D10.3–Compilation Report of NeXOS Workshop 1 through 3 proceedings

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Deliverable D10.3 – Compilation Report of NeXOS Workshops 1 through 3 proceedings

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Project Coordinator: Eric Delory

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Abstract

Deliverable D10.3 is the compilation of the proceedings from the three workshops and associated mini-workshops conducted during the NeXOS project. The first, early in the project, focused on requirements and user interfaces. It brought together representatives of stakeholder communities in order to understand their needs and validate the NeXOS requirements. WP 1 incorporated the recommendations of the workshop into the final requirements documentation for the sensors and systems.

The second workshop engaged both the research and business communities (development and application themes) to review sensor and sensor system developments. This workshop was a combination of dissemination and opportunities for feedback, and was held at a point in the project when there was some maturity in developments and yet still time for adaptations. This was a technical workshop with presentations by key project partners, and opportunities for discussion with workshop participants. Posters were encouraged to allow one-to-one discussions of technical details. Small working group sessions were held around key program interest areas including sensors, systems integration, calibration and validation and software/end-user interface.

The last workshop was held toward the end of the project, and highlighted sensor systems developed by the project. It demonstrated the applications and outcomes of the project to the broad community of stakeholders. This workshop, held toward the end of the project, focused on stakeholders as system users and on industry for transition of the technology and capabilities. An objective of the workshop was to provide selected users with a direct experience of looking at data and systems outputs and interfaces.

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1. Overview

The NeXOS outreach program was organized around mini-workshops, which were grouped into 3 workshops according to the phase of the project (see Figure 1)

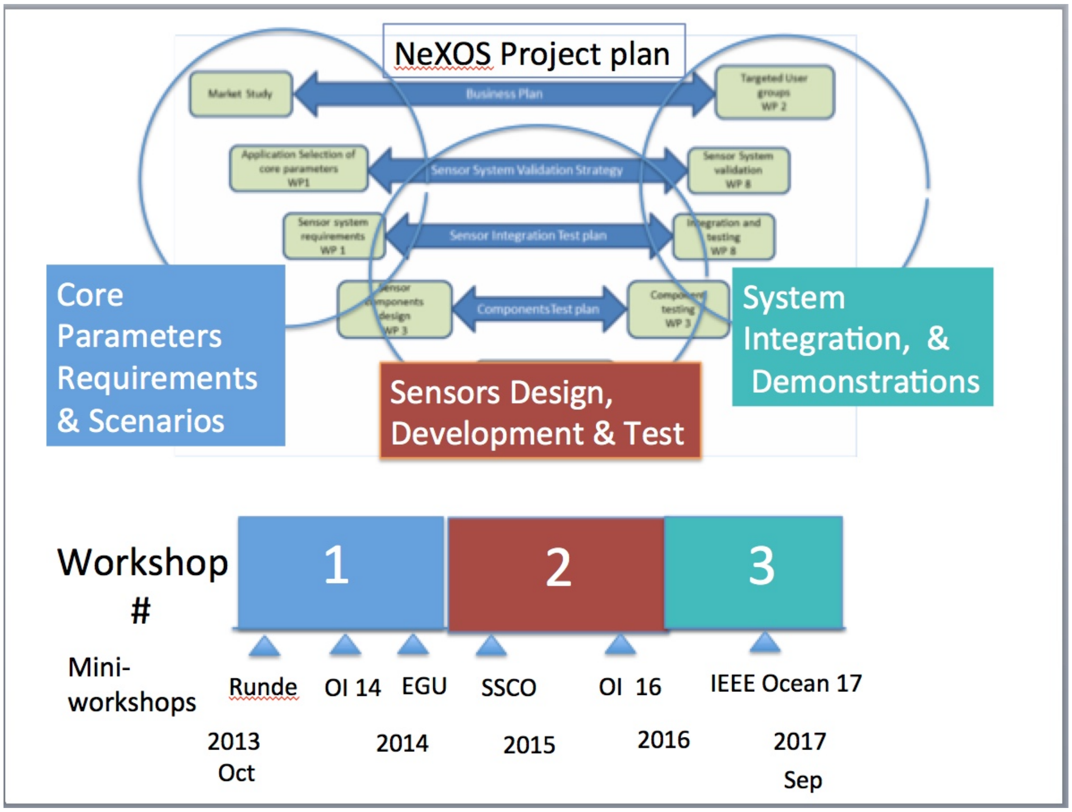

Figure 1 The Dissemination and Outreach Workshops follow the major phases of the NeXOS project

Workshop 1 initiated the collection of sensor requirements, working with the oil and gas, fisheries and transportation industries during one-on-one interviews in Runde, Norway, with the oceanographic platform manufacturers during OI 2014 in London, UK, and with the science community at EGU 2014.

Workshop 2 focused on sensor innovations, development and transversal capabilities, as well as initial demonstrations of NeXOS passive acoustic and optical sensors. It included the "Sensor Systems for a Changing Ocean" (SSCO), which was developed within the framework of the Brest Seatech week (October 2014), and the Oceanology International 2016 which prioritized interfacing with prospective users, and sensor demonstrations. This second workshop engaged both the research and business communities (development and application themes) to review sensor and sensor system developments.

Workshop 3 marked the nearing of NeXOS completion. Within the context of the MCS/IEEE Ocean 17 conference, the NeXOS team presented the new sensor capabilities, in detail during the technical session, and engaged the stakeholder communities in a panel discussion.

2 Workshop 1 – collecting sensor requirements

As indicated in section 1 above, the first workshop was a collection of three mini-workshops, which focused on different user communities. The Runde mini-workshop focused on collecting sensor requirements from the oil and gas, shipping, marine, and fishing industries.

2.1 Runde Mini-workshop

The Runde mini-workshop was conducted over two days. Day 1, April 2, 2014, focused on sensor requirements for the shipping, oil, and marine industries. Day 2, April 3, 2014, addressed the fishing industry.

2.1.1 April 2, 2014 SENSORS REQUIREMENTS WORKSHOP - workshop Agenda

Chair: Mr. Jay Pearlman; Co-chair: Mr. Christoph Waldmann

8:30 – 9:00 – Introduction, background, Objectives and Methodology of the Workshop

9:00 – 9:45 – 5min presentations of each of the participants:

10:00 – 10:30 Work session 1

Participants	Interviewers
Ulstein Yard	Jean-François Rolin; Ayoze Castro
Rolls-Royce Marine	Christoph Waldmann; Eric Delory
CMR	Johan Gille; Oliver Zeilinski
METAS	Joaquin Del Rio; Jay Pearlman

10:30 – 11:00 Work Session 2

Participants	Interviewers
Windtec	Jean-François Rolin; Ayoze Castro
Statoil	Christoph Waldmann; Eric Delory
MMC Green Technology	Johan Gille; Oliver Zeilinski
Powex	Joaquin Del Rio; Jay Pearlman

For those who were not being interviewed, NeXOS facilitators conducted a parallel poster session, with scenarios focus.

2.1.2 Day 1 Workshop Presentations and Discussions.

Nils Roar Hareide gave a brief introduction to the Runde Environment Center. Christoph Waldmann then gave an introduction to the NeXOS project. He summarized the project work packages tasks and contributions, with emphasis on transversal innovations, such as biofouling. He then summarized the sensor innovations in the areas of optical sensors, passive acoustics sensors, Recopesca (fisheries). Christoph then introduced the other 3 projects awarded in the same call. The integration and test process for NeXOS follows a V diagram. User scenarios will guide the requirements definition. Christoph listed 4 scenarios under development, and indicated that there may be 2 more. Eric Delory, coordinator for the NeXOS project, asked that attendees think in terms of their vision 4 to 5 years downstream.

Around the room introductions followed:

Windtec – they make pressure vessels from wound carbon fiber;

Ulstein Yard – three representatives attended the session; they do ship systems, off-shore vessels; their goal is to make ships smarter;

MMC Green technology – Havard Gjelseth; their focus is on water treatment – sampling of water; oil & water sensor technology; currently, their bring the water samples back to the lab, and analysis takes 4 to 6 weeks;

Runde – Nils Roar, Karsten; communications and demonstrations; gliders;

Norwegian Institute for water research – Emiliane Reggiani: in-situ solution for sensors; monitoring carbon dioxide in sea-water;

Statoil – Christian Collin Hansenthey: they have all kind of platforms; chem-bio sensors for monitoring of leakages & environmental mapping of the sea floor from start to end of field (sub sea and on shore); subsea is their primary focus looking at water column and sea floor; they need commercial applications (ROV, AUV, Gliders, buoys); they are also involved in treatment of ballast water;

METAS – Terje Torkelsen; they are in Bergen, developing sensors for gas leakage based on active acoustics; they are also involved in an ocean observatory;

Powex – Vidar Hanse; Custom electronic design and software development for seismic market; their main interest is interfacing sensors;

Rolls Royce marine – Leif Vartal is a naval architect, working in the R&D department; they create a range of equipment for ships (products and systems for cost effective and energy efficient ships); they deliver electric power systems, thrusters and control systems for ships; they want to understand better the environment ships are operating in; their goal is to improve energy and cost efficiency (wind and current relative to ship motion; Leif Rune Solas works on systems and software design, including sensor network and data analysis;

CMR – David Pedie is a member of the instrumentation department at CMR. Research funder in Bergen; research in instrumentation with ultrasound and optics; builds buoys and autonomous vessels for environmental monitoring.

Other participants, primarily members of the NEXOS project, are listed in Table 1 below.

Table 1 NeXOS participants to the Runde mini-workshop

First Name	Last Name	Organization
Ayoze	Castro	PLOCAN
Joaquin	del Rio	University of Catalonia
Eric	Delory	PLOCAN

Johan	Gille	Ecorys
Bjorn	Hjelle	REC
Karsten	Kvalsund	REC
Françoise	Pearlman	IEEE
Jay	Pearlman	IEEE
Emanuele	Reggiani	NIVA
Nils	Roar Hareide	Runde
Jean-François	Rolin	IFREMER
Daniela	Voss	University of Oldenburg
Christoph	Waldmann	Marum
Patrice	Woerther	IFREMER
Oliver	Zielinski	University of Oldenburg

Following the introductions, each team met separately for the interviews. There were two interviewers as indicated in the agenda above, and one or two interviewees depending on the attendees. Following the interview sessions, a summary chart was presented on each interview (Christoph Waldmann, Jay Pearlman, Jean-François Rolin, Johann Gille).

2.1.3 Runde Day 1 Summary of the session

Company: Windtec. Interviewees: Svein; Interviewer: Ayoze Castro. The company manufactures housings of composites materials: carbon-epoxy and Glass-epoxy. Bonded End-caps are made of several materials: steel, aluminum, titanium, etc…Major interest is in the ageing and water ingress challenges. There was an exchange with IFREMER on water testing criteria. For NeXOS, there is interest in participating in the reliability and durability and costs optimization on pressure housings in WP3. Protection of the housings is done by polyurethane coating.

Company: Ulstein Yard; Interviewees: Rune Volden, Oyvind Gjerde Kamsvag, Anne Hestflatl; Interviewer: Ayoze Castro.

The company produces specialized ships (20-70m) including On board Systems and ROVs (from other manufacturers). Sensors are integrated to add value to the product. Sensor measurements include wind, wave, currents, fuel consumption, oil in water. Their goal is to understand and optimize their consumption, footprint and environmental effects. Biofouling on ship hull results in water resistance and increased fuel consumption. They are interested in collaboration in Data Distribution System on board and corresponding Sensor Interfaces. Although the sensors add value to the final product and the importance for customers are well recognize, it is difficult to quantify costs. NeXOS areas of interest: Research vessels scenarios & Work Package 4 are examples where the project could be of interest.

Company: CMR – Autonomous surface vehicles. Interviewer: Johan Gille. Platforms are developed. Sensors are up to the users. They are not really interested in sensor performance (those are defined by the user needs/sensor manufacturers.). Calibrations also are up to the user. Application time is in the order of months. They use standard interfaces. The Science community is first market, with the industry market emerging. They are looking at order s size of 100 platforms. Competitors are coming up. •Limitations are SWaP (esp. Power) and biofouling. NeXOS addresses these items.

Companies: Stat Oil; Interviewer: Christoph Waldmann. Cost effectiveness is a major driver for sensor innovations during the upcoming years. Cost effectiveness refers to production and operations. Environmental monitoring applications are calling for larger number of devices spread over a particular region. Robustness/Reliability is of utmost importance, as well as biofouling, and long-term stability. They are detecting environmental changes not just in the water column but also in the sediments. Highest sensitivity is needed to detect trends. Particular needs include Sensor networking, and standard interfaces.

Company: Rolls Royce; interviewer: Christoph Waldmann. They are gathering the following information: altimeters for ship movement in the sea; sound emission and vibration to determine engine health; biofouling detection and assessment – When shall the ship go into the dock?

Company: METAS. Interviewee: Terje Torkelsen, Technology Director. Interviewer: Jay Pearlman. The company was created in the mid 1990s at the Institute of Marine Research; cabled acoustic observatory in the Ofoten Fjord to study migration, abundance and behavior of Norwegian Spring spawning herring (Godø et al., 2005.).

The company's products include acoustic observatories using acoustic sounders to assess and understand biomass and fisheries. Automatic oil and Gas leakage systems, carbon leakage monitoring; depths up to 6000 m. Sensors are cameras, hydrophones (IcListen), active acoustic (EK-60), biomass, CO2, CTD, turbidity, (some laser plankton counters), magnetometers (remote) some sediment traps and bottom sampling. Capabilities: multiple communication links (cable, satellite, etc) with up to 200Mb/sec; deployments up to one year - issues are biofouling and battery life; future ideas – docking for gliders and AUVs to their undersea observatory. Issues – does not see convergence of observatory and autonomous platforms with a single sensor design.

Company: MMC Green technology - Ballast water treatment. Interviewee: Havard Gjelseth; Interviewer: Johan Gille. Systems are being sold, but there is a need for sensors to measure living non-reproductive organisms. Driven by IMO requirements. Large market potential (over 50.000 ships). Lifetime is up to 30 years (as the ship) and long maintenance cycles (2-5 years). This is outside the scope of NEXOS. Regarding Bilge water treatment, current systems are unreliable (Parts Per Million measurement). Despite that fact, the Internal Maritime Organization requirements are met. Market driver is environmental awareness. SWaP, and biofouling are not a problem. Price should be below 10.000 EUR. There is a link to WP5 and NeXOS partner expertise available, Follow-up possibilities should be explored.

Company: Powex; Interviewee: Vidar Hansen - R&D Manager - +47 41141691; Interviewer: Jay Pearlman. The company is nine years old and has 13 employees, including 9 engineers. Products include Engineering Services, hardware, software and firmware for selected measurement and electronic products – lighting, positioning (GPS) and tracking of towed arrays. Sensor requirements – flow down of customer requirements using off-the-shelf sensors. Priorities in sensor selection – power consumption, price and time to market (descending order?); product reliability is important and is either well demonstrated or they test the products before deployment. Interests – sensor interfaces, integration into their products; possibly submerged hydrophone sensing in the future. Issues for NeXOS – sensor maturity with sufficient field experience to reduce deployment risk. They allow for flexibility in sensor adaption design.

In a follow-on discussion, Eric Delory asked the attendees "if you were the coordinator of NexOS" where would you take the project? The participants stressed the use of industrial products; it is important to understand the environment in which the ships are operating (especially in the open ocean rather than in sea trials).

How do we handle the information, which was collected today? We will provide a summary statement on the NeXOS intranet; the detailed information will be used in the engineering process, and through the scenarios. We will synthesize the collected information, review it with participants, and then make the summary public.

2.1.4 April 3, 2014 FISHERIES REQUIREMENTS WORKSHOP - Workshop Agenda

Chair: Mr. Jay Pearlman; Co-chair: Mr. Patrice Woerther

8:30 – 9:00 – Introduction, background, Objectives and Methodology of the Workshop

9:00 – 9:30 – 5 min presentations of each of the participants

The interview participants are indicated in Table 2 below.

Table 2 Interview participants in Runde

Participant	Interviewer	Group
Trond-Inge Kvernevik, Managing director, A.S Fiskevegn	Jean-François Rolin, Patrick Woerther	Group 1
Per Froystad, Froystad Fiskevegn	Jay Pearlman, Christoph Waldmann	Group1
Roar Pedersen FHF, Norwegian Research Foundation for Fishery and aquaculture	Jean-François Rolin, Patrick Woerther	Group 2
Andreas Leine, Skipper Leinebjourn	Jay Pearlman, Christoph Waldmann	Group2

2.1.5 Day 2 Workshop Presentations and Discussions.

Eric Delory gave a brief introduction. Christoph Waldmann briefed the NeXOS project. He summarized the project work packages tasks and contributions, with emphasis on transversal innovations, such as biofouling. He then summarized the sensor innovations in the areas of optical sensors, passive acoustics sensors, and Recospesca (fisheries). Patrice Woerther from IFREMER then discussed Recopesca.

Following the Recopesca presentation, there was a question and answer session.

Does the crew have to do anything? They only need to make sure that the sensor is connected to the net. The system is already developed and works; NeXOS is developing 2 extra sensors. Do the fishermen have access to the data or is it used for research? It is not used for research only; every year an e-mail is sent to each fisherman with a link to the collected physical profile.

Jay Pearlman followed, stressing that the NEXOS team wants to understand the user needs. Participant introductions are summarized below.

Andreas Leine, skipper of the Leinebjourn - Fishing boat owner

Per Froystad (Froystad Fiskevegn) per@froystadas.com - Gillnet manufacturer

Roar Pedersen FHF roar.pedersen@fhf.no - Norwegian fisheries and aquaculture (sensors to find lost fishing gear)

Trond-Inge Kvernevik, Managing director, A.S Fiskevegn trond@fiskevegn.no (Norwegian Research Foundation for fishery and aquaculture) - Supplier of fishing gear; marine scientist (solving data acquisition problems especially in developing countries); hydrographic and position data acquisition; define criteria of sensor usage; passive gear (long lines and gillnets).

The interviews followed and are summarized below.

2.1.6 Day 2 Summary of the session

The findings for day 2 were summarized by Jay Pearlman and Jean-François Rolin.

Company: Froystad Fiskevegn AS.

The company provides fishing equipment, gill nets and innovation in use.

Products include improved gill nets and approaches to optimizing catch for coastal fisheries. Community Issues - There are varying techniques for nets and understanding the bottom environment (40-300 meters). Needs for Sensor – means to lay out nets more effectively, possibly using transponders. Gillnets – need to know about temperature (1), current (2) and topography (3) at the bottom (the number indicates the prioritization), with emphasis on real time information. Inputs from NeXOS - we need further dialogue.

Comments – suggestion of having embedded sensors in the net fishing lines for monitoring temperature or other variables.

Company: M/S Leinebjorn.

They are fishing for herring, mackerel and blue whiting using various techniques.

Community Issues: the fishermen need to understand the fish environment (inside their head); address locations and response. As far as the need for sensors, the only item mentioned was a desire for improved visualization. Inputs from NeXOS – no direct comments. Jean-François Rolin asked if we could make micro eddy environments around the perimeter of the Seiner nets. It would be a different customer than the larger models with resolution of 300m. Nets are about 250m diameter when deployed.

Company: Fiskvegn.

They are equipment provider and GIS. They are promoting temperature measurements, and correlation of data. Additional parameters include bioluminescence; methane. They correlate hydrocarbon pockets and biomass (input to scenario?). The value of data is much greater if the position data is known (spatial resolution).

Company: Roar Pedersen.

They have a great interest in lost gear sensors. They run boats servicing fish farms, and are interested in oxygen sensors for aquaculture. The other issue is turbidity.

In closing, Eric Delory thanked the attendees for their participation and Nils Roar for hosting the workshop.

2.2 Mini-workshop at Oceanology International 2014

The second requirement mini- workshop was conducted at Oceanology International (OI) in London on March 12, 2014. The objective was to discuss sensor requirements with platform and sensor manufacturers who were attending the conference. In addition to advertising the workshop broadly among the ocean community, in the day that preceded the workshop, we distributed in-person invitations to sensor and platform manufacturers at their booth. They were invited to join us in one of two sessions on Wednesday March 12th.

2.2.1 OI Session 1 Agenda

Due to the logistics of the OI venue (the doors did not open until 9:00), this first session was primarily attended by NeXOS partners, with a few exceptions as for instance a researcher from Shangai, China, and a representative from Liquid Robotics, the German company CONTROS and the Christian Michelsen Research Center, Norway.

Agenda (OI Session1)

South Gallery Meeting Room 9

Wednesday March 12 2014

9:00 – 9:15	Welcome, introductions around the room, agenda
9:15 - 9:35	Introductions to NeXOS (sensors and scenarios)
9:35 – 10:10	Community directions and issues (participant discussion)
10:10–10:25	Recommendations to NeXOS (sensors, platforms and systems)
10:25-10:30	Summary, plans for follow up.

2.2.2 Presentations (OI Session 1)

Eric Delory, coordinator for the NeXOS project, opened the meeting. He asked that attendees think in terms of their vision 4 to 5 years downstream.

Christoph Waldman prior to giving a brief presentation, asked for around the table introductions. See section 2.2.3 for a list of participants. Christoph Waldman's presentation was aimed at enabling networking. He summarized the project work packages tasks and contributions, with emphasis on transversal innovations, such as biofouling. He then summarized the sensor innovations in the areas of optical sensors, passive acoustics sensors, Recopesca (fisheries). Christoph then introduced the other 3 projects awarded in the same call. The integration and test process for NeXOS follows a V diagram. User scenarios will guide the requirements definition. Christoph listed 4 scenarios under development, and indicated that there may be 2 more.

Jay Pearlman addressed the purpose of the workshop. The project is looking for community direction, especially regarding important issues to be solved within 5 years. He opened the discussion to the participants.

2.2.3 Participants (OI Session1)

The fourteen participants included, in the order in which they were seated around the table:

Loic Dussod, IFREMER, representing Jean-François Rollin, NeXOS chief engineer;

Wenxiang Zhang, Normal University, Shanghai, China is working on coastal water issues with focus on acoustic sensors;

Peer Fietzel, Contros, sensor provider;

Michael Cookson, Liquid robotics, platform provider, with particular interest in networked systems;

Rüdiger Heuermann, TriOS, NeXOS Optical sensor provider;

Svein Østerhus , Uniresearch;

Francoise Pearlman, IEEE, workshop organization;

Jay Pearlman, IEEE, NeXOS outreach and dissemination;

Eric Delory, PLOCAN, NeXOS project coordinator;

Johan Gille, Ecorys, economist;

David Peddie, Christian Michelsen Research (CMR), instrumentation;

Oliver Zelinsky, Carl von Ossietzky Universität Oldenburg Institute for Chemistry and Biology of the Marine Environment (ICBM);

Daniela Voss, ICBM;

Christoph Waldman, MARUM, chief scientist, interested in measurements and data quality.

2.2.4 Discussions. (OI Session1)

Johan Gille– Economists look at the situation with and without the NeXOS innovations; the question to be considered is how will the identified scenarios make life easier?

Mike Cookson, liquid robotics – Their company is focusing on network connected model; power costs; discovering sensors on the network; identifying them, and identifying calibration needs (how to interpret the data, and keep it in perspective).

Peer Fietzel, Contros – Inter-comparability of sensors; it is relatively easy to integrate sensors; one needs to address platform sensor connections; two-way communication allow interaction with the platforms.

Rüdiger Heuermann, Trios – we need to get more information from the sensor (for example – when does a light source have to be replaced); this leads to intelligent sensors; the key elements include cheaper standard interfaces, visibility of the sensors through the platform, exposing sensor information.

Coastal work from China – the focus is on calibration and accuracy.

Jay Pearlman - is there an agreed upon calibration for each parameter?

Bandwidth; communication standards but also HW, connectors; cut down on variables.

Eric Delory – Regarding platform to shore communications, it is hard to have standard protocols due to mobile network restrictions; one needs a light touch, starting small (bare minimum); Sensor ML has been criticized for being over powerful.

Christoph Waldman – we need to understand data protocols (open description of data protocol, versus proprietary protocols which are not detailed)

Rüdiger Heuermann, Trios – adapt the interface to the platform; it is market driven; some protocols are more flexible and adaptable; standardization is an iterative process.

Mike Cookson, Liquid robotics – their new platform has Ethernet on it.

All attendees went through the questionnaire. See Appendix I for a blank questionnaire.

2.2.5 Summary (OI Session 1)

Christoph Waldman provided a summary of the discussions.

Topics included reliability and trustworthiness, and sensor networking concepts. Sensors should provide information for housekeeping; standardization should be extended to hardware components (the physical communication layer is the most costly to change); Standards on the hardware side are most important because they do not have the continuing flexibility that software has; standardization on a few voltages for power supplies would help in efficiency and cost; and having a few standards for communications (liquid robotics); Norway - Climate research with long term stations – biofouling, standards; how to meet transnational access (Svein Uni Research); system deployed for at least 10 years. Jay brought up self-calibration for satellite sensors; there are tensions between a lot of data immediately released and quality assurance of data; data should be fit for purpose; more and more data is generated and data should be made open as soon as possible, but broad distribution raises further issues of quality assurance; data should be made available when quality is known. Climate data – fisheries management needs data soon whereas climate data can wait a year or two.

End of session 1 at 10:45AM

2.2.6 OI Session 2 Agenda

This second session was well attended as shown below.

South Gallery Meeting Room 9

Wednesday March 12 2014

11:00 –11:15 Welcome, introductions around the room, agenda

11:15 - 11:35 Introductions to NeXOS (sensors and scenarios)

11:35 – 12:10 Community directions and issues (participant discussion)

12:10–12:25 Recommendations to NeXOS (sensors, platforms and systems)

12:25-12:30 Summary, plans for follow up.

2.2.7 Presentations (OI Session 2)

Eric Delory gave the introduction: NeXOS wants to open a dialogue with all workshop participants to ensure that what we are developing is what the community needs.

Christoph Waldman gave an overview on the NeXOS project – see summary of session 1 presentation.

Jay Pearlman stressed the interactive nature of the session. He asked the attendance ”What are the issues; what is important to you”? He then opened the discussions.

2.2.8 OI Participants (OI session 2)

Attendees list (in order of location around the table):

Steffen Assumann, Geomar;

Luisa Cristini, Fix-O3 project manager, NOC;

Noelia Ortega, CTN, new technology in underwater acoustics;

Joaquin Del Rio, UPC, interoperability;

Yann Lepage, ACSA, gliders;

Patrice Brault, ACSA, gliders;

Wilhelm Pedersen, HZG;

Richard Baggaley, St Andrews, passive acoustics;

Ken Foote, IEEE OES, observer;

Jan Buerman, ASL active acoustics;

Oliver Zielinski, Carl von Ossietzky Universität Oldenburg Institute for Chemistry and Biology of the Marine, optical sensors;

Daniela Voss, ICBM;

Veronica Bonitz, Oceanic;

Mikell Taykor, Bluefin, AUVs;

Tobias Boehme, 4H-Jena;

Patrick Farcey, IFREMER;

Laurent Mortier, ENSTA/UPMC;

Steimar Iversen, SAIV AS, CTD/Buoys;

Eric Delory, PLOCAN, NeXOS coordinator;

Françoise Pearlman, IEEE, workshop organization;

Jay Pearlman, IEEE, NeXOS outreach and dissemination;

Christoph Waldman, MARUM, NeXOS chief scientist, interested in measurements and data quality.

2.2.9 OI Discussions (OI session 2)

Laurent Mortier (ENSTA) – is there already a horizontal forum?

Eric Delory – we are cooperating with the 3 other projects; we will share best practices across the projects; we will have common event in 2015 at EGU.

Christoph Waldman– using metrology offices that are more strongly involved (more formalized view; accreditation possibly at the end)

Jay Pearlman – How about observatories?

Luisa Cristini – They are also involved in standards.

Patrice Brault– power is the main issue for gliders; bio-fouling develops for sensor after 1 month; calibration of sensor (on the vehicle versus outside vehicle) and de-calibration, how to correct the data.

Steffen Assmann, Geomar – chemistry center; calibration free methods for PH for example; proof for correctness; avoid system, which is too complex; focus on durability (as few parts as possible).

Patrice Brault, ACSA – Software to facilitate the processing of the data; use the experience of manufacturers.

Laurent Mortier - Facilities for calibration (NERC);i inter-calibration during mission (ship, glider and buoy); long growth to process the ARGO data .

Jay Pearlman– how do we bring the Argo lessons learned?

Geomar – include point of view of the scientist

Ferry boxes (Unknown speaker) – automatic system; people on board have nothing to do to operate the system.

Joaquin del Rio, we should look at interoperability on the instrument side; try to introduce mechanisms to make instruments smarter; right now, for Argo floats, it is difficult to change one sensor for another.

Patrice Brault, ACSA cost of integrating a new sensor is between 50 and 100K Euros

Ferry box – get a signal from sensor indicating the need for calibration

Luisa Cristini – fix-03 project is focused on moorings; there is a need to communicate between the projects which use different platforms; she welcomes any suggestions regarding exchanging more information.

Oliver Zielinski– are people more interested in flexible or specialized sensor (one task, one range, one environment)?

Eric Delory– this is the reason for the call; we are against the current trend; need to push in the flexibility direction, compensate for the current trend.

Oliver Zelinsky– black box versus open access, which permits seeing what is happening inside; look to other industries

Christoph Waldman distributed the questionnaires.

2.2.10 OI Session 2 summary

After a break, Christoph Waldmann provided the following summary:

•Build up a forum across projects to address standardization issues, access to cal facilities and calibration (JERICO, Forum of coastal technologies)

•Not just focus on data interface standards but add aspects on power communication

•Calibration issue - Exchange of best practices between companies and public organizations, message from sensor system in regard to calibration intervals

•Need for data preprocessing inside sensors

•Lower integration costs by better exploitation of sensor systems (single versus multiple use)

•Quantifying quality

•Consideration of the different levels of introducing standards and best practices (IEEE).

2.3 EGU 2014

Session SPM1.22 Opportunities and requirements for ocean in-situ sensors – NEXOS, was organized during the European Geophysical Union (EGU), on Tuesday 29 April, 15:30 – 17:00 Room R9. The objectives of the conveners, Jay Pearlman and Christoph Waldman, was to give the geoscience and cyberinfrastructure experts who generally attend this conference, an opportunity to express their thoughts regarding ocean sensors.

2.3.1 EGU Session Details - Invitation and Agenda.

The invitation to EGU participants is shown below:

"NEXOS is a new European project focused on the next generation of in-situ ocean measurements capabilities using lightweight, low power, optical and passive acoustic sensors. NEXOS will be designing, building and field-testing the new sensors over the next four years. The resulting compact integrated systems will be deployed from mobile and fixed ocean observing platforms.

We are interested in EGU participant's inputs to help shape the NEXOS development through a discussion of your needs and requirements for such sensors and systems.

Please join us."

Agenda

15:30 – 15:45 Welcome, introductions around the room, agenda - Jay Pearlman

15:45 – 16:05 Introductions to NeXOS (sensors and scenarios) – Christoph Waldmann

16:05 – 16:15 Sensor challenges – Bob Weller (WHOI)

16:15 - 16:45 Questionnaire - All

16:45 – 17:00 Group summary and discussion – Christoph Waldmann

2.3.2 EGU session Presentations and discussions

After a brief introduction of the attendees (see attendance list below), Christoph Waldmann discussed the purpose of the workshop. He introduced the NeXOS vision, highlighted the NeXOS partners, who include both scientists and Small and Medium Enterprises., thus leading to both technical and economic considerations for sensor innovations. NeXOS is favoring a comprehensive approach for transversal innovations. Domain specific innovations include optical sensors (hyperspectral); passive acoustic sensors (migration of cetacean mammals); and Recopesca for fisheries. Christoph discussed the end-to-end approach, including a demonstration phase, and a "V" systems engineering approach. He also briefly introduced the user scenarios, which are going to guide the design. The scenarios were defined by users iwho are members of NeXOS, taking into consideration the mix of proposed sensors, as well as the mix of platforms.

Bob Weller from WHOI agreed to speak on short notice, and share his experience with sensors, and vision forward. He referenced two ocean meetings, one in 1999 in St Raphael, France; and the second in 2009 in Venice. By the Venice meeting, the need for sensors had evolved tremendously, leading to a desire "to measure everything everywhere". Bob is working on the Ocean Observing Initiative (OOI), funded by NSF. The project includes over 800 individual sensors and 47 types of measurements (from temperature, ph, biomass, nitrate, to turbidity). He stressed that, to lower cost, one needs to consider the end to end situation. While a sensor, by itself, may be cheap, amount of labor for calibration and maintenance can add a significant amount to the cost. Bob was asked by customers to deploy instruments for longer durations, such as 2 year instead of 1, which exacerbates bio-fouling issues. Sensors that are self-calibrating should be considered.

Jay Pearlman spoke next, asking the participants to expand the discussion. What are their experiences regarding the sensors from an end-to-end view point, including data considerations?

The attendees were then asked to fill out the questionnaire and return it to Christoph Waldmann. While the participants were filling out the questionnaire, Christoph summarized the key points from the informal discussion, for presentation at the end of the session.

2.3.3 EGU Session summary.

This section provides a summary of the discussions, which took place during the session. They have been reorganized into several key topics as shown below.

Overall considerations

Consider the full deployment and operation "environment" for each sensor, including all steps of preparation and deployment. This includes not only the sensors physical performances within the environment, but also use of tools, training, human factor considerations, calibration, and handling of data provided by the sensor. Expertise of people operating the sensors and instruments should be leveraged during the design phase and in the definition of operating procedures. This includes looking for best practices and sending someone to the 9th International Marine Technician, INMARTECH 2014, Symposium to be held at Oregon State University (OSU) in Corvallis, Oregon on November 18-21, 2014. INMARTECH symposia were initiated with the purpose of providing a forum for marine technicians to meet and exchange knowledge and experiences, thereby aiming to improve equipment performance, deployment, and operational techniques during scientific cruises on research vessels. In addition, increasing the duration of a deployment will result in increased bio-fouling issues. From a cost standpoint, capitalization is one aspect, which needs to be complemented by considerations about operational expenses.

Sensor intelligence and autonomy

Sensors should have enough intelligence to allow for autonomy. This could include the following: ability to be remotely addressable; ability to do self reporting; detecting major faults in functionality and providing a technical status; detecting if relocated; identifying themselves in the network or by certain techniques like QR code or RFID. It would be extremely useful for the sensor to always know where it is related to a specific reference; on a ship, currently they rely on human to survey the sensor location.

Sensor calibration

Should calibration be performed at the institution or on the sensor itself? This may depend on the situation, and availability of appropriate venue. Cost of calibration needs to be taken into account. It was suggested that calibration should cost less that the whole instrument.

Data considerations

With the proliferation of data, and the increased availability of open data, expectations have changed: the data is likely to be shared and used for other purposes than originally anticipated. As a result, Metadata should be more comprehensive. A number of suggestions follow: the data model needs to include sensor self-reporting, to alleviate conditions, such as operations on wet deck, where last minute changes may go un-recorded; calibration time should be included in the metadata; also, use of semantic data streams (MSFT) could be used to repurpose a sensor. Sensor web enablement and observation services could be used as an easy method to share the metadata.

Other considerations.

The highest accuracy systems are often not the ones that suit the application in the ocean environment. Look for "fit for use", stable and affordable (standard deviation over time is more important than absolute accuracy of the tool). Consider quality test for real time observations.

Missing measurements

The following items were mentioned as measurements which needed to be added: wave measurements from shipboard platforms and buoys; oxygen as proxy for ecosystem health.

2.3.4 EGU Attendees Information.

A list of attendees to the EGU session is provided in Table 3 below.

Table 3 EGU session participants

Last Name	First Name	Organization	Job Title	Technical area of interest	e-mail
Pfeiffenberger	Hans	AWI	Lead IT	Data Publication	Hans.pfeiffenberger@awi.de
Oggioni	Alessandro	CNR-IREA		Data Management	Oggioni.a@irea.cnr.it
Pepe	Monica	CNR-IREA	Researcher	Data Management	Pepe.m@irea.cnr.it
Manzella	Guiseppe	DLTM	Consultant		Guiseppe.manzella@dltm.it
Corgnati	Lorenzo	CNR-ISMAR	Researcher	Marine Imaging	Lorenzo.cognati@sp.ismar.cnr.it
Ullgreen	Jenny	NERSC	Postdoc	Physical Oceanography	Jenny.ullgren@nersc.no
Geyer	Florian	NERSC	Researcher	Physical Oceanography	Florian.geyer@nersc.no
Heywood	Karen	UAE	Professor	Gliders Oceanography	k.heywood@uea.ac.uk
Jay	Pearlman	IEEE	WP Lead	Sensors	Jay.pearlman@ieee.org
Francoise	Pearlman	IEEE	Dissemination	Sensors	jsp@sprintmail.com
Christoph	Waldmann	Marum	Scientist	Sensors	waldmann@marum.de

Stocks	Karen	SIO	Data Center	Info systems	kstocks@uscd.edu
Chandler	Cyndy	WHOI	Info Systems		cchandler@whoi.edu
Leadbetter	Adam	BODC	Data Scientist		alead@bodc.ac.uk
Smith	Shawn	COAPS/FSU	Marine data scientist	Underway ship MET/TSG	smith@coaps.fsu.edu
Weller	Bob	WHOI			rweller@whoi.edu
Cristini	Luisa	NOC	Project Manager	Operational Oceanography	l.cristini@noc.ac.uk
Heslop	Emma	SOCIB	Researcher	Sensors/gliders	eheslop@socib.es

2.3.5 Requirements summary

The questionnaires collected during the three mini-workshops were turned over to WP1 for their evaluation. The outcome was documented in D1.1, Requirements Framework, (see 140319-NXS-WP1_D1.1vFinal) sections 6 and 7. Due to the variety of sensors being addressed, the responses were organized into three categories, as a function of the sensors/applications. The categories included: acoustic sensors, optical sensors and sensors used for fisheries. A copy of the initial blank questionnaire is enclosed in Appendix 1 to this document. Inputs from OI and EGU of high relevance to NeXOS are summarized in Table 4 below. For further details see document 140319-NXS-WP1_D1.1vFinal, Table 2, Summary of inputs received on requirements and NeXOS response.

Table 4 Summary from the sensor requirements questionnaires (OI and EGU)

Typical deployment duration	1-3 months

Sensor Stability referred to full scale range	Physical sensors .3ppt Biochemical 5%
Communication requirements	real-time plus internal storage
Sensor purchase price	5 – 15 K Euro
Annual expenditures for sensors	100 - 300 K
Data standards	NetCDF, Metadata ISO 19115, 19139
Data interface standards	Hardware side – serial like RS 232, TCP-IP or mediators as for instance PUCK Software side – OGC standards under investigation
Sensor calibration	Typically carried out by manufacturers and then checked before and after deployment
Biofouling	No best strategy available but very much needed

Further remarks:

One should focus not just on the sensor but keep in mind the full process chain (end-to-end approach)

As part of global observation programs like WOCE or ARGO calibration procedures have been developed that seemed to be not applied consistently in other observation programs.

Typically service and maintenance sum up to the procurement costs with 1-2 years.

3 Workshop 2

3.1 NeXOS Workshop 2 Overview

NeXOS workshops provide a means of outreach to focus communities and are an opportunity to gather inputs and recommendations from these communities. Three sets of workshops have been identified for NeXOS. Workshop 1 was a collection of three mini-workshops, which were conducted in 2014, and focused on requirements for the NeXOS sensors. Workshop 2, which is the subject of this section, was focused on sensor innovations, development and transversal capabilities, as well as initial demonstrations of NeXOS passive acoustic and optical sensors.

NeXOS Workshops 2 included two workshops. The first one (workshop 2.1), entitled "Sensor Systems for a Changing Ocean" (SSCO), was developed within the framework of the Brest Seatech week (October 14 through 16, 2014). This technical workshop included presentations by key project partners, and offered many opportunities for discussion with workshop participants. The second workshop (workhop 2.2) took place within the Oceanology International 2016 (March 2016), and prioritized interfacing with prospective users, and sensor demonstrations. This second workshop engaged both the research and business communities (development and application themes) to review sensor and sensor system developments. As a combination of dissemination and opportunities for feedback, workshop 2.2 was held at a point in the project when there was some maturity in developments and yet still time for adaptations. Both workshops were organized by NeXOS WP10, and are contributing to the NeXOS workshop Milestone.

3.2 Workshop 2.1 - "Sensor Systems for a Changing Ocean" (SSCO),

The workshop flyer is enclosed under 3.2.1 to this report. The final agenda for the workshop is provided as 3.2.2. As a follow-up to the workshop, all of the papers were uploaded to IEEE XPLORE where they were each given a DOI and identified as part of the SSCO workshop. A total of 24 papers were uploaded (see the list of papers in section 2.3; the title for each paper contains a hot link to the paper abstract; the paper itself can be downloaded for those who can log on to XPLORE).

Selected SSCO papers were expanded and peer-reviewed in order to form a digital collection as part of the Journal of Oceanic Engineering. The papers that were accepted were published electronically on XPLORE immediately when given the final approval by the Editor-in-Chief. Each paper belonging to the collection was tagged, and searchable according to the tag. Further detail is provided in 3.2.4. Daniel Toma (daniel.mihai.toma@upc.edu) and Oliver Zelinski (oliver.zielinski@uni-oldenburg.de) served as guest editors for the collection. A summary of each presentation is given in section 3.2.5 and a brief conclusion is provided in 3.2.6.

3.2.1 SSCO 2014 Flyer

Figure 2 SSCO flyer page 1

Figure 3 SSCO flyer page 2

3.2.2 SSCO Workshop Program

The workshop program is summarized in Table 5 below.

Table 5 program for the SSCO Workshop

Date	Time	Session Title	Session chair
October 14, 2014	2:00 PM – 3:30 PM	New sensor programs - 1	René Garello
Author		**Title**	
Delory E.		NeXOS development plans in ocean optics, acoustics and serving systems interoperability	
McNamara, E		Cost-effective sensors, interoperable with international existing ocean observing systems to meet EU policies requirements	
Brault, P.		The Sense Ocean project and technologies of sensors used	
Date	**Time**	**Session Title**	**Session chair**
October 14, 2014	4:00 PM – 5:30 PM	New sensor programs - 2	Jay Pearlman
Author		**Title**	
Waldmann C.		Intelligent sensors? Why they are so important for future ocean observing systems	
Delory E.		Developing a new generation of passive acoustics sensors for ocean observing systems	

Date	Time	Session Title	Session chair
October 15, 2014	9:00 AM – 10:30 AM	Environmental sensors	Jean-François Rolin
Author		**Title**	
Rioual S.		Development of environmental sensors for monitoring of corrosion in marine offshore and wind energy industries	
Diler E.		Biofilm sensor for the deep sea	
Reggiani E..		Underwater spectrophotometric detection: scaling down ocean acidification monitoring	
Hermida X.		140620-004 hidroboya: the "sample&hold" platform in the analog to digital understanding of our waters	
Date	**Time**	**Session Title**	**Session chair**
October 15, 2014	11:00 AM – 12:00 AM	Smart Sensor Interface	Patrick Farcy
Author		**Title**	
Toma D		Smart electronic interface for web enabled ocean sensor systems	
Jirka S.		A sensor web architecture for sharing oceanographic sensor	
Date	**Time**	**Session Title**	**Session chair**
October 15, 2014	2:00 PM – 3:30 PM	Passive and Active Sensors	Christoph Waldmann
Author		**Title**	

Foote K.		Maintaining quality of acoustic data: calibration methods for active and passive devices, with extended sampling volume	
Bonnel J.		Range and depth estimation of bowhead whale calls in the arctic using a single hydrophone	
Kinda B.		Passive acoustic monitoring of coastal dynamical oceanographic phenomena using single hydrophone	
Tusa Jumbo E.		Implementation of a fast coral detector using a supervised machine learning and gabor wavelet feature descriptors	
Date	**Time**	**Session Title**	**Session chair**
October 15, 2014	4:00 PM – 5:30 PM	Introduction to panel session "ocean and coastal environment sensors"	Patrick Farcy
Chair		**Title**	
Eric Delory		Panel session "ocean and coastal environment sensors" Panel members– Jean-Francois Rollin, Patrick Farcy, Madeleine Goutx, Jay Pearlman	
Date	**Time**	**Session Title**	**Session chair**
October 16, 2014	9:00 AM – 10:30 AM	Sensors and observatories	Jean-François Rolin
Author		**Title**	
Gille J.		Marine sensors; the market, the trends and the value chain	

Rolin J.		NeXOS contribution to the adaptation of system analysis engineering tools for mature and reliable ocean sensors	
Auffret Y.		Coastal observatory as a development platform for marine instrumentation	
Laes-huon A.		Long term in situ survey of total dissolved iron concentrations in deep ocean	
Date	**Time**	**Session Title**	**Session chair**
October 16, 2014	11:00 AM – 12:30 PM	Other sensors	Madeleine Goutx
Author		**Title**	
Goutx M.		Performance of the minifluo-uv sensor for monitoring ocean and coastal environments	
Wollschläger J.		Continuous observation of relevant biological and environmental parameters by absorption and fluorescence. Special focus on an integrating cavity approach	

3.2.3 SSCO presentations available in IEEE XPLORE

Development of environmental sensors for monitoring of corrosion in marine offshore and wind energy industries Yasri, M. ; Khalifeh, R. ; Lescop, B. ; Gallee, F. ; Diler, E. ; Thierry, D. ; Rioual, S.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000379
Publication Year: 2014 Page(s): 1 - 4 **IEEE CONFERENCE PUBLICATIONS**

Biofilm sensor for deep sea Diler, E. ; Larche, N. ; Thierry, D. ; Degres, Y.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000368
Publication Year: 2014 Page(s): 1 - 5 **IEEE CONFERENCE PUBLICATIONS**

NeXOS development plans in ocean optics, acoustics and observing systems interoperability Delory, E. ; Castro, A. ; Waldmann, C. ; Rolin, J.-F. ; Woerther, P.

; Gille, J. ; Del Rio, J. ; Zielinski, O. ; Golmen, L. ; Hareide, N.R. ; Pearlman, J.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000382
Publication Year: 2014 Page(s): 1 - 3 **IEEE CONFERENCE PUBLICATIONS**

Intelligent sensors — Why they are so important for future ocean observing systems Waldman, C. ; Del Rio, J. ; Toma, D. ; O'Reilly, T. ; Pearlman, J.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000378
Publication Year: 2014 Page(s): 1 - 5 **IEEE CONFERENCE PUBLICATIONS**

Long term in situ survey of total dissolved iron concentrations on the MoMAR observatory Laes-Huon, A. ; Legrand, J. ; Tanguy, V. ; Cathalot, C. ; Blandin, J. ; Rolin, J.-F. ; Sarradin, P.-M.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000366
Publication Year: 2014 , Page(s): 1 - 6 **IEEE CONFERENCE PUBLICATIONS**
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Smart electronic interface for Web Enabled Ocean Sensor Systems Toma, D.M. ; Del Rio, J. ; Jirka, S. ; Delory, E. ; Pearlman, J.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000375
Publication Year: 2014 , Page(s): 1 - 4 **IEEE CONFERENCE PUBLICATIONS**

Passive acoustic monitoring of coastal dynamical oceanographic phenomena using single hydrophone Kinda, G.B. ; Bonnel, J.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000374
Publication Year: 2014 ,Page(s): 1 - 5 **IEEE CONFERENCE PUBLICATIONS**

Underwater potentiostat for real-time electrochemical corrosion measurements Masmitja, I. ; Del Rio, J. ; de Damborenea, J.J. ; Conde, A.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000386
Publication Year: 2014 Page(s): 1 - 4 **IEEE CONFERENCE PUBLICATIONS**

Optimization of a Wi-Fi radio antenna for underwater applications Makhoul, G. ; Le Pennec, F.

Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000385
Publication Year: 2014, Page(s): 1 - 2 **IEEE CONFERENCE PUBLICATIONS.**

Range and depth estimation of bowhead whale calls in the Arctic using a single hydrophone Bonnel, J. ; Thode, A.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000373
Publication Year 2014, Page(s): 1 - 4 **IEEE CONFERENCE PUBLICATIONS.**

Developing a new generation of passive acoustics sensors for ocean observing systems Delory, E. ; Corradino, L. ; Toma, D. ; Del Rio, J. ; Brault, P. ; Ruiz, P. ; Fiquet, F.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000383
Publication Year: 2014, Page(s): 1 - 6 **IEEE CONFERENCE PUBLICATIONS.**

Coastal observatory as a development platform for marine instrumentation Auffret, Y. ; Bouvet, P.-J. ; Loussert, A. ; Amate, L. ; Munck, D.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000372
Publication Year: 2014 Page(s): 1 - 4 **IEEE CONFERENCE PUBLICATIONS.**

NeXOS contribution to the adaptation of system analysis engineering tools for mature and reliable ocean sensors Galvan, B.J. ; Marco, A.S. ; Rolin, J.-F. ; Delauney, L.

Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000370
Publication Year: 2014, Page(s): 1 - 6 **IEEE CONFERENCE PUBLICATIONS.**

Marine sensors; the market, the trends and the value chain Gille, J. ; de Swart, L. ; Giannelos, I. ; Delory, E. ; Castro, A.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000369
Publication Year: 2014 , Page(s): 1 - 14 **IEEE CONFERENCE PUBLICATIONS.**

Underwater spectrophotometric detection: Scaling down ocean acidification monitoring Reggiani, E.R. ; Bellerby, R.G.J. ; Sorensen, K.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE

DOI: 10.1109/SSCO.2014.7000376
Publication Year: 2014 , Page(s): 1 - 5 **IEEE CONFERENCE PUBLICATIONS**

Performance of the MiniFluo-UV sensor for monitoring ocean and coastal environments Goutx, M. ; Bachet, C. ; Ferretto, N. ; Germain, C. ; Guigue, C. ; Tedetti, M.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000364
Publication Year: 2014 , Page(s): 1 **IEEE CONFERENCE PUBLICATIONS**

Low-cost inertial measurement of ocean waves Kennedy, D. ; Walsh, M. ; O'Flynn, B.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000387
Publication Year: 2014, Page(s): 1 - 2 **IEEE CONFERENCE PUBLICATIONS**

A Sensor Web architecture for sharing oceanographic sensor data Jirka, S. ; Mihai Toma, D. ; Del Rio, J. ; Delory, E.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000365
Publication Year: 2014, Page(s): 1 - 4 **IEEE CONFERENCE PUBLICATIONS**

Hidroboya TM: The 'Sample&Hold' platform in the analog to digital understanding of our waters Fernandez Hermida, X.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000367
Publication Year: 2014, Page(s): 1 - 4 **IEEE CONFERENCE PUBLICATIONS**

COMMON SENSE: Cost-effective sensors, interoperable with international existing ocean observing systems, to meet EU policies requirements Cleary, J. ; McCaul, M. ; Diamond, D. ; Lassoued, Y. ; González García, M.B. ; Ribotti, A. ; Díez, C. ; Rovira, C. ; Sáez, J. ; Challiss, M.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000384
Publication Year: 2014, Page(s): 1 - 7 **IEEE CONFERENCE PUBLICATIONS**

Maintaining quality of acoustic data: Calibration methods for active and passive devices, with extended sampling volume Foote, K.G.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000377

Publication Year: 2014, Page(s): 1 - 5 **IEEE CONFERENCE PUBLICATIONS**

Underwater acoustic communication messaging time stamp applied to global time synchronization Pallares, O. ; Del Rio, J. ; Bouvet, P.-J.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000380
Publication Year: 2014, Page(s): 1 - 5 **IEEE CONFERENCE PUBLICATIONS**

The trans-national access in FP7 and H2020: A tool for sensor testing, observing system validation and collaborative research Sparnocchia, S. ; Farcy, P. ; Delory, E.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000381
Publication Year: 2014, Page(s): 1 - 3 **IEEE CONFERENCE PUBLICATIONS**

Implementation of a fast coral detector using a supervised machine learning and Gabor Wavelet feature descriptors Tusa, E. ; Reynolds, A. ; Lane, D.M. ; Robertson, N.M. ; Villegas, H. ; Bosnjak, A.
Sensor Systems for a Changing Ocean (SSCO), 2014 IEEE
DOI: 10.1109/SSCO.2014.7000371
Publication Year: 2014, Page(s): 1 - 6 **IEEE CONFERENCE PUBLICATIONS**

3.2.4 SSCO Special Collection

Authors of papers published in the proceedings of the Sensor Systems for a Changing Ocean had the opportunity to develop manuscripts based on their papers and to submit such manuscripts for publication in the peer-reviewed IEEE Journal of Oceanic Engineering. The manuscripts submitted to the Journal represented a development of the SSCO paper, including, for instance, addition of referenced, historical and scholarly context for the authors' contribution, elaboration of materials and methods, presentation of results with a discussion of their significance and potential expansion in future work. The following papers were published:

Table 6 SSCO papers published in IEEE Journal of Oceanic Engineering

Stéphane Rioual		**French Corrosion Inst., Brest, France**	*Development of Wireless and Passive Corrosion*	Yasri, M.; Khalifeh, R.; Lescop,

			Sensors for Material Degradation Monitoring in Coastal Zones and Immersed Environment	B.; Gallee, F.; Diler, E.; Thierry, D.
Oriol Pallares	**oriol.pallares@upc.edu**	**Electron. Dept., Univ. Politec. de Catalunya (UPC), Vilanova i la Geltru, Spain**	*TS-MUWSN: Time Synchronization for Mobile Underwater Sensor Networks*	Del Rio, J.; Bouvet, P.-J.
Jochen Wollschläger	**Jochen.Wollschlaeger@hzg.de**	**Helmholtz-Zentrum Geesthacht, Centre for Materials and Coastal Research, Institute of Coastal Research, Max-Planck-Str. 1, 21502 Geesthacht, Germany**	*In Situ Observations of Biological and Environmental Parameters by Means of Optics—Development of Next-Generation Ocean Sensors With Special Focus on an Integrating Cavity Approach*	Voss, D.; Zielinski, O; Petersen, W.
Agathe Laës-Huon	**Agathe.Laes@ifremer.fr**	**IFREMER Centre de Brest Laboratoire**	*Long-Term In Situ Survey of Reactive Iron Concentration*	Julien Legrand, Virginie Tanguy,

		Détection, Capteurs et Mesures Unité de Recherches et Développements Technologiques	*s at the EMSO-Azores Observatory*	Cécile Cathalot, Jérôme Blandin, Jean-François Rolin, PierreMarie Sarradin

3.2.5 Workshop 2.1 Summary

A brief summary of each presentation abstract is provided below, with particular attention to design information for the NeXOS sensors.

SSCO workshop, Tuesday Oct 14

New Sensor Programs – 1 - Chair René Garello

Eric Delory – NeXOS development plans in ocean optics, acoustics, and conserving system interoperability

A growing concern about the health of the world oceans resulting from multiple stressors as for instance effects of climate change and increasing offshore activities leads to the need of better observational tools and strategies. The objective of the NeXOS project is to serve those needs by developing new cost-effective, innovative and compact integrated multifunctional sensor systems for ocean optics, ocean passive acoustics, and an Ecosystem Approach to Fisheries (EAF), which can be deployed from mobile and fixed ocean observing platforms, as well as to develop downstream services for the Global Ocean Observing System, Good Environmental Status of European marine waters and the Common Fisheries Policy.

Eric Delory highlighted the NeXOS project major elements, and expected contributions:

Narrowing down requirements through scenarios; addressing competitiveness, and planned innovations (transversal and specific themes). Transversal innovations include sensor interface interoperability (implemented by development of smart interfaces, sensor data interoperability, implemented through OGC SWE. Domain specific innovations focus on optical sensors, passive acoustics, and EAF Recopesca (in place and to be improved). In addition, the project is performing economic assessment and addressing industrialization regarding the new sensors– market maturity varies quite a bit depending on sector. The value chain is analyzed, looking at the added value of a sensor, from components to services. Other project activities include integration and validation, and dissemination and outreach to engage with stakeholder communities

Eoghan McNamara – COMMON SENSE: Cost-effective sensors, interoperable with international existing ocean observing systems, to meet EU policies requirements

The COMMON SENSE (CS) project aims to develop cost-effective, multi-functional innovative sensors to perform reliable in-situ measurements in the marine environment. The COMMON SENSE sensors focus on key parameters including eutrophication, heavy metals, marine litter (microplastics) and underwater noise. The project will focus on increasing the availability of sensor data and observations through the development and implementation of the Common Sensor Web Platform (CSWP), a software platform that will integrate the COMMON SENSE sensor data and observations and deliver them to the Web, in standard formats and through standard interfaces.
In order to monitor the state of marine environment using cost-effective sensors, COMMON SENSE is developing sensors and related web platforms for detection of nutrients in marine environment. This includes observing elevated level of nutrients that causes eutrophication (Baltic and Mediterranean); monitoring of nitrate, nitrite, phosphate and ammonia – microfluidic analytical systems; colorimetric chemical assays; LED-based optical detectors, using wireless comm.. They have had good experience with long-term deployment of systems, and validated colorimetric technology. Heavy metal measurements are performed via screen-printed electrode; the electrode is integrated into nutrient systems (mercury, copper, lead, and cadmium). Microplastics detection and quantification is performed using Infrared detectors. COMMON SENSE will validate the sensor system independently based on previous techniques with a variety of platforms; the hydrophone will be installed on the wave-glider; the nutrient sensors testing will be done on platforms buoys and research vessels.

Patrice Brault (NKE) for Doug Connelly – The Sense OCEAN project and technologies of sensors used

Sense OCEAN is a 4-year project focusing on sensor development addressing the biochemical model of the ocean system. The partners have been involved in several projects together. The project benefits from considerable experience, by the partners in previous EU projects including 'MossClone', 'ATWARM', 'SENSEnet ITN, Labonfoil, Micromare, Icon and

ESONET. This has created a considerable infrastructure and expertise within the consortium. This consortium addresses a challenging problem - to provide the marine sector with a cheap mass deployable integrated multifunctional sensor package that can be deployed aboard (small) massively arrayed and cost-efficient platforms yet measure all of the major biogeochemical parameters required for effective understanding, modeling and management of the ocean productivity and resources. No single technology is able to make all of these measurements, and many excellent techniques are extremely difficult to miniaturize, reduce power consumption and make sufficiently robust to be used in a small long-lived marine sensor package.

Patrice talked about the underpinning technology. To achieve the envisioned low-cost, small integrated mass producible and mass deployable multi-parameter sensor suite requires the adoption of standard systems and architecture across the range of sensors. These systems that are common are the sensor package electronics, communications systems, data management, connectors and interfaces, mechanical systems, resources and their management (power and reagents if used), shared analytical systems and biofouling protection.

Parameters observed include carbonate, O2, nutrients and chlorophyll. They are measured using the following technologies: optodes, electrochemical sensors, lab-on-a-chip sensors, and multi-parameter optical sensors. They are using existing technology but working on miniaturization. SENSE OCEAN is also developing very small sensors for CO_2 and NO_2, which is a more challenging technology. The objective is for production and integration of multi-sensor packages. The goal is for producing 10 copies of each sensor. They are monitoring each sensor development by TRL; the target for multisensory package is TRL6. Platforms targeted for demonstrations include floats, moorings and AUV.

New Sensor Programs – 2 Chair Jay Pearlman

Daniel Toma for Christoph Waldmann – Intelligent sensors? Why they are so important

The complexity of installations in the oceans to carry out observations on specific processes and to detect long-term trends has grown significantly in the past years. This applies also to the type and number of sensors that are in use in observing systems. In these days, sensors need to be compatible with different platforms that are in use like floats, gliders or moorings and accordingly also to different data acquisition systems. Facilitating the integration process in existing or newly established observing systems comes with a real benefit for the operators and is important for the broader application of different sensors. However, how to achieve the goals is under debate. The most serious obstacle for all initiatives is the willingness of stakeholders to adopt a strategy and, even more so, to adopt a specific architecture to enable interoperability across platforms and observing systems. Therefore, the situation at this point in time is characterized by the fact that parallel approaches have been developed (IEEE 1451, the OGC set of standards, etc.) that are ready to be evaluated but still lacking the full support by the community. Therefore it seems to be a good time to consider and to agree on the implementation of interoperability arrangements. These and related aspects were discussed in this presentation.

Some of the options addressed are listed below: comparing non-standard implementation OGC Programmable Underwater Connector with Knowledge (PUCK) is a very simple standard, used by some US manufacturer; OGC PUCK equipped system automatically determines instruments on ports, loads drivers and metadata. In addition, NeXOS is proposing to implement a Smart electronic interface for sensors and instruments (SEISI).

Table 7 OGC PUCK versus current non-standard implementation

	Non-standard	**OGC PUCK**
Which ports have instrument?	Configuration file	Issue PUCK “soft break” to port, listen for response
What kind of instrument on port?	Configuration file	PUCK datasheet has manufacturer, model codes
Instrument serial number?	Configuration file, or ask with non-standard protocol	PUCK datasheet has UUID
Bind metadata?	Configuration file	Auto load from PUCK payload or database using PUCK UUID key
Load instrument driver?	Configuration file	Auto load from PUCK payload or driver library using PUCK UUID key

Eric Delory – developing a new generation of passive acoustic sensors for ocean observing systems

A NeXOS project objective is to develop cost-effective, innovative, and compact multifunctional sensor systems for passive ocean observation that can be deployed from mobile and fixed platforms, with data services contributing to the GEOSS, the Marine Strategy Framework Directive (MSFD) and the Common Fisheries Policy of the European Union. In particular, a goal is the monitoring of MSFD Good Environmental Status descriptors 1 (Biodiversity) and 11 (Underwater Noise) as minimal requirements. The development of innovative hydrophones includes a focus on the pre and post-processing of acoustic information and improved transducer integration, reducing size and overall procurement and operations cost while increasing functionality. This is a challenge when looking at the range of frequency and dynamic signal levels illustrated in Figure 4 below.

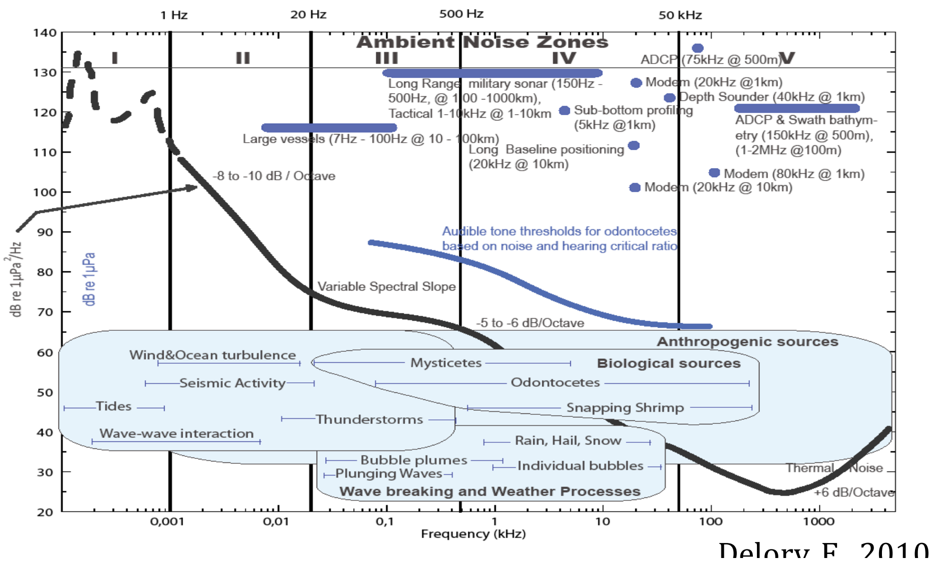

Figure 4 Passive acoustic environment

An important part of the effort will thus focus on the need for greater dynamic range. In addition, the integration on autonomous platforms, such as gliders and profilers is important when looking forward to a new generation of sensors and observations. One of the limitations of mobile, autonomous sensors is communication bandwidth. Thus the acoustic sensor system should have embedded processing that can be reconfigurable in order to address bandwidth limitations for multiple applications. The first phase of the project consisted in interacting with scientific communities and the industry in order to narrow down initial requirements and possibly extend the planned functionalities to new applications.

Potential functionality may include:

- Marine mammals (MSFD Desc. 1)
- Ambient noise statistics (baseline studies)
- Anthropogenic noise (MSFD Desc 11 + EIA directive)
- Software modularity for the potential inclusion of:
  - wind, wave and rain measurements
  - gas release (measure leaks in carbon storage)
  - acoustic diagnosis of key infrastructure.

Eric Delory gave an ambient noise demonstration re marine mammals – Humpback whales (most difficult one); blue whale – 80 species thus complexity of identification; dolphin behind sperm whale; bottelnose dolphin; ambient noise at PLOCAN (3 types of sounds mixed together – snapping shrimps, marine energy converter, ferry).

The project objectives are to develop compact, multifunctional, cost-effective, very low-power sensors with high dynamic range. The sensors will operate on multiple platforms, be capable of "Plug and play" (PUCK protocol) and be Web-enabled using OGC SWE.

Environmental sensors Chair Jean-François Rolin

Erwan Diler – Biofilm sensor for corrosion (French institut de la corrosion)

In natural seawater, surfaces will be rapidly covered by microorganisms that form a thin film called biofilm. It is now generally recognized that biofilms may affect the electrochemical behavior of metals and alloys and thereby may accelerate the corrosion of the material. Biofilms formed in seawater around the World does not necessarily present the same aggressiveness in terms of corrosion risk. For example recently some high alloy stainless steel corrosion failures were attributed to the particular aggressiveness of biofilms, which form in tropical seawaters. In deep sea, the biofilm activity as well as the corrosion risk induced by these phenomena has to be assessed. Monitoring the biofilm growth is crucial. There are 3 potential families of sensors: electrochemical, vibration, and optical. The objective of the present study is to develop an autonomous sensor able to characterize seawater biofilms through their electrochemical effects on stainless steel surface. The sensor is able to in-situ detect the potential ennoblement and to quantify the cathodic reduction efficiency of biofilmed stainless steel, which is a major parameter to quantify the risk of corrosion propagation on these alloys, as well as the bacterial presence and activity. This sensor will be able to be deployed down to 3000 m depth for long-term measurements.

Emanuele Reggiani – Underwater spectrophotometric detection: scaling down ocean acidification monitoring

The increasing demand for monitoring capabilities required by ocean acidification survey programs is forcing sensor developers to find suitable arrangements for long-term, drift-free deployments.

There is a long list of In situ monitoring challenges:

- accuracy/precision/response time
- automation
- long term drift
- portability (usage of bulky laboratory instrumentation (and related difficulty of maintenance) prevent from in situ extensive monitoring campaigns and inter-comparisons)
- power requirements and consumption
- frequency of measurements (spatial coverage) - current C analysis rely on standard gas and synthetic water references for calibration (several calibration process during a single measurement session);
- costs installation/maintenance
- sensitivity to bio-fouling
- ruggedness
- ease of use/maintenance/remote control
- modularity/embedded systems

The increasing application of micro-technology will help the development of fault-free, calibration-free solid state probes. Spectrophotometry already helps oceanographers in retrieving fundamental datasets of high quality data about the status of ocean health, both in surface and deep water, and including carbon biogeochemistry. This work describes the advancements on two spectrophotometric flow-through devices optimized for pH and carbonate detection with accuracy limited by the knowledge of equilibrium properties of reagents in seawater.

2 measurements: 1 before and one after application of reagent

application- ocean acidification monitoring

Instrumentation development

Xulio Fernandez Hermida; Hidroboya TM: the "sample and hold" platform in the

analog to digital understanding of our waters

Hidroboya is a platform to measure water quality parameters. It effectively surpasses the crucial problem of the fouling in the sensors. The main idea behind Hidroboya is to keep the sensors in a chamber (the sampling chamber) where they are kept in a wet and dark environment between the times the measurements are to be done. When a measurement is to be done, the water enters into the chamber and after a time (a few seconds to let the sensors get stabilized in the new environment), the measurements are done. After that, using an air compressor, the water is put again into the point it has been picked (any number of meters in the column of water) and the sensors are left in the wet and dark conditions that are ideal for them to perfectly be conserved until the next measurement process.

A Video from an installation was shown. The challenges are associated with long-term measurements: turbidity data is affected by fouling. The approach is to keep the sensor dry and away from water (filled with fresh water if necessary). For the sampling approach, the sensors are located in a sampling chamber with 0.3 liter of volume (enough for the sensors to read properly), the chamber is kept dark, to further avoid fouling; two holes let the water enter and the air go out and vice-versa. The limitations are the temperature at each sampling point. The simulator is helpful to understand the fundamentals.

Smart sensor interface - Chair Patrick Farcy

Daniel Toma for Simon Jirka – sensor web architecture

This paper introduces the Sensor Web architecture of the NeXOS project. It shows how interoperable standards help in creating an infrastructure for sharing oceanographic observation data and in integrating sensor data into applications. Important technological foundations of the NeXOS Sensor Web architecture are the concepts of spatial data infrastructures and the Sensor Web Enablement framework of the Open Geospatial Consortium. As a result an architectural concept for sharing oceanographic sensor data has been developed, which is introduced in this paper.

An architecture diagram is provided in Figure 5. It shows a standard open data portal for client to access under 3 cases (new multifunctional sensor, existing sensor, data heavy system)

Functional Requirements are listed below:

– Pull access to observation data (i.e. following a request/response pattern)
– Push delivery of observation data
– Visualization of the collected observation data

– Transfer of collected observations from sensors into the Sensor Web components (i.e. by delivering the data into an observation database)
– Automatic conversion of sensor readings into a Sensor Web protocol.

Non-functional requirements are primarily concerned with re-use, interoperability, and open source. Web enablement relies on standardization of data formats and (web) service interfaces, as well as integration of sensors and sensor data into spatial data infrastructures.

The following list shows which standard is used for which NeXOS component:

- Web Service for Sensor Configuration: OGC Sensor Planning Service 2.0; this interface can be accessed from control centers
- Web Service for Pull Access: OGC Sensor Observation Service 2.0 with support of O&M 2.0 and SensorML 2.0
- Web Service for Push Delivery: OGC Sensor Event Service or Pub/Sub enhancement for the SOS 2.0
- Data Viewer: SOS 2.0 Web Client
- Observation Database: Re-use of existing databases (e.g. PostgresSQL, Oracle, MySQL); ensuring flexible integration into the SOS 2.0 via an abstraction
- Sensor Bridge: Based on the SID concept; this component either pushes directly data into an observation database or uses the transactional SOS operations for this purpose

At the Sensor System level, the Smart Electronic Interface for Sensors and Instruments (SEISI) - based Sensor Systems support both a pull-based data access interface (i.e. based on the SOS standard) as well as a push-mechanism for delivering data into observation databases. Non-SEISI Systems will need to be integrated into the Sensor Web architecture through dedicated Sensor Bridges.

Important goal of NeXOS is to provide Guidance on how to apply Sensor Web technology in Oceanography.

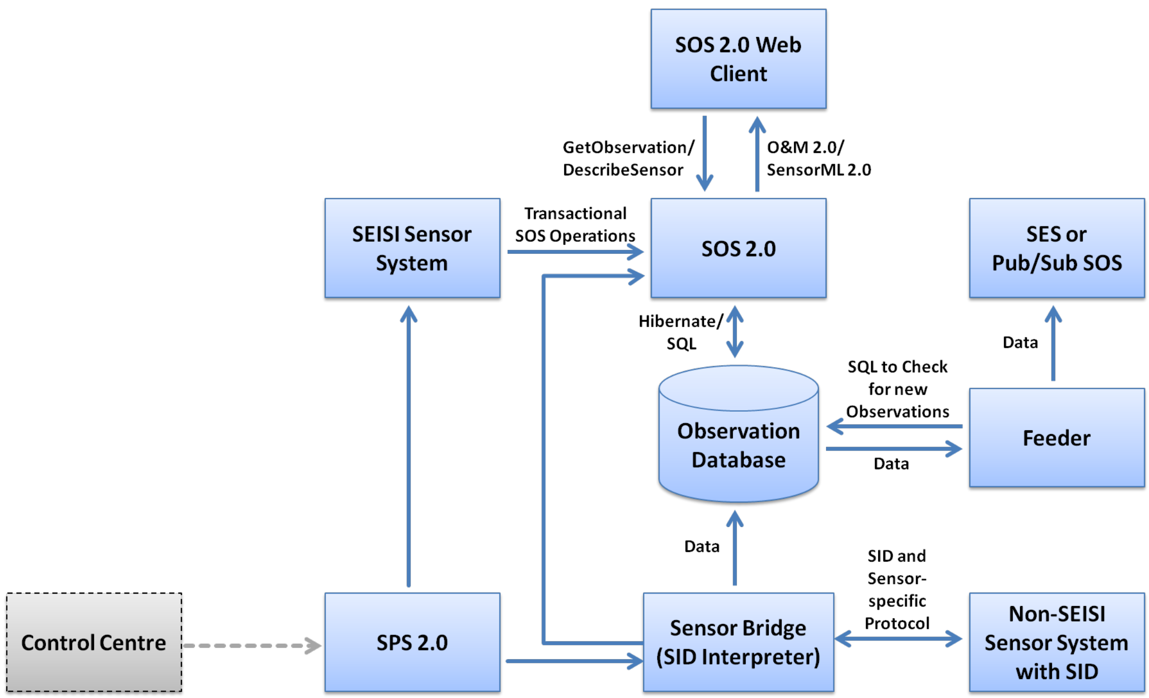

Figure 5 NeXOS sensor web implementation

Daniel Toma - Smart electronic interface for web enabled ocean sensor systems

The main objectives of Smart electronic Interface for sensors and Instruments (SEISI) is to develop an interface capable of providing a standard communication interface for non-standard sensors with analogue output and instruments with analogue or digital output. SEISI is actually a set of standards and functionalities to enable Web-based sharing, discovery, exchange and processing of sensor observations, and operation of sensor systems. The Goal is to minimize the integration time with different types of observing systems and platforms, and to maximize the interoperability with upper communication layers.

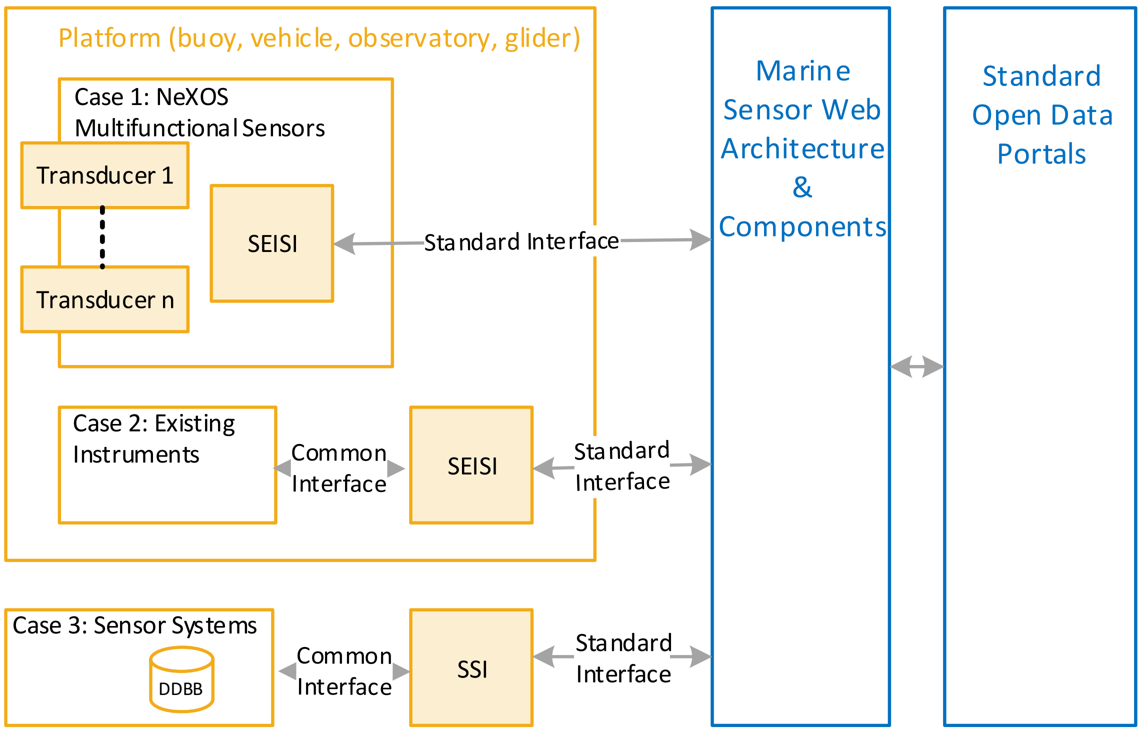

Figure 6 Smart Electronic Interface for Sensors and Instrumemts (SEISI)

The SEISI prototype reads SensorML from PUCK payloads in instruments, actuators, or platforms to automatically configure the onboard services (enable/disable SEISI input interface, or enable/disable output interface Ethernet, RS232). This was illustrated using a Ferry box scenario. In NeXOS, all sensors will have a PUCK interface.

Passive and active sensors Chair Christoph Waldmann

Ken Foote – Maintaining quality of acoustics data: calibration methods for active and passive devices, with extended sampling volume

A key technology that continues to evolve to meet special requirements of underwater sampling and observation is that of acoustics. This technology is used both actively to ensonify fish, zooplankton, other marine organisms, and the environment, and passively to listen to and record sounds produced by marine organisms and other sources, e.g., shipping and environmental noise. When calibrated, acoustic devices offer the potential for quantification. The essential case for calibration is made, and principal methods for the calibration of active and passive devices are reviewed in this presentation. These include the standard-target method for the calibration of active devices, e.g., sonars, and the three-transducer spherical-wave reciprocity method for the calibration of passive devices, e.g., electroacoustic transducers and hydrophones. Recent advances in understanding the spatial structure of the transducer near field may safely extend the range at which such calibrations can be performed, as well as extending the range of measurements themselves. This extension can be quantified through the acoustic sampling volume. Reference is also made to the IEEE Oceanic Engineering Society (OES) Standards Initiative, with website at http://www.oceanicengineering.org/page.cfm/cat/105/OES-Standards-Initiative/, which is providing a forum for dissemination of information on standards, protocols, quality assurance procedures, and best practices that are important in ocean engineering. This includes information on current calibration methods for acoustic instruments.

J. Bonnel - Range and depth estimation of bowhead whale calls in the arctic using a single hydrophone

Bowhead whales generate low-frequency vocalizations in shallow-water Arctic environments. The propagation of these sounds is adequately described by normal mode theory. Indeed, at low-frequency the environment acts as a dispersive waveguide. The propagated signal can be modeled by a sum of normal modes, and the source position can be inferred from the different modal arrivals. However, this requires estimating the modes from the received signal. Traditionally, modal arrivals are separated using synchronized hydrophone arrays. Here a nonlinear signal processing method called warping is used to filter the modes on just a single hydrophone. Once modes are filtered, the source depth and range can be estimated using classical Matched Mode Processing. This methodology is illustrated on an experimental bowhead whale vocalization recorded in the Beaufort Sea. Because seabed properties are not well known, it is necessary to jointly perform source localization and geacoustic inversion.

G. B. Kinda – passive acoustic monitoring of coastal dynamical oceanographic phenomena using single hydrophone

During long-term passive acoustic monitoring in shallow water in Iroise Sea, the time series of the ambient noise recorded with a single hydrophone showed some unusual striations in the time-frequency domain. The changes in the striation slopes are related to the tidal oscillations, which induce a change in the water depth of the waveguide. The observed striations are highly correlated with the tides, and this phenomenon is classically described by a simple scalar γ called the depth-frequency waveguide invariant. However, the observed invariant $\gamma_{obs} \simeq -1$ differs from the canonical $\gamma = -2$ value. A theoretical approach is developed to explain the observed γ_{obs}, and particularly its dependence on the bathymetry in a range-dependent environment.

Eduardo Tusa – Implementation of a fast coral detection using a supervised machine learning and Gabor wavelet feature description

The task of reef restoration is very challenging for volunteer SCUBA divers, if it has to be carried out at deep sea, such as 200 meters, and low temperatures. This kind of task can be properly performed by an Autonomous Underwater Vehicle (AUV) that are able to detect the location of reef areas and approach them. The aim of this study is the development of a vision system for coral detections based on supervised machine learning. In order to achieve this, a bank of Gabor Wavelet filters is used to extract texture feature descriptors; we use learning classifiers, from OpenCV library, to discriminate coral from non-coral reef. We compare: running time, accuracy, specificity and sensitivity of nine different learning classifiers. We select a Decision Trees algorithm because it shows the fastest and the most accurate performance. For the evaluation of this system, we use a database of 621 images (developed for this purpose) that represents the coral reef located in Belize: 110 for training the classifiers and 511 for testing the coral detector. In conclusion, they achieved a maximum accuracy of 70%, and a lot of future work remains.

Ocean and coastal environment sensors - Chair Patrick Farcy

Patrick Farcy – Introduction to panel session

Trans National Access (TNA) objectives; (ocean, and coastal) and FIXO3 (open ocean)

Panel – Eric Delory (chair), Jean-Francois Rollin, Patrick Farcy, Madeleine Goutx, Jay Pearlman.

To open the JERICO and $FixO^3$ network of coastal and open ocean observatories to transnational users by providing free-of-charge access to facilities for R&D experiments and in situ testing in order to

- establish a long-term alliance between users and partners, facilitating staff exchange and mutual scientific collaboration – collaboration in future research projects.
- build an European facility for Science dedicated to innovation (new sensors, new automated platforms) – collaboration with industry.
- promote the cost-effective use of the infrastructures.

- promote the infrastructures by transferring know-how from partners to users, with a view to future expansion that will include new partners (possibly also from non-EU countries).

Following panelists' introduction, the discussion focused on expectations for the next 5 to 10 years (biodiversities, fisheries, etc…) based on individual experience as well as outcomes from the workshop over the last two days.

A member from the audience asked how we could use observatories to improve R&D cost for sea trials. Answers included emphasizing observatories consistency, trying to have the same testing infrastructure, following standards and best practices for test beds, promoting in-situ testing (ships of opportunity, ferry boxes, free facilities via Jericho), focusing on Quality control of the data (example Mercator data). AtlantOS may facilitate the sharing of infrastructures, if the project is funded.

The next topic to be addressed was sensor calibration. It was noted that the ocean community does not have independent national calibration facilities for sensors. The concept of reference sensors was mentioned, however manufacturers try to become the one reference. In JERICO, inter-comparison of methodologies are used for calibration.

Forum for sensor providers.

What about scientists? They are looking at all kind of data; for example in acoustics, there are essential ocean variables, which are being defined;what do we really need to measure? We need initiatives for validating data (example MyOcean,SeaDataNet); there is also the issue of meta-data (adequate description); it needs to be machine-readable.

Sensors and observatories – Chair Jean-François Rolin

Johan Gilles - Marine sensors; the market, the trends and the value chain

This market analysis is based on the work performed for the EU/FP7 project NeXOS that focuses on preparing the new generation of multi-functional maritime sensors. Naturally, such a venture cannot be successful without a prior thorough assessment of the market status and an in depth understanding of the user needs and the upcoming market trends. Therefore the market assessment we have performed has the following objectives:

- to map the current and upcoming applications of maritime sensors in the various fields of implementation

- To create a solid understanding of the structure of the market for maritime sensors;
- To draw the sector's value chain indicating the activities that produce added value to maritime sensor activities;
- To assess the competitiveness of the European maritime sensor industry; and
- To identify the trends for the future development of the respective market segments as well as the barriers for further development of the market.

The main focus of the study is to assess the market for optic sensors, passive acoustic sensors and the Ecosystem Approach to Fisheries (EAF) sensor system. These maritime sensors have been identified to be applied or have potential application in a big variety of activities ranging from environmental monitoring and climate change research to seismic research and marine mammals. The value chain of the market has been drawn to depict the distinct activities that add value to maritime observation activities. The activities on the main branch of the value chain include sensor manufacturing, sensor developing and integrating into platforms as well as adapting the sensors to the needs of the maritime observations, operating them, analyzing the collected data and exploiting the results of the observations. Currently there is no clear distinction of activities performed by each stakeholder group resulting in varying perceptions of the range of value-adding activities that different stakeholders focus on. However a set of main stakeholder groups with more or less distinct behavior has been identified and includes: i) sensor manufacturers; ii) sensor developers; iii) service providers and iv) end-users of environmental monitoring services. In our research, we have identified the main and most promising market segments for maritime sensor activities and distinguished 3 perspectives of sensor use that actually drive the user requirements for sensors. These perspectives are: i) research, ii) industry and iii) research and development. In this study we dive into the growth expectations of the different market segments beyond the traditional, long-standing markets of Europe and North America looking into the developments on a global scale. Main market segments, which make use of marine sensors include

- Industrial water quality
- Research
- Offshore oil & gas
- Environmental monitoring
- Ocean renewable energy
- Port security
- Aquaculture & Fisheries
- Deep-sea mining.

As far as competitiveness of the sector is concerned, the European sensor market position in the world is assessed compared to the ongoing strong position by the North American sector and a SWOT analysis is performed to highlight the strengths, weaknesses, opportunities and threats for the European sensor manufacturer industry. Further, the prospects of potential competitors rising in other geographical areas and claiming a part of the global market pie are assessed. Potential recommendations to strengthen the position of the European industry could include establishing common standards and developing appropriate business models that would help industrialization of products or placing emphasis on SMEs taking into account the maturity level of each product market.

NeXOS aims at producing the next generation of ocean sensors by addressing six main scientific and technical innovations. The Value chain for environmental monitoring; focuses on value adding activities. There are four Stakeholder groups (developers, manufacturers, service providers and end users).

Jean-Francois Rolin - NeXOS contribution to the adaptation of system analysis engineering tools for mature and reliable ocean sensors

Current sensors address the needs of scientific ocean research as well as operational oceanography and environmental monitoring including assessment of the coastal areas.

A goal of NeXOS is to improve the temporal and spatial coverage, resolution and quality of marine observations. This presentation will address the following 3 topics:

1. -Technology Readiness Level of oceanographic sensor systems.
2. - Key function of the anti-fouling device
3. Case study of glider reliability.

The Technology Readiness Levels (TRLs) are now successfully used for oceanographic equipment. Technology readiness analysis tells you what are the weak points preventing from reaching the next level. We use this analysis as a metric of achievements in the NeXOS project. Marine environment constraints are known to be critical. The designer has to take into account surrounding functions dealing with data availability, interoperability, modularity, robustness, which are in fact major objectives of the NeXOS project. Reliability analysis in the context of marine sensor systems is in many cases a key issue. Some sensors will be deployed for long-term autonomous missions, some of them, for instance on-board Argo Floats, will never be recovered. Those need to perform with a rather small amount of failures. The failure events are not only coming from the operations at sea but also from several steps of the data dissemination process: metrology, associated metadata, processing, etc. In order to achieve this goal, it is necessary to consider several alternative configurations of the system design in such a way that functional specifications remain unchanged but enhance dependability. This is framed in the reliability allocation problems, usually addressed by first obtaining Fault Tree models of the system and then performing cost-constrained optimization of whole system reliability. The most common criteria used to overcome reliability issues consist in applying redundancy on critical components to provide backup in case of failure of some component, using diversity (i.e. components from different manufacturers) in redundant parts so as to avoid common cause failures and employing physical dispersion (i.e in a redundant configuration, locate components in different parts of the system).

The next topic focuses on anti-fouling devices (one such was just patented by IFREMER). For every sensor system, a particular innovative input for sensor biofouling protection will be evaluated in NeXOS. Currently, bio-fouling may invalidate sensor measurements within days or weeks. It is necessary to remove and clean sensors often (monthly on some sites) and/or an expert is regularly checking, with remote tools, the validity of data. The approach for developing an anti-fouling system for NeXOS is shown in Figure 7 below.

The aim is to reach the maximum sensor operation duration without maintenance given a biological activity in a given site. The site dependence may result in various thresholds to treat the fouling sensor input.

A case study on glider reliability was then discussed, based on work from the Groom project.

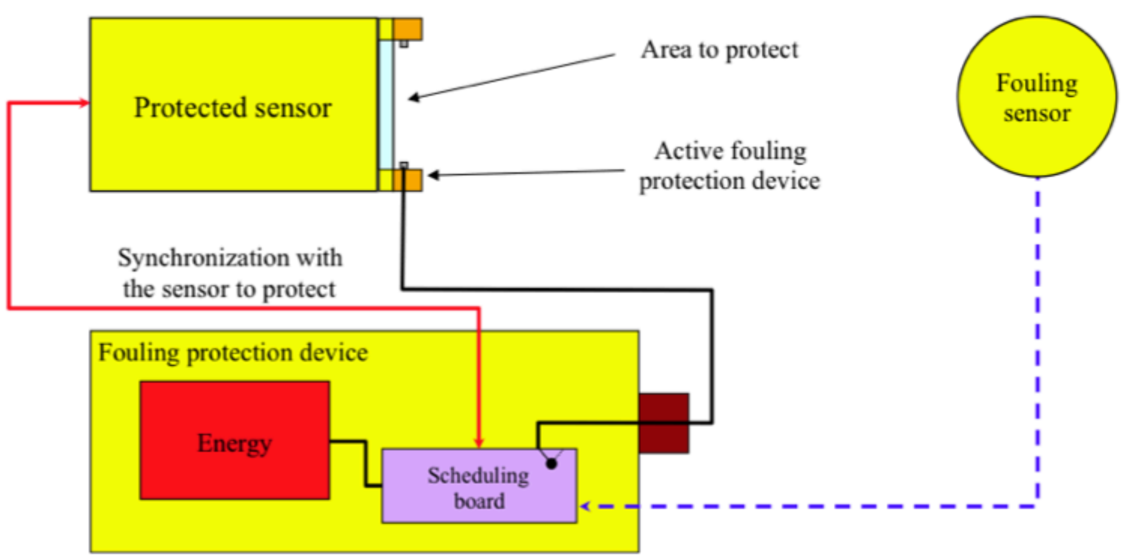

Figure 7 Anti-fouling strategy

Yves Auffret - Coastal observatory as a development platform for marine

instrumentation

Sea Test Base / Celadon is a non-profit organization, which offers testing facilities mainly based on a coastal non-cabled observatory, dedicated for designing, testing and qualifying marine sensors and marine instruments in real conditions. This platform can be considered as an experimental laboratory at sea, available 24/7/365 from the Internet to address sea fishing, oceanography, oil & gas industry, cable companies, marine security and naval defense. In a first step, we describe, analyze and compare the differences in terms of architecture and services between conventional marine cabled, non-cabled observatories and Sea Test Base facilities. In a second step, we present the results obtained with this platform to design, improve and qualify the hardware and the algorithms for a Multiple-Input and Multiple-Output (MIMO) modem for underwater acoustic communication. In conclusion, we present the upcoming extension of Sea Test Base, which consists of a shared open platform based on a mesh network including buoys and a pontoon, dedicated to underwater acoustic experiments at sea. The goal is to bring together commercial, research and education facilities using both on shore and off shore facilities. Based on prior examples (Natura 2000) it takes about 6 months to set up such a test base.

Agathe Laes-Huon - Long term in situ survey of total dissolved iron concentration on MoMAR observatory

Study of the temporal dynamics of faunal assemblages and their habitat at the Lucky strike vent was performed using the TEMPO ecological module on the MoMAR (Monitoring of the Mid-Atlantic Ridge) dee- sea observatory. An in situ analyzer (CHEMINI) was implemented onto this structure in order to determine total dissolved iron concentrations associated with an optode and a temperature probe. Hence, we present here the long term in situ analysis of total dissolved iron (6 months, 2013-2014) at the Eiffel Tower edifice. The daily analyzed in situ standard (25µmol.L-1) showed an excellent reproducibility (1.07%, n=522), illustrating the good analytical performances of the CHEMINI, validating the iron concentrations measured by the instrument. CHEMINI was reliable, robust over time for in situ analysis. The averaged total dissolved iron concentrations for the 6 months period remain low ([DFe] = 7.12 ± 2.11 µmol L-1, n = 519), but display some noticeable variations related to the temperature. Indeed, iron and temperature correlated significantly, and frequency spectra indicated a maximal contribution of frequencies around 4-5 days for both variables.

Other sensors – Chair Madelaine Goutx

Madelaine Goutx - Performance of the minifluo-uv sensor for monitoring ocean and

coastal environments

Understanding the biogeochemical functioning of the ocean requires high frequency recordings of DOM Dissolved Organic Matter (DOM) descriptors that traditional tools such as chromatography cannot provide. For the last 10 years, the technological developments of fluorescence sensors have attempted to cover this need. Optical properties allow to properly characterizing DOM and can be acquired at high frequency. In this context, our laboratory developed the MiniFluo-UV sensor, a prototype of miniaturized submersible fluorometer for the detection of aromatic compounds that fluoresce in the UV domain. The qualification of the sensor consisted of measurement of drift, linearity, repeatability, sensitivity to light, temperature and pressure, and detection limits of quantification of phenanthrene and tryptophan in standard solution. Validation was made by comparing measurements of phenanthrene concentrations in crude oil WSF by means of the MiniFluo and different fluorimeters. Here, we show results of deployments of this MiniFluo-UV sensor in two distinct areas, 1) the North Western Mediterranean during the continuous monitoring of the surface water layer in the Gulf of Lion (DEWEX cruise, winter and spring 2013) and 2) the coastal marine area of Marseille bay heavily impacted by urban activities. The pattern of raw counts enabled to distinguishing interesting distributions of DOM in relation to hydrological features and spring biological production in the Gulf of Lion. It also revealed accumulations of contaminants in marine areas under anthropic pressure. The sensor concept is shown below. The Sea Explorer glider is the targeted platform.

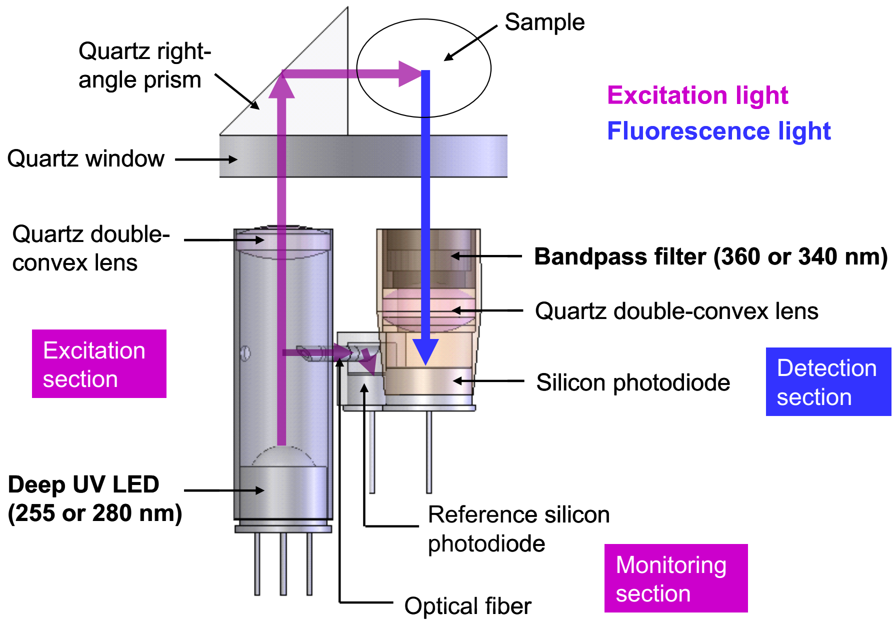

Figure 8 Minifluo sensor design; Sea Explorer glider on the right

In conclusion, the minifluo is a promising sensor. There is however a lot to do such as a better calibration, as well as integration in the NeXOS communication/management system, and possibly protection from fouling.

Jochen Wollschläger Continuous observation of biological and environmental parameters by optical absorption and fluorescence – special focus on an integrating cavity approach

The Marine environment is highly dynamic, and under stress due to human activities. Comprehensive environmental monitoring requires reliable measurements in high spatiotemporal resolution. Parameter related to biology are often difficult to measure, and Information is required about a broad range of elements such as

- Phytoplankton (biomass & composition)
- Suspended matter
- Chromophoric dissolved organic matter (CDOM)
- Hazardous substances (e.g. polycyclic aromatic carbons).

Optical methods are especially suitable for high resolution measurements. They are rapid, convenient, and many water constituents are optically active, and detectable by fluorescence.

Measurement of the inherent optical properties (IOPs) of the water can use attenuation, absorption, or scattering. The matrix –fluorescence sensor relies on fluorescence, to perform detection and discrimination of polycyclic aromatic hydrocarbons (PAH), colored dissolved organic matter (CDOM), and other substances such algal fluorescence, and chlorophyll-a. The matrix fluorescence sensor will operate on multiple platforms ((wave)gliders, floats, FerryBox, and fixed stations), while the integrating cavity (PSICAM) uses hyperspectral absorption (see Figure 9 below).

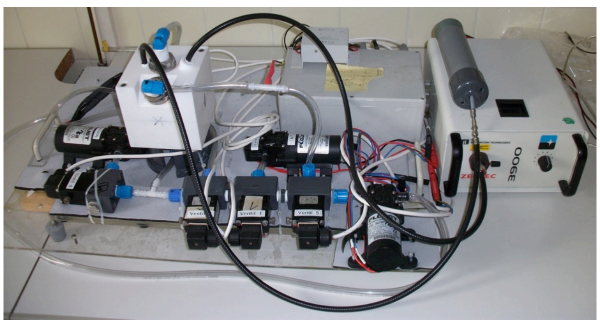

Figure 9 Integrating Cavity (PSICAM)

3.2.6 SSCO workshop conclusion

As mentioned earlier in this document, a growing concern about the health of the world oceans leads to the need of better observational tools and strategies, which are addressed by the Ocean of Tomorrow (OoT) projects, and others gathered for the workshop. The objective of the NeXOS project is to serve those needs by developing new cost-effective, innovative and compact integrated multifunctional sensor systems for ocean optics, ocean passive acoustics, and an Ecosystem Approach to Fisheries (EAF). The SSCO presentations and discussions centered on the engineering of emerging technologies and standards to provide cost-effective solutions. The new sensors will be deployable from mobile and fixed ocean observing platforms, and the resulting data will feed downstream services for the Global Ocean Observing System, Good Environmental Status of European marine waters and the Common Fisheries Policy. The proposed technology and implementation will be demonstrated to stakeholders, such as during the Oceanology International 2016 conference discussed below.

3.3 Workshop 2.2 - Oceanology International (OI) 2016, London, U.K

OI 2016 is the leading international event for Ocean related hardware and software activities and it includes the presence of both Scientific and Business communities. During the three days of the OI2016, OoT projects, including NeXOS's partners had the opportunity to show the current progresses on sensor developments and transversal innovations.

Demonstrations took place each day at the tank of the Ocean of Tomorrow booth, showing the capabilities of the O1, A1 (Optical and acoustic sensors) and Sensor Web Enablement. It was a great opportunity to discuss with international stakeholders from research and business areas, with the objective to better understand their needs and shaping the marketability of our future products. There was good attendance at the booth throughout the conference.

It was also an opportunity for workshops and round table among the Ocean of Tomorrow FP7 projects in order to collaborate to maximize impacts and implementation of each project's innovation.

In addition, in order to assess the added value of the NeXOS sensors, some case studies have been developed where the NeXOS sensors benefits and the added value they bring can be identified and measured. Since relevant data (of technical and especially monetary nature) are extremely scarce, we participated in OI2016 to get a good look at what other technology is available on the market, what kind of future developments are to be expected in the field and rub shoulders with various industry experts exhibiting there, with the objective of retrieving said information.

This section describes the NeXOS demonstration planning and conduct, coordination of OoT events, participation in other events , and one-on-one discussion with stakeholders.

Figure 10 OI 2016 Exhibit Hall

3.3.1 OI activities and schedule

The main activities for the NeXOS team focused on the following items:

1) Presented for the first time was a demonstration of the Optical Matrixflu O1 and passive acoustic A1 sensors including the plug and play mechanisms developed during the project (full sensor web enablement and OGC-PUCK support), and receive feedback from the attendance – a 30 minute time slot was given for each demonstration, twice on Tuesday and twice on Thursday. Other timeslots during the conference were used by other OoT projects.

2) Participate in a community meeting where all OoT projects presented key outcomes using a lightning forma, also known as "Ignite". This format allows for 20 charts to be briefed in 5 minutes, with the charts advancing automatically. Each project also had a poster for the case where more detailed information was desired

3) Participate in a closed OoT meeting, to coordinate the interactions between the projects and the platform providers; and discuss approaches to standards, and

4) Reach out to individual exhibitors, discussing technology and standards. The project was well represented at the above events as well as others by the following partners:

- IEEE was in charge of the overall outreach, coordination and logistics
- SMID and PLOCAN focused on the acoustic sensor – SMID provided the A1 sensor, and PLOCAN the underwater sound generator, and CTN helped with the algorithm development.
- TriOS focused on the O1 optical sensor for the demonstration
- UNOL presented NeXOS, its optical sensors and the O1 innovation in a panel on blue economy
- AMU presented recent scientific findings based on optical sensor innovations
- 52N make feasible the web data visualization.
- UPC developed the plug and play mechanisms and also gave a presentation at the SWE workshop
- and ECORYS focused on one on one discussions regarding technology benefits.

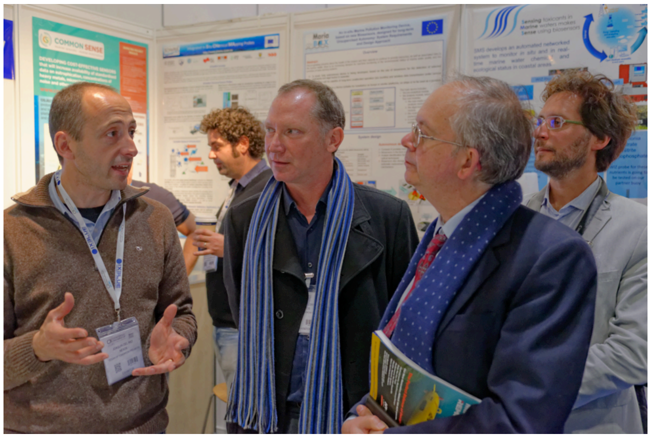

Figure 11 Joaquin del Rio and Eric Delory discuss the A1 SENSOR

An overview of the day-by-day activities is shown in Table 8 below.

Table 8 Overview of Agenda OoT days 1 -3

<table>
<tr><td>Time</td><td colspan="5">Tuesday March 15</td></tr>
<tr><td></td><td colspan="5">Oceans of tomorrow day 1</td></tr>
<tr><td>9</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>11-12</td><td></td><td></td><td></td><td></td><td rowspan="2">OOT sensor demo 30 min</td></tr>
<tr><td>12- 13</td><td></td><td></td><td></td><td></td></tr>
<tr><td>13-13.30</td><td></td><td></td><td rowspan="4">Marine Technology and Services Sector Role in the Blue Economy</td><td></td><td rowspan="2">closed OOT project meetings</td></tr>
<tr><td>13.30-14</td><td></td><td></td><td rowspan="3">Workshop Sensor Web Enablement (SWE)</td></tr>
<tr><td>14-14.45</td><td rowspan="2">FiX03 innovation meet</td><td></td><td rowspan="2">OOT poster session</td></tr>
<tr><td>14.45-15</td><td>Eric Delory</td></tr>
</table>

	industry	speech	conference	hosted by the EU-EuroFleets II project - Room 6 South Gallery of the Excel Centre 13.30-17h	
15-16					OOT sensor demo 30 min x2
16-17					
17-17.30			**EMSO-EMSODEV meeting**		
20					OOT Dinner

Time	**Wednesday March 16th**	
	Oceans of tomorrow day 2	
9		Open Ocean & Coastal Observatories Workshop
10		
11-11.30	OOT sensor demo 30 min x2	
11.30-12		
12-13		
13-13.30	OOT s' presentation	
14		

14.40	
15.30	
15.30	Round table OOT
17	
17.30	

	Thursday March 17th
	Oceans of tomorrow day 3
10-11	NeXOS demo Common sense OOT
11-12	SENSOCEAN demo
12-13	
13-14	OOT sensor demo 30 min x4
14-15	

3.3.2 OoT Demonstrations

Three scheduled demonstrations were performed by the NeXOS team at the booth of the Ocean of Tomorrow projects on the exhibit floor:

- *Tuesday 15th March 2016 at 15:00*
- *Wednesday 16th March 2016 at 11:00*
- *Thursday 17th March 2016 at 10:00*

A water tank was available for the demonstration (see Figure 9) at the back of the booth. A small buoy commercial buoy was equipped with a computer board which provided an interface between the NeXOS sensors and the server. During the demo, Sensor O1 was attached to the network. It was automatically identified. Sensor data was displayed. Substances were released in the water tank to force sensor readings to change. Sensor principles were explained. Each demo allowed the audience to be in direct contact with the presenter and permitted in depth discussions to take place.

Other more informal demonstrations were performed outside the schedule. Here is the list of people who gave us contact information and show interest during the demo:

Christophe Penkerch *penkerch@obs-vlfr.fr*

Dr. Luca Sanfilippo *luca.sanfilippo@systea.it*

Hervé Precheur *hp@sensorlab.eu*

Chris Cardwell *chris.cardwell@noc.ac.uk*

Laurent Mortier *Laurent.mortier@ensta-paristech.fr*

Lola Rodriguez *lrodriguez@leitat.org*

Figure 12 Oliver Zielinski demonstrates O1 optical sensor

The following lessons were identified as a result of the demonstration:

1) Logistics and demo preparation

The OoT booth was shared between the 8 projects, and despite having specific time slots for each project demonstration, and everyone being willing to cooperate, sharing a booth between all OoT projects was a challenge. Each project brought flyers, posters and other documentation, and space for displaying the material was limited. Thus the material was frequently rearranged as a function of who was running a demonstration. In addition, when using a demo tank, it should be placed at the front of the booth, rather than in the corner, where access was limited. If possible, each demonstration should be dry run on the day before the official demonstration to ensure a smooth conduct and no surprises. In addition, due to the environment at OI, where there are a lot of exhibitors with specific marketing objectives, it was clear that in addition to the distribution of flyers, the demonstration should be advertised aggressively to the individual booths in the exhibit area.

2) Demonstration conduct

Figure 13 Joaquin del Rio discusses interoperability strategy

There was attention and recognition for NeXOS even in the presence of the many other projects and vendors at the meeting and their various handouts, posters, and give-aways. Avoid explaining software, standards and protocols.

3) Highlighting of other relevant events

Ensure that attendees to the demo are also aware of other relevant events such as the SWE workshop and the blue economy, where NeXOS was present as well. There were a number of side events that were organized during OI which were constructive and provided exchange of information with users and private sector vendors.

3.3.3 Open OoT meeting

The open OoT meeting was held on March 16 (the second day) in one of the conference rooms above the exhibit hall. The venue and presentation schedule are shown irrespectively n Figure 14 and table 9 below:

Figure 14 Eric Delory presents NeXOS sensors to the OoT teams

Table 9 Agenda for Open OoT meeting

Time	Project	Speaker	Title
13:00-13:20		Jay Pearlman	Introduction to OOT and welcome
13:20-13:25	BRAVOO	Jan Roelof van der Meer	Biosensor developments in the BRAAVOO project
13:25-13:30	Discussion & Questions		
13.30-13:35	COMMON SENSE	Sergio Martinez	COMMON SENSE: Cost effective sensor to meet EU policies requirements
13:35-13:40	Discussion & Questions		

13:40-13:45	ENVIGARD	Björn Suckow	EnviGuard - Development of a biosensor technology for environmental monitoring and disease prevention in aquaculture
13:45-13:50			
13:50-13:55	MARIABOX	Matteo Bonasso	MARIne environmental in situ Assessment and monitoring tool BOX
13:55-14:00	Discussion & Questions		
14:00-14:05	NEXOS	Eric Delory	NeXOS - Multifunctional Web Enabled Ocean Sensor Systems for the Monitoring of a Changing Ocean
14:05-14:10	Discussion & Questions		
14:10-14:20	Short Break		
14:20-14:25	SCHEMA		
14:25-14:30	Discussion & Questions		
14.30-14:35	SENSEOCEAN	Doug Connelly	SenseOCEAN – Marine sensors for the 21st Century
14:35-14:40	Discussion & Questions		
14:40-14:45	SMS		
14:45-14:50	Discussion & Questions		
14:50-14:55	BRIDGES	Michael Field	Bringing together Research and Industry for the Development of Glider Environmental Services
14:55-15:00	Discussion & Questions		
15:00-15:05	Sea-on-a-Chip	Mariella Farre	

15:05-15:10	Discussion & Questions
15:10-15:30	Break, networking and refreshments
15:30-17:00	Round Table Session - What can Ocean of Tomorrow do for you?

The list of attendees is shown in Table 10 below.

Table 10 OoT meeting attendees

First Name	Surname	Email Address
Chris	Cardwell	chris.cardwell@noc.ac.uk
Hugo	FERREIRA	hf@lsa.isep.ipp.pt
Mary-Lou	Tercier-Waeber	marie-louise.tercier@unige.ch
Bjorn	Suckow	bsuckow@ttz-bremerhaven.de
Marinella	Farre	mfuqam@cid.csic.es
Pamela	Cardillo	pamela@aquatt.ie
Carla	Sands	carla.sands@noc.ac.uk
Lola	Rodriguez	lrodriguez@leitat.org
Enoc	Martinez	enoc.martinez@upc.edu
Simone	Meme	simone.meme@plocan.eu
Jan	Van der Meer	janroelof.vandermeer@unil.ch
Joaquin	Del Rio	joaquin.del.rio@upc.edu
Doug	Connelley	dpc@noc.soton.ac.uk

Matteo	Bonasso	matteo.bonasso@kontor46.eu
Damien	Malarde	dmalarde@nke.fr
Mark	Bowkett	mbowkett@tellab.ie
Sergio	Martinez	smartineznavas@leitat.org
Patrice	Brault	pbrault@nke.fr
David	Turner	dturneresq@gmail.com
Sagar A	Sumaria	info@soethicalmedia.com
Marie-Camille	Lemee	mariecamille.lemee@gmail.com
Torsten	Thiele	tors10th@icloud.com
Elizabeth	Paull	epaull@aquatecgroup.com
Andy	Hamflett	andy.hamflett@nlaltd.co.uk
Kieran	Breheny	kieran.breheny@h-scientific.co.uk
David	Elson	david.elson@innovateuk.gov.uk
Alessandro	Giusti	alessandro@cyric.eu
Jose	Pinto	zepinto@fe.up.pt
Jose	Braga	jbraga@lsts.pt

OI 2016 Ocean of Tomorrow Open Meeting Notes.

A representative for each project gave a “flash” 5 minute presentation.

- **BRAAVOO**: Jan Roelof van der Meer, *"Biosensor developments in the BRAAVOO project"*
- **COMMON SENSE**: Sergio Martinez, *"Cost effective sensor to meet EU policies requirements"*

• **ENVIGARD**: Björn Suckow, *"Development of a biosensor technology for environmental monitoring and disease prevention in aquaculture"*
• **MARIABOX**: Matteo Bonasso, *"MARIne environmental in situ Assessment and monitoring tool BOX"*
• **NeXOS**: Eric Delory, *"Multifunctional Web Enabled Ocean Sensor Systems for the Monitoring of a Changing Ocean"*
• **SCHeMA**: Mary-Lou Tercier-Waeber, *"Integrated In situ Chemical Mapping Probes"*
• **SenseOCEAN**: Doug Connelly, *"Marine sensors for the 21st Century"*
• **SMS**: Sergio Bodini, "Sensing toxicants in Marine waters makes Sense using biosensors"
• **BRIDGES**: Michael Field, *"Bringing together Research and Industry for the Development of Glider Environmental Services"*
• **Sea-on-a-Chip**: Mariella Farre, "*Real time monitoring of SEA contaminants by an autonomous Lab-on-a-CHIP biosensor"*

Stakeholders – what can OoT do for you?

As the meeting did not attract the number of stakeholders hoped for it was discussed how the projects could target them better. As most projects are required to create a stakeholder engagement document as one of the deliverables, it would be a good idea to share these. There was also a concern due to overlapping stakeholders that if all the projects were to contact them separately we could flood them and thus disengage them.

It was considered a good idea to involve EC project Columbus and collaborate with them to increase engagement. Pamela Cardillo offered to make contact with Columbus and see if this would be something they would be interested in.

MariaBOX has a Work Package task to create a business interest group and is willing to share the information from this.

Another stakeholder event should be arranged (in 2017) and broadly advertised to ensure attendance.

It was also discussed that it would be a good idea to separate the stakeholders into two groups, such as producers and buyers as they have very different interests and therefore should be targeted differently.

BRIDGES commented that they use the Marine Cluster and considered them an efficient go between with BRIDGES and stakeholders and that maybe that is something OOT should consider.

It was also commented on that it was hard to get stakeholder involvement in meetings in other countries to where they are based and that we should use the diversity of the consortia to our advantage. However there is no replacement for having an expert present but we should share our documentation and become more proficient at being able to represent one another. This needs some co-ordination and dissemination of international events. Johan Gille offered to volunteer but stressed that he needed commitment from all the projects.

Events

Linking stakeholder events onto international meetings such as Oceanology International proves more effective than having separate stakeholder events as the stakeholders would already be present and wouldn't need extra resource to attend. We need to start identifying future international conferences for opportunities, the Columbus project may be able to help with this.

SCHeMA has to hold a stakeholder workshop as a deliverable on their project so it might be useful for them to organize the next event.

Sea-on-a Chip commented that they invite stakeholders to technology meetings but as they are a small project do not get a great response so are very keen on combining their efforts with other projects.

Patrick Farcey - **Platform sharing (JERICO NEXT)**

The project JERICO NEXT has 35 infrastructures available for deployment through TNA calls. The project will pay for T&S provided the infrastructure is not available within your home country.

They can help with:

- ✓ Sensor calibration
- ✓ System validation
- ✓ In situ long term testing (up to 6 months)
- ✓ Cross calibration with existing systems
- ✓ Antifouling
- ✓ Remote access real time data
- ✓ Capacity building

Handouts were distributed. The first call opens 2nd May 2016 (deadline 11th July 2016).

Contact email: jerico.tna@ismar.cnr.it

It was also stressed that it was not a complicated process to get access to JERICO infrastructure, there are more facilities than demand so good proposals will get through.

EC project AtlantOS was also mentioned as they are trying to improve access to platforms in countries such as the US/Canada/Brazil which you cannot access through the TNA system.

Bartering of oceanographic observatories – similar to the OFEG system may be available in the future.

Common Visualization and Intercomparison Approaches

Intercomparison Approaches

Comparisons could be made in a number of ways such as trading samples or sharing platforms. However some samples cannot be traded due to degradation.

It was suggested the group could try to draw together at testing events such as The Nutrient Challenge or XPRIZE.

SCHeMA has a deliverable on best practice on intercomparison. Would Mary-Lou mind taking the lead on this?

Common Visualization

It would be good to have a sensor observation client that would pull all data from all sensors and places to a common platform, or all sensors in the same place or on the same platform.

Next Meeting:

Suggestions included:

- Poland on 17-19th May. Lola Rodriguez will send out details
- Seatech week in October
- Martech in October in Barcelona
- EuroGOOS workshop in June – probably too soon

Also a teleconference in 6 months' time (October)

Actions

1) **All:** Share a stakeholder engagement document on OOT dropbox
2) **Pamela Cardillo:** To make contact with Columbus and see where they are willing to collaborate
3) **Johan Gille:** To coordinate stakeholder engagement

4) **Joaquin Del Rio:** To take lead on development of common visualization
5) **Lola Rodriguez:** To send out details of meeting in Poland 17-19th May

3.3.4 OoT closed meeting

The attendees list is shown in Table 11 below.

Table 11 OoT closed meeting aattendees

Name	Project	Organization	email
Simone Memè	Nexos	PLOCAN	simone.meme@plocan.eu
Sergio Martinez	CommonSense	LEITAT	smartineznavas@leitat.org
Lola Rodriguez	CommonSense	LEITAT	lrodriguez@leitat.org
Pamela Cardillo	CommonSense	Aquatt	pamela@aquatt.ie
Matteo Bonassio	MariaBox	Kontor46	matteo.bonasso@kontor46.eu
Alessandro Giusti	MariaBox	Cyric	a.giusti@cyric.eu
Matt Mowlem	Sense OCEAN	NOC	matm@noc.ac.uk
Johan Gille	Nexos/Bridges	Ecorys	Johan.Gille@ECORYS.COM
Sophie Leeuwenburgh	Bridges	Ecorys	sophie.leeuwenburgh@ecorys.com
George Tzimourtot	NeXOS	Ecorys	George.Tzimourtos@ecorys.com
Doug Connels	Sense OCEAN	NOC	dpc@noc.soton.ac.uk
Eric Delory	NeXOS	PLOCAN	eric.delory@plocan.eu
Jay Pearlmann	NeXOS	IEEE	jay.pearlman@ieee.org

Laurent Mortier	Bridges	Ensta	mortier@ensta.fr
Michael Field	Bridges	Armines	michael.field@upmc.fr
Mark Bowkett	CommonSense/Sense OCEAN	-	mbowkett@tellab.ie
Sergio Bodini	SMS	Systea	sergio.bodini@systea.it
Chrysi Laspidou	SMS	Thessaly Univ	laspidou@uth.gr
Luca Sanfilippo	SMS	Systea	luca.sanfilidro@systea.it

Introduction

The meeting began with the message that although we need to respect our own project commitments there is a real need to work together.

The ALSO meeting in February 2015 was brought up and there was a desire to compare the OoT group thoughts then to thoughts now on the following items:

- Standards and best practices
- Common interface standards
- Exchange of toxin samples
- Chemical and methods
- Continuity of work after project completion
- Addressing antifouling
- Assessing cost-benefit and what would be worthwhile for individual projects

This was followed by a more formal Agenda:

- Data and information system protocols
- Platforms for testing
- Best Practices
- Joint Dissemination

Data and information system protocols

There is a desire for all projects to be using the same data and information system protocols.

Common Sense and NeXOS are using the SWE and Puck protocol, whilst Sense OCEAN, Mariabox and SMS are all using their own variants of this.

There is a need to demonstrate interoperability and front-end data visualization from different projects. (Using our SOS to visualize sensors from other project and vice-versa)

There are some details of standards used on a spreadsheet in the OoT dropbox, however creation of a more detailed library of documents to focus standards would be of benefit.

Further discussion on the implementation of standards is to be held on 16/03/16.

Platforms for testing

There is a need for more ship time and opportunity for sensor demonstration. A suggestion was for each project to put opportunities they were aware of online so projects could check the websites when planning a deployment. However it was pointed out that these deployments were already available to all in one single place (rather than multiple websites) on a spreadsheet in the OOT dropbox. This spreadsheet should be kept updated and if anyone does not have access they are to contact Sergio Martinez (smartineznavas@leitat.org) to be granted access.

It was also noted that it may be attractive to test similar sensors from different projects together.

Common measurements

Possibly add tests to dropbox so we can compare and get gold standard measurements. TELLabs are manufacturing samples, which could be shipped frozen to partners then results compared.

EC project EMSO are testing new technology so maybe we could tie in with them. Also competitions such as Xprize and The Nutrient Challenge are good opportunities to compare our sensors with industry.

Best Practices

The EC Project AtlantOS is tasked with building a compendium of Best Practices and we should work in conjunction. EC project JERICO has offered to share their best practices, we should use this information and build on it.

Do we want to add a registry to the spreadsheet in the OoT dropbox and add our best practices?

Joint Dissemination

We would like to spread this beyond the lifetime of the project – it may be possible to do this within the AtlantOS project.

3.3.5 SWE workshop

During the workshop, NeXOS partners had the opportunity to participate to different conferences and activities providing information on the progresses done under the project framework until March 2016.

Sensor Web Enablement (SWE) workshop UPC attended the SWE workshop entitled

Workshop Sensor Web Enablement (SWE) for oceanography, status of developments, international coordination and dialogue with industry, hosted by the EU-EuroFleets II project

Place: Oceanology International 2016, Room 6 South Gallery of the Excel Centre, London, UK

Date: Tuesday 15 March 2016, 13.30 – 17.00 hours;

Contact: Dick M.A. Schaap – MARIS (dick@maris.nl)

Program

Presentations of 15 minutes with 5 minutes spare for some direct questions

13.30 – 13.40 hours – registration

13.40 – 13.55 hours – Introduction by Dick M.A. Schaap – MARIS (Netherlands) (short intro about Eurofleets, SWE importance and cooperation between several EU projects; programme of the Workshop; aims of the Workshop to establish dialogue with other interested parties, including industry, in particular manufacturers of platforms and instruments);

13.55 – 14.15 hours – The Eurofleets2 on board data management system (EARS) development by Jordi Sorribas – CSIC (Spain) (development of EARS for research vessels with functions and modular components; illustration how SWE standards will streamline the data flow from shipborne instruments to EARS to the shore; short explanation of developed profiles for selected instruments)

14.15 – 14.35 hours - *Sensor Web Enablement (SWE) standards by Joaquin del Rio, UPC (SPAIN) (SWE, its components* (SensorML, O&M, SOS), PUCK for automatic configuration, state of the art and examples)

14.35 – 14.55 hours – Importance of Controlled Vocabularies by Alexandra Kokkinaki – NERC-BODC (United Kingdom) (importance of vocabularies; SeaDataNet NVS services; ongoing developments as part of the Sense OCEAN project)

14.55 – 15.25 hours – break for refreshments

15.25 – 15.45 hours – The X-Domes project by Janet Fredericks – WHOI (USA) (the X-Domes project, its objectives and activities)

15.45 – 16.05 hours – Presentation by Elena Partescano – OGS (Italy) (presentation of the pilot with SWE for observation platform(s) in the Adriatic Sea)

16.05 – 16.25 hours – Presentation by Paolo D'Angelo – ETT (Italy) (the Schema project with involvement of industry, SWE application, and links to the European EMODnet Physics portal giving overview and access to metocean data streams)

16.25 – 17.00 hours – Panel discussion and wrap-up by Dick M.A. Schaap – MARIS (Netherlands)

Abstract:

OGC provides a family of standards specifications called 'Sensor Web Enablement' (SWE) which includes detailed information about the sensors making measurements and the platforms that carry the sensors using the Sensor Model Language (SensorML), general models and XML encodings for sensor Observations and Measurements (O&M), and a protocol to provide access to observations from sensors and sensor systems in a standard way (Sensor Observation Service (SOS)).

Various projects in Europe, USA and Australia are making progress with adopting Sensor Web Enablement (SWE) and developing SWE standards. These can be applied by operators of operational marine observation systems to describe in more detail their observations and to provide standardised access to these observations using the Sensor Observation Service (SOS) protocol. This can provide a way for direct access to the related data streams from operational sensor systems, such as real-time ocean monitoring networks and underway data from systems on board research vessels.

Partners from several EU funded projects and initiatives in Europe (such as Eurofleets2, SeaDataNet II, BRIDGES, FixO3, JericoNext, NeXOS, SenseOcean, Schema, ODIP II), USA

(IOOS, X-DOMES), and Australia (AODN) have teamed up to avoid interoperability issues and to tune the development of marine profiles of OGC SWE standards that can serve as a common basis for developments in multiple projects and organisations.

The SWE Workshop at OI2016 will give an overview of the present state of developments and a panel discussion. Manufacturers of instruments and platforms are invited for sharing their views on adoption of SWE standards. This should give a fruitful dialogue for finetuning SWE standards in the near future.

Aims of the Workshop:

- Dissemination and creation of awareness within a larger audience of what we are doing and what it might bring them
- Identification of industry contacts to start a further dialogue, followed by possible collaboration and implementation opportunities.
- **Who can attend**: the workshop is open for everybody. Target persons are developers and managers of operational oceanography observing systems on board of vessels and on networks of observation platforms; manufacturers of observation instruments and manufacturers of observation platforms; marine and ocean data managers.

3.3.6 OoT Data working group

The data interoperability working group was created as a follow-on to the OoT closed meeting discussed in 3.4 above. A webex meeting was held on May 2nd. The minutes of the meeting of the OoT data interoperability WG are provided below.

The meeting was attended by Justin Buck, Joaquin del Rio, Cristiano Fugazza, Simon Jirka, Thomas Loubrieu, Enoc Martinez, Jay Pearlman, and Daniel Toma.

The agenda started with a discussion of approaches and possible collaboration in the data and interoperability elements of the sensor and observation systems. NeXOS and Common Sense are adopting the PUCK/SWE with sensor ID, characteristics and data transmitted from the platform to the repository. Sense Ocean embeds an ID in the sensor and then transmit that plus data to repositories. The ID is referred to a look up table to get the sensor characteristics. The latter reduces both the need for new platform interfaces and the bandwidth requirements to adapt to current platforms. The former reduces the sensor configuration uncertainty and facilitates platform integration once interfaces for PUCK are available.

With respect to data access, NOC has developed a logic to use ERDAPP for brokering and a related interfaced with US IOOS. They have a document on this they offered to the WG. Derrick Snowden is hosting a meeting next week on the subject. For Sensor Web Enablement (SWE), Simon Jirka led a discussion on a common template form the SWE marine profile that could be adopted by all projects. Thomas said that he was doing a SWE template for AtlantOS. Bridges is also working in this area. In addition the SWIKI marine profile group is collecting approaches. Simon said that he would have a *document ready for review* in about two weeks. A focus meeting in this area was set for mid May (later set for May 18) to discuss/review the document.

There was agreement also to address SensorML as part of this activity. Christiano may lead this - confirmation needed. There was interest in having Flow diagrams for sensor and observations data for each of the OoT projects to then be discussed by the WG. Daniel offered to provide one from NeXOS. Justin said he would contact Alexandra for a diagram. The question was raised if we should address best practices that should go beyond formal standards. It was agreed to address this initially by email. We discussed the idea of a common visualization. There was interest and it would be good to have a discussion in the next month.

Figure 15 OoT data interoperability working group

3.3.7 Blue Economy conference

Oliver Zeilinski from UNOL participated in the Blue economy conference. He was a panel member in the sensor innovations session. He gave a resentation (10 minutes, 10 slides) and answered a subsequent number of questions as well as general panel discussion on sensor innovations. There were over 60 attendees.

The ECORYS team attended a session on Marine technology and service sector role in the blue economy: various presentations were given on the use of different forms of monitoring and their added value to economic sectors. However there was no quantification of such and it appeared that a number of methods are still in a pre-development (low TRL) stage.

During the Maritime clusters session, a panel debated on how to develop maritime clusters and how collaboration plays an important role. Examples were given of various marine sectors using monitoring as one of their support mechanisms

Underwater autonomous vehicles session - UAVs will be an important category of platforms to carry sensors, and improvements made there (such as battery quality, navigation depth & duration) will be important factors for the increase of quality of sensors (e.g. less power use, interoperability).

3.3.8 Other activities

In addition to the demonstrations and workshops, the NeXOS partners had many opportunities for one-on-one discussions.

For example, the UNOL team noted that they met with the following peopl*e*

- 15.3.16 SeaBird Scientific, Geoff MacIntyre, Director, General interest in future sensors and interoperability, also for Float platforms
- 16.3.16: CNRS-Laboratoire Oceanographic de Villefranche, Dr. Edouard Leymarie, Engineer responsible for the Bio-Argo-Float integration of optical sensors. Showed O1 sensor and other NeXOS innovations, including OGC-PUCK interoperability.
- 17.3.16: Scott McLean, Technical Coordinator of Ocean Network Canada, Victoria BC. Interested in OGC-PUCK capable sensors for integration in cables observatory.
- 17.3.16: Annie Nguyen, Shell Xprize, Interested in optical sensors for biogeochemical parameters and hazards
- 17.3.16: Wolfgang Zahn, Project Funding Organization in Germany, Interest in OoT innovations in general and especially in the progress in standardized interfaces

3.3.9 OI mini-workshop Summary and Conclusion

The NeXOS team was very positive about the time spent at OI2016. NeXOS partners believed that it is important to be present for such type of events. It represents a huge effort, as there are so many activities, but it is an effective way to show what we are doing in the project, to the community a large. Conferences and journals are not always as "open" to the community as the OI is. Posters and flyers were present at the OoT booth and were appropriate. Given the fact that all OoT projects provide a good dissemination strategy, the NeXOS project needs to think about even more targeted and appealing ways of presenting its results. As a side note, it is important to advertise and cross-link all our NeXOS presentations (such as the SWE presentation by UPC and the blue economy panel participation by UNOL).

The booth, the presentations, and the posters were appropriate for the different target audiences. The feedback from stakeholders after the demonstrations was very positive. The matrixFlu achieved a positive resonance due to its flexibility, ruggedized and very compact design. A very positive response was seen for the NeXOS interfaces (OGC-PUCK, plug-and-sense capacity, Sensor Web Enablement) as well.

During the three days of the conference, team members had conversations with exhibitors in almost every booth relative to sensors and monitoring. The NeXOS team approached a variety of exhibitors ranging from all-around solution providers (e.g. Kongsberg, Sea-Bird, Teledyne) to instrument (e.g. RTSYS, Valeport) and ROV manufacturers (e.g. Saab Seaeye), cable providers etc. The discussions revolved around what are the major shortcomings of today's sensors and relevant instruments, where can new developments add the most value and what is their view on goals the NeXOS partners are working on achieving (interoperability, standardization etc).

As a first conclusion, it is necessary to mention the variety of different perspectives and how this impacts the approach to exhibitors. People from all-around companies like Teledyne and SeaBird tended to agree with the need for further technological development but pointed out that they offer all solutions with their products, a sort of one-stop-shop solution. Furthermore, they depicted that standardization has major drawbacks as each specific client has very specific needs and that brings customization requirements. The same are applicable for the data produced, as well as for security/secrecy reasons.

Exhibitors that do not provide directly sensors but make products that facilitate the use thereof (ROVs, vessels etc.) tend to have a different view. For example, Saab Seaeye representative pointed out that incompatibility between sensors (different cables, fitting needs etc.) results in a great percentage (80% he stated) of deployment preparation time being consumed in fitting and plugging in different modules. Probe manufacturers, vessel providers etc. shared a similar opinion. Other benefits that were pointed out from a possible standardization between sensors are:

- Avoiding having duplicate sensors on the same platform (thus more space for other instruments or less energy needs)
- Minimization of production time
- Less mistakes in preparation procedures
- Possibility to scale up through selling of databases

Generally, the main notion was that incompatibility drives costs up from a logistics point of view. On another note, most of the exhibitors agreed that current technology is sufficient for the market needs and that issues regarding size, weight and depth capability can be solved directly or indirectly.

Finally, the only point where all of the approached representatives seemed to agree upon was the importance of power consumption. Although energy storage solutions are evolving very fast (reaching 600Wh/kg in 2018), providing higher capacity, low power consumption by the sensors was deemed the most important factor in achieving added value. Besides the cost of batteries itself (reaching 9000 euros/kWh in 2018), a large portion of the costs has been identified to come from the need to visit deployment sites often, due to power restrictions. That translates into a lot of man-hours as well as the additional costs of operating/renting suitable vessels for transportation.

3.3.10 Picture gallery

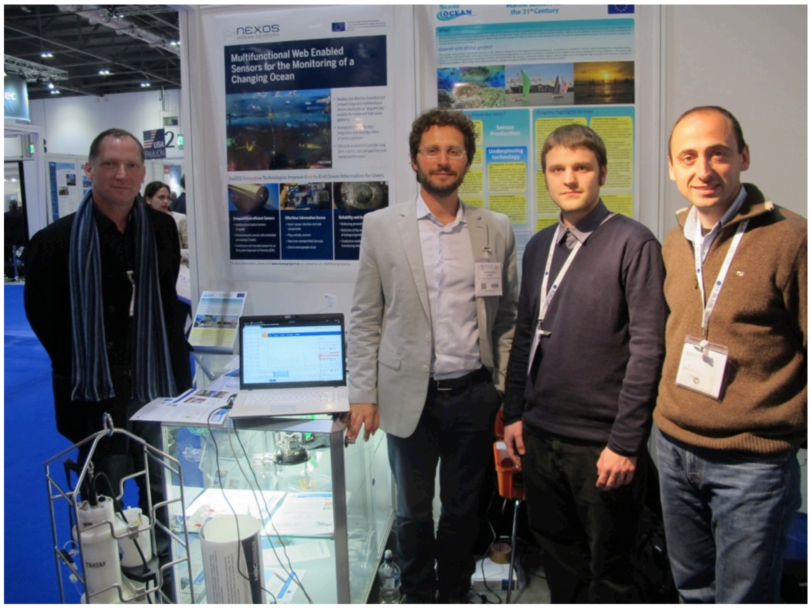

Figure 16 NeXOS booth displays with Eric Delory, Simone Meme, Daniel Toma and Joaquin del Rio (left to right)

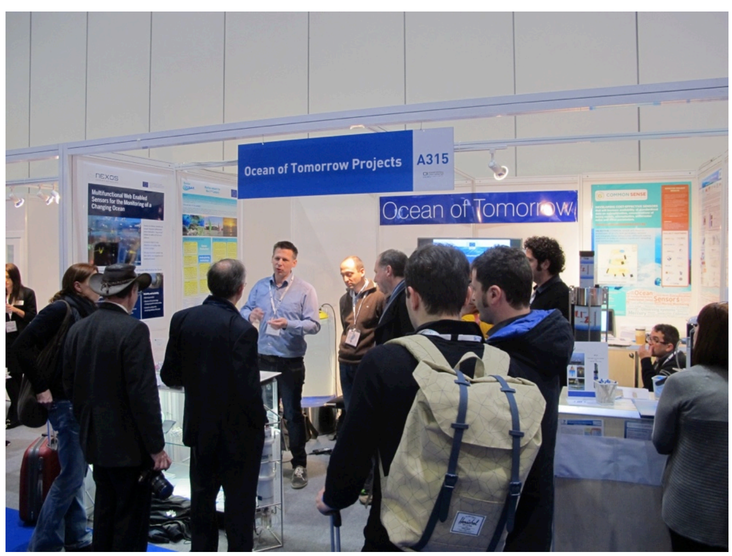

Figure 17 NeXOS sensor demonstration

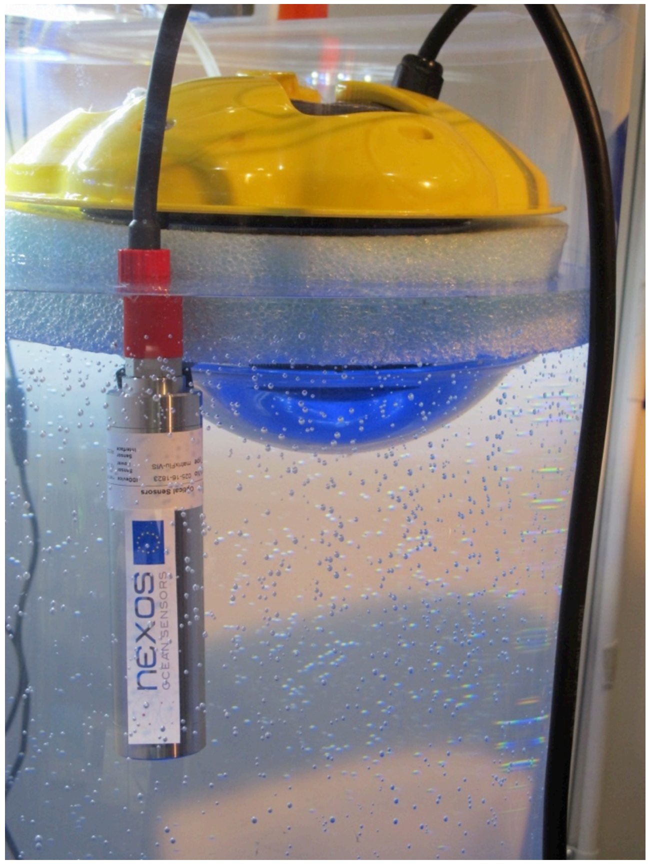

Figure 18 O1 and A1 sensors in demonstration tank

Figure 19 Sensor innovation discussion, Marylou Tercier (SCHeMA) and Jay Pearlman (NeXOS)

4 Workshop 3

The third NeXOS workshop was conducted in conjunction with the IEEE 2017 Ocean conference, in Aberdeen, Scotland.

4.1 Workshop 3 introduction

The Oceans 17 MCS/IEEE conference, held in Aberdeen Scotland, June 19 through 22, carried the theme of "A vision for sustaining our marine futures ". Fitting well with the theme, was an active participation from the NeXOS team, to include: the invited closing plenary presentation by Eric Delory, NeXOS coordinator; contributions to the technical program with focus on the new cost-effective sensor technologies (presentations/papers on passive acoustic sensors)– Eric Delory, optical sensors – Oliver Ferdinand, and sensor/platform system integration – Lars Golmen); a one-day workshop coordinated by the IEEE NeXOS team on Oceans of Tomorrow (OoT) sensors, followed by a panel of stakeholders. The NeXOS technical presentations, together with the stakeholder panel, form NeXOS workshop 3. A summary report of Workshop 3 follows.

4.2 Summary of technical presentations/papers

***NeXOS, Developing and evaluating a new generation of in-situ ocean observation systems* - Jay Pearlman**

Many changes are occurring in the ocean, not only in physical properties such as temperature warming, but also in the chemistry and biology of the ocean. Understanding how these changes are driven and their sensitivity to inputs is an element of the key environmental descriptors identified by the European Marine Strategy Framework Directive (MSFD). The Marine Directive aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020. The ultimate goal is to protect the resource base upon which marine-related economic and social activities depend. The Directive furthers the ecosystem approach to the management of human activities having an impact on the marine environment, integrating the concepts of environmental protection and sustainable use. In-situ data are necessary for comprehensive modeling and forecasting of ocean dynamics. Yet, collection of in-situ observations on the needed scales of space and time is inherently challenging and prohibitive from the perspective of both time and resources. This paper addresses the innovations and significant developments in NeXOS for a new generation of acoustic, optical and fishery in-situ sensors that address these challenges. These sensor systems are multifunctional (single sensor systems addressing several phenomena), can be deployed on a large majority of ocean monitoring systems from surface to the seafloor, and operate for long periods with less maintenance. In addition, at the system and user interface level, the publication of data uses processes and formats conforming to OGC SWE standards and consistent with global ocean observing initiatives and ocean portals such as the Copernicus marine environment monitoring services. During the last three years, NeXOS has achieved a number of milestones, providing ten new sensors along with important transverse capabilities for anti-fouling and data management. The optical sensors include monitoring of marine contaminants such as hydrocarbons and components of the carbon cycle. New sensor systems for passive acoustic measurements with extended dynamic range include internal post-processing of acoustic information to reduce communication loads. Two additional sensors (chlorophyll-a and oxygen) have been added to the Recopesca system to support an Ecosystem Approach to Fisheries (EAF) for improving measurement of stock relevant parameters, such as fluorescence (proxy of chlorophyll-a) as well as physical parameters (T, S, Depth) and fish species. Interface with the sensors is through a miniaturized smart sensor interface common to all new NeXOS sensor systems and a PUCK implementation facilitates streamlined platform interfaces. A common toolset for web-enabled and reconfigurable downstream services supports marine databases and data facilitators, from SeaDataNet to GOOS and the Global Earth Observation System of Systems (GEOSS). This paper provides description of sensors and their capabilities along with validation testing.

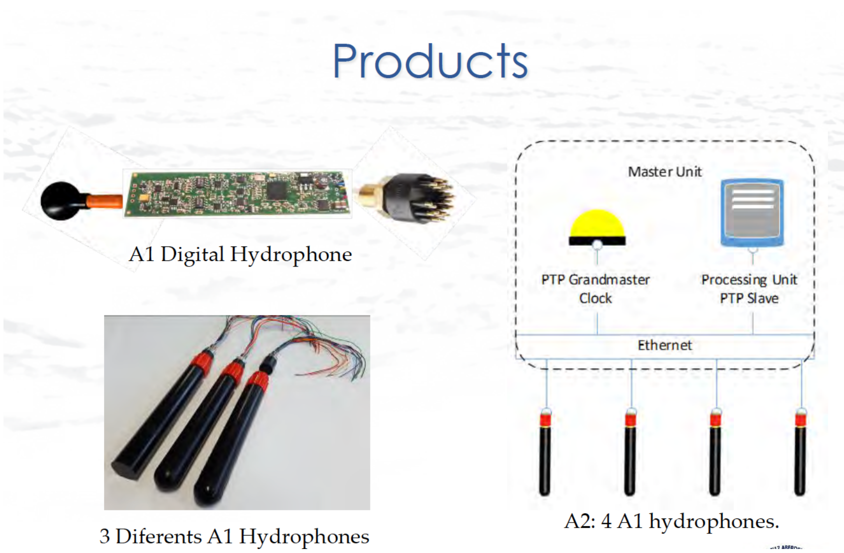

Figure 20 NeXOS acoustic sensors

***New compact passive digital acoustic sensor devices with embedded preprocessing* – Eric Delory**

The development of new cost-effective and compact multifunctional sensor systems for a sustainable and integrated approach to ocean monitoring is the main objective of the NeXOS project. Within this context, the company SMID Technology manufactured two passive acoustic sensor systems, A1 and A2, as new types of small dimension, low power and innovative digital hydrophone systems. A1 is a standalone small, compact, low power, low consumption digital hydrophone with embedded pre-processing of acoustic data, suitable for mobile platforms with limited autonomy and communication capability.

A2 is a compact volumetric hydrophone system, enabling real-time measurement of underwater noise and of several soundscape sources. It consists of an array of four A1 digital hydrophones with Ethernet interface and one master unit for data processing. A2 is is mainly designed to be used on fixed platforms with less limited power autonomy and/or communication capability.

Next generation fluorescence sensor with multiple excitation and emission wavelengths – NeXOS MatrixFlu-UV – Oliver Ferdinand

Ocean health observations have been performed for hundreds of years. Optimizing the process of gathering information on status as well as changes of oceanographic parameters through research cruises is however still challenging and recently developed robotic opportunities need to be enhanced. Using mobile and autonomous platforms like gliders, buoys and surface platforms (here sailbuoys) is an innovative and cost-effective way to obtain large datasets even under unfavorable conditions.

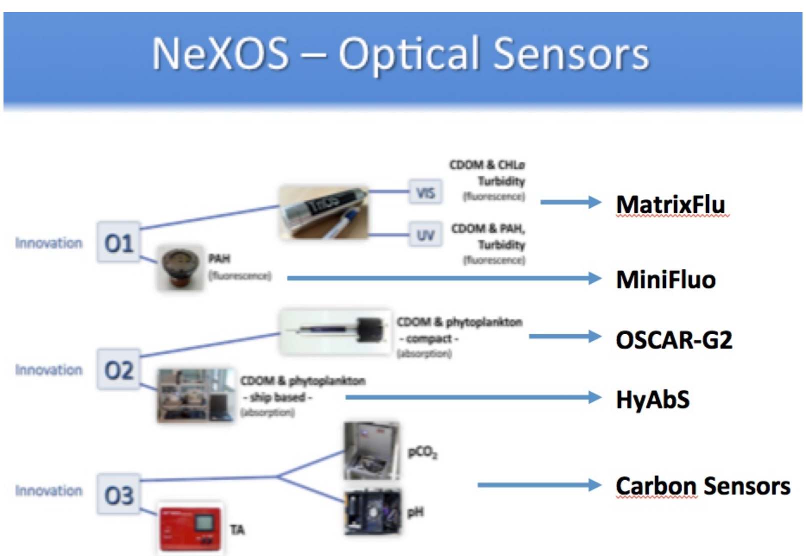

Figure 21 NeXOS Optical Sensors

Developing suitable sensors, like the optical fluorescence sensor MatrixFlu-UV, which can be deployed on those platforms, is one of the major goals of "Next generation Low-Cost Multifunctional Web Enabled Ocean Sensor Systems Empowering Marine, Maritime and Fisheries Management" (NeXOS, a European Union funded project). The sensor concept of multiple excitation and emission configuration, its proof-of-principle and verification results for colored dissolved organic matter related chemical compound humic acid are represented. An extended concentration series, using sensor and reference detector in parallel, showed clearly a linear correlation (coefficient of determination of R2 = 0.99) between data measured with the sensor and the reference measurement. In combination with the other wavelengths excitation-emission combinations, the MatrixFlu-UV offers a true ultra-compact multi-parameter option for upcoming ocean observation activities.

***Validation and demonstration of novel oceanographic sensors on selected measurement platforms in the NeXOS project*– Lars Golmen**

This presentation and paper describe the initial planning and outcomes of validation and demonstration efforts for oceanographic sensors in the EU-funded project NeXOS. The project has developed novel, multi-functional optical and acoustic sensors for environmental monitoring and mapping. These sensors are subject to validation and demonstration in real sea conditions, as illustrated in Table 12 below. The Platform/sensor pairing in NeXOS, according to platform owner and the TIVD plan numbering. A1 and A2 are the two acoustic sensors, single and array. O1 is the Matrix fluorometer, O2 is the cavity absorption chamber sensor and O3 means the carbon system sensors. EAF stands for environmental approach to fisheries. The target demonstrations are located in the Canary Islands, Spain (Can), Norway (Nor), and the Mediterranean sea (Med). Procedures for validations are described, followed by examples of successful demonstrations provided either delayed or real-time, to users through a Sensor Web Enablement capability developed in the project. An end-to-end approach warrants full coverage of the system engineering chain, i.e. from requirements to demonstration. The project is user- and market oriented. Scientific research, industry and manufacturers are working together to refine requirements and performance characteristics, on basis of user scenarios containing requirements on such as functionality and data quality.

Table 12 Validation and Demonstration activities

	matrix of platforms and sensors					
tivd #	**platform name**	**platform owner**	**type of platform**	**sensors to integrate**	**sensing principle**	**target demo mission**
A1.1 O2.2	estoc tb	PLOCAN	stand alone mooring	O2 Hyabs	passive acoustics and optics (fluor)	can4 can5
A1.2 O1.4	wave glider	PLOCAN	surface glider	A1 O1 matrixflu uv	passive acoustics and optics	can1 can2
A1.3	provor	NKE	profiler	A1 # 3	passive acoustics	can3
A1.4 mini.1 t3.2	sea explorer	ALSEAMAR	glider	A1 # 4, O1 miniflu antifouling syst	passive acoustics	nor2 nor1
O3.2	sail buoy	CMR	surface vessel	O3 cbon2-sv	optics	nor3
O3.1 O3.4	ferrybox	NIVA	vessel	O3 cbon2-fb O3-cbon3-fb	optics	nor5
O2.1 O1.2 O1.3	ferrybox	HZG	vessel	O2 Hyabs O1 matrixflu vis/uv	optics	nor4
EAF.3 EAF.5	fishing vessel	rec	vessel	EAF 3 EAF-5	optics	nor6
eaf.4 eaf.6	fos/foos vessel	CNR	vessel	EAF-4 EAF-6	optics	med3

O3.3 A2.1	obsea	UPC	fixed, cabled observatory	O3-cbon2-sv A2	optics and passive acoustics	med4 med2
A1.3	beacon	CNR	moored buoy	A1	passive acoustics	med1
t3.2-t3.3	biofouling test station	Ifremer	basin/pool	antifouling syst.	biofouling sensor	not defined

4.3 Stakeholder Panel

Jay Pearlman introduced the panel objectives. The preceding OoT sessions summarized the new cost-effective technologies being developed by the OoT projects. The resulting sensors have evolved from maturity level 4 to ready for manufacturing. In an earlier session, Jay asked Why should people care? “Seas and oceans have a huge impact on our daily lives, providing an essential part of our wealth and well-being”.

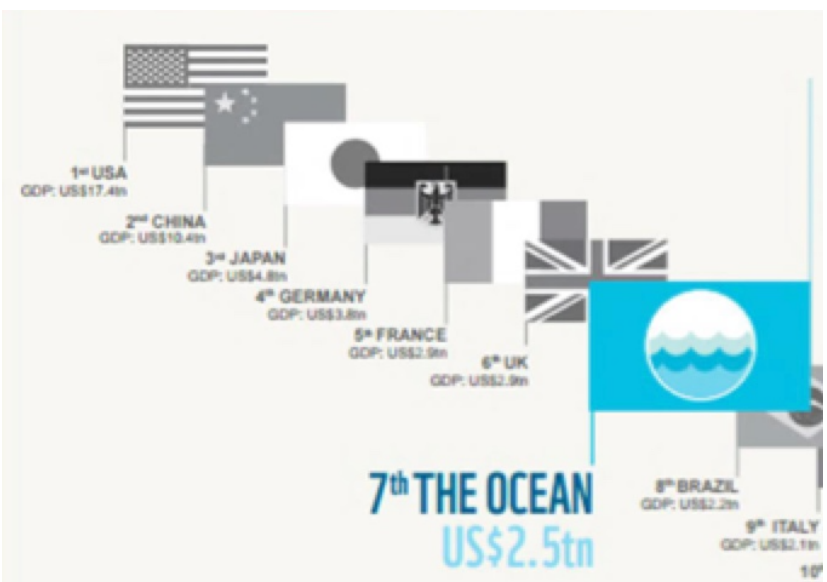

Figure 22 Blue Economy

They are not only a critical source of food, energy and resources, but also provide the majority of Europe's trade routes". The annual gross marine product, which is the equivalent of a country's GDP, would rank the oceans blue economy as number 7 worldwide, (Craig McLaine, NSF).

A diagram from GOOS ocean services comprised of climate, operational ocean services and ocean health. is rapidly decomposed into a multitude of threads; after 2 or 3 cycles, applications are pervasive, and need to be addressed in an integrated way.

The stakeholder panel includes six experts in the areas of coastal management, oil and gas, and fisheries. They come from science, industry and the European Commission. Table 3.1 below provides a list of the panel participants.

Before introducing panel members, Jay summarized a list of questions he had given to each of the participants:

- What are the key challenges for ocean observation in the area of interest;
- If we could improve the measurements, what difference would it make;
- What is the first application we should consider;
- What is the future vision, what path are we taking; and if anyone has a sense of it, what is the potential market size and timing and who are the customers.

These are important issues for the community developing sensors.

Table 13 Introducing panel participants

1. Applications Panel	Organization	Areas of interest
Gareth Davis	Aquatera	Marine Energy
Gordon Drummond	SubseaUK	Technology for subsea environment
David Green	University of Aberdeen	Marine and Coastal Zone Management
David Murphy	AquaTT	Knowledge Transfer for Impact
Iain Shepherd	EC DG Maritime Affairs & Fisheries	Environment/Fisheries
Tom Williams	Institute for Marine Research	The Reference Norwegian Fishing Fleet

Panel introductions

Dr. Gareth Davies is the managing director of Aquatera. He has worked as an environmental consultant for over 20 years. He trained initially as a marine biologist, obtaining his doctorate in deep-sea biology. Since founding Aquatera Ltd in 2000, Dr. Davies has been deeply involved in the development of the marine renewables industry in Scotland. During the last 17 years, He has lead and participated in many of the 100 or so studies that Aquatera has completed in this sector.

Dr. Gordon Drummond has been involved in the Subsea sector since 1994, initially offshore on diving vessels and more recently in an engineering capacity. Gordon has a PhD and MBA from the Robert Gordon University. In the last 10 years with Subsea 7, he has been leading and executing research initiatives and implementing them into the businesses as new capabilities. Presently he is the Project Director of the National Subsea Research Initiative (NSRI).

Prof. David Green is with the University of Aberdeen where he is Director - Aberdeen Institute for Coastal Science and Management as well as director of the Centre for Marine and Coastal Zone Management. He is a Fellow of the Royal Geographical Society (FRGS) and a Fellow of the British Cartographic Society (F.B Cart.S.) He has published a number of books on Coastal Zone Management and Geographical Information Systems (GIS). David is also Editor in Chief of the Journal of Coastal Conservation, Planning and Management (Springer).

Mr. David Murphy has managed AquaTT since September 2000 and has extensive experience of European Comission projects in education, training and RTD, having coordinated nine projects and participated in more than twenty-five others. He was facilitator of the Knowledge Management Thematic Area of the European Aquaculture Technology and Innovation Platform, which brought together private and public stakeholders to promote and coordinate research and development to improve competitiveness in the European aquaculture industry. David leads the AquaTT team in the overall design and implementation of proven methodologies for facilitative stakeholder consultation processes in AquaTT projects including the COLUMBUS project - Monitoring, Managing and Transferring Marine and Maritime Knowledge for Sustainable Blue Growth.

Mr. Iain Shepherd works in DG MARE, the Directorate-General for Maritime Affairs and Fisheries – where he is engaged in Maritime Policy in the Atlantic, Arctic and outermost regions. He has been addressing the importance of marine data for the development of the blue economy on local and regional level as well as European Knowledge Infrastructure towards a European Marine Observation and Data Network. He brings to the panel a strong knowledge of the issues relating to marine sustainability.

Figure 23 Panel members – Jay Pearlman, David Green, Tom Williams, David Murphy, Gordon Drummond, Gareth Davies, Iain Shepard (left to right)

Figure 24 Iain Shepard European Commission DG Mare

Mr. Tom Williams is a senior engineer with the research group at the Institute of Marine Research on Fisheries dynamics and is Project manager for the Norwegian Reference fleet. Comprising in 2017 14 large, high seas fishing vessels and 24 smaller coastal fishing vessels (9-15 meter), the Reference Fleet provides detailed information on catches and the overall fishing activities. The objectives of the activities are long-term and high-quality biological sampling of catches, documentation of fishing effort and species composition of total catches, collecting of special samples from fisheries and, of particular important, contributing to the development of cooperation between fishermen and scientists in areas of data, but also in motivating the fishing fleet as ships of opportunity. The panel participants then proceeded around the table addressing the questions asked earlier by Jay.

The panel participants then proceeded around the table addressing the questions asked earlier by Jay.

Iain Sheperd – he would like to address sustainability. It is very difficult to produce long time series in observations Since 2002 the EU has spent Euros70 Million Euros per year on fish information (length, age, weight, sex of the fish) and 20 Million on research., so more on observation than research. This is because the fisheries data are needed by the EU as it has exclusive competence in assuring the quality of the fish. On space measurements relevant to the ocean , they have spent170M per year (due to the space lobby. Overall, they spend 350 Million Euros on marine research, but nothing on observations. They are trying to build up a case for spending more on observations, by highlighting economic benefits due to reduction in uncertainty. As an example, they built a topographic map of Europe using old data put together; the UK met office said it ”massively” improved the storm surge in the North Sea.

We need more economic information to build a case.

Gareth Davies works in the marine renewable energy sector. In this sector, they were asked to observe the ocean in more detail. In the UK, probably 30% of the money used in this sector is funding research in marine observation. Measuring and understanding waves and tides is a challenge; they have point sources or small areas, but they do not have a transparency at a scale which relates to the structure they are putting in the water. The observation tools they have do not provide the wideness or the specificity of measurements needs. Just because we can measure something, does not mean that we should do it (do not burden industry sector unnecessarily).


Figure 25 Gordon Drummond

Gordon Drummond represents the national subsea initiative, which is charged with commercialization of oil and gas, wind, waves. For oil and gas, their key challenge is the movement to ever deeper water (2000 to 4000 meters, far off shore). In order to price structures, they need to know the weather and the behavior of the sea. Improved measurements would vastly improve pricing, making more applications economically viable. This applies to oil and gas, but also to other applications, such as offshore wind, floating wind, and sub-sea mining. The establishment of deep offshore structures, which need to be unmanned, will provide the first application, as they require measurements of significant wave height, and clear water currents. For the future vision, the focus is on reliability, and sustainability for the life cycle of these assets (30 years). Drift, and calibration are big issues. Market size and timing? There is a huge market, including energy, aquaculture resource, economic impact assessment, and environmental impact. Assessment. About the timing: it is coming soon.

David Murphy is general manager of AquaTT, a foundation. They manage knowledge research and bring it to end-users. This is done through dissemination, and technology transfer to industry. They partner with research consortia. For example, they helped with the generation of the Common Sense video, which was shown earlier. They also work on improving methodologies. The EU over the last 10 years has spent over 2 Billion Euros in marine research. Are we getting the value creation from this research? This is investigated under the COLUMBUS project (blue growth). They are researching old projects, capturing knowledge from those projects and looking at market readiness and applications for end users. If they see the potential, they try and transfer that knowledge to users in the value chain. For example, the commission has invested a lot in the OoT projects on sensors, which provide enabling technologies. COLUMBUS analyzes those projects, considering those, which are already on the market and those, which are at lower TRLs and need support or another mechanism to take them towards market. Their target is to remove regulatory barriers..

Tom Williams works for the Norwegian reference group. He is a middleman between the fishermen and scientists regarding communications and data collection. The fishermen measure and identify their catches, and collect the data that the scientists need to give good scientific advice. This started in 2000 for fisheries management. In addition, there are other uses for the reference group. The fishermen are out nearly every day and the scientists may need information such as heavy metal content in a particular location. The fishermen are trained in basic data collection and have the equipment on board. This provides an opportunity for quasi real time information. Regarding the question about key challenges – it is primarily cost; the institute has 5 research vessels. There is an additional one in Tromso, which does all the surveys; in comparison, the Norwegian fishing fleet has 350 high seas fishing vessels, and 6000 coastal fishing vessels. Applying these resources to ocean observations really provides benefits and reduces cost. They are thinking of establishing data sharing between the fishing fleet and scientists using crowd -sourcing methods (fishermen collect data which are shared back to them in a way which they find useful. They plan to demonstrate this approach in a project – catch data from large vessels can be packaged and redistributed providing tools for fishermen to plan their harvesting strategy (win win). There have been many discussions about data quality, scientists are interested in high quality data; the fishermen are interested in simple temperature data. Scientific grade sensors are expensive; fishermen sensors are not so. Are they going to start with what is available or what is really needed? The coverage of the ocean is much greater if you are willing to synch your requirements with the lower grade data. Then, it includes the fishing fleet.

Figure 26 Tom Williams

David Green is doing marine coastal management. He used to be a geographer with a lot of experience in environmental chemistry, oceanography, remote sensing and GIS. Quite a bit of his interest has moved to mapping the coastal environment. Because of the coastal zone management aspect, they are quite interested in the linkage between the coast and the marine environment. As a geographer, David is interested in spatial data and also changes in the environment; he and his colleagues are spending quite a bit of time moving toward larger resolution, higher scale information. Regarding the questions asked earlier, the focus would be on conversion of data to information. The growth in the smaller technologies is where his interest lies: Remote sensing, UAVs, SUVs, space born to high altitude aircraft, to under water. He particularly focuses on UAVs due to the need for high resolution data to fill some of the data gaps. In the coastal areas, they have now developed miniaturized sensors (they may not be cheap). He was quite interested in the last talk this afternoon in low cost systems. This is an area to watch; it is not perfect but is moving toward providing information, which can be useful for planning and decision-making. It is quite interesting to see the level of detail in the smaller low-cost platforms. The prices are still quite high but moving rapidly.

Jay Pearlman - another theme was developed, pervasiveness of data. How do you collect it; how do you know what is good and what is not good data? Also, in the long term, how do we get this technology to be used by more than the scientists for planning and decision making?

David Green – we have lots of data. We are gradually moving toward standards. The emphasis is on using the data. The example of the mobile phone and autonomous flight tools illustrate what is becoming possible.

Question from the audience

This last theme leads us to address the politics of data. Who gathers it; who owns it, who is going to pay for it; what is the security about it?

David Murphy – it is not just the questions about the data but what is the integrity of the decision making process. The technical quality of the data is often far better than the decision process itself. We need to address the disparity between what people think about the quality of the data and the opinion of the end user. We will be spending a lot of money to no purpose if we do not have confidence in the integrity of the decision making process.

Question to Tom Williams

With crowd sourced data, in addition to errors and inaccuracies due to the use of cheap sensors, could there also be an issue of deliberate distortion, given these highly competitive players?

Tom Williams

Data from fisherman has always be treated as nebulous. It was quite bold of the institute (IMR) to take the first step in 2000 when they started the reference fleet and started to collect the data and use it. It is important not to stop at the first hurdle. We should nor say - We do not know if we can trust the data, so we are not going to try it.

As an example, the reference fleet documents total catches. So each fisherman documents everything including what they throw over board, including possible illegal items. We have an agreement with the fisherman that the fish state will not be shared with the authorities, and the authorities respect that. They see that it is better if the fisherman can report honestly to us. There is still a lot of questions about the reliability of the data. For example, If you consider sea birds bycatch, what can you do with the data? If no sea birds were reported in the data, you could say that, but you do not know if it is true or not; if some sea birds are reported, there is at least a minimum of sea birds as reported. Looking for cost effective ways, you might learn through the process how to improve the data. Communication through the whole chain is very important. Because he is familiar with the data, he is aware of cases where scientists have misunderstood the data. Scientists should not use the data without finding out how it was collected and whether there was any potential bias.

Gareth Davies

There are incentives in all kinds of life for misrepresenting information, and there are probably as many scientists and instrument manufacturers as fisherman who to so. It is important not to target one group but rather show them that it is in their interest.

Comment from Jean-Francoise Rolin

The Reocpesca system is a French system which captures data from catches, temperature, salinity, and turbidity It took 7 years to put in place. There is a nice publication by one of their colleagues. The level of the scientists is the top level. It is a good model for deep-sea mining and other deep sea operations.

Jay Pearlman

How do you balance regulatory versus information; how do you balance the use of the information versus the collection?

Iain Shepherd – They collect data once and use for many purposes. When you use that strategy, it becomes hard to decide what to collect. Use bathymetry as an example; if you collect the data for navigation, or for storm surges, or wind farms, how do you decide what to collect with a limited budget. They had a group doing stress testing (for example site your wind farm), and found that the wind index was totally inadequate. They found similar situation for fisheries data, coastal data. They have a long way to go.

Gareth Davies

For AIS, you can go on an AIS website, and get density map of shipping levels, which can probably answer 99% of what you need. Before AIS you did not have any of that information. You are back to the level of information you need. We have far more data that we ever had in a whole history of mankind. Saying that we do not have enough data is an excuse. You have to start searching.

Comment from Eric Delory

For certain topics such as weather, met agencies or port authorities have a lot of data, but for others such as nutrients there is not much, For the marine strategy descriptors, lots of data are missing. There are gaps and technological solutions we are working on, and we hope that there is convergence in interests, leading to increased cost effectiveness. Eric notes that he has a hard time finding data in his own field, even though he knows that the data has been collected and has been told it is freely available. There is a lot to be done on certain components of the system to make sure the directive gets a response.

David Murphy

The Marine Strategy Framework Directive (MSFD) is a major opportunity for sensor projects. What he has not heard today is the cost benefit analysis; what are the options to measure one of the descriptors, and how would it be rolled out across the member states? How do you compare future potential solutions to the existing ones, Decide what is the cost now versus the cost in 5 or 10 years. Look at existing methods versus new methods coming from these projects to predict if it would be cost beneficial to use these methods and what regulatory approvals you would need to replace the existing methods.

David Green

Things are changing now. Take the example of the Scotland national marine planning directive. The original data set was quite limited and is now growing more and more rapidly. They are now thinking about the gaps. What do we need to do regarding planning. In the example of fishing, one may want plots on maps which fisherman are not ready to give you, but there are important elements for conflict resolution. Resolution of generalized data may work for selected areas of the coast,,, but not for hydrographic surveys. Solutions such as Lidar come up but do not work well in Scotland due to water-color; thus one needs to find other solutions. These things are coming to light very quickly. We have come a long way in 25 years.

Tom Williams

Keeping your good fishing spots secret. We split fisheries into two: pelagic fisheries where they go out and actively hunt moving schools of fish – they have always had a culture for sharing; for commercial fisheries (bottom fishing where the fish is more static) the good spots are kept secret. But that has changed a lot over the last few years due to AIS. Everybody knows where you are and if you stay in an area for a while, they know that something is going on. There is a change in the culture. Re proposing data sharing, there is still some resistance;

"we are quite happy to share but not in real time, may be in a week".

Jay Pearlman

Come back to an old subject – the gap between research and development and production; gap between creating capabilities and using the information for a specific purpose. Two of you are in that area (Gordon and Iain),The ocean environment in a new age. Are there differences between the way things can be and should be handled?

Gordon Drummond

The Marine energy space is a hostile environment. The better it is for the energy companies, the tougher it is for the rest of them. They go toward mechanization, increased automation, and communication. People working in this industrial environment go to work in a hostile site; they are 6 feet tall with big gloves and big boots. Compare this environment to the fragility of sensors in a lab environment.

David Murphy

At the macro level, society is better educated. The commission is looking for a value proposition creation for research investments. That is driving a focus on how to measure value creation for research. What are the processes in the life cycle to improve, optimize and get better results from research investment. How do you select priority needs, put out polls, and post -project support?

Gareth Davies

What is the most fundamental piece of data which is needed? It is the seabed. Having a topographical representation of the sea-bed at a reasonable resolution is step number 1.It feeds into fisheries, oil and gas, and also ecosystem considerations. Need to combine the technological knowledge with the inate/acquired knowledge from experience.

Comment – in Norway, all of the ships collect the topographical information and share it. "if you want the maps, join the club"

We reached the end of the session and Jay thanked all of the participants.

5 Summary and Looking Forward

The NeXOS outreach program was organized around mini-workshops, which were grouped into 3 workshops according to the phase of the project.

. Workshop 1 initiated the collection of sensor requirements, working with the oil and gas, fisheries and transportation industries during one-on-one interviews in Runde, Norway, with the Oceanographic platform manufacturers during OI 2014 in London, UK, and with the science community at EGU.

Workshop 2 focused on sensor innovations, development and transversal capabilities, as well as initial demonstrations of NeXOS passive acoustic and optical sensors. It included the: "Sensor Systems for a Changing Ocean" (SSCO), which was developed within the framework of the Brest Seatech week (October 2014) , and the Oceanology International 2016 which prioritized interfacing with prospective users, and sensor demonstrations. This second workshop engaged both the research and business communities (development and application themes) to review sensor and sensor system developments.

Workshop 3 marks the nearing of NeXOS completion. Within the context of the MCS/IEEE Ocean 17 conference, the NeXOS team presented the new sensor capabilities, in detail during the technical session, and engaged the stakeholder communities in a panel discussion.

The following quotes are illustrative of the key concerns of the stakeholders and should be of particular interest to sensor developers:

Building a case for observation – " they built a topographic map of Europe using old data put together; the UK met office said it "massively" improved the storm surge in the North Sea. We need more economic information to build a case.

For oil and gas, the key challenge is the movement to ever-deeper water (2000 to 4000 meters, far off shore). In order to price structures, they need to know the weather and the behavior of the sea. Improved measurements would vastly improve pricing.

Applying the resources of the Norwegian fishing fleet to ocean observations would really provide benefits and reduces cost.

They collect data once and use it for many purpose. When you use that strategy, it becomes hard to decide what to collect.

For the marine strategy descriptors, lots of data are missing. There are gaps and technological solutions we are working on, and we hope that there is convergence in interests, leading to decreased cost.

The commission is looking for a value proposition creation for research investments. That is driving a focus on how to measure value creation for research. What are the processes in the life cycle to improve, optimize and get better results from research investments?

What is the most fundamental piece of data, which is needed? It is the seabed. Having a topographical representation of the seabed at a reasonable resolution is step number 1.It feeds into fisheries, oil and gas, and also ecosystem considerations.

Appendix I – Blank questionnaire for assessing requirements evaluation (used on March 12 for both sessions).

Note: the questionnaire below was used by attendees for both sessions. Subsequently, the questionnaire was updated, and the updated version was used for the next workshop.

Questionnaire on Sensor Requirements

Description of the sensor application scenario (text)

Sensor and System Parameters of interest (Listing)

Measurement Applicaton - Parameter 1

<u>Sensor Characteristics</u>

a. Range, accuracy, precision

b. Temporal sampling scheme (response time)

c. Communication requirements (real-time or internal storage)

d. Size and constraints

e. Power and operations cycle

f. Costs

i. How many ocean sensors do you buy or sell annually?

ii. What is the approximate purchase price per sensor?

iii. What is the price with respect to the deployment platform?

iv. Is cost of observation a relatively minor or major issue in your activity?

v. Calibration requirements

Deployment configuration

1. Platforms

2. Spatial distribution of sensors (depth, horizontal distances)

3. Deployment time interval

Standards that have to be followed

1. Standard for time stamping

2. Standard for geo location

3. Interfaces

4. Data Standards

5. Mechanical integration

6. Testing procedures (pressure testing, calibration procedures, pre- and post-deployment procedures)

Special considerations

1. Environmental challenges,

2. biofouling

3. corrosion issues

4. Specific service and maintenance requirements

Any other comment

Name, Organization, Country, Date (text)

Activity sector(s) (text)

User / Operator / Consulting / Manufacturer (->OEM, Integrator, Service provider)/ Distributor (please circle)