D4.1–SEISI analog and digital front end

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THE OCEAN OF TOMORROW

COOPERATION

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Abstract

The deliverable D4.1 on Smart Electronic Interface for Sensor Interoperability (SEISI) analog and digital front end describes the transducers interfaces of the SEISI, consisting of three submodules: an analogue interfaces, a point-to-point interface and a multi-drop interface, according to the NeXOS transducers requirements developed for the optical, passive acoustics and the EAF sensor systems.

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1 Acronyms and Abbreviations

AUV: Autonomous Underwater Vehicle

CAN: Controller Area Network (CAN) is a network protocol that was first developed in 1986, by Robert Bosch, and is documented in ISO 11898 and ISO 11519. It is a bus topology of embedded microcontrollers that connects devices, sensors and actuators in systems for real-time control applications.

DoW Description of Work

I2C: Inter-Integrated Circuit

OEM: Original Equipment Manufacturer

OGC: Open Geospatial Consortium

PIP:Project Implementation Plan

TRL: Technology Readiness Level

SEISI: Smart Electronic Interface for Sensor Interoperability

SensorML: Sensor Modelling Language

SID: Sensor Interface Descriptor

SPI: Serial Peripheral Interface

SSI: Standard Software Interface

SWE: Sensor Web Enablement as the OGC suite of standards

UART: Universal Asynchronous Receiver/Transmitter

USB: Universal Serial Bus.

2 Glossary

- **Actuator**: a mechanical device that accepts a data signal and performs an action based on that signal (IEEE Definition).
- **Interoperability**: The ability of two or more systems or components to exchange information and to use the information that has been exchanged (IEEE Definition)
- **Platform**: Device that can host one or several sensor systems. A platform can be fixed or mobile. Examples of mobile platforms are gliders and other AUVs, drifters, profilers and vessels. Examples of fixed platforms are buoys, moorings, seafloor cabled observatories. Platforms with ocean sensors may be referred to as ocean observing systems.
- **Technology Readiness Level**: The concept of Technology Readiness Level (TRL) was developed by NASA and ESA for space systems [http://en.wikipedia.org/wiki/Technology_readiness_level] and has recently introduced in ocean observation to identify the stages that a technology needs to pass in order to bridge the gap between research and development and production/operations
- **Sensor**: an electronic device that produces electrical, optical, or digital data derived from a physical condition or event. Data produced from sensors is then electronically transformed, by another device, into information (output) that is useful in decision making done by 'intelligent' devices or individuals (people) (IEEE Definition).
- **Transducer**: an electronic device that transforms energy from one form to another.(Examples: microphone, thermometers, antenna). For the purpose of this document, a transducer is a sensor and/or actuator (IEEE Definition).

3 Executive Summary

This document describes the Analog and Digital Front End for the NeXOS Smart Electronic Interface for Sensor Interoperability (SEISI). The SEISI Analog and Digital Front End consists of a multifunctional interface for several types of sensors and instruments, as well as for the new multifunctional detectors to be developed by WP 5, 6, and 7. The SEISI is responsible for data communication to each payload. Data are made available to the SEISI interface communication controller to be relayed to the NeXOS Sensor Web data management system.

The purpose of this Analog and Digital Front End is to ensure that the sensors and actuators developed/deployed in NeXOS can be integrated in an interoperable manner with SEISI so that it is available for further adaptations. As a result a framework has been defined which comprises the following components:

- Analog transducer, or array of analog transducers requiring an analog front-end, a digital conversion as part of the hardware interface, and software interface (SEISI) (as may be required in WP5 and WP6)
- Digitised transducer or array of digitised transducers (i.e. that include an Analog to Digital converter), sharing a common hardware and software interface (as may be required in WP5 and WP6)
- Distributed sensors (e.g. sensor network) under an existing control and communication layer, where data is located in repositories and only a Standard Software Interface (SSI) is required (e.g. new sensors for the EAF-RECOPESCA, WP7)

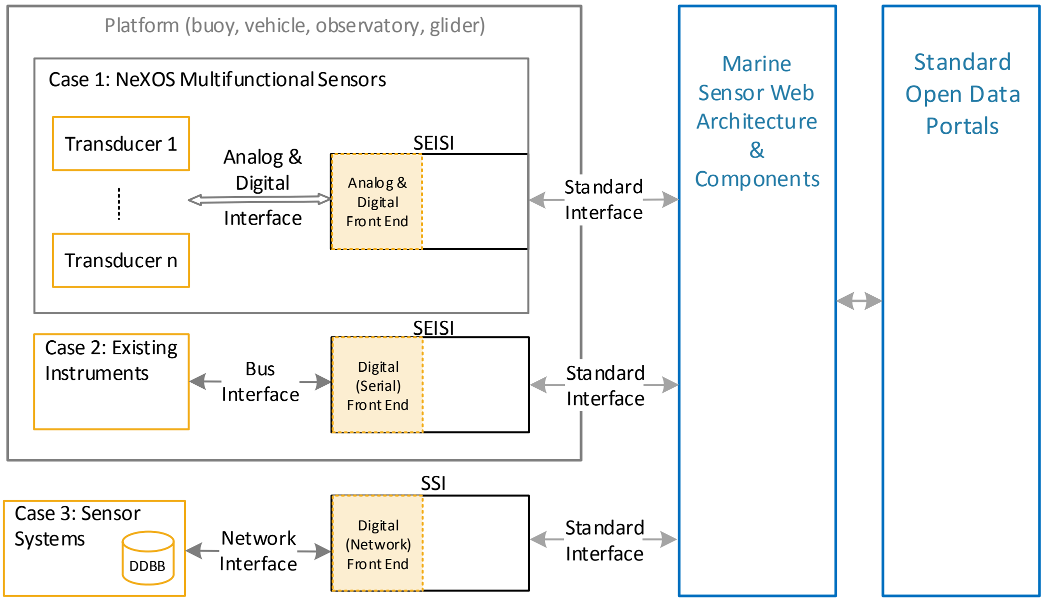


Figure 1 Sensor systems based on SEISI and SSI. The Analog and Digital Front End represents the connection of SEISI and SSI with the heterogeneous transducers, instruments and data sources

4 Introduction

The sensors developed and deployed within NeXOS will collect data for oceanographic research and society at large. Because there are a high number of transducers types, an approach is needed to provide adaptability and modularity for sensor interfacing and multiplatform requirements. This is exactly the objective of the SEISI Analog and Digital Front End presented in this deliverable.

A driving factor behind the design of the SEISI Analog and Digital Front End was the provision of a cost-efficient solution which allows instrument manufacturers such as Original Equipment Manufacturers (OEM) to integrate their sensors and actuators seamlessly into a multi-parameter instrument. This aim of a cost-efficient approach is achieved through several characteristics of the SEISI architecture:

- Re-Usability: The components of the NeXOS SEISI architecture will be as generic as possible and will use standardized interfaces. A single Smart Electronic Board will operate multiple sensors and actuators. Thus, instrument manufacturer will be able to re-use the resulting architecture in multiple application contexts beyond NeXOS.
- Interoperability / Plug and Play: Through the use of standardized interfaces, the integration of sensors and actuators into SEISI and finally in observatory networks will require less effort. Therefore, through the use of international standards for the communications of SEISI with the NeXOS data management systems, the integration of sensor data into applications can counterintuitively require less effort to perform.
- Open source: For each component of the NeXOS SEISI architecture an open source implementation will be provided. This will allow instrument manufacturers to rely on free implementations.
- Low-power and compactness: use of reliable low-power components and technologies for integration on mobile platforms.

The remainder of this document is structured as follows: Section 3 provides a description of the prerequisites extracted from the NeXOS Description of Work (DoW), Project Implementation Plan (PIP) and scenario progress from WP1, Technology Readiness Level report (TRL) from WP3, specification of components developed in WP 5, 6 and 7 and introduces relevant existing work such as standardization activities and research projects. In chapter 4 the architecture and components of the SEISI Analog and Digital Front End is defined. Finally, the document closes with conclusions provided in chapter 5.

5 Reference documents and requirements analysis

The SEISI Analog and Digital Front End will provide a common interface with transducers, allowing SEISI to be a multifunctional platform that will satisfy the size, cost and multiplatform integration requirements.The purpose of the plan is to compile and further detail the Description of Work for the development of the Analog and Digital Front End for SEISI. The plan also needs to comply with the Project Implementation Plan (D1.3) and scenarios developed within WP1 and the engineering specifications for hardware and software for agreed functionalities provided in D3.1 and D3.2 (WP3). Moreover, the development of the SEISI Analog and Digital Front End will satisfy the sensors/actuators interface requirements that are identified in the description of the sensor system for optical measurement of marine environmental parameters (D5.1) the description of sensor systems for passive acoustic monitoring of noise, bioacoustics and related variables (D6.1) and the description of the new RECOPESCA sensor system (EAF) provided in D7.1 and D7.2 (WP7).

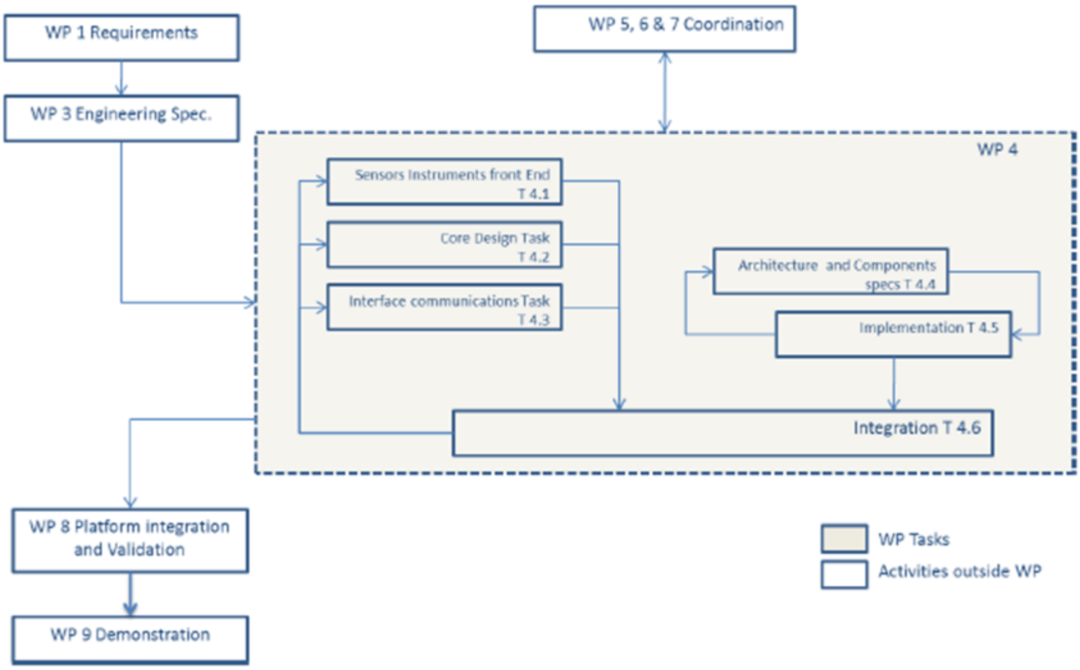


Figure 2 Structure of work package 4 and links with other work packages.

5.1 Implementation Plan

According to the Project Implementation Plan (D1.3), within NeXOS it has been decided to follow a systems engineering approach which means in general that all steps in the development process shall be part of an overall master plan and are all well documented. Figure 3, a so called V - diagram illustrates the different levels of planning and development. In this diagram the upper level represents the application layer where application scenarios, relevant parameters, and the required specifications are defined and evaluated.

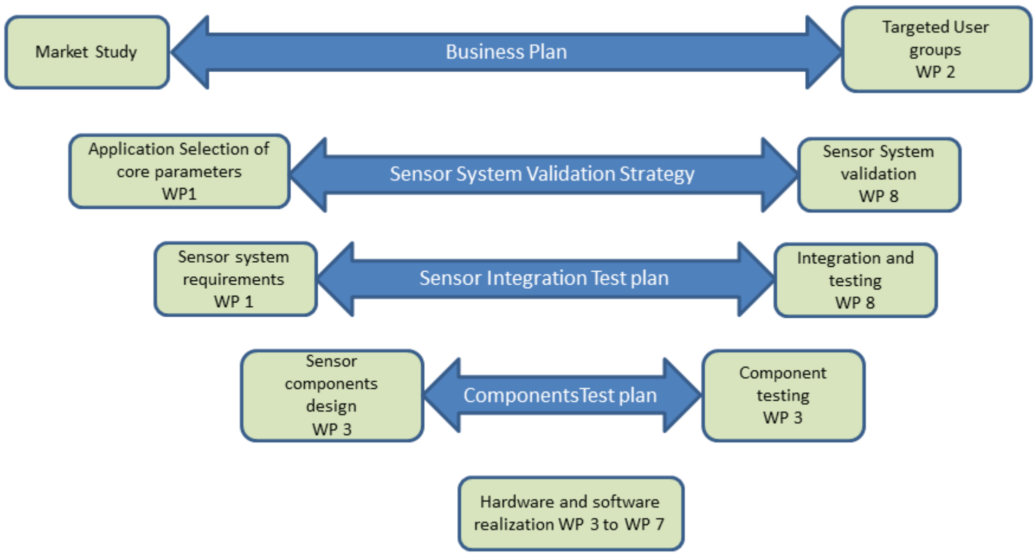


Figure 3 The V - diagram describing the steps in the development process

To be able to define the requirements for sensor systems that will be developed in NeXOS it has been decided to develop user scenarios. These requirements are products of scenarios in regard to the type of observations programs the users would like to implement. Based on these scenarios, requirements such as to develop compact and integrated sensor systems, deployable from multiple platforms like glider, profilers or long-term mooring stations and having multiple functionalities, were identified.

5.2 Technology Readiness Level and Functional Analysis

The sensor systems developments in NeXOS will have to fulfill the user requirements in their actual operation scenario. These developments will be carried out under the consideration of the Technology Readiness Level (TRL). The TRL will analyze all the aspects of the development of the sensor systems such as re-usability, interoperability, open source software, power consumption. Therefore, these developments might reach higher TRLs and provide more complete functions with: smart sensor interface, redundant sensors and safer electronic interfaces and computing capacities.

5.3 Requirements of the bio-fouling protection system

These requirements will be the subject of an update due to the fact that the system interfacing needs within NeXOS for the bio-fouling protection depend on the delivery of D3.3, which is due Month 24.

5.4 Requirements of the sensor system for optical measurement of marine environmental parameters

Three type of sensor system for optical measurement are going to be developed in NeXOS project. Therefore,according to **WP5**, three transducer types will be developed for these sensor systems as follows:

- the matrix-fluorescence sensor for the detection of dissolved substances (such as polycyclic aromatic hydrocarbons) and (coloured) dissolved organic matter.
- the hyperspectral cavity absorption sensor for investigation of phytoplankton and other absorbing components.
- the Carbon sensor to measure carbon cycle relevant parameters such as pH and CO2; and CH4

The transducers Front End requirements are listed In Table **1**.

Table 1 Optical sensors described in D5.1

<table>
<tr><th colspan="2">Transducer</th><th>Output signal</th><th>Control signal</th><th>Sampling period</th><th>Input power</th></tr>
<tr><td colspan="2">Matrix-fluorescence</td><td>RS485, with MODBUS protocol</td><td>RS485, with MODBUS protocol</td><td><5sec</td><td>9..36VDC, <250mA at 12 VDC</td></tr>
<tr><td colspan="2">Hyperspectral cavity absorption</td><td>RS485, with MODBUS protocol</td><td>RS485, with MODBUS protocol</td><td>N/A</td><td>12-24 V</td></tr>
<tr><td rowspan="3">Carbon sensor</td><td>solid state relays</td><td>SPI or I2C</td><td rowspan="3">4x 50mA programmable current sources (4 D/A 12 bit, or PWM)
8x CMOS/TTL lines</td><td rowspan="3">N/A</td><td rowspan="2">5 - 15 VDC, max. 200mW</td></tr>
<tr><td>LEDs driver</td><td>N/A</td></tr>
<tr><td>spectrophotometer</td><td>USB
2x 0–1 VDC (12 bit and 100μV accuracy)</td><td></td></tr>
</table>

i. Matrix-fluorescence transducer

Design considerations

The new matrix-fluorescence transducer will be a combination of three excitation and four emission wavelengths in one sensor unit. The communication interface of the matrix-fluorescence transducer is based on the RS485 serial bus with MODBUS protocol [17].The SEISI can implement the MODBUS protocol standards MODBUS master using the EIA/RS485 serial communications with these transducers.

ii. Hyperspectral cavity absorption transducer

Design considerations

The hyperspectral cavity absorption transducer will contain the components necessary for absorption measurements in a water-proof housing: the integrating cavity itself (equipped with water in- and outlets), a light source consisting of several, separately controlled LEDs, and a spectrometer. All these components will be integrated in one sensor unit having as communication interface the RS485 serial bus with MODBUS protocol.

iii. Carbon transducer

Design considerations

Other requirements for the Carbon transducer are:

- On board memory in order to process the data acquired by the spectrophotometer (at least 64Gbyte)
- A processor to manipulate the raw data and calculate the absorbance spectra.
- Memory to store raw spectral data and results of calculation.

5.5 Requirements of the sensor system for passive acoustic monitoring of noise, bioacoustics and related variables

Based on the scenarios requirements for passive monitoring of noise, marine mammals and seismics with hydrophones on gliders, profilers and long-term mooring stations, in NeXOS two passive acoustics sensor systems will be designated.

- A1: Compact, low power multifunctional passive acoustics sensor system, enabling on-platform measurement and characterization of underwater noise and several soundscape sources, aimed for platforms with limited autonomy and/or communication capability.
- A2: Compact multifunctional passive acoustics sensor system, enabling real-time waveform streaming for the measurement of underwater noise and several soundscape sources, aimed for platforms with unlimited autonomy and/or communication capability.

NeXOS sensors A1 and A2 will be capable of measuring and processing underwater noise and bioacoustics activity (minimal requirements) and potential additional variables as identified in WP1. The devices consist of a digital passive acoustic transducer or transducer array, the raw signal of which can then be pre-processed on-board the interface as may be required by the host transmission constraints. A2 will be equipped with positioning sensors (pan, tilt, and compass) to allow detection and tracking of noise sources. The device will allow integration of acoustics-relevant oceanographic sensors (sound velocity, temperature, depth) for real-time propagation modelling.

In Table **1** there are listed the transducers Front End requirements.

Table 2 List of the acoustic sensors described in D6.1

Transducer	Output signal	Control signal	Sampling period	Input power
Acoustic sensor A1	2x SPI 16 bit	1x CMOS/TTL line	up to 10us	2.7 to 3.6 VDC,0,7 mW at 3,3 VDC
Acoustic sensor A2	4x SPI 24 bit	8x CMOS/TTL lines 1 PWM signal	up to 10us	4.75 to 5.25 VDC, at 5VDC 31 mW/Ch at 50 ksps; 7 mW/Ch at 10 kSPS

i. Acoustic sensor of A1

A preliminary design of the A1 transducer (single hydrophone) is composed of the sensitive element and a two-channel signal conditioning stage (made of preamplifiers, anti-aliasing filters and SAR Analog to Digital Converters).

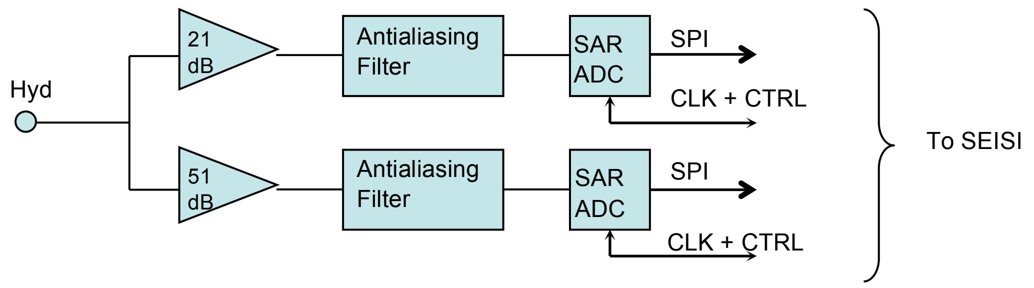


Figure 4 NeXOS A1 Transducer stage (preliminary - currently being optimised)

Therefore the transducer of the A1 is a digitised transducer that consists of two Micropower SAR AD converters of 16 bit and 100 kSPS.

<u>Design considerations (to date)</u>

- The digitized transducer consists of two different channels with SAR ADC, each channel with a different gain:

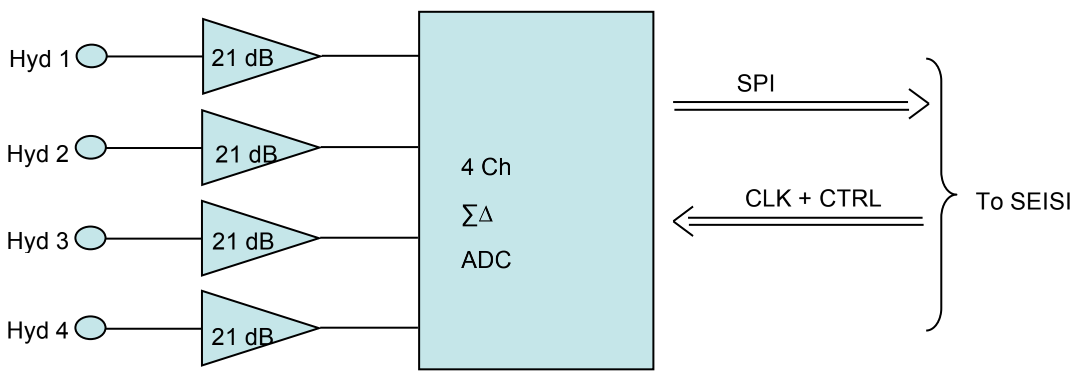
  Low gain channel: 21 dB (receiving sensitivity: - 180 dB re 1 µPa)

  High gain channel: 51 dB (receiving sensitivity: - 150 dB re 1 µPa)

- The power consumption of the complete chain (see diagram of Figure 4) will be 26 mW at 2.7 V.
- The proposed preamplified hydrophone has a input equivalent noise of + 33 dB re 1 µPa / √Hz in a bandwidth from 2 kHz to 50 kHz.

ii. Acoustic sensor of A2

The transducer of A2 is composed of four sensitive elements, four preamplifiers and one 4-Ch ∑∆ Analog to Digital Converter



Therefore the transducer of the A2 is a digitised transducer that consists of one 4-Ch ∑∆ Analog to Digital Converter of 24 bit and 144 kSPS.

<u>Design considerations (to date)</u>

- The high ADC dynamic range (110 dB) allows the use of a single channel for each hydrophone preamplifier gain: 21 dB
- Sigma Delta A/D converter does not need anti-aliasing filter and then allows an easy

selection of the sampling frequency

- The power consumption of the complete chain (see diagram of Figure 4) depends on the sampling frequency and will be 150 mW at 5 V at the maximum sampling frequency (TBD, max 100kS/s).
- The proposed preamplified hydrophone has an input equivalent noise of + 25 dB re 1 μPa / √Hz in the bandwidth from 2 kHz to 50 kHz

5.6 Requirements of the RECOPESCA sensor system

The new EAF (Ecosystem Approach to Fisheries management) sensors capable to measure Oxygen and Chlorophyll will complement the collected data on fishing activity, temperature and salinity, as provided by the current RECOPESCA and FOOS systems. Therefore, IFREMER in collaboration with CNR and NKE will produce prototypes of probes (EAF sensors) for dissolved oxygen and fluorescence (as a proxy of chlorophyll) following the technical specifications in this document and in Deliverable 7.1. For the development of these probes, existing sensor components, are evaluated in order to select inexpensive components offering adequate accuracy for the new RECOPESCA sensor system.

According to D7.2, the transducers Front End requirements of the most commonly used sensors that have the characteristics suitable for the new RECOPESCA EAF sensors, as summarised in Table **3** and

Table **4**.

Table 3 Common Characteristics of Dissolved Oxygen sensors

Transducer	Output signal	Control signal	Sampling period	Input power
To be determined	RS-232, RS485, or 0 - 5 VDC	RS-232	From 1 second	6 - 24 VDC; 35 mA to 250 mA

Table 4Common characteristics of Chl-a fluorescence sensors

Transducer	Output signal	Control signal	Sampling period	Input power
To be determined	0–5 VDC or RS-232	RS-232	From 5 second	3 - 15 VDC, <300mW

Design considerations

Based on the specifications of the new RECOPESCA sensor system, these new sensors should have a battery life and memory capacity allowing to remain mounted on the fishing gear for at least 6 month (minimum 1 measurement per minute) and should be stable for the same period.

6 Specification of architecture and components for SEISI Front End

The SEISI hardware and software architecture is proposed to enable interoperable Web access to marine sensors [1, 18]. As planned in the NeXOS DoW, the architecture will satisfy international standards, defined by ISO [2], OGC [3, 4], and the INSPIRE directive [5], to enable integration of marine sensors with existing observing systems. As shown in Figure **5** the SEISI will provide a multifunctional interface for many types of current sensors and instruments, as well as new multifunctional sensor systems proposed in NeXOS. The SEISI will facilitate a set of standard services for data distribution and easy access for the provider and end user of the NeXOS sensor systems [6]. Accordingly, the link between the NeXOS Sensor Web architecture components and the SEISI platforms is based on open standards that are maintained by the Open Geospatial Consortium (OGC). Hence, SEISI will provide standard services for Data Access Service, Data Push Service and Configuration Service based on the existing standard specifications. Therefore, the sensor systems that will be deployed on cable observatories, buoys or ships, most of them with RF link of limited bandwidth, will have all the services mentioned above through a light implementation of OGC Sensor Observation System (a.k.a. SOS) [7] and OGC Sensor Planning Service (SWE IoT SPS) [8]. The glider and profiler technologies used in global observation with communication via costly and energy-demanding satellite links of very low bandwidth and discontinuous will have only a Data Push Service which will be defined based on the available standard solution.

To allow the instrument manufacturers to seamlessly set up a new sensor systems based on the SEISI platform, a software layer is proposed, which sits between a transducer driver and a user application, to provide a single common interface to all supported transducers. This software layer encapsulates the transducer interface details. Moreover, SEISI will provide an auto configuration of the SEISI sensor system and SEISI front end based on SensorML, which contains a description about the system and the transducers and is located inside each SEISI system in the OGC PUCK payload [9].

A flash memory card (up to 64 GB) is used to store data if the link between the SEISI sensor system and NeXOS Sensor Web data management system is a temporary connection (satellite link) or accidentally damaged. Moreover, autonomous SEISI sensor systems will store data on the flash memory card.

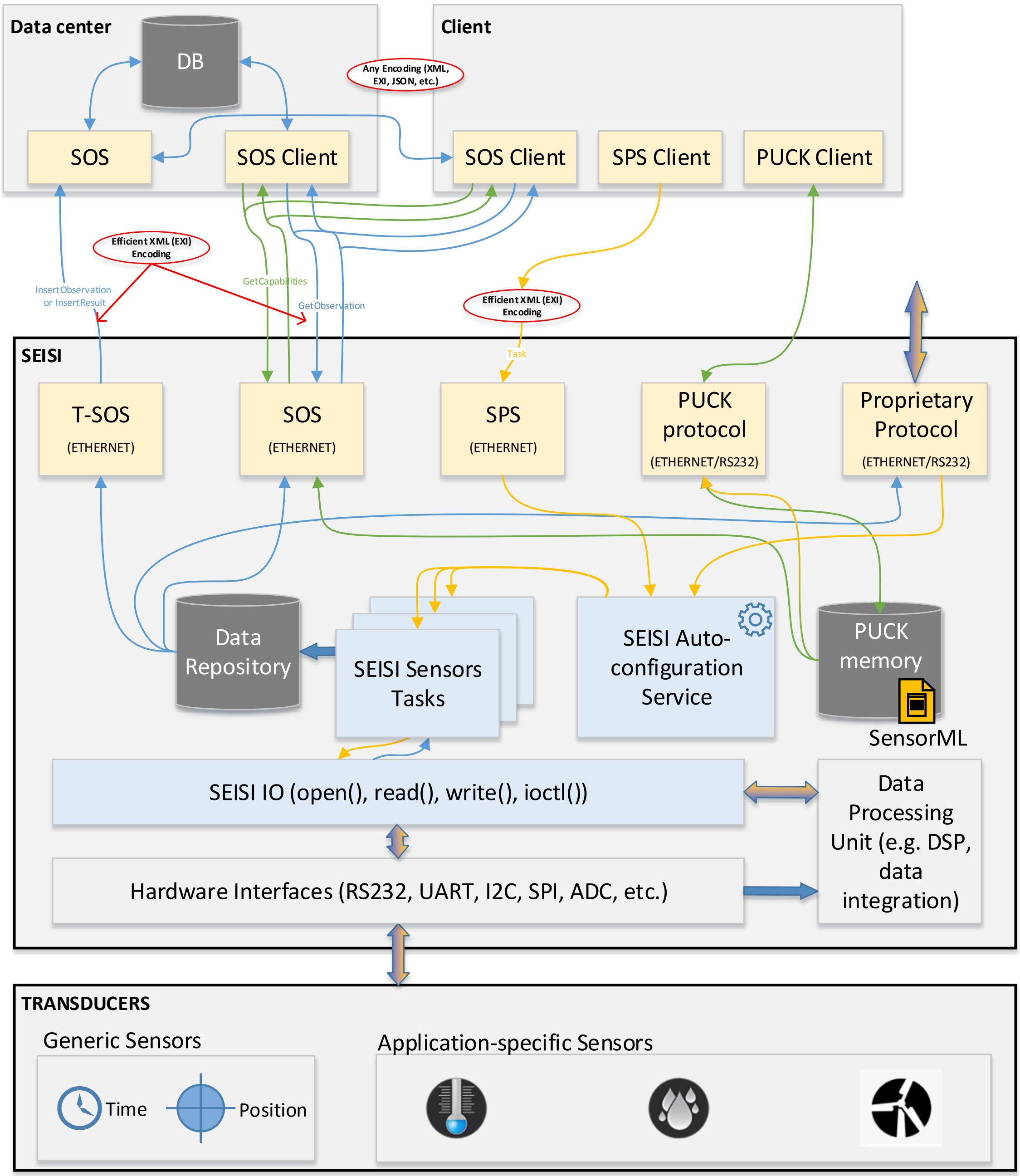


Figure 5 SEISI hardware and software architecture and link with OGC SWE high level components of NeXOS

Three main modules compose the instrument front-end:

- An analogue interface that provides signal conditioning and analog to digital converter capabilities for different types of sensors. This module will take into account the accuracy, precision, impedance coupling and frequency sampling characteristics needed for several types of marine sensors.
- A point-to-point interface that provides the communication with digital instruments when a point to point link is used e.g. RS232, SPI or I2C.
- A multi-drop interface that provides a modular designable to communicate with digital instruments when a multi-drop link is used e.g. RS485, RS422, CANBus [11-15]or USB.

Figure **6** depicts the functional blocks of the SEISI hardware which will provide interfaces for many types of current sensors and instruments, as well as new multifunctional detectors, and the auto configuration functionality based on the SensorML. SEISI will be the gateway to access transducers data and transducers configuration using interoperable standards avoiding end users interaction with proprietary protocols.

Moreover the SEISI platform will provide synchronization and power to any payload connected through the Transducer Interface.

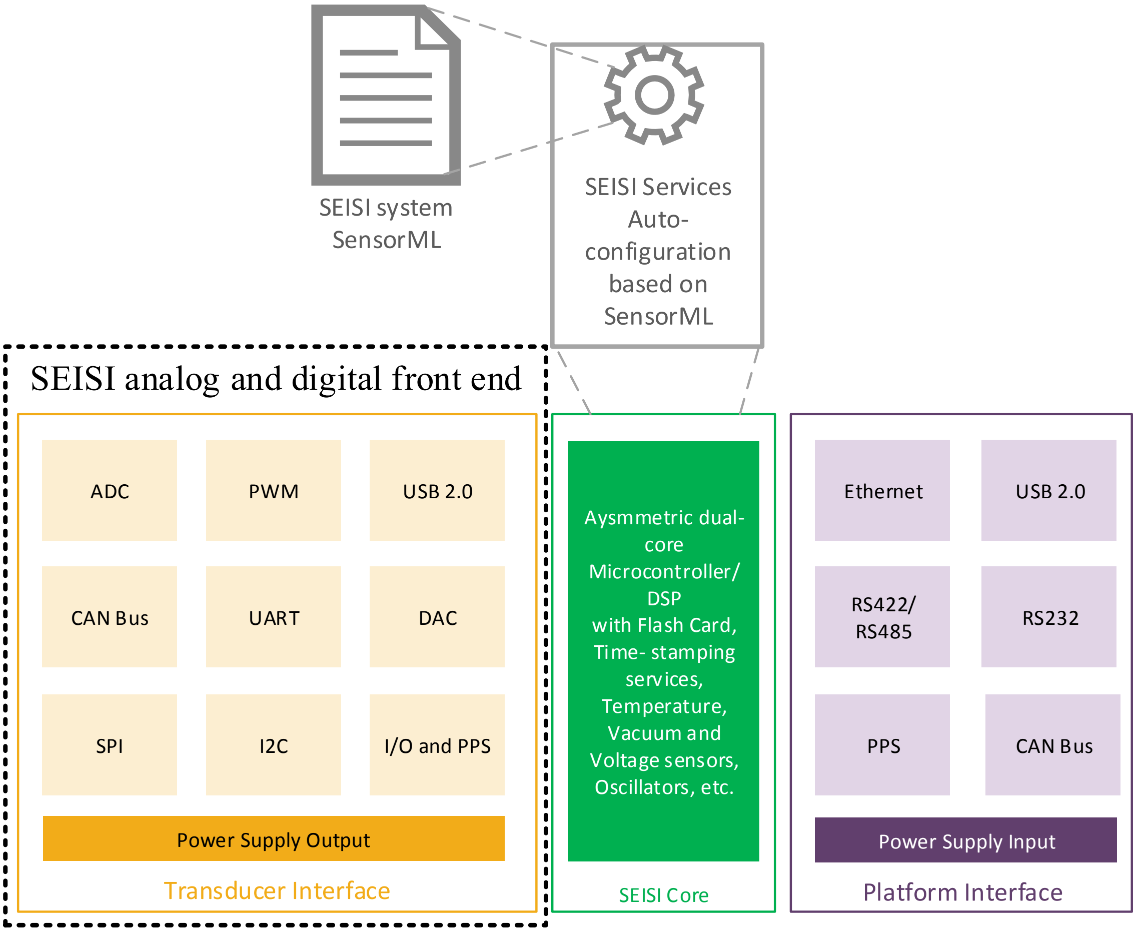


Figure 6Analog and digital front end of SEISI platform for transducers interfaces implementing analogue interfaces such as A/D and D/A converters,point-to-point interfaces such as I2C, SPI, PWM, UART (RS232), multi-drop interfaces like CAN or USB 2.0 and UART (RS485 and RS422), and other control signals such as PPS and Digital I/O)

6.1 Transducers Power Supply

The SEISI platform will provide 3.3 VDC (2.7V to 3.6V), 5 VDC (4.75V to 5.25V) and 12 VDC (9.6V to 16V) with an overall fused rating of 3A.The 3.3 VDC and 5 VDC will be available from an onboard regulator. The 12 VDC voltage will be direct from the battery source or external supply via cable and so should beconsidered unregulated.

Power consumption for each payload should allow for up to 5W when operating. Sleep mode power consumption should be less than 0.3W in sleep mode.However, for case scenarios such as autonomous platforms (e.g. gliders or profilers), the power consumption for all payload should be less than 1W when operating and sleep mode power consumption should be less than 0.1W. Payloads shall have suitable internal protection and fusing such that they fail safe and allow the bus to continue to operate. Power specifications of the NeXOS transducers are listed in Table **5**.

Table 5NeXOS transducers power supply specifications

Transducer	3.3 VDC	5 VDC	12 VDC	Input Current
Matrix-fluorescence			**X**	**<250mA**
Hyperspectral cavity absorption			**X**	**N/A**
Carbon sensor		**X**	**X**	**<40 mA**
Acoustic sensor of A1	**X**			**<10mA**
Acoustic sensor of A2		**X**		**<30mA**
Dissolved Oxygen sensors			**X**	**35 to 250 mA**
Chl-a fluorescence sensors		**X**	**X**	**<50 mA**

6.2 Analog transducer or array of analog transducers

Based on the requirements for analog transducer, or array of analog transducers, an analog front-end providing a digital conversion as part of the hardware interface and software interface will be provided by the SEISI platform. The analog interface may be required in WP5 (e.g. for the carbon sensor system, where the spectrophotometer transducer has two analog output signal of 0–1VDC and requires resolution of 12 bits and accuracy of 100μV) and WP7 (e.g. Chlorophyll sensor has an analog output of 0-5VDC). The analog interface specifications of related NeXOS transducers are listed in Table **6**.

Table 6 NeXOS analog transducers specifications

Transducer	Analog interface	Resolution	Sampling frequency
Carbon sensor	**ADC of 0-1V output voltage**	**12 bit**	**N/A**
Carbon sensor	**DAC**	**12 bit**	**N/A**
Dissolved Oxygen sensors	**ADC of 0-5V output voltage**	**12 bit**	**1 Sample/s**
Chl-a fluorescence sensors	**ADC of 0-5V output voltage**	**12 bit**	**8 Sample/s**

6.3 Digitised transducer or array of digitised transducers

Digitised transducers or array of digitised transducers refer to those transducers that include an Analog to Digital converter). The point to point front end may be required in WP5 (e.g. for the carbon sensor system, the solid state relays are controlled through an SPI interface and the spectrophotometer communicates through USB), in WP6 (acoustic sensors of A1 and A2 are communicating through SPI interface) and WP7 (most of the proposed sensors have an RS232 interface). The point to point interface specifications of the NeXOS transducers are listed in Table **7**.

Table 7 NeXOS digitized transducers specifications

Transducer	Digital interface	Data size	Sampling frequency	Additional Processes
Carbon sensor	**SPI and USB**	**16 bits**	**N/A**	**Storage of the raw data, timestamp acquired data and calculate the absorbance spectra**
Acoustic sensor A1	**2x SPI**	**2x 16 bits**	**up to 100 kSample/s**	**Signal processing, timestamp acquired data and data storage**
Acoustic sensor A2	**4x SPI**	**4x 24 bits**	**up to 100 kSample/s**	**Signal processing, timestamp acquired data and data storage.** **Pan, tilt and compass. Salinity temperature, Depth (under definition in WP6).**
Dissolved Oxygen sensors	**RS-232**	**N/A**	**1 Sample/s**	**Timestamp acquired data, data storage**
Chl-a fluorescence sensors	**RS-232**	**N/A**	**8 Sample/s**	**Timestamp acquired data, data storage**

6.4 Distributed sensors

Distributed sensors (e.g. sensor network) under an existing control and communication layer, where data is located in repositories and only a Standard Software Interface (SSI) is required (e.g. new RECOPESCA sensor system, WP7)

As explained in D4.3, for integrating existing infrastructures with the Sensor Web framework the first step to achieve is to make the collected sensor data available through an SOS server. This way, all further SWE components are able to access the observation data and use it for further purposes (e.g. event processing, visualisation, and analysis). Two main scenarios may be distinguished:

- the observation data shall be gathered from the sensors and is not yet put into a central data store. This scenario may be required in WP5 (e.g. for the Matrix-fluorescence sensor system with MODBUS protocol)
- the collected data is already available in a database such as for the RECOPESCA sensor system.

In scenario a) technologies such as SID [16] and appropriate SID interpreters can be used to decode the data delivered by the sensors and to push it into the relevant SWE services. Such an interpreter can be included in a bridge component which connects individual loggers or sensors to Sensor Web data stores.

In scenario b) for the case of the Recopesca system, there are several options for connecting a database server with a SOS server.One of these options is to connect the SOS with the database through an abstraction layer as explained in D4.3.

Specifications of distributed sensors systems in NeXOS are listed in Table **8**.

Table 8 NeXOS Distributed transducers specifications

Distributed sensors	Communication protocol	SSI implementation
Matrix-fluorescence	**MODBUS**	**SID interpreters**
Hyperspectral cavity absorption	**MODBUS**	**SID interpreters**
RECOPESCA sensor system	**RECOPESCA Database**	**Abstraction layer such as the SOS Hibernate framework**

6.5 Synchronization module

The SEISI platform can provide IEEE-1588 capabilities to each sensor. Moreover, the SEISI will be equipped with a high accuracy clock from 3.10^{-6} to 3.10^{-8} sec., TXCO (Temperature Compensated Crystal Oscillator) and MCXO (Microcomputer Compensated Crystal Oscillator). Therefore, the SEISI platform can provide high accuracy timestamps for all data acquired form the onboard transcoders. A PPS output signal for synchronization will also be available for any type of transducer that may need to be synchronized. Hence the PPS output signal and NMEA data can provide GPS emulation for autonomous observatories [18].

7 Conclusions

This document provides an overview of the ongoing development and the hardware and software configutaions of the SEISI Analog and Digital Front End. Based on the general requirements for the transducers interfaces, the document provides a generic approach which will guide the SEISI Front End developments.

Based on the transducer interface specifications of the NeXOS sensor systems, a detailed specifications of the following components has been established: (a) transducer power supply, (b, c) transducer analog and digital interface, (d) software interface for distributed sensor systems and (e) synchronization module. The detailed specifications comprise specific information about the transducers, interfaces and their parameters and further guidance for implementation.

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