Recommendations on communication platform and data standards to facilitate autonomous operations, high performance computing and the integration of large data sets.

DigiMon Digital monitoring of CO_2 storage projects

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Scope

D2.6 Recommendations on communication platform and data standards to facilitate autonomous operations, high performance computing and the integration of large data sets

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1.2	18.10.2021	Update after review by Norce	Kjetil Åsgard

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- TNO Nederlandse Organisatie voor toegepast -natuurwetenschappelijk Onderzoek
- Geotomographie GmbH
- LLC Lawrence Livermore National Security
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- REPSOL –NORGE AS

Commented [MBH1]: Dette er en glipp fra vår side. Vi glemte å legge Oxford inn i malen da de kom inn i prosjektet. Malen er oppdatert nå.

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1 Background

The use of standards for wired and wireless communication and power transfer in the subsea environment has lagged compared to use of standards on land (ref. telecom standards, wireless networks , power distribution etc.). Recent years has seen an increased focus on standards, pushed by oil and gas operators as well as other users of subsea control & communication systems, sensors and instrumentation. Work to agree on standards has to some degree been hampered by the ubiquitous use of proprietary legacy products.

Commented [HI2]: Would rather use the term WLAN and/or wireless networks, not only WiFi specifically. Other wireless standards might be more relevant for comparison.

Collaboration with the main players in carbon storage is a key factor in achieving the goal of an accelerated digitized monitoring and early warning system. Using established technology and standardization from the oil and gas industry is important to achieve optimal technical solutions and further to keep the cost at an acceptable level. Established existing products and solutions under development can thus be used in future data collection with a minimum of customization. Offshore carbon storage will be located remotely and will depend on on-site communication infrastructure. With access to local infrastructure, the last distance to various sensors for collecting CCS monitoring data should take place using established standards. It can be wired solutions with fiber or wireless connections to sensors in the area. There may also be autonomous units that are out retrieving data from remote sensors. Data can then be uploaded from docking stations with standardized interfaces for communication. Understanding communication infrastructures in use today and solutions that are under development through collaboration and standardization are of utmost importance to achieve Digimon's goals.

An open architecture standards-based system will lead to a fully integrated digital solution with reduced costs and Improved value - by multiple use of a common sensing infrastructure. This document is intended to provide a glimpse into the efforts on standardization of subsea platforms required for autonomous operations and the handling off large volumes of data.

2 Standards

2.1 Wired Communication

2.1.1 Subsea Instrumentation Interface Standardisation (SIIS)

SIIS: https://siis-jip.com/

The Subsea Instrumentation Interface Standardization (SIIS), a JIP run by OTM Consulting, was established in 2003. With a remit to create an open standard for the benefit of the oil and gas industry as a whole.

Recommended Practice (RP) and text for an American Petroleum Institute (API) Standard, which defines three instrument interface protocols for communication between subsea control modules and subsea sensors:

- Level 1: Analogue Devices: These devices are 4-20mA sensors, 2 wire loop powered analogue output sensing devices.
- Level 2: Digital Serial Devices (CANopen).
- Level 3: Ethernet TCP/ IP Devices.

SIIS level 3 Ethernet is the most relevant communication protocol for the subsea wired infrastructure, providing Ethernet to autonomous vehicles docking stations or PODs for wireless communication. Synchronization and timing can be provided through the Ethernet connection. Network Time Protocol (NTP) is the recommended method for synchronization. IEEE 1588 can be used for high accuracy time synchronization.

Referring to the OSI model ISO/IEC 7498-1. The Recommended Practice specified by SIIS specifies the Physical Layer, Data Link Layer and Network Layer. Higher layer transport and application, see Figure 1, are not covered.

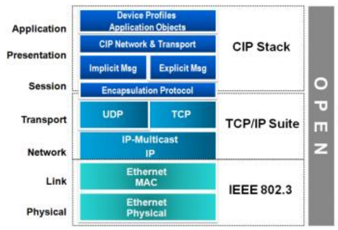

Figure 1. OSI/ISO layers model.

2.1.2 Synchronization

Synchronization requirements needs attention for IEEE 1588 V2 PTP or Synchronous Ethernet systems.

Synchronous Ethernet is an ITU-T standard for computer networking that facilitates the transference of clock signals over the Ethernet physical layer. PTP 1588 is an IEEE standard for Precision Clock synchronization in data network making it suitable for measurement and control systems.

- Synchronous Ethernet: SyncE—ITU-T Rec. G.8261
- 1588 (IEEE 1588-2008 or version 2)

2.2 Wireless Communication

SWiG: https://subseawirelessgroup.com/

The Subsea Wireless Group (SWiG) is an international oil and gas industry network promoting interoperability for subsea wireless communications (radio frequency, acoustic, free-space optic, inductive power, hybrid). The network was established in 2011.

Subsea wireless communications are used to transmit data (e.g. control and monitoring messages) over relatively short distances subsea. This type of network requires little or no infrastructure apart from the communicating devices.

Commented [HI3]: This description should be valid for all SWiG communications (even if data rates and distances are very different). I suggest that this part is moved to the general introduction of SWiG standards, and that the difference between the different version are highlighted even more (both with respect to performance and application areas).

2.2.1 SWiG Acoustic Standard

The standard defines protocol and compatible interconnection for data communication devices using audio frequency acoustic transmission in a subsea environment.

The objective of this standard is to provide a simple acoustic protocol that satisfies requirements of interoperability and interchangeability for acoustic data communication devices. This is achieved by a simple and well-defined standard named SWiGacoustic. SWiGacoustic is derived from the NATO STANAG 4748 (formerly known as Janus).

2.2.2 SWiG Optical Standard

The SWiGoptical document, as part of the SWiG standard, presents a framework for communications and control amongst underwater devices. SWiGoptical satisfies the requirements of interoperable communication amongst heterogeneous, compliant devices from different manufacturers to create an integrated system. SWiGoptical targets subsea process operations and supports monitoring and control applications. For

example:

- Process control
- Equipment and process monitoring
- Diagnostics and maintenance
- Data exchange / bulk data exchange / data harvesting
- Live video streaming
- Underwater vehicles real time control
- Internet of things for subsea applications

- Access points
- Enable networking capabilities

2.2.3 SWiG Inductive Standard

The SWiG inductive power and data standard is used for subsea wireless power transfer and data communication. It consists of a primary (PRI) and secondary (SEC) device that uses near field magnetic induction between coils. The system contains a full duplex communications protocol that enable the primary device to take complete control of the power transfer. It can also accommodate a high-speed direct data connection.

2.2.4 SWiG Radio Standard

Wireless system which operates underwater using signal within the radio spectrum. Typical frequencies used from 100Hz to 2.4GHz. Range is limited to a few centimeters at higher frequencies and a few meters at lower frequencies in seawater. Radio systems are unaffected by many factors that commonly interfere with other transmission standards.

2.2.5 SWiG Multiple Standards for Wide Area Network

Wireless standards can be combined to optimize range and bandwidth. E.g autonomous underwater vehicles (AUV) can utilize acoustics long range communication for mission tasks and control and switch over to optical communication at close range for uploading of data or live HD video transfer. Inductive data and power transfer can also be combined in docking station for data upload and battery charging.

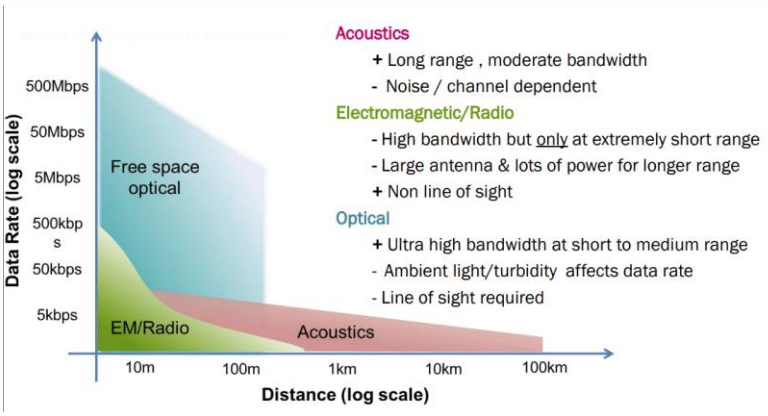

Figure 2. Wireless standards range and bandwidth

2.3 Data exchange & recording

Data exchange for geophysical applications have been standardized by several organizations. Society of Exploration Geophysicists (SEG) is one that we have most experience with and that has been widely used in the industry. The main standards used for data recording are the SEG-Y and the SEG-D standards.

SEG: https://library.seg.org/seg-technical-standards

For our real time passive seismic applications we have utilized WITSML feeds to interface with other systems. WITSML is one of the standards from Energistics.

Energistics: https://www.energistics.org/

3 Octio/Gravitude use cases

3.1 Acoustics

Tide gauge with acoustics modem communication during gravimetry surveys for uploading of tidal data.

Commented [HI4]: Consider "low to moderate bandwidth" for acoustics. At least long range can only support low data rates.

When the ranges approaches zero, far larger data rates can be achieved by EM/Radio – ref. wireless connectors. But this is maybe not relevant here? However, if this is included, inductive solutions could also be added to the diagram.

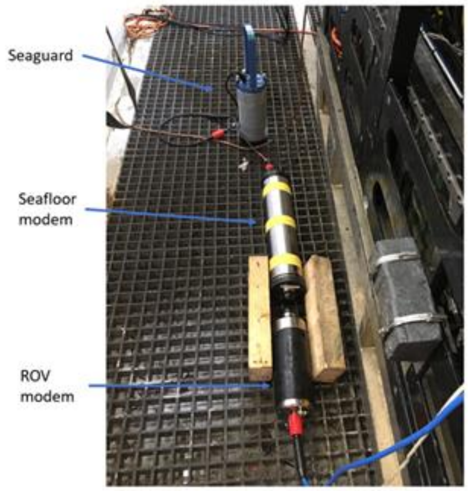

Figure 3. Gravitude survey, modem test before seafloor deployment.

3.2 Gravimetry Survey with ROV

Setup for a gravimetry survey. Instrument communication via ROV for live data collection and control of instrument. Sensor data are collected by the multiplexer located on the ROV. Data is sent to surface via communication fibres in the ROV tether.

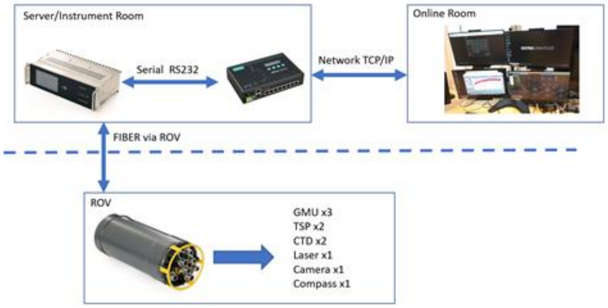

Figure 4. Survey communication

3.3 SIIS Plugfest

An event during which hardware devices are tested for interoperability with emerging standards by physically connecting them together.

Based upon a simple non-redundant topology, a Plugfest was conducted to undertake testing to verify SIIS Level 3 communications between host subsea control system and sensors & instruments under various operating conditions. The subsea controller and instrument equipment used subsea compliant and self-powered electronics/processing equipment. Network interoperability of Octio Seismic system was tested during this event.

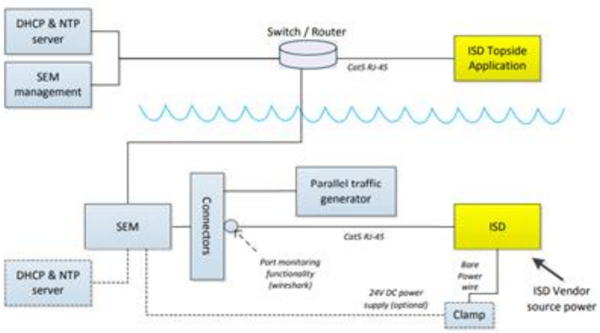

Figure 5. Test setup for SIIIS Level 3 communication.

3.4 Permanent Reservoir Monitoring (PRM) infrastructure

A typical implementation of a PRM system consists of a backbone termination head providing power and fiber communication to the Seismic system sourced by a standard DC power & Fiber Optic subsea distribution network.

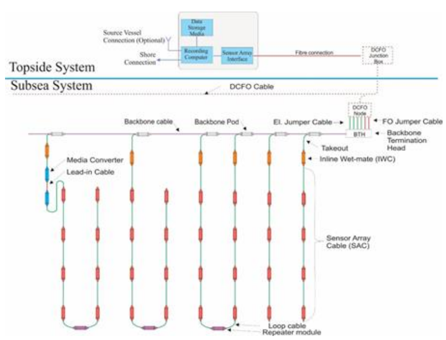

Figure 6. Octio Permanent Reservoir Monitoring system with Backbone Termination Head connected to a DC / FO system.

A DC/FO subsea infrastructure delivers power and Fibre Optic (FO) communication from onshore or offshore host facilities to subsea production systems.

3.5 Octio DrillWatch operations and data transfer to shore

Improved communication networks offshore enable data collection and control from onshore locations. Tampnet is a major provider in the North Sea and often a part of the communication infrastructure in Octio/Gravitude projects. Available capacity and up-time is typical factors that must be considered for the various projects. Aspects here is relevant for CCS depending on type of sensor systems and data requirements. Considerations regarding data processing capacity and data storage onshore/offshore. Backup offshore or close to sensor systems if land lines are limited on stability or capacity.

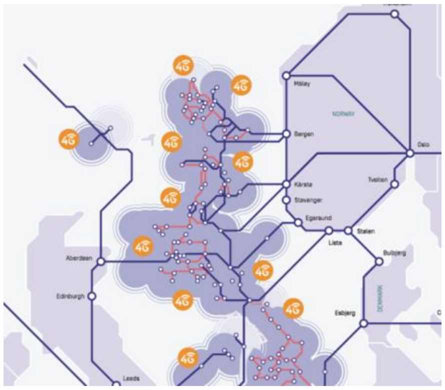

Figure 8. Tampnet coverage map

https://www.tampnet.com/coverage-maps

4 Recommendations

4.1 Data Standards

4.1.1 Subsea data communication

Recommended practice and leading standards to facilitate autonomous operations and subsea digitalization is worked out by the SIIS and the SWIG group. Enabling interoperability from many vendors and reducing implementation cost. Communication and power infrastructure to subsea installations and sensor systems are one of the most cost driving elements. Cooperation here is a major cost saver.

- SWiG: https://subseawirelessgroup.com/
- SIIS: https://siis-jip.com/

4.1.2 Synchronization in time-critical applications

Seismic data collection requires accurate control of timing controlled from e.g a GPS source. This needs attention when planning or designing data collection infrastructure. Use case example can be a DAS system combined with a seismic node system with separated locations that requires accurate synchronization of the data.

Recommended telecom standards:

- Synchronous Ethernet (SyncE—ITU-T Rec. G.8261)
- 1588 (IEEE 1588-2008 or version 2) PTP timing
- IETF RFC 5905: Network Time Protocol (NTP)

4.2 Communication Platform

Example of communication platform, see Figure 7, supporting data collection from the seismic system, docking of AUV, communication with remote systems. Communication from onshore centers or offshore rig installations preferably supported by field infrastructures like DC/FO system or subsea factory plant SIIIS level 3 takeout. Alternatively proprietary cabling to subsea installation. Some type of backbone subsea control module (POD) solution is often required to handle power and communication conditioning for the different applications. From that point numerous types of sensors and support for autonomous systems can be connected. It can be docking of AUV with charging and uploading of survey data, download of new mission plans and tasks for the AUV, acoustic long-range communication with environmental sensors or AUV status update.

The OCTIO seismic system can also provide power and communication for a POD at the far-end of the seismic cable layout for autonomous vehicle support. E.G Blue Logic universal open-standard subsea drone docking stations enables the development of AUV equipped with gravimeters for CCS data collection. Surveys giving data that can be combined with data from other sensor systems.

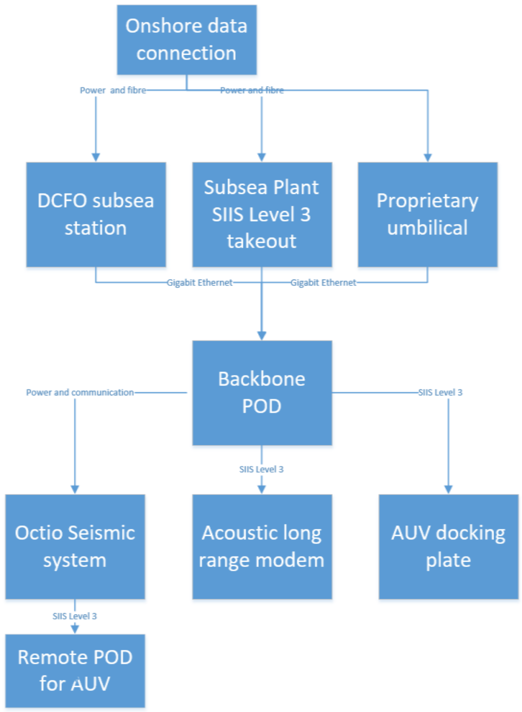

Figure 7. Example of communication platform for subsea infrastructure and sensor systems.

5 References

Power and communication distribution:

ttps://www.offshore-energy.biz/asn-wins-northern-lights-contract/

https://web.asn.com/DCFO-subsea-control.html

https://www.tampnet.com/coverage-maps

Subsea standardization groups:

SWiG: https://subseawirelessgroup.com/

SIIS: https://siis-jip.com/

Data and telecom standards:

https://www.ieee.org

https://www.itu.int/en/Pages/default.aspx

https://www.ntp.org/rfc.html

Subsea equipment for autonomous operations:

https://www.bluelogic.no/news-and-media/subsea-docking-station-sds-

https://stinger.no/home.php/underwater-intervention-drone-uid/

https://oceaninfinity.com/wp-content/uploads/2019/10/OI_FactSheet_NewBrand_V1_Hugin600.pdf