorite for deployments in high-volume traffic areas such as ports and harbors, where the data is often integrated into a Vessel Traffic Monitoring System. In fact, the Monitor has been selected for most major port programs undertaken in the United States.

The Monitor offers a choice of three frequencies and ranges, to meet a wide array of data requirements. The unit also offers a flexible upgrade path, which includes an external battery pack, pressure sensor, bottom tracking capability for moving boat applications, and directional wave measurement. [1]

Table 10: Teledyne RDI WHM 300 kHz Technical Specifications [1]

Parameters	Current velocity	
Water Profiling	Depth Cell Size1	Typical Range2 110m
	Vertical Resolution	
	1m	83m 14.0cm/s
	2m	93m 7.0cm/s
	4m	103m 3.6cm/s
	8m	116m2 1.8cm/s
Long Range Mode	8m	154m 3.7cm/s
Profile Parameters	Velocity Accuracy	0.5% of water velocity relative to ADCP +/-0.5cm/s
	Velocity resolution	0.1cm/s
	Velocity range	+/-5m/s default, +/-20m/s max
	Number of depth cells	1-255
	Ping rate	2Hz (typical)
Echo Intensity Profile	Vertical resolution	Depth cell size, user configurable
	Dynamic range	80dB
	Precision	+/-1.5dB
Transducer and Hardware	Beam angle	20°
	Configuration	4-beam, convex
	Internal memory	Two PCMCIA card slots; no memory card included
	Communications	Serial port selectable by switch for RS-232 or RS-422. ASCIIor binary output at 1200-115,200 baud
Environmental	Standard depth rating	200m; optional to 500m, 1000m, 6000m

	Operating temperature	-5° to 45°C
	Storage temperature (without batteries)	-30° to 60°C
	Weight in air	7.0kg
	Weight in water	3.0kg
Software	TRDI's WindowsTM-based software included: WinSC—Data Acquisition System; WinADCP—Data Display and Export;	
Power	Input Power	20–50VDC
Standard Sensors	Temperatures (mounted on transducer)	Range -5° to 45°C, Precision +/-0.4°C, Resolution 0.01°
	Tilt	Range +/-15°, Accuracy +/-0.5°, Precision +/-0.5°, Resolution 0.01°
	Compass (fluxgate type, includes built-in field calibration feature)	Accuracy +/-2°5, Precision +/-0.5°, Resolution 0.01°, Maximum tilt +/-15°
Dimensions	228.0mm wide x 201.5mm long (line drawings available upon request)	

1.1.2 Turner C3 Submercible Fluorometer

Figure 8: C3 Fluorometer [2]

These Submersible Fluorometers can be configured with up to three or six optical sensors ranging from the deep ultraviolet to the infrared spectrum. Internal memory storage capacity combined with an external submersible lithium ion battery allow the C3 or C6P to run during extended or short-term deployments. Each unit comes with a factory-installed temperature sensor. Factory-installed depth sensors and mechanical wipers are also available. The durable delrin housing is highly resistant to harsh environments. Antifouling copper tape pieces are included for placement on the C3 optical head to reduce bio-fouling on and around the sensors. An antifouling copper plate is available as an option for both the C3 and C6P for longer deployments. The Integrator Firmware option is recommended when the C3 or C6P are used as part of a continuous sampling system that requires 24/7 streaming data collection. C-Soft Windows™ based software allows for intuitive calibration, data-logging set-up and file management capabilities as well as data integration. [3]

Table 11: C3 Submersible Fluorometer Specifications [2]

Parameters	Depth, Turbidity, Chlorophyll, Fluorescence
Physical Specifications	
Weight in Air	1.64 kg
Length	23 cm;
Diameter	10 cm;
Material	Delrin Plastic
Temperature	-2 to 50 degrees C.
Depth	0 to 600 meters
Electrical Specifications	
Output	Digital (ASCII) Analog (0 – 5 v olt)– optional C3 only
Interface	RS232 Interface
Minimum Sample Interval	1 Second
Minimum Power Supply	8 - 30 volts; 5 watts
Maximum Current Draw @ 12 volts	– operational 200 mA – sleep mode 3 mA

1.1.3 SEABIRD 5P-1 WATER PUMP for Turner C3 Submersible Fluorimeter [4]

Figure 9 SEABIRD 5P-1 Water Pump [4]

The SBE 5T / 5P pump is a modular component on several Sea-Bird CTD packages. The 5T / 5P is standard equipment on the SBE 9plus CTD and 25 / 25plus Sealogger CTD, and optional equipment on the SBE 16plus V2, 16plus-IM V2, and 19plus V2 SeaCAT CT(D) Recorders. The highly reliable pump flushes water through the conductivity cell at a constant rate, independent of the CTD's motion, improving dynamic performance. Operational characteristics of the 5T and 5P are identical, but the housings and depth ratings differ (5T titanium housing to 10,500 m; 5P plastic housing to 600 m).The pump may also be suitable for custom applications, where pressure heads are less than 300 cm of water and flow rates are less than 100 ml/sec.

- Centrifugal pump head
- Long-life, brushless, DC, ball-bearing motor
- Pump impeller and electric drive motor coupled magnetically through housing, providing high reliability by eliminating moving seals
- Pumping rates and motor current for various applications.

Options:

Voltage/power and RPM selections – Pump is configured by selecting voltage range, and one of several motor speed options (1300, 2000, 3000, and 4500 rpm speeds have been established to meet various flow requirements; other speeds can be set by adjusting a potentiometer). Typical settings include:

- #3 winding, 10-18 VDC, 2000 rpm – typical for SBE 16plus V2, 16plus-IM V2, or 19plus V2 with pumped auxiliary sensor(s), and for SBE 25plus
- #3 winding, 10-18 VDC, 3000 rpm – typical for SBE 9plus
- #3 winding, 6-16 VDC, 2000 rpm – typical for SBE 25

- Plastic (600 m, Weight in air 0.5 kg, in water 0.1 kg) or titanium (10,500 m) housing.
- XSG or wet-pluggable MCBH2 connector.

Operation

Motor speed and pumping rate remain nearly constant over the entire input voltage range (< 1% change in speed for 1-volt supply voltage change). Unrestricted flow rate with no head is 100 ml/sec* at 2000 rpm. Flow changes are nearly linear with speed changes. With unlimited supply current, turn-on surge is 1.8 A* maximum, dropping to steady state in 0.25 sec*. If power supply current is limited to 200 mA*, the motor comes up to speed in 0.30 sec*. A series diode is installed in the input power line to prevent damage if wires are accidentally reversed.

1.1.4 SEABIRD SBE37 SMP-ODO MicroCAT C-T (P)

Figure 10: Sea-Bird SBE37 SMP-ODO [4]

The SBE 37-SMP-ODO pumped MicroCAT is a high-accuracy conductivity and temperature (pressure optional) recorder with Serial interface (RS-232 or RS-485), internal batteries, Memory, integral Pump, and Optical Dissolved Oxygen. The MicroCAT is designed for moorings or other long-duration, fixed-site deployments.

Data is recorded in memory and can be output in real-time. Measured data and derived variables (salinity, sound velocity, specific conductivity) are output in engineering units.

Memory capacity exceeds 380,000 samples. Battery endurance varies, depending on sampling scheme and deployment temperature and pressure. Sampling every 15 minutes (10 °C, 500 dbar), the MicroCAT can be deployed for almost 9 months (25,000 samples). [5]

Table 12: Sea-Bird SBE37 SMP-ODO [4]

Parameters	Conductivity, Temperature, (Depth), Dissolved Oxygen
Physical Specifications	
Weight in Air	4,2 kg
Weight in Air	2,3 kg
Length	61 cm;
Width	14 cm;
Height	10 cm
Material	Titanium

Temperature	-5 to 45 degrees C.
Depth	2000 meters
Electrical Specifications	
Power Supply & Consumption	7.8 Amp-hour (nominal) battery pack, 257 KJoules (derated for calculations) 25,000 samples CTD-DO (see manual)
Optional External Power	0.25 Amps at 9-24 VDC
Memory Capacity	380,000 samples CTD-DO
Interface	RS-232 or RS-485 interface
Software	Seasoft© V2 Windows software package

1.1.5 Sea-Bird WET Labs ECO FLNTU(RT)

Figure 11: Sea-Bird WET Labs ECO FLNTU(RT) [6]

WET Labs offers the Environmental Characterization Optics (ECO) series of meters that incorporate a common set of options with a single basic design to make them ideal for a wide variety of deployments.

The FLNTU:

- Combines the unparalleled sensitivity of the ECO fluorometer with an optical scattering measurement at 700 nm for simultaneous determination of turbidity
- Ranges for output tailored to the environment
- Allows for assessment of fluorescence and turbidity variability and interactions
- Digital and analog output for easy integration into analog CTD packages or serial data streams
- Provides excellent precision, reliability and overall performance at a fraction of the cost and size of similar instruments [5]

Table 13: Sea-Bird WET Labs ECO FLNTU(RT) Specifications [5]

Parameters	Optical Turbidity & Fluorescence
Electrical Specifications	
Digital output resolution	12 bit
Internal data logging	Optional
Internal batteries	Optional
Connector	MCBH6MP
Input	7–15 VDC
Current, typical	60 mA
Current, sleep	140 µA
Data memory	90,000 samples
Sample rate	User selectable to 8 Hz
Interface	RS-232 output (9200 baud)
Environmental Specifications	
Temperature Range	0 – 30°C
Depth Rating	600 m
Mechanical Specifications	
Diameter	6.3 cm
Length	12.7 cm (standard)
Weight in air	0.4 kg (standard)
Weight in water	0.02 (standard)
Materials	Acetal copolymer (standard)
Options	

EFLNTU(RT)	Analog and RS-232 serial output with 4,000-count range. Unit operates continuously when power is supplied.

1.1.6 Vaisala PTB220 barometers (DWD Sensor) [7]

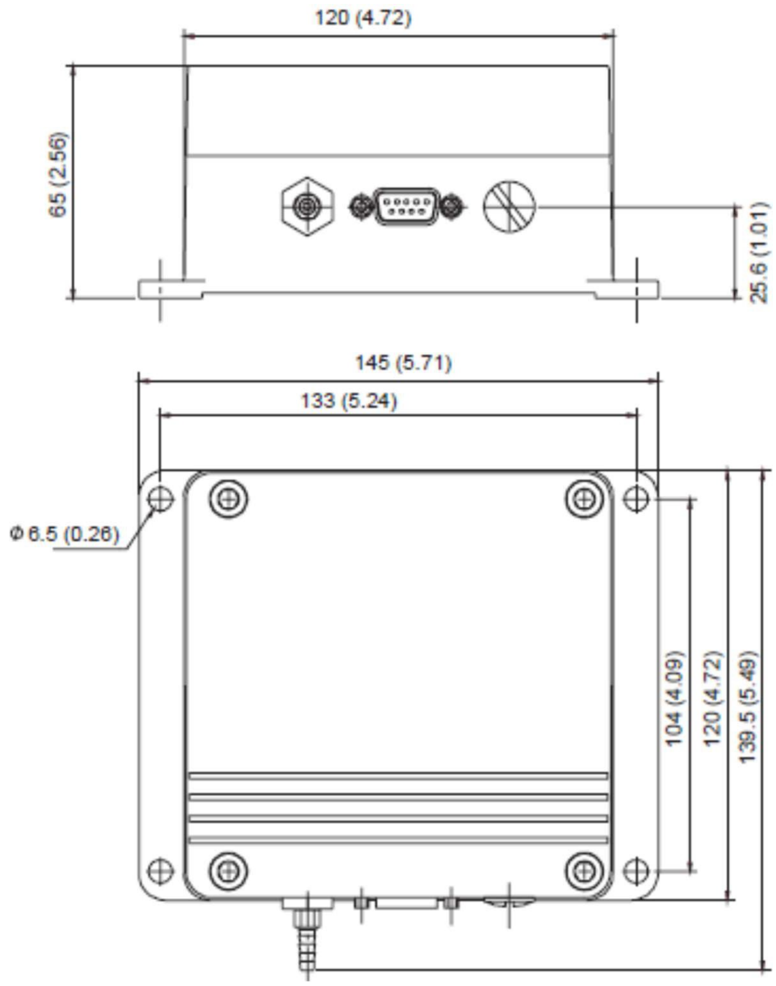


Figure 12: Vaisala PTB220 barometer [7]

The PTB220 series barometers are fully compensated digital barometers designed to cover a wide range of environmental pressure and temperature. They can be used successfully both in accurate pressure measurement applications at room temperature and in demanding automatic weather station applications.

The PTB220 series digital barometers use the BAROCAP® silicon capacitive absolute sensor developed by Vaisala for barometric pressure measurement applications. The measurement principle of the PTB220 series digital barometers is based on an advanced RC oscillator and three reference capacitors against which the capacitive pressure sensor and the capacitive temperature compensation sensor are continuously measured. The microprocessor of the barometer performs compensation for pressure linearity and temperature dependence.

The pressure and temperature adjustment in the PTB220 consists of seven temperature levels over the operating temperature range of the barometer and of six to eleven pressure levels over the operating pressure range of the barometer at each temperature level. The calculated individual basic pressure and temperature adjustment coefficients are stored in the EEPROM of each pressure transducer. The user cannot change these basic factory adjustments.

The multipoint fine adjustment for pressure and the final pressure calibration of the PTB220 Class A barometers is done using a manual Ruska 2465 dead-weight tester. The multipoint fine adjustment and calibration of the Class B barometers is done automatically using electronic working standards.

The PTB220 series digital barometers are available with one, two or three pressure transducers. Although one pressure transducer is usually the most appropriate configuration, some applications may benefit from additional pressure transducers. Two or three pressure transducers provide for a self-diagnostic feature: the user can set an alarm limit within which the pressure transducers must agree for reliable measurement. The PTB220 series barometers can also be configured to measure two separate pressures.

A local LCD display on the cover is also available as a configuration option. The display has a backlight, which makes the display easy to read at any light conditions. The display has two rows and it can simultaneously indicate the barometric pressure, the three-hour pressure trend and the WMO pressure tendency code.

The user can define various specific application settings, such as serial bus settings, averaging time, output interval, output format, display format, error message field, pressure unit and pressure resolution. It is also possible to select different sending modes for power-up situation such as the free running mode, the stand- by mode and a mode with one automatically sent message. A fast measurement mode with ten measurements per second can also be selected. The factory settings have been chosen so that both a fast settling time and a high resolution are achieved. In applications where fast settling time is not required, longer averaging times are recommended to reduce environmental pressure noise.

As a standard, there are RS 232C full duplex and bidirectional TTL level serial interface in the barometer. In addition the user can select either an RS 485/422 two-wire half duplex serial interface or a pulse output interface with user selectable pulse rate, pressure resolution and pressure offset.

1.2 Equipment

1.2.1 Raspberry Pi 3 Modell B+ [8]

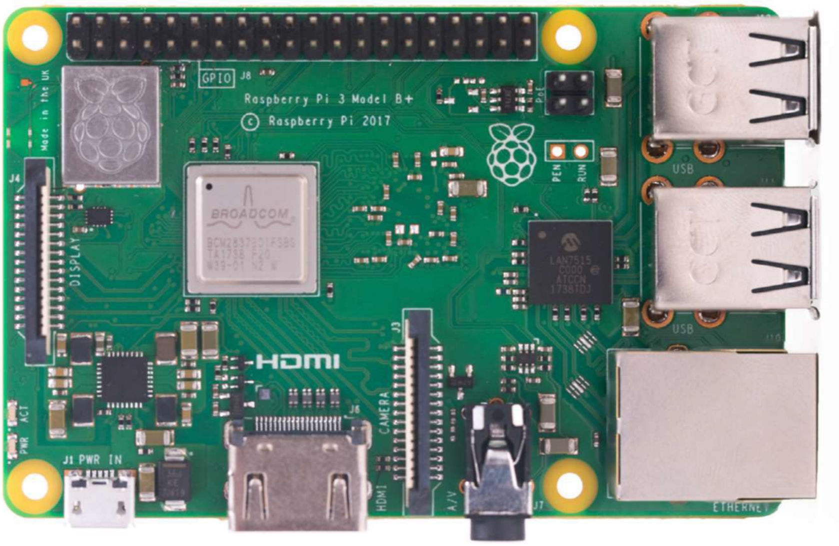


Figure 13: Raspberry Pi 3 Model B+ [8]

The Raspberry Pi 3 Model B+ is the latest product in the Raspberry Pi 3 range, boasting a 64-bit quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and PoE capability via a separate PoE HAT.

The dual-band wireless LAN comes with modular compliance certification, allowing the board to be designed into end products with significantly reduced wireless LAN compliance testing, improving both cost and time to market.

The Raspberry Pi 3 Model B+ maintains the same mechanical footprint as both the Raspberry Pi 2 Model B and the Raspberry Pi 3 Model B.

Table 14: Raspberry Pi 3 Model B+ Specifications [8]

Processor	Broadcom BCM2837B0, Cortex-A53 64-bit SoC @ 1.4GHz
Memory	1GB LPDDR2 SDRAM
Connectivity	• 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE • Gigabit Ethernet over USB 2.0 (maximum throughput 300Mbps) • 4 × USB 2.0 ports

Access	Extended 40-pin GPIO header
Video & Sound	1 × full size HDMI MIPI DSI display port
	MIPI CSI camera port 4 pole stereo output and composite video port
SD card support	Micro SD format for loading operating system and data storage
	5V/2.5A DC via micro USB connector 5V DC via GPIO header Power over Ethernet (PoE)–enabled (requires separate PoE HAT)
Environment	Operating temperature, 0–50°C
Product Lifetime	The Raspberry Pi 3 Model B+ will remain in production until at least January 2023.

1.2.2 IRIDIUM/GNSS Receiver

4.3.2.1 IRIDIUM RUDICS Modem NAL Satellite Modem A3LA-RG

Figure 14: Satellite Modem A3LA-RG [7]

The A3LA-RG is an A3LA-RM with an internal GPS receiver. It allows SBD, SMS, data switch and RUDICS connectivity to the Iridium network. With a connected DPL handset, the A3LA-RG can place voice calls. It is can encrypt data with AES-256 bit. It can also monitor network status to prevent lock-up. [7]

Key Features [7]:

- Low-cost
- Small form-factor
- Capable of SBD, SMS, data switch, RUDICS and voice.
- AES-256 bit encryption
- Built-in GPS receiver
- RS-232 interface
- Functionally is the same as the 9522B
- 60% smaller in volume than the 9522B
- Ca. 50% lighter than the 9522B
- A3LA-RG-MIL is certified to MIL-STD-810G standards and IP67 rating

Table 15: NAL Satellite Modem A3LA-RG Technical Specifications [7]

Mechanical Specifications	
Dimensions	102 mm x 61 mm x 24 mm
Weight	201 g
Data/PWR Interface	25-Pin D-Sub
Antenna Interface	TNC female connector for Iridium, SMA female connector for GPS
Enclosure	Hard-anodized aluminum (EMI/EMC shielded)
Electrical Specifications	
Input Voltage Range	4.0V to 5.4V or 5.0V to 32V
Nominal Input	5VDC
Idle Power	175mA @ 5V
Transmitted Power	420mA @ 5V
RF Boards	
Iridium Tranceiver	Iridium 9523
GPS Reiceiver	u-blox MAX-6Q
Environmental Specifications	
Operating Temperature	30oC to +70oC
Operating Humidity	< 75% RH

4.3.2.2 Iridium Transceiver – Iridium Core 9523

Figure 15: Iridium Core 9523 [8]

Iridium Core 9523 is Iridium's smallest, lightest and most advanced voice and data satellite transceiver module ever, enabling simplified global voice and data connectivity through the world's furthest reaching network.

Over 90% more compact than our previous model and featuring standardized connectors, it easily integrates into new partner products to reach previously under-served consumer and vertical markets – and drive global communications in ways never thought possible. [8]

Features [8]:

- Pole-to-pole global coverage
- Ultra compact form factor
- Single-board transceiver
- Standardized connectors
- Voice, Circuit Switched Data and RUDICS
- Short Burst Data (SBD) capable
- Direct PCB integration
- FCC, Industry Canada, and CE approval (*For applications using an antenna with a gain of up to 3dbi)*

Capabilities [8]:

- Iridium Voice, SMS, Circuit Switched Data and RUDICS
- Maximum mobile originated SBD message size 1960
- Maximum mobile terminated SBD message size 1890

Table 16: Iridium Core 9523 Technical Specifications [8]

Environmental Specifications	
Operating Temperature	-30ºC to + 70ºC

Storage Temp.	-40°C to + 85°C
Storage Humidity	≤ 93 % RH
RF Parameters	
Frequency Range	1616 MHz to 1626.5 MHz
Duplexing Method	TDD (Time Domain Duplex)
Input/Output Impedance	50 Ω
Multiplexing Method	TDMA/FDMA
DC Power Input	
VBAT Power Input Specifications	
Nominal Voltage	+3.7 V
Voltage Limits	+3.2 V to +6 V
Maximal Current	500 mA
VBAT Typical Current at Nominal	+3.7 V
Standby Current	70 mA
Peak Current during Call	300 mA
Average Current during Call	110 mA
VBOOST Power Input	
Nominal Voltage	+27 V
Absolute Maximal Voltage	+35 V
Maximal Recommended Voltage	+32 V
Minimal Voltage during Call Transmit Burst	+10.5 V
Maximal Current	1 A
VBOOST Power Consumption	

Typical Average Power during Call	2.3 W
Maximal Average Power during Call	3.1 W

4.3.2.3 Internal Iridium Modem GPS Receiver

Figure 16: u-blox 6 GPSQ module [11]

The MAX-6 module series brings the high performance of the u-blox 6 position engine to the ultra miniature MAX form factor. u-blox 6 has been designed with low power consumption and low costs in mind. Intelligent power management is a breakthrough for low-power applications. These receivers provide high performance and a high level of integration capability in a tiny package. This makes them perfectly suited for end products with strict size and cost requirements. The DDC interface provides connectivity and enables synergies with u-blox wireless modules. [11]

Table 17: u-blox 6 GPSQ Technical Sepcifications [11]

Environmental Specification	
Operating Temperature	-40 C to +85 C
Storage Temperature	-40 C to +85 C
Electrical Specification	
Power Supply	2.7 V – 3.6 V
Power Consumption	41 mA (continuous) 12 mA Power Save Mode (1 Hz)
Backup Power	1.4 V – 3.6 V, 22 µA
Supported Antennas	Active and passive

4.3.2.4 U-Blox EVK-M8N

Figure 17: u-blox EVK-M8N Evaluation Kit [12]

EVK-7, EVK-8 and EVK-M8 evaluation kits make evaluating the high performance of u-blox 7, u-blox 8, and u-blox M8 positioning technology simple. The built-in USB interface provides both power supply and high- speed data transfer, and eliminates the need for an external power supply. u-blox 7, u-blox 8, and u-blox M8 evaluation kits are compact, and their user-friendly interface and power supply make them ideally suited for use in laboratories, vehicles and outdoor locations. Furthermore, they can be used with a PDA or a notebook PC, making them the perfect companion through all stages of design-in projects.

EVK-M8N:

- u-blox M8 Evaluation Kit with TCXO, supports u-blox M8 concurrent GNSS chips, LEA-M8S, MAX-M8Q, MAX-M8W, NEO-M8N, NEO-M8Q
- Active GPS / Galileo / GLONASS / BeiDou

Table 18: u-blox EVK-M8N Evaluation Kit [12]

Specifications	
Dimensions	105 x 64 x 26 mm
Serial Interfaces	- 1 USB V2.0 - 1 RS232, max. baud rate 921,6 kBd DB9 +/- 12 V level 14 pin – 3.3 V logic - 1 DDC (I2C compatible) max. 400 kHz - 1 SPI – clock signal max. 5,5 MHz – SPI DATA max. 1 Mbit/s
Timing Interfaces	1 Time pulse output1
Power Supply	5V via USB or external powered via extra power supply pin 14 (V5_IN) 13 (GND)
Normal Operating temperature	-40°C to +85°C

4.3.2.5 Iridium GPS Dual Antenna AT1621-162

Figure 18: Aero Antenna AT1621-162 [10]

The AT1621-162 is a combined Iridium & GPS antenna and is designed to work primarily for marine applications and other harsh environments. The antenna has a pipe thread mount that enables it to be securely mounted without the connectors being exposed to the environment. The antenna is fitted with SMA female connectors for both the GPS and Iridium connections and will work with all major brands of Iridium/GPS based devices [10].

Table 19: Aero Antenna AT1621-162 Technical Specifications

Mechanical Specifications	
Diameter	7.6 cm
Height	7,9 cm
Weight	127 grams
Connector Iridium	SMA Female
Connector GPS	SMA Female
Mount type	3/4' thread
Finish	Weatherable Polymer (White)

Environmental Specification	
Operating Temperature	-40 C to +71 C
Waterproof	IPX7
Electrical Specification	
Frequency	1621 ±5 MHz
	1575 ±5 MHz
Polarization	Right hand circular
Axial Ratio	3 dB Max
Radiation Coverage	See datasheet [11]
Gain	Iridium: passive
	GPS L1: 26 dB (35mA)
Voltage	Iridium: passive
	GPS L1: 3VDC
Noise Figure	2,5 dB max.
Impedance	50 Ω
VSWR	<2.0:1
Power Handling	10 Watt