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International Telecommunication Union
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Recommendation

ITU-T G.9730.1 (08/2024)

SERIES G: Transmission systems and media, digital systems and networks

Access networks – Metallic access networks

Dedicated scientific sensing submarine cable system

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Recommendation ITU-T G.9730.1

Dedicated scientific sensing submarine cable system

Summary

Submarine scientific sensing activities including the measurement of temperature, pressure, vibration, acceleration, salinity, etc, are important for climate monitoring and disaster risk reduction. Dedicated submarine cable sensing systems have been constructed around the world.

Recommendation ITU-T G.9730.1 addresses the dedicated submarine cable system for scientific sensing applications. It covers the aspects related to submarine cable system architecture, functional blocks, interfaces between various set of sensors and optical fibre submarine cable.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T G.9730.1	2024-08-29	15	11.1002/1000/16050

Keywords

Climate monitoring, disaster prediction, scientific sensing, set of sensors, submarine cable system, underwater junction box.

* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

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Dedicated scientific sensing submarine cable system

1 Scope

This Recommendation addresses the dedicated submarine cable system for scientific sensing. It covers the aspects related to submarine cable system architecture, functional blocks, interfaces between various sets of sensors and submarine cables. This Recommendation covers qualitative high-level sensing characteristics and features as well as telecommunication interfaces used to monitor the ocean and climate change as well as for disaster warning.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.652] Recommendation ITU-T G.652 (2024), *Characteristics of a single-mode optical fibre and cable*.

[ITU-T G.653] Recommendation ITU-T G.653 (2010), *Characteristics of a dispersion-shifted single-mode optical fibre and cable*.

[ITU-T G.654] Recommendation ITU-T G.654 (2024), *Characteristics of a cut-off shifted single-mode optical fibre and cable*.

[ITU-T G.655] Recommendation ITU-T G.655 (2009), *Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable*.

[ITU-T G.656] Recommendation ITU-T G.656 (2010), *Characteristics of a fibre and cable with non-zero dispersion for wideband optical transport*.

[ITU-T G.657] Recommendation ITU-T G.657 (2024), *Characteristics of a bending-loss insensitive single-mode optical fibre and cable*.

[ITU-T G.971] Recommendation ITU-T G.971 (2024), *General features of optical fibre submarine cable systems.*

[ITU-T G.972] Recommendation ITU-T G.972 (2024), *Definition of terms relevant to optical fibre submarine cable systems*.

[ITU-T G.977] Recommendation ITU-T G.977 (2015), *Characteristics of optically amplified optical fibre submarine cable systems.*

[ITU-T G.978] Recommendation ITU-T G.978 (2010), *Characteristics of optical fibre submarine cables.*

[ITU-T G.979] Recommendation ITU-T G.979 (2016), *Characteristics of monitoring systems for optical submarine cable systems.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 submarine portion: See [ITU-T G.972].

3.1.2 land portion: See [ITU-T G.972].

3.1.3 terminal station: See [ITU-T G.972].

3.1.4 optical fibre submarine cable: See [ITU-T G.972].

3.1.5 optical submarine repeater: See [ITU-T G.972].

3.1.6 branching unit (BU): See [ITU-T G.972].

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 underwater junction box (UJB): It includes equipment for scientific monitoring data collection and transmission, power supply and voltage transition, fault isolation, interfaces.

3.2.2 primary underwater junction box (P-UJB): Underwater junction box (UJB) that is connected directly or via a branching unit (BU) to the trunk cable.

3.2.3 secondary underwater junction box (S-UJB): Underwater junction box ((UJB) that is connected to a primary underwater junction box (P-UJB) and is used for the extension of the set of sensors.

3.2.4 set of sensors: Different kinds of sensors grouped together for submarine scientific sensing.

3.2.5 wet-pluggable interface: An interface that can be connected and disconnected underwater to an underwater junction box (UJB).

3.2.6 sensor data processing and storage (SDPS): A device used to process and store the data generated by sensors in the submarine portion.

3.2.7 wet-pluggable connector: Connector that is used for the wet-pluggable interface.

3.2.8 land station: Station that could be located in terrestrial stations or offshore platforms.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AUV Autonomous Underwater Vehicle

BU Branching Unit

DA Double Armoured cable

DFOS Distributed Fibre Optic Sensing

LW Light Weight cable

LWP Light Weight Protected cable

MC Maintenance Controller

NTP Network Time Protocol

PFE Power Feeding Equipment

PTP Precision Time Protocol

P-UJB Primary Underwater Junction Box

RA Rock Armoured cable

ROV Remotely Operated Vehicle

SA Single Armoured cable

SDPS Sensor Data Processing and Storage

S-UJB Secondary Underwater Junction Box

TTE Terminal Transmission Equipment

UJB Underwater Junction Box

5 Conventions

None.

6 Dedicated submarine scientific sensing system general requirements

The dedicated submarine scientific sensing system incorporates different sensor sets (e.g., temperature, pressure, vibration, accelerometer, salinity, etc.) for climate monitoring and disaster prediction.

The dedicated submarine scientific sensing system uses the transmission equipment to transport the data collected by different sensors through fibre pairs.

The system provides continuous power for the set of sensors and transmission equipment.

These set of sensors could be controlled and managed remotely from land stations.

At land stations, devices for receiving, processing and storing data generated by the sensor sets are provided.

7 Submarine scientific sensing system architecture

7.1 System categories

7.1.1 Unrepeatered system with power feeding

Short distance dedicated scientific sensing system could use unrepeatered systems, shown in Figure 1, as no repeaters for communication purposes are needed. The sensing system uses power feeding equipment (PFE) in the land portion and submarine cable with electrical conductor for power transmission and the set of sensor data collection and transport in submarine portion.

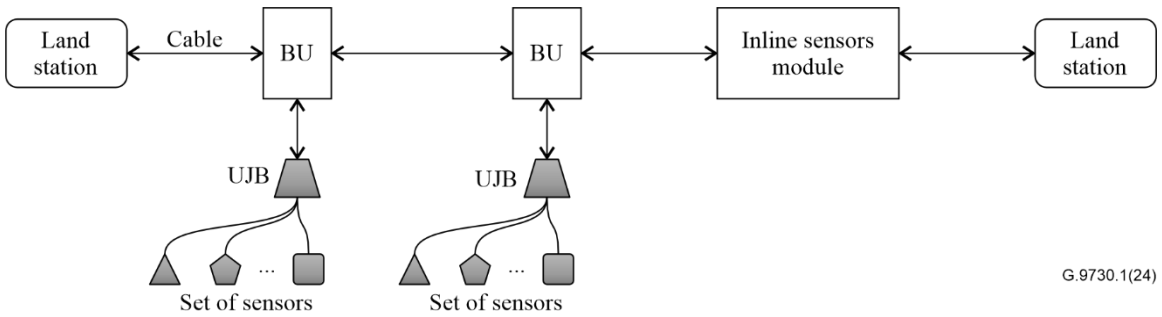

Figure 1 – Unrepeatered scientific sensing system

7.1.2 Repeatered system

Long distance dedicated scientific sensing systems need optical submarine repeaters to carry the information data at the required performance, which is defined in [ITU-T G.977]. An example of a repeatered scientific sensing system is shown in Figure 2.

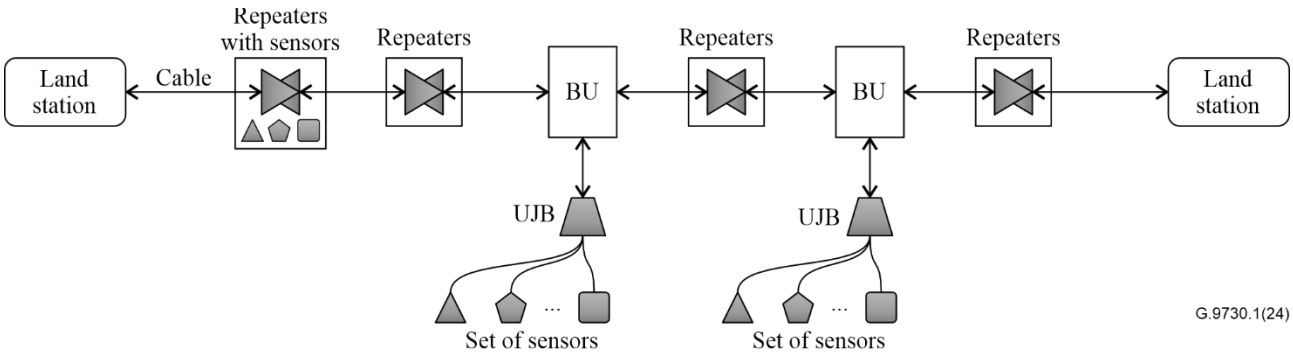

Figure 2 – Repeatered scientific sensing system

7.2 System topologies

7.2.1 Chain topology

System topology could be a single ended chain as shown in Figure 3. The data generated by the set of sensors are transported to one land station.

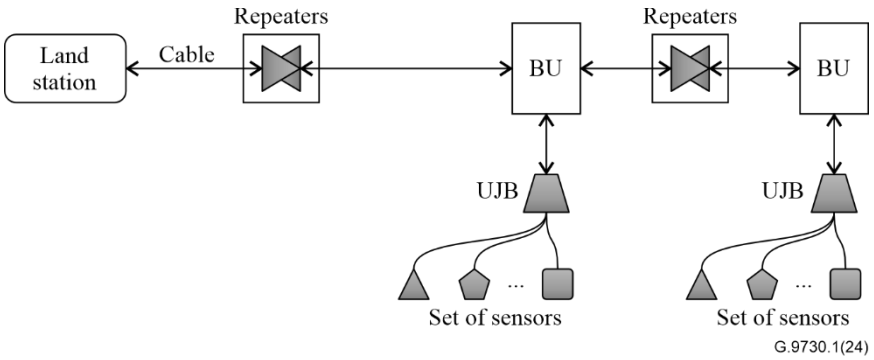

Figure 3 – Chain topology

7.2.2 Ring topology

System topology could be a ring type as shown in Figure 4. The data generated by set of sensors are transported to one land station with two directions for transmission path protection.

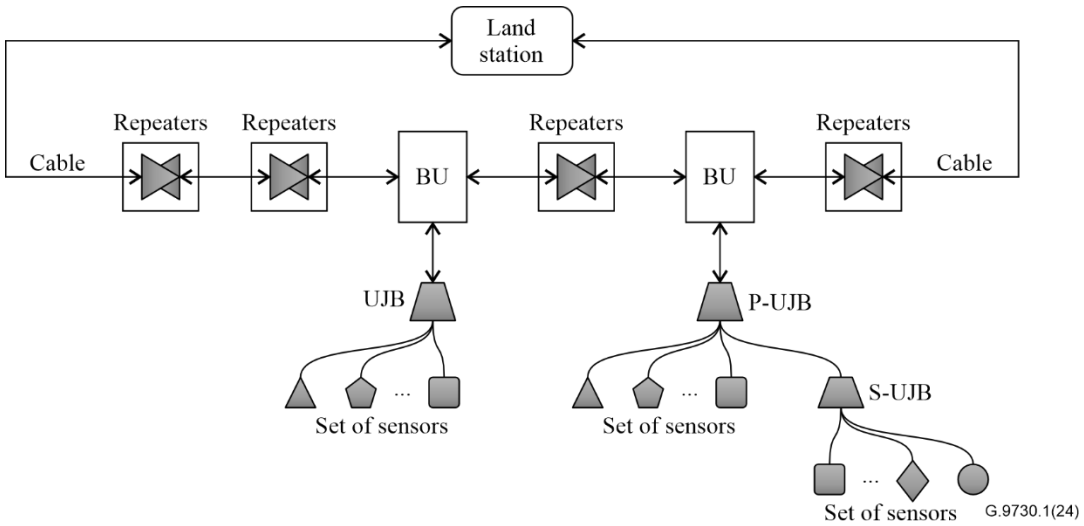

Figure 4 – Ring topology

7.2.3 Horseshoe topology

System topology could be of horseshoe type as shown in Figure 5. A Set of sensors is connected to two different land stations ensuring protection for both transmission path and land portions.

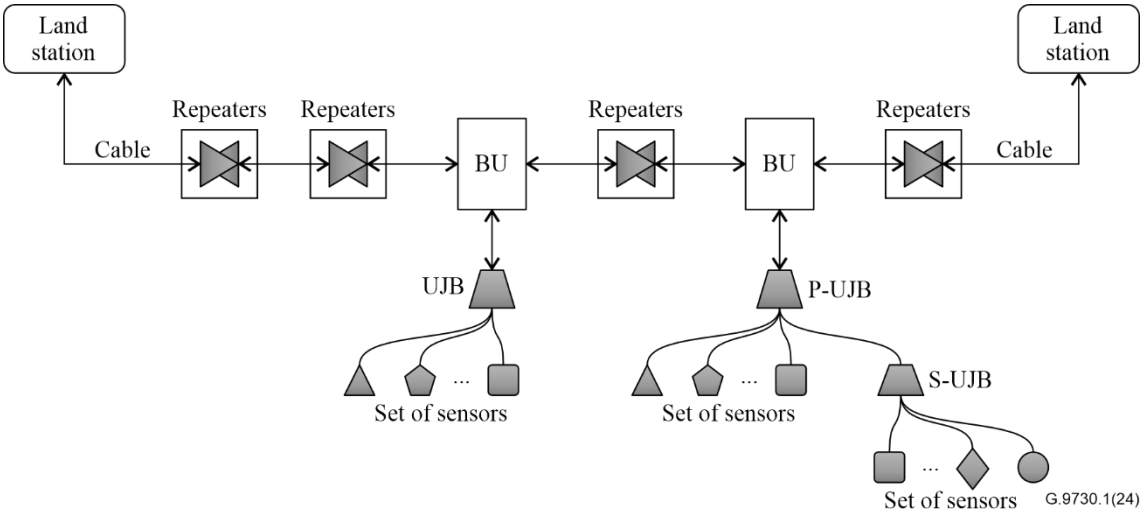

Figure 5 – Horseshoe topology

7.2.4 Mesh topology

System topology could be mesh for flexibility and robustness as shown in Figure 6. Cross connectors could be used to connect multiple directions.

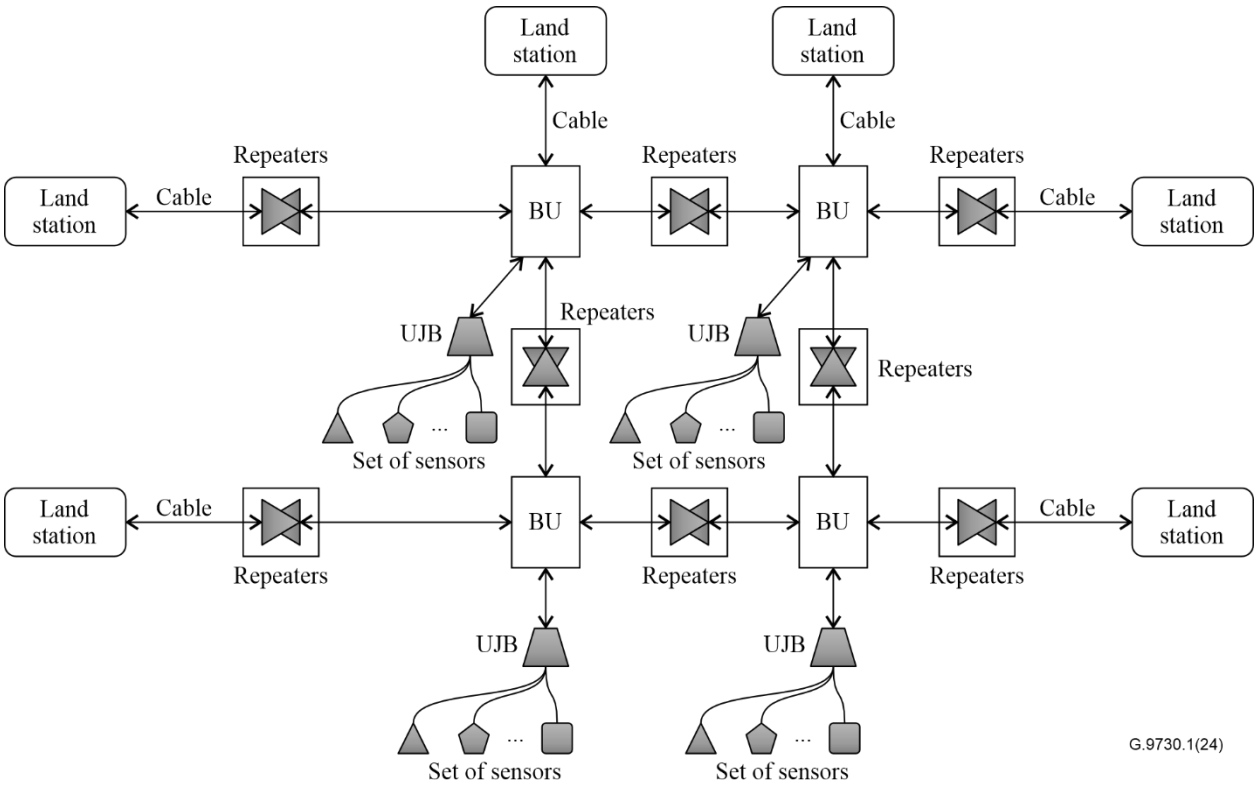

Figure 6 – Mesh topology

8 Submarine scientific sensing system function blocks and requirements

Several function blocks are needed in submarine scientific sensing system. An example of a repeatered scientific sensing system is shown in Figure 7.

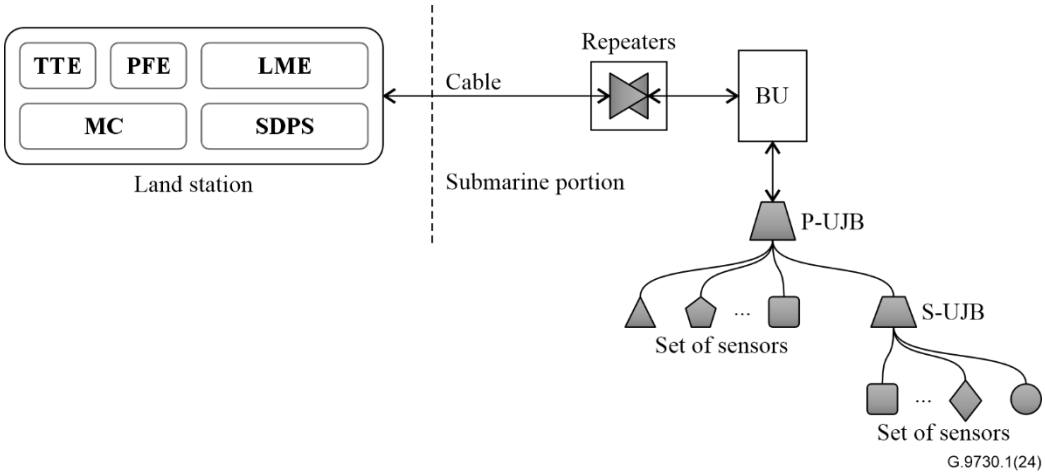

Figure 7 – Example of dedicated submarine scientific sensing system function blocks

8.1 Submarine cable

8.1.1 Cable types

The cables defined in [ITU-T G.978] are applicable to the dedicated scientific sensing systems, such as light weight cable (LW), light weight protected cable (LWP), single armoured cable (SA), double armoured cable (DA) and rock armoured cable (RA).

8.1.2 Fibre types

The single-mode fibres defined in [ITU-T G.652], [ITU-T G.653], [ITU-T G.654], [ITU-T G.655], [ITU-T G.656] and [ITU-T G.657] are applicable to the dedicated scientific sensing systems.

8.2 Power supply system

The power supply system provides the power load required for powering the sensors as well as for data sampling, processing and communication functions.

According to the work type of the power supply, different modes can be used including constant-voltage power supply or constant-current power supply.

8.2.1 Constant-voltage power supply

The submarine cable operates in a constant voltage mode with all UJBs connected in parallel.

8.2.2 Constant-current power supply

The submarine cable operates in a constant current mode with all UJBs serially connected.

8.3 Underwater junction box (UJB)

8.3.1 Primary underwater junction box (P-UJB)

P-UJB is the main UJB in the submarine cable link. It contains the submarine transmission equipment, different kinds of interfaces to the BU, different kinds of interfaces to the set of sensors, and optionally interfaces to secondary underwater junction box (S-UJB) for extension.

Figure 8 shows two examples of P-UJB having the BU inside or outside. Figure 8(a) considers P-UJB case with an outside BU. Different kinds of interfaces could be used to connect the P-UJB to the outside BU. For the BU integrated in the P-UJB, the interface to the BU is inside the P-UJB as shown in Figure 8(b).

The submarine transmission equipment within the P-UJB works in a coordinated manner with the terminal transmission equipment in the land stations.

For the ring, horseshoe and mesh topologies, the route switching functions are needed in BU.

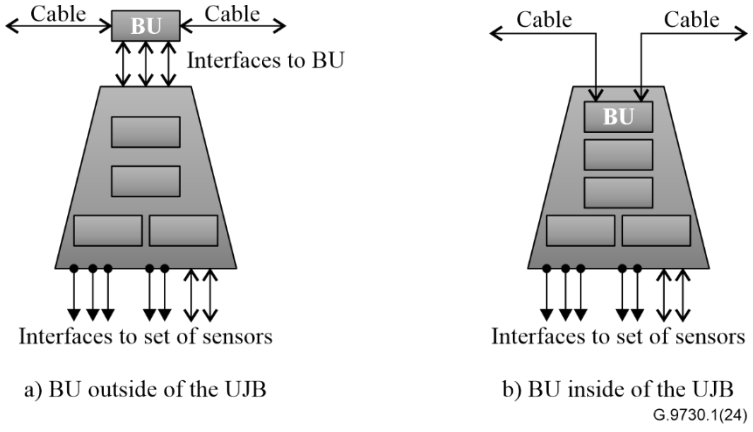

Figure 8 – Examples of UJBs

8.3.2 Secondary underwater junction box (S-UJB)

S-UJB connects to P-UJB in the submarine cable link for the extension of set of sensors. It contains interfaces to P-UJB, different kinds of interfaces to the set of sensors. Transmission equipment could be used in S-UJB to communicate with P-UJB.

8.4 Optical submarine repeaters

For scientific monitoring systems extending over a long distance, optical submarine repeaters are required in the transmission system. Repeater specifications are defined in [ITU-T G.977].

The inline optical submarine repeater housings could contain sensors, as shown in Figure 2.

8.5 Branching unit

Branching units (BUs) are used to branch a spur cable with UJBs. A BU is also used to isolate faulty a cable or faulty UJBs with power path switching.

The BU could be standalone in the submarine cable link, or the BU function could be implemented inside of the P-UJB as shown in Figure 8(b).

8.6 Different sets of sensors

8.6.1 Set of sensor types

Two types of sensing techniques could be used in the scientific sensing system, namely localized sensing and distributed sensing.

8.6.1.1 Localized sensing

Sensors could be incorporated at one or multiple points along the cable.

8.6.1.1.1 Temperature sensors

The main parameters of temperature sensors are:

- Range [min, max]
- Initial accuracy
- Stability (drift)
- Sampling rate
- Sample resolution

8.6.1.1.2 Pressure sensors

The main parameters of pressure sensors are:

- Range [min, max]
- Overpressure tolerance
- Accuracy
- Maximum allowable drift after a settling in period
- Accuracy after drift correction
- Hysteresis
- Repeatability
- Sampling rate
- Noise floor
- Sample resolution

8.6.1.1.3 Accelerometers

The main parameters of the 3-axis accelerometer are:

- Configuration
- Response range
- Resonance frequency

- Full scale range
- Noise floor
- Amplitude response
- Linearity
- Cross-axis sensitivity
- Sampling rate
- Sample resolution

8.6.1.1.4 Seismometer

The main parameters of seismometer are:

- Configuration
- Frequency bandwidth
- Dynamic range
- Noise floor
- Sensitivity
- Clip level
- Sampling rate
- Sample resolution

8.6.1.1.5 Other sensors

Additional sensors could be used depending on the monitoring application such as vibration, etc.

8.6.1.2 Distributed sensing

The fibre by itself could be used for distributed fibre optic sensing (DFOS), DFOS can be categorized by backscattering type and feed forward type.

Similarly, acoustic signals propagating through the water can be used in backscattering mode and forward propagating mode for sensing.

8.6.2 Sensor performance

Sensor performance requirements depend on the agreed sensor specifications, but the following should be considered:

- variations arising from the measurement circuitry
- the aging of any measurement circuit components
- realistic geopositioning accuracy
- realistic orientation deviation from absolute earth reference
- environmental variations, including depth, ambient temperature and seabed conditions.

8.7 System interface

8.7.1 Optical interface

The optical interface may be used between the set of sensors and the UJB to carry raw data delivered by the sensors.

8.7.2 Electronic interface

The electronic interface may be used for data transmission between the set of sensors and the UJB.

The electronic interface is used to supply power to the set of sensors.

8.7.3 Hybrid optical and electronic interface

Some applications could use both optical and electronic interfaces between the set of sensors and the UJB. Generally, the optical interface is used to transmit data while the electronic interface is used to supply power.

8.7.4 Wet pluggable interface

Wet pluggable interface could be connected and disconnected underwater for system construction, extension and maintenance. This is usually accomplished using a remotely operated vehicle (ROV) tethered to a ship. Wet-pluggable interface uses watertight connectors. Watertight connectors include dry mate connectors and wet-pluggable connectors.

8.7.5 Wireless interface

Wireless interfaces include wireless communications interfaces (e.g., acoustic modems, optical wireless transceivers, etc.) and wireless power transferring interfaces between the UJB and external devices, for example an autonomous underwater vehicle (AUV).

8.8 Land portion

8.8.1 Terminal transmission equipment

Terminal transmission equipment (TTE) characteristics depend on the amount of data needed to be carried from the set of sensors in the submarine portion to the land station.

8.8.2 Maintenance controller

A maintenance controller (MC) is used for the supervision and remote maintenance activities of the equipment in the submarine portion including UJBs, cables, repeaters, BU and the different kind of sensors. MC is also used for land portion terminal transmission equipment maintenance purposes as defined in [ITU-T G.972].

8.8.3 Sensor data processing and storage

The network management system stores the recorded sensor data and provides an interface to the client for their transfer. The processing and storage of the large amount of data are difficult and complicated tasks.

Data is reported in natural units, e.g., °C for temperature, m/s^2 for acceleration, and Pa for pressure.

8.8.4 Time and synchronization

Timing and synchronization functions are used by TTE, the transmission equipment in the UJB and the set of sensors. Network time protocol (NTP), precision time protocol (PTP) or other protocols could be implemented depending on accuracy requirements.

9 Reliability and maintenance

9.1 Reliability

9.1.1 System reliability

System reliability includes the reliability of TTE, cables, repeaters (if used), BU, UJB.

9.1.2 Sensors reliability

Different sensors may have different reliability and design life.

9.2 Maintenance

The BU could isolate faulty cable or faulty UJBs, and the UJB could isolate any faulty sensors. Sensors should work independently without affecting the other sensors when faulty. For the UJB with wet-pluggable interfaces, the set of sensors could be changed underwater.

9.3 Monitoring function

Detailed monitoring function requirements and recommended parameters for submarine cable systems are defined in [ITU-T G.979]. Monitoring function requirements of UJBs are needed for dedicated submarine scientific sensing systems.

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